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**Research for Rural
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2016**





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FOREWORD

The four independent reviewers estimated each paper and recommended 77 articles for publishing at the proceedings consisted of 2 volumes, which started life as presentations at the Annual 22nd International Scientific Conference “Research for Rural Development 2016” held at the Latvia University of Agriculture, in Jelgava, on 18 to 20 May 2016.

In the retrospect of four months later, we can count the Conference as a great success. The theme – Research for Rural Development - attracted participation more than 160 researchers with very different backgrounds. There were 125 presentations from different universities of Poland, Turkey, Tajikistan, Lithuania, Croatia, Czech Republic, Kazakhstan, Mexico and Latvia.

Thank you for your participation! I’m sure that you have learned from the presentations and discussions during the conference and you can use the outcomes in the future.

The cross disciplinary proceedings of the Annual 22nd International Scientific Conference “Research for Rural Development 2016” (2 volume since 2010) are intended for academics, students and professionals. The subjects covered by those issues are crop production, animal breeding, agricultural engineering, agrarian and regional economics, food sciences, veterinary medicine, forestry, wood processing, water management, environmental engineering, landscape architecture, information and communication technologies. The papers are grouped according to the sessions in which they have been presented.

Finally, I wish to thank Organizing and Scientific Committee and the sponsors for their great support to the conference and proceedings.

On behalf of the Organizing Committee
of Annual 22nd International Scientific Conference
“Research for Rural Development 2016”

A handwritten signature in black ink, appearing to read 'Ausma Markevica'.

Ausma Markevica
Latvia University of Agriculture

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TREE DAMAGES BY ICING IN SCOTS PINE (*PINUS SYLVESTRIS* L.) STANDS AND FACTORS AFFECTING THEM

Endijs Bāders, Andis Adamovičs, Mārtiņš Puriņš, Baiba Džeriņa

Latvian State Forest Research Institute 'Silava'

endijs.baders@silava.lv

Abstract

Icing notably increases the mass of a tree crown, causing damage to the tree. So far, a very limited number of studies have assessed the icing influence on coniferous trees, none of them in Latvia. The aim of the study was to assess the influence of tree parameters and recent thinning on the proportion of damaged trees and the type of damage in Scots pine stands. The study sites were located in the eastern part of Latvia, damaged in December 2012. In total, 98 pine dominated stands of different age were selected randomly. Eight (mean) plots per stand were established; in each plot, all trees larger than 2.1 cm were measured and the type of damage assessed. The above-ground biomass from 12 randomly selected stands (57 dominant trees) of different age was weighted with and without icing. The biomass of pine with icing exceeded that without 1.5 ± 0.27 times. The mean proportion of damaged trees in pine dominated stands was 26%; the proportion of broken trees peaked in the middle-aged stands (41 – 70 years old), but the largest proportion of pooled bent and uprooted trees was found in the young (11 – 20 years old) stands. The proportion of damaged dominant trees was affected by the slenderness coefficient – a higher proportion of such trees was found among more slender trees. The results suggest that the risk of icing damage could be reduced by silvicultural measures boosting individual tree stability.

Key words: natural disturbance, stem breakage, stem bending.

Introduction

The freezing rain, i.e. phenomena when liquid precipitation freezes on a cooled surface, causes icing (Drage, 2005). In Latvia, favourable conditions for occurrence of freezing rain are caused by the dominant western wind direction, which moves the cyclones of the North Atlantic Ocean (Jordi & Sultan, 2009), as well as by increasing continentality from west to east (Draveniece, 2007). Historically, freezing rain has been more frequently observed in the eastern part of Latvia, and it is not expected to decrease due to climatic changes. For instance, in Germany the damage of trees caused by snow and icing occurs after each 3 – 7 years (Rottmann, 1985), but in Sweden notable damage (from 100 thousand to 1 million m³ wood) has been caused by ten snow storms at the end of the last century (Schroeder & Eidmann, 1993). In contrast to some other natural disasters, e.g. forest fire which affects the survival and regeneration of pines (Zadiņa, Donis, & Jansons, 2015), the icing cannot be prevented. A number of studies have been done to understand the regional differences of the formation of freezing rain (Carrière *et al.*, 2000; Makkonen & Ahti, 1995). However, the monitoring of icing is mainly related to increased loading to infrastructure, e.g. power lines. The effect of icing on forest stands has been studied less and includes the combination with other factors, mainly snow and wind. Icing increases loading on the tree stem and crown, causing mechanical deformation or irreversible damage. The layer of 1 – 2 cm thick icing is believed to cause notable damage of branches (Greene, Jones, & Proulx, 2007). However, the individual stem integrity depends on many factors, among which the main are physically-mechanical

properties of wood, the accumulated amount of ice, additional loading of snow load, duration of loading and wind speed (Bragg, Shelton, & Zeide, 2003). The type (Croxtton, 1939; Irland, 2000) and severity of damage differs between the stands due to the differences of tree species composition, age structure, density, spatial distribution of crowns (Turcotte *et al.*, 2012), as well as between individual trees due to the differences of stem straightness, branching symmetry and structure, root vitality (Bragg, Shelton, & Zeide, 2003; Hauer, Werner, & Dawson, 2008; Päätaalo, Peltola, & Kellomäki, 1999); thus information of precise thresholds is missing. Nevertheless, most of these characteristics can be altered by silvicultural measures (Goodnow, Sullivan, & Amacher, 2008). Therefore, the aim of the study was to assess the influence of tree parameters and recent thinning on the proportion of damaged trees and the type of damage in Scots pine dominated stands.

Materials and Methods

The Scots pine (*Pinus sylvestris* L.) dominated stands were assessed in the eastern part of Latvia (Rēzekne, Baltinava, Balvi and Kārsava municipalities) after the icing event in December 2012. In 12 pine stands of different age classes, 55 broken and bent dominant pines representing diameter at breast height from 2 to 17 cm were randomly selected and cut. The above-ground biomass with icing was weighted using KERN HCB scales (*precision* 200 g). The tree biomass was measured repeatedly after the icing melted.

The icing damage was assessed in randomly selected 98 pine dominated (at least 70% from standing volume) stands with the minimum area of

Table 1

The characteristics of the studied stands

Age, years	N	G, m ² ha ⁻¹	DBH, cm	H, m	Number of measured trees	Proportion of damaged trees, %
11 – 20	12 (12)	5	8	6	3506	32
31 – 40	7 (7)	17	14	14	179	42
41 – 50	4 (1)	24	18	19	1867	29
51 – 60	19 (16)	26	20	21	2110	26
61 – 70	2 (1)	19	25	22	129	36
71 – 80	15 (7)	29	26	24	2462	23
91 – 100	18 (6)	33	28	26	488	37
>101	21 (3)	31	28	24	1902	24

N – total number of stands (number of stands thinned during the last 3 years); G – stand basal area; DBH – mean diameter at breast height; H – mean height.

0.8 ha; according to the stand inventory data, the age of the stands was 12–123 years. The stands were evenly distributed across the study area and were located on dry mineral soils (forest types according to Bušs (1976): sandy and loamy automorphic soils (*Cladinoso–callunosa*, *Vacciniosa*, *Myrtillosa*, *Hylocomiosa*), wet mineral soils (*Vaccinioso–sphagnosa*, *Myrtilloso–sphagnosa*), poor peat soils (*Caricoso–phragmitosa*), as well as on drained mineral and peat soils (*Myrtillosa mel.* and *Myrtillosa turf.mel.*), respectively. In each stand, eight (mean) sample plots of 200 m² area were established. Sample plots were evenly distributed within the stand, located at least 10 m from its edges. For each tree, the type of icing damage (not damaged, bent, broken or uprooted) was denoted, and the height and diameter at breast height (DBH) was measured (Table 1). Trees smaller than 2.1 cm DBH were not included in the study. Trees were classified as ‘bent’ if the stem deviation from vertical axis exceeded 15°, including trees with bent top; if the stem deviation exceeded 85° (including fallen trees), the tree was classified as ‘uprooted’. During the analysis, ‘bent’ trees were pooled with ‘uprooted’ trees due to the low number of the latter trees; further named as ‘bent/uprooted’ trees. In total, data of 12,643 trees were analysed. The slenderness coefficients, defined as the ratio of tree height to DBH, were calculated from individual tree data. Stands are especially prone to ice and snow caused damages in the first years after thinning (Bragg, Shelton, & Zeide, 2003). Therefore, the influence of thinning was assessed between the ‘recently’ thinned, i.e. during the last 3 years and the ‘other’ stands – not thinned or thinned more than 3 years ago.

The normality of data was assessed by Shapiro-Wilk test. The relationship between the tree above-ground biomass with and without icing and the relationship between the proportion of broken and

bent/uprooted trees and stem DBH were assessed by the linear model. The one-way analysis of variance was used to assess the differences of the proportion of broken and bent/uprooted trees between the stands of different age and the differences of the proportion of damaged trees in the recently thinned and the other stands between the stands of different age.

Results and Discussion

The weight of the dominant pines with icing 1.5 ± 0.27 times exceeded that without ice in the naturally moist condition. The biomass of pine and weight of icing on it were significantly and tightly related ($r=0.71$; $p<0.01$) (Fig. 1). However, notable variation of the icing weight for pines of different sizes was noted, presumably caused by the asymmetry of a tree crown or influenced by wind. The information of threshold of icing mass or layer beyond which the tree broke is missing; some authors have reported the threshold of layer thickness 1.0 – 2.5 cm (Greene, Jones, & Proulx, 2007; Hauer, Werner, & Dawson, 2008).

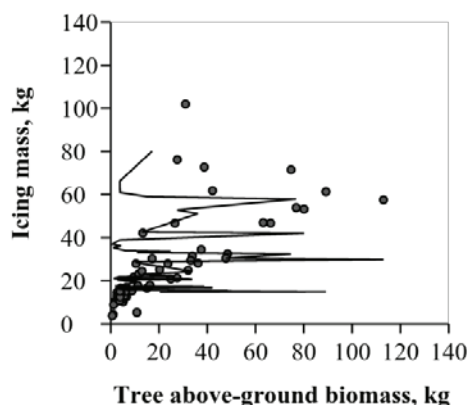


Figure 1. The relation between the tree biomass and icing mass.

In the studied stands, the proportion of damaged spruces, pines and birches was 20, 26 and 32%, respectively; in total 26% of all trees. A higher proportion of trees were broken than bent/uprooted: 18 and 7%, respectively. During the icing event, the soil was unfrozen, presumably increasing the proportion of the bent and uprooted pines. The effect of soil conditions on the type of damage has been reported (Gregow, 2013; Peltola *et al.*, 1999). For instance, on frozen soil a higher number of pines are broken or bent, while on unfrozen soil the uprooting is more common, especially for spruce due to its shallow root system (Gregow, 2013). Also the interaction between abiotic factors affects the type of damage. For instance, the snow loading of at least 20 kg m⁻² with simultaneously increasing wind force will more likely cause stem breakage than uprooting (Gregow, 2013). The assessment of such interaction was not possible in our study since the icing affects a

certain discrete location and no meteorological station was located in it.

The proportion of damaged trees was significantly ($p < 0.05$) affected by the stand age (Fig. 2). The lowest proportion (6%) of the broken trees was in the youngest stands; it peaked (26 – 35%) at the middle-aged stands, significantly exceeding the proportion of broken trees at the other age classes. Among the older stands, the proportion of broken trees was 14 – 21%. The proportion of bent/uprooted trees showed an opposite pattern: the highest proportion (22%) of such trees was found at the age of 11 – 20 years, and the lowest (4%) – at the age of 71 – 80 years. In the older stands, the proportion of bent/uprooted trees slightly increased; a high proportion (18%) of such was obtained at the age of 100 – 110 years, which was represented by only one stand. Similar observations were done in Finland (Nykänen *et al.*, 1997), indicating that the snow accumulation has a

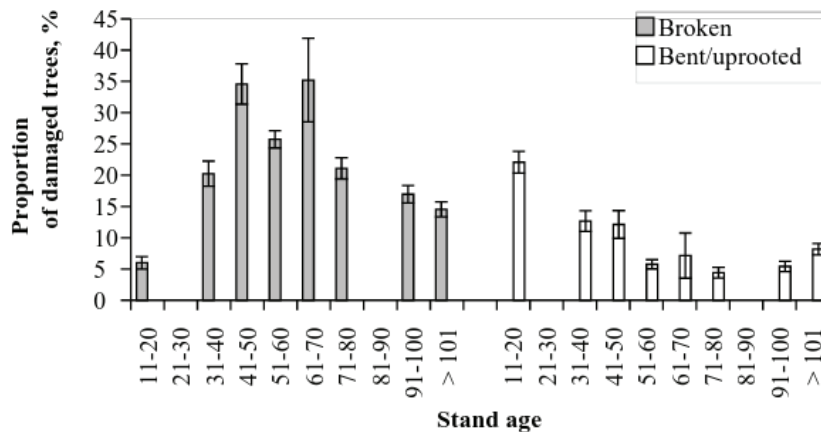


Figure 2. The proportion of broken and bent/uprooted trees in pine dominated stands according to the stand age. The error bars denote 95% confidence interval.

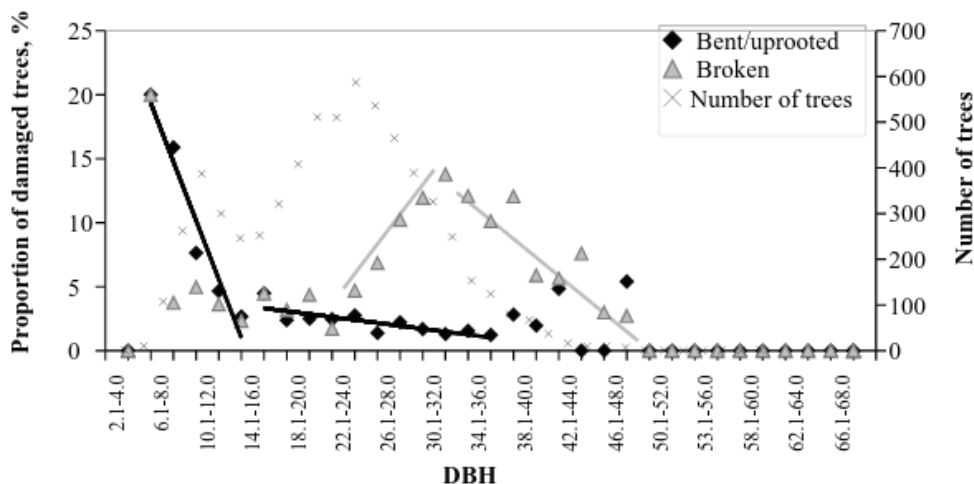


Figure 3. The proportion of the damaged dominant pines according to the diameter at breast height (DBH). The significant ($p < 0.05$) trends are denoted by lines: grey – broken trees; black – bent/uprooted trees.

Table 2

The coefficients of equations () of the proportion of damaged dominant pines according to the diameter at breast height (DBH) classes

Type of damage	DBH classes, cm	Coefficients		R ²		p-value	
		b ₀	b ₁	b ₀	b ₁		
Bent/uprooted	4-12	0.28529195**	-0.0459033**	0.94	0.005		
	14-34	0.0492392***	-0.0022955**	0.66	0.002		
Broken	6-20	0.04812071**	-0.0019466	0.19	0.285		
	22-30	-0.2067749**	0.02321109**	0.99	0.001		
	32-48	0.35563495***	-0.0145005***	0.86	0.000		

* p<0.05; ** p<0.01; *** p<0.001.

high probability of uprooting tree groups in young, dense stands (slender trees with short, asymmetric crown) but the stem breakage more frequently occurs in the middle-aged and mature stands.

The proportion of bent/uprooted dominant pines had a significant negative relation to the tree DBH: it decreased rapidly for trees 4.1-14.0 cm DBH (Fig. 3; Table 2) and continued to decrease gradually for pines of 14.1 to 36.0 cm DBH. For larger pines (DBH 36.1-48.0 cm), the proportion of bent/uprooted pines fluctuated. In contrast, the proportion of broken pines had a significant positive relation to the tree DBH for trees 22.1-32.0 cm, peaking at 15.1%. After the peak, the proportion of broken pines decreased (DBH 32.1-50.0 cm) with a slight fluctuation. These results are consistent with the observation in the mature spruce-beech stands, where the proportion of the broken trees caused by the snow loading showed a positive relationship to the tree DBH until the peak of ca. 15% for trees with DBH 18 – 20 cm, followed by a gradual decrease for larger trees (Hlásny *et al.*, 2011). Stem breaks if its bending resistance is lower than the strength of roots; for instance, for spruce the stem resistance to breakage has a tight relation to the tree diameter and can be described by the function DBH³ (Nykänen *et al.*, 1997; Petty & Worrell, 1981). In contrast, the uprooting occurs if the accumulated snow

and ice loading exceeds the strength of roots (Valinger, Lundqvist, & Bondesson, 1993) – that is more likely to happen to older (mature or over-mature) trees with a relatively large DBH and crown (Peltola *et al.*, 1999), but is also observed in young, thinned stands (Hlásny *et al.*, 2011). The root resistance to uprooting can be described by the function H x DBH², indicating a substantially larger importance of tree DBH than height (H) on the uprooting probability (Peltola *et al.*, 1999), presumably due to larger root biomass for trees with larger DBH, as determined in empirical studies in young Scots pine stands (Bārdulis, Jansons, & Liepa, 2011, 2012).

In our study, the damaged trees had a larger stem slenderness coefficient than undamaged trees, regardless of the thinning: in the recently thinned stands it was 1.07 and 0.93 and in the other stands 1.01 and 0.94, respectively. This trend remained in the assessment of the diameter classes and slenderness groups of the pines (Fig. 4). Likewise, other studies also have confirmed that the slenderness has a significant effect on the wind and snow caused damage in pine stands (Päätaalo, Peltola, & Kellomäki, 1999). For instance, under the snow load of 60 kg m⁻² simultaneously with 9 m s⁻¹ wind, slender trees (tree height 12 – 24 m, slenderness coefficient >0.83) had a higher probability of stem breakage; and the

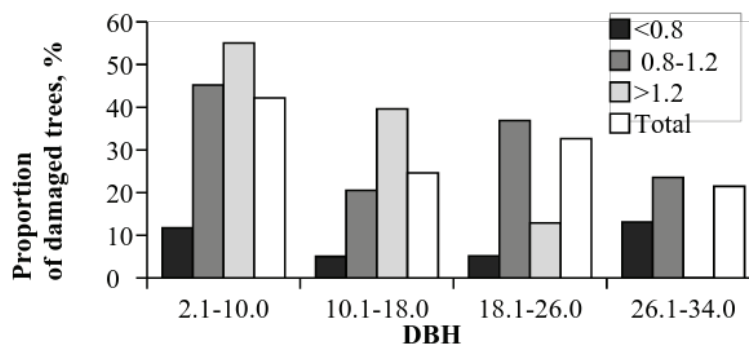


Figure 4. The proportion of the damaged pines according to the diameter at breast height (DBH) class and slenderness coefficients.

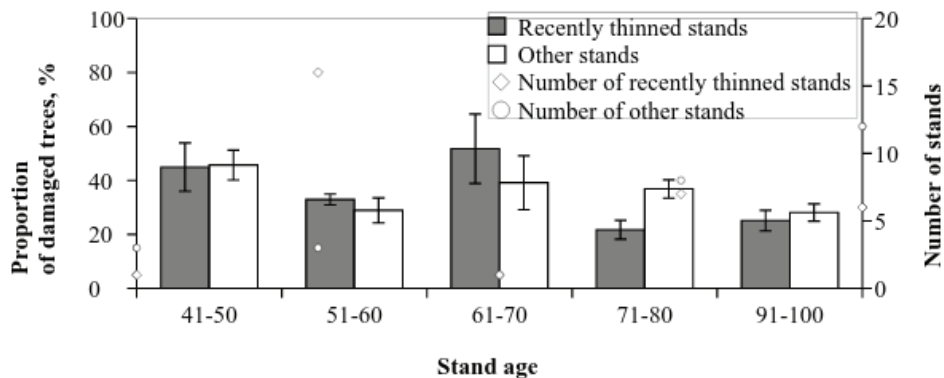


Figure 5. The proportion of damaged dominant trees according to the stand age in the recently thinned stands (i.e. thinned during the last 3 years) and in the other (i.e. thinned earlier or not thinned) pine dominated stands. The error bars denote 95% confidence interval.

proportion of broken trees decreased with decreasing slenderness coefficient of a tree. Also, the icing damage is more likely for the relatively slender trees; the reported threshold 0.9 – 1.0 (Bragg, Shelton, & Zeide, 2003; Cannell & Morgan, 1989; Nykänen *et al.*, 1997). Tree breeding as a financially viable activity is practised in a number of countries in the Baltic Sea region, including Latvia (Gailis & Jansons, 2010; Jansons, Gailis, & Donis, 2011; Jansons *et al.*, 2015a) and it has showed a notable effect on the growth traits of Scots pine (Jansons, 2005; Jansons *et al.*, 2006). It has been demonstrated, that genetics has a notable influence on the tree slenderness (Kroon, Andersson, & Mullin, 2008) and, therefore, genetics can affect the probability of icing caused damages. Also genotype x environment interaction (Jansons, 2008) might be of importance. For instance, changing climate will affect both height and diameter growth of pines (Jansons *et al.*, 2013a; Jansons *et al.*, 2013b; Jansons *et al.*, 2015b), but not to the same extent, presumably altering the slenderness of trees (Salminen, Jalkanen, & Lindholm, 2009). The influence of genetics (provenance) was a significant factor affecting reaction of Scots pine to different climatic conditions (Rieksts-Riekstiņš *et al.*, 2014), supporting the assumption that genetics might modify the effect of climatic changes on the tree slenderness coefficient. Nevertheless, genetics (both at clone and provenance level) can have a significant influence also on the biomass distribution, including the height of the mass point, and crown properties of young (25 - 39 years) coniferous trees. However, these differences were related to the influence of genetics on growth traits that tightly correlated with the particular crown traits, but not due to 'direct' genetic influence (Jansons *et al.*, 2014; Lībiete-Zālīte & Jansons, 2011).

In the recently thinned stands, the proportion of the damaged (pooled all types of damages) dominant trees were similar to that in the other stands: 25 and 26%, respectively. However, no clear relation of the

proportion of damaged trees was found according to the DBH groups or age decades (Fig. 5). Significant differences were found only within the age class of 71 – 80 years: the proportion of the damaged dominant trees in the recently thinned stands was lower ($p < 0.05$) than in the other stands. Presumably, the level of damage caused by icing was affected not simply by the timing of thinning but, in particular, by the applied management, represented as the noted influence of the slenderness on the proportion of damaged trees. This assumption is supported by results from dense, unthinned stands, where trees with a high slenderness coefficient and asymmetric, small crowns are prone to wind, snow and icing, moreover – mainly the dominant trees are damaged (Nykänen *et al.*, 1997). Similar results were obtained when 30 – 100 years old managed stands were compared with similar age, unmanaged (delayed or no thinning, very slender trees) stands. In the latter, the threshold of tree breakage and uprooting is notably lower than in the managed stands: the stem broke under the snow load of 10 – 25 kg m⁻² and 54 – 60 kg m⁻² (Päätaalo, 2000; Peltola *et al.*, 1999), but uprooting occurred under the snow load of 10 – 23 kg m⁻² and 17 – 53 kg m⁻², respectively (Päätaalo, 2000). In the long term, thinning may decrease the probability of damage by 40% (Valinger, Lundqvist, & Bondesson, 1993) but the recently thinned stands are especially prone to icing (Bragg, Shelton, & Zeide, 2003). The possible cause of these differences from our results is, that the timing of the thinning (age of stand) or the proportion of the removed stand basal area could have a stronger effect than the time passed after the thinning itself. Trees need to adjust to the altered conditions, i.e. to increase stem diameter (and taper) and anchor the root system, and this time is reported to be from three (Zubizarreta-Gerendiain *et al.*, 2012) to eight (Nykänen *et al.*, 1997) years.

Conclusions

In the area where the icing weight was 50% of the above-ground biomass of Scots pine in the naturally moist condition on unfrozen soils, the proportion of the damaged trees in the pine dominated stands was 26%. The type of damage was related to the stand maturity: the highest proportion of broken pines was found in the middle-aged stands, but the highest proportion of bent pines – in the young stands. The recently thinned stands had no clear differences of the proportion of the damaged dominant trees in comparison to the other stands. However, the applied management influenced

the proportion of damaged trees, as indicated by more frequent damages to pines with a higher slenderness coefficient. Therefore, the results suggest that the risk of icing damage of Scots pine could be reduced by silvicultural measures to increase the individual tree stability.

Acknowledgements

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INFLUENCE OF ALTERED PRECIPITATION REGIME ON MORPHOLOGY OF SAPLINGS OF SCOTS PINE AND SILVER BIRCH

Oskars Krišāns, Juris Kalniņš, Mārtiņš Puriņš, Rolands Kāpostiņš, Āris Jansons

Latvian State Forest Research Institute 'Silava'

aris.jansons@silava.lv

Abstract

Prolonged summer drought periods are forecasted for the Baltic Sea region during the 21st century, thus increasing the risk of drought stress of saplings used in forest regeneration. Nevertheless, the vitality of young stands might be increased by the selection of suitable planting material. The aim of this study was to estimate the effect of changes in distribution of summer precipitation on height increment, biomass distribution and root morphology of Scots pine and silver birch planting material commonly used in the forest regeneration in Latvia.

Containerized pine and bare rooted birch saplings, planted in three different soil types, were subjected to altered distribution of summer precipitation, provided by the use of automated shelter. Sheltered saplings were weekly irrigated with the sum of precipitation of a corresponding period, while afield planted saplings had an unchanged precipitation regime and served as control. Height increment was measured once per week and estimation of morphology of saplings was done after the end of every vegetation season.

Significant ($p < 0.05$) differences in height increment, and shoot and root biomass were observed among the same planting material in different irrigation regimes and soil types. In the control plots of peat soil, pine had a significantly ($p < 0.05$) larger height increment while birch-significantly ($p < 0.05$) smaller compared to experiment. Forecasted longer drought periods might reduce the growth of Scots pine in fertile forest types but silver birch growth might be affected in fertile mineral soils in future.

Key words: water deficit, altered distribution of precipitation, biomass distribution.

Introduction

The shift of climatic zones northwards for 272-645 km (Ohlemüller *et al.*, 2006) and transformation of forest ecosystems (Hickler *et al.*, 2012) is forecasted for Europe as a result of global climate change in future. Till the end of the century, the north part of Europe and Baltic Sea region will experience an increased mean air temperature of 3.2 °C and more frequent periods (≥ 10 days) without precipitation; however, the amount of precipitation will remain the same as nowadays (Jansons, 2010; IPCC, 2014; Palmer, 1965).

An increase of mean air temperature in combination with longer meteorological drought periods intensifies evapotranspiration causing drought stress and hindering growth of saplings (Xu, Zhou, & Shimizu, 2010). During the vegetation period in the Baltic Sea region, insufficient soil moisture can be a limiting environmental factor for survival of saplings used in forest regeneration, particularly for the first year plantations (Dinger & Rose, 2009; Haase & Rose, 1993; Jansons *et al.*, 2013; Matisons, Elferts, & Brūmelis, 2012; Possen *et al.*, 2011; Rolando & Little, 2008; Thomas, 2009; Vegis, 1964).

Research on the effect of changes in distribution of summer precipitation on growth and vitality of Scots pine (*Pinus sylvestris* L.) and silver birch (*Betula pendula* Roth.) has not been done, although, both species have different levels of drought tolerance (Cregg & Zhang, 2001; Possen *et al.*, 2011) and high economic importance in Latvia. Such experiments can provide us with a crucial information about the

potential effect of future climatic changes. Therefore, the aim of this study was to assess the effect of changes in distribution of summer precipitation on height increment, biomass distribution, and root morphology of Scots pine and silver birch planting material commonly used in forest regeneration in Latvia.

Materials and Methods

The study was carried out during 2013 and 2014 in the central part of Latvia in Vecumnieki (24°29'44E, 56°37'51N). The location of the site corresponds to mean level of continentality of Latvia (Draveniece, 2007; Klavins & Rodinov, 2010). In both seasons, July was the warmest and driest month when the mean air temperature reached 17.9 and 19.4 °C; whilst monthly sums of precipitation were 32.2 and 21.3 mm in 2013 and 2014, respectively. In July 2014, 24 days without precipitation were observed, while only 17 precipitation-free days occurred in 2013. The longest continuous precipitation-free periods were 9 and 10 days in July 2013 and 2014, respectively (Figure 1).

The study was an experiment aiming to assess the effect of precipitation regime on the growth of pine and birch saplings. Containerized Scots pine and bare rooted (PLUG+1) silver birch saplings, obtained from commercial nurseries, were planted in six blocks (10 m²) filled with three different soils-fertile mineral soil from *Hylocomiosa*, peat soil from *Myrtillosa turf. mel.* and poor sandy soil from *Cladinosa-callunosa* stands. Three blocks were subjected to altered irrigation while other three received natural

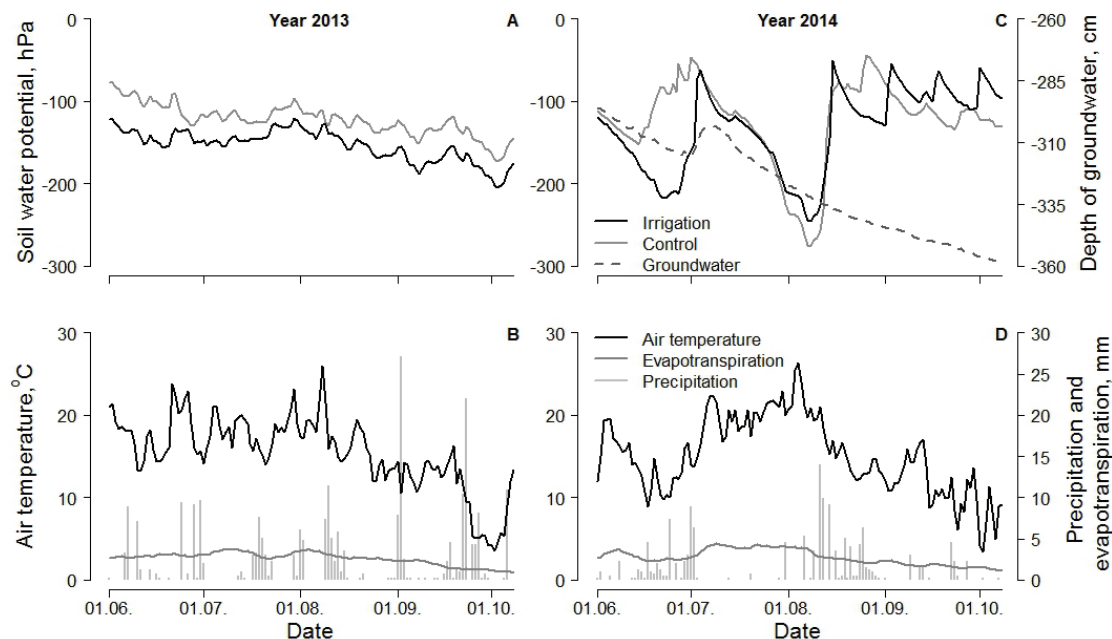


Figure 1. Daily average soil water potential in the depth of 0,5 m (A, C), depth of groundwater (C), daily average air temperature, evapotranspiration and daily sum of precipitation (B, D) in 2013 and 2014 (Krišāns *et al.*, 2015).

precipitation as control, obtaining six combinations: fertile mineral soil with irrigation (FMW) and control (FMC); peat soil with irrigation (PEW) and control (PEC); and poor sandy soil with irrigation (PSW) and control (PSC). To prevent root competition and mechanical damage during excavation, each sapling was planted in geotextile bucket (volume = 10 l). Perimeter of each block was sealed with hydro isolation to avoid horizontal movement of soil water. Saplings were grown for one vegetation season.

The precipitation regime was altered by interception of natural precipitation and controlled irrigation. Automated polycarbonate shelter (81% transparency of visible light) controlled by rain sensor Rain-Click (Hunter Industries, Inc.) was used. The saplings were irrigated regularly - once per week in 2013 and once per 10 days in 2014. The amount of water supplied was the same as the natural precipitation in the respective period.

The height of saplings was measured after the plantation and before harvesting. In autumn, entire plants were harvested, roots were washed from soil. In the laboratory, above-ground and below-ground parts of saplings were separated, dried for 72 hours in 105 °C until constant mass and weighted with the precision of 0.01 g. Root morphometric parameters of Scots pine saplings grown in 2014 were measured with WinRHIZO (Regent Instruments Inc.). Meteorological parameters were monitored in the study site using Wireless Vantage Pro2 (Davis Instruments) weather station. Soil water potential at 0.5 m depth in each block

was measured by T8 (UMS GmbH) tensiometers. Ground water level and temperature was recorded by Mini-Diver (Schlumberger Ltd.) sensor.

For each sapling, absolute and relative height increment was calculated. To characterize biomass allocation, shoot/root ratio (SRR) was calculated. The differences of height increments, root morphometric parameters and biomasses among irrigation treatments and soil types were analysed by two-factor analysis of variance (ANOVA) using Tukey's HSD post-hoc test. The linear relationships between different sapling parameters were quantified by Pearson correlation analysis.

Results and Discussion

Changed distribution of summer precipitation did not affect the survival of pine and birch saplings during the study. Soil water deficit develops when the soil water potential drops below soil field capacity which for most of peat and mineral soils is between 100 and 330 hPa (Lambers, Chapin, & Pons, 2008; Parr & Bertrand, 1960; Ritchie, 1981). During the study, soil water potential did not fall below this level in any treatment combination. The dynamics of soil water potential differed between both studied periods (Figure 1). Compared to 2013, the soil water potential had a higher variation for both irrigation treatments in 2014, which can be explained by longer precipitation-free and inter-irrigation periods. Due to low daily precipitation and high air temperature, water from soil surface evaporates faster than during the irrigation

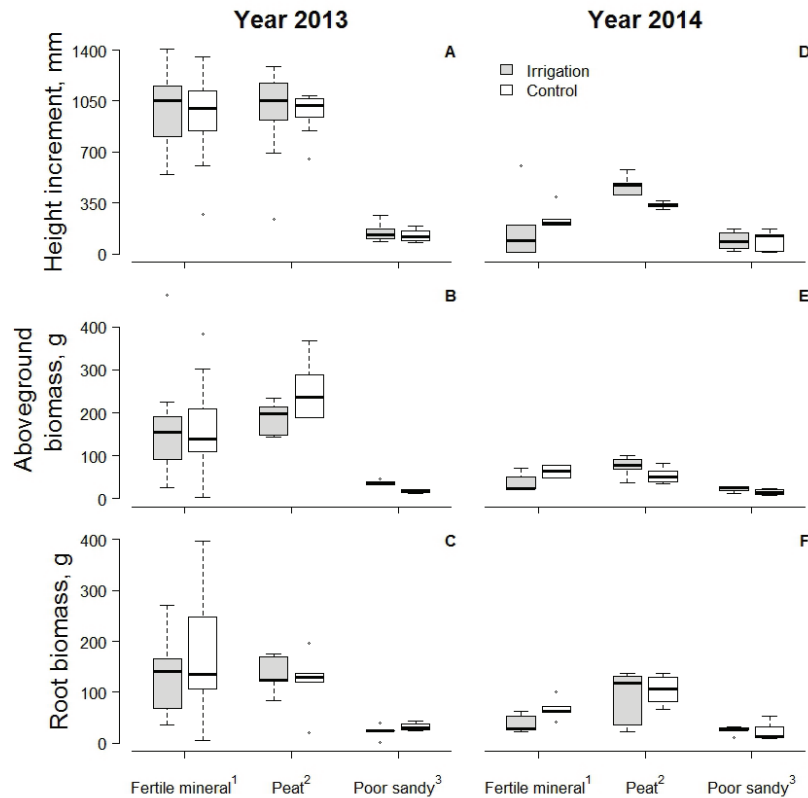


Figure 2. Height increment (A, D), above-ground (B, E) and below-ground biomass (C, F) of saplings of silver birch in all treatment combinations in 2013 and 2014 (1 – *Hylocomiosa*, 2 – *Myrtillosa turf. mel.*, 3 – *Cladinoso-callunosa*).

when larger amount of water is supplied, providing deeper infiltration (Parr & Bertrand, 1960). This explains a lower soil water potential in the control in July 2014.

Both species had significantly ($p < 0.05$) larger annual height increments and biomasses in fertile mineral and peat soils compared with poor sandy soil for both studied periods (Figure 2 and Figure 3). Maximum height increment for birch reached 1400 and 605 mm in 2013 and 2014, respectively; whilst maximum height increment of pine was 280 and 330 mm, respectively. Differences in height increments between moisture regimes were not significant ($p < 0.05$) for both species in 2013. However, in 2014, significantly ($p < 0.05$) larger height increments and above-ground biomasses for birch were observed in FMC compared with FMW. Surprisingly, the opposite was observed for birch in peat soil, where height increment and above-ground biomass were significantly ($p < 0.05$) larger in the irrigated treatment (Figure 2). Pine saplings planted in peat had significantly ($p < 0.05$) larger height increment and root biomasses in control than in irrigation, although above-ground biomasses were significantly ($p < 0.05$) larger in irrigation. In fertile mineral soil, both biomasses of pine from control were significantly

($p < 0.05$) larger compared with irrigation; however, height increment did not differ significantly ($p < 0.05$). The only differences of morphometric parameters between irrigation regimes of pine saplings in 2013 were for root biomass in poor sandy soil (Figure 3).

In the control plots, Scots pine saplings had larger relative height increments compared with irrigated ones in all soil types. In fertile mineral soil, the difference was significant ($p < 0.05$), reaching 151% and 130.1% in control and irrigation, respectively. In poor sandy soil, initially significantly ($p < 0.05$) smaller control saplings had larger relative height increment compared with the irrigation treatment (108.7% and 98.6%, respectively) (Figure 3 and Figure 4). In peat soil, pine saplings of the control plots had a larger relative height increment (146.6%) compared to irrigation (128.2%); however, differences were not significant ($p < 0.05$). Birch saplings had significantly ($p < 0.05$) smaller relative height increments compared to pine. Additionally, the only significant ($p < 0.05$) difference was observed between PEC (49.1%) and PEW (66.4%); however, in other soil types, the control saplings had a larger relative height increment.

It has been shown that moderate water deficit may stimulate the formation of root biomass, increasing fine root surface area and depth, reaching water

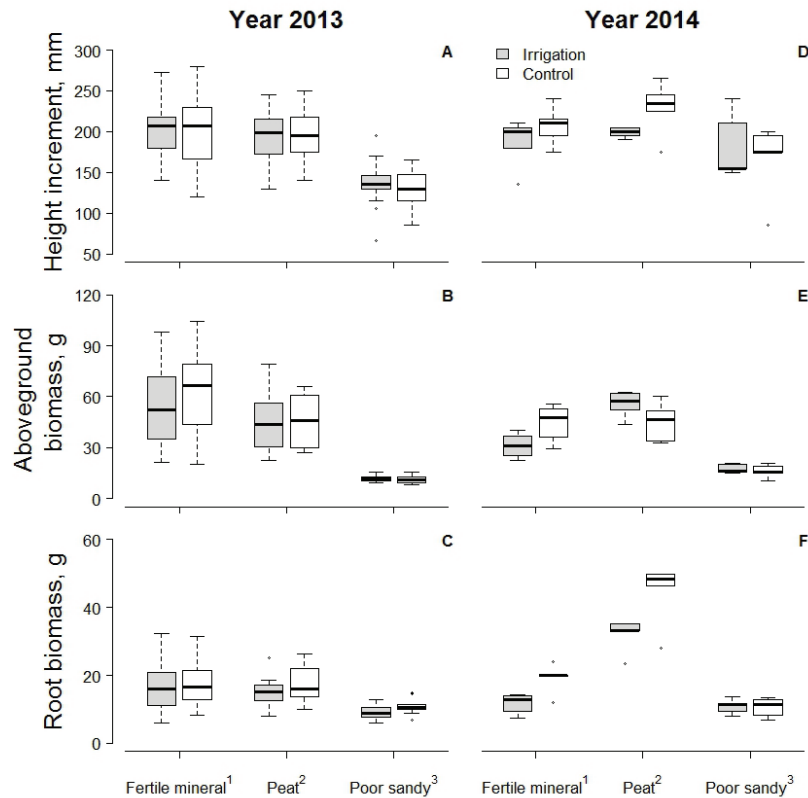


Figure 3. Height increment (A, D), above-ground (B, E) and below-ground biomass (C, F) of Scots pine saplings in all treatment combinations in 2013 and 2014 (1 – *Hylocomiosa*, 2 – *Myrtillosa turf. mel.*, 3 – *Cladinoso-callunosa*).

in deeper soil layers (Grossnickle & Blake, 1987; Lambers, Chapin, & Pons, 2008); whilst formation of an above-ground biomass could be ceased. Such phenomena have been observed for Norway spruce saplings in a similar experiment (Krišāns *et al.*, 2015); however, pine and birch saplings did not have such a tendency in this study (Figure 2 and Figure 3). Moreover, saplings with larger height increments had larger root biomass indicating better growth in both treatments (Figure 2 and Figure 3).

The SRR can be used to characterize distribution of above-ground (water transpiring) and root (water absorptive) biomasses (Pallardy, 2008), hence drought adaptive strategies (Bernier, Lamhamedi, & Simpson, 1995). In our study, mean SRR values for pine saplings were 2.7 and 2.73 in 2013 and 2014, respectively, whilst for birch only 2.06 and 1.31, respectively. These results correspond with differences in biomasses and height increments between the study years (Figure 3). Lower values of SRR means a potentially higher drought tolerance (Maass *et al.*, 1989; Bernier, Lamhamedi, & Simpson, 1995), as water absorptive surface is larger than transpiring. The SRR values compared with the height increment and the initial height of sapling before planting describes the potential susceptibility of the planting material

to drought. Significant ($p < 0.05$) Pearson correlation between SRR and height increment was observed only for pines in both treatments ($R^2 = 0.38$; $p < 0.001$ and $R^2 = 0.12$; $p < 0.05$ in control and irrigation, respectively) in 2013 (Figure 5). Hence larger and faster growing saplings might be affected by drought more severely, particularly, in the first vegetation season after planting. Relation between SRR and the height of pine sapling before planting ($R^2 = 0.38$; $p < 0.001$ in both control and irrigated plots) was similar. Hence the initial height of containerized Scots pine saplings apparently is not related with susceptibility to water deficit during the first season after planting.

Significant ($p < 0.05$) differences in morphology of Scots pine roots were observed (Figure 6) between both treatments. In both peat and fertile mineral soils, saplings from the control treatments had significantly ($p < 0.05$) larger roots compared to irrigation treatment. Only the root volume and projected area of roots did not differ significantly ($p > 0.05$) between the treatments in fertile mineral soil. Yet, on mineral soils, root parameters between treatments were similar ($p > 0.05$). Mean values of root morphological parameters from PSC were larger than PSW, although the initial height of pine saplings before planting was significantly ($p < 0.05$) larger in PSW, suggesting faster

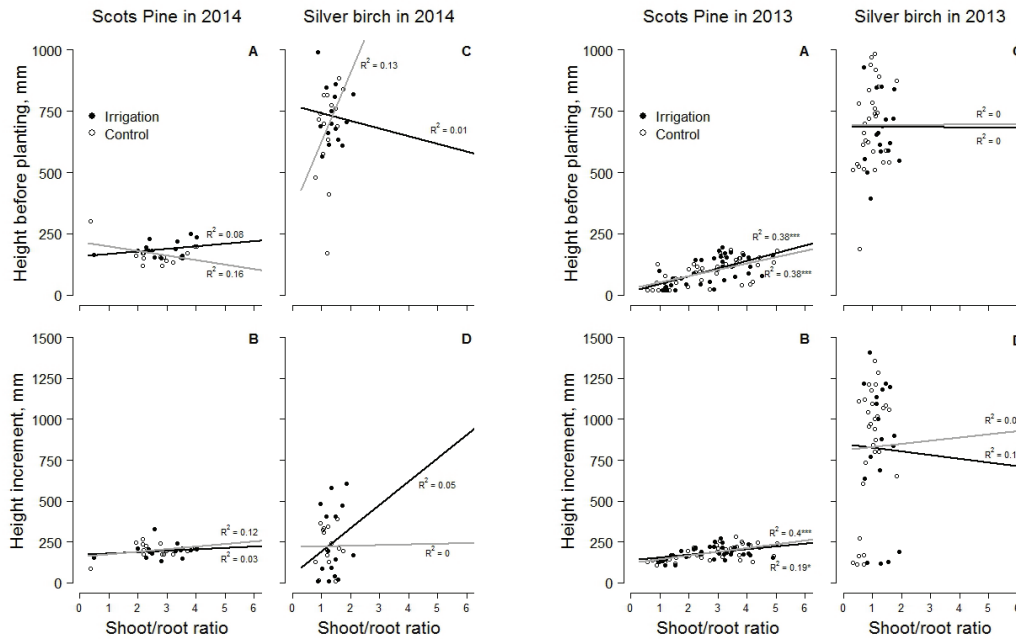


Figure 5. Relation between shoot-root ratio of saplings (Scots pine - A, B; silver birch - C, D) and the height of saplings before planting and height increment in all treatment combinations in 2013 and 2014. Significance of correlation coefficients – p – value <0.05 (*), <0.01 (**), <0.001 (***)).

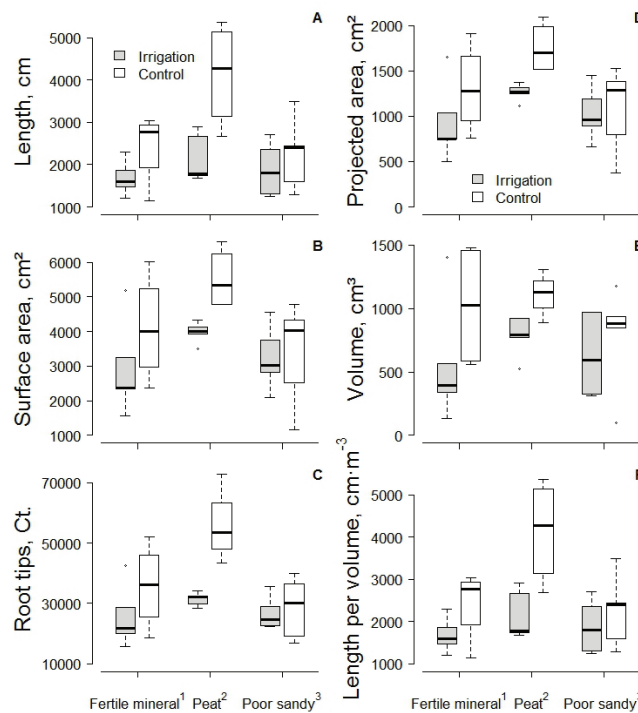


Figure 6. Total length (A), surface area (B) count of tips (C), projected area (D), volume (E) and length per volume of roots (F) of pine saplings in all treatment combinations in 2014 (1 – *Hylocomiosa*, 2 – *Myrtillosa turf. mel.*, 3 – *Cladinoso-callunosa*).

growth of Scots pine saplings under more frequent precipitation regime. Significantly ($p < 0.05$) larger total lengths and numbers of root tips in peat soil can be explained by a higher soil porosity and higher field capacity facilitating root distribution.

The results of this study showed a significant ($p < 0.05$) negative effect of altered distribution of summer precipitation on growth of containerized Scots pine saplings. Significantly ($p < 0.05$) larger relative height increments of pine saplings in control

plots indicate disturbed growth under extended precipitation-free periods. Although containerized saplings from commercial nurseries have noticeable reserves of nutrients, soil fertility had a significant effect on growth as shown by differences in increment among different soils. Also, soil fertility had mediating effect on susceptibility to precipitation regime, as the differences (absolute and relative) between the irrigation treatments were greater in fertile soils.

Conclusions

1. Altered distribution of summer precipitation that corresponds to RCP8.5 global climate change scenario did not affect the survival of saplings of Scots pine and silver birch. Although the altered precipitation regime decreased height increment

of containerized Scots pine saplings, the opposite was observed for silver birch, particularly on peat soil, suggesting positive effect of less frequent but stronger precipitation.

2. Containerized Scots pine saplings develop significantly ($p < 0.05$) larger total root biomass in a peat compared to mineral soils under natural precipitation regime; however, surface area and total root volume did not differ significantly ($p < 0.05$) between soil types.

Acknowledgement

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GROWTH OF *FAGUS SYLVATICA* IN YOUNG MIXED STAND: CASE STUDY IN CENTRAL LATVIA

Līga Purina, Andis Adamovics, Juris Katrevics, Zaiga Katrevica, Baiba Dzerina

Latvian State Forest Research Institute 'Silava'

liga.purina@silava.lv

Abstract

Climatic changes are shifting the potential tree distribution limits of many tree species northwards. One of such species is *Fagus sylvatica*, currently represented in Latvia only by a few stands. In order to increase knowledge on its potential use in the forest management, the aim of our study was to characterize the growth of beech in a young stand in the central part of Latvia. The stand of beech and spruce, mixed in rows with an initial spacing of 2.5 x 2.5 m in *Oxalidos* forest type was assessed. Survival of European beech in clearcut was similar to that observed for the native Norway spruce (73% and 79%, respectively), but both height and diameter were notably and significantly superior for wildlings at the mean age of 15 ± 2 years, reaching on average 7.4 ± 0.30 m and 8.9 ± 0.69 cm, respectively. Increasing ring width with increasing tree age for both tree species was observed until the last four years, when large and increasing superiority of beech over spruce, coinciding with reduction of ring width of spruce, was noted. It was most likely caused by intensified competition due to very wide crowns formed by young beech trees in the plantation with wide spacing: average crown radius reached 2.4 ± 0.16 m, for few trees exceeding even 4 m.

Key words: introduced tree species, mixed stand, adaptability, survival, European beech.

Introduction

Climate envelop models are used to predict changes of species distribution due to climatic changes. Generally, northward shift of the vegetation zones, therefore also the species distribution is expected in Europe (Walther *et al.*, 2002; Kullman, 2008). However, the actual natural changes of the borders of tree species areals are much slower, since the spread is determined by the distance of seed dispersion, affected by numerous factors including forest fragmentation. To ensure that the expected improvement in forest productivity due to warmer climate (Lindner *et al.*, 2010) is realized, the adjustments in forest management practice and introduction of potentially suitable tree species, in this way altering the predicted natural changes in forest composition (Hickler *et al.*, 2012), are crucial (Petit *et al.*, 2004). Increasing the number of tree species used in forestry also allows forest managers to diversify risks as well as find the most suitable alternative for any particular site, considering not only growth but also increasing probability of damages by abiotic factors (Seidl *et al.*, 2014). It is predicted, that northeastern limit of European beech (*Fagus sylvatica* L.) might occur in the Baltic States by the end of the 21st century (Kramer *et al.*, 2010), since the already occurring climatic changes in Latvia are reflected as an increase of temperature in the dormant period and spring (Lizuma *et al.*, 2007), making the conditions more suitable for the requirements of this species (Bolte, 2007). However, it is not advisable to rely on the theoretical considerations, therefore ecological demands, i.e. climatic limitation of growth of this tree species should be comprehensively evaluated. Detailed information on climate-growth relationships can be obtained via dendrochronological analysis.

This technique was applied for the assessment of relationships between tree ring width (TRW) and climatic variables for beech in Latvia. Chronologies of TRW, which covered the periods 1949 – 2012 were produced. Variation of TRW was affected by drought-related climatic variables, temperature in the previous July and August, as well as an effect of spring and autumn temperature was observed. It was found that during the recent decades July precipitation also has become significant (Jansons *et al.*, 2015a). The latter might have a negative effect on beech growth since intensification of heat and drought events are expected (Avotniece *et al.*, 2010).

Successful natural regeneration is the first indication of species to thrive in the particular conditions. Abundant regeneration has been found in canopy openings of the few existing beech stands in Latvia (Purina *et al.*, 2013), limited mainly by light conditions (Jansons *et al.*, 2016). Even so, the results proved very high shade tolerance of this tree species in comparison to other common trees species in Latvia (Jansons *et al.*, 2016) as well as broadleaved tree species with northernmost point of distribution limit being in the territory of our country – European hornbeam (*Carpinus betulus* L.). Hornbeam understory distribution and abundance was significantly linked to light parameters, particularly – diffuse radiation (Purina *et al.*, 2015). Growth of beech under shelterwood, as recommended for its regeneration (Ritter *et al.*, 2005), mainly due to high spring frost risk (Aranda *et al.*, 2002), was similar to that found for other shade-tolerant species – Norway spruce: the mean height in particular study plots was 62 and 64 cm, respectively (Jansons *et al.*, 2016). However, the growth of young beech seedlings planted in clearcut (with higher temperature amplitude) has

not been assessed previously in Latvia. Productivity of old beech trees, assessed in several permanent sample plots in the western part of Latvia, was high in comparison to native tree species (Dreimanis, 1995). However, only middle-aged and mature stands were assessed in this study, but not young stands. Due to already occurring changes in climatic conditions, meteorological factors (and periods) notably affecting increment of trees are changing (Jansons *et al.*, 2015b), therefore gathering of information about early growth from currently mature trees (using sample tree cutting) is not advisable. In order to improve the knowledge on the potential of beech use in Latvia, the aim of our study was to characterize growth of this tree species in young stands in the central part of our country.

Materials and Methods

A planted stand of European beech (*Fagus sylvatica*) and Norway spruce (*Picea abies*) has been established in the central part of Latvia on a flat terrain on fertile, well-drained clayey soil *Oxalidosa* forest type. Climate in the study area is mild, the mean annual temperature is $\sim +6.1$ °C, July is the warmest month, with mean temperature $\sim +16$ °C, and January is the coldest month, with mean temperature ~ -3.6 °C. The period when the mean daily temperature exceeds 5 °C is ~ 185 days. Annual precipitation sum is ~ 560 . Most of the precipitation falls during summer.

Planting was carried out in spring of 2004 in clearcut using two-year old spruce plants and beech wildlings from natural regeneration under the canopy of beech stand in the western part of Latvia.

The ground was scarified in rows and single-row mixture of beech and spruce was used (one row of beech, adjacent – spruce etc.). Distance between rows varied from 2 to 3 meters (average 2.5 m) and distance between saplings in row was 2.5 meters.

The height and the diameter of breast height (DBH) of each tree on January 2016 were measured for altogether 116 beeches and 124 spruces. For beech

the largest radius of crown (as defined by the longest branch) was measured. For spruce height increment of last three years was measured. Increment cores from several trees as close to ground as possible were taken with Pressler borer. In the laboratory, air-dried cores were fixed and gradually grinded (sandpaper roughness 100, 150, 250 and 400 grains per inch). Tree-ring width was measured using LINTAB 5 (RinnTECH) measurement system with the precision of 0.01 mm. There were no signs (like old stumps of young trees) that any pre-commercial thinning has been carried out before.

Significance of differences was calculated using ANOVA.

Results and Discussion

Density of trees was relative, similar to that expected at the particular height in young stands in Latvia for broadleaved trees: 580 ha⁻¹ of beech and 620 ha⁻¹ of spruce. The survival of beech was 73% and it was similar to that of Norway spruce (78%). A higher survival might be expected as a result of successful plantation; however, this level is also not uncommon in the plantation of native tree species, as reported, for example, for Silver birch in Finland, where survival was on average 82% after 6th growing season and 79% after 11th, and notable and significant effect of timely (and effective) weed control in the first years on this parameter was found (Hytönen & Jylhä, 2005). There was no information on the tending carried out in the studied area, therefore, the impact of it can't be analysed. Even a higher survival (94%) at the age of 8 years had been found in beech provenance trial in Croatia, noting general adaptedness and phenotypic stability of the material (most of the provenances) based on this information (Ivanković, Bogdan, & Božič, 2008).

The average DBH of beech was 8.9 ± 0.68 cm and it significantly exceeded the average DBH of spruce (3.0 ± 0.41 cm) (Fig. 1). Also, the average height of

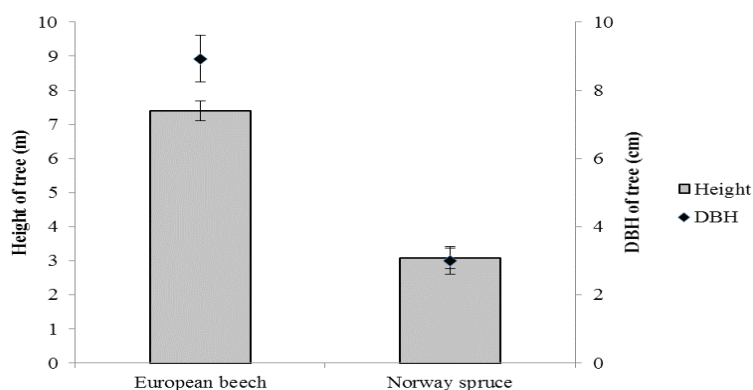


Figure 1. The average height and diameter of breast height (DBH) of European beech and Norway spruce (\pm confidence interval).

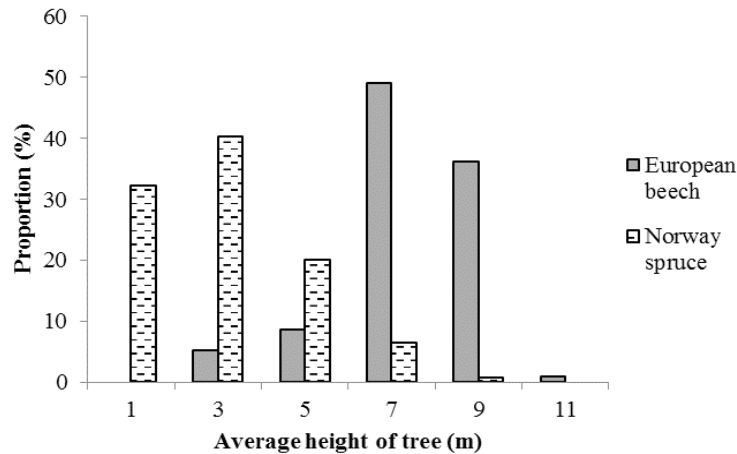


Figure 2. Tree distribution in the height groups.

beech was superior to the average height of spruce (7.4 ± 0.30 and 3.1 ± 0.30 m, respectively). Comparison of height curves of both tree species revealed that spruce with height under 7.5 m had greater DBH than beech. It was in accordance to the expected, since largest (dominant) spruces were compared to suppressed beeches. DBH of beech with height over 7.5 m become notably larger but there were no spruces so high to compare with.

The average values did not reflect the differences between species clearly enough, therefore trees were arranged into height groups (Fig. 2). At the moment in the area dominated beech; most of those had the height of 6.1 to 8 m (49%) and of 8.1 to 10 m (36%) and there was no beech with the height under 2 m. Meanwhile, the majority of spruce had the height of 2.1 to 4 m and of 0.1 to 2 m. Also there were no spruce trees higher than 10 m. Superiority of beech was even more pronounced in diameter the greatest proportion (28%) of beech had DBH from 10.1 to 12 cm while 66% of spruce had DBH less or equal 4 cm. The height of beech varied from 2.5 m to 10.5 m, DBH from 1.1 cm to 15.0 cm, for spruce the height of tree was from 0.5 m to 7.1 m and DBH was from 0.5 cm to 9.2 cm. In the analysis of natural regeneration in canopy opening in beech stand in Latvia Jansons *et al.* (2016) found a notably wider range of heights for beech than for spruce (from 7 to 254 cm vs. from 18 to 170 cm, respectively), even so the mean height of both tree species was similar (62 and 64 cm, respectively). Also, in our study the distribution was wider of beech, but presumably due to differences in spacing or competition, the interspecies differences were more pronounced for diameter of trees, than for height.

Annual increment depends both on growth intensity (mm day^{-1}) as well as on the length of the growing period. Notable differences between spruce and beech in the timing of height growth had been observed in Slovakia: height increment

of beech trees started earlier than that of spruce, but lasted a shorter time (~ 45 days vs. ~ 70 days, respectively); however, the total length of the annual shoot of both species was similar (Konôpka, 2014). In contrast, high importance of determination of the total length of height increment (and therefore growth superiority over other tree species) due to a very long growth period had been found for hybrid aspen (*Populus tremuloides* \times *P. tremula*) in Latvia (Jansons *et al.*, 2014). Radial and height growth of different tree species often is affected by contrasting meteorological factors, as demonstrated in numerous dendrochronological analyses (Senhofa *et al.*, 2016; Matisons *et al.*, 2015; Jansons *et al.*, 2013a; Jansons *et al.*, 2013b). Therefore, the increment might be larger for one species at a particular year and for another – in the next year and it is important to evaluate the total increment over longer time. Overall, a faster growth in young stands, especially after the initial years of establishment, had been found for Norway spruce than for beech, even so beech might outcompete other shade-tolerant species in the situation with limited light availability (Galbraith-Kent & Handel, 2008; Wagner *et al.*, 2010). In older stands the productivity of beech might be similar or higher than that of spruce trees in appropriate soil conditions, as found also in the sample plots in beech stands in western Latvia at the age of 115 years, where the height of dominant trees was 34.8 m, basal area 50.5 m^2 and yield 818 m^3 (Dreimanis, 2006).

Since our study site was a mixed stand with not a very high density, it is important to notice the results of meta-analysis of data from beech-spruce mixed stands in Europe: in these stands maximum productivity is reached in lower density than in pure beech or spruce stands (Pretzsch, 2003). Growth of beech can be promoted by admixture of spruce, particularly on fertile sites (Pretzsch *et al.*, 2010), but overyielding of mixed stands occurs less frequently on rich sites

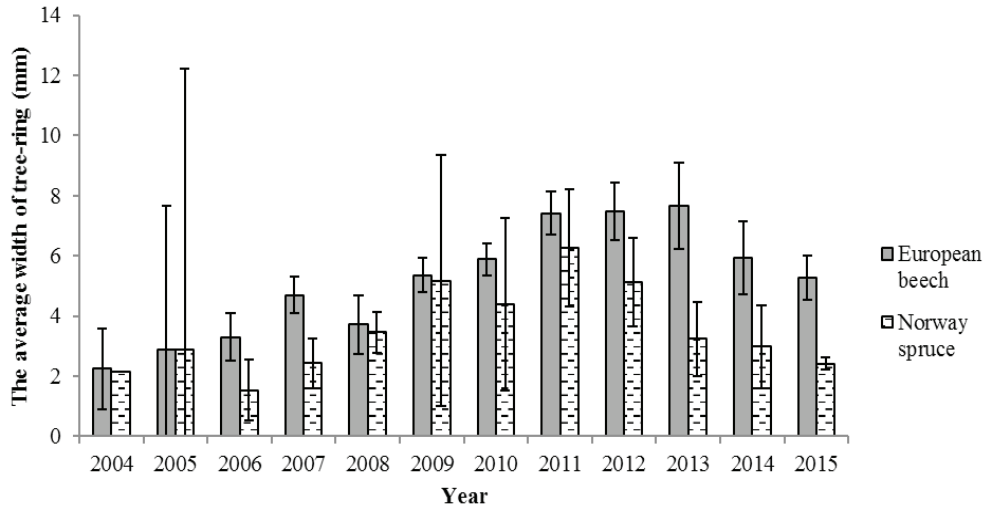


Figure 3. The average width of annual tree ring (\pm confidence interval) for European beech and Norway spruce.

than on poor and appears to be based on an admixture effect, with spruce reducing the severe intra-specific competition common in pure beech stands (mostly naturally regenerated with high density, that is not the case in our study site).

Differences in growth might be part of the explanation of observed height and diameter superiority of beech in our site. Another potential source is unknown differences in initial tree parameters. Based on analysis of increment cores, the age of beech wildlings varied from 12 to 19 years (on average 15 ± 1.9 years), while the age of planted spruce was 12 years. It means that beech wildlings could be higher and with a larger root system at the start that could have caused greater increment in the first years (even so the growth could have been affected by re-planting stress, possible root damages). Nevertheless, due to large initial spacing, the effect of size differences on

spruce due to competition most likely was negligible during the first 3-6 years, but might have affected it during later years. It was in line with findings of radial increment analysis (Fig. 3), demonstrating large and increasing superiority of beech over spruce during the last four years (coinciding with the reduction of ring width of spruce) and some growth reduction also of beech during the last two years, most likely due to further intensified competition, since the overall trend of increasing radial increment with increasing age of plantation can be observed and was disrupted. The ring width of the largest cored beech trees also was marginally reduced during the last two years. The width of tree ring for spruce was more varying. The maximal tree ring width for beech was 7.7 ± 1.2 mm, for spruce – 6.3 ± 1.9 mm.

The tendency of height increment of spruce in the last three years was similar to the tendency of

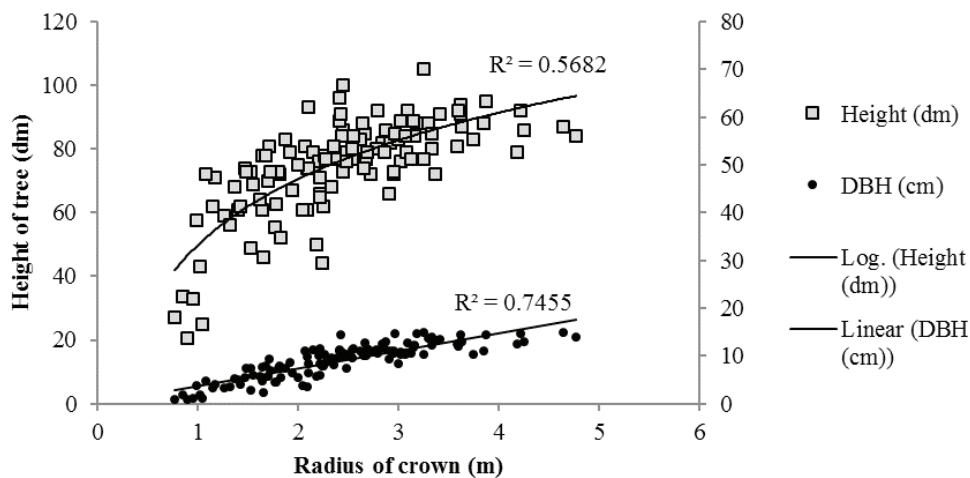


Figure 4. The correlation of beech crown radius with DBH and height of tree.

radial increment – it was slightly, but not significantly decreasing. Presumably, the relatively smaller spruce trees invested most resources into the height increment (retaining it on average 38 ± 2.7 cm – not large for spruce at that age comparing to those which have been measured in tree breeding trials) to catch up with beech and get better light conditions. On average, beech were higher and less affected by competition in the dense stand.

Very intense competition in the stand was demonstrated also by the largest crown radius of beech, reaching on average 2.4 ± 0.16 m, i.e. the distance between the trees in row and between rows. In fact, the number of trees value of this parameter even exceeded 4 m (Fig. 4). The growth of beech trees was notably affected by the length of branches - used as an indicator of crown size, i.e. the total production of organic matter. This parameter had a strong and significant correlation with both the height of the tree and DBH ($r = 0.71$ and $r = 0.87$, respectively).

Our results are in line with findings of other studies, suggesting that both species might co-occur, at least in fertile sites (Madsen & Larsen, 1997; Bolte *et al.*, 2007). However, with low initial density beech occupies the area more efficiently, relating long branches and using all the light resources available.

The tree species in natural stands adapt in such a way and persist in understorey with limited light for a long period, until a disturbance creates canopy opening and releases its growth (Wagner *et al.*, 2010).

Conclusions

1. Survival of European beech in clearcut in mixed stand with Norway spruce was similar to that observed for the native tree species. At the age of 15 ± 2 years the average height of beech trees was 7.4 ± 0.30 m, the average DBH was 8.9 ± 0.69 cm.
2. European beech wildings exceeded the height and diameter of Norway spruce saplings 12 years after planting significantly and notably: by 140% and 196%, respectively.
3. The mean annual radial increment of European beech almost three times exceeded the increment of Norway spruce in the same conditions (0.74 and 0.25 cm per year, respectively).

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LONG-TERM INFLUENCE OF LARGE FOREST FIRE ON GROUND VEGETATION

Liga Purina¹, Inga Straupe², Liga Liepa², Zane Libiete¹, Mara Zadina¹, Aris Jansons¹¹Latvian State Forest Research Institute 'Silava'²Latvia University of Agriculture

aris.jansons@silava.lv

Abstract

Fire is a major disturbance in hemiboreal forests; it affects not only trees, but also ground vegetation. Previous studies have analysed the succession of ground vegetation after the fire, but not addressed the impact of the size of the burned area on revegetation of it. Therefore, the aim of our study was to assess the differences in post-fire ground vegetation in relation to the distance from the edge of the affected area. Vegetation data were collected using Braun-Blanquet method in three sites (122 sample plots) affected by forest fire and five clearcuts (not affected by fire) (92 plots), all regenerated by Scots pine 6 – 7 years before the assessment. The number of ground vegetation species (in all sites predominantly birds or wind dispersed) as well as their projective cover was not affected by the distance from the nearest edge of burned or clearcut, except in burned sites on dry sand soil (*Vaccinosa* and *Myrtillosa*), where herbaceous plant and shrub cover was decreasing (from 23.5% to 11.6%) and bryophyte and lichen cover – increasing (from 3% to 13.9%) with an increasing distance from the edge of the area. The total number of plants in burned areas was twice smaller than in clearcut in the same soil conditions but such large difference in projective cover was not observed. There were no significant differences between burned and clearcut areas in respect to Ellenberg's indicator values on both soil types, as well as no trend in Ellenberg's values for soil moisture in relation to distance from the nearest stand edge.

Key words: post-fire regeneration, post-fire colonization, plant dispersal, natural succession, moisture regime.

Introduction

Disturbances – abrupt change in forest (stand), affecting majority of trees – are a major force changing and creating vegetation structures and composition in forested ecosystems (White, 1979). Forest ecosystems are influenced by anthropogenic disturbances as well as by natural disturbances such as forest fire, windthrow, water level fluctuations, desiccation, insect outbreaks, pathogens, browsing damages by large herbivores (Kuuluvainen, 2002).

In Northern Europe forest fire is assumed to be the main natural disturbance, influencing vegetation composition and structure, even though during last century the majority (>95%) of forest fires occur due to human activities. In Latvia about 970 ha of pine forests are affected by fire every year (Zadiņa *et al.*, 2015). The influence of forest fires in a particular forest site are dependent on various factors such as site specific factors, stand composition and fire behaviour (Angelstam, 1998).

Fire alters the microclimatic conditions, for instance, light, regime of moisture and temperature changes in the affected area. It is also known that fire affects biogeochemical cycles such as carbon cycle (Flannigan *et al.*, 2000). Major post-fire changes are related to invasion of pioneer phase species (De Grandpré *et al.*, 1993). Post-fire conditions in the affected areas are characterized by thinner soil humus layers, higher pH and more available nutrients in soil for plants (Simard *et al.*, 2001). After a high intensity forest fire, soil aggregates lose their stability, therefore enhancing soil degradation (Vacchiano *et al.*, 2013). To compare with forest on dry soil, forest on wet soil

does not have seed reserves in the ground that would be 'responsible' for gradual change of species or succession after a large-scale disturbance when light and other conditions differ (Priedītis, 1999).

Ground vegetation plays an important role during the early stages of forest stand development. Colonization is rapid (within five to seven years) with communities dominated by fast-growing vascular plants (Greene *et al.*, 1999) which occupy all microsites (De Grandpré *et al.*, 1993). Species composition of early successional communities are typically dominated by shade intolerant, nutrient demanding species which colonize from seeds or regenerate from underground rhizomes, and can remain dormant for up to 100 years and grow rapidly in response to the abundance of resources (Hart & Chen, 2006). Bryophyte and lichen species are not a large component of vegetation communities during the earlier stages of post-fire succession. Following fire, the number of species, i.e., the species richness, increases quickly, and continues to increase throughout the early stages of post-fire succession, as a large number of plant species colonize growing spaces initially free of competition (Greene *et al.*, 1999). The number of species after forest fire can be remarkable - Rees and Juday (2002) have reported the presence of 80 species on burned stands in Alaska, while Abrams and Dickmann (1982) recorded 89 species on burned stands in Northern Michigan (Hart & Chen, 2006).

Ground vegetation communities following fire and harvesting can be considerably different. Post-logging communities are more similar compositionally to the pre-disturbance communities compared to those

resulting from fire (Noble *et al.*, 1977; Rees & Juday, 2002). These communities are dominated primarily by tolerant bryophytes and vascular plants, most of which are present in late successional communities prior to clear-cutting. A number of pioneering species is absent in these stands (Hart & Chen, 2006).

Composition of ground vegetation depends not only on the intensity and type of fire, creating various microenvironmental conditions but, presumably, also from the size of the affected area. Large, high-intensity forest fire would stop transpiration of water via trees in a significant area, and, it is assumed, could cause degradation of forest ecosystem: its partial or complete change to swamp ecosystem. Numerous studies have addressed the succession of ground vegetation after forest fire, however, to the best of our knowledge, the influence of forest fire size has not been analysed. Therefore, the aim of our study was to assess the differences in post-fire ground vegetation in relation to the distance from the edge of the fire-affected area.

Materials and Methods

Data collection was carried out in the summer of 2014 in the middle and western part of Latvia in three places affected by forest fire and reforested with Scots pine 6 – 7 years ago. Transects with 122 sample plots (size 1x1m) were established on poor mineral soils with normal moisture regime – further in text referred to as “dry sand soils” (forest types *Vaccinosa* and *Myrtillosa*) and drained mineral soils (forest types *Vaccinosa* mel. and *Myrtillosa* mel.). For control, 92 sample plots were established in five sites in 6 – 7 years old Scots pine stands planted after the clearcut on the same forest types. Relief in all sites was flat. Transects were drawn perpendicular to the edge of the nearest forest stand with height exceeding 10 m. Sample plots were placed systematically (every 30 m) on those transects: 3 m on each side of the transect in each of the points. First sample plot of transect was placed 25 m from the forest stand to avoid direct influence of the trees in neighbouring stand. Ground vegetation data were collected using Braun-Blanquet method (Braun-Blanquet, 1964). Projective cover of each ground vegetation species (%) was assessed as well as the total projective cover of layer herbaceous plants and shrubs (E1) and layer mosses and lichens (E0) with the precision of 1%. In case some species were detected, but projective cover did not reach 1%, it was stated as 0.5%.

All sample plots were divided in four zones according to the distance from the nearest forest stand: zone I: 25 – 50 m, zone II: 51 – 75 m, zone III: 76 – 100 m, zone IV: over 100 m.

Information from databases BioPop, Ecological Flora Database, Bioflora on functional types of plants,

types of seed dispersal, need for moisture, Raunkier *life forms* and Ellenberg's indicator values (Ellenberg *et al.*, 1992) were gathered and used to compare ground-vegetation between the stated zones. Occurrence of plants was characterized by their constancy, calculated as a proportion of sample plots, where the plant was present from the total number of sample plots. Based on frequency of occurrence constancy a class was assigned to each species (I: occurrence < 21%, II: 21 - 40%, III: 41 - 60%, IV: 61 - 80%, V: 81 - 100%) (Markovs, 1965; Muller – Dombois & Ellenberg, 1974). Significance of differences was calculated using ANOVA.

Results and Discussion

In total, after forest fire on dry sand soils 18 species of herbaceous plants, bryophytes and lichens were found. The number of species per zone varied, in zone I it was 5 (on average 5), in zone II it was 4 – 8 (on average 5.5), in zone III it was 3 – 7 (on average 4.8) and in zone IV it was 2 – 9 (on average 4.3) species. The average number per zone was 4.9 species. Most frequently occurring species (constancy class V) were *Polytrichum juniperinum* Hedw. (characteristic pioneer species of coniferous forests after disturbance) and *Calluna vulgaris* (L.) Hull (characteristic of dry pine forests and after fire on dry, poor soils). Frequently occurring species (constancy class III) were *Carex ericetorum* Pollich (characteristic of pine forest on dry soil) and *Calamagrostis epigeios* (L.) Roth (characteristic of pine forest on dry soil in early-successive plant societies), rarely occurring species were *Chamaenerion angustifolium* (L.) Scop. (typical of early-successive plant societies in dry clearings and burnings) and *Vaccinium vitis-idaea* L. (characteristic of evergreen bush – pine plant society on dry pine forest and clearing) (constancy class II), but 12 species were very rare – constancy class I.

In the control sample plots on dry sand soil 39 species of herbaceous plants, bryophytes and lichens were found. The number of species per zone I, II, III and IV was 5 – 8 (on average 6.7), 2 – 7 (on average 5.3), 6 – 9 (on average 7.5) and 5 – 6 (on average 5.5), respectively. The average number in all zones was 6.2 species. Very frequently occurring species (constancy class IV) were *Dicranum polysetum* Sw., *Pleurozium schreberi* (Brid.) Mitt. (both characteristic of coniferous forest) and *Calluna vulgaris*, frequently occurring species (constancy class III) were *Vaccinium vitis-idaea*, *Vaccinium myrtillus* L. (characteristic of relative dry clearings and burnings of pine forest) and *Polytrichum juniperinum*. The rest of species were relative rare (constancy classes II and I).

The number of species in all our sample plots was lesser than on average stands in *Vacciniosa* and *Myrtillosa* (it varies from 80 to 100 species) (Liepa *et*

al., 2014). Besides many plants – successful colonizers dominated in our study without important role into early succession (Hart & Chen, 2006). Most often species presented in the area after fire occurred as a result of local colonization from seeds and propagules located in the humus layer (Granstrom, 1982; Rydgren & Hestmark, 1997). Furthermore, in Canadian boreal forests De Grandpré *et al.* (1993) found that up to 70% of all species that occurred after fire were present before fire but species dominant before were not usually abundant following fire (Peltzer *et al.*, 2000). But domination of typical tolerant bryophytes and brush, as well as a greater number of bryophytes and lichen species, in general, was indicative that in the control sample plots (without influence of fire) composition of species was more similar to the structure of species before disturbance (Hart & Chen, 2006).

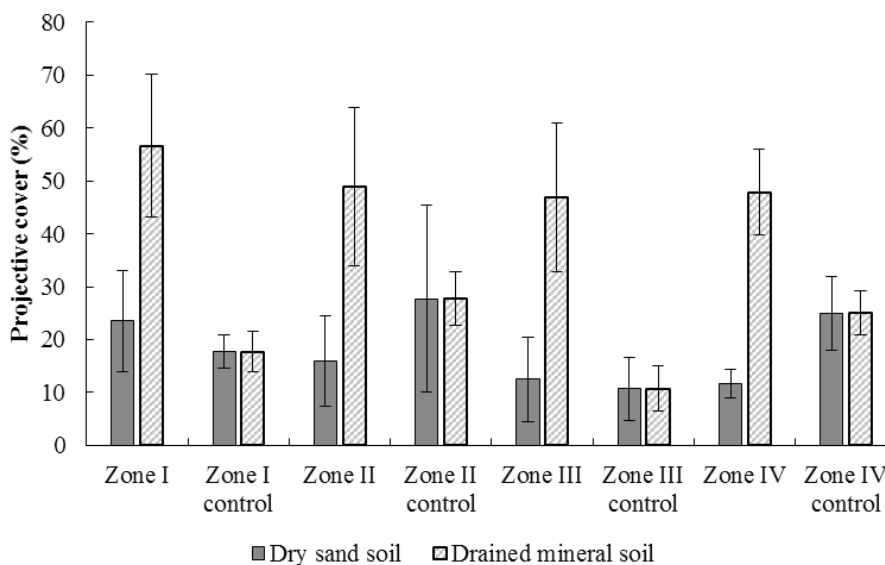
In burned sample plots on drained mineral soil 48 species of herbaceous plants, bryophytes and lichens were detected. Their number per zones I, II, III and IV was 3 – 11 (on average 4.5), 3 – 13 (on average 6.9), 4 – 17 (on average 6.8) and 4 – 11 (on average 6.8) species, respectively. The average number in all zones was 7.1 species. Very frequently occurring species (constancy class IV) were *Vaccinium vitis-idaea* and *Calluna vulgaris*, frequently occurring species (constancy class III) were *Molinia caerulea* (L.) Moench (characteristic of clearings of drained forests on soil with high humidity), *Pleurozium schreberi* and *Vaccinium myrtillus*. The remaining species were detected relatively seldom (constancy classes II and I).

In the control sample plots on drained mineral soil 94 herbaceous plants, bryophytes and lichens were detected. Their number per zone I, II, III and IV was 3 – 11 (on average 8.2), 6 – 19 (on average 13), 8 – 19 (on average 11.2) and 3 – 17 (on average 8.9) species, respectively. The average number in all zones was 10.3 species. Very frequently occurring species (constancy class IV) were *Molinia caerulea* and *Vaccinium myrtillus*. Frequently detected were also *Pleurozium schreberi*, *Rubus idaeus* (characteristic of clearings on nitrogen-rich soil), *Polytrichum juniperinum* and *Vaccinium vitis-idaea* (constancy class III). The rest 87 species were found very rarely (constancy class I).

The number of species in all our sample plots was close to average stands in *Vacciniosa* mel. and *Myrtillosa* mel. (it varies from 50 to 110 species) (Liepa *et al.*, 2014), that indicated a variety of different conditions and ecological niches in drained forest. In our sample plots dominated tolerant species – bushes, herbaceous plants and bryophytes.

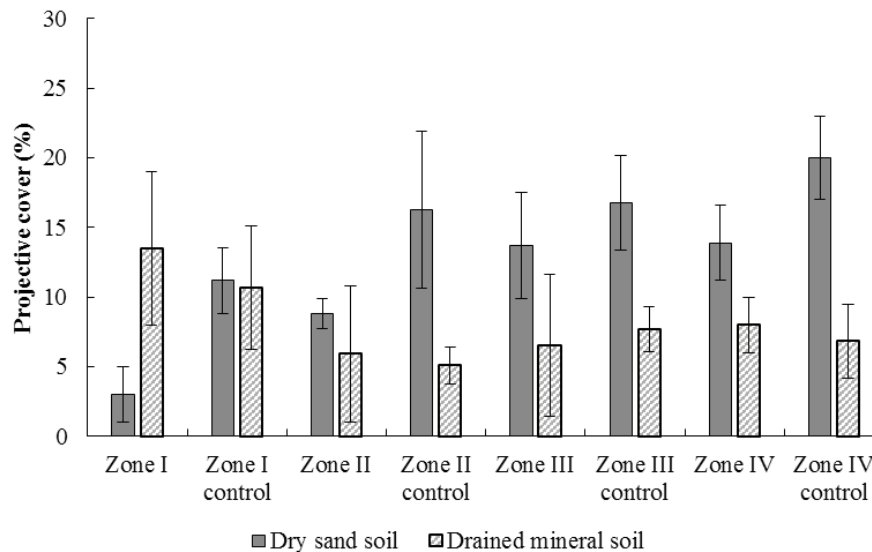
The projective cover of herbaceous plants and shrub layer (E1) in burned areas on sand soil was: 23.5% in zone I, 16% in zone II, 12.5% in zone III and 11.6% in zone IV (Fig. 1). Projective cover of bryophytes and lichen layer (E0) was 3%, 8.8%, 13.7% and 13.9%, respectively (Fig. 2). The projective cover of layer E1 was decreasing but projective cover of layer E0 – increasing by increasing distance from the nearest forest stand edge.

The projective cover of layer E1 in control on sand soil in zones I, II, III and IV was 17.7%, 27.7%, 10.8%, 25%, respectively, and projective cover of layer E0 was 11.2%, 16.3%, 16.8% and 20%, respectively. In



zone I: 25 – 50 m, zone II: 51 – 75 m, zone III: 76 – 100 m, zone IV: over 100 m

Figure 1. The average projective cover of plants and shrub layer (E1) on dry sand and drained mineral soil (\pm SE) depending on distance from the edge of burned or clearcut (control) area (zone).



zone I: 25 – 50 m, zone II: 51 – 75 m, zone III: 76 – 100 m, zone IV: over 100 m

Figure 2. The average projective cover of bryophytes and lichen layer (E0) on dry sand and drained mineral soil (\pm SE) depending on distance from the edge of burned or clearcut (control) area (zone).

the control sample plots the projective cover of layer E0 was larger than in burning sample plots, and its projective cover was increasing by increasing distance from nearest forest stands edge. But projective cover of layer E1 was least affected by distance from nearest forest stands edge, the smallest value was in zone III but the greatest in zone IV.

Projective cover of layer E1 in burnings on drained mineral soil in zones I, II, III and IV was 56.6%, 49%, 46.9% and 47.3%, respectively. Projective cover of layer E0 was 13.5%, 15%, 14% and 8%, respectively. The largest projective cover of layer E1 was in zone I and it decreased by distance from the forest edge. The smallest projective cover of layer E0 was in zone IV, in other 3 zones it was similar.

Projective cover of layer E1 in the control plots on drained mineral soil was smaller than in burnings and was quite similar in all zones: 40.2% in zone I, 37.9% in zone II, 35% in zone III and 41% in zone IV. Projective cover of layer E0 was 10.7%, 5.1%, 7.7% and 6.8%, respectively. In control sample plots, the projective cover of layer E0 was smaller than in burning sample plots, the largest value was in zone I close to the forest edge.

Dispersal of seeds or spores in burnings on sand soil in zone I was predominantly done by birds (36.7%), to a lesser extent by wind (26.7%) and autochorous (self-dispersal) (26.7%). Only zone I plants were dispersed by ants, determined by closeness of forest. In zones II, III and IV plants mostly were dispersed by wind (61.7%, 57.8% and 63.8%, respectively), but also important was autochorous (21.7%, 30.6% and 17.3%) and dispersal by birds (16.7%, 11.7%

and 19.0%, respectively). In the control plot on sand soil in all zones dominated dispersal by birds (53.3%, 58.3%, 41.7% and 33.24% in zones I, II, III and IV) and wind (44.2%, 41.7%, 50% and 11.3%, respectively). Plants dispersed by ants occurred only close to the forest edge, in zone I. Plants dispersed by water were detected in zone 4, which can be explained by increasing moisture more than 100 meters away from the forest edge.

In burnings on drained mineral soil dominated dispersal by wind (57.1%, 42.9%, 40.1% and 31.1%) and birds (40.2%, 41.8%, 32.2% and 48.5%). Plants dispersed by ants and autochorous plants occurred unequally in all zones, and dispersal by water was not notable. In the control on drained mineral soil the dispersal of seeds or spores was determined primarily by birds (46.9%, 32.5%, 35.9% and 44.4% in zones I, II, III and IV), to lesser extent by wind (27.0%, 22.3%, 36.5% and 34.9%, respectively) and also plants with autochorous dispersal type were present (14.9%, 25.8%, 8.7% un 11.3%). Dispersal by water in control was more important than in burnings (9.8%, 10.0%, 7.9% and 5.6%), which can be explained by greater moisture than in burnings.

In all objects were detected species with different life forms – hemicryptophytes, chamaephytes, geophytes and therophytes, but its distribution in zones differed (Raunkiaer, 1934). Therophytes had the lesser proportion in all zones.

In burnings on dry sand soil in all zones the majority of species were geophytes (average proportion 42.5%), but chamaephytes and hemicryptophytes were to a lesser extent (30% and

Table 1
Average Ellenberg's values (\pm SE) in different distances from the edge (zone) of affected –
clearcut (control) or burned – area

Zone*	Moisture in dry sand soil	Moisture in drained mineral soil	pH in dry sand soil	pH in drained mineral soil	Nitrate in dry sand soil	Nitrate in drained mineral soil
Zone I	5.6 \pm 0.12	6.1 \pm 0.17	2.0 \pm 0.39	2.0 \pm 0.14	1.2 \pm 0.03	1.8 \pm 0.09
Zone I, control	5.6 \pm 0.17	7.1 \pm 0.38	2.2 \pm 0.18	3.2 \pm 0.44	1.7 \pm 0.13	2.7 \pm 0.36
Zone II	5.6 \pm 0.2	5.9 \pm 0.16	2.3 \pm 0.58	2.4 \pm 0.25	2.2 \pm 0.7	2.2 \pm 0.28
Zone II, control	5.4 \pm 0.13	6.6 \pm 0.14	2.0 \pm 0.29	4.2 \pm 0.28	1.8 \pm 0.28	3.3 \pm 0.19
Zone III	5.2 \pm 0.26	6.0 \pm 0.19	3.2 \pm 0.8	2.5 \pm 0.27	1.8 \pm 0.23	2.2 \pm 0.25
Zone III, control	5.3 \pm 0.09	6.4 \pm 0.25	2.4 \pm 0.25	3.1 \pm 0.43	1.9 \pm 0.2	2.5 \pm 0.45
Zone IV	5.6 \pm 0.07	5.6 \pm 0.13	2.3 \pm 0.2	2.1 \pm 0.13	1.8 \pm 0.13	1.6 \pm 0.14
Zone IV, control	5.6 \pm 0.04	6.7 \pm 0.19	2.5 \pm 0.01	4.0 \pm 0.35	1.6 \pm 0.02	2.8 \pm 0.25

*zone I: distance 25 – 50 m, zone II: 51 – 75 m, zone III: 76 – 100 m, zone IV: over 100 m from the nearest edge of the affected area

24.3%, respectively). But in the control on dry sand soil hemicryptophytes dominated (average proportion 57.5%), chamaephytes and geophytes to a lesser extent (26.8% and 15%, respectively). In burnings on drained mineral soil in all zones most represented were hemicryptophytes (average proportion 61.5%), but chamaephytes and geophytes were less common (average proportion 20.8% and 11.8%, respectively). In control also dominated hemicryptophytes (56.3%), less represented were geophytes (27.5%) and chamaephytes (15.6%). Analysis of plant moisture requirement showed that in burned areas on dry sand soil only mezophytes were detected (100%). In control on dry sand soil most species in zones I to III were mezophytes (average proportion 97%), the rest were mezohigrophytes, but in zone IV higrophytes had a notable proportion (45.3) that indicated moist soil. The distribution differs in burned areas on drained mineral soil: average proportion of mezophytes was only 55.6%. The proportion of higrophytes increased from 0% to 2.2% and proportion of mezohigrophytes decreased from 15% to 1% by increasing distance from the nearest forest edge. In control, the tendency was the same as in burned areas: mezophytes were 87.2%, the proportion of mezohigrophytes decreased from 15.1% to 1.2% and proportion of higrophytes increased from 3.0% to 6.6%.

Ellenberg's indicator values are arranged in Table 1. Those values show that average moist, acid to very acid, nitrogen-poor soils dominated both in the burned and control areas on dry sand soil. In sample

plots on drained mineral soils moist, acid to average acid, nitrogen-poor soils dominated. There were no significant differences between burned and clearcut areas in respect to Ellenberg's indicator values on both soil types.

Conclusions

1. The total number of ground vegetation species both in forest types on dry sand soil (*Vaccinosa* and *Myrtillosa*) as well as in forest types on drained mineral soil (*Vaccinosa* mel. and *Myrtillosa* mel.) in burned areas was twice smaller than in clearcut areas. There was not a clear trend in changes of the number of ground vegetation species in relation to distance from the edge of the affected area in any of the analysed sites after fire or after clearcut.
2. Projective cover of herbaceous plant and shrub layer was almost twice higher in sites on richer (drained mineral) soils in comparison to sites on poorer (dry sand) soils; difference in projective cover of bryophyte and lichen layer was not so pronounced. There was no clear tendency in changes of projective cover in relation to distance from the stand edge in any of the assessed areas except in burned sites on dry sand soil, where herbaceous plant and shrub cover was decreasing (from 23.5% to 11.6%) and bryophyte and lichen cover – increasing (from 3% to 13.9%) with an increasing distance from the edge of the area.
3. In forest types on dry sand soil in burned areas only mezophytes were detected, but in clearcut

areas up to 100 m from the edge – mezophytes (average proportion 97%), but further – also a large proportion (45%) of higrophytes, indicating moist soil. In forest types on dry sand soil in burned and clearcut areas the proportion of higrophytes increased (from 0% to 2.2% and from 3.0% to 6.6%, respectively), but proportion of mezohigrophytes decreased (from 15% to 1%)

with increasing distance from the nearest forest edge. No trend in Ellenberg's values for soil moisture in relation to distance from the nearest stand edge was noted.

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GENETIC DIFFERENCES IN NEEDLE CAST DAMAGE OF SCOTS PINE (*PINUS SYLVESTRIS* L.)

Kaspars Polmanis^{1,2}, Darta Klavina¹, Talis Gaitnieks¹, Imants Baumanis¹, Andis Lazdins¹

¹Latvian State Forest Research Institute 'Silava'

²Latvia University of Agriculture

kaspars.polmanis@silava.lv

Abstract

The impact of climatic and genetic factors on needle cast damage, as well as relationship between the degree of damage and survival and growth of trees was evaluated in the study. The analysis was done in two series of experiments, both established in two locations in Latvia (central and eastern part). Needle cast damage (in 5 grade scale) as well as the height and height increment, diameter of root collar and survival of trees were assessed. Results suggest that the degree of needle cast damage was influenced by the genetic, as well as climatic factors, and also their interaction. The average degree of needle cast damage in experiment of open-pollinated families was 4.7 ± 0.01 in central and 4.6 ± 0.03 in eastern Latvia; in the experiment of control-crossed families it was 4.6 ± 0.02 in central and 3.4 ± 0.04 in eastern Latvia. The impact of genetics on the needle cast damage degree was statistically significant ($p < 0.05$), and this effect was observed when any of growth traits (diameter, height or height increment) was used as a covariate in analysis. Results suggest the potential to select more resistant families, since the genetic correlation of grade of the damage between locations was significant ($r = 0.40 - 0.72$) and therefore improve also the growth of trees, since the grade of the damage had a negative correlation with growth traits both at provenance and family mean level ($r = -0.69$ and $r = -0.42$; $p < 0.01$).

Key words: forest tree breeding, adaptation, genotype x environment interaction, provenance selection.

Introduction

Global climate change is predicted not only to increase the duration of the growing season, but also the sum of active temperatures and number of warm days (when the average air temperature is above $+5$ °C) and to alter the precipitation regime. These changes will affect growth of the trees (Jansons *et al.*, 2013a) and the effect might be different for different tree species (Jansons *et al.*, 2013b, 2014a, 2015a; Augustaitis *et al.*, 2015; Šēnhofa *et al.*, 2016), as well as for provenance within a tree species (Rieksts-Riekstiņš *et al.*, 2014). Meteorological factors limiting growth are also changing as the climate changes (Jansons *et al.*, 2015c). Climate change will affect tree growth not only directly but also indirectly: by determination of the presence and vigour of various species of fungi, which in turn will affect the survival and growth of the trees, depending on their resistance against a particular pathogen.

One of the most important group of needle pathogens of Scots pine (*Pinus sylvestris* L.) in nurseries and young stands (up to 24 years) are *Lophodermium* spp. fungi (Drenkhan, 2011), mostly *Lophodermium seditiosum* (Minter, Staley, & Millar), which in the territory of Latvia is characterized by a high genetic diversity (Moročko-Bičevska *et al.*, 2010) and a one-year development cycle (Ortiz-García *et al.*, 2003). Researches in Estonia have found that epidemics of *Lophodermium* spp. are largely determined by the sum of precipitation from May till August in the previous year, while the average air temperature in summer (except August) had no significant impact on the spread of the infection (Drenkhan, 2011). Favourable

weather conditions for this disease have been observed in recent years – humid and warm autumn (as well as the end of summer) and mild winters (Martinson, 1979; Stenström & Arvidsson, 2001). In recent years, in Latvia other diseases significantly affecting needles have been identified, too: *Diplodia pinea* (Desmo.) J. Kickx and *Dothistroma septosporum* (Adamson *et al.*, 2015). Tree breeding (and use of selected material in forest regeneration) can have an important role in the reduction of *Lophodermium* spp. and other needle cast diseases, since it is well developed and financially viable activity in Latvia (Gailis, & Jansons, 2010; Jansons *et al.*, 2011, 2015b) with proven effect on quantitative traits of Scots pine (Jansons, 2005, 2008; Jansons *et al.*, 2006). Therefore, the existing basis of experimental trials and infrastructure as well as platform for propagation (seed orchard) can be used to improve the resistance of needle cast simultaneously with other traits. Earlier studies have indicated the potential role of genetics in resistance to the needle cast (Liesebach & Stephan, 1996), but this effect may vary between the populations within a species. Therefore, the aim of the study was to assess the damage of the needle cast in climatically different planting locations in Latvia and influence of the pine genetics on it.

Materials and Methods

Assessment of damages caused by needle cast for Scots pine was carried out in 2 series of experiments located in the Scots pine forests and bordering the Scots pine stands (at least on one side), therefore with a possibility of the needle cast infection. The first

series consisted of an experiment of Scots pine open-pollinated families (hereinafter – open-pollinated experiment) altogether 226 (the average number of families from one provenance – 18), established in the central (57°00'N, 23°10'E) and eastern (56°40'N, 25°58'E) parts of Latvia. The second series consisted of a control-crossed trial (hereinafter – control-crossed experiment), established in the central (56°41'N, 24°26'E) and eastern (56°40'N, 25°58'E) parts of Latvia. This experiment involved 10 clones, crossed by diallel scheme; taking into account that not all crossings had been successful, in both sites 72 families were located. These families were divided into 5 groups: Group 1 – crossings between Ugale clones, Group 2 – crossings between Kalsnava clones, Group 3 – crossings between Ugale and Kalsnava clones, Group 4 – open-pollinated families of Ugale clones, Group 5 – open-pollinated families of Kalsnava clones. Needle cast damage in the first series was assessed during the second growing season, in the second – during the sixth. In both series evaluation was done visually in 5 grade scale, depending on the proportion of damaged (brown) one-year old needles: 1st grade – 0-5%; 2nd grade – 6-35%; 3rd grade – 36-65%; 4th grade – 66-95% and 5th grade – 96-100%. Additionally, in the second series the tree height and diameter (at root collar), as well as the height increment in the third, fourth and fifth growing season was measured. Single factor and two-factor analysis of variance and correlation analysis were used to evaluate the influence of various factors on analysed traits and relationships between these traits.

Results and Discussion

In both experiments (open-pollinated and control-crossed) pines were notably affected by the needle cast infection. The average grade of the needle cast damage

in open-pollinated trial in central Latvia was 4.7 ± 0.01 and in eastern: 4.6 ± 0.03 , but in both location of control-crossed experiment 4.6 ± 0.02 and 3.4 ± 0.04 , respectively. In both series of experiments statistically significant ($p < 0.001$) impact on the planting site of the needle cast damage grade was found. It conforms to the results of other studies (Martinsson, 1979). In both series lower grade of the needle cast damage was observed in plantations in the eastern Latvia, where characterised by higher continentality and the increasing daily temperature range (Draveniece, 2007). Such differences over a long period of time had led to evolutionary adaptation of the Scots pine: provenance from the western part of the country when planted in the eastern part was unable to achieve the same average height and diameter as “local” provenances (Jansons, Baumanis, 2005). Such results were consistent across numerous provenances and progeny plantations, therefore 2 provenance regions had been established in Latvia – Western and Eastern (26 March 2013 CM Regulations No. 159 ‘Regulations on forest reproductive material’). Since the sites in both series of trials are located in different provenance regions, it is possible that climatic differences have largely influenced the results – observed differences in grade of the needle cast damage between the sites.

Long-term meteorological data for the period from 1961 to 2010 demonstrated that in August, when the infection of *Lophodermium* is spread and significant impact of weather conditions on the occurrence of the disease is observed (Drenkhan, 2011), the average daily temperature in the eastern part of Latvia was significantly lower than in the central part (Fig. 1). In the previous year (before the needle cast damage assessment), the average daily temperature in August in the eastern part of Latvia was lower than in other locations. A higher sum of precipitations was

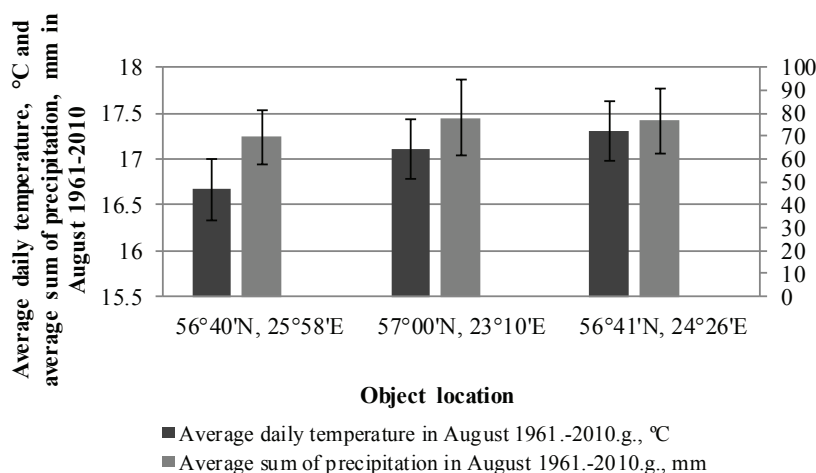


Figure 1. Average daily air temperature and sum of precipitation (\pm confidence interval) in August 1961 – 2010 in locations of open-pollinated and control-crossed progeny trials (Harris *et al.*, 2014).

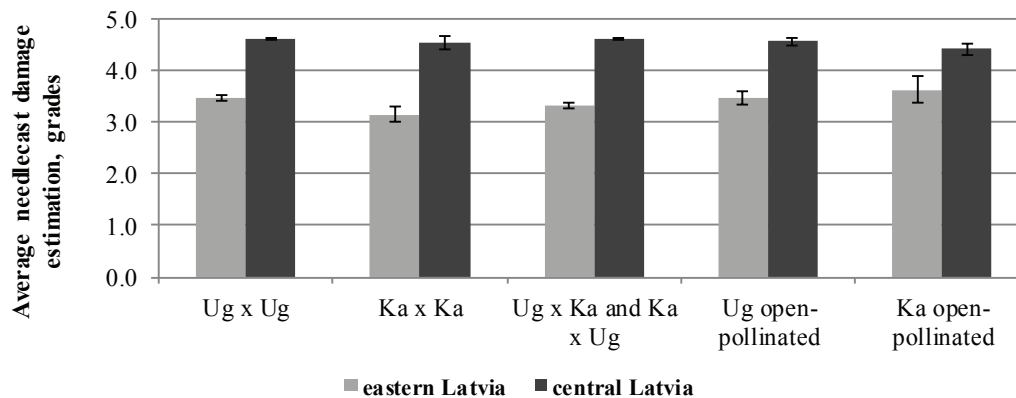


Figure 2. Estimation of needle cast damage (\pm confidence interval) of different groups in a control-crossed progeny trial in two locations.

Ug x Ug – crossings between Ugale clones; Ka x Ka – crossings between Kalsnava clones;

Ug x Ka un Ka x Ug – crossings between Ugale and Kalsnava clones;

Ug – open-pollinated families of Ugale clones; Ka – open-pollinated families of Kalsnava clones.

observed in location in the central part of Latvia, which also contributes to the spreading of the needle cast (Drenkhan, 2011). In the year prior to the needle cast damage, differences were not observed during the assessment of rainfall, however, the meteorological stations were located in the distance of 10 – 20 km from the experimental sites, therefore the more accurate information about precipitation (which may vary locally) is lacking.

In both series of experiments, the level (grade) of the needle cast damage was largely determined by genetics: both open-pollinated and control-crossed family had a statistically significant ($p < 0.001$) impact on the degree of the needle cast damage. In both open-pollinated progeny trials a statistically significant impact of provenance was observed, too: in the eastern part of Latvia $p < 0.05$, provenance average grade of the needle cast damage ranged from 4.33 to 4.72; in the central part of Latvia $p < 0.001$, provenance average grade of the needle cast damage ranged from 4.51 to 4.78. In a similar study with a smaller set of material (60 open-pollinated families, representing 5 provenances) a significant provenance impact on damages of the needle cast disease at the fourth growing season was not found, but in a study with a larger set of material (207 families from seven provenances) – a significant impact was found during the third growing season (Jansons, Neimane, & Baumanis, 2008). Similarly, other studies have found significant differences of resistance to the needle cast between provenances from the same or different countries (Squillace *et al.*, 1975; Stephan & Scholz, 1981; Бауманис, 1983; Ostry & Nicholls, 1989; Vuorinen, 2008). In our study, similar to the impact of provenance, the group in the control-crossed experiment also had a statistically significant impact on the needle cast damage grade, ranging from 3.15 to

3.64 in the eastern part of Latvia and from 4.42 to 4.62 in the central part of the country (Fig. 2).

In our study, in both series of experiments a statistically significant ($p < 0.001$) correlation between the degree of needle cast damage in different locations was found: in the control-crossed experiments Pearson correlation coefficient $r = 0.72$; in open-pollinated $r = 0.40$. A tighter correlation in the control-crossed experiment can be explained by higher genetic homogeneity in comparison to open-pollinated families. In both series significant genetics x location interaction was observed, too i.e. some families had a high mean grade of the needle cast damage only in one of the locations.

Analysis of a single-tree data in the open-pollinated progeny trials revealed a significant ($p < 0.001$) interaction effect between the planting site (location) and provenance, as well as between the planting site and family. Descendants of many provenances had a relatively stable (similar) grade of the needle cast damage in both locations, e.g. Tukums, Dundaga, Ugales and Lubanas provenances were characterized by relatively low, but Bauska and Jaunjelgavas provenances – high grade of the needle cast damage; however, certain provenances had a notably different grade of the needle cast damage between locations e.g. Kalsnava. Still, it should be noted, that the degree of the needle cast damage was generally high and varied in relatively small range. Analysis of a single-tree data in control-crossed experiment revealed a significant ($p < 0.001$) interaction between the plantation site (location) and crossing (family), and between the location and the group of crossings. Most of the groups of controlled crossings kept grade of the needle cast damage relatively stable in both locations, e.g. crosses between Kalsnava clones had a relatively low degree of the needle cast damage in both sites.

In our study, on the whole, no differences in grade of the needle cast damage related to the adaptation to a particular growth area (provenance region) were found (i.e. it was not found that in the western provenance region pines from this region would have a lower grade of the needle cast damage than pines from the eastern region, or vice versa), while the particular provenance (and family) significantly influences the resistance to the needle cast. Some earlier studies conformed the effects of genotype and environment interaction on resistance to needle cast (Baumanis, 1975; Millar, 1975; Martinsson, 1979), but others – rejected it (Squillace *et al.*, 1975).

Relationship between the degree of the needle cast damage with survival and growth was assessed in our study. The correlation between the degree of the needle cast damage and survival in a series of open-pollinated progeny trial was negative and statistically significant – both at provenance and family mean level ($r = -0.69$ and $r = -0.42$; $p < 0.01$). Similarly, Jansons *et al.* (2008) found that the grade of the needle damage had a significant impact on the survival in open-pollinated families at the age of 3 years. In the control-crossed experiment during our study the degree of the needle cast damage statistically significantly correlated with tree growth parameters, both at the individual tree and family (controlled crossing) level. The tightest negative Pearson correlation coefficients were found

between the degree of needle cast damage and stem diameter at a root collar at the age of 5 years ($p < 0.001$; at the individual tree level in the eastern and central Latvia $r = -0.29$ and $r = -0.38$, at family mean level: $r = -0.48$ and $r = -0.69$, respectively), as well as between the grade of the needle cast damage and the height increment of the year before the assessment ($p < 0.001$; at the individual tree level in the eastern and central Latvia $r = -0.28$ and $r = -0.31$, at family mean level: $r = -0.59$ in both locations (Fig. 3). In other studies, a significant negative correlation between the degree of the needle cast damage and tree growth parameters have been found, too (Baumanis, 1975; Squillace *et al.*, 1975; Martinsson, 1979; Ostry & Nicholls, 1989).

In our study, values of Pearson correlation coefficient (between growth traits and needle cast damage grade) of the control-crossed families were higher than those of individual trees, suggesting significant influence of genetics – slower growing families were characterized by lower resistance to the needle cast infection, possibly because they had already suffered from it before the assessment, resulting in a decreased height growth. Similarly, Jansons *et al.* (2008) found that the degree of the needle cast damage not only had a significant ($p < 0.001$) impact on the height increment of trees in a current year, but also a higher degree of the needle cast damage was found for the trees that were relatively smaller in the

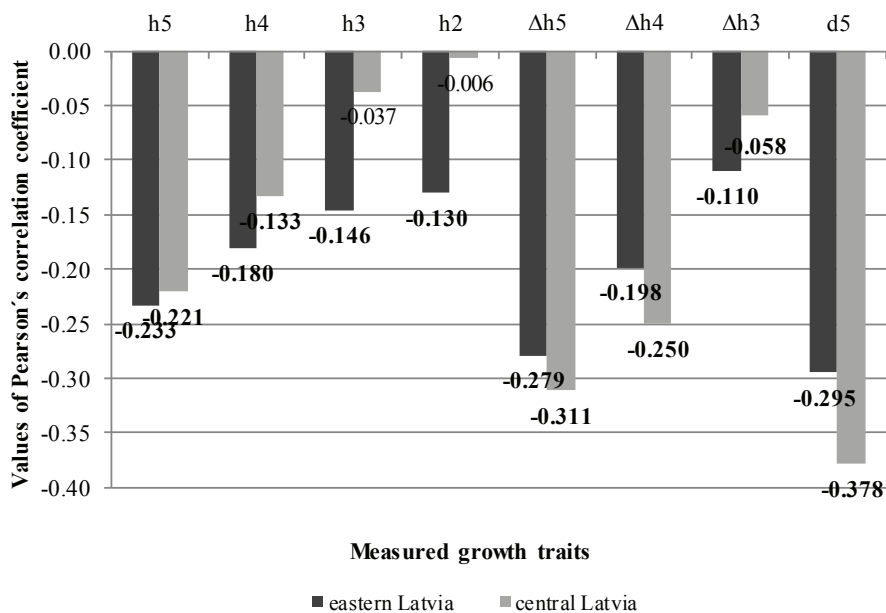


Figure 3. Comparison of values of Pearson's correlation coefficient depending on the degree of needle cast damage and growth traits at individual tree level in control-crossed experiment.

h5 – height of trees at age of 5 years; h4 – height of trees at age of 4 years;

h3 – height of trees at age of 3 years; h2 – height of trees at age of 2 years

Δh5 – height increment of trees in the 5th growing season;

Δh4 – height increment of trees in the 4th growing season,

Δh3 – height increment of trees in the 3rd growing season; d5 – root collar diameter of trees at age of 5 years

Significant values marked in bold.

year prior to the needle cast damages. Other authors have pointed out that provenances resistant against the needle cast were characterised also by higher productivity (Liesebach & Stephan, 1998).

Analysis of the grade of the needle cast damage in the control-crossed experiment where growth traits (height, height increment, root collar diameter) were used as covariates (thus excluding their impact) still resulted in a statistically significant ($p < 0.01$) impact of family and group of crossings. This result confirms that the degree of the needle cast damage is not only linked to the tree growth, but is also directly affected by genetics of trees.

Conclusions

1. The grade of the needle cast damage in open-pollinated and control-crossed experiment was statistically significantly ($p < 0.001$) affected by the location. In both series of experiments the grade of the needle cast damage was lower in locations with a higher average daily temperature in August.
2. The grade of the needle cast damage in all locations was statistically significantly ($p < 0.05$) influenced by genetics (family of trees), as well as the group of controlled crosses (in control-crossed experiment)

or provenance (in open-pollinated experiment); significant impact of interaction between the tree genetics and the planting site (location) was found, too, suggesting a local adaptation of separate families (provenances).

3. Genetically more uniform material (controlled crosses) had stronger correlation between the grade of the needle cast damage and locations than less homogenous material (open-pollinated progenies): $r = 0.72$ and $r = 0.40$, respectively.
4. The correlation between the degree of the needle cast damage and tree survival at family and provenance level, as well as between the degree of the needle cast damage and growth traits (height, height increment and root collar diameter) was significant.
5. Study confirms that heredity has a significant impact on the intensity of damage.

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IMPACT OF NEEDLE CAST DAMAGE ON SANITARY CONDITION IN YOUNG *PINUS SYLVESTRIS* STANDS IN CENTRAL LATVIA

Kaspars Polmanis^{1,2}, Olga Mieziņa², Imants Baumanis¹, Andis Lazdins¹

¹Latvian State Forest Research Institute 'Silava'

²Latvia University of Agriculture

kaspars.polmanis@silava.lv

Abstract

Recent studies have demonstrated the occurrence of different needle cast (*Lophodermium spp.*) species in young Scots pine *Pinus sylvestris* L. stands in different regions of Latvia. The impact of these fungi has been known also historically, but is predicted to increase in future due to climate changes that are forecasted to have a positive impact on presence and vigour of various species of fungi. The aim of the study was to characterize the needle cast damage in young Scots pine stands in central Latvia. Material was collected in 12 Scots pine stands at the age of 3 to 26 years in 28 plots with a total area of 8.1 ha in the middle of two consecutive growing seasons (years 2012 and 2013). The impact of disease was visually assessed using a 5 grade scale, depending on the proportion of damaged (brown) one-year old needles. Incidence of damaged trees (P, %) and damage intensity (R, %) was calculated and used to characterize the occurrence and severity of the infection in the stands as well as its link to other stand parameters. Damage incidence (ranging from 20 to 100%), as well as the intensity (from 4 to 35%) was slightly (incidence-also significantly) higher in 2013 in comparison to 2012; correlation between those two parameters was strong in both years ($r = 0.94$ and $r = 0.84$, respectively). The stand age, density (ranging from 1200 to 6900 trees ha⁻¹) and tree height did not significantly correlate with the damage incidence or intensity. Forest type (*Hylocomiosa* or *Myrtillosa mel.*) was not a significant factor, too.

Key words: Scots pine, young stand, resistance, fungi infection.

Introduction

Coniferous forests have considerable economic importance in the Baltic countries, demonstrated both by the share of forestry sector in GDP and share of wood and wood products in total export value. Therefore, it is important to address any threats that might negatively affect vitality and growth of trees. Currently, most of such threats are associated with rapidly progressing climate changes (Edenhofer *et al.*, 2014). Relation between meteorological factors and increment (both height and radial) of Scots pine has been well studied and results mainly demonstrate a slightly positive influence of the predicted changes on tree growth (Jansons *et al.*, 2013a, b, 2015). However, genetics too plays an important role in determining the tree-climate interaction and, therefore, survival and vitality of trees (Jansons 2005; Jansons *et al.*, 2006). For example, the results of provenance trial series analysis revealed that some provenances from different geographic origins planted together might have a very similar yield while others – very different, therefore climatic conditions of the place of origin need to be considered in discussion of the potential suitability of a particular forest reproductive material for a specific site (Rieksts-Riekstins *et al.*, 2014).

Climatic changes are predicted to affect productivity of forest stands not only due to changes in stress levels of trees (Voronova *et al.*, 2014) and impact on their growth, but also due to changes in patterns in natural disturbances, the most important among them being wind-storms (Seidl *et al.*, 2014). Differences in allocation of biomass in trees, related

to both genetics and environmental factors, might affect their resistance against the impact of wind (Bārdulis, Jansons, & Liepa, 2011, 2012; Jansons *et al.*, 2014). Climatic changes might also alter the impact of the diseases on trees. For Scots pine in nurseries and young stands (up to 25 years) needle cast is one of the most important diseases (Drenkhan, 2011). In Latvia, needle cast disease is caused by 4 different pathogenic fungi – *Phacidium infestans* Karst., *Lophodermium seditiosum* Minter, Staley & Millar, *Hypodermella sulcigena* (Karst.) Tub. and *Lophodermium pinastri* Chev. (Bankina *et al.*, 2003). In recent years, in the Northern Baltics (Estonia) other diseases significantly affecting needles are identified: *Diplodia pinea* (Desmo.) J. Kickx and *Dothistroma septosporum* (Drenkhan & Hanso, 2009). The most important from above-mentioned needle pathogen is *Lophodermium seditiosum* (Minter, Staley & Millar), characterized by a high genetic diversity in territory of Latvia (Moročko-Bičevska *et al.*, 2010) and a single year development cycle (Ortiz-García *et al.*, 2003). The opportunity to select toughest (both – the least damaged and best recovering from the damages of the needle cast) genotypes and provenances had been proven by different tree breeding experiments (Jansons, Neimane, & Baumanis, 2008; 2016; Neimane *et al.*, 2016). Weather conditions favourable for this disease have been observed during recent decades – humid and warm autumn (as well as the end of summer) and mild winters (Martinsson, 1979; Diwani & Millar, 1990; Stenström & Arvidsson, 2001; Hanso & Drenkhan, 2007), making this time period

Table 1

Location and parameters of studied stands

Object location		Area, ha	Forest type	Age, years	Stand average H, m	Stand average DBH, cm	Stand density, trees ha ⁻¹	Area of sample plot, m ²
Latitude	Longitude							
56°43'N	23°44'E	0.5	As	3	0.3	1.0	2667	50
56°43'N	23°44'E	0.4	As	3	0.5	0.9	2533	50
56°43'N	23°45'E	0.6	As	3	0.7	1.3	3500	50
56°43'N	23°45'E	0.3	As	3	0.7	1.6	3900	50
56°43'N	23°45'E	0.3	As	3	0.6	1.3	6900	50
56°43'N	23°44'E	0.4	As	4	0.6	1.0	6000	50
56°43'N	23°44'E	0.4	As	15	6.8	7.6	2600	50
56°43'N	23°44'E	0.5	As	15	6.5	8.2	2100	50
56°43'N	23°46'E	0.4	As	16	7.4	8.2	2700	50
56°43'N	23°45'E	1.1	Dm	23	13.7	14.5	1300	200
56°43'N	23°45'E	1.8	Dm	23	12.4	14.0	1483	200
56°43'N	23°43'E	1.4	As	26	12.4	15.5	1200	200

suitable for the studies of occurrence and impact of this disease. The aim of the study was to characterize damages of the needle cast in young stands of Scots pine in the central part of Latvia.

Materials and Methods

Twelve young Scots pine stands were randomly selected for the study in Zemgale regional forestry (Jelgava and Ozolnieki district). The empirical material was collected during the growing season of 2012 and repeatedly in 2013 in 28 sample plots. The total surveyed area of young stands was 8.1 ha (Table 1). Plots were placed on the diagonal of each compartment in equal distances. The plot area depended on the mean height of the trees in the stand: if it was smaller than 12 m, area of sample plots was 50 m² (radius 3.99 m), but if it was 12 m or larger the area of sample plot was 200 m² (radius 7.98 m). Height and diameter of every tree was measured. Diameter measurements were done with caliper with 1 mm precision at the breast height (1.3 m) for trees higher than 1.3 m and at the root collar for trees smaller than 1.3 m. Height measurements were made with a measuring stick for up to 5 m tall trees and with the ultra sound height measuring device VERTEX IV for taller trees, in both cases with precision of 0.1 m.

Forest types were determined in accordance with the Latvian national forest classification system (Bush, 1981). Plots were placed in stands of two forest types: *Hylocomiosa* (Dm) and *Myrtillosa mel.* (As) is a forest type on drained soils (Sarma, 1948), characterised by the mesotrophic (average fertility) soil (Laiviņš, 2014).

Needle cast was visually assessed for every tree in 5 grade scale, depending on the proportion of damaged

(brown) one-year old needles: 1st grade – 0.1 - 5%; 2nd grade – 6 - 35%; 3rd grade – 36 - 65%; 4th grade – 66 to 95% and 5th grade – 96 - 100% of damaged needles. To characterize the health status of young stands, the damage incidence (needle cast grade 2 - 5) (Formula 1) and damage intensity (Formula 2) (Miezite *et al.*, 2013) were calculated:

$$P = \frac{n \cdot 100}{N} \quad (1)$$

where P – damage incidence (%);
n – number of damaged trees (trees ha⁻¹);
N – total number of trees counted (trees ha⁻¹).

$$R = \frac{\sum (n_i \cdot b_i)}{N \cdot k} \cdot 100 \quad (2)$$

where R – damage intensity (%);
n_i – number of damaged trees (trees ha⁻¹);
b_i – level of damage (in grades);
N – total number of trees counted (trees ha⁻¹);
k – highest level of damage (in grades).

Single factor analysis of variance and correlation analysis were used to evaluate the influence of various factors on analysed traits and relationship between these traits (Liepa, 1974; Liepa, 1996; Arhipova & Bāliņa, 2003).

Results and Discussion

The incidence of the needle cast damage and intensity of the damage impact was analysed in *Hylocomiosa* and *Myrtillosa mel.* forest types. Overall,

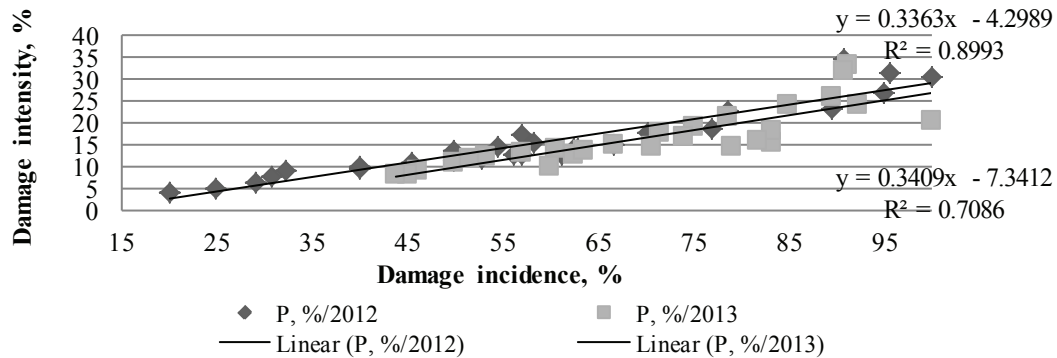


Figure 1. The relationship between the incidence of needle cast damage and damage intensity in young Scots pine stands in 2012 and 2013.

in Jelgava district 6 Scots pine stands in *Myrtillosa mel.* forest type were surveyed. In Ozolnieku forest district 6 Scots pine young stands – 4 of them representing *Myrtillosa mel.* and 2 *Hylocomiosa* forest type - were surveyed. The results demonstrated that the incidence of the needle cast ($p = 0.13$; $\alpha = 0.05$) and intensity of damage ($p = 0.11$; $\alpha = 0.05$) were not significantly different between the forest types. Presumably, it is due to similar conditions for the fungi in both forest types: for successful development of *Lophodermium spp.* acidity of the O horizon or litter layer needs to be pH 3.5 - 4.0 (Шевченко & Чилиюзик, 1986) and it was close to these limits both in *Hylocomiosa* (3.4 - 5.5) and *Myrtillosa mel.* (3.7 - 5.4) (Bārdule *et al.*, 2009).

Incidence of needle cast damage was significantly ($p = 0.03$; $\alpha = 0.05$) higher in 2013 in comparison to 2012 (70.8% vs. 58.9%, respectively), however intensity of the needle cast damage was not significantly ($p = 0.54$; $\alpha = 0.05$) different and reached 16.7% and 15.5%, respectively (Fig. 1). The incidence of the needle cast damage and damage intensity were strongly linked, suggesting that higher occurrence of the infection will not only affect more trees, but will affect a larger share of proportion of trees to a higher extent.

Dendrometric parameters, such as tree diameter (D) and tree height (H) might be affected by the impact of the infection both as the cause and the effect i.e. there might be lower resistance for weaker (smaller) trees in the stand and the impact of the disease might weaken the trees causing their growth to lag behind that of not affected trees. The impact might differ also in different stands of different age due to the mean size of the tree (and thus the amount of available nutrients). Such relationship had been observed in analysis of impact of pests. For example, the study in Estonia demonstrated, that severe defoliations by sawflies *Bupalus piniaria* occurred in 1930 - 1932, 1980 - 1981 and 1990 - 1992; by *Neodiprion sertifer* – in 1938 - 1939, 1948 - 1950, 1958 - 1960, 1962, 1965 - 1966, and 2007; and by *Diprion pini* – in 1981 - 1982.

The result of outbreaks of these pests was a significant reduction of radial increment of younger pines (age of 3 - 11 years) during 2 years following the insect defoliation. Height increment decreased significantly already during the calamity year as well as during the next 2 years. For older pines (age of 25 - 33 years), both radial and height increment was significantly reduced in the year of the calamity, but growth reduction during 2 following years was insignificant (Hanso & Drenkhan, 2012).

The age of our study stands ranged from 3 to 26 years and the mean height – from 0.2 m to 13.8 m. Allocation of the studied stands in 2 age groups (age up to 15 years and older) demonstrates very similar average needle cast incidence in both groups, 59.2% and 58.4%, respectively; difference was not significant ($p = 0.41$; $\alpha = 0.05$). Analysis of all stands as a single group did not reveal any significant age-related trend in incidence (Fig. 2) or intensity of damages. It indicates the needle cast disease is capable of infecting Scots pines at different age. However, the impact on growth might be different depending on the tree age, as demonstrated by the study in Estonia, where in the younger Scots pines (3-11 years), the radial growth of trees decreased (in comparison to the long-term mean) significantly in the year of *Lophodermium* epidemic and 2 years after the epidemics by 12 and 18%, respectively. Similar decrease in height growth was observed – 18% and 17%, respectively. No significant growth reduction was registered for older pines (22 - 33 years) during the first years after the *Lophodermium* needle cast epidemics (Hanso & Drenkhan, 2012). Similarly, a study in Denmark showed that another fungus *Chalara fraxinea* has a significant negative impact on the growth of common ash (*Fraxinus excelsior*) in up to 15 years old stands (Skovsgaard *et al.*, 2010).

Similar to age, the tree height (mean of the stand) was not a significant factor affecting incidence of the disease, as demonstrated by correlation analysis (Fig. 3), as well as analysis of variance carried out

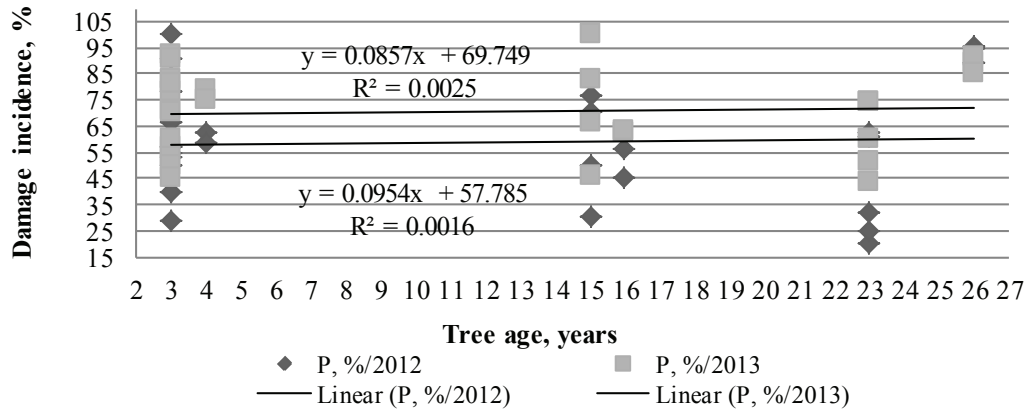


Figure 2. Needle cast damage incidence in Scots pine stands at different age.

between 2 height groups of trees and the incidence of disease ($p = 0.53$; $\alpha = 0.05$) or intensity of damage ($p = 0.41$; $\alpha = 0.05$). Analysis at a single-tree level demonstrated, that there is a link between the tree height and needle cast damage grade: damage intensity affected the height increment of 3 and 4 year old Scots pines ($\alpha = 0.001$). Lower height increment of more damaged trees resulted in a smaller total height (Jansons, Neimane, & Baumanis, 2008).

Density ranged from 1200 to 6900 trees ha^{-1} in the surveyed young stands. The study proved that there is no significant difference ($p = 0.51$; $\alpha = 0.05$) between the damage incidence in different stand density groups or a visible trend linking incidence or intensity of the needle cast damages to the stand density (Fig. 4). This finding contrasts with earlier studies, concluding that trees damaged by the needle cast occur more frequently with increase of the stand density (Voroncova & Semenkova, 1982). In opposition to that a study in Sweden showed that not only growth of each individual tree, but also its resistance to various diseases had been boosted in plantation with lower

density (Lundqvist & Elfving, 2010). Presumably, the differences in results between our findings and the results of other studies might be due to different range of stand densities analysed.

The results indicate, that further studies should address other factors presumably responsible for the differences in Scots pine resistance against the needle cast disease, namely, genetics (at provenance or family level) and tree position in the stand (plantation), as well as the effect of admixture of other tree species that has been demonstrated to be linked to another disease – pine twisting rust (*Melampsora pinitorqua* (Braun) Rostrum.) in Scots pine stands in Finland (Mattilaa, Jalkanenb, & Nikulab, 2001). Similarly, the assessment of genetic correlations between intensity of the disease and parameters of trees might be of importance for elaboration of recommendations for the tree breeding, as well as for the development of the most appropriate (cost-efficient) method to increase resistance in the areas most of all affected by the disease.

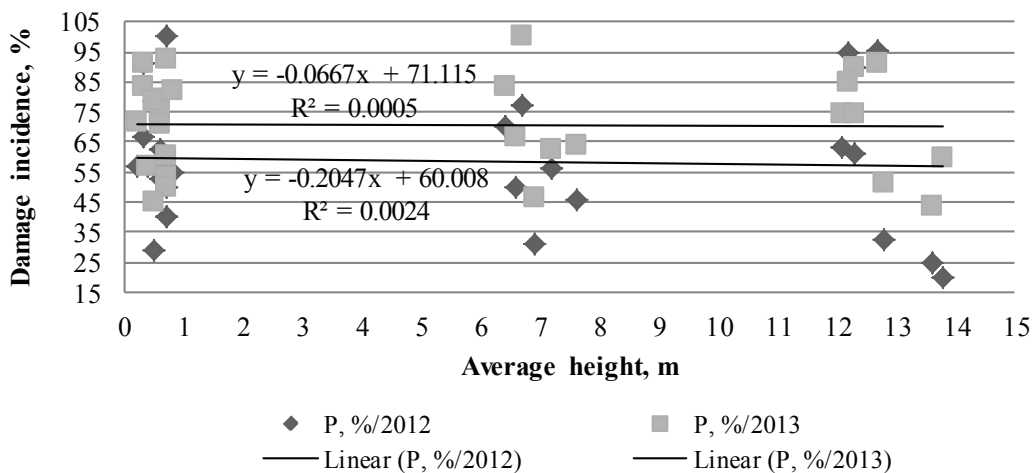


Figure 3. Needle cast damage incidence in Scots pine stands with different tree height.

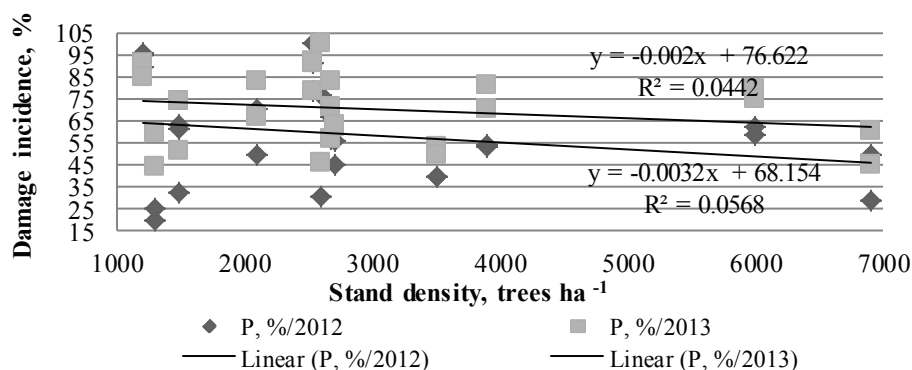


Figure 4. Needle cast damage incidence in Scots pine stands with different density.

Conclusions

1. Mean incidence and intensity of the needle cast damage in the studied sites in 2012 was 58.9% and 15.5%, respectively; while in 2013 – 70.8% and 16.7%, respectively. Difference between the years for the incidence was significant ($p = 0.02$; $\alpha = 0.05$), while for the intensity – not significant.
2. The needle cast disease was found in different age (from 3 to 26 years), height (from 0.2 to 13.8 m) and density (from 1200 to 6900 trees ha⁻¹) Scots pine stands; neither of those factors had a significant impact on the occurrence (incidence) or intensity of the disease.

3. The occurrence and severity of the needle cast disease was not significantly different between plots in *Hylocomiosa* and *Myrtillosa mel.* forest types.

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QUALITY CHANGES DURING SUMMER–AUTUMN LONG-TERM STORAGE OF SCOTS PINE (*PINUS SYLVESTRIS* L.) ROUNDWOOD

Jānis Magaznieks, Mareks Millers, Zelma Gžibovska

Latvia University of Agriculture

janis.magaznieks@inbox.lv

Abstract

Latvia at the moment does not have precise data about long-term storage of Scots pine. Long-term storage in warm season may lead to significant damages for high priced timber, income reduction for timber sellers and quality loss risk for timber buyers, therefore, roundwood is transported as soon as possible, because of the risk of blue stain, crooks and insect damages. Results of this study on Scots pine were obtained during summer–autumn season of year 2015. Scots pine timber quality changes in long-term storage were analyzed in 4 sample stacks – set up in summer (25 July) and stored for 100 days. In every sample plot there was a control pile, a pile with harvester spike damages, a pile with bark damages and a pile with harvester spike and bark damages. There were 32 timber assortments in every pile in order to determine also the emplacement effect in stack.

In this study a high correlation was found between pine timber quality changes and meteorological conditions, side surface damages and storage length. By analyzing the proportion of blue stain in cross-section and its changes during storage between control assortments and assortments with bark and harvester damages, significant differences were observed, therefore it can be concluded that not only bark damages influence the proportion of blue stain, but also harvester spike rollers. Based on the results of this study, we can predict maximum storage duration during summer–autumn period in Latvia, and it is set from 9 – 16 days.

Key words: Scots pine, roundwood, storage, blue stain.

Introduction

When the highest quality timber assortments are stored a few days too long, it can significantly influence the price of 1 m³ because of the quality reduction (blue stain, drying crooks and insect damages). If roundwood has somewhat different color from the natural one, the price for that kind of timber is reduced significantly. Usually wood discoloration has either microbial or non-microbial origin and there could be cases when both factors – biotic and abiotic are involved (Uzunovic *et al.*, 2008).

Maximum storage duration is one of the most important factors for reaction time in logistics system. By knowing the maximum storage duration, it will be easier to plan timber transportation and cutting intensity when conducting concentration cuttings in Latvia's state forests in respect to economic value of these resources. Meteorological parameters and timber moisture should be the main reasons for extensive blue stain damages.

Usually blue stain fungi do not cause significant changes in mechanical properties of the wood as they cannot digest components of the wood cell wall (Fleet, Breuil, & Uzunovic, 2001).

Staining fungi – usually caused by different fungal genera, can grow up to 2 cm per day longitudinally along the tracheid and parenchyma of softwoods (Uzunovic & Webber, 1998). Mechanical equipment, especially harvesters, apparently play a significant role in blue stain dissemination (Uzunovic, O'Callahan, & Kreber, 2004).

Millions of dollars annually are spent by forest product industry on fungicides in order to control sapwood staining fungi, but these agents do not

have long lasting effectiveness desired and present significant environmental concerns (Hoffman & Breuil, 2004).

There are many other possible ways to control sapwood staining fungi besides the chemical treatment: freezing and snow storage, water storage and storage under an elevated carbon dioxide (CO²) atmosphere, log drying, reduction of mechanical damage, control of insect vectors and fungal food reduction through 'sour-felling' or biological protection, applying sprinkling system (Shupe *et al.*, 2008, Uzunovic *et al.*, 2008).

The aim of this research was to determine the quality changes of Scots pine (*Pinus sylvestris* L.) during summer–autumn long-term storage. By having warmer spring and autumn, forest logging is possible all year long with higher intensity, after that should follow fast harvesting, forwarding and roundwood transportation. This was the reason to establish this research and to understand how to optimize all cycle from harvesting until sawing in mills. In the future this study may help to understand economic losses for every day that timber is overstored and will be practically applicable in timber trade.

Materials and Methods

To assess quality changes of timber in summer–autumn season, four timber storages were created with a variety of side surface damages in order to determine the suitable duration of storage without sacrificing superior timber quality, thus satisfying the interests of buyers and sellers. It is necessary to create all timber storages in a forest under the canopy; in that way including the factor of forest climate conditions.

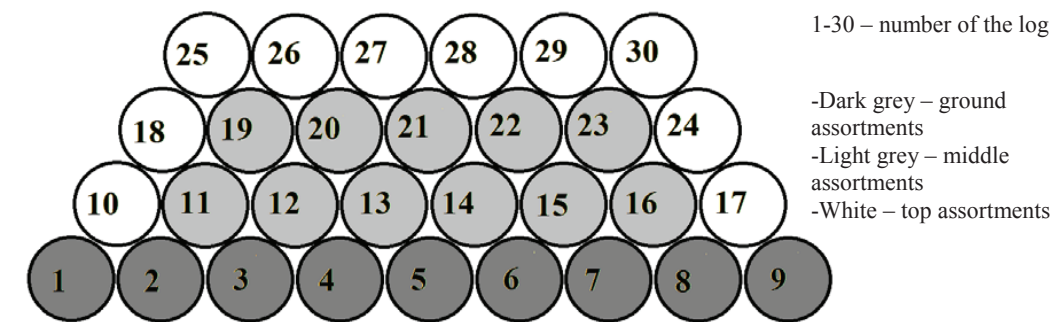


Figure 1. The scheme of assortment emplacement.

One pile consisted of 30 to 32 assortments with a diameter of 10 – 30 cm and the bark thickness 2 mm – 3 cm and a length of 1 m (Fig. 1). Since the discoloration of sapwood and cracks mainly develop from the end plane, it was not necessary to choose assortments longer than one meter, because it is fully enough to evaluate the reduction of quality in 50 cm distance from each of assortment end planes.

H. Solheim (1992) confirmed that in the first two weeks after the bark beetle *Ips typographus* attack, discoloration is not visible. That is why the first sample survey time was set after 15 to 20-day period of storage. Later timber storages were surveyed every 15 – 30 days depending on the season. In each survey 7 – 8 assortments were prepared and described. Sample discs were prepared from the log ends.

Evaluation of the assortment emplacement in the storage (Fig.1):

- 1 – 9 changes in quality are evaluated for assortments standing on the ground;
- 11 – 16 and 19 – 23 changes in quality are evaluated for assortments located in the middle of the stack;
- 10, 17, 18 and 24 to 30 evaluation of assortment emplacement on the top of the stack and its impact on timber quality.

In order to assess variety of preparation ways, 4 timber storages were created at the same time in each plot with different damages of side surface.

1. Control – assortments without side surface damages.
2. Damaged bark – assortments with the side surface of the bark bruised over the entire length.
3. Harvester spike roller damages – assortments that have damages from harvester pike roller, but do not have bruised bark made by debarking knives.
4. Harvester spike roller and bark damages – assortments with bruised bark and damaged side surface by harvester spike roller.

Assortments from every timber storage got the number in accordance with the scheme shown in Figure 1, in order to track these segments every time when resorting the timber storage and when dealing with processing of data. Storages were placed 10 to 15 cm apart from each other to evaluate changes in quality inside and outside the storage. Five discs of the assortment were sawn off in one survey, as shown in the scheme (Fig. 2). For the first disc on the outside only sapwood was sawn 3-5 mm in depth, in order to assess the quality requirements of assortments at purchasing. Every subsequent disc was sawn in 50 mm.

To describe the proportion of blue stain, it is necessary to determine the percentage of sapwood discoloration by excluding heartwood. Therefore, sapwood and blue stain basal area of sample discs was calculated by using special image processing

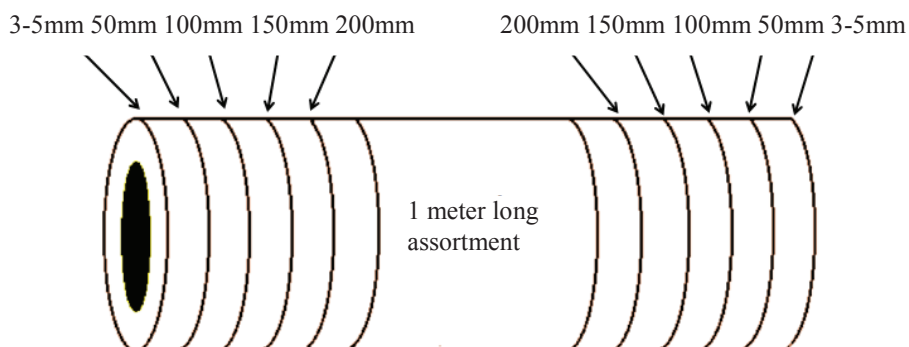


Figure 2. Roundwood cross-cutting section length.

software 'ImageJ'. The total area of sapwood and blue stain was marked with different colors already in the forest. By establishing images with different distance from the end plane we could assess damage intensity in the longitudinal direction. For further data analysis for every sample disc we made the measurement of heartwood basal area, sapwood basal area and area of discoloration. In order to get the meteorological data, temperature and precipitation was obtained from www.meteo.lv by using the data of the nearest meteorological station. The sum of positive temperature and sum of precipitation during storage period was used.

Two independent sample mean values ± 2 standard errors are characterized by a 95% confidence interval. If two independent samples with 95% confidence intervals overlap with each other, then the difference between them will not be statistically significant. To determine the significance of multiple factors, multiple factor linear regression was used. For this analysis IBM SPSS Statistics 20 was used.

Results and Discussion

Blue stain can form in different stages of wood processing. It may appear in storage and delivery stage, as well as on the finished product if conditions are favourable (Shupe, Lebow, & Ring, 2008). Nutrients, oxygen, appropriate temperature and moisture are essential factors for the development of fungus. Assuring optimal conditions for fungus may result in appearance of blue stain already after a few days (Hubbard *et al.*, 2005).

At the beginning of timber storage survey – 25 July 2015, attention was paid to the moment when signs of blue stain appeared on the edge plane until 5 mm depth. In the summer season blue stain in the control pine roundwood appeared on the 16th day of storage. When conducting regular surveys of timber stacks, one could observe that on some individuals blue stain starts to develop on day 29 of storage. On pine roundwood with bark damages the first signs of blue stain can be observed on the 12th day, but on some particular individuals signs of blue stain can be observed only after 24 days of storage. A similar trend can be observed also for roundwood with harvester spike roller damages. The first signs of blue stain can be observed already after 10 days of storage, but on some individuals – only after 22 days. The most rapid appearance of blue stain was found on roundwood that has both signs of harvester spike roller and bark damages. The first signs of blue stain were visible already after 9 days of storage, but on some individuals – after 18 days.

From the available information we can conclude that after the appearance of first signs of blue stain, in 9 – 13 days blue stain can be observed on all the

stored pine timber samples. In the same way it can be observed that side surface damages of roundwood affect the process of drying, hence the development of blue stain.

In the start of drying process after the tree felling and cross-cutting, the moisture content of sapwood decreases in accordance with current climate, wood properties and bark damages. Decreasing moisture content of wood results in an increased risk of blue stain. When the relative moisture of sapwood decreases below 50%, the risk of wood staining increases noticeably (Peek & Liese, 1974; Liese & Peek, 1984).

Drying process of roundwood depends on the degree of bark damages. Results of Nurmi and Lehtimäki (2011) confirm that in winter season bark is damaged the least. From literature sources and practical knowledge we know that wood dries faster when bark is removed. In past it was done manually with hands. Nowadays, when the wood harvesting process is mechanized, a part of the bark is damaged or removed in debranching procedure by the harvester spike rollers and debranching blades.

Weather conditions are of high importance in the drying process. The most important factors are: temperature, relative humidity, rainfall and wind speed. Stand location and relief also play an important role on temperature under canopy layer. The amount of heat required for evaporation of moisture is transferred from atmospheric air, which takes up wood moisture in the form of water vapour (Heiskanen, 1953).

When preparing logs by harvester, usually bark is bruised in three places in the form of stripes. Also later forwarder and truck with greifer bucket bruises bark in the middle of assortment while loading the timber.

In the further analysis we will look at sapwood discoloration development depending on the duration of storage at a depth of 5mm from roundwood edge plane taking into account the surface damages. Analyzing the impact of storage duration in the summer, it can be observed that the discoloration proportion in the sapwood part increases with storage time. It is also possible to observe that discoloration develops faster and with a greater intensity on the pine roundwood with a side surface damage.

In order to determine whether the discoloration proportion statistically significantly differs between the pine roundwood with a variety of side surface damages taking into account duration of storage, the average indicator values are represented together with ± 2 standard errors.

When analyzing the proportion of blue stain in depth of 5 mm from the edge of the plane and the changes depending on the duration of storage, it can be observed that there are significant differences in proportion of discoloration from day 25 to 70 of

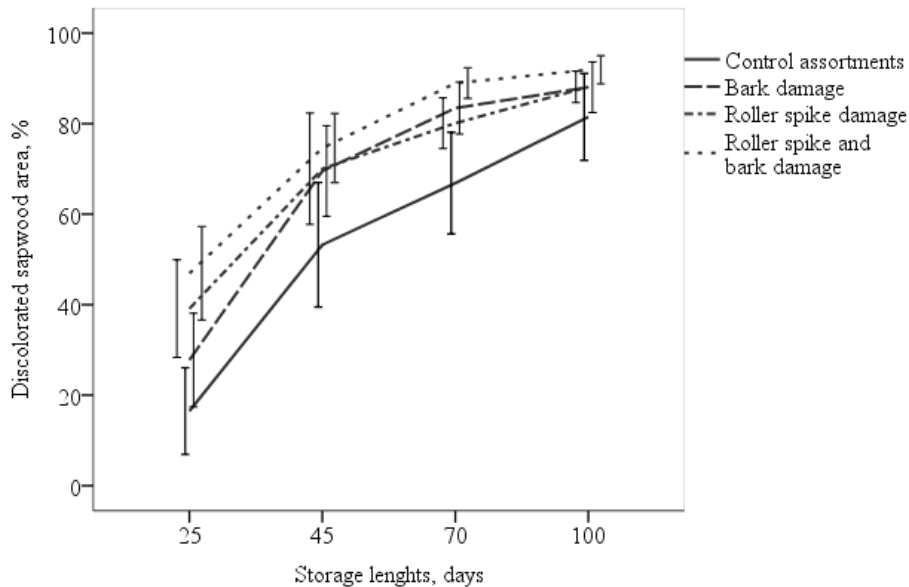


Figure 3. Sapwood discoloration ratio changes depending on the storage duration (± 2 standard errors).

storage between the control timber and timber with a harvester spike roller damages and bark damages. There are also significant differences in proportion of the discoloration when comparing control timber and timber with harvester spike roller damages on the 25th day of storage (Fig. 3).

The control timber discoloration proportion in sapwood part ranges from 16% (25th day of storage) to 81% (100th day of storage). The proportion of discoloration in sapwood of timber with harvester spike roller damages and timber with bark damages ranges from 47% (25th day of storage) to 92% (100th day of storage). In general, it can be observed that the rapid development of discoloration in depth of 5 mm from the edge plane occurs up to 45th day of storage, when the proportion of discoloration in sapwood part reaches:

- 53% for the control timber;
- 70% for wood with bark damages;
- 70% for timber with harvester spike roller damages;
- 75% for timber with harvester spike roller damages and bark damages.

Thereby, roundwood that is processed by harvester is subjected to a greater risk of being infected with a fungus, not only because a big part of bark is being bruised, but also because of the damages made by harvester head feed rollers (Uzunovic, O'Callahan, & Kreber, 2004).

Also K. Lee and J.N. Gibbs (1996) concluded that damages caused by harvester head feed rollers on the side surfaces of *Pinus nigra* affect the duration of storage in the warm period of year.

In the further analysis considering various wood surface damages and the storage period duration, the

changes of discoloration proportion in sapwood part in the direction from the edge of the plane to middle, will be assessed. In general, it can be observed that the proportion of sapwood discoloration tends to decrease from the end of roundwood towards the middle part. This can be explained by the fact that most of the moisture is released from the endings of the timber, where there are favorable conditions for the development of blue stain. For conifers water transpiration occurs only in the sapwood part, while in the core it has stopped.

The same as for roundwood with different kind of surface damages, also for control roundwood without any visible damages we can observe smaller proportion of discoloration in the direction from the end plane to the middle part (Fig. 4).

When analysing discoloration proportion changes in the sapwood part in the direction from the end plane to the middle, it can be observed that the most important discoloration proportion reduction is from the end plane (5 mm) to 50 mm. Further, with increasing distance from the end plane, discoloration proportion decrease is not significant or even remains unchanged.

Storing pine logs for 25 days with a variety of side surface damages, the following discoloration proportion changes in sapwood part in the direction from the end plane to the middle can be observed:

- control timber at 5 mm – 16%, 50 mm – 9%, 200 mm – 6%;
- timber with bark damages at 5 mm – 28%, 50 mm – 15%, 200 mm – 9%;
- timber with harvester spike roller damages at 5 mm – 39%, 50 mm – 21%, 200 mm – 18%;

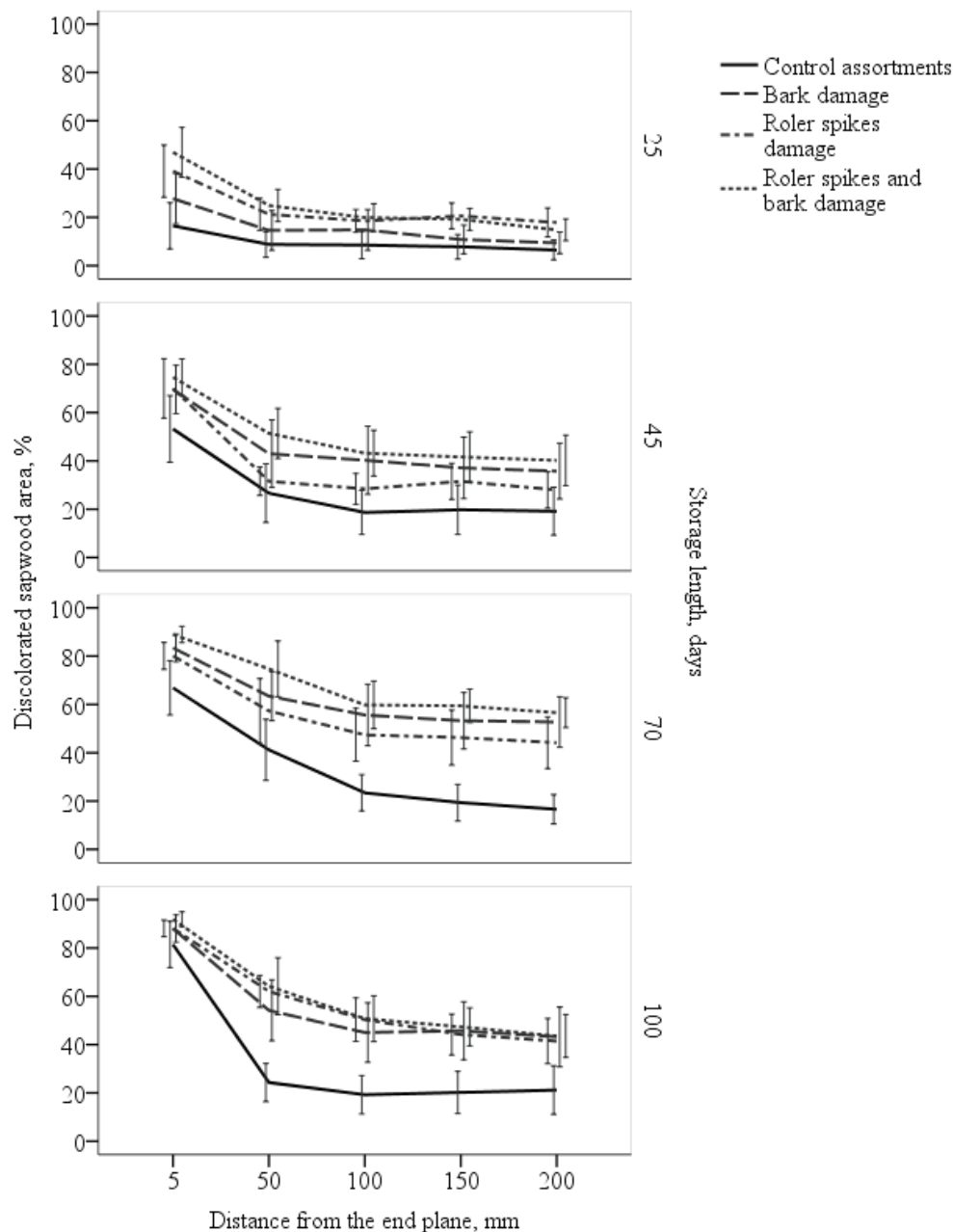


Figure 4. Sapwood discoloration ratio changes depending on the storage duration (± 2 standard errors).

- timber with harvester spike roller damages and bark damages at 5 mm – 47%, 50 mm – 25%, 200 mm – 15%.

Storing pine logs for 45 days, the following discoloration proportion changes in sapwood part in the direction from the end plane to the middle can be observed:

- control timber at 5 mm – 53%, 50 mm – 27%, 200 mm – 19%;
- timber with bark damages at 5 mm – 70%, 50 mm – 43%, 200 mm – 36%;
- timber with harvester spike roller damages at 5 mm – 70%, 50 mm – 32%, 200 mm – 28%;

- timber with harvester spike roller damages and bark damages at 5 mm – 71%, 50 mm – 51%, 200 mm – 40%.

In turn, after the 100-day storage of pine logs, the following changes in discoloration proportion were observed in sapwood part in direction from the end plane to the middle:

- control timber at 5 mm – 81%, 50 mm – 24%, 200 mm – 21%;
- timber with bark damages at 5 mm – 88%, 50 mm – 54%, 200 mm – 43%;
- timber with harvester spike roller damages at 5 mm – 88%, 50 mm – 62%, 200 mm – 41%;

Table 1

Meteorological parameters during the storage

Parameter	Storage period			
	Day 1. – 25.	Day 26. – 45.	Day 46. – 70.	Day 71. – 100.
Sum of positive temperature, °C	472	314	330	134
Sum of precipitation, mm	37	94	25	3

Table 2

Results of multiple factor linear regression

Parameters	Unstandardized Coefficients		t	p - value
	B	Standart. Error		
Constant	-4.688	4.767	-0.983	0.032
Roundwood surface damages	7.374	0.919	8.023	0.000
Distance from the end plane, mm	-0.478	0.046	-10.473	0.000
Precipitation sum, mm	0.162	0.061	2.667	0.008
Positive temperatures sum, °C	0.039	0.012	3.305	0.001

- timber with harvester spike roller damages and bark damages at 5 mm – 92%, 50 mm – 64%, 200 mm - 44%.

According to these results, the summer-autumn period in Latvia is favourable for the development of sapwood fungus. Acquainted with the various authors' studies, we can conclude that the temperature (minimum, maximum and optimum) for the growth of fungus differs slightly. This could be due to other changing circumstances, such as differences in humidity. S. Hubbard *et al.* (2005) claims that optimum temperature for fungus is 20-30 °C, but the fungus may still occur in a temperature range of 4-55 °C. According to S. Olaf (2006), the minimum temperature for the development of fungus depends on the species; it may be from 0-3 °C. The optimum temperature is 18-29 °C and the maximum is 40 °C.

In our situation, for regression analyses the sum of positive temperature and precipitation was used. At the end of storage period the average temperature and precipitation dropped (Table 1) and it caused a slight decrease of fungal damage

To more fully characterize the changes of discoloration proportion in summer-autumn period in sapwood part, multiple factor linear regression was used for analysis in order to assess the wider effect of different factors. The main task of regression analysis is to study the connection between the performance characteristic (discoloration) and factorial signs (side surface damages, storage duration till the 45th day, sum of the positive temperatures, the distance from the end plane up to 50 mm, the sum of precipitation and relative air humidity) and evaluate the function

of this correlation. When conducting multiple factor linear analysis, roundwood side surface damages are recoded in digital form (1- control; 2 - bark damages; 3 - harvester spike roller damages; 4 - harvester spike roller damages and bark damages).

After performance of multiple factor linear regression, it can be concluded that damages of the roundwood surface, distance from the end plane (5-50 mm), the amount of precipitation and the sum of positive temperatures significantly affect the roundwood discoloration proportion changes in the sapwood part (Table 2). Linear regression determination coefficient $R^2 = 0.57$, while the correlation coefficient $r = 0.752$.

Conclusions

1. The most significant factors influencing the proportion of sapwood discoloration in pine roundwood are side surface damages, the distance from the end plane, precipitation sum and the sum of positive daily temperatures in the storage period.
2. Depending on the roundwood side surface damages, the first signs of discoloration appear from 9th to 16th day of storage, while on all of the logs in timber storage discoloration can be observed in 9 – 13 days after the first signs of discoloration are detected.
3. Analyzing the proportion of discoloration and its changes depending on the duration of storage, it can be observed that between the control timber and timber with harvester spike roller and bark damages there are significant differences in the proportion of discoloration, so it can be concluded

that wood products processed by harvesters are faster infected by fungus, not only because of bruised bark, but also because of damages caused by harvester spike roller.

4. Analyzing the changes in proportion of discoloration in sapwood in the direction from the end plane of log to the middle, the most significant reduction of discoloration proportion can be observed from the end plane (5 mm) to 50 mm.
5. The most rapid discoloration development in sapwood continued until the 45th day of storage, which can be explained by the fact that during this

period there was a high average air temperature which is one of the statistically significant factor ($p=0.001$). After this period there was a decrease in the average air temperature, resulting in decrease of discoloration development intensity.

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PRODUCTIVITY AND QUALITY OF HYBRID ASPEN AT THE AGE OF 18 YEARS

Martins Zeps¹, Andis Adamovics¹, Janis Smilga¹, Linards Sisenis²

¹Latvian State Forest Research Institute ‘Silava’

²Latvia University of Agriculture

martins.zeps@silava.lv

Abstract

Fast-growing hybrid aspen clones are recommended for establishment of plantation on abandoned agriculture land in Northern Europe. In this study we assessed the productivity, quality and assortment structure of hybrid aspen clones at final felling. Data were collected during the hybrid aspen clonal experiment conducted in the central part of Latvia. Large variation in the productivity level between different clones was affected by growth and survival. From the compared 5 most and least productive clones, based on the yield $\text{m}^3 \text{ha}^{-1}$, the faster growing clones have about 17% better survival rate at age 10. Also, the mean annual increment (MAI) differed notably and significantly ($p < 0.05$, $\alpha = 0.05$) between hybrid aspen clones at the age of 18 years ranging from 7 to $34 \text{ m}^3 \text{ha}^{-1} \text{year}^{-1}$. Theoretical assortment structure of hybrid aspen at the age of 18 years was the following: $43 \pm 4.86\%$ of small dimension saw logs (SDS logs), $21 \pm 4.86\%$ high quality saw logs (HQS logs), $18 \pm 4.33\%$ pulpwood, $4 \pm 0.77\%$ firewood and $13 \pm 0.08\%$ of logging residues (tops). The outcome of HQS logs on average is more than 30% from the 5 best clones and further increase can be predicted with age. Stem volume ($H^2 = 0.32$), height ($H^2 = 0.47$) and quality parameters (stem straightness - $H^2 = 0.73$, branch angle - $H^2 = 0.60$) had a high heritability and large differences between clones, indicating notable possibilities to improve the productivity of plantations via selection of the best-growing genetic material.

Key words: survival, thinning, heritability, *Populus tremula* × *P. tremuloides*.

Introduction

Broadleaved tree species (*Populus*, *Salix*) and their hybrids are most often used for establishment of short-rotation plantation on abandoned agricultural lands in the Baltic and Nordic countries (Zeps *et al.*, 2008; Tullus *et al.*, 2012). One common choice is crossing between European aspen (*Populus tremula* L.) and American aspen (*Populus tremuloides* Michx.), in the literature referred to as “hybrid aspen”. Due to the heterosis effect, the potential productivity of hybrid aspen exceeds that of any of the parent species (Smilga, 1968; Liesebach *et al.*, 1999) as well as other short-rotation tree species (Jansons, 2013, 2014a). Productivity can further be boosted by fertilization, creating both short-term (Van den Driessche, Rude & Martens, 2003) and long-term – up to 15 years (Jansons *et al.*, 2016) – effect on the increment of trees. The recommended length of rotation period for hybrid aspen in Finland and Sweden is between 20 and 30 years. Production goal of the first rotation – saw logs and pulpwood; the target yield – $300\text{-}400 \text{ m}^3 \text{ha}^{-1}$ (Hynynen, Ahtikoski, & Eskelinen, 2004; Rytter & Stener, 2005, Tullus *et al.*, 2012). The second rotation originates from root suckers (Smilga, 1968; Liesebach *et al.*, 1999) and, due to low (no) costs of early management and relative high density, its production goal can also be biomass for energy: using 10-year rotation as much as 9 tons of dry matter per year can be produced (Rytter, 2006). The demand for energy wood is increasing in recent years primarily due to different support mechanisms intended to reduce the use of fossil fuels and reach the European Union’s CO₂ emission reduction targets (COP21). Combined heat and power plants are built in municipalities,

ensuring the demand for woody biomass 7.5 mill m^3 loose already in 2011 and steady increase of it since then due to opening of larger plants in the cities like Jelgava and Ventspils (Būmanis *et al.*, 2014). Also, a number of pellet factories have been built during recent years, increasing the demand for firewood and creating a potential market also for biomass from short-rotation plantations (Būmanis *et al.*, 2014).

Tree breeding as a financially viable activity is practised in a number of countries in the Baltic Sea region, including Latvia (Gailis & Jansons, 2010; Jansons, Gailis, & Donis, 2011; Jansons *et al.*, 2015a) and it has showed a notable effect on the growth traits (Jansons, 2005; Jansons *et al.*, 2006). Continuous selection of clones capable to produce the highest increment in particular climatic conditions (Jansons *et al.*, 2014b; Šēnhofa *et al.*, 2016) as well as to reduce damages (Zeps *et al.*, 2016) is feasible for hybrid aspen. Since profitability of hybrid aspen plantation at the first rotation to a large extent depends on the proportion of high-quality saw logs, also traits affecting natural pruning and stem straightness need to be included in the selection criteria (Stener & Karlsson, 2004). Based on the results of short-term experiments, the genetic gain in each of the traits can be estimated at a particular age and, using the assumptions on age-age genetic correlation and increment, also at the rotation age. However, to test the assumptions as well as to control solid data for land owners interested in the establishment of the plantations, it is essential to obtain data also from trials at harvesting age. The oldest hybrid aspen properly replicated trials in Latvia had recently reached this age; therefore the aim of our study was to assess the productivity and quality

of hybrid aspen clones and assortment structure at the final felling.

Materials and Methods

Material was collected in the clonal trial (experiment No 62 – Baumanis, Jansons, & Gaile, 2005), established on a former agricultural land (drained fertile soil) using one-year old micro-propagated containerized plants, with initial spacing 2 × 2 m (2500 trees ha⁻¹). Altogether 31 clones were used – 24 hybrid aspen, 5 diploid common aspen and 2 triploid common aspen – placed in 15 tree block plots in 4 replications. Extensive beaver damages occurred during the trial; only clones represented in at least 2 replications outside the area affected by beaver were used for analysis. Systematic thinning, removing every second tree (by diagonals of the trail) was carried out at the age of 12 years. All trees were assessed at the age of 8, 10, 12 (before and after thinning) and 18 years; from the first inventory only mean values of clone were available. During each assessment the tree height and breast height diameter

were measured, presence of spike knots, browsing damages or signs of cancer (*Entoleuca mammata*) was noted. Branch thickness was visually assessed relative to that of similar diameter trees in the trial in 3 grades: grade 1 – thin, grade 2 – average, and grade 3 – thick. Branch angle in the middle part of crown was assessed using 3 grade scale, where grade 1 – angle with stem axis ≥ 85°, grade 2 – 75° ≤ angle < 85°, grade 3 – angle < 75°. Stem straightness was assessed using 3 grade scale, where grade 1 – straight, grade 2 – slightly bent (one curve deviating from vertical axis of the stem at least 5 cm), grade 3 – bent (more than one curve). Stem volume was calculated using equation elaborated by Liepa (1996), developed for common aspen, since the height – diameter relationships in the trial did not suggested notable differences in stem form between common and hybrid aspen. The yield was calculated as the sum of stem volumes divided by the area of the plot, i.e. survival differences were included in the result. Broad sense heritability (H²) of traits was calculated based on variance components derived from additive linear model using SAS PROC

Table 1

Yield and survival of hybrid aspen clones at different age

Clone	Yield (m ³ ha ⁻¹) at the age of					Survival (%) at the age of		
	18	12		10	8	18	12	10
		harvested	standing*					
3	242	60	163	130	81	38	69	71
4	507	149	298	257	137	47	90	97
6	318	79	187	160	90	43	80	83
9	608	96	275	228	134	57	90	97
10	293	48	167	129	81	37	50	50
12	349	84	182	135	64	43	80	83
15	349	45	159	138	71	43	60	63
16	447	102	255	215	106	47	80	83
19	454	92	252	218	129	50	83	90
20	381	100	222	181	89	40	73	80
24	274	66	144	126	69	37	70	73
23	284	69	150	120	51	42	93	96
30	447	83	222	174	102	44	71	78
34	396	86	216	163	92	43	82	83
36	212	70	164	120	72	47	90	90
39	269	60	145	102	51	42	80	82
41	521	103	281	250	150	50	80	90
46	482	71	187	144	97	50	90	97
49	117	27	66	50	49	29	58	69

*standing –before thinning

MIXED function, as defined by Falconer & Mackay (1996). Assortment structure was calculated based on formulas developed by Ozolins (2002). Minimal top diameter for HQS logs is 18 cm, length 3.1 m; for SDS logs the respective figures were: 12 cm and 2.5 m, for pulp wood: 6 cm and 3 m, for fire wood 3 cm and 3 m. Quality was not considered when dividing stems into assortments.

Results and Discussion

Survival (before thinning) of hybrid aspen clones was $82 \pm 6.0\%$ (mean \pm 95% confidence interval), but for common aspen clones it was significantly lower: $68 \pm 7.3\%$ (Table 1). Survival of hybrid aspen was similar to that found in Estonia at the age of 5 years – 81% (Tullus *et al.*, 2007) and slightly lower than reported in Sweden – 96% (Stener & Karlson, 2004). Lower survival in our trial could be a result of insufficient weed control (resulting in competition for moisture) or browsing damages caused by rodents, which are mentioned as the main causes of tree death in plantations on former arable land during the first years after their establishment (Melchior & Seitz, 1966). A significant clonal difference in early survival was found in plantations in Germany, mainly linked to differences in resistance against prolonged periods without precipitation (Ilstedt & Gullberg, 1993). In our trial differences between clones were notable too (at the age of 10 years – from 50 to 97%), however, the small number of replications limit the possibility to estimate the statistical significance of the observed differences. Genetically determined differences ($H^2 = 0.25$) in survival had been found also in 14-16 years old plantations, linked to browsing damages by cervids and the influence of diseases (Ilstedt & Gullberg, 1993). The major diseases affecting plantations of hybrid aspen are cancers (*Hypoxylon mammatum* and *Leucostoma niveum*). In our experiment the occurrence of cancers was very limited (only a few cases), therefore, it was not possible to draw any conclusions on differences among clones in this respect.

Mean standing volume in the experimental plantation at the age of 18 years was $366 \pm 59.2 \text{ m}^3 \text{ ha}^{-1}$ and it was close to that expected or found at harvesting age in other studies of this hybrid (Hynynen, Ahtikoski, & Eskelinen, 2004; Rytter & Stener, 2005; Tullus *et al.*, 2011, Tullus *et al.*, 2012). Very large variation in this trait between clones was caused both by growth and survival, but part of it, presumably, also by random error due to the small size of plot and limited number of replications. The mean annual increment (MAI) of the hybrid aspen clones at the age of 8 years was $11.3 \pm 1.8 \text{ m}^3 \text{ ha}^{-1} \text{ year}^{-1}$, but for the common aspen $4 \text{ m}^3 \text{ ha}^{-1} \text{ year}^{-1}$; at the age of 10 years the respective figures were $16.0 \pm 2.6 \text{ m}^3 \text{ ha}^{-1} \text{ year}^{-1}$ and $7.1 \text{ m}^3 \text{ ha}^{-1} \text{ year}^{-1}$; at the age of 12 years (before thinning) $16.4 \pm$

$2.4 \text{ m}^3 \text{ ha}^{-1} \text{ year}^{-1}$ and $7.3 \text{ m}^3 \text{ ha}^{-1} \text{ year}^{-1}$; but at the age of 18 years: $20.3 \pm 3.3 \text{ m}^3 \text{ ha}^{-1} \text{ year}^{-1}$ and $10.0 \text{ m}^3 \text{ ha}^{-1} \text{ year}^{-1}$. The mean productivity of the hybrid aspen was more than double that of European aspen; this observation is in line with results found in other studies (Hynynen, Ahtikoski, & Eskelinen, 2004). The current annual increment between the age of 8 and 10 years was $35 \pm 6.6 \text{ m}^3 \text{ ha}^{-1} \text{ year}^{-1}$, in the next two years decreased to $18 \pm 2.6 \text{ m}^3 \text{ ha}^{-1} \text{ year}^{-1}$, but after the thinning from age 12 to 18 years, the increment was $28 \pm 6.0 \text{ m}^3 \text{ ha}^{-1} \text{ year}^{-1}$. These results demonstrate a notable response of hybrid aspen to changes (optimum) of environmental conditions and suggest a strong impact of competition between the trees and a negative effect of delayed thinning. It is in accordance with the results obtained in other countries, suggesting the use of high density ($2500 \text{ trees ha}^{-1}$) plantations for energy wood production with no thinning and rotation age of 10 years (Liesebach *et al.*, 1999, Karačić, Verwijst, & Weih, 2003). In plantations for saw log production, a lower initial density ($1100\text{-}1600 \text{ trees ha}^{-1}$) and one or two thinnings (depending on the length of rotation – 20 or 25 years) have been recommended (Rytter & Stener, 2005; Tullus *et al.*, 2007; Tullus *et al.*, 2012). Prompt reaction to the thinning can be seen also from changes in basal area: before thinning it was $25 \text{ m}^2 \text{ ha}^{-1}$ for hybrid aspen and $15 \text{ m}^2 \text{ ha}^{-1}$ for European aspen, as a result of thinning it decreased to $11 \text{ m}^2 \text{ ha}^{-1}$ and $9 \text{ m}^2 \text{ ha}^{-1}$, respectively, but already within 6 years it reached $32 \text{ m}^2 \text{ ha}^{-1}$ and $16 \text{ m}^2 \text{ ha}^{-1}$, respectively.

The total increment (including the volume extracted in thinning) at the age of 18 years for best hybrid aspen clone reached $39.1 \text{ m}^3 \text{ ha}^{-1} \text{ year}^{-1}$, exceeding the figures reported in other studies (Rytter *et al.*, 2002; Stener & Karlsson, 2004; Tullus *et al.*, 2012; Rytter & Stener, 2005), not exceeding $25.8 \text{ m}^3 \text{ ha}^{-1} \text{ year}^{-1}$ at the age of 23 years (Johnsson, 1976, Tullus *et al.*, 2012). Even if only the mean annual increment was considered, it was higher than described by growth curve developed for hybrid aspen in southern Sweden and Denmark – areas with a longer vegetation period than in Latvia (Jakobsen, 1976). MAI differed notably and significantly ($p < 0.05$, $\alpha = 0.05$) between hybrid aspen clones, at the age of 18 years ranging from 7 to $34 \text{ m}^3 \text{ ha}^{-1} \text{ year}^{-1}$ (Fig. 1).

Ranking of clones based on their MAI remains relatively stable at different ages of assessment: correlation ranges from 0.89 to 0.95 ($p < 0.05$, $\alpha = 0.05$), indicating that relatively early selection for this trait ensures accurate results. It conforms to a study in Sweden, where strong genetic correlations between values of traits at the age of 4 years and at the age of 9 years were found: for tree diameter – 0.9 and for tree height – 0.87 (Stener & Karlsson, 2004).

Mean height of hybrid aspen at the age of 8 years reached $11.5 \pm 0.43 \text{ m}$, at 10 years: $13.9 \pm 0.50 \text{ m}$,

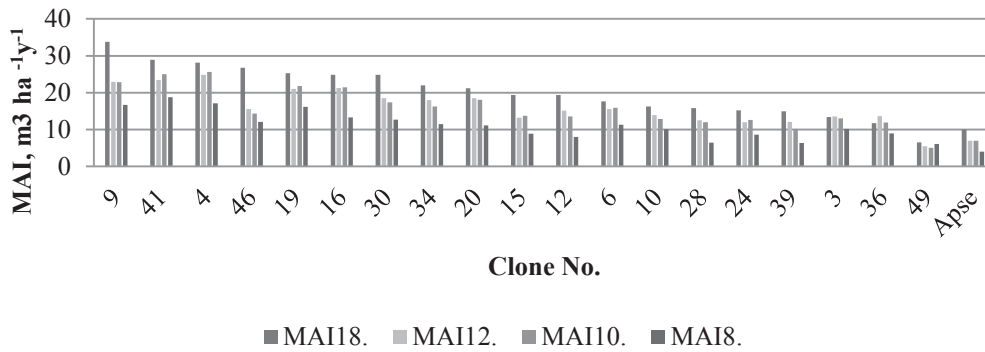


Figure 1. Mean annual increment (MAI) of hybrid and European aspen at 8, 10, 12 and 18 years.

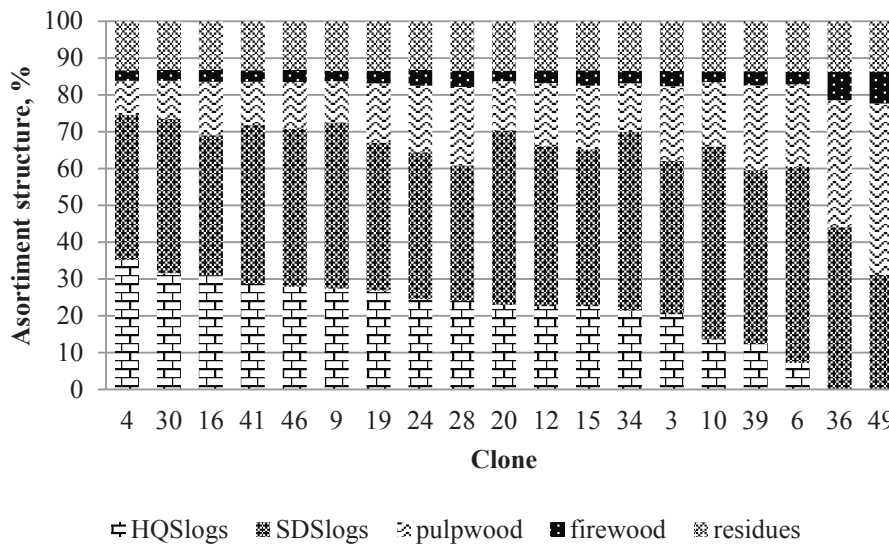


Figure 2. Hybrid and European aspen clone assortment structure
HQSlogs - high quality saw-logs; SDSlogs - small dimension saw-logs.

at 12: 15.5 ± 0.50 m and at 18 years: 21.6 ± 0.84 m. Annual height increment remains relative stable over the observed period, ranging from 1.44 m at the age of 8 years to 1.20 m at the age of 18 years.

Assortment structure of hybrid aspen at the age of 18 years was the following: $43 \pm 4.86\%$ of SDSlogs, $21 \pm 4.86\%$ of HQSlogs, $18 \pm 4.33\%$ of pulpwood, $4 \pm 0.77\%$ of firewood and $13 \pm 0.08\%$ of logging residues (tops). Notable differences between clones in the proportion of HQSlogs (from 0 to 35%, i.e. from 0 to $174 \text{ m}^3 \text{ ha}^{-1}$) and SDSlogs (from 31 to 53%, i.e. from 26 to $277 \text{ m}^3 \text{ ha}^{-1}$) were found, emphasizing the importance of breeding and selection of proper clone to maximize the productivity of plantation (Fig. 2.).

Additional volume, mostly pulpwood and firewood, was extracted in thinning. Since the systematic thinning was used, the mean stem volume of cut and remaining trees did not differ significantly (Table 2), but harvested volume (i.e. income for the plantation owner) differed notably between clones: from 27 to $149 \text{ m}^3 \text{ ha}^{-1}$ (mean: $78.3 \pm 12.9 \text{ m}^3 \text{ ha}^{-1}$). Since the

yield before thinning was $197 \text{ m}^3 \text{ ha}^{-1}$ on average, the decision to harvest the plantation at that time could also be considered.

To ensure high genetic gain, not only differences between clones and stability of ranking between selection and target age is important, but also heritability of traits. In our study the highest heritability was found for tree height ($H^2 = 0.47$), stem straightness ($H^2 = 0.73$) and branch angle ($H^2 = 0.60$); heritability of other traits was moderate: for stem diameter $H^2 = 0.27$, stem volume $H^2 = 0.32$, presence of spike knots $H^2 = 0.21$. Relative high heritability ($H^2 = 0.38 - 0.39$) for tree height, stem diameter and volume had been found also in the analysis of hybrid aspen trials in Sweden (Stener & Karlson, 2004); even higher – $H^2 = 0.60$ for tree height and $H^2 = 0.51$ for stem diameter – in Finland (Yu & Pulkkinen, 2003). Differences in heritability between the studies may to some extent be affected by the age of trees: it was found, that heritability for tree height is gradually decreasing with age, but for stem diameter – increasing

Table 2

Mean stem volume of hybrid aspen clones at different age

Clone	Mean stem volume (m ³) at the age of				
	18	12		10	8
		harvested	standing*		
4	0.43 ± 0.08	0.14 ± 0.02	0.13 ± 0.02	0.11 ± 0.01	0.06
9	0.43 ± 0.06	0.12 ± 0.02	0.12 ± 0.01	0.09 ± 0.01	0.06
41	0.42 ± 0.06	0.14 ± 0.04	0.14 ± 0.02	0.11 ± 0.01	0.07
30	0.40 ± 0.06	0.12 ± 0.03	0.12 ± 0.01	0.09 ± 0.01	0.05
46	0.39 ± 0.08	0.07 ± 0.02	0.08 ± 0.01	0.06 ± 0.01	0.04
16	0.38 ± 0.09	0.12 ± 0.02	0.13 ± 0.02	0.10 ± 0.01	0.05
20	0.38 ± 0.09	0.12 ± 0.02	0.12 ± 0.02	0.09 ± 0.01	0.04
34	0.37 ± 0.05	0.09 ± 0.02	0.11 ± 0.01	0.08 ± 0.01	0.04
19	0.36 ± 0.09	0.11 ± 0.02	0.12 ± 0.02	0.10 ± 0.01	0.06
15	0.32 ± 0.09	0.11 ± 0.03	0.11 ± 0.02	0.09 ± 0.01	0.04
12	0.32 ± 0.07	0.09 ± 0.03	0.09 ± 0.01	0.06 ± 0.01	0.03
10	0.32 ± 0.07	0.14 ± 0.03	0.13 ± 0.02	0.10 ± 0.02	0.06
24	0.3 ± 0.10	0.08 ± 0.3	0.08 ± 0.02	0.07 ± 0.01	0.04
6	0.29 ± 0.07	0.09 ± 0.01	0.09 ± 0.01	0.08 ± 0.01	0.04
28	0.27 ± 0.09	0.07 ± 0.02	0.09 ± 0.01	0.07 ± 0.01	0.03
39	0.26 ± 0.05	0.06 ± 0.01	0.07 ± 0.01	0.05 ± 0.00	0.03
3	0.26 ± 0.07	0.08 ± 0.02	0.09 ± 0.02	0.07 ± 0.01	0.05
36	0.18 ± 0.03	0.06 ± 0.02	0.07 ± 0.01	0.05 ± 0.01	0.03
49	0.16 ± 0.06	0.04 ± 0.01	0.05 ± 0.01	0.03 ± 0.01	0.03

*standing –before thinning

(Stener & Hedberg, 2003). The value of heritability is also affected by a specific set of clones and design of experiment: it is usually higher in trials where single-tree plots are used in many replications (Stener & Karlson, 2004; Zeps *et al.*, 2008). Heritability of stem quality traits is usually lower than growth traits – it has been found in our study as well as in the analysis of the hybrid aspen trials in Sweden, where $H^2 = 0.27$ for branch angle and $H^2 = 0.29$ for number of branches (Stener & Karlson, 2004). However, other approaches to improve stem quality (like pruning) are costly; therefore, these traits are considered in tree breeding. In our study, significant differences between clones were found in branch thickness, branch angle, as well as frequency of spike knots. On average 32% of trees had thin branches, 10% - narrow branch angle, 23% - spike knots. Genetic correlation between the quality traits was weak, indicating, that they are controlled by different set of genes. Significant moderate negative genetic correlation was found between branch thickness and stem diameter ($r = -0.52$; $\alpha = 0.05$), demonstrating the difficulties to select trees based

on multiple traits. Complexity of selection is further increased by negative genetic correlation between productivity traits and stem straightness (Stener & Karlson, 2004). This trait also was significantly affected by clone, but the reason for curves at any particular case might vary – apical dominance can be affected by drought stress, insects etc.

Conclusions

1. Survival of hybrid aspen at the age of 12 years differed between clones and was on average 82%, notably and significantly exceeding that of European aspen (68%).
2. Notable decrease of current annual increment at the age 10 to 12 years, as well as the positive reaction of trees (increase of increment) after the thinning at age 12 years proves the necessity of thinning in hybrid aspen stands with a relative high density (2500 trees ha⁻¹) and survival, if the intended rotation period exceeds 10 years.
3. The mean annual increment (MAI) of the hybrid aspen clones at the age of 8 years was 11.3 ± 1.8

$\text{m}^3 \text{ha}^{-1} \text{year}^{-1}$, but for European aspen $4 \text{ m}^3 \text{ha}^{-1} \text{year}^{-1}$; at the age of 18 years: $20.3 \pm 3.3 \text{ m}^3 \text{ha}^{-1} \text{year}^{-1}$ and $10.0 \text{ m}^3 \text{ha}^{-1} \text{year}^{-1}$, respectively. The height of hybrid aspen at the age of 18 years was $21.6 \pm 0.84 \text{ m}$. Both stem volume and height had a high heritability and large differences between clones, indicating notable possibilities to improve the productivity of plantations via selection of best-growing genetic material.

4. Notable differences between clones were found both in the mean annual increment, ranging from 7 to $34 \text{ m}^3 \text{ha}^{-1} \text{year}^{-1}$, and proportion of

HQSlogs, ranging from 0 to 35%, i.e. from 0 to $174 \text{ m}^3 \text{ha}^{-1}$.

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IMPACT OF WOOD ASH AND POTASSIUM SULPHATE FERTILIZATION ON GROWTH OF NORWAY SPRUCE STAND ON ORGANIC SOIL

Modris Okmanis, Ilona Skranda, Andis Lazdiņš, Dagnija Lazdiņa

Latvian State Forest Research Institute 'Silava'

modris.okmanis@silava.lv

Abstract

Wood based ash can be used as a liming material and fertilizer in forest, thus providing a solution for utilization of wood ash and formation of additional increment of trees, especially on organic soils, where lack of potassium and phosphorus is a well known factor limiting the growth of trees. Yet, many studies have been made with adverse results mostly because of different soil types and species investigated. However, by now the best results on fertilization with wood ash have been found on drained peatlands, where some nutrient deficiencies have emerged. The aim of this study was to find out the growth response of Norway spruce on drained organic soils after spreading of potassium sulphate (K_2SO_4) and wood ash (WA). The experiment was carried out in three middle aged Norway spruce (*Picea abies*) stands on drained mineral and peat soil. Experiment consisted of three replications of each treatment in each stand including WA, K_2SO_4 and the control on 400 m² sub-sample plots each. The diameter and height of trees were measured. The samples of increment cores were collected 4 years after fertilization to determine the additional volume increment, which varied from 8.5 m³ ha⁻¹ to 19.2 m³ ha⁻¹ in WA plots and from 9.7 m³ ha⁻¹ to 17.2 m³ ha⁻¹ on K_2SO_4 plots. Both - the wood ash and potassium application - significantly increased the increment of Norway spruce on drained mineral and peat soil, although no significant differences were found between the treatments ($p = 0.82$, $\alpha = 0.05$).

Key words: forest fertilization, additional increment, wood ash.

Introduction

One of the aims of forest policy in Latvia is to maintain and increase the productivity of forests. Fertilization is considered as one of the tools to increase forest value (Lībiete, 2012; Bergh & Hedwall, 2013). Necessity and impact of fertilization depend on many factors - stand age, soil type, species etc., and all of them should be considered before application of the measure. Studies have revealed that nitrogen (N) addition to oligotrophic upland sites can bring a positive result of tree increment, but application of potassium (K) and phosphorus (P) containing fertilizers alone has no significant effect on tree growth on upland sites (Jacobson, 2003; Moilanen *et al.*, 2013) or can have even negative effect (Brais, Bélanger, & Guillemette, 2015), while Hytönen (2003), Sikström, Almqvist, & Jansson (2010) and Moilanen *et al.* (2013) have found P deficiency in drained peat lands and positive tree growth response after application of P containing fertilizer on these sites. Drained forest lands are highly distributed in Latvia. In total, about 32% of forest lands are drained and 16% of these stands are covered with Norway spruce, which is the third highly distributed tree species in Latvia (about 18.3% of forest land cover, VMD, 2016).

Spruce is relatively fast-growing species, especially at a young and middle age when it is also the most productive tree species in Latvia (Zviedris, 1960; Bisenieks, 1997). Zālītis & Lībiete (2004) have found sharp productivity decrease in 40-year-old spruce stands on drained peatlands. In 2010 dieback of Norway spruce stands was observed on drained

organic and drained mineral soils. Mostly the middle aged stands were affected (Lazdiņš, Mieziņa, & Bārdule, 2011; Mieziņa, Okmanis, & Indriksons, 2013; Klavina *et al.*, 2016a) and correlation between the tree foliage damages and the K content in soil was found (Bārdule *et al.*, 2012). Moilanen *et al.* (2013) conclude that fertilization with wood ash shows the best results in stands with visual symptoms of P deficiency on N rich drained peat soils. In Latvia peatlands, including drained lands, are the richest with nitrogen forest soils (Bārdule *et al.*, 2009).

Selection of fertilizers is essential depending on the deficiency of certain nutrients. Several fertilizers in the form of sulphates, nitrates and chlorides are known as sources of K. The last group (KCl) can cause soil pollution with chlorine if exceeding dosages are applied. Instead of manufactured mineral fertilizers, which usually consist of several elements and require investment to buy the fertilizer, wood ash could be used at no cost and considering balanced amount of macro and micro-nutrients except N. The latest tendencies in energy sector (Būmanis *et al.*, 2014) will lead to increase of ash production in future. Already now industrial applications and households use 7.7 mill. m³ of woody biomass (CSP, 2015), which means about 150 thousand tonnes of wood ash production annually. The question of utilization of wood ash should be solved in near future. Numerous studies have been made by now in relation to the use of wood ash as soil amendment. Wood ash contains numerous elements which can improve soil fertility (Demeyer, Voundi Nkana, & Verloo, 2001; Saarsalmi, Mälkönen, & Piirainen, 2001; Moilanen, Silfverberg,

Table 1

Treated stand location and parameters by 2011

Stand	Age, years	Latitude	Altitude	Treatment	DBH, cm	H, m	G, m ² ha ⁻¹	M, m ³ ha ⁻¹
Ks47*	47	56° 51' 25''	23° 40' 45''	C	22.1	18.2	13.1	117.0
				K ₂ SO ₄	23.1	18.5	21.3	190.8
				WA	21.9	18.0	19.0	171.5
Ks43*	43	56° 51' 32''	23° 41' 23''	C	26.0	19.3	22.9	205.9
				K ₂ SO ₄	25.9	19.3	21.2	191.0
				WA	25.6	19.2	23.7	213.1
As36**	36	23° 27' 35''	23° 27' 35''	C	21.5	18.0	17.0	154.4
				K ₂ SO ₄	21.4	18.2	14.2	128.0
				WA	22.2	18.4	19.3	174.5

*Forest type - *Myrtillosa turf. mel.*; **Forest type - *Myrtillosa mel.*

DBH – mean diameter at breast height; H – mean height; G – basal area; M – stock volume.

& Hokkanen, 2002; Ozolinčius *et al.*, 2007; Brais, Bélanger, & Guillemette, 2015; Okmanis, Lazdiņa, & Lazdiņš, 2015). The application of wood ash has other advantages, for example, Ozolinčius *et al.* (2007) state that wood ash increases denitrifying and ammonifying microorganisms and cellulose decomposers. Klemedtsson *et al.* (2010) have found that fertilization with ash reduces greenhouse gas emissions from soil; Klavina *et al.* (2015) concluded that a high dose of wood ash application had increased the diversity and richness of ectomycorrhizal fungi in a long term. Considering that the content of phosphorus in wood ash is low, Hytönen (2003) concluded that K content is predominantly responsible for a positive impact of the wood ash applied as a fertilizer. The aim of this study was to find out the growth response of Norway spruce on drained soils after application of potassium sulphate containing mineral fertilizer and wood biomass ash.

Materials and Methods

Experiment was carried out in 3 middle aged Norway spruce stands on mesotrophic drained peat soil (*Myrtillosa turf. mel.*) and drained mineral soil (*Myrtillosa mel.*). Characteristics of stands are provided in Table 1. Nine systematically located square (400 m², 20×20 m) sample sub-plots were set in each stand in summer of 2011 with 11 m long buffer zone between them. The diameter of every tree was measured at 1.3 m height to an accuracy of 1 mm in every sub-plot. The heights of 10 trees in every sub-plot were measured to an accuracy of 0.1 m using a hypsometer.

In June 2011, wood ash (WA, 2.5 t ha⁻¹) was applied in 3 sub-plots of each stand and 145 kg ha⁻¹ of potassium sulphate (K₂SO₄) containing mineral fertilizer was applied in another set of 3 sub-plots

and the remaining sub-plots were left untreated as control (C).

The amount of K applied to soil was approximately 65 kg ha⁻¹ for WA and 62 kg ha⁻¹ for K₂SO₄, respectively. WA contained a considerable amount of other macro and micro-nutrients (Table 2). Chemical content of K₂SO₄ was provided by manufacturer. Potassium (K), calcium (Ca), magnesium (Mg) and manganese (Mn) in WA were determined using an atom absorption spectrophotometer (ISO 11466:1005). Phosphates (P) were determined with colorimetry in aqua regia (LVS 298 (2002), LVS ISO 11466: 1995, LVS EN 14672 (2006)). Total sulphur (S) was determined using ELTRA CS-530 method, oxidizing S to SO₂ at 1340 °C (ELTRA CS 530 methodology). Every set of 3 sub-plots in each stand was combined into one sample plot (1200 m²) for determination of dendrometric parameters within a treatment. The basal area, mean tree height, diameter and stem volume were calculated for each plot. The stem volume (including bark) was calculated using empirical functions provided by Liepa (1996).

Table 2

Chemical content of applied fertilizers, g kg⁻¹

Element	P	K	Ca	Mg	Mn	S
WA	10.9	26	224.8	30.9	3.1	-
K ₂ SO ₄	-	430	-	-	-	180

In November 2015, the increment cores of all trees from all sample plots were collected at 1.3 m height with the Pressler borer. In total 423 cores were collected and analysed during the study. Cores were glued on desks, then the surface of cores was grinded so that every increment ring can be visually

identified. The prepared cores were scanned with the high resolution scanner Epson Expression 10000 XL and following measurements of width of the annual increment rings were made with WinDENDRO software, which provides 0.001 mm accuracy. The average annual radial increments of the last 16 years (12 years of retrospection period and 4 years for the evaluation of fertilization effect) were calculated for each stand and the treatment. The additional volume increment was calculated according to I. Liepa (1996). Regression analysis of retrospective period was done to calculate prognostic annual radial increments in the last four years. The first factorial variable was natural logarithm of radial increments of the average tree in the control plots and resulting variable – natural logarithm of the radial increments of average tree from fertilized plots. Significance and conformity of hypothesis were estimated after the evaluation of regression and the following power regression (Formula 1) was set:

$$i'_j = \beta_0 + i'_{k;j} \beta_1^j \quad (1)$$

where i'_j – prognostic annual radial increment, $i'_{k;j}$ – annual radial increment of the control plots, β_0 and β_1 – coefficients of power function.

Statistical significance of the difference of the addition volume increment per unit of stand basal area between treatments within the experiment was evaluated using analysis of variance (ANOVA).

Results and Discussion

Previous studies have been made on distribution of fine root in fertilized plots and it was found that biomass of fine roots is significantly reduced during the first year after the application of fertilizers (Kļaviņa *et al.*, 2016b), despite the fact that positive tree growth response was observed already 1 year after the fertilization (Figure 1).

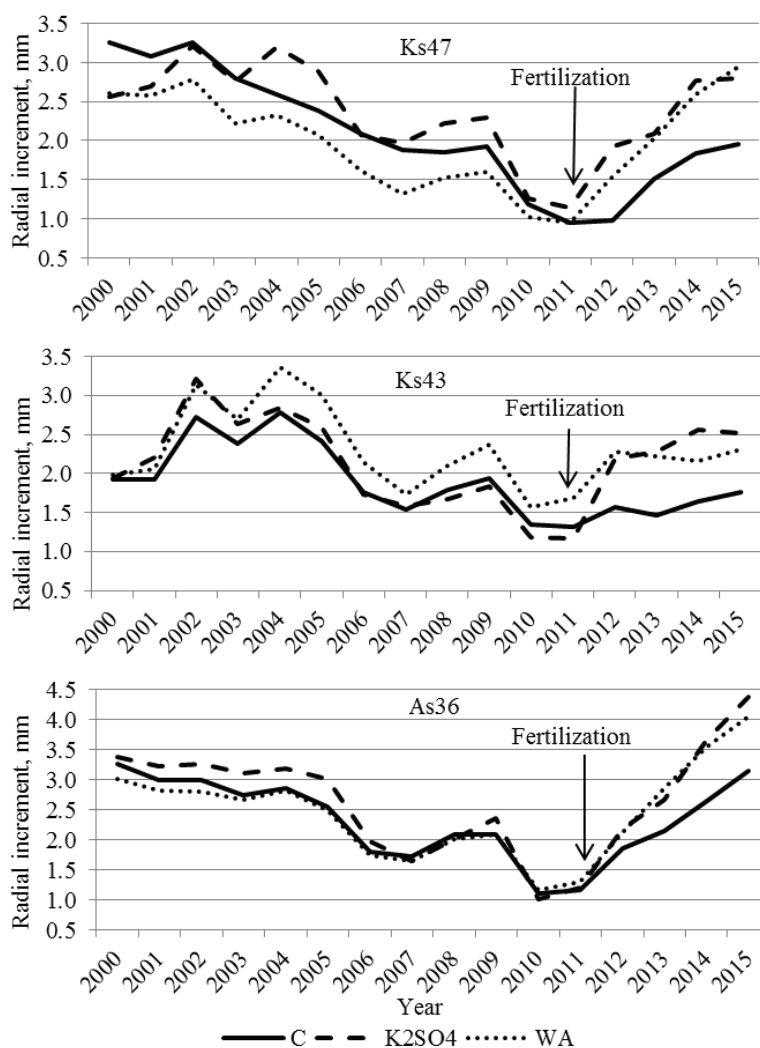


Figure 1. Average values for radial increment of Norway spruce in the control and fertilized plots.

Table 3

Results of regression analysis

Stand	Regression	R ²	p-value	Lower β ₁	Upper β ₁	Equation
Ks47	C-K ₂ SO ₄	0.868	1.05×10 ⁻⁵	0.58	1.02	y = 1.2252x ^{0.8014}
	C-WA	0.953	6.01×10 ⁻⁸	0.77	1.06	y = 0.8897x ^{0.9141}
Ks43	C-K ₂ SO ₄	0.961	2.23×10 ⁻⁸	1.10	1.47	y = 0.8359x ^{1.287}
	C-WA	0.939	2.10×10 ⁻⁷	0.81	1.16	y = 1.1784x ^{0.9831}
As36	C-K ₂ SO ₄	0.976	2.14×10 ⁻⁹	1.01	1.27	y = 0.951x ^{1.1388}
	C-WA	0.991	1.23×10 ⁻¹¹	0.83	0.95	y = 1.0699x ^{0.8883}

Fertilization improved the radial growth of trees so that in older stands (Ks47 and Ks43) it almost reached the highest increment values during the analysed period, but in younger stand (As36) even overreached the previous radial increments. It is important to note that the radial increment increased the most rapidly in the youngest stand. This could be related to the conclusion made by Lībiete, Jansons, & Zālītis (2009) conclusion that spruce stands reach the productivity peak at the age range of 21 to 40 years. Visible tendencies of the growth difference points to the continuous effect of fertilization. Both, K₂SO₄ and WA applications express similar growth response, which approve hypothesis of potassium deficiency in Norway spruce stands on drained soils, as both treatments include similar doses of K.

The average increments of the control trees used to compare both fertilization cases statistically significantly differ in the retrospection period. Therefore, the regression analysis was done by comparison of the control and each of the fertilized plots so that the additional increment can be calculated for each case separately. Equations provided in Table 3 were elaborated with high coefficient of determination values as a result of the analysis. P-values of all equations are smaller than significance level ($p < \alpha = 0.05$) and hypothetical value of β₁ (β₁ = 0) is out of the 95% confidence interval (Arhipova & Bāliņa, 2006). All equations are statistically significant.

The highest increase of radial growth in the last year of observation according to prognostic values was observed in Ks47-WA plot (80 %) and the lowest in Ks43-WA plot (13%).

The tendencies of dynamics of the increase of stock volume in Figure 2 demonstrate that the effect of fertilization is continuous and future investigations should be done to recognize the total cumulative additional volume increase so that the economic analysis can be done. Many studies reveal that wood ash has a long term influence on tree increments. Jansons *et al.* (2016) concluded that the duration of effect of the NPK fertilizers applied to planting spot of Norway spruce is 15 years effect resulting in 17

% higher stem volume compared to the unfertilized plots. Saarsalmi *et al.* (2014) reported that fertilization of upland site induced up to 71 % higher increase of stem volume during 5 years after the application of nitrogen combined with wood ash. In the same study, a significant difference between the increment in treated and control plots was found only 6 years after the application of stabilized wood ash on peatland; although during the following 10 years stem volume increment in the ash-treated plots was 25 % higher than in the control plots (Saarsalmi *et al.*, 2014). Sikström, Almqvist, & Jansson, (2010) concluded that signs of the wood ash fertilization can be recognized even 26 years after the application in elemental composition of the Scots pine needles and as an additional annual volume increment varying from 1.2 to 1.4 m³ ha⁻¹ yr⁻¹. In Sweden even 30 years after the fertilization some evidence of additional growth and chemical content of needles can be found when ash in combination with N is applied (Saarsalmi *et al.*, 2012). Similarly, the study in Finland on drained mire identified that wood ash causes additional increment even 50 years after the application (Moilanen, Silfverberg, & Hokkanen, 2002).

The difference between the stock volume in fertilized plots (m) and the prognostic stock volume (mt) appears as the cumulative additional stock volume increment in Figure 2. By the year 2015, the highest value of the cumulative additional stock volume increment was observed in Ks47-WA plot (19.2 m³ ha⁻¹) and the lowest value was in the WA plot in the stand Ks43 (8.5 m³ ha⁻¹). In the Ks43-WA plot the basal area was much lower than in other plots (Table 1). Bergh *et al.* (2014) concluded that in a non-thinned pine stand the cumulative volume increment was higher than in thinned stands. It is significant to ensure optimal stand density before fertilization to obtain a better result. At the same time, it is important to consider the dimension of trees and to improve the growth of large dimension trees. In the K₂SO₄ fertilized plots values of the cumulative additional stock volume varied from 9.7 m³ ha⁻¹ (As36) to 17.2 m³ ha⁻¹ (Ks43).

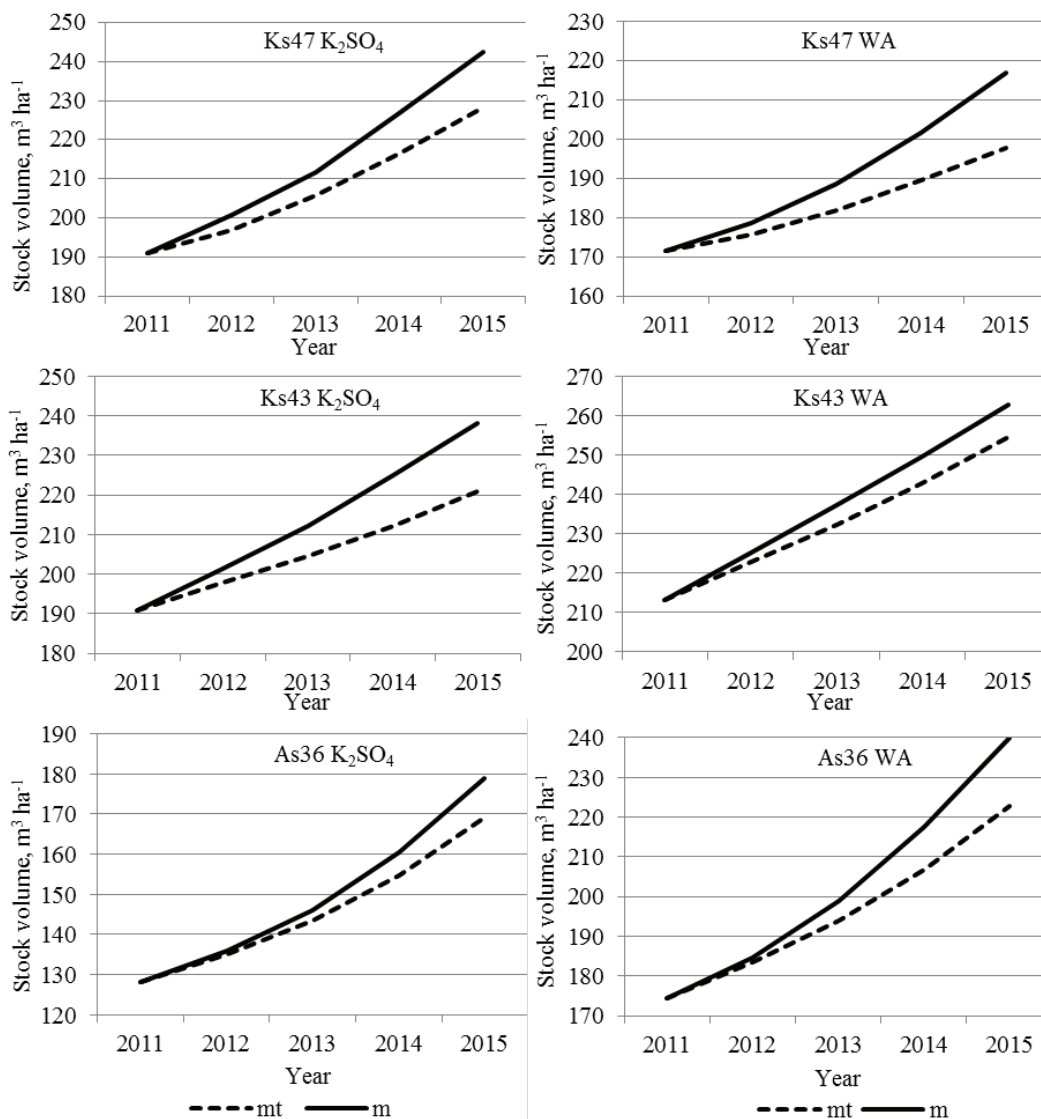


Figure 2. Dynamics of stock volume after fertilization (m) compared to prognostic stock volume (mt).

Increase of the volume increment per unit of the stand basal area can be used for a better comparison of effect of the fertilization between treatments (Table 4, Liepa, 1996).

ANOVA two factor analysis (the first factor as treatment and the second factor as year of observation) with replications (3 stands) demonstrates that there are

no significant (95% probability) differences between fertilization with wood ash and K containing mineral fertilizer ($p = 0.82, \alpha = 0.05$). It can be concluded that a similar effect could be acquired with similar doses of potassium irrelevant to the type of fertilizers; however, complex fertilizers, like wood ash, can act longer according to the research data (Moilanen, Silfverberg,

Table 4

Increase of volume increment per unit of stand basal area in each plot

Year	Increase of volume increment per unit of stand basal area, m ³ m ² yr ⁻¹					
	Ks47-K ₂ SO ₄	Ks47-WA	Ks43- K ₂ SO ₄	Ks43-WA	As36- K ₂ SO ₄	As36-WA
2012	0.17	0.16	0.15	0.10	0.07	0.07
2013	0.09	0.18	0.19	0.11	0.10	0.18
2014	0.18	0.26	0.21	0.06	0.21	0.26
2015	0.18	0.32	0.18	0.06	0.24	0.29

& Hokkanen, 2002; Sikström, Almqvist, & Jansson, 2010; Saarsalmi *et al.*, 2012).

Conclusions

1. The potassium containing mineral fertilizer and wood ash improve the growth of Norway spruce on drained mineral and organic soils already after the first year of application.
2. The impact of the fertilizers continuously increases during 4 years after the application of wood ash or potassium sulphate. The stem volume increment of trees in fertilized plots has increased significantly; further investigations are necessary to evaluate the duration of the impact and economic assessment should be made.
3. Four years after the application of fertilizers, the cumulative additional stock volume increment varied from 8.5 m³ ha⁻¹ to 19.2 m³ ha⁻¹ in

wood ash treated plots and from 9.7 m³ ha⁻¹ to 17.2 m³ ha⁻¹ in potassium sulphate treated plots; however, no statistically significant differences between treatments were found.

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SOIL COMPACTION IN YOUNG STANDS DURING MECHANIZED LOGGING OF BIOFUEL AND ROUNDWOOD ASSORTMENTS

Uldis Prindulis¹, Santa Kalēja², Andis Lazdiņš²

¹Latvian State Forest Research Institute 'Silava'

²Forest sector competence center Ltd., Latvia

uldis.prindulis@silava.lv; andis.lazdins@silava.lv

Abstract

Impact of a variety of forestry machine types on soil compaction is evaluated in this study according to the measurement of soil penetration resistance at 0 to 80 cm depth. It is concluded in the study that soils with poor bearing capacity (PBC), comparably small penetration resistance and organic layer thicker than 5 cm are less vulnerable to soil compaction. The use of small-size forwarder Vimek 610 allows to reduce soil compaction to an insignificant level in comparison to the control sites, and most or ruts disappear within a few days in PBC conditions. Whereas John Deere 810E, which belongs to the middle-size class of forwarders, significantly compacts soil through the whole measured depth in similar conditions. Rottne F10B and John Deere 810E forwarders represent the same weight category, and soil compaction due to the use of these machines on soils with moderate bearing capacity (MBC) is similar too; however, on soils with weak (WBC) and good (GBC) conditions results are different, mostly due to a different amount of extracted roundwood in both trials. Tracked forwarder was used only in GBC conditions and the results demonstrated significant compaction only down to 22 cm depth. The trials confirm that the depth of the intensity of impact depends on the weight of the machine and amount of material extracted; however, additional measurement data are necessary to characterize the impact quantitatively in different conditions.

Key words: soil compaction, forwarding, penetration resistance.

Introduction

The demand for woody biomass as renewable material, including small dimension logs and solid biofuel is expected to rise in future. The growing demand can be met both, by increasing of planted areas of fast-growing trees and their hybrids (Jansons *et al.*, 2013, 2014), as well use agroforestry systems (Rancane *et al.*, 2014) and by more efficient extraction of wood during forest thinning operations, especially on soils with low bearing capacity which represents high bioenergy potential, but also considerable risk of harmful impact on the remaining stand during intensified extraction of biomass (Lazdiņš & Thor, 2009; Lazdiņš *et al.*, 2013; Liepiņš *et al.*, 2015). Specialized forest machinery including small forwarders is of crucial importance to increase the output of biomass from small size tree harvesting operations (Spinelli *et al.*, 2010; Spinelli & Magagnotti, 2010).

The Vimek 610 forwarder is not unique in its 'small size' class, however, it is one of the few machines of this kind produced serially. The forwarder is equipped with the same engine as the Vimek harvester, front tires of the forwarder are slightly bigger and rear tires are smaller than those of the harvester. Clearance of the machine is 40 cm. Reach length 5 m, weight of fully loaded machine is about 10 tonnes (Lundberg, 2013).

Soil compaction during logging process has been studied since early 1970s. During the first trials it was proposed that soil compaction can have a negative impact on future stand development and health (Eriksson, 1981). Since that time many new studies

have appeared; however, till nowadays there is no common vision about all processes interacting with the soil compaction and relationships between the stand growth and soil compaction. The studies in Latvia demonstrate that soil compaction has a long lasting effect and there is a considerable difference depending on the type of the machines. The most important is the type of forwarder used in the operations. The use of tracked forwarders results in a considerably smaller impact appearing only at a topsoil layer, but wheeled machines in the same conditions can compact soil down to 80 cm depth, even without visually identifiable signs of rutting (Lupiķis *et al.*, 2014; Lupiķis *et al.*, 2015).

Knowing that tree roots are distributed mainly in the topsoil layer and the range of the distribution of roots considerably exceeds tree crown projection (Perry, 1982), it is obvious that not only the roots of trees growing near technological corridors (further in text – TC) have been damaged during forwarding, but also roots of those trees which are located more than 3 metres from TC. Damages of roots can cause tree infection. The most common infection of this type in Latvia is root rot, which is a well-known follower of the forest management activities, especially in coniferous forests (Kļaviņa *et al.*, 2013).

Early studies on the soil compaction consider that it can improve soil water permeability (Barden & Pavlakis, 1971); more recent studies demonstrate considerable decrease of water movement speed in soil in compacted areas (Batey, 2009; Taghavifar & Mardani, 2014) approving the potentially harmful impact of the compaction on the hydrological

properties of soil. Soil compaction also is a threat for plants and trees, because if soil penetration resistance is higher than 3 MPa then roots cannot or it is hard for them to penetrate those layers of soil (Lazdiņš, 2015) and in previous studies (Bassett *et al.*, 2005; Cubera *et al.*, 2009), the length of the main root system was constrained by soil compaction.

Soil compaction during mechanized logging is a result of direct and indirect impact of different factors. Some of them have been mentioned by Cambi M. *et al.*, 2016, like soil texture and moisture; as well as content of organic matter, terrain, characteristics of wheels (type, size, shape and air pressure), weight of machine and the number of trips (DeJong-Hughes, 2003; Duiker, 2004; Wolkowski & Lowery, 2008; Cambi *et al.*, 2015).

Different technical solutions are developed to reduce mechanical impact on soil. Constructors of forest machines are working on solutions to make logging machines more optimized for thinning operation, so to minimize the impact on soil and secure high productivity of the machines. The most commonly addressed solution is customization of chassis (increased size of wheels or replacement of wheels with tracks) to increase support surface and reduce maximum pressure on soil. Alternate trend is the increase of machine capacity to reduce cumulative pressure on soil due to bigger loads, as well as the opposite trend – development of small machines and optimization of forwarding process to move machines to a different category, where the key for reduction of the negative impact is planning of the forwarding trials (Sutherland, 2003; Sakai *et al.*, 2008).

Freezing and thawing significantly decrease the penetration resistance in the upper layers of compacted soils according to several studies. Studies in the United States confirmed that after one winter containing several cycles of freezing and thawing the penetration resistance of farm soils was reduced by 73, 68, and 59% at depths of 0 to 10, 10 to 20, and 20 to 30 cm, respectively (Jabro *et al.*, 2012, 2014). Similar results have been described by European authors (Özgan *et al.*, 2015). Studies in Latvia have demonstrated that in

deeper soil layers (below 40 cm) soil compaction can persist for decades (Liepiņa *et al.*, 2014).

The aim of this study is to compare influence of different types of forwarders (conventional, small and tracked) on soil compaction in young forest stands with different soil bearing capacity, as well as to evaluate if the initial soil penetration resistance can be used to compare forwarding conditions.

Materials and Methods

Data collected from 34 forest stands from different regions of Latvia (Skriveri, Koknese, Vecumnieki and Talsi) are evaluated in this study. The main criteria for selection of stands was the height of an average tree (below 12 m) and management history (no pre-commercial thinning done before). Some of dry and wet forest site types Oxalidososa, Hylocomiosa, Caricoso–phragmitosa and Myrtillosa (Liepa *et al.*, 2014) were represented with broadleaved dominant tree species (birch, black alder, grey alder). The age of those experimental objects varies from 10 to 16 years in inventory data.

Thinning and biomass extraction was done in summer and autumn, 2013. Impact of meteorological conditions, like precipitation on soil bearing capacity during forwarding was considered by measurement of soil penetration resistance at 0-80 cm depth. The penetration resistance was measured after forwarding on technological corridors and in untouched stand area using digital penetrometer, directly after forwarding. Measurements were done in pairs of plots, where 3...5 measurements (sub-plots) are done on technological corridor (TC and 3...5 measurements were repeated 3...5 m from a side of TC in similar conditions. The measurements of the penetration resistance in each TC was repeated at every 50 m. If the TC was shorter than 200 m, the sub-plots were located in denser network. In total, 5353 measurements were used in the study, respectively, in the group where soil bearing capacity is poor (PBC) it is 457; in the group of weak soil bearing capacity (WBC) – 1351; in the group where soil bearing capacity is medium (MBC) – 2032, but in the group with a good soil

Table 1

Data classification for analysis

Soil bearing capacity	In text	Average penetration resistance at 0...80 cm depth (MPa)	Biomass forwarder			
			John Deere	Rottne	Timbear	Vimek
poor	PBC	0.5...1.0	X	-	-	-
weak	WBC	1.0...1.5	X	X	-	X
moderate	MBC	1.5...2.0	X	X	-	X
good	GBC	2.0...2.5	X	X	X	-

Table 2

Technical specifications of forwarders

Producer	Model	Power of engine (kW)	Drive	Own weight (tonnes)	Load capacity (tonnes)
John Deere	810 E	95	8 tyres	12.9	9.9
Timbear	Light logg C	97	4+2 caterpillar trucks	12.0	10
Rottne	F10B	116	8 tyres	12.9	9
Vimek	610	44	6 tyres	4.9	5

bearing capacity (GBC) - 1513. All measurement data from the control sites were split into 4 groups depending on the machine used for biomass transportation. Then the average soil penetration resistance at 0..80 cm depth was calculated for every control sub-plot to characterize soil bearing capacity and different forwarding conditions. Depending on the average values of the soil penetration resistance, all sub-plots were split into 4 soil bearing capacity groups (Table 1). The marking 'X' in Table 1 marks the conditions, where the specified forwarder is used. Further data analysis is done by comparison of the difference between the soils penetration resistance in the control and TC sub-plots.

The average extracted biomass from each TC in the trials was between 15 and 25 m³. The influence of type of forwarder on soil compaction in different conditions (initial soil bearing capacity) was evaluated in the study. Considering the conclusion of several researchers on dominating role of forwarders in compaction of soil, the type of harvester is not evaluated in the study (Lazdāns, 2004; Eliasson, 2005; Gebauer *et al.*, 2012). Technical specifications of forwarders are shown in Table 2.

Significance level was calculated with $p < 0.05$; $\alpha = 0.05$, and descriptive statistics were carried out with the Microsoft Excel 2013 statistical software package.

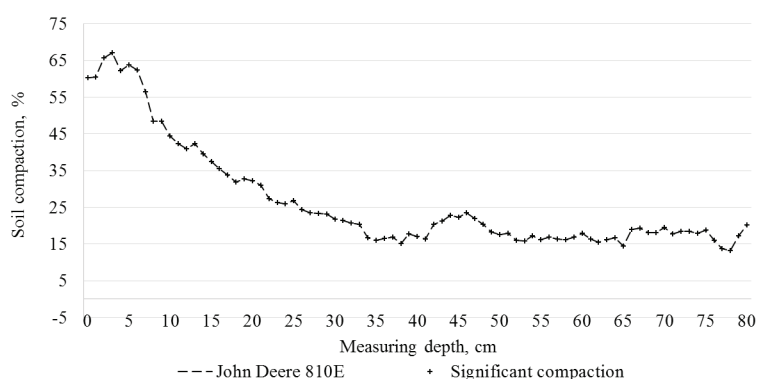


Figure 1. Soil compaction in comparison to control on soils with poor bearing capacity (PBC).

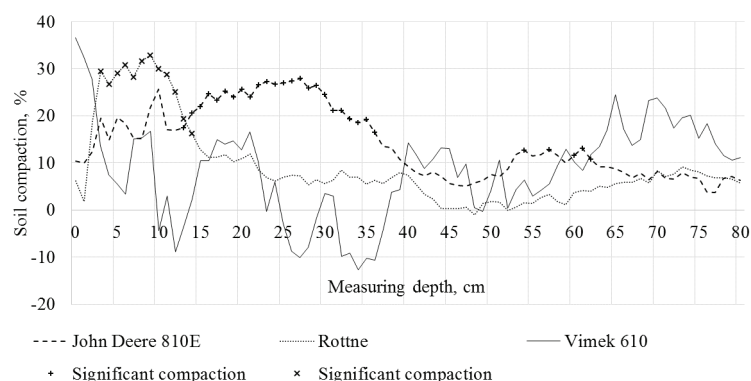


Figure 2. Soil compaction in comparison to control on soils with weak bearing capacity (WBC).

Results and Discussion

The results of the study demonstrate a different impact of the evaluated forwarders on the soil compaction in four groups of soil bearing capacity. In the first group of the soil bearing capacity (PBC) only John Deere 810E forwarder was used. Results in Fig. 1 demonstrate that average-class forwarder significantly compacted soil through the whole measured layer. Significant differences ($p < 0.05$) have been detected down to 80 cm depth (marked with '+' in fig. 1). Soil compaction in the upper layers down to 18 cm depth exceed the control by 30%.

Fig. 2 summarizes results from the WBC group of soils. In this group forwarding was done with 3 forwarders – John Deere 810E, Rottne F10B and Vimek 610. Significantly compacted soil was found in areas where John Deere 810E forwarder was used (significant difference at 13...37 cm and 54...63 cm depth). In areas extracted by the Rottne forwarder significant difference between control and TC was detected only at 3...15 cm depth. Using the small Vimek 610 forwarder, no significant differences of the soil penetration resistance were found between the control and TC in WBC sites.

Fig. 3 demonstrates summary of the results in the MBC group of soils. Forwarding was done with 3 types

of forwarders – John Deere 810E, Rottne F10B and Vimek 610. Significant compaction of soils is detected in all cases, but the most visible difference is found at a topsoil level. Significant compaction ($p < 0.05$) of soil using John Deere 810 forwarder is found at 0...50 cm depth, using Rottne forwarder – at 0...38 cm depth, but in areas where roundwood is extracted using Vimek 610 – at 0...26 cm depth. The highest rate of compaction of topsoil within this group is found in sub-plots, where small-size Vimek 610 forwarder is used; however, the impact is relatively shallow. The reason for similar impact by the Vimek 610 can be due to a smaller surface area of tyres resulting in an increased pressure on soil. At the same time Vimek is affecting mostly the topsoil layer – below 26 cm depth the difference is insignificant. It means that soil can return to the initial condition during freezing in winter.

Figure 4 displays summary of the results in the GBC group of soils. In the GBC group forwarding of roundwood was done by three machines – John Deere, Rottne and Timbear. Significant compacted layers of soil are not detected deeper than 22 cm in sub-plots where Timbear was used. In case of John Deere, considerable compaction was found down to 18 cm depth, whereas in case of Rottne the soil was

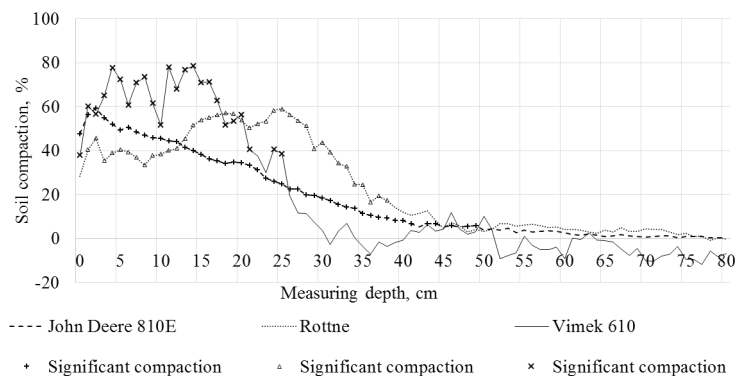


Figure 3. Soil compaction in comparison to control on soils with moderate bearing capacity (MBC).

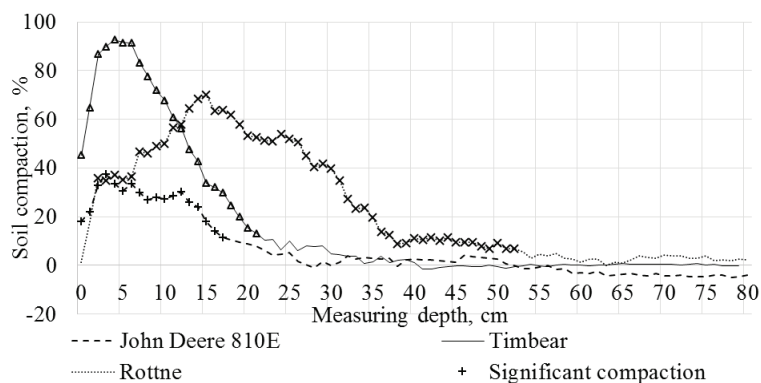


Figure 4. Soil compaction in comparison to control on soil with good bearing capacity (GBC).

significantly compacted down to 52 cm depth. John Deere and Rottne are very similar by the technical specification, but in stands where Rottne was used significant soil compaction is detected more than twice deeper in comparison to areas extracted by John Deere. Subsequent investigation explained this by considerably longer TC in stands extracted by Rottne, respectively more roundwood (25 m³ in each corridor) was transported in these TC; respectively 10 passes instead of 6 passes with John Deere. In case of Timbear, significantly compacted soil layer is comparably shallow, because this machine is on tracked chassis, therefore has a larger contacting surface area resulting in smaller pressure. The result conforms with some of earlier studies, for instance by Bredberg, 1976, who compared machines on wheels with bogie-track and machine on tracks chassis with larger contacting surface area. However, he also concluded that the number of passes is an important factor to consider when comparing different types of the machines. While the number of forwarding passes is growing, the difference between tracked and wheeled machines is decreasing. The study results highlight the potential risk of soil damages while working in areas characterized by good bearing capacity, where no visible soil damages (ruts) (Sutherland, 2003) usually can be detected and, therefore, operators and foresters are not concerned about soil protection measures during forwarding. To avoid potentially

harmful impact on soil, it is especially important in moderate and good conditions to establish strip-roads in a direction, which does not intercept with horizontal flow of groundwater to avoid accumulation of exceeding water, and to leave harvesting residues on TC to reduce the machine pressure on soil.

Figure 5 demonstrates soil compaction on TC in comparison with the control depending on the forwarder and a group of the soil bearing capacity at different soil layers. In case of John Deere 810E, the soil compaction and depth of compaction has reduced with an increase of the initial soil penetration resistance (bearing capacity). The level of compaction exceeding 20% in comparison to the control in soils with an average initial (control) penetration resistance of 0.5...1.0, 1.0...1.5 and 1.5...2.0 MPa is found down to 30 cm depth, whereas in the group of soils with initial soil penetration resistance of 2.0...2.5 MPa (GBC) it is observed only down to 10 cm depth. Although Rottne and John Deere forwarders are similar according to the technical specification, the results show a considerable difference between these machines. It is observed that soil compaction is decreasing with an increase of depth of the penetration on soils with smaller initial soil penetration resistance (0.5...1.0 MPa, WBC group of soils). Whereas if the initial soil penetration resistance is increasing (MBC and GBC group of soils), the tendency is different and down to a depth of 20 cm the level of soil

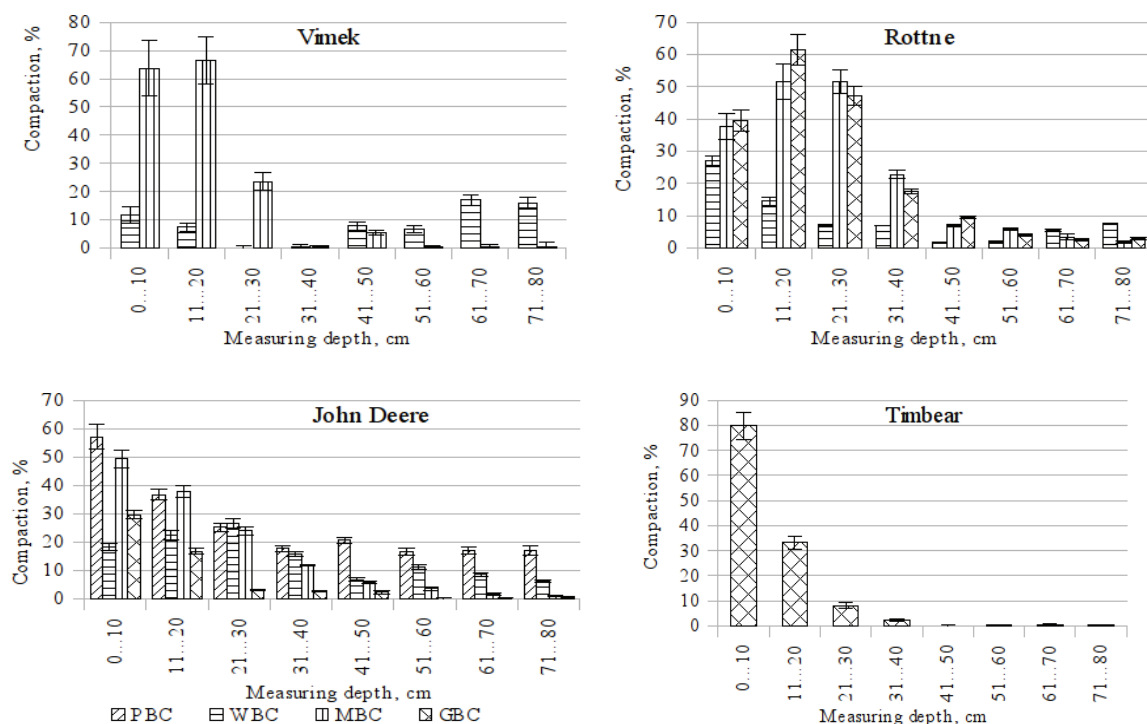


Figure 5. Soil compaction in comparison to control split by the forwarder and group of bearing capacity with standard error of mean.

compaction on TC increases, but in deeper soil layers it is decreasing. The soil compaction exceeding 20% in comparison to the control is observed down to 30 cm depth in the MBC group of soils and down to 10 cm depth in the WBC group.

In case of small-size forwarder Vimek 610, the most significant soil compaction is found in soils representing the MBC and WBC groups. Soil compaction exceeding the level of 20% in comparison to the control is found only in the MBC group of soils, while in the WBC group of soils it is not exceeding the level of 20 % throughout the whole depth of the measured soil layer.

There is relatively little data on Timbear forwarder. Only one type of conditions (GBC) is covered by the study. It is found that compaction exceeding the level of 20% in comparison to the control is not deeper than 20 cm and in contrast to other middle-size forwarders (John Deere and Rottne) the soil compaction is decreasing rapidly with an increase of depth of the measurement.

Soil compaction can be considered as a critical if the penetration resistance reaches 3 MPa. If the penetration resistance reaches this value, it means that roots of trees cannot penetrate the soil. However, the most important threat to future forest development, according to the recent studies, is not compaction itself, but the negative impact on horizontal flows of groundwater in soil (Lazdiņš, 2015). The level of soil compaction overreaching the critical value is found only in study sub-plots in the GBC group of soils, but it is found in both, the control and TC sub-plots. It should be noted that soil compaction due to off-road forwarding of roundwood usually has not significant influence on the development of roots in temperate climatic conditions. Researchers from different countries conclude that the main threat is disturbed horizontal flows of groundwater due to the soil compaction resulting in paludification of forests (Lousier, 1990; Malmer & Grip, 1990; Jim, 1993; Gebauer, 2012); however, empirical data on the influence in Latvia is limited.

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Conclusions

1. Statistically significant soil compaction ($p < 0.05$) down to 20 cm depth is found in the moderate bearing capacity and good bearing capacity groups of soils for all types of forwarders, whereas in the weak bearing capacity group of soils compaction exceeding 20% in comparison to the control is found for John Deere and Rottne forwarders down to 30 and 10 cm depth, respectively, but in case of Vimek the compaction of the weak bearing capacity group of soils is not detected.
2. Comparison of John Deere and Rottne forwarders highlights relationship between the number of passes and depth of compaction of soil and depth of significantly affected areas, but the study does not provide sufficient amount of data to evaluate this relationship for small-size forwarder and tracked forwarder.
3. Soil compaction due to the off-road forwarding of roundwood is found in all groups of soils, but areas with bigger soil penetration resistance are subjected to higher risk of the soil compaction than soils with smaller soil penetration resistance.
4. Tracked forwarder generates a relatively small impact located at a topsoil level, but the average impact at topsoil level is bigger in comparison to middle-size wheeled forwarders. The compaction of topsoil, which does not affect the growth of roots, should not be considered as negative impact, because according to the results of other studies it returns to initial status during several cycles of freezing.
5. The number of studies should be increased to evaluate the impact of compaction on horizontal groundwater flows; however, available information on the potential threats highlights need for careful planning of direction of technological corridors to avoid clogging of water flows in soil, and harvesting residues should be placed in TC to avoid compaction if there is risk of negative impact on water flows.

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SAPROPEL AS AN ADHESIVE: ASSESSMENT OF ESSENTIAL PROPERTIES

Vaira Obuka¹, Karlis Veitmans², Zane Vincevica-Gaile¹, Karina Stankevica¹, Maris Klavins¹¹University of Latvia²Latvia University of Agriculture

vaira_obuka@inbox.lv

Abstract

Recently, a renewed interest in non-harmful, environmentally friendly adhesives has ensued among the industry professionals, both environmental and healthcare scientists. In this study, organic rich lake sediments (sapropel) from two lakes located in Latgale Region of Latvia were used as a glue to investigate the potential use of such adhesive for manufacture of composite materials from wood. Sapropel is a valuable resource with multiple areas of application, e.g., agriculture, balneology. Available amount of sapropel in Latvia is estimated at up to 2 billion m³. Prior the tests, characterization of sapropel samples was done. Properties of the obtained composite material samples from wood and sapropel, as well as the mechanical properties were investigated. Tests involved the assessment of static bending strength and shear strength tests, durability according to their operating performance (D₁-D₄), as well as dried natural peat tensile strength perpendicular to the grain direction were determined and compared to the literature data; and the opportunities to use new composite materials in accordance with to the standards were discussed. The results of the study revealed an insight into possibilities to develop products of higher added value from sapropel as adhesive in combination with various resources. Results indicated that the samples made from Lake Pilvelis sapropel gain to better results of bending strength determination (parallel bending - 88.7 MPa). The aim of this study was to explore options to produce veneer using two kinds of sapropel as a glue and to determine the optimal properties according to the standards, as well as to characterize properties of the obtained composite material.

Key words: natural adhesive, sapropel, static bending strength, tensile strength, wood composite materials.

Introduction

Over the past century, there has been a dramatic increase in the growth of the material consumption; thus, the necessity for a wider use of local resources and available natural materials is among the priorities worldwide. Development of natural adhesives is a highly innovative research area, as the product range and the expansion of global consumption will also increase the adhesive consumption. The global market of adhesives was estimated to be 8 977 m³ in 2013, and it is expected to reach 12 392 m³ by 2020, growing at a CARG of 4.7% from 2014 to 2020 (Kattakota, 2015). At the world level, sectors of civil engineering and building construction consume 60% of raw materials extracted from the lithosphere; thereby, the construction sector is one of the largest consumption sectors of adhesives in the world. Due to the rising environmental and economic concerns, there is an acute need for natural glues made from materials of animal and plant origin containing, for example, proteins or starch as a binding agent (Bribián, Capilla, & Usón, 2011; Stefano *et al.*, 2009).

Most of the adhesives currently used contain toxic substances, pollute the environment and induce serious human and animal health risks. Major groups of glue are produced on a formaldehyde and vinyl basis, covering 92% of the overall adhesive consumption. Furthermore, formaldehyde adhesives are made from non-renewable resources. Accordingly, the wood composite industry currently has one of the challenges to look for possibilities of environmentally friendly adhesives derived from renewable resources (Yuan & Kaichang, 2006).

Sapropel is a partially renewable geological resource (Segliņš & Brangulis, 2002); it is a fine-grained organic-rich sediment or sedimentary rock and refers to inland waters of lacustrine environment (Emeis, 2009). Sapropel is a valuable resource of natural origin. It is estimated that available reserves of sapropel in Latvia amount to 700 – 800 million m³, and 1.5 billion m³ underlie the peat layer, but in total 2 billion m³ are deposited (Segliņš & Brangulis, 2002). Sapropel can be used in different economic fields such as agriculture, veterinary medicine, livestock farming, construction, medicine, balneology, and cosmetic applications. It is assessed that sapropel has adhesive properties with high ability to bind as well as a plasticity and shape holding ability (Obuka *et al.*, 2015). Therefore, it can be used as a binder for manufacturing of environmentally friendly materials. In this research, water repellence and adhesive properties are underlined as significant characteristics of sapropel (Brakšs *et al.*, 1960; Gružāns, 1960; Штин, 2005). The aim of this study was to explore options to produce veneer using two kinds of sapropel as a glue and to determine the optimal properties according to the standards, as well as to characterize properties of the obtained composite material.

Materials and Methods*Description of sapropel samples*

Organic rich freshwater sediments (sapropel) were extracted from the lakes and used as an adhesive material. Sapropel sediments were sampled from two lakes in Latvia – Lake Veveru and Lake Pilvelis, located in Rezekne District, Latgale Region.

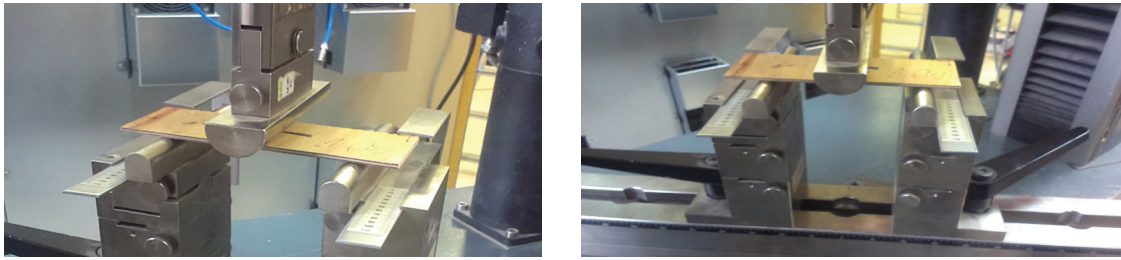


Figure 1. Veneer – sapropel static bending strength test.

Raw material of composites

Birch wood veneer with a thickness of 1.5 mm and moisture content of 6% was used for the preparation of plywood. Samples for determination of tensile shear strength: beech wood planks with a thickness of 5 mm and moisture content of 6% and with density 700 – 750 kg m³ were used for the preparation of composite material samples for the tests. Peat samples: dried natural peat was used for tests with the moisture content of 16.4% and with density 90 – 250 kg m³.

Loss on ignition

Loss on ignition (LOI) method was applied in order to estimate the content of carbonate matter, moisture content and the organic matter of sediments. Moisture content of sapropel was determined after drying at 105 ± 1 °C, following organic matter estimation at 550 °C for 4 h. The content of mineral substances was determined after heating at 900 °C for 2 h (Heiri, Lotter, & Lemcke, 2001). The content of dry matter was estimated after drying at 105 ± 1 °C according to standard EN 827.

Sample preparation and testing

Static bending strength (parallel and perpendicular to the grain direction), shear strength test according EN 314-1 (requirements) and EN 314-2 standards were tested (Figure 1). The sapropel samples were mixed completely just before the preparation of three-layer plywood of dimensions 4×250×250 mm. Glue spreading level for Lake Veveru sapropel was 276 – 290 g m² and 264 – 288 g m² for Lake Pilvelis sapropel. The plywood was pressed under the pressure of 2.0 MPa for 24 hours, at 100 °C for first 16 hours. The samples were stored for one day at temperature 20 ± 3 °C with 65 ± 5% relative humidity until reaching equilibrium moisture content. Subsequently, the plywood panel was cut into shear specimens with the dimension of 4×50×150 mm to determine its bending strength and 4×25×200 mm to define shear strength.

Adhesive strength of sapropel durability according to their operating performance conformity to EN 205 standard was measured. The sapropel samples were mixed completely just before the preparation of beech blanks fabrication of dimensions 10×75×600 mm.

Glue spreading for Lake Veveru sapropel and Lake Pilvelis sapropel was 290 – 310 g m². In addition to understanding the sapropel properties used as a glue, comparing to glue that already exists in market, the samples made with PVA - Polyvinyl acetate glue were used. The planks were pressed at 100 °C under the pressure of 1.0 MPa for 24 hours. The samples were stored for one day at 20 ± 3 °C with 65 ± 5% relative humidity until reaching equilibrium moisture content. Subsequently, the plywood panel was cut into shear specimens with the dimension of 10×20×150 mm to determine the tension shear strength.

Dried natural peat and sapropel as a glue were tested for tensile strength perpendicular to the grain direction according to standard EN 319. The sapropel samples were mixed completely just before the preparation of the samples of dimensions 32×50×50 mm. Glue spreading level was 1600 g m² for Lake Veveru and Lake Pilvelis sapropel. The driedpeat-sapropel samples were pressed under the pressure of 0.1 MPa for 48 hours. The samples were stored for one day at 20 ± 3 °C with 65 ± 5% relative humidity until reaching equilibrium moisture content. The material samples made from dried natural peat and sapropel were tested for tensile strength perpendicular to the grain direction.

After cooling specimens at ambient conditions, the test specimens were measured for the previously mentioned methods using Zwick Z100 universal testing machine. The data in this research were processed by routine statistical analysis and displayed by the standard deviation.

Results and Discussion

Within the study, an adhesive for veneer was made using two kinds of sapropel derived from Lake Pilvelis (cyanobacteria sapropel) and Lake Veveru (green algae sapropel). The following characteristics of the sapropel samples were determined: solid content, moisture, density, and dry ash content (Heiri *et al.*, 2001). Sapropel samples differ from one another in terms of moisture (%), organic matter content (%), amount of carbonates (%) and solid content (%). For example, the Lake Pilvelis sapropel sample contains 1.26% carbonates, its moisture is 85.97%, and the

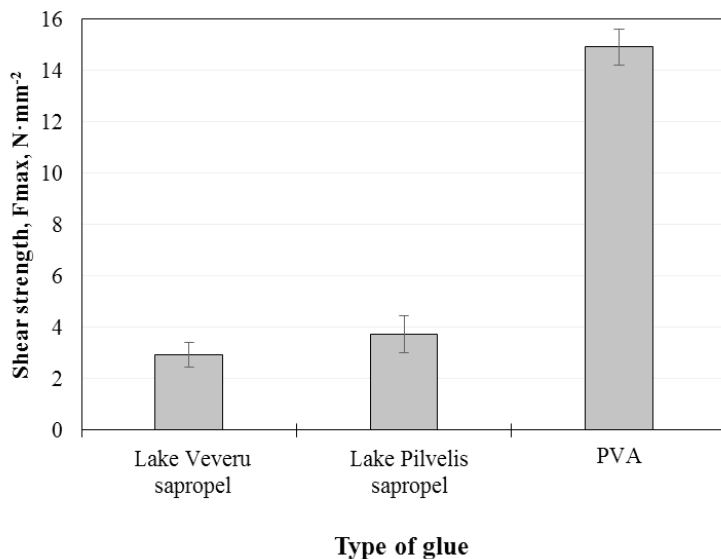


Figure 2. Durability test according to adhesive operating performance.

colour is dark greenish brown with homogeneous and jelly-like structure, with density 1.10 g cm^3 and solid content 30.1%. The moisture level of Lake Veveru sapropel sample is higher – 97.66%; it has lower density – 1.08 g cm^3 and the organic matter content reaches 86.25%, but solid content is 27.1%.

Adhesive strength of sapropel was tested by gluing veneer, plywood and natural dried peat. Several tests were performed: static bending strength (parallel and perpendicular to the grain direction) and shear strength testing, durability according to their operating performance dried natural peat (sapropel as a glue) tensile strength perpendicular to the grain direction. The total number of tested samples is 110.

Shear strength properties of wood composites bonded with Lake Pilvelis and Lake Veveru sapropel, as well as PVA (Polyvinyl acetate) glue was compared according to standard EN 205 (Figure 2).

As anticipated, the PVA bonded wood composites yielded the highest strength comparing to Lake Veveru and Lake Pilvelis sapropel samples. Comparing both sapropel samples, Lake Pilvelis sapropel showed a bit higher bonding strength by 28%. Compared to PVA, the dry strength of Lake Pilvelis sapropel used as an adhesive was about 4 times lower, respectively, while PVA-beech plywood sample achieved $15.11 \text{ N} \cdot \text{mm}^{-2}$, but Pilvelis beech test result was only $3.67 \text{ N} \cdot \text{mm}^{-2}$. In literature it is possible to find information about similar tests done with recovered sludge protein used as an adhesive (Pervaiz & Sain, 2011). If comparing in the article stated results with results of sapropel used as an adhesive in the current study, it is possible to say that shear strength properties are quite similar. Shear strength for recovered sludge protein used as an adhesive was about $2 \text{ N} \cdot \text{mm}^{-2}$ (Pervaiz & Sain, 2011).

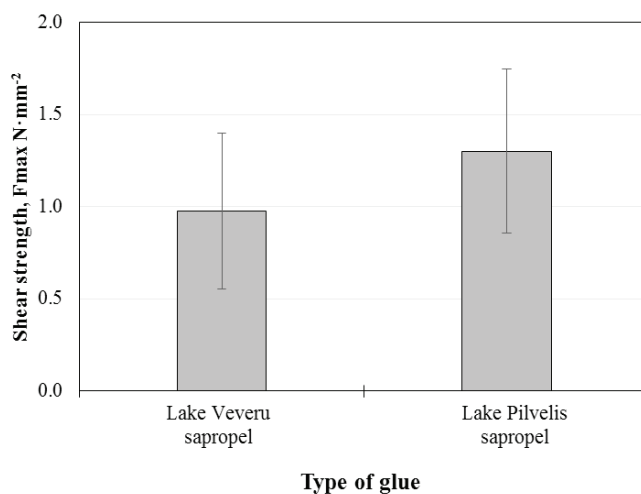


Figure 3. Plywood bonding quality using sapropel as a glue.

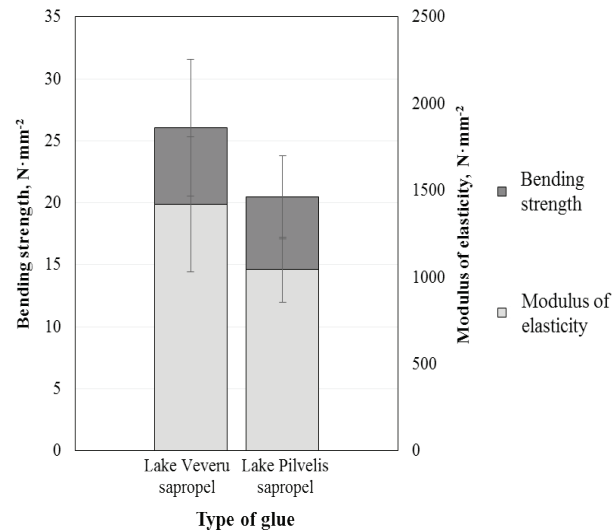


Figure 4. Bending strength parallel of plywood composites.

Bonding quality was determined according to the requirements of standard EN 314-1, the only exception was that samples were not treated in water. Two types of sapropel were tested (Figure 3).

Bonding quality test results using Lake Veверu sapropel showed shear strength F_{max} 0.98 ± 0.42 N·mm⁻², while using Lake Veверu sapropel F_{max} 1.30 ± 0.45 N·mm⁻². Results of samples made with Lake Pilvelis sapropel showed higher results by 33%. According to the requirements of standard EN 314-2 for plywood bonding, the quality of composite material must be at least 1 N·mm⁻², otherwise wood particles left on tested bond area have to be taken in consideration. All tested samples had 0% of wood particles. It was possible to state, that the sapropel as a glue was not penetrating into wood. Since the requirements of standard EN 314-1 were applied only for sample formation, it was not possible to find any comparison of other similar composite materials described in literature.

Values of elasticity modulus were estimated for specimens with plywood orientation parallel (Figure 4) and crosswise (Figure 5) to the specimen longitudinal direction. Modulus of elasticity and bending strength was done according to the requirements of standard EN 310.

Bending strength for Lake Veверu sapropel samples orientated parallel to the specimen longitudinal direction was 26.08 ± 5.50 N·mm⁻², modulus of elasticity 1419.80 ± 387.74 N·mm⁻². Bending strength for Lake Pilvelis sapropel samples orientated parallel to the specimen longitudinal direction was 20.47 ± 3.36 N·mm⁻², modulus of elasticity 1043.80 ± 187.70 N·mm⁻². Samples using Lake Veверu sapropel as an adhesive showed by 27% higher bending strength and by 36% higher modulus of elasticity.

Bending strength for Lake Veверu sapropel samples orientated crosswise to the specimen longitudinal direction was 88.55 ± 19.68 N·mm⁻², modulus of elasticity 16424.10 ± 2558.30 N·mm⁻². Bending strength for Lake Pilvelis sapropel samples orientated crosswise to the specimen longitudinal direction was 86.44 ± 11.79 N·mm⁻², modulus of elasticity 1043.80 ± 187.70 N·mm⁻². Samples using Lake Veверu sapropel as an adhesive showed by 2% higher bending strength and by 15% higher modulus of elasticity.

The results obtained from the bending strength parallel and crosswise to the grain direction of plywood composites revealed that the composites where Lake Veверu sapropel was used as an adhesive had better results among the analysed sapropel samples. According to the standard EN 636, it is possible to determine bending strength and bending modulus classes for plywood. Referencing to the standard EN 636, samples with Lake Veверu and Lake Pilvelis sapropel used as an adhesive corresponded to the class F10/40 E5/120.

In addition, tests according to the standard EN 319 were performed to detect dried natural peat and sapropel as a glue for tensile strength perpendicular to the grain direction. The results obtained were as follows: 0.077 MPa for Lake Pilvelis sapropel used as an adhesive, but for Lake Veверu sapropel used as an adhesive - 0.067 MPa. This test of dried natural peat and sapropel used as a glue for tensile strength test showed that the material strength (dried natural peat) is relatively lower; thus, the test results do not reveal the real properties of sapropel used as a glue. It is important to mention that the adhesive seam strength is higher than the material's ability to hold off the tensile test. High porosity is the reason of low mechanical strength of the derived dried peat composite material.

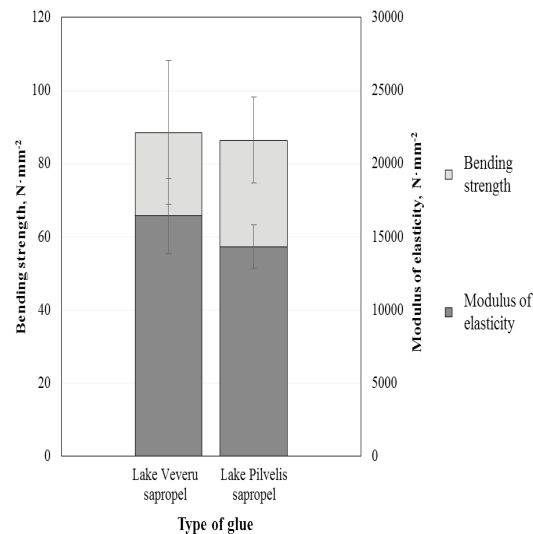


Figure 5. Bending strength crosswise of plywood composites.

As a further study area, the modification in adhesion strength of sapropel adhesives might incorporate biochemical modifications, such as enzymatic treatments, and the purification of crude proteins to the next level. Various different crosslinkers (Lei *et al.*, 2014), for example, epoxy resin (EPR), melamine-formaldehyde (MF) and their mixture EPR+MF, SPI (soy protein based glue) were used and compared in other studies. More promising possibility lies in mixing sapropel with other high strength adhesives such as PF, which can also improve water resistant characteristics of these bio-based glues.

Several reports have shown that secondary sludge (SS) from a kraft paper mill can be used as a source of biomass to recover protein and investigate its potential use as a wood adhesive. As mentioned in the literature review, other results are comparable to this research (Pervaiz & Sain, 2011), and the results of our study showed shear strengths of wood composites bonded with different adhesives, in this case secondary sludge, 1.0 MPa. Therefore, recovered sludge protein (RSP) adhesive showed two times better result than sapropel as a glue in this research.

Conclusions

Returning to the question posed at the beginning of this study, that it is a challenge to produce plywood from organic rich lake sediment (sapropel) applied as a glue, it is now possible to state that the first test results reveal that there is an opportunity to use sapropel as a potential adhesive, but there is a need

for further experiments. Performed tests indicated that higher adhesive properties can be attributed to Lake Pilvelis sapropel which is richer in solid content. Shear strength properties tests showed Lake Pilvelis samples possessing a higher bonding strength by 28%. Bonding quality test also showed higher results by 33%. It would be interesting to assess the effects of sapropel modification and after that to form new experiments with more detailed investigation. The present study confirms previous findings and offers additional evidence, which suggests that the granulometric composition of the material (size of particles), surface area and other characteristics of the material used as a glue, binder or filler have an effect on the binding with sapropel. The advantage of this study was a practical demonstration that sapropel can be used as an adhesive for plywood manufacturing. The research extends our knowledge of using natural materials and local resources, such as sapropel, as well as birch wood veneer, and it is possible to develop environmentally friendly composite materials for the construction industry, adjusting for the need of utilization in future.

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EVALUATION OF ECOSYSTEM SERVICES IN RIPARIAN FORESTS USING BENEFIT TRANSFER METHOD

Mārcis Saklaurs, Jānis Krūmiņš, Inga Straupe, Ilze Jēkabsons

Latvia University of Agriculture
marcis.saklaurs@llu.lv

Abstract

The aim of this paper is to evaluate ecosystem services in riparian forests of Latvia using benefit transfer method. The core of benefit-transfer method is to transfer economic costs from one economic situation to another by using pilot indicators, thus saving time and monetary resources of the research. This method also is applicable for transfer of value of ecosystem services to research territories where such values have not been set. As to the evaluation of ecosystem services in riparian forests, data derived from these indicators are compared with the situation in riparian forest stands. Successful application of this method depends on the quality of existing research and their transferability. For example, the data on research of non-timber values can be used to set these values in riparian forests. Value of ecosystem services for 1 ha riparian forest stand in Latvia judging by 1) N and P removal (N - 8.14 euro ha⁻¹ y⁻¹; P - 2.16 euro ha⁻¹ y⁻¹), 2) Valuing carbon capture (478.6 euro ha⁻¹ y⁻¹); 3) Valuing noise buffering (2.02 euro ha⁻¹ y⁻¹); 4) Valuing air purification (NO_x - 1332.5 euro ha⁻¹ y⁻¹, NH₃ - 216 euro ha⁻¹ y⁻¹, particulate matter - 792 euro ha⁻¹ y⁻¹); 5) Valuing pollination (timber - 15.25 euro ha⁻¹ y⁻¹, non-timber - 4 euro ha⁻¹ y⁻¹) total at 2850.67 euro ha⁻¹ y⁻¹, which is significantly more than just the traditionally viewed timber value.

Key words: benefit transfer, forest value, riparian forests, ecosystem services.

Introduction

With the EU Biodiversity Strategy the member states were called to map and assess the state of ecosystems and their services in their national territory by 2014, with the assistance of the European Commission. Member states also must assess the economic value of ecosystem services and promote the integration of these values into accounting and reporting systems at EU and national level by 2020. Due to the large scale of interest in the evaluation of ecosystem services, several member states e.g. Belgium, Italy, UK etc. already have assessed values of most important ecosystem services. However, in Latvia ecosystem services have not been widely valued yet. In this paper the evaluation of variable ecosystem services in riparian forests of Latvia has been done.

There are about 12 500 rivers and other types of water courses with the total length of about 37500 km in Latvia (Saklaurs *et al.*, 2015). Today the use and management of riparian forests is a topical issue for various target groups – forest owners, policy makers and general public. As riparian forests are a transit zone between water and terrestrial ecosystems, they provide several ecosystem services and products. There are different methods for evaluation of ecosystem services and one of the methods is the usage of benefit transfer method.

Benefit transfer involves economic values that may be either positive or negative. In the latter sense, the terminology refers to a process of transferring economic costs from one economic situation to another. “Benefit transfer uses economic information captured at one place and time to make inferences about the economic value of environmental goods and services at another place and time (Wilson & Hoehn,

2006)”. Using this approach, economic estimates are either transferred as monetary value units (e.g., means or medians) or as value functions conditioned on explanatory variables that define the attributes of an ecological and economic choice setting. Value functions may be estimated using different approaches: 1) original value data (Loomis, 1992), 2) estimated using the meta-analysis of summary value functions (Woodward & Wui, 2001), 3) derived from a process of econometric calibration as in structural benefit transfer (Smith, Van Houtven, & Pattanayak, 2002).

“The benefit transfer approach has spread steadily in the last few decades as decision makers have sought timely and low cost ways to assign monetary values to goods and services that are not commonly traded in the marketplace. Conducting original valuation research is time consuming and expensive (Wilson & Hoehn, 2006)”.

Applicability of the benefit transfer method has been used in the research of riparian forests. These forests are very diverse judging by several aspects: 1) borderline of 2 different ecosystems (water and forest); 2) these territories are very inconsistent as the forest stand, the vegetation, soils, hydrological regime, relief, biodiversity, and other factors often differ even within the sub-compartment level; 3) the territory is important for the society as it is used for several activities, for example, tourism, gathering berries and mushrooms, swimming, walking, a source of inspiration; 4) within the territory there are natural resources that the society is willing to use for acquisition of economic goods.

The aim of this research is to evaluate ecosystem services in riparian forests of Latvia using benefit transfer method.

Materials and Methods

Ecosystem Services can be subdivided into economic benefits (provisioning services), regeneration services (supporting services), stabilizing services and conservation services (regulating services), life-fulfilling or cultural services (Millennium Ecosystem Assessment, 2003; Saklaurs & Krumins, 2015).

For valuation of ecosystem services in riparian forests of Latvia the benefit transfer method is used where simplified quantification functions and indicator values from different international research are used. The benefit transfer method is used to estimate economic values for ecosystem services by transferring available information from studies already completed in another location and/or context. Thus, the basic goal of benefit transfer is to estimate benefits for one context by adapting an estimate of benefits from another context.

Steps for application of the benefit transfer method:

- Step 1: Identify existing studies or values that can be used for the transfer.
- Step 2: Decide whether the existing values are transferable.
- Step 3: Evaluate the quality of studies to be transferred. The better the quality of the initial study, the more accurate and useful the transferred value will be. This requires the professional judgment of the researcher.
- Step 4: Adjust the existing values to better reflect the values for the site under consideration, using whatever information is available and relevant.

In the research information from literature is transferred into practical quantification functions for the most relevant services of riparian forest in Latvia for which sufficient information is available. These are:

- 1) CO² capture (contribution to climate regulation),
- 2) N and P sequestration in forest biomass (contribution to water quality and climate regulation),
- 3) Improvement of air quality by capturing pollutants as PM10,
- 4) Noise mitigation by providing a buffer function,
- 5) Pollination.

The quantification of the service “water retention” (flood control) depends on too many factors for a simple quantification function, so it was left out of the scope of this research project.

In the data summary of N and P balance sheets, 26 data sources from hemi boreal zone with major part of research from Latvia, Estonia and Sweden were used.

Following methods have been used to approximate the values of ecological services that were transferred to the riparian forests of Latvia:

Valuing N and P removal - Damage Cost Avoided, Replacement Cost, and Substitute Cost Methods

- Valuing carbon capture - Market Price Method
- Valuing noise buffering - Contingent Valuation Method
- Valuing air purification - Damage Cost Avoided, Replacement Cost, and Substitute Cost Methods
- Valuing pollination - Market Price Method

Economic benefits (provisioning services) are expressed using the market value of said goods. Benefits of riparian forest are evaluated and monetized as non-timber values, timber, etc. Provisioning services hardly provide any benefits in areas where biodiversity is the primary objective. (Liekens et. al 2009; Liekens et. al 2010). Taking into consideration the research territories, the provisioning services were seen as insignificant for the scope of this paper.

Life-fulfilling services (cultural services) are expressed through: willingness to pay (WTP) and willingness to accept (WTA). Both of them are used to create a hypothetical market situation to assess people’s willingness to pay for non-use value provision, using the *contingent valuation* - CV (social surveys that include hypothetical scenarios with descriptions of alternatives such as WTP to improve an existing situation in order to enjoy wider benefits from ecosystem services) and *choice experiments* - CE (Turner et al., 2010). Surveys are used in ecosystem service assessment, using the above mentioned methods – CV and CE. During a survey the public attitude towards environment (i.e. riparian forests) is established. To deal with issues that are related to riparian forests and evaluate the associated risks, the public attitude to the various obligations that would promote improvement of environmental condition and means to fund the necessary improvement measures must be clarified (Saklaurs, 2015).

Revealed preference methods use the relation between ecosystem services and one or a few market goods, grounding this method on information on the behaviour of individuals and businesses in market where ecosystem services can be indirectly purchased (Turner et al., 2010). The most important estimation methods are: *production function method* (assumes that conservation of good environmental quality is an investment in future production of goods and services), *travel cost method* (studies the amount of financial and time-consuming travel costs that arise in order to use ecosystem services for recreation), *hedonic price method* (assessing the prices that people pay for goods that are related to ecosystem services, analysing information on prices in the housing market) and *defensive expenditure method* (focuses on data on human behaviour).

Conservation services are evaluated using data sets that may be gathered as a part of the valuation and

whose collection is not resource-demanding. During the field work, data on quality of the forest ecosystem are gathered, by describing the plant societies, forest stand and dead timber (Liepa *et al.*, unpublished). On the other hand, the stabilizing services (water and air purification, etc.) and partly regeneration services (permanence of carbon sequestration) are hard to evaluate for riparian forests without conducting costly and time-consuming additional research. Thus, the benefit transfer method is used for objective evaluation.

Results and Discussion

Valuing N and P removal

The methodology to assess N and P capture in riparian forests is to compare human-made water treatment plant operating costs and the amount of nutrients fixed by forest ecosystem. By analyzing the forests capabilities of accumulation of N and P, balance sheet calculations were made. They were based on ideas of Ranger and Turpault (1999), Malmaeus and Karlsson (2010) that the input \pm output nutrient budget is the simple algebraic balance between inputs and outputs of an ecosystem, based on a one year period.

By summarizing the N and P balance sheets with previously acquired data, the N and P removal in the territory of Latvia within forest ecosystems is 3.97 kg ha⁻¹ yr⁻¹ and 0.63 kg ha⁻¹ yr⁻¹. The operating costs of man-made water treatment plants (intended for 10000 people) are 2.12 euro kg⁻¹ for N and 3.44 euro/kg for P (Brambis & Laicāns, 2011). If we transfer these values to the forest of Latvia, we get that every year every 1 ha of forest land fixes N and P for 8.14 euro and 2.16 euro. If we scale it down to smaller settlements (500 inhabitants), the value of this ecosystem service increases considerably - 78.16 euro ha⁻¹ for N and 6.01 euro ha⁻¹ for P. Based on the rotation cycle of common birch – 71 years, the minimal value of N and P fixation is 577.94 euro for N and 153.36 euro for P. If we again scale it down to 500 people, the values are 5549.36 euro for N and 426.71 for P.

Valuing carbon capture

An ETS – sometimes referred to as a cap-and-trade system – caps the total level of greenhouse gas emissions and allows those industries with low emissions to sell their extra allowances to larger emitters. By creating supply and demand for emissions allowances, an ETS establishes a market price for greenhouse gas emissions. The cap helps ensure that the required emission reductions will take place to keep the emitters (in aggregate) within their pre-allocated carbon budget (World Bank, 2016).

Abadie and Chamorro (2008) made summary statistics for CO₂ emission allowances for 2006 – 2012 period of expiration. Results showed that in the

period of 2006 – 2007 from 430 observations CO₂ mean price was 11.15 +/-5.88 euro t⁻¹ and in period of 2008 – 2012 from 1325 observations CO₂ mean price was 18.63 +/-2.37.

Gorte (2009) proved that temperate forests, including the ones in Latvia, averages carbon stocks of 62 t C in biomass, 106 t C in soil, which put together is 168t ha⁻¹ C. but Watson *et al.* (2000) discovered that average carbon stocks are 96 t C in biomass and 122 t C in soil, which constitutes 217 t ha⁻¹ C in total. Watson *et al.* (2000) also proved that temperate forests average an uptake of 7.0 t of C ha⁻¹ y⁻¹. As 1 t C = 3.67 t CO₂, then temperate forests may accumulate 25.69 t of CO₂ ha⁻¹ y⁻¹. Regarding the fixed 25.69 t of CO₂ ha⁻¹ y⁻¹ and the established price range of 18.63 +/- 2.37 euro t⁻¹ CO₂, the forest of Latvia fixes CO₂ for the value of 478.6 +/- 60.8 euro y⁻¹.

Valuing noise buffering

Research (Dwyer *et al.*, 1992) shows that trees and shrubs significantly reduce noise. Wide belts of tall dense trees combined with soft ground surfaces can reduce apparent loudness by 50% or more. Cook and Haverbeke (1974) says that density, height, length and width of tree belts are the most effective factors in reducing noise rather than leaf size and branching characteristics.

Cook and Haverbeke (1974) tell that width of vegetation belts is a significant noise reduction factor. Greater width resulted in more trees on the acoustic pathway, producing greater absorption and diffusion. Nasiri *et al.* (2015) have found that on average a 20 m wide forest stand can reduce the noise level by 10.5 dB, but 100 m wide stand gives reduction of 14.4 dB.

Berglund, Lindvall and Schwela (1999) uses cost-benefit analysis for the assessment of noise pollution. The objective is to identify control actions that achieve the greatest net economic benefit. To determine the costs of control action, the abatement measures used to reduce noise pollution must be known. This is usually the case for direct measures at the source and these measures can be monetarized. Costs of action should include all costs of investment, operation and maintenance. As riparian forests already have a pre-existent noise buffer with vegetation - trees and bushes, then there is no need for special noise reduction actions.

For an average value of forested land in Latvia at 1000 euro ha⁻¹ (State land service of Latvia, 2013), excluding the timber value, if the property is purchased for housing purposes, then the noise reduction factor elevates the property value by 144 euro ha⁻¹, given that the forest stand is at least 100 m wide. Using as base the average rotational cycle of common birch (71 years) as the turnover time for the forest ecosystem and the width of forest stand at 100 m, authors of

this paper got the result that riparian forests in Latvia generate 2.02 euro ha⁻¹ y⁻¹ in noise reduction value.

Valuing air purification

Quite often air pollution contributes to global warming and significant impact to forest and water ecosystems and their services. European forests absorb approximately 10% of Europe's annual greenhouse gas emissions, according to the latest State of Europe's Forests report (Michalak, 2011).

Trees exchange gases with the atmosphere and capture particulates that can be harmful to people. Emission of pollutants impacts the air quality, chemical makeup of precipitation, deposition of chemicals in soil and water, as well as acidification (SO₂, NO_x, NH₃), eutrophication (NO_x, NH₃) and ground level ozone layer (NMGOS, NO_x) (LEGMC, 2016).

The improvement of air quality is monetized through the marginal damage cost, the cost of the damage caused by one extra unit of pollution. Knowing the extent to which an improvement of air quality reduces the damage to the human health or economy, it is possible to obtain information that can be used to value the service. Particulate matter, nitric monoxide and ground-level ozone are three most recognized substances harmful to human health (EEA, 2015). Liekens *et al.* (2009) made a connection between the capture of particulate matter by vegetation and the concentrations in ambient air that are at the basis of negative health effects. European research on health effects of particulate matter has developed indicator values regarding the capturing of particulate matter. Health effects - chronic mortality, morbidity (including chronic bronchitis and diseases of the lower airways (CAFE, 2001).

Liekens *et al.* (2009) has calculated the value for emissions of PM₁₀ for fireplaces (including households) at 36 euro kg⁻¹. Value of capturing fine dust = 0.84 x 36 euro kg⁻¹ = € 30 kg⁻¹ captured dust. Value of capturing particulate matter: 0.5 x 36 euro kg⁻¹ = 18 euro kg⁻¹ captured dust.

For the valuation of the capture of NO_x and also NH₃ authors of this paper rely on the estimation of external costs for the emission of 1 kg of NO_x. Adjusted for inflation it is 6.5 euro kg⁻¹. On the basis of weighting factors from the literature (aerosol formation factor), we can estimate the environmental damage costs. (De Leeuw, 2002; Van Steertegem, 2009). Because there is greater uncertainty about the NH₃ contribution to the effects on human health that can only be included in a sensitivity analysis.

Witteveen, van der Jagt and Tänzer (2006) estimates for capturing and/or effects on concentrations of NO₂, ozone and NH₃ are 205 kg ha⁻¹ of NO_x and 45 kg ha⁻¹ of NH₃ y⁻¹ in a forest. Witteveen *et al.*

(2006) estimates the capturing of particulate matter at 50 kg ha⁻¹ without underbrush and 100 kg ha⁻¹ with underbrush y⁻¹. In turn, Oosterbaan (2006) estimates 36 kg ha⁻¹ without underbrush and 44 kg ha⁻¹ with underbrush y⁻¹. Only in a few cases the riparian forest is without underbrush so the lowest estimated value was considered (44 kg ha⁻¹ y⁻¹).

Europe's sustained ground-level O₃ concentrations damage forests and plants by reducing their growth rates. O₃-induced growth reductions also result in an economic loss for forest owners. Karlsson (2005) has calculated that prevailing mean ozone exposure has the potential to reduce forest growth by 2.2% and the economic return of forest production by 2.6%.

Latvian forest statistics (VMD, 2016) states that the average volume of timber in a forest stand is 181.14 m³ ha⁻¹. According to LLC (2011), the average value of forest stand in Latvia is 1387 euro ha⁻¹ (with an interest rate of 4.25%). Accordingly, 1 ha of forest stand in Latvia loses 36.06 euro of its value y⁻¹ due to O₃-induced growth reductions.

Valuing pollination

There are very large gaps in the knowledge base on the economic value of pollination services especially in forestry (Hanley, Ellis, & Breeze, 2013). The pollination provides two-fold benefits for ecosystems of riparian forests: 1) natural pollination of vegetation; 2) natural genetic variation of pollinators. Most of the existing studies that evaluate the economic importance of pollination services focus on agriculture and the honey bee (Nabhan & Buchmann, 1997). Pollination and pollinator importance in the riparian forests is high due to the fact that many plant species can propagate only with insect interaction. And in case the pollinators disappeared, the entire ecosystem would collapse. (Kearns, Inouye, & Waser, 1998). Thus the pollination also has *Noneconomic Considerations*. For example pollinator-dependent plant communities help to bind the soil, reducing erosion that fouls creeks and impacts habitat for a wealth of aquatic life from salmon to mussels (ESA, 2016). Forested areas provide both forage and protection from excessive sun or wind for the main part of pollinators. Forest trees, especially deciduous forest trees, are excellent for shading beehives. Riparian buffer strips follow the contours of the stream or other watercourse they are protecting, and their multi-layered format (zone 1 - trees along the water, zone 2 - shrubs behind and upslope from the trees, zone 3 - native grasses behind and upslope from the shrubs) offers many opportunities for siting hives and/or providing bee forage. Riparian buffer strips will help ensure the health and survival of these "busy" workers (Hill, 1998).

Currently established approaches for pollination service value calculations are:

1) Proportion of total value attributed to insect pollination = annual production value x insect dependence factor (Losey & Vaughan, 2006; Liekens *et al.*, 2009; Hanley, Ellis, & Breeze, 2013)

2) Direct managed pollination value = hive rental cost (Burgett, Rucker, & Thurman, 2004)

3) Replacement value = (annual production value attributed to insect pollination) - (annual production value using pollinator replacement) (Allsopp, De Lange, & Veldtman, 2008)

The information available on direct effect of pollination in riparian forest of Latvia is limited. Subsequently in this case the “Proportion of total value attributed to insect pollination” method was used, supplementing it with annual production value and insect dependence factor. Liekens *et al.*, (2009) created a formula for determination of wild insect pollination value based on plant reliance of insect pollination (A) and plant dependence on pollination by insects (B) coefficients (from 0 to 1).

Wild insect pollination value: $D = C \times A \times (1-B)$, where

C = turnover (yield x sales value) (euro year⁻¹)

D = proportion of sales per plant that can be attributed to wild pollinators (euro year⁻¹).

For main economically important tree species, which are found in riparian forests of Latvia, birch (*Betula pendula*), Scots pine (*Pinus sylvestris*), Norway spruce (*Picea abies*), European aspen (*Populus tremula*), black alder (*Alnus glutinosa*) and grey alder (*Alnus incana*) the pollination mostly happens through abiotic factors, mainly wind, more seldom water. Thus insect dependence factor is 0.

Some species as small-leaved lime (*Tilia cordata*) and Norway maple (*Acer platanoides*) are pollinated by insects. Still as the small-leaved lime in forest biotopes mostly propagate through stump offshoots, the insect contribution is marginal. The flowers of Norway Maple are cross-pollinated primarily by bees, including honeybees, bumblebees, and Andrenid bees. From economically important tree species Norway maple and small-leaved lime together with less important species constitute 0.11% of total area (VMD, 2016), so insect dependence factor is set at 0.011.

Bilberry (*Vaccinium myrtillus*), lingonberry (*Vaccinium vitis-idaea*) and cranberry (*Oxycoccus palustris*), are economically important plant species that are found mainly in pine forest plant societies. Here the main pollinators are bees – Hymenoptera, Anthophila and many other types of insects (Rodríguez & Kouki, 2015). Thus we can conclude that insect dependence factor is 1.0 for dwarf shrubs. With an average value of forest stand in Latvia at 1387 euro (with interest rate of 4.25%) (LLC, 2011), pollination value for forest stand is 15.27 euro ha⁻¹ y⁻¹ using dependence factor of 0.011%. The commercial plants in Latvia are valued at 4 euro ha⁻¹ y⁻¹ and applying the dependence factor of 1, the pollination value is also 4 euro ha⁻¹.

Summary of values of ecosystem services for riparian forests in Latvia

The quantification functions and the indicators for valuation of ecosystem services for riparian forests in Latvia can be used on every decision scale, because the

Table 1

Summary of values of ecosystem services for riparian forests in Latvia

	Volume per ha	Value per volume	Total value, euro ha ⁻¹ y ⁻¹
<i>Nutrient removal</i>	kg ha ⁻¹ y ⁻¹	Euro kg ⁻¹	
N	3.97	2.12	8.14
P	0.63	3.44	2.16
<i>Carbon capture</i>	t ha ⁻¹ y ⁻¹	Euro t ⁻¹	
CO2	25.69	18.63	478.6
Noise buffering	-	-	2.02
<i>Air purification</i>	kg ha ⁻¹ y ⁻¹	euro kg ⁻¹	
NOx	205	6.5	1332.5
NH3	45	4.8	216
Particulate matter	44	18	792
<i>Pollination</i>			
Timber	-	-	15.25
Non-timber	-	-	4
		Total	2850.67

growth in a regulating service is relatively linear with the size of the area or the number of areas. The study presented in this paper definitely is not exhaustive. Further research will deliver new information on ecosystem services and specific ecosystems.

In Table 1 the summary of values of ecosystem services for riparian forests in Latvia is given.

This study reveals that in the riparian forests of Latvia timber itself is not a major benefit if we look at these forests from ecosystem service prospective. Riparian forests play an important role for such ecosystem services as air purification, carbon capture, pollination, etc. In near future forest management practices in Latvia should be revisited because forests provide multiple benefits for human welfare.

In this paper the presented quantification and valuation functions are built on the present knowledge and data availability. Described list of ecosystem services is not complete, because it was not possible to derive quantification functions for all the ecosystem services. They will be improved in the future when new scientific insights emerge and better data become available especially for use of riparian forests.

Conclusions

1. Benefit transfer method is applicable for transferring of value of ecosystem services to riparian forests

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in territories where such values have not been set and there is limited time and monetary resources. Additional research is needed to estimate the correctional values for riparian forests as these are very dynamic and diverse ecosystems.

2. The value of ecosystem services for riparian forests in Latvia for 1 ha forest stand consisting of 1) N and P removal; 2) carbon capture; 3) noise buffering; 4) air purification; 5) pollination totals at 2850.67 euro y⁻¹, which is significantly more than just the traditionally viewed timber value.
3. With the benefit transfer method the largest value of ecosystem services for riparian forests in Latvia accounts for air purification and is 1332.5 euro ha⁻¹ y⁻¹.
4. For valuation of such ecosystem services as “water retention” (flood control), it is necessary to conduct an interdisciplinary study by creating hydrological model for riparian forests.

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WOOD FIBER INSULATION MATERIAL**Karlis Veitmans, Uldis Grinfelds**

Latvia University of Agriculture

Latvian State Institute of Wood Chemistry

kaveit88@gmail.com

Abstract

As worldwide trends are changing gradually and sustainable resources economy and reduction of hazardous emissions are coming to the forefront, several industry sectors are forced to revalue their resource consumption. The main emphasis is currently placed on the recycling of by-products. One of the methods, definitely, includes burning of by-products to generate power, however it is not always the most efficient one. By-products must be used in the manner that ensures that they provide high added value for the operation of the company and are environmentally friendly. This research focuses on the use of the by-products of birch (*Betula*) veneer manufacturing, in order to obtain thermal insulation material. The following characteristics of the wood fiber insulation material were determined: thermal conductivity, water absorption, vapour permeability, and prototype reaction to fire. The characteristics of the obtained wood fiber thermal insulation material: thermal conductivity $0.038 \text{ W}\cdot\text{m}^{-1}\cdot\text{K}^{-1}$; water absorption $12 \text{ kg}\cdot\text{m}^{-2}$; the conformity of the material even to D fire reaction class was not determined. The principal conclusion: the wood fiber thermal insulation material conforms to the requirements set for thermal insulation materials.

Key words: use of by-products, wood fiber, cellulose fiber, thermal insulation.

Introduction

As the technologies develop and the range of possible solutions for improving the level of comfort increases, a steep surge in energy consumption has occurred. Climate change caused by the emissions of greenhouse gases is a topical problem that is currently faced by the European Union and the world. This problem is aggravated by the consumption of natural gas and oil resources.

The proportion of energy inefficient buildings in Latvia is still high. Buildings need to be insulated in order to save resources that have been used for the obtaining of thermal energy. A wide range of thermal insulation material is on offer nowadays, each of them having their own advantages and drawbacks. Only some of the offered thermal insulation materials are able to reach set requirements. Not only physical and mechanical indicators are significant for a contemporary consumer, but also the effect of the product on the environment. Manufacturing of thermal insulation materials could become one of the future challenges of Latvia's forestry industry. Forestry sector companies are investing in equipment to raise its efficiency and productivity. Unfortunately, the generation of by-products in the manufacturing process is inevitable. The companies of industry mainly use these by-products for the production of thermal energy or sell them to other companies. Export of these by-products is inefficient, since they are sold as low added value products. Further processing of by-products into thermal insulation materials is one of the solutions of increasing the income. The amount of exported woodchips and sawdust is 1,340,100 t (Ministry of Agriculture, 2014) in Latvia. Veneer manufacturing process is one of the leaders in the production of woodchips as a by-product. The type

and proportion of wood processing side materials in the manufacturing of birch veneer is as follows (Ministry of Agriculture, 2005): sawdust; cellulose woodchips 6%; fuel and technological woodchips 39%; bark 10%, veneer cut-offs; lathe dust. This paper will review the possibilities of the manufacturing of thermal insulation material from by-products of plywood manufacturing process.

Three types of thermal transfer are presented in nature: thermal conduction – spread of heat within a solid body, liquid or gas; convection - spread of heat within liquid or gas, where the heat is transferred by heated molecules of the environment; irradiation - spread of heat in the premises by means of infrared radiation. All three types of thermal conductivity are active simultaneously in nature, however, one of them always predominates. Thermal insulation materials are materials with high resistance to the heat transfer. Thermal insulation may consist of one material or a combination of several materials, which, if used and assembled correctly, reduces the flow of heat. Thermal insulation reduces the flow of heat in outdoors-indoors and indoors-outdoors direction as a result of high resistance to heat conductivity (Al-Homoud, 2004). Low thermal conductivity is the principal characteristic for thermal insulation material. Thermal conductivity is the time indicator of constant flow of heat (W) through a homogeneous material with the thickness of 1 m, in the direction that is perpendicular to isothermal sheets, which is caused by the temperature difference (K) within the sample. Thermal conductivity, (λ) is expressed as $\text{W}\cdot\text{m}^{-1}\cdot\text{K}^{-1}$ unit (Schiavoni *et al.*, 2016). Thermal conductivity directly depends on the temperature and moisture of the material. Thermal conductivity is the indicator of efficiency of any thermal insulation material. Thermal

resistance is the indicator of the resistance of the material to heat transfer by inhibiting conductivity, convection and radiation. Thermal resistance is directly dependent on the thermal conductivity, thickness and density. The unit of thermal resistance is $\text{m}^2 \cdot \text{K} \cdot \text{W}^{-1}$ (Al-Homoud, 2004).

Thermal insulation materials resist the flow of heat thanks to multiple microscopic cells containing immobile air, which inhibit the transfer of heat by preventing the flow of air. The immobile air contained within the thermal insulation material, not the material itself, ensures the resistance to the movement of heat. The structure of closed cells ensures the reduction in thermal radiation. Thermal insulation materials that are developed on the basis of air cell principle, cannot exceed the thermal conductivity of air. Thermal insulation materials can be classified differently, however, two principal types of classification are generally used: by principle of operation and by chemical origin. Classification according to the principle of operation distinguishes the following thermal insulation materials: convective, reflective and vacuum insulation materials. According to chemical origin the materials are classified into: inorganic and organic insulation materials. Most commonly used inorganic insulation materials are rock wool and glass wool. Thermal conductivity for rock wool $0.033 \text{ W} \cdot \text{m}^{-1} \cdot \text{K}^{-1}$ (Schiavoni *et al.*, 2016) and for glass wool $0.043 \text{ W} \cdot \text{m}^{-1} \cdot \text{K}^{-1}$ (Stazi *et al.*, 2014). Most commonly used organic insulation materials are expanded polystyrene – thermal conductivity $0.031 \text{ W} \cdot \text{m}^{-1} \cdot \text{K}^{-1}$, extruded polystyrene – thermal conductivity $0.032 \text{ W} \cdot \text{m}^{-1} \cdot \text{K}^{-1}$, polyurethane – thermal conductivity $0.022 \text{ W} \cdot \text{m}^{-1} \cdot \text{K}^{-1}$ and phenolic foam – thermal conductivity $0.018 \text{ W} \cdot \text{m}^{-1} \cdot \text{K}^{-1}$ (Schiavoni *et al.*, 2016). All inorganic and insulation materials that are based on fossil fuels share same common problem: the production of those insulation materials causes significant pollution to environment, especially energy consumption during production and there is no renewable materials used. Also during the disposal of these insulation materials there are problems with recycling at the end of use (Binici & Aksogan, 2016). A solution for pollution and sustainable environment management is the use of green organic insulation materials and use of recycled materials. Nowadays most commonly used green organic insulation material is cellulose fibre, it is an eco-friendly thermal insulation material made from recycled paper fibres, material has good thermal conductivity properties – $0.037 \text{ W} \cdot \text{m}^{-1} \cdot \text{K}^{-1}$ (Hurtado *et al.*, 2016). Similar insulation material is from wood fibres; usually it is produced from woodworking by-products such as wood chips, thermal conductivity – $0.038 \text{ W} \cdot \text{m}^{-1} \cdot \text{K}^{-1}$ (Geving, Lunde, & Holme, 2015a; Schiavoni *et al.*, 2016). It is possible to find information about other

similar insulation materials such as hemp, flax, sheep wool, cork and jute fiber - they all share approximately the same thermal conductivity – $0.038 \text{ W} \cdot \text{m}^{-1} \cdot \text{K}^{-1}$ (Schiavoni *et al.*, 2016). The most common problem for this type of insulation materials is reaction to fire; without adding adjuvants to insulation materials they do not exceed class E (Schiavoni *et al.*, 2016), it can be increased by using borax and boric acid as it is done while producing cellulose fiber insulation material (Hurtado *et al.*, 2016).

This study concentrates on wood fiber insulation material from birch plywood production by-products. In literature it is possible to find articles where are tested hygrothermal properties of wood fiber based materials and concluded, that wood fiber based materials in the dry state can be considered as thermal insulators (Vololonirina, Coutand, & Perrin, 2014). Other studies are about investigations of moisture conditions in wood frame walls with wood fiber insulation, where wood fiber insulation material, in free flow and batt form, is compared with glass wool in different conditions during 200 day period, and it is concluded that wood fiber insulation performed similar to glass wool (Geving, Lunde, & Holme, 2015b). In all studies wood fiber origin was soft wood. Information about the use of hardwood as wood fiber insulation material in other studies is limited, also information about using of plywood production by-products to produce insulation materials is very narrow. The objective of the research is to determine the suitability of by-products of plywood manufacturing for the production of a wood fiber thermal insulation material.

Materials and Methods

The preparation of wood fiber is one of the most important processes. The raw materials for the production of wood fiber are by-products of veneer manufacturing: 'tears' 70% and 'cores' 30%.

Tears are pieces of irregular shape and thickness (the maximum thickness does not exceed 2.5 mm), which are generated in the scoring process of the veneer logs. Cores are cylinder-shaped part of the veneer log and are generated at the end of veneer log scoring. The tears and cores were transformed into woodchips. Single-stage TMP (Thermo mechanical pulp) process was used to obtain wood fiber from woodchips. Parameters of defibration were: 145 °C temperature, steam pressure 0.4 MPa. In order to improve the properties of wood fiber as an insulation material, borax and boron were added. Borax - sodium tetraborate decahydrate $\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$. Borax was added to the material in order to improve its biological protection. Boric acid H_3BO_3 - is used as a fire retardant. Chemicals were added in amount of 12% (boric acid) and 7% (borax) of thermal insulation material. The application of wood fiber was performed in dry form,

by dividing them into categories by density. In order to determine the conformity of the tested material to the requirement for thermal insulation materials, it was compared to commercially available cellulose fiber thermal insulation material. Density groups of thermal insulation material samples were: $40 \text{ kg}\cdot\text{m}^{-3}$; $50 \text{ kg}\cdot\text{m}^{-3}$; $60 \text{ kg}\cdot\text{m}^{-3}$.

The study was conducted at the Latvia University of Agriculture and the Latvian State Institute of Wood Chemistry from 09.01.2012 to 04.01.2013.

Thermal conductivity

Thermal conductivity was determined in accordance to LVS EN 12667 standard using HFM 436 Lambda device. Three samples from each density groups were prepared according to the specification of the device.

Water absorption

Water absorption of thermal insulation material was determined in accordance to LVS EN 1609 standard. $200\times 200\times 100 \text{ mm}$ samples were prepared in order to perform tests. Considering the fact that the standard is applicable for thermal insulation materials of a sheet shape, it was adapted to the properties of bulk thermal insulation material. A surface box with the sieve (sieve opening diameter 4 mm) was prepared. The dimensions of the box were chosen to form samples according to the standard. The sample was embedded in the sieve box and submerged into water. Sample was removed from the tank after 24 hours and placed on a 45 degree sloped surface and kept there for 15 minutes. After the performance of these operations, the sample was weighed and its mass m_{24} was determined. Five samples of each density group of insulation materials were tested.

Vapour permeability

Vapour permeability was determined according to LVS EN 12086. Considering its applicability it was adjusted for bulk thermal insulation materials by preparing a specific tank. Glass vessels filled with the saturated solution of KCl (potassium chloride) were placed at the bottom of the tank. The samples for the test were prepared from a 100 mm diameter and 100 mm high pipe by attaching a glass fiber sieve at the bottom of the pipe, which helped to hold the bulk material. The vessel with P_2O_5 (phosphorus pentoxide) was placed under the pipe. Five samples of each density groups were weighed and placed in the tank. After 24 hours samples were removed and weighed. In order to determine vapour permeability, the mathematical calculation indicated in LVS EN 12086 is used.

Conformity of the material to fire reaction class

Sample of insulation material was prepared according to standard LVS EN 13823. To adapt standard requirements for bulk thermal insulation material, wires were used to hold the tested material. Data collected were analysed with an appropriate statistical software program.

MS Excel programme package was used in order to statistically process the obtained results using standard deviation, arithmetic mean value and method of descriptive statistics.

Results and Discussion

Thermal conductivity

Thermal conductivity is one of the most important properties of thermal insulation materials (TIM).

The numerical value of thermal conductivity quotient (TCQ) increases with the increase in the

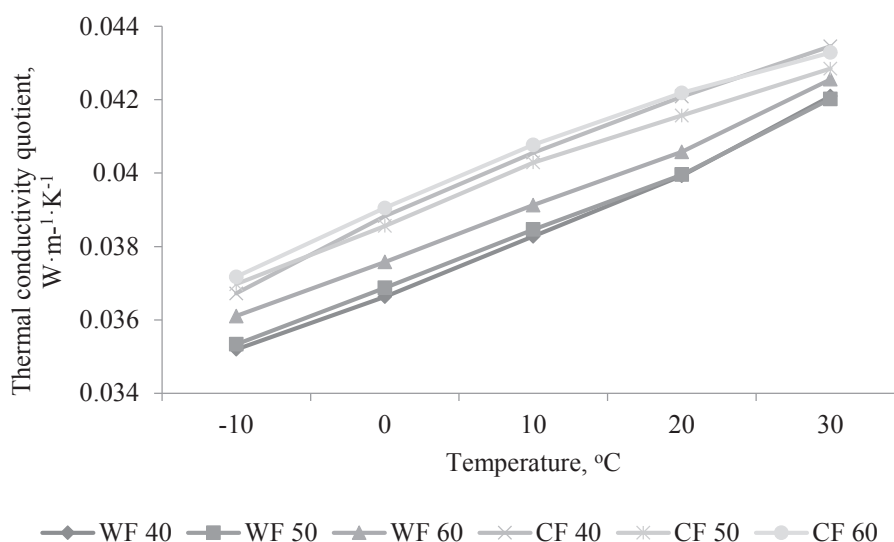


Figure 1. Thermal conductivity of thermal insulation materials depending on their density and temperature: WF – wood fiber; CF – cellulose fiber.

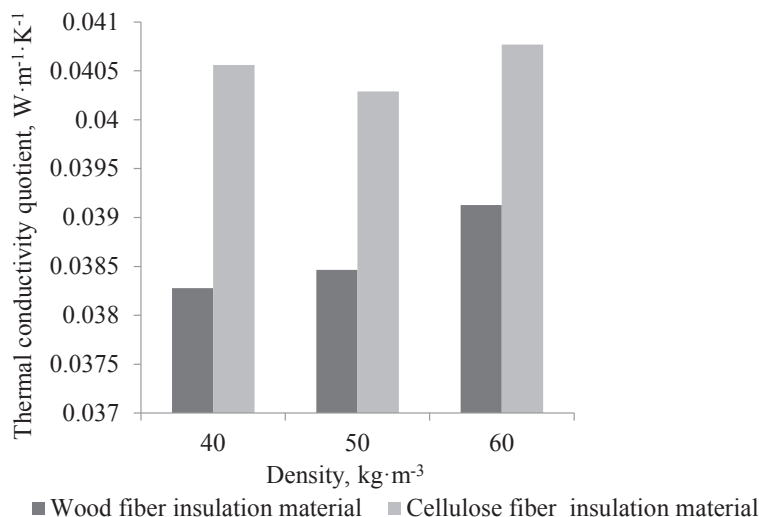


Figure 2. Comparison of thermal conductivity quotient by thermal insulation material.

temperature (Fig. 1). The increase in numerical value of TCQ of TIM points to deterioration of their properties, in this case, the higher the temperature, the larger the amount of heat that the TIM conducts. The TCQ for wood fiber TIM with the density of 40 kg·m⁻³ increases by 0.0069 W·m⁻¹·K⁻¹ or by 20%, if the temperature increases from -10 to +30 °C, respectively: at the density of 50 kg·m⁻³ it grows by 0.0067 W·m⁻¹·K⁻¹, or 19% and at 60 kg·m⁻³ – by 0.0064 W·m⁻¹·K⁻¹, or 18%. In a cellulose fiber TIM with the density of 40 kg·m⁻³ the TCQ increases by 0.0067 W·m⁻¹·K⁻¹ or by 18%, respectively: at the density of 50 kg·m⁻³ it grows by 0.0059 W·m⁻¹·K⁻¹, or 16% and at 60 kg·m⁻³ – by 0.0061 W·m⁻¹·K⁻¹, or 16%. The conclusion can be drawn that the higher is the density, the slower is the increase in TCQ as the percentage of the initial TCQ.

The comparison of TCQ of WF CIM by the density of application thereof allows the conclusion that the applied sample with the density of 60 kg·m⁻³ has a numerically higher value of TCQ. This means that excessive compacting of WF is inefficient because at a higher consumption of material the properties of thermal insulation material deteriorate. The comparison of TCQ of CF TIM by their density allows the conclusion that the embedded samples with the density of 40 and 60 kg·m⁻³ have a numerically higher value of TCQ. This means that too low, as well as too high compacting of applied CF in the TIM is inefficient.

The TCQ of a material is determined at the temperature of 10 °C. The comparison of both materials graphically (Fig. 2) demonstrates that the thermal conductivity of WF TIM is lower. In the density group of 40 kg·m⁻³ TCQ of WF is 0.0383 W·m⁻¹·K⁻¹, that of CF is 0.0406 W·m⁻¹·K⁻¹, which is by 6% higher. In the density group of 50 kg·m⁻³ the TCQ of WF is 0.0385 W·m⁻¹·K⁻¹, that of CF is 0.0403 W·

m⁻¹·K⁻¹, which is by 5% higher. In the density group of 60 kg·m⁻³ the TCQ of WF is 0.0391 W·m⁻¹·K⁻¹, that of CF is 0.0408 W·m⁻¹·K⁻¹, which is by 4% higher. It can be concluded that as the temperature increases, the thermal conductivity of both materials tends to be equalised, but at the temperature of 10 °C CF TIM has higher capacity to conduct heat. Determined values of thermal conductivity quotient of wood fiber insulation material are similar to organic thermal insulation materials 0.038 W·m⁻¹·K⁻¹ and similar to commonly used nonorganic insulation materials rock wool 0.033 W·m⁻¹·K⁻¹ (Schiavoni *et al.*, 2016) and glass wool 0.043 W·m⁻¹·K⁻¹ (Stazi *et al.*, 2014).

Water absorption

Upon mutual comparison of the differences in average values of water absorption (Fig. 3) of WF TIM and various densities of thermal insulation material application, it can be observed that water absorption for: (distribution marks represent standard deviation) WF 40 – 7.87±0.18 kg·m⁻²; WF 50 – 11.37 ± 0.05 kg·m⁻²; WF 60 – 16.37 ± 0.20 kg·m⁻²; CF 40 – 16.74 ± 0.23 kg·m⁻²; CF 50 – 23.60 ± 0.28 kg·m⁻²; CF 60 – 16.37 ± 0.51 kg·m⁻².

It can be observed that: WF 40 with WF 50 – material with the density of application of 50 kg·m⁻³ absorbs by 3.5 kg·m⁻² or 44% more water. Water absorption for: WF 40 – 7.87 ± 0.18 kg·m⁻²; WF 50 – 11.37 ± 0.05 kg·m⁻²; WF 60 – 16.37 ± 0.20 kg·m⁻²; CF 40 – 16.74 ± 0.23 kg·m⁻²; CF 50 – 23.60 ± 0.28 kg·m⁻²; CF 60 – 16.37 ± 0.51 kg·m⁻². WF 40 with WF 60 – material with the density of application of 60 kg·m⁻³ absorbs by 8.5 kg·m⁻² or 108% more water; WF 50 with WF 60 - material with the density of application of 60 kg·m⁻³ absorbs by 5 kg·m⁻² or 44% more water. Upon the comparison of WF TIM with CF TIM at similar densities of application, the average values

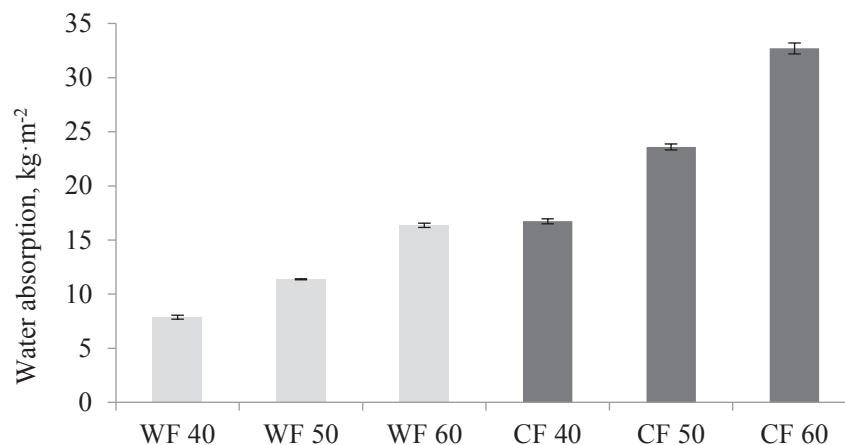


Figure 3. Summary of water absorption results:
WF – wood fiber; CF – cellulose fiber.

of water absorption results were: WF 40 with CF 40 – the water absorption of CF TIM with the density of $40 \text{ kg}\cdot\text{m}^{-3}$ is by $9 \text{ kg}\cdot\text{m}^{-2}$ or 113% higher than that of WF TIM of the same density; WF 50 with CF 50 – the water absorption of CF TIM with the density of $50 \text{ kg}\cdot\text{m}^{-3}$ is by $12 \text{ kg}\cdot\text{m}^{-2}$ or 108% higher than that of WF TIM of the same density; WF 60 with CF 60 – the water absorption of CF TIM with the density of $60 \text{ kg}\cdot\text{m}^{-3}$ is by $16 \text{ kg}\cdot\text{m}^{-2}$ or 100% higher than that of WF TIM of the same density.

Vapour permeability

Water vapour permeability (Fig. 4) shows the multiplication of the conducting capacity and thickness of the tested sample. Water vapour permeability is the property of material for homogeneous products.

It is equal to the amount of water vapour, which is transferred within a unit of time through a unit of area of the product, given the vapour pressure between the planes of the item and item thickness (Vulans, 2011).

Upon mutual comparison of WF 40 with WF 50 (distribution marks represent standard deviation) – the water vapour permeability of the material with the density of $40 \text{ kg}\cdot\text{m}^{-3}$ is by $0.06 \text{ mg}\cdot\text{h}\cdot\text{m}^{-1}\cdot\text{Pa}^{-1}$ or 24% higher; WF 40 with WF 60 – the water vapour permeability of the material with the density of $60 \text{ kg}\cdot\text{m}^{-3}$ is by $0.02 \text{ mg}\cdot\text{h}\cdot\text{m}^{-1}\cdot\text{Pa}^{-1}$ or 6% higher; WF 50 with WF 60 – the water vapour permeability of the material with the density of $60 \text{ kg}\cdot\text{m}^{-3}$ is by $0.08 \text{ mg}\cdot\text{h}\cdot\text{m}^{-1}\cdot\text{Pa}^{-1}$ or 32% higher. Upon mutual comparison of WF 40 with CF 40 – the water vapour permeability of the WF TIM with the density of

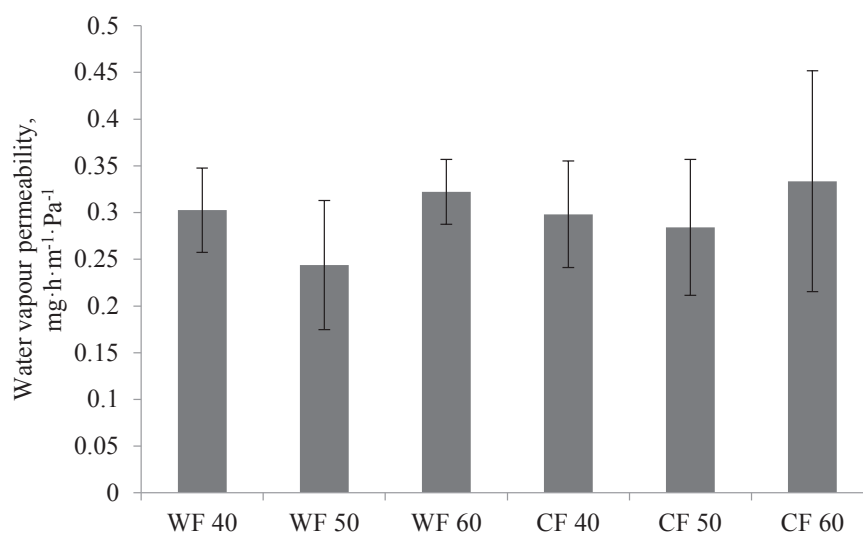


Figure 4. Water vapour permeability depending on density and insulation material:
WF – wood fiber; CF – cellulose fiber.

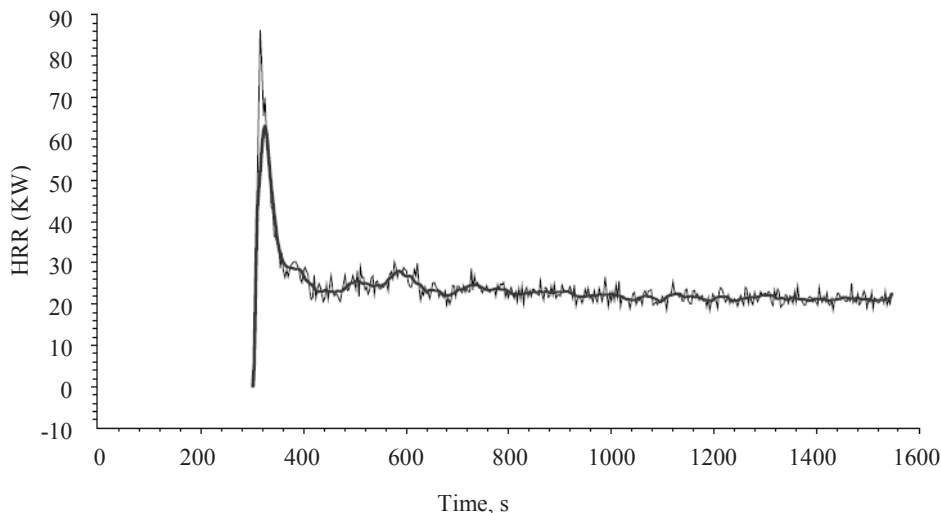


Figure 5. Changes in the heat release rate (HRR) of wood fiber thermal insulation material with time.

40 kg·m⁻³ is by 0.004 mg·h·m⁻¹·Pa⁻¹ or 1% higher; WF 50 with CF 50 – the water vapour permeability of the CF TIM with the density of 50 kg·m⁻³ is by 0.04 mg·h·m⁻¹·Pa⁻¹ or 17% higher; WF 60 with CF 60 – the water vapour permeability of the CF TIM with the density of 60 kg·m⁻³ is by 0.01 mg·h·m⁻¹·Pa⁻¹ or 4% higher. The conclusion can be made that samples in the density group of 50 kg·m⁻³ demonstrate lower water vapour permeability.

Fire reaction class

All construction products must have known fire reaction parameters, which determine the reaction of the material to flame exposure.

Fire reaction is the capacity of the material to catch fire, the speed of fire spread and combustion capacity. There are 7 fire reaction classes depending on the type of material, which are classified according to LVS EN 13501-1 standard. The dynamic change

of material combustion is characterised by the heat release rate for the wood fiber thermal insulation material (Fig. 5).

A rapid increase in the heat release rate is observed at the moment of catching flame. The maximum heat release rate is reached within approximately 30 s. After rapid increase in heat release rate a comparatively steep decrease in heat release rate is observed, and in the following phase of burning the heat release rate remains constant.

The speed of fire spread is characterised by fire growth rate (Fig. 6).

The most important parameter that characterises the burning of material and its influence on the overall development of fire is the total heat release (THR). Like heat release rate, the changes of FIGRA index demonstrate considerable increase at the beginning of the test, followed by rapid decrease. The total heat release THR increases gradually without steep peaks.

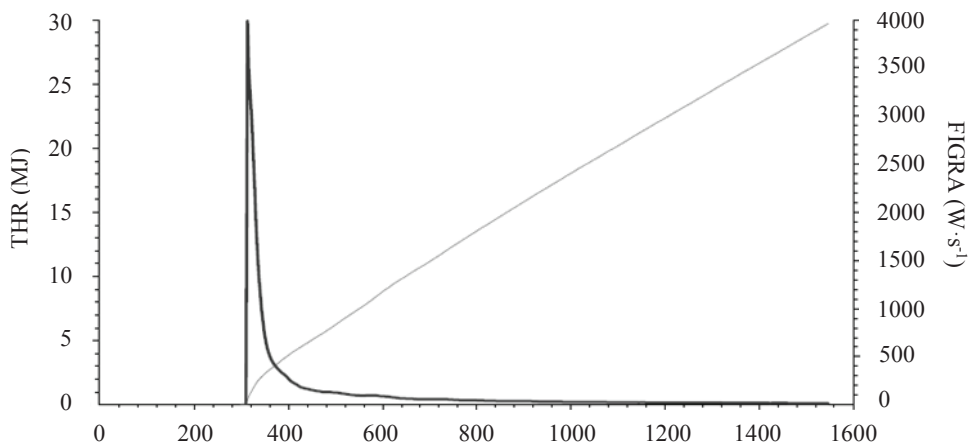


Figure 6. Changes in the fire growth rate (FIGRA) and total heat release (THR) with time: — FIGRA; - - - THR.

The rapid increase in the heat release rate (HRR) and fire growth rate (FIGRA) index and the following drop in these indicators can be explained by the high surface area of the insulation material, as the wood fiber creates a fluffy surface that rapidly catches fire, when it has burned off, the flame disappears. After the performance of this experiment, the conformity of wood fiber thermal insulation material to minimum requirements of D fire reaction class could not be confirmed.

The fact that natural settlement of the thermal insulation material was not researched can be mentioned among the weak points of the research, which could prove to be a significant problem, considering the structure of the insulation material. In order to increase the thermal reaction class, the permeating of the fibers with fire retardant and fungicide solutions can be performed in order to ensure better binding of the chemicals with the fiber, as a result of which a higher fire safety class could be reached.

Conclusions

1. Birch wood fiber can be used to obtain a high quality thermal insulation material, which can be applied by using the spraying technology and used for thermal insulation of private buildings.
2. Thermal conductivity quotient of wood fiber thermal insulation material with density: 40 kg·m⁻³ is 0.0383 W·m⁻¹·K⁻¹; 50 kg·m⁻³ is 0.0385 W·m⁻¹·K⁻¹; 60 kg·m⁻³ is 0.0391 W·m⁻¹·K⁻¹. Value

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of thermal conductivity quotient of wood fiber thermal insulation material is characteristic of organic thermal insulation materials and similar to commonly used nonorganic insulation materials - rock wool and glass wool.

3. Wood fiber thermal insulation material demonstrates high water absorption capacity of 7.87 ± 0.18 kg·m⁻² with density 40 kg·m⁻³; 11.37 ± 0.05 kg·m⁻² with density 50 kg·m⁻³; 16.37 ± 0.20 kg·m⁻² with density 60 kg·m⁻³, however, it is lower than that of cellulose fiber thermal insulation material.
4. During the fire reaction class determining experiment, the wood fiber thermal insulation material failed to demonstrate the conformity even to D class.
5. All parameters obtained during the experiments are directly dependent on the density of material application. The optimum density of wood fiber material application is 40 kg·m⁻³, both, in terms of economic use of wood fiber and technical thermal parameters.

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DYNAMICS OF RURAL AREAS DEVELOPMENT IN POLAND - CONVERGENCE ANALYSIS

Agnieszka Wojewódzka-Wiewiórska, Hanna Dudek

Warsaw University of Life Sciences, Poland

agnieszka_wojewodzka@sggw.pl; hanna_dudek@sggw.pl

Abstract

The article deals with the issue of rural development in Poland. The aim of the article is to determine the dynamics of change in the level of socio-economic development of rural communes in Poland (NUTS 5) in the years 2004 – 2014 through verification of the hypothesis of the existence of beta-convergence. The beta-convergence approach is verified by econometric modelling techniques. The statistical data came from the Local Data Bank (LDB) of the Central Statistical Office (CSO). Based on the analysis of changes in the development level of the rural areas in Poland it was stated that there is convergence. However, the strength of the convergence process is different depending on the dimensions of development. It reported a strong relationship between the average growth rate of aggregate indicators relating to the financial dimension. In other dimensions, such as labour market, living conditions, health and social care, education, demography and culture, it showed the occurrence of slow convergence processes.

Key words: development of rural areas, diagnostic variables, beta-convergence, Poland.

Introduction

The course of socio-economic development in Poland is characterized by spatial differentiation, which can be seen both across regions and districts. Taking into consideration the level of development, we usually distinguish a better developed western part of the country ('Poland A') and the less developed eastern part ('Poland B'), and this distinction is considered to be relatively stable (OECD, 2008; Hryniewicz, 2010). The existence of disparities in the levels of development is a characteristic feature not only of Poland but also of many other European countries (Bański, 2009), especially developing ones. There are many reasons for this and it is worthwhile presenting some of the causes which are specific only to Poland. Among these causes are historical conditioning factors, that is to say subdivisions of Poland's territory dating back at least to the time of the partitions of Poland in the 18th century, the period of centrally planned economy after the Second World War, the effects of system transformation of 1989 and its social and economic consequences (Wilkin, 1999; Bański, 2003; Grosse, 2004). Other important factors included changes in the administrative division of the country¹ and the effective development policy pursued by the authorities of the particular regions (NUTS 2) and local government units (NUTS 4 and 5) (Grosse, 2004; Strzelecki, 2008). The above-mentioned factors were extremely important in shaping the course of development processes.

A detailed discussion about the level of economic development in Poland reveals clear-cut differences between the central part of the country (Mazowieckie Voivodship with Poland's capital Warsaw) and other regions, as well as the disparity between the development level of rural areas, and that of the remaining areas (Grosse, 2004; Rosner & Stanny, 2014). The causes of disparities observed in rural areas are a resultant of multiple economic, social, political and cultural phenomena and they are often determined, like in the case of other areas, by historical heritage (Rosner, 2007). Rural areas are extremely important since they cover the vast part of the country: according to the classification of the Central Statistical Office of Poland (CSO), they occupy 93 percent of the area inhabited by 40 percent of Poland's population (CSO, 2014)².

Studies on differentiation of the level of socio-economic development which have been conducted in Poland, including the study of rural areas, show that the differentiation that already exists today tends to deepen, which can especially be observed in the administrative regions, i. e. in voivodships (Stanny & Drygas, 2010). Thus, the question arises whether there is convergence in socio-economic development of rural areas, that is to say whether the relatively less developed areas grow faster than the remaining ones, which leads to decreasing differences and allows the particular areas to reach a similar level.

1 Nowadays in Poland there exists a three-level administrative division, introduced on 1 January 1999. The largest units are voivodeships (there are 16 voivodeships), the second-level units are counties (380), and the smallest units are communes (2479). There are three types of communes (NUTS 5): urban (12%), rural (63%) and mixed (urban-rural) – 25%.

2 Both in Poland and in the EU, there is no universal definition of rural areas (Rakowska & Wojewódzka-Wiewiórska, 2010; Rakowska, 2013), and many criteria are used to classify these areas (Duczowska-Małysz, 1998; Wieliczko, 2006). The most common method for distinguishing rural areas is definitely the classification used by the Central Statistical Office of Poland according to which rural areas are rural communes and rural parts in urban-rural communes. The Office collects statistical data for these units, which results in the fact that this approach is very frequently used in government documents and in scientific research. Due to a very limited availability of the data regarding the rural part in urban-rural communes, the present study comprises rural areas which are understood as rural communes.

The purpose of the paper is to determine the dynamics of change in the level of socio-economic development of rural communes in Poland in the years 2004 – 2014 through verification of the hypothesis of the existence of convergence. In order to achieve this goal, econometric methods were used in the present study.

Materials and Methods

The level of socio-economic development of 1565 rural communes and its temporal changes were determined using a development index (S). The data were taken from the Local Data Bank (LDB) of the Central Statistical Office (CSO) of Poland and they covered the years 2004 – 2014. The level of development of the communes was determined

Table 1

Set of variables selected to determine the socio-economic development level of rural communes in Poland

Symbol	Variable name and dimension	Character of variable
Public finances/ Wages and incomes of the population		
x ₁₁	Own commune budget revenues per capita in PLN	Stimulant
x ₁₂	Capital commune budget expenditures per capita in PLN	Stimulant
x ₁₃	Total commune budget expenditures per capita in PLN	Stimulant
x ₁₄	Total commune budget revenues per capita in PLN	Stimulant
Labour market		
x ₂₁	Employment rate within the working-age population	Stimulant
x ₂₂	Number of enterprises per 1000 inhabitants	Stimulant
x ₂₃	Percentage of registered unemployed in the population of working-age	De-stimulant
x ₂₄	Employed persons per 1000 inhabitants	Stimulant
x ₂₅	Percentage of the working-age population in the total population (actual place of residence)	Stimulant
Living conditions		
x ₃₁	Persons using water supply system in % of total population	Stimulant
x ₃₂	Persons using sewage system in % of total population	Stimulant
x ₃₃	Persons using gas in % of total population	Stimulant
x ₃₄	Length of the water supply network in km per 1 km ²	Stimulant
x ₃₅	Length of the sewerage network in km per 1 km ²	Stimulant
x ₃₆	Average useful floor area per 1 person	Stimulant
x ₃₇	Number of dwellings per 1000 population	Stimulant
x ₃₈	Number of dwellings with a central heating (in % of the total of inhabited dwellings)	Stimulant
x ₃₉	Number of dwellings with a bathroom (in % of the total of inhabited dwellings)	Stimulant
Health and social care		
x ₄₁	Death rate (number of deaths per year per 1000 people)	De-stimulant
x ₄₂	Number of health centers per 1000 inhabitants	Stimulant
x ₄₃	Number of pharmacies per 1000 population	Stimulant
Education		
x ₅₁	Number of local councillors with higher education in relation to the total number of councillors	Stimulant
x ₅₂	Number of primary schools pupils per 1000 inhabitants	Stimulant
x ₅₃	Number of lower secondary schools pupils per 1000 inhabitants	Stimulant
Demography		
x ₆₁	Population per 1 km ²	Stimulant
x ₆₂	Natural increase per 1000 population	Stimulant
Culture		
x ₇₁	Number of library users per year per 1000 persons	Stimulant

in several stages. First, diagnostic variables were chosen to describe the development level using meritorical, formal and statistical criteria (Strahl, 2006; Wojewódzka, 2007; Zeliaś, 2000; Sej-Kolasa & Zielińska, 2002; Famulska & Znanięcka, 2004). The limitation of the number of variables chosen on the basis of meritorical criteria was the result of the specificity of the Polish public statistical system (including the Local Data Bank), which does not collect some of the data at the level of communes, in which data is incomplete or it is lacking in some years, which makes it impossible to compare some data during the period under review. This study fills the gap in the literature of the subject in the field of a real course of development processes in rural areas in the context of convergence at a local level (Guzal-Dec & Zwolinska-Ligaj, 2012; Kołodziejczyk 2014), especially in view of transformation which took place following Poland's accession to the EU in 2004.

Taking into consideration the formal criteria, the study took into account diagnostic variables which are measurable, universal, high quality, interpretable, complete and available. Variables were grouped into particular categories comprising a definite dimension of development.

Ultimately, on the basis of the methodology presented in the paper twenty-seven variables were chosen from the set of potential indices characterizing the development of rural communes and they were subdivided into seven spheres of development (Table 1).

A set of diagnostic variables contains variables having different directions of influence on the analysed phenomenon. Stimulants are variables, high values of which indicate that a given object (commune) is superior from the point of view of rural development. The opposite holds true for de-stimulants, that is, high values justify classifying an object as being inferior (Dudek & Krawiec, 2007). Two diagnostic variables are recognized as de-stimulants while the remaining ones— as stimulants.

Based on the statistical criteria, to assess the variability of potential diagnostic features (variables) one can use the coefficients of variation. It is commonly required that the variability of the feature should be greater than 10%. Variables that do not meet this condition do not have sufficient discriminant ability. Afterwards, excessively correlated variables should be eliminated, since they carry a similar informational value. For this purpose one can apply the Hellwig's parametric method of variable selection (Hellwig, 1968).

The next step includes the calculation of aggregate indicators encompassing variables from a given

dimension. Thus, in order to ensure comparability of the final diagnostic variables, normalization of the data is required (Zeliaś, 2002). This means, among others, that it is necessary to strip variables of their natural units, through which diagnostic characteristics are expressed. Normalization is conducted according to the following formulas (Kukuła & Bogocz, 2014; Chrzanowska & Drejerska, 2016):

$$z_{kji} = \frac{x_{kji} - \min(x_{kji})}{\max(x_{kji}) - \min(x_{kji})} \quad (1)$$

and

$$z_{kji} = \frac{\max(x_{kji}) - x_{kji}}{\max(x_{kji}) - \min(x_{kji})} \quad (2)$$

for stimulants and de-stimulants respectively, where:

x_{kji} – value of j -th diagnostic variable in k -th dimension for i -th object (commune), $i = 1, 2, \dots, 1565$,
 $\min(x_{kji})$ – minimum value of j -th diagnostic variable X_j in k -th group (dimension), $k = 1, 2, \dots, 7$
 $\max(x_{kji})$ – maximum value of j -th diagnostic variable X_j in k -th dimension.

The aggregate synthetic indicator is calculated as the arithmetic mean of normalised variables according to formula:

$$S_{ki} = \frac{1}{L_k} \sum_{j=1}^{L_k} z_{kji} \quad (3)$$

where:

L_k – number of variables in k -th group (dimension), $k = 1, 2, \dots, 7$,
 z_{kji} – value of j -th normalised variable in k -th dimension for i -th object (commune), $i = 1, 2, \dots, 1565$.

The values of aggregate indicators range from 0 to 1, wherein the higher the value of indicator S_{ki} , the higher the level of development of a given i -th object (commune) in k -th dimension.

In the final step of the statistical analysis, convergence phenomenon in each group (sphere) is examined. There are many approaches to testing the occurrence of this phenomenon. The most common concept of convergence is beta-convergence. This concept has been widely employed in the literature on economic growth.

Beta-convergence occurs when less developed economies tend to grow faster than more developed ones³. It involves estimating the following regression model (Próchniak & Rapacki, 2009):

3 The methods applied in the study were derived from the theory of economic growth and are used mainly in modeling GDP *per capita* (Wójcik, 2008). However, in recent years they have been successfully used in the empirical analysis to verify the convergence of the level of development and the standard of living (Mazumdar, 2002; Dudek, 2014; Jordá & Sarabia, 2015).

$$\frac{1}{T}(\ln S_{kiT} - \ln S_{ki1}) = \alpha + \beta \ln S_{ki1} + \varepsilon_i \quad (4)$$

where:

S_{kit} – value of k -th aggregate indicator S_k for i -th object (commune) and t -th year, $t=1$ or T ,

$(\ln(S_{kiT}) - \ln(S_{ki1}))/T$ – average growth rate of indicator S_k ,

ε_i – error term with finite variance σ^2 and mean equal zero,

α and β are the parameters to be estimated,

i indicates object and k – number of dimensions (in our analysis $i=1, 2, \dots, 1565$ and $k=7$).

Beta-convergence occurs when the average growth rate of an indicator depends negatively on its prior value⁴. It holds when parameter β in regression (4) is significantly negative.

Results and Discussion

Taking into account the statistical criteria, the following four diagnostic variables were excluded from the study:

percentage of the working-age population in the total population, total commune budget expenditures per capita in PLN, total commune budget revenues per capita in PLN and the number of dwellings with a bathroom (in % of the total of inhabited dwellings). The final set of diagnostic variables encompasses 23 diagnostic variables. All these variables are normalised according to formulas (1) and (2) and aggregated into synthetic indicators for each of the 7 groups (spheres) using method (3). Their higher values indicate the higher the level of socio-economic development of the rural communes. Aggregate indicators enable us to examine whether the convergence phenomenon occurs in each dimension.

For each of the seven aggregate synthetic indicators beta-convergence models (4) are estimated.

The results of the econometric analysis are presented in Table 2.

On the basis of information given in Table 2, one may record beta-convergence in all seven dimensions. Estimates of regression parameters β in all models built for every dimension are significantly negative. It means that the growth rates of each aggregate indicator depend upon its initial level, and they are inversely correlated. It should be noted that the strongest relationship refers to the first dimension (financial dimension). This relationship is displayed in Figure 1.

The results for the financial dimension indicate that the catching-up process takes place, i.e. poorer communes improved their situation faster than the richer ones. In the case of the other dimensions of the relationships between the average growth rate in the years 2004 – 2014 and their level in 2004 are much weaker. The slope of the regression ranges from -0.016 (for health and social care dimension) to -0.031 (for culture dimension). It indicates a slow convergence process in these areas. Moreover, low values of the R-squared coefficient inform us about heterogeneity of rural communes in these areas. The extreme example is the estimated model for aggregate indicator S_5 (educational dimension) with R-squared below 0.10 (see Figure 2).

Figure 2 shows that many data points fall further from the regression line resulting in high absolute values of residuals and leading to low R-square. Such a situation is caused by a great diversity of rural communes in Poland. Perhaps the division of the communes into more homogeneous groups or/and inclusion of other explanatory variables which influence economic growth would provide more precise results. A deeper insight into convergence processes could also be achieved by using panel data. It should be noted however that, as seen from Figure 2

Table 2

Regression results of beta-convergence for aggregate indicators of socio-economic development

Dimension		Estimates		
Number	Name	α	β	R^2
1	Public finances/ Wages and incomes of the population	-0.270*	-0.080*	0.686
2	Labour market	-0.021*	-0.020*	0.127
3	Living conditions	-0.011*	-0.019*	0.195
4	Health and social care	-0.013*	-0.016*	0.165
5	Education	-0.049*	-0.029*	0.086
6	Demography	-0.024*	-0.029*	0.255
7	Culture	-0.038*	-0.031*	0.166

Note: asterisk * indicates significance at 0.01.

4 When growth is related to the initial level of the indicator only (other variables do not play significant roles at all), convergence is said to be unconditional or absolute.

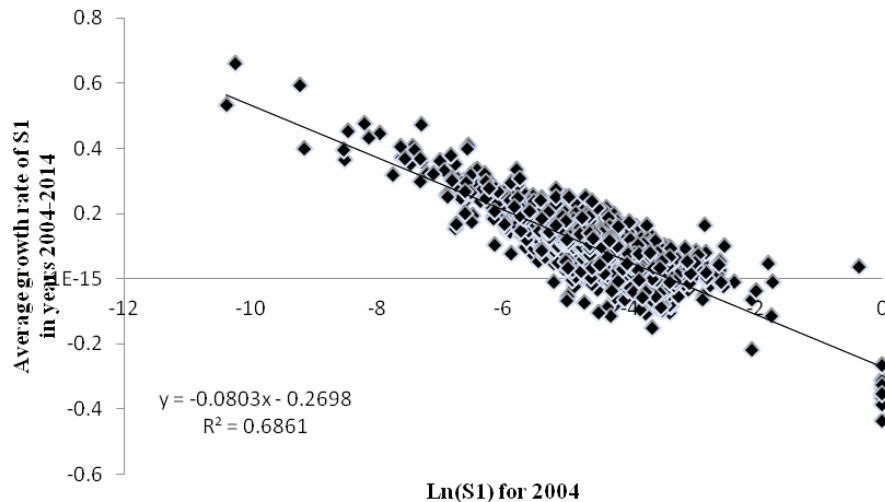


Figure 1. Results of regression analysis for S_1 (financial dimension).

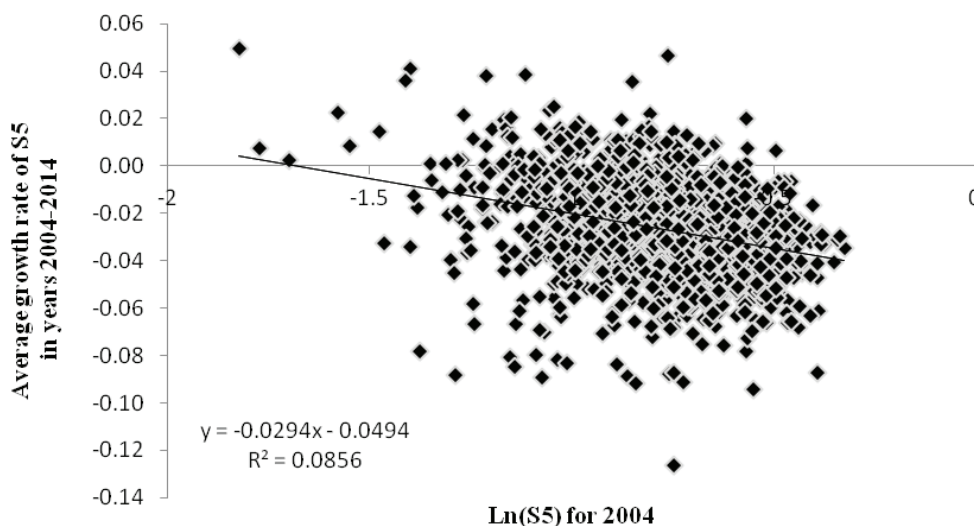


Figure 2. Results of regression analysis for S_2 (educational dimension).

and Table 2, the slope of regression line is significantly negative and therefore there is a beta-convergence among rural communes in the time period 2004 – 2014.

The results confirm the conclusions from research of other authors, namely, that rural areas in Poland are clearly differentiated in terms of the level and dynamics of socio-economic development (Rosner, 2007; Rosner & Stanny, 2014). It turned out that apart from the existing spatial differences they relate to the various spheres of development.

Conclusions

Convergence is defined as the tendency for the levels of a some chosen indicators to equalise over time. This phenomenon has been rarely analysed in the context of the rural development at a local level, thus this study hopes to fill this gap to some extent. The paper presents an empirical application

of the concepts of beta-convergence to examine the convergence of socio-economic development between rural communes in the period from 2004 through 2014. The results are as follows:

1. On the basis of this study the occurrence of the process of beta-convergence in the development of rural communes was found.
2. Research results revealed a moderately strong relationship between the average growth rate of aggregate indicator referring to the financial dimension and its levels in 2004.
3. As regards the remaining dimensions considering labour market, living conditions, health and social care, education, demography and culture, the occurrence was found of slow convergence processes.
4. Due to of the heterogeneity of rural communes it would be interesting to carry out in-depth research taking into account the specificities of regions and

determinants of rural development. Such analyses should be conducted in the future research.

The level of rural development is essential from an economic and social viewpoint, thus monitoring

changes in this area is an important aspect in the framework of cohesion policy.

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ANALYSIS OF TURKISH TRADITIONAL FOOD REGARDING E-BUSINESS AND E-MARKETING

Coskun Serefoglu

Ankara Development Agency, Turkey
cserefoglu@gmail.com

Abstract

Turkish traditional food producers are mainly subsistence and semi-subsistence farmers who have a limited marketing knowledge. They thus encounter a significant number of problems during the supply chain due to the lack of capital, awareness and equipment, as well as underutilized resources and insufficient rural infrastructure. They are also not actively encouraged by the policies implemented at the regional level. The majority of the food reaches consumers either directly (the less common purchases from the farmer) or via a number of intermediaries. If the current volume of traditional food is compared with the past production volume, it can be clearly seen that there is a sharp decrease in the production in contrast to the rapidly increasing population. This study aims to find willingness of Turkish consumers to pay for a MarketMaker website – an electronic trading platform of traditional products in Turkey. The estimations rely on data collected from 157 persons covering all regions in Turkey through an online survey in August, 2015. The average willingness to pay (WTP) annually was found to be about 32 Turkish Liras (TRY) for all observations including zero bids and TRY 164 excluding zero bids. The results of the probit model show that age, marital status and shopping in traditional food markets were identified by the model to have a significant impact on the probability of WTP.

Key words: E-marketing, e-trading, traditional food, WTP, MarketMaker.

Introduction

As of 2004, E-business becomes ‘just business’ since the positive cash flow and plateau of profitability move positively (Roveredo, 2015; Strauss, El-Ansary, & Frost, 2006). However, online shopping for food or groceries is not as common as for electronics and clothing. According to TÜBİSAD (2014), the rate of people using online shopping is 87% in England, with Germany and Japan following with 79% and 77%, respectively. Turkey is lagging behind with 24%. The average rate of online retail is 5.5% for the developed countries while 3.5% for the developing ones. Online retail in Turkey is only 1.3% (TÜBİSAD, 2014).

The CVM (Contingent Valuation Method) is called ‘contingent’ valuation as the information is used on how people think they would be willing to pay in certain hypothetical situations that are contingent on being in the actual situation (Whitehead & Blomquist, 2001). Cummings, Brookshire & Schulze (1986) considered that the CVM has some advantages. First, it has a relatively more information with respect to data on the characteristics of respondents and second, it uses primary data rather than secondary data which are created for different purposes. Lastly, the CV methodology may have the highest validity when the hypothetical scenario is similar to a familiar market choice situation as in a model that we will build. Thus, our research is basically based on the CVM. There are not too many studies in literature to measure WTP on traditional food marketing through e-trade. However, many studies are focusing on e-commerce applications and payment models in agriculture. Kuboye and Ogunjobi (2013) and Thielepean and Soundararajan

(2014) studied the marketing of agricultural products by developing a secured web application in Nigerian market and Indian market, respectively. Concerning e-marketing of producers, Carpio *et al.* (2013) measured the willingness to pay for MarketMaker agricultural products of U.S. producers. Zapata *et al.* (2013) employed contingent valuation method in order to find producers’ willingness to pay for the services provided by MarketMaker respondents. From the consumers’ perspective, Schneider and Ceritoglu (2010) analysed the relationship between WTP and images of food products in Turkey. Jekanowski, Williams and Schiek (2000) researched if the quality perceptions play an essential role for food purchase decisions.

This study estimates Turkish citizens’ willingness to pay (WTP) for establishing a MarketMaker website – an electronic trading platform of traditional products in Turkey. These estimates rely on data collected from 157 persons covering all regions in Turkey through an online survey in August, 2015. 32.4% (32) of respondents indicate that they are willing to pay for an electronic platform to be established. The average WTP annually was found to be about TRY 32¹ for all observations including zero bids and TRY 164 excluding zero bids. The results of the probit model show that age, marital status and shopping from traditional food markets were identified by the model to have a significant impact on the probability of WTP.

The paper is divided into five sections. Following the introduction, methodology is covered in section 2. The third section basically explains the development

¹ TRY 1 equals roughly € 0.3

of traditional food in Turkey. Results and discussions appear in section four and the final section ends with a short conclusion.

Materials and Methods

Determining Sample Size

The sample size is defined by considering the current Turkish population and calculated according to the formula provided by Fink (2003);

$$n = \frac{N}{(1 + N * p^2)} \tag{1}$$

Where n is the sample size determined, N is the population size, p is the level of precision. Although the sample size is estimated as 96 at 90% confidence level and a 5% margin of error, 162 samples were collected during the August 2015. The estimations finally were made with 157 samples after five samples were trimmed due to the implausible extreme values regarding payment provided by respondents.

Survey and Data Generation

Before the survey was shared with respondents via online survey, preliminary feedback was obtained from five Turkish consumers by using the face-to-face interview method in order to see the likely challenges that the respondents might have. Upon completing the pre-tests with the Turkish consumers, the link to the online survey was widely distributed through the social networks such as Facebook, LinkedIn and consumer forums in between 1-31 August, 2015. The survey mainly comprised three parts. The first part covered the questions to elicit perceptions which are related to Internet and E-trade. WTP questions were included in the second part and in the last part; they focussed on the personal profile questions. The scenario is built around the consumers that are provided with a detailed information about Food MarketMaker created in the

United States and asked them whether or not they would be willing to pay for the creation of a similar platform in Turkey. The dependent and independent variables can be seen in Table 1. As clearly seen in the table, the dependent variable is willingness to pay for an electronic platform to be established while some of the independent variables are income, education, age, trust in products and shopping in the traditional product markets. A question, referring to the consumer willingness to pay for a virtual marketplace where they can purchase traditional products was asked and the subsequent question comes with how much they would be willing to pay for it.

Regression Models of the CVM

Probit and logit which are known as non-linear functions of unknown coefficients in literature are widely applied in binary choice models. Though both models may give similar results, there are slight differences because of the tail of observations. Amemiya (1981) expressed the opinion that the samples with heavier tails are more appropriate for logit models. A similar stance was made by Cakmakyapan and Goktas (2013). They observed that logit model is generally preferred for large sample sizes (500 and 1000) and probit model is usually for smaller sample sizes. So, probit model will ultimately be employed for estimations because of the sample size. Alternatively, tobit model will be applied to measure WTP amounts that are obtained through single bounded dichotomous questions since the endogenous variable includes zero values.

Probit Model

The Probit model is defined by Wooldridge (2006) as $Z_n = X_n\beta + u$. Where β is a vector of parameters including the intercept term; x_n is a vector of covariates; u is the error term which either has the standard logistic distribution or the standard normal distribution. In either case, u is symmetrically

Table 1

Variables and Definitions

Variables	Definition
Willingness to pay	1=willing to pay for electronic trade platform; 0=unwilling to pay
Income	monthly
Age	individual
Trust	1=People find traditional products reliable; 0=People find traditional products unreliable
Marital Status	1=Married people; 0=Single
Shopping from traditional product markets	1=Visiting/Shopping markets; 0=Never visiting/shopping

distributed around zero. Z_n is the unobservable amount that respondents are willing to pay for the establishment of a MarketMaker platform.

WTP_i is the observed dichotomous variable stating whether the individual pays or not. It can be defined as follow:

$$WTP_n = 0 \text{ if } WTP_n^* \leq 0; \tag{2}$$

$$WTP_n = 1 \text{ if } WTP_n^* > 0 \tag{3}$$

As it is indicated by Wooldridge (2006), the main goal in binary responses is to explain the effects of x on the response that follows the probability $P(y=1|x)$.

$$P(WTP=1|x) = P(WTP_n^* > 0|x) = P[e^{-(\beta_0 + x\beta)}] = 1 - G[-(\beta_0 + x\beta)] = G(\beta_0 + x\beta). \tag{4}$$

The direction of the effect of x_j on $E(WTP^*|x) = \beta_0 + x\beta$ and $E(WTP|x) = P(y=1|x) = G(\beta_0 + x\beta)$ is similar to each other. $\tag{5}$

on $E(WTP|x) = P(y=1|x) = G(\beta_0 + x\beta)$ is similar to each other. $\tag{6}$

It is not possible to apply OLS due to the non-linear nature of $E(y|x)$. Maximum likelihood methods thus must be used in order to estimate the limited dependent variable models. The maximum likelihood can be written as follows (Wooldridge, 2006):

$$f(WTP|xi;\beta) = [G(xi\beta)]^y [1-G(xi\beta)]^{1-y}, \text{ WTP}=0,1 \tag{7}$$

It can be seen that when $y=1$ results in $G(x, \beta)$ and when $y=0$, we get $1 - G(xi\beta)$. The function of log likelihood for observation is a function of the parameters and the data (xi, yi)

$$li(\beta) = WTP_i \log[G(xi\beta)] + (1-WTP_i) \log[1-G(xi\beta)]. \tag{8}$$

Tobit Model

The general formulation of the Tobit model can be expressed in the following way (Greene, 2000; Wooldridge, 2006):

$$WTP_n^* = X_i\beta + u_i; \tag{9}$$

$$WTP = 0 \text{ if } WTP_n^* \leq 0; \tag{10}$$

$$WTP = WTP^* \text{ if } WTP_n^* > 0. \tag{11}$$

$$E[WTP_n^*|x_n\beta] \text{ is } x_n\beta. \tag{12}$$

Where the n th individual, X_n is a vector of explanatory variables, u_i is a random disturbance term, and β is a parameter vector common for each

individual. By assuming that the random error is independent and normally distributed among respondents, the expected WTP for an observation drawn at random from the population is

$$E[WTP|x_n] = \phi(X_n\beta/\sigma) + x_n\beta + \sigma\lambda_n \tag{13}$$

$$\text{Where } \phi(X_n\beta/\sigma)/\Phi(X_n\beta/\sigma); \tag{14}$$

Where ϕ represents the normal distribution function and σ represents the standard deviation. Moreover, the expected value of WTP for observations above zero, which will be called $E(WTP^*)$, is simply $X\beta$ plus the expected value of the truncated normal error terms. The expected WTP can be expressed as

$$E(WTP) = \phi(X\beta/\sigma)E(WTP^*). \tag{15}$$

Wooldridge (2006) points out that the function of the tobit model which is based on maximum likelihood estimation can be shown as;

$$\ln L(\beta, \sigma) = \sum_{i=1}^N WTP_n(WTP_n=0) \ln [1-G(x_n\beta/\sigma)] + (WTP_n>0) \ln \{ (1/\sigma) g[(WTP_n - x_n\beta)/\sigma] \}. \tag{16}$$

Where $G(\cdot)$ is the standard normal cumulative distribution function; $g(\cdot)$ is the standard normal density function; and σ refers to the standard deviation of the error term. By maximising the log-likelihood function, the Tobit estimator $\hat{\beta}$ is obtained.

The Development of Traditional Food in Turkey

Grabum (1997) describes the tradition as ‘it was the name given to those cultural features which, in situations of change, were to be continued to be handed on, thought about, preserved and not lost’. EU defines traditional food products as a result of agricultural practices that preserve and enhance rural environments. Another definition made by Vanhonacker *et al.* (2008) is that ‘A traditional food product is a product frequently consumed or associated to specific celebrations and/or seasons, normally transmitted from one generation to another, made with care in a specific way according to the gastronomic heritage, with little or no processing/manipulation, that is distinguished and known because of its sensory properties and associated to a certain local area, region or country’. Although there is not a consensus for definition of traditional foods in the world, it can be defined that traditional foods are based on the historic methods of preparing and preserving foods varied from generation to generation, culture to culture, and climate to climate. Industrialization is mainly seen as a serious threat which affects traditional food negatively.

The main regulatory body in Turkey is the Ministry of Food, Agriculture and Livestock which encourages the traditional foods. The rich spectrum of artisanal products as well as traditional food is a great opportunity for Turkey which reflects different cultures, each with their own, often distinctive, dietary traditions. The main weakness is considered to be the low level of education of labour force. Pesticide use and reaching to raw material are seen as a threat to the development of traditional foods (Kalkınma Bakanlığı, 2014). A specific report on Food products and Security prepared by the Ministry of Development put some targets for the development of local/traditional foods. Target 9.1. refers to production and marketing of local/traditional foods, by protecting product diversification, under an appropriate branch according to the food safety standards. Another target 9.2. points out incentives on the market research for foreign demand, which might be given by the public institutions and NGOs such as chambers of industry and trade (Kalkınma Bakanlığı, 2014).

In Turkey, the traditional foods are more and more attracting the interest of consumers and manufacturers who have concerns about their health with industrial food, the organic structure of which is believed to expose people to changes through external factors, such as some chemical ingredients. But the markets of local/traditional food leave much to be desired. Moreover, there is a growing gap between the local producers and consumers in Turkey since they cannot market what they produce due to the lack of niche markets and financial problems while there is always a great demand for it from consumers. Sayılı & Büyükköroğlu (2013) stated that 62.6% of Turkish consumers do not prefer to use e-marketing for food products since they mainly find food products distrustful. So, having a GI of a product makes it considerably easier to sell a local product through e-marketing in local or international markets where people feel mistrustful. Similarly, Tsekouropoulos *et al.* (2011) found that e-marketing of food and drink accelerates the increase of their sales as they attract

customers not only locally to shops but also in the e-shops on the internet.

Results and Discussion

The estimations hinge on data collected from 157 persons covering all regions in Turkey through an online survey in August, 2015. 32.4% (32) of respondents indicate that they are willing to pay for an electronic platform to be established while 68% (125) are unwilling to pay. When the question of ‘why you are unwilling to pay for an electronic platform’ was asked, the respondents stated that this type of investment should be established by the Government rather than citizens. Another important fact about shopping of traditional products on internet is the factor of trust. Only 1% of the respondents state that the traditional products being marketed over internet are genuine while the rest find it distrustful or they have a neutral attitude.

Descriptive statistics for the sample are reported in Table 2. Concerning gender and age, 59.24% (93) of the 157 respondents, which were considered in the study, are males, and 40.76% (64) are females, which represents all of Turkey. It is also shown that 52.23% (82) of the surveyed respondents are 18 – 30 years old, followed by individuals aged 31 – 45 and 46 – 64, representing 43.95% (69) and 3.82% (6) of the sample, respectively. The educational attainment of the respondents is in favour of the higher level of education, 58.60% (92) acquired a bachelor degree followed by 30.57% (48) of post graduate degree. When comparing the above figures with the data of TURKSTAT as in Table 4, our sample has higher income and education levels, and a higher percentage of males.

Regarding the working status, more than half of the respondents (52.87%) are employed in the public sector, while 21.02% and 4.46% of the respondents work in the private sector and are self-employed, respectively. The income level of respondents shows that the sample consists of people with middle and higher income. Respondents from low, medium and

Table 2

Comparison of sample

Sociodemographics	Sample	Turkey's Population*
Female (%)	41	49.8
Household Size	3.3	3.6
Graduates (%)	58.6	12
Median Income	3.4	1838
Median Age	30.4	31

*Elaborated from data extracted from TURKSTAT.

Table 3

Probit model

Variable	Coefficient	Standard error	Marginal effect	Standard error
Constant	-0.721568	0.7301442		
Age	*-0.4632444	0.2604197	*-0.1163926	0.0636254
Working condition	-0.033488	0.0530874	-0.008414	0.0133228
Education level	-0.260484	0.2539027	-0.065448	0.063388
Marital status	0.4643098**	0.2214218	0.1166603**	0.053348
Purchasing traditional food from Internet	0.3111675	0.3751962	0.0781824	0.0937737
Shopping from traditional food markets	0.8044376***	0.2748356	0.2021191***	0.064848
Income	-0.2448574	0.2617282	-0.0615217	0.06532
***Indicates significance at 1% level, **at 5% level, *at 10%				

high income level consisted of roughly 15.29%, 19.11% and 41.40%, respectively. The average size of the household of sample was found 3.3, whereas the average household of Turkish population is 3.6 as shown in Table 2.

With regard to the basic preferences stated by Turkish consumers for e-commerce of traditional food, the survey results showed that approximately 61% of respondents disagree about the reliability of traditional food selling in the market or website. A similar stance comes from Sayılı and Büyükköroğlu (2013) who found that 62.6% of Turkish consumers do not prefer to use e-marketing for food products since they mainly find food products distrustful. A question of 'the most important three factors for consumers' purchasing of traditional products' was asked to those shopping for traditional food, approximately 55% of the respondents indicate healthier choice while 48% go for it since they find traditional food more natural.

The respondents overwhelmingly say Yes to the question asking if the consumers take into account the brand of the product they purchase. More than 82% of respondents state that they do shopping on Internet and 52.5% of them bought/ordered electronic equipment and clothes and sports goods on the Internet while only 7.4% bought/ordered food or groceries.

The relationship of independent variables with dependent variable 'willingness to pay for a MarketMaker' was analysed. According to the results, the respondents who found traditional products in the market unreliable are willing to pay more than those who found it reliable. Shopping via internet plays an essential role for willingness to pay. The respondents actively shopping on Internet are more willing to pay than those who do not shop there. Another interesting result comes from shopping in traditional product markets. The respondents visiting traditional markets are less willing to pay than those usually visiting traditional product markets. Younger respondents are more willing to pay than older respondents. Higher

income groups are more willing to pay than lower income groups.

Variance Inflation Factor (VIF) should not ideally exceed rule of 4, rule of 10 in literature. If it exceeds the rule of thumb, it is regarded as casting doubts on the estimations of regression analysis. As attentively viewed from the results, the VIF values among independent variables change between 1.02 and 1.38 and mean VIF value is 1.17 which has a sufficiently concrete evidence that there is no serious multicollinearity in the model.

The average WTP annually was found to be about TRY 32 for all observations including zero bids and TRY 164 excluding zero bids. Zapata *et al.* (2013) found the estimated aggregate annual economic value as \$ 361,960. Table 3 exhibits the estimation results provided from the ordered probit model. As is illustrated, marital status and shopping for traditional food on Internet were identified by the model to have a significant impact on the probability to WTP while the age of respondents was found to negatively impact the probability to WTP. However, income and education were not found to have a significant impact, positive or negative, on the probability to WTP.

Being married increases the probability of WTP by 11%. This can easily be explained with a bigger tendency to e-trade of traditional foods than singles. Shopping for traditional food on internet increases the probability of WTP by 20%. Contrariwise, the age of the consumers were found to have a negative effect on the WTP. Older respondents decrease the probability of WTP by 11%.

Table 4 summarizes the results of the Tobit model concerning their marginal effects. Individuals who are married and do shop over Internet have higher WTP. To put it in context, married people raise the WTP amount by TRY 128, and similarly, shopping for traditional food on Internet raises the WTP amount by TRY 193 respectively, *ceteris paribus*. A survey conducted by Carpio, *et al.* (2013) shows that producers

Table 4

Tobit model

Variable	Coefficient	Standard error	Marginal effect	Standard error
Constant	-94.92328	209.2325		
Age	-114.675	76.54291	-23.44676	15.391
Working condition	-5.067288	14.83697	-1.036072	3.03179
Education level	-52.94824	72.08346	-10.93059	14.996
Marital status	128.3928*	66.00492	26.25156**	13.089
Purchasing traditional food from Internet	97.35431	102.7739	21.55273	24.559
Shopping from traditional food markets	193.1561**	81.93771	38.85785**	15.576
Income	-50.47709	73.51922	-10.48939	15.479
***Indicates significance at 1% level, **at 5% level, *at 10%				

are, on average, willing to pay \$47.02 annually for the services they receive from MarketMaker.

Conclusions

This study aims to analyse the traditional food market in Turkey from the perspective of Turkish consumers and introduce the concept of MarketMaker in order to measure the WTP of Turkish consumers. The study is based on the online survey. So, stated preferences are merely observed. E-marketing of Turkish traditional products is not developed well in spite of the fact that there is a rich variety of traditional products representing different geographical regions. Although there is a growing demand for traditional products, marketing of these products is not satisfactorily demanded by the consumers

due to the lack of trust and maybe the ability to use internet applications. For instance, the education level and income level surprisingly are found to have no important impact on WTP.

A direct connection has been found between the ages of respondents and WTP. The older people, who are not familiar with e-trade applications, are not willing to pay for an e-trading platform since they do not trust it. The only caveat of this study is that the consumers' perspectives are merely reflected, on the basis of stated preferences. So, one more study focusing on covering revealed preferences should be carried out. Also, the producers and producer unions are not considered in the analyses. So, what producers and producer unions think about this kind of platform need to be searched for healthy policy implications.

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PRODUCTIVITY OF LATVIAN AND LITHUANIAN RURAL FARMS AND MAIN FACTORS INFLUENCING IT

Armands Veveris¹, Vaida Sapolaite², Liene Dambina¹

¹Institute of Agricultural Resources and Economics, Latvia

²Lithuanian Institute of Agrarian Economics

arman2@inbox.lv

Abstract

The aim of the paper is the assessment of the changes in productivity expressed as the share of production costs in total output and its breakdown by major cost types of Latvian and Lithuanian farms over the period of the implementation of Rural Development Programme (RDP 2007 – 2013). The country's agricultural productivity is determined by comparison of the total agricultural output value (in producer prices) and total inputs which include intermediate consumption expenditure, depreciation, labor costs and other external costs. The information for the analysis was sourced from the standardized Farm Accountancy Data Network (FADN) data. The results show that productivity level is higher in Lithuanian farms, although the tendency is that the share of costs in production value is increasing in Lithuania, so the difference between two countries is reducing. The changes of productivity in both countries infer the relative growth in the productivity in crop farming both in Latvia and Lithuania respective to dairy farming, as well as the productivity of large farms respective to small and medium farms. The comparisons of major cost items reveal an especially high level of energy costs in Latvia, as well as a high and soaring level of depreciation in Lithuania, especially in dairy farms. In the future policy making, it is worthwhile to design the measures targeting the confinement of risks and negative trends identified in the study.

Key words: agriculture, productivity, farms, output, input.

Introduction

The objective of the study is the assessment of the changes in productivity expressed as the share of production costs in total output and its breakdown by major cost types of Latvian and Lithuanian farms over the period of the implementation of Rural Development Programme (RDP 2007 – 2013).

The topicality of the research is supported by previous findings suggesting generally higher intermediate consumption costs per production unit in Latvia if compared to the EU average and neighbouring countries. It would be appropriate to compare the data of two neighbouring countries – Latvia and Lithuania – to reveal the common and different tendencies of its development. Thus, the necessity arises to assess the changes over the programme period: what is the impact of the programme on production costs - have the costs grown or declined, and in which subsets? The analysis has been provided both for industry level and main farm grouping level by comparison of FADN data for Latvia and Lithuania.

To reach the research objective, the following tasks are set: (1) To assess the changes in the share of costs in total output in Latvian and Lithuanian agricultural farms over the period of the implementation of RDP; and (2) To analyze the structured data by main farming types (field crops and milk production) and by farm sizes (standard output groups).

Due to the format limitations, the paper includes a concise analysis of results only for main groups of specialization and overall analysis of different farm size groups.

Materials and Methods

The selection of the research methods and description of the general situation were based upon the previous national and international research on competitiveness and its assessment along with the research on dynamics of the share of the costs in production output.

The methods of economic analysis used in the present study comprise monographic and graphic methods, time series analysis with linear regression, comparative analysis along with the analysis and synthesis.

The information for the analysis was sourced mainly from weighted or standardized FADN data.

To get representative results, the sample survey data are extrapolated to similar farms by using weights. Every farm from FADN database has its weight, thus the results obtained represent all farms whose size exceeds the FADN threshold: standard output (SO) is greater or equals EUR 4,000 annually. In 2014, 24,000 or about 30% of total operating farms in Latvia were above this threshold (Central Statistical Bureau of Latvia, 2013) and 53,000 or 31% in Lithuania (Statistics Lithuania, 2013). The data on farms below the FADN size threshold are not available. Nevertheless, it should be noted that farms covered by FADN virtually represent the entire commercial sector of the agriculture: according to the structural surveys of CSB, farms above the FADN threshold provide 93.5% of total standard output (SO) in Latvia and 89% in Lithuania. Some 80% of agricultural land in Latvia is attributed to these farms (in Lithuania even 93%), and the share of them in agricultural labour input at

Full Time Employment (FTE) units are 56% in Latvia and 67% in Lithuania (2013). Thus, the analysis of this sample data provides a representative insight on commercial agricultural production.

The FADN standardized results from 2006 to 2014 are used for the analysis at industry level and grouped levels. Such period is chosen to explain one year before and one year after the Programme. Considering the significant share of the field crop farming and dairy farming in agriculture of both countries, these sectors are addressed particularly. Both sectors are sufficiently represented by FADN to enable the representative assessment. The exact number of farms varies by year as some farms undergo a change in specialization over time. There are about 33 – 35% of dairy farms and 27 – 35% of field crop farms in FADN sample of both countries. Other special fields do not have a sufficient number of farms to include them into the research.

The country's agricultural productivity is determined by comparison of the agricultural production value (producer prices) and total input costs which include intermediate consumption expenditure, depreciation, labor costs and other external costs (rent, interest and taxes linked to production).

To evaluate the intensity of involvement in various RDP 2007 – 2013 projects in particular farm size groups, the analysis is adjusted accordingly. There are six economic size groups in the Latvian FADN depending on their standard output. In Lithuania there are some differences in that division: the first group is divided into two parts (so 7 groups are in total), but the largest group begins from EUR 250,000 standard output per year instead of EUR 500,000 as in Latvia.

For the convenience, farms with SO of up to EUR 25,000 are considered 'small'. Farms with SO of more than EUR 25,000 and up to 100,000, constitute „medium” group. Finally, farms with the SO of EUR 100,000 and more are considered 'large'. The suggested breakdown is supported by the size and nature of farming operations, as well as the economic results.

Results and Discussion

The productivity of a company or entire sector is expressed by production in value terms divided to costs (Coelli *et al.*, 2005). The value of the indices thus obtained itself is not explicable. However, the change rate of the indices over time indicates the growth of production in value terms that is not associated with the increase in costs, and as such, it directly shows the changes in the efficiency of production process over time. Moreover, productivity indices enable country comparisons to evaluate the relative national competitiveness of a country. Both of these comparisons are important in the assessment of a competitiveness level and its changes (Irz & Jansik,

2015). The interpretations of the competitiveness vary. Some authors point to a relative nature of the concept emphasizing the lack of the explanatory power of single indices alone considering the entire range of aspects associated with the competitiveness and its complex nature (Latruffe, 2010). Nonetheless, the industry level research predominantly focuses on the productivity. Paul Krugman considers productivity an important element of outcome competitiveness (Aiginger, 2006). UK Department for Environment, Food and Rural Affairs virtually infers competitiveness as economic efficiency or productivity (Irz & Jansik, 2015).

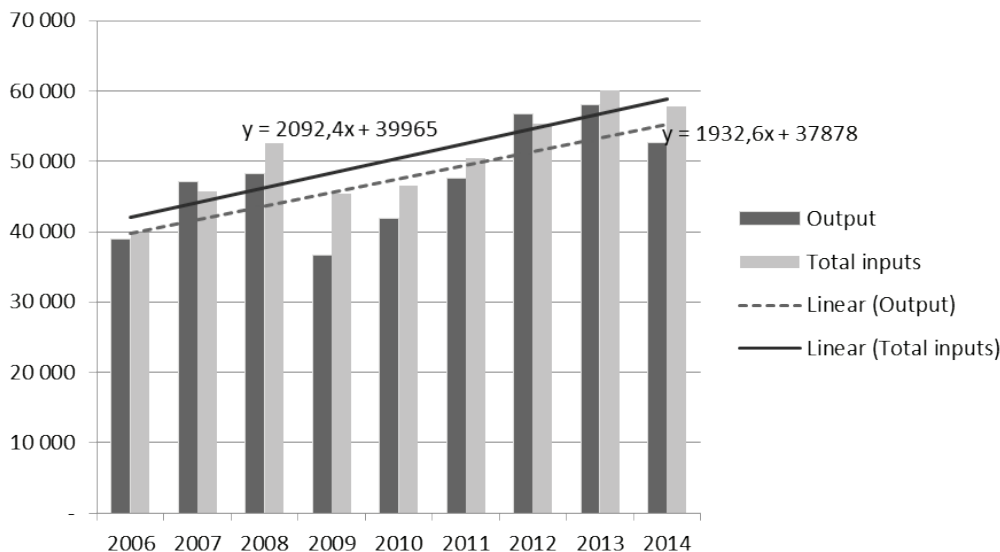
Interpreting the concept of productivity calculation, the researchers put forward similar views that the higher productivity can lead to economic growth. The productivity analysis in agriculture has been carried out using Data Envelope Analysis (DEA). DEA is a method of measuring the efficiency of the farm and allows to study separately the resources or products and their various relations of effectiveness assessments (Baležentis, Kriščiukaitienė, & Baležentis, 2009).

The scientists exploring the indicators of productivity (Tamosaitiene *et al.*, 2010) defined the assessment of economic activity of farm and their resource efficiency by using the relative financial indicators.

The authors agree that there are factors such as technology, innovation, management, research and development which increase the productivity. A higher productivity associated with economic growth rates should be assessed based on the foreign direct investment (FDI) impact on the productivity, as well as determined whether there is a correlation between the volume of FDI and labour productivity of the country (Laskiene & Pekarskiene, 2011).

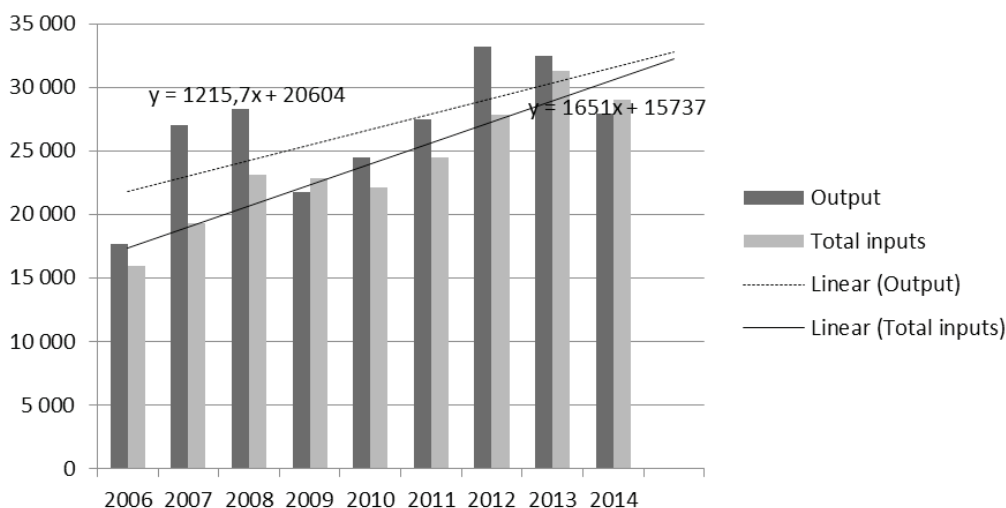
For agricultural farms in Lithuania and Latvia increasing the productivity remains an essential problem. Therefore, it is appropriate to identify the factors that determine agricultural productivity, provide its improvement opportunities, which will allow both countries to increase the competitiveness of the economy in the long term. One of the most important factors is to support agriculture. It should be noted that the rise in agricultural production since 2004 has been significant after Latvia's and Lithuania's accession to the EU. The support obtained from the EU and national budget stimulates agricultural production, while increasing the value added and income. Support funds are sufficient not only to maintain the farm incomes, but also to give more for investment purposes.

The size of both Latvian and Lithuanian average farm economy has grown from 2006 to 2014. The weighted average production in value terms (output) in a single Latvian FADN farm has increased from



Source: Calculations of authors based on FADN data

Figure 1. Trends of output value and total input for an average Latvian FADN farm (EUR, 2006 – 2014).



Source: Calculations of authors based on FADN data

Figure 2. Trends of output value and total input for an average Lithuanian FADN farm (EUR, 2006 – 2014).

EUR 38,900 in 2006 to EUR 58,000 in 2013 (Figure 1). Since then, in 2014 it has declined to EUR 52,700; so the total growth since 2006 is by 35%. The annual fluctuations are mainly attributed to the market situation in the particular year (prices for grain, milk and other products). The growth in total input in value terms follows almost a proportional pattern, and the total growth of average farm costs from 2006 to 2014 is by 45% in Latvia. It is important that only in two years during this period (2007 and 2012) the total output in producer prices was slightly higher than total inputs. It was due to exceptionally high crop prices. In all other years, the farmers' income was ensured only with the help of subsidies (on average farm).

Similar tendencies we see in Lithuania (Figure 2) – in this country the average farm agricultural output increased even by 58%, but total input – even by 81.8% in 2014 compared with 2006. During the period 2006 – 2014 it can be noted that input was growing faster than output. Yet, there is one big difference from Latvia: only in two years – 2009 and 2014 – the farm costs were higher than the value of agricultural output. In all other years there was a positive output-input value balance in Lithuania farms.

During the period of 2006 – 2014, the highest value of agricultural output per farm was produced at EUR 33,199 in 2012. It was by more than 40% less than in average FADN farm in Latvia at the same year.

The most profitable year for farmers was the year 2007 when the average profits amounted to EUR 7,685 per farm. Whereas, in Latvia the maximum net profit was only EUR 1,462 per farm – more than 5 times less than in Lithuania.

If we compare input/ output ratio and its tendency in these countries, we can see that in Latvia this ratio is about 106% (input higher than output) and slightly increasing, but in Lithuania it is less, with a strong tendency to increase: from 75% in 2006 to 94% in 2014 (trend data). The average share of costs in the EU countries stands at the 88% of production output in value terms and it is stable; so the production in value terms substantially surpasses the costs. Hence, the dependency upon subsidies in Latvia is significantly more pronounced than in EU in general. In the last years the same tendency has also been observed in Lithuania.

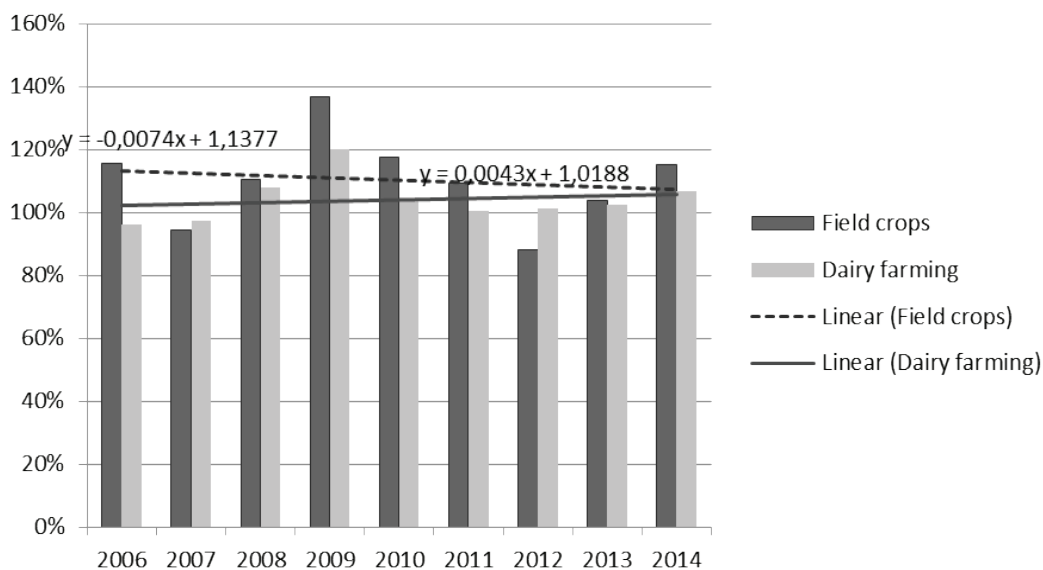
The main types of specialization in agriculture of both countries in question are field crop farming and dairy farming. Thus the substantial trends in farms within these industries are analysed separately. The dynamics of total costs in these industries is mapped in Figure 3 for Latvia and Figure 4 for Lithuania.

According to Latvian data, the share of total input in output of crop farms exceeds the overall average. This rate for crop farms in 2014 stood at 115% while the overall average was only 110%. Nevertheless, the linear trend suggests the decline in the share of the costs. However, the data per year varies significantly and the comparison with the respective crop and dairy prices leads to a conclusion that the product price fluctuations is the main factor behind the differences in shares of total input per year.

Nevertheless, there are other factors that influence the ratio of input and output. Moreover, farms in both specialization groups vary either by trends in changes of the ratio or the range of the changes. It is obvious that from 2012 to 2014 when the grain prices were markedly lower, the share of the costs in output grew by 28 percentage points from 88% to 115%. This points to the relatively high risks in crop farming where productivity is very dependent upon the situation in the global markets and yields (these can be volatile) as the productivity in industry in 2007 and 2012 when prices were high was higher than in other industries, in 2008 and 2013 (medium prices and average yields) it resembled the whole sector. For other years, in turn, when either prices or yields were lower (2006, 2010 and 2011) the share of the total input in output exceeded the agricultural average markedly.

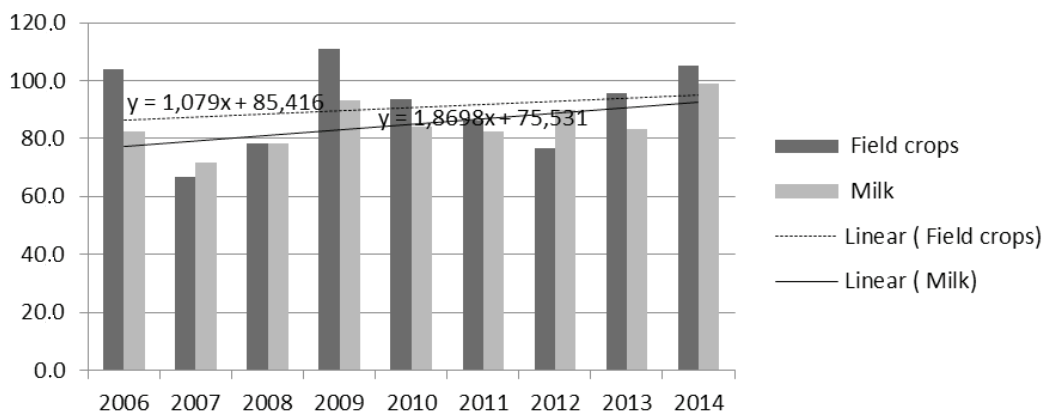
In dairy farming, the ratio of input is slightly lower than in crop farming and in agriculture in total (107%, 115% and 110%, respectively) with annual fluctuations significantly less pronounced. However, in comparison with crop farming in dairy farming ratio of input is growing as shown by general trend line. Only in 2006 and 2007 it was less than 100%. After that the ratio soared to a 120% maximum in 2009. From 2010 to 2013 the ratio was rather even – at 100% – 104% from the output.

Such a situation provided profits for farms considering the size of support payments that accounted for about a third of output. In 2014, in turn, the share of costs grew to 107% or 5 percentage points from output, reflecting the 5% decline in average milk price.



Source: Calculations of authors based on FADN data

Figure 3. Ratio of total input in output value at Latvian field crop and milk farms 2006 – 2014 (%).



Source: Calculations of authors based on FADN data

Figure 4. Ratio of total input in output value at Lithuanian field crop and milk farms 2006 – 2014 (%).

As of 2014, the ratio of costs increased by 5 percentage points to 107% of output, reflecting the 5% decline in average milk price. The results of 2014 were not fully affected by dairy crisis yet and milk price in the first half of the year was higher than in 2013.

The comparison of these two industries leads to a conclusion that up to 2011, in general, the milk production in terms of costs was more efficient if compared to crop farming (lower ratio of input in output) albeit from this time on the trend has receded and the share of input in both industries has almost levelled. It should be noted that in FADN farm group from 2006 to 2014 the investment support for dairy farms was higher than in crop farms (6.1% and 5.1% from output, respectively). Aggregate support including all subsidies and state support for dairy farming is higher than for crop farming (36.6% and 32.2%, respectively). For all farms, irrespective of their specialization, the average ratios stand between these two industries: the share of total subsidies in output stands at 33.6%, including investment subsidies at 5.6%.

In Lithuania, the ratio of total input in output in the field crop farms was much lower than in Latvia, although, it exceeded the overall average too, except in 2007 and 2012. This rate for crop farms in 2014 made up 105% while the overall average was 104%. Nevertheless, the linear trend suggests the average at the same level in the share of the input. As in Latvia, there are high year-by-year fluctuations. The largest share of the input – 126% was in 2009, and the lowest – 69% in 2007.

In dairy farming, the ratio of input is lower than in crop farming and in agriculture in total (99%, 105% and 104% in 2014). Contrary to the crop farming, the ratio of input in dairy farms is growing, as shown by general trend line (Figure 4). At the same time, the value of total input is less than output value for all

observed years, although the comparative advantage over Latvian farms is reduced. In 2007, this share was 70% in Lithuania and 97% in Latvia, but in 2014 – 99% in Lithuania and 107% in Latvia.

Taking into account the varying development trends, in particular, the farm size groups (including the rapidly falling number of small farms while these farms in aggregate still do employ the largest share of agricultural workforce), one of the research tasks is the study of the differences of productivity and its changes in farms depending upon their size.

The input and output ratio was compared in all economic size groups covered by FADN (in all 6 size groups according to the Latvian FADN classification and 7 groups in Lithuanian classification). The research revealed a more marked trend in input increase for small farms with SO less than EUR 50,000. While in 2006 in all farm groups with SI less than EUR 50,000 the costs did not exceed the output and for these the ratio against the output was markedly lower than in larger farms, in 2014 the share of costs is still the lowest for small farms at 104% from output and the 100% threshold is surpassed in all size groups.

In medium-small farm group (SI from EUR 25,000 to 50,000) the growth in input-output ratio is especially pronounced: from 100% in 2006 to 120% in 2014. At the same time, the second largest farm group (SI from EUR 100,000 to 500,000) has seen a relative decline in the ratio: from 112% in 2006 to 109% in 2014 (Table 5.2). These changes point to a relative disadvantage of production just for small farms (including medium ones with SI to EUR 50,000). This facilitates the concentration of production while at the same time draining workforce out of agriculture considering the concentration of labour in small farms (according to the CSB data on 2010 small farms with economic sizes of up to EUR 15,000 provide 73% of employment in agriculture).

Table 1

Ratio of main input items in output value in Lithuanian and Latvian farms by main types of specialization (%)

Special field/ years	Lithuania				Latvia			
	Field crops		Milk		Field crops		Milk	
	2006	2014	2006	2014	2006	2014	2006	2014
Total inputs:	103.7	105.2	82.4	98.9	115.4	115.1	96.0	106.8
Intermediate consumption:	74.4	74.8	63.8	64.7	80.7	80.8	75.2	81.1
Feedingstuffs	0.1	4.4	32.6	35.3	4.3	1.5	36.1	36.2
Fertilizers & crop protection purchased	31.7	33.7	4.4	3.9	26.4	30.7	2.6	3.7
Energy costs	13.8	12.7	9.6	9.5	17.8	14.1	12.6	13.7
Purchased seeds and seedlings	17.6	8.4	4.7	1.9	10.8	10.5	2.3	2.4
Maintenance of buildings and machinery	5.4	5.4	6.0	5.3	7.0	6.8	7.3	8.8
other costs	29.3	34.1	18.6	34.1	34.7	34.3	20.7	25.7
Depreciation	17.5	25.6	14.6	28.3	19.2	21.1	11.6	13.5
Wages paid	4.6	3.3	1.1	3.1	9.1	8.0	6.6	10.0
Rent and interest paid	7.3	5.2	2.9	2.7	6.4	5.2	2.5	2.2

Source: Calculations of authors based on FADN data.

In Lithuania the tendencies in the farm size groups are quite similar to those in Latvia. There is a sharp increase of input-output ratio in farms of less than EUR 50,000 of SO, and the only farm group with reduced input-output ratio is the largest farm group with SO of EUR 250,000 and more: from 103% in 2006 to 91% in 2014.

In the evaluation of the strengths and weaknesses of Latvian farms as well as to reveal the opportunities for improving the productivity, analysis of cost structure is crucial. Hence the main constituents of total input are selected and their dynamics over the period covered are studied, and comparisons of Latvia and Lithuania are provided to assess the changes over the implementation of LAP 2007 – 2013.

The shares of all the most important input constituent parts of the production costs are provided in Table 1.

The calculations show that the changes in Latvian cost structure over the years covered are not intrinsic: relative costs of fertilizers and energy are still high. It has already been mentioned in previous research (Veveris, 2009) that these stand markedly above the EU average. Moreover, the share of fertilizers and plant protection grows with more pronounced increase of these items in Lithuania. Energy costs, in turn, are markedly higher in Latvia for both specialization groups in question.

Generally, the intermediate costs in Latvia over the period covered have grown in dairy farming while in

Lithuania the changes both in dairy and grain farming are insignificant.

As for other costs not included in the intermediate consumption, a very marked growth in depreciation has occurred in Lithuania. This constituent has increased in Latvia, too, albeit less markedly. This brings evidence of large investment in Lithuanian agriculture in recent years. It has to be mentioned that the share of labour costs in Latvia is essentially higher than in Lithuania. Interest and land lease payments, in turn, are relatively small in both countries with a declining share in output.

The cost structure in dairy farms, of course, is different if compared to crop farming with feed costs dominating. This constituent along with energy costs previously has been mentioned as the weaker cost item in Latvia.

Conclusions

1. During the time period from 2006 to 2014, the ratio of output and input has been volatile. While changes by year have been closely adhered to prices of basic products, the basic trend line still shows a relatively high share of input in the output – exceeding 100%. It means that at an average commercial farm subsidies play an important role to support income both in Latvia and Lithuania.
2. On the average, in all farm groups by specialization and size the share of both total

- input and intermediate consumption has increased. However, marked differences do exist: in crop farms at the beginning of the period it stood above the average while in dairy farms it was below the average. Nevertheless, a trend for this ratio seen towards the 2014 was that of levelling out in both types of farms.
3. The share of input in the output on Latvian farms in comparison with Lithuania is higher albeit virtually stable according to the trend line, while in Lithuania the share grows.
 4. The changes of productivity in both countries infer the relative growth in the productivity in crop farming both in Latvia and Lithuania respective to dairy farming, as well as the productivity of large farms respective to small and medium farms.
 5. A marked surge in the share of input in the output from 2006 to 2014 has occurred in the farms of the smallest sizes (with SO to EUR 50,000). It means the production in small farms (including medium ones) has become relatively disadvantageous.
- This facilitates the concentration of production, while at the same time, draining workforce out of agriculture considering the concentration of labour in small farms.
6. During the period observed, the indices of competitiveness for small and medium farms have deteriorated while in large farms they have improved. Thus the necessity exists in the future to increase the share of the support for improvement of the competitiveness of small and medium farms, especially considering the role of these farms in shaping the rural socio-economic environment including the employment.
 7. The results obtained prove the necessity of a special input support to improve the energetic efficiency in Latvian and Lithuanian farms using the measures for the reduction of costs for feed, fertilizers and other direct costs. These measures would provide for the decline in the dependency of farmers on subsidies and allow for the increase in farming income.

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FACTORS SHAPING MANAGEMENT STYLE OF A MANAGER: A CASE STUDY OF KAUNAS DISTRICT NON-GOVERNMENTAL ORGANISATIONS

Lina Marcinkevičiūtė, Jan Žukovskis

Aleksandras Stulginskis University, Lithuania

Lina.Marcinkeviciute@asu.lt; Jan.Zukovskis@asu.lt

Abstract

The scientific literature does not contain any single classification of management style. When dividing management styles into the classic and the new, the changes towards the nature of manager's exposure to employees are taken into account. When analysing the structure of manager's style, it is necessary to take into consideration the key factors: the conditions shaping management style, the opportunities for the manager to change and improve it purposefully. The efficiency of manager's behaviour, together with the choice of management style, result in various objective and subjective factors. *Objective factors include the factors* which cannot (or very little) be affected by the environment. *Subjective factors* depend only on personal qualities which can be developed and improved. This article deals with objective and subjective factors shaping management style of a manager. The results of the empirical study on the structure of management styles of Kaunas district non-governmental organisations (hereinafter referred to as NGOs) have been presented, as well as the most significant advantages and disadvantages of objective and subjective factors shaping management style. Based on the data of the theoretical analysis and empirical study, improvement directions of the problematic factors of NGOs management styles have been identified and substantiated, taking into consideration the elimination of management style drawbacks.

Key words: manager, personal management style, objective and subjective factors.

Introduction

The success or failure of any organisation always has an impact on employees and their management. People management is the most important function of the organisation and guarantees its existence. Improper management in the organisations leads to high staff turnover, low inner motivation, and poor work results. The prevailing opinion is that the manager's behaviour with the staff or his/her management style influences job satisfaction, psychological climate, and work efficiency.

It may be noted that not only management culture but also the conception of the manager's role in the organisations have recently been changing. The modern manager has to analyse and solve problems, be a leader, keep learning and provide learning opportunities for others, be acquainted with politics and administration, be able to develop and implement strategic planning, be able to gather teams together, and involve employees into the change management. The management process in the organisation is mainly determined by *management style of the manager*, i.e. interrelated management methods, standards of conduct, rules that the manager uses at work in order to encourage employees to achieve organisational goals. The real management style is not the one which is used in relationship with employees, but the one which is experienced, noticed and valued by employees.

Non-governmental organisations is a part of Lithuanian civil society. They can provide significant benefits for small funds since NGOs perform on a voluntary basis and attract financial support from various funds. Theoretically, it is difficult to define the role of a manager in the NGO, as the manager

does not command his/her direct and legally defined employees but his/her colleagues-volunteers. There has been an insufficient number of studies and definitive findings which would allow to decide what objective and subjective factors of the management style shape the structure of the management style and what impact they may have on the activity efficiency of NGO members.

The object of the study is objective and subjective factors shaping management style of a manager.

The aim of the study is to determine and substantiate the improvement directions for management styles of Kaunas district NGOs managers.

The tasks of the study:

1. To analyse objective and subjective factors shaping management style of a manager.
2. To determine the advantages and disadvantages of objective and subjective factors shaping management styles of NGOs managers.

Research methods include the analysis of scientific literature, questionnaires, structural interview, methods of summarising and comparison.

Materials and Methods

Theoretical analysis of objective and subjective factors shaping management style.

The scientific literature does not contain any single classification of management style. When dividing management styles into the classic and the new, the changes towards the nature of manager's exposure to employees are taken into account. Classical management styles (autocratic, patriarchal, *et al.*) emphasise the authority of the manager, hierarchy and blind obedience, while new management styles (the

delegation, collegiality, etc.) are more in line with the modern conditions; they focus on employees' involvement in the decision-making process, skills and potential for growth.

Due to the constantly changing and unstable environment, the work of a manager has become complex and difficult. It is worth noticing that management depends on the level of each manager's education, their experience, psychological characteristics, value system, when understanding and interpreting the same management processes, focusing on one or other most important aspects of management. Having carried out the theoretical analysis, it has been identified that Jag (1982) and Bryman (1992) were analysing the characteristics of managers, Hogg (2001) showed her interest in differences of assigned and emergent managers, Kotter (1990) and Rost (1991) examined the differences between management and leadership, Zaccaro, Kemp, and Baderi (2004) were interested in the level of managers' intelligence, Mumford, Harding, and Fleishman (2000) focused on the technical, social and conceptual skills, Bass (1990) dealt with transactional and transformational leadership. Lithuanian scholars started investigating the phenomenon of management only in the last decade of the 20th century. The first studies were prepared by Jucevičienė (1996), Razauskas (1997), Šilingienė (2000), Juozaitienė (2004), Ginevičius (2008), Bakanauskas (2011), *et al.*

In the scientific literature, the management style of the 21st century (Binder Freytag (2013); Eriksson-Zetterquist, Mullern, & Styhre (2011)) is generally regarded to as a complex entirety of the relationships

between the manager and his/her subordinates. The manager carries out the assigned functions following his/her individual style, as his/her personal qualities and staff qualities both are distinctive.

The prevailing opinion (Pakhar, 2011) is that the diversity and complexity of the manager's and his/her subordinates' relationship results in the diversity of individual management styles, although, certain criteria, according to which significant features are grouped and analysed, may be pointed out. There is no single classification of an individual management style. Different authors and different schools classify them in a different way. Different classifications emphasise specific characteristics of an individual management style, according to which they identify and describe certain types of management styles. It can be assumed that management style depends on personal traits and manager's orientation, however, the effectiveness of management is also determined by certain situational factors. These factors include the needs and personal qualities of subordinates, the nature of the task and the requirements. Hence, the manager should be able to change his/her behaviour depending on a specific situation.

Each manager can form a purely personal, individual and unique management style. This results in every human identity, his/her own characteristics, and some factors that either depend on him/her or not. (Eriksson- Zetterquist, Mullern, & Styhre, 2011).

In the scientific literature (Parolini, Patterson, & Winston, 2009; Schneider & George, 2010; Gonos & Gallo, 2013), there is a number of different views on the factors that determine management style. There

Table 1
Objective and subjective factors shaping management style (based on Binder & Freytag (2013); Eriksson- Zetterquist, Mullern, & Styhre (2011); Parolini, Patterson, & Winston, (2009) *et al.*)

Objective factors	Elements of the factor
Specifics of the managed organisation	Activity aims, nature of organisation performance (type of provided services), target market (sex, age, education), funding for the activity, cooperation with other organisations, strategic planning of organisation activity
Specifics of the addressed issues	Motives of members to participate in the communal activity, participation of volunteers in the communal activity
Level of management	Level of manager's responsibility, distribution of work, control of performed tasks, decision-making process
Peculiarities of the managed staff	Competence of organisation members, motivation of organisation members
Career path and school of the manager	Levels of manager's career, direct managers
Subjective factors	Elements of the factor
Manager's personal qualities	Manager's psychological characteristics, level of manager's intelligence, self-confidence
Reason of manger's emergence	Manager's formal duties in the organisation, the level of manager's authority
Education	Professional knowledge, manager's qualification, manager's competence

is no consensus of the opinion about factors that influence management most. When analysing the structure of manager's style, it is necessary to take into consideration the key factors: the conditions shaping management style, the opportunities for the manager to change and improve it purposefully. The efficiency of manager's behaviour, together with the choice of management style, result in various objective and subjective factors. *Objective factors include the factors* which cannot (or very little) be affected by the environment. *Subjective factors* depend only on personal qualities which can be developed and improved. The objective and subjective factors determining the formation of manager's personal style are presented in Table 1.

Specifics of the managed organisation determines the organisational aims and objectives, the nature of its activity. The need for an appropriate management style occurs. Managers should adjust their own style to the nature of the managed organisation activities.

Specifics of the addressed issues is stipulated by the nature of conditions which may occur in the organisation. These conditions are usually temporary and, after some time, they become normal again. Various conditions may occur: difficult, extremely difficult, and extreme. If the situation is ordinary, it is possible to negotiate, consider, or discuss, but a critical situation requires strict, clear, specific and unambiguous management (Šilingienė, 2011).

Level of management also affects management style. It has been observed that the higher the position in the hierarchical structure is occupied by the manager, the more often he/she uses democratic management style. The reason for this is that the addressed issues at the highest level usually have a strategic nature, and such issues are usually discussed collegially. Lower-level managers are more likely to use autocratic management level. Apart from the level of management influence, it is possible to observe the relationship between management style and manager's education. The higher educational level the manager achieves, the more he/she tends to use democratic management, often refusing autocratic management. The same applies to the work experience in management: the wider it is, fewer possibilities that the manager is an autocrat exist. Liberal style is often preferred by the inexperienced managers.

Peculiarities of the managed staff is one of the most important factors influencing the management style. It was noticed by the representatives of situational theories, claiming that the maturity level of subordinates requires appropriate behaviour style of the manager. The lower level of the staff, containing very few initiative members, causes difficulties for the democratic manager when motivating them for effective performance. Using strict methods for such

subordinates, the autocratic manager, on the contrary, may achieve fairly good results. However, if the level of education of subordinates is quite high, they are in demand for the satisfaction of higher level needs. Traditional methods of autocratic management for these employees are not acceptable (Pakhare, 2011).

Career path and school of the manager. Former direct managers have a significant impact on the formation of a personal style in manager's career. Usually at the very beginning of career, the inexperienced manager tries not only to copy his/her teacher's management style, but even imitates his/her speaking style and posture. However, the opposite scenario is possible if manager's personal experience is very negative, taking into account his/her former manager. Thus, there is a chance that being a manager will allow him/her to do exactly the opposite.

Manager's personal qualities. Manager's personal qualities influence management style, but there are a lot of qualities, characteristics, abilities and behavioural traits which are really essential for effective management. The effective manager should have basic personal qualities and skills such as competence, organisational skills, sense of responsibility, dutifulness, and honesty.

Reason of manager's emergence. The reason of manager's emergence may influence management style. If the manager was "shouldered" by influential authorities, one can expect a certain management style. But if he/she become the manager due to his/her abilities, intelligence, experience and expertise, a completely different management style may be expected (Gonos & Gallo, 2013).

Education. It has been noticed that considerable impact is made by education of the manager. The higher qualification the manager has, the greater possibility that he/she will be inclined to democratic and even liberal management style. In contrast, if the manager is unskilled, incompetent, uncommunicative and uncooperative, he/she usually uses violence.

All the factors mentioned above are partly congenital and partly acquired. The subjective factors, precisely, make personal management style very individual and unique. Only purposeful work with oneself, engaging in training, developing self-control, improving individual qualities, enables targeted shaping of their own personal management style.

Results and Discussion

The results of the empiric study of the factors shaping management style of Kaunas district NGOs managers.

The study was carried out in the period of 2014-2015. The study involved 14 NGOs which had registered their activities in Kaunas district (selected at random). For the collection of primary information,

there was a structured interview method used for NGOs managers, while NGOs staff and volunteers had to fill in the questionnaires. In total, the study involved 14 managers, 43 employees and 73 volunteers.

Having systematised the information obtained during the empirical study, the advantages and disadvantages of the objective and subjective factors shaping NGOs managers' management styles have

been presented (Table 2). Due to large amount of information, the table provides only general insights and summarised statements (of both managers and employees).

Having analysed and identified the advantages and disadvantages of the factors determining management structure of NGOs managers, possible improvement directions were distinguished (Table 3).

Table 2

Advantages and disadvantages of *objective* and *subjective* factors forming the management style of Kaunas district NGOs' managers (created by authors)

Elements of the factor	Advantages	Disadvantages
OBJECTIVE FACTORS		
<i>1. Specifics of the managed organisation</i>		
Aims of organisation activities and types of services	Specifically formulated aims bring members of the organisation together for common activities.	A narrow range of social services is influenced by the lack of premises funding and special professional knowledge. Existing financing options allow to specialise only in one service area.
Characteristics of organisation members (sex, age, education)	Young members of the organisation are perspective, show initiative, have new ideas, can achieve better results.	Older members are not active and avoid innovations. Secondary education and vocational education do not provide knowledge, necessary for the development and implementation of local projects.
Funding of organisation activities, cooperation with other organisations	Member's fee is steady income planned in advance, guaranteeing minimum community activities.	Lack of attention of public authorities impedes the implementation of projects and funding opportunities. Limited financial resources restrict organisation activities. Ineffective collaboration with other organisations does not ensure the adaptation of "good practise" examples.
Strategic planning of organisation activities	Strategic planning provides opportunities for applying innovations, it increases productivity and reduces the risk of incorrect decisions.	Segmental attention to the strategic planning does not allow to specify organisation activities and demotivates organisation members.
<i>2. Specifics of the addressed issues</i>		
Motives of the members for participation in community activities	The participation of members in community activities ensures positive changes in the surrounding environment.	Studies on activity motives are not carried out systematically, which leads to the reduction of work efficiency.
Volunteer participation in community activities	Volunteering encourages everyone to unite, helps everyone to feel needed.	Lack of volunteers limits activity results of the organisations.
<i>3. Control level</i>		
Responsibility level of the manager	Responsibility designation for members of the organisation empowers them to take actions, encourages to work better.	Limited liability reduces the initiative of members of the organisation to act.
Work allocation	Work allocation encourages initiative and collaboration of the members.	Inappropriate allocation works reduce work efficiency.
Work control	Effective control system helps to avoid undesirable deviations in the future.	Lack of control functions influences the irrational work distribution for members of the organisation.
Management style	Issues are solved collectively, the initiative of members is encouraged.	Waste of time slows down decision-making process.
Decision-making process	The decisions made collectively improve the psychological atmosphere at work and motivate employees.	The ignorance of members' opinions when making important strategic decisions limits innovative activities of the organisation.

<i>4. Peculiarities of the managed staff</i>		
Competence of organisation members	The efficiency of the organisation is determined by professional members of the organisation, who are constantly searching for new ideas and solutions.	Limited competence and skills of the members impede the implementation of innovation and development.
Motivation of organisation members	The appropriate combination of motivation tools ensures efficient work of the organisation.	Lack of motivation leads to lower operational efficiency.
<i>5. Career path and school of the manager</i>		
Career levels of the manager and direct managers	Personal experience of the manager influences the choice of management style.	The manager without management experience imitates work style of the former managers.
SUBJECTIVE FACTORS		
<i>1. Manager's personal qualities</i>		
Manager's psychological characteristics	The effective activity of the organisation depends on psychological characteristics (initiative, creativity, ability to solve problems) of the manager.	Negative psychological features limit problem solving process, work structuring, communication, development perspectives, high quality of management is inaccessible.
Manager's level of intelligence	Intelligence: cleverness, ability to learn, quickly master new things, solve problems.	Low level of intelligence complicates problem solving processes and implementation new ideas and innovations.
Self-confidence	The manager is self-confident, feels self-assured about knowledge and skills.	Excessive confidence of the manager negatively influences the mastery of organisation members.
<i>2. Reason for the manager's emergence</i>		
Manager's formal duties in the organisation	Formal duties of the manager in the organisation determine the specific contribution of manager to organisation activities.	Excessive formal duties of the manager demotivate members in structuring and sharing organisation tasks.
Manager's influence level	Management by communicating and collaborating. Positive management qualities: verbal activity, awareness, desire to know the opinion of others, presentation of new ideas.	Excessive influence level of the manager in daily (routine) tasks negatively affects independence and self-actualization of the members.
<i>3. Education</i>		
Manager's professional knowledge	Innovative professional knowledge positively influences the internal environment of the organisation.	Lack of professional knowledge complicates managers' efforts of to carry out their duties in community organisations.
Manager's qualification and competence	Appropriate competence and qualification of the manager lead to rational management of the organisation.	Lack of competence and skills does not allow to achieve good performance and efficient performance in the organisation.

Organisation management oriented improvement direction. NGOs strategically planned activities would be oriented towards the long-term perspective of the organisation, they would clearly indicate the main activity directions, reduce the risk of wrong decisions, and unite members of the organisation for a common goal. *The positive effects of this improvement direction:* proper organisation of work, members perform their tasks on time, improve the quality of services, and work efficiency increases.

When members are not involved in the strategic planning, goals of the organisation may not be achieved, the desired result may not be obtained, the resources of the organisation may be expended, effective activities of the organisation may not be

performed. *The positive effects of this improvement direction:* the actions of organisation members are guided, efforts of the members are combined, and the danger of random decisions is avoided.

The control system would help to evaluate the performance of tasks, the difficulties faced by members of the organisation, avoid deviations in the future, which may arise from the lack of planning, organisational problems, management difficulties and motivation mistakes. *The positive effects of this improvement direction:* mutual communication between the manager and members, members of the organisation pay more attention to the tasks assigned to them. The effective control system would allow members of the organisation to evaluate

Table 3

**Improvement directions for NGOs managers' management style
(designed by the authors)**

Name	Components
Organisation management oriented improvement direction	Strategic prevision of the possibilities for community organisations. Activity planning, involvement of members in the strategic planning. Determination of control system for the works in process. Involvement of NGOs members in the decision-making process.
Collaboration oriented improvement direction	Determination of cooperation with other organisations. Prevision of financial resources search opportunities.
Activity organisation oriented improvement direction	Work allocation and responsibility are given for members of the organisation. Identification of activity motives of community members. Determination of possibilities to attract volunteers.
Human resources management oriented improvement direction	Competence establishment of higher education and community members. Systematic promotion of non-formal education for NGOs members. Determination of motivation measures for NGOs members. Finding possibilities to attract young members to the organisation.
Manager's competence oriented improvement direction	Identification of professional knowledge and competence of the manager.

and improve their work, and to increase the work efficiency.

The decision-making process in NGOs is important as it determines activities of the organisation. Appropriate decisions lead to the existence of the organisation and achievement of goals. It is important to involve members of the organisation into decision-making process: ability to make decisions collectively not only strengthens the team, but also makes the work more efficient. *The positive effects of this improvement direction:* members have an opportunity to participate directly in activities of the organisation, collective decision-making encourages the responsibility of members, freedom to decide occurs, the sense of new ideas and collaboration is promoted.

Collaboration oriented improvement direction. The purpose and activities of NGOs determine the need to collaborate with other organisations, local authorities, and greater collaborations with these institutions and inclusion of these subjects in activities of the organisation would have a positive impact on the achievement of community goals. *The positive effects of this improvement direction:* more efficient achievement of goals, better organisation of work, high-quality services, greater satisfaction of needs and priorities, more rational and effective decisions.

The success of NGOs activity and attainment of objectives depend on the financial resources, the partnership with other NGOs, business companies, and local authorities. Local authorities would help organisations to carry out their activities, they would be one of the funding sources. In order to ensure the capacity of NGOs in solving social problems, an important aspect should be the relations with local business organisations, which could ensure financial

and material support sources. *The positive effects of this improvement direction:* more efficient activities of the organisations and attainment of objectives.

Activity organisation oriented improvement direction. Work allocation in NGOs is different from other organisations because their members work as volunteers, and their activities are not regulated. Work allocation should be carried out by collectively allocating tasks or by the manager's request to perform specific tasks. When the manager suggests performing tasks based on personal skills, members of the organisation are encouraged to perform such tasks which they are able to do best. Designation of the responsibility to members of the organisation enable them to act, stimulate to work better. *The positive effects of this improvement direction:* more experience is acquired, members can improve, the responsibility for their actions is given, members can fully participate in the activities of the organisation, members' personal contribution and motivation for efficient performance of the organisation occur.

The activity motives of NGOs members are factors which determine the involvement of members in the community activities. The study revealed that the studies of the activity motives carried out systematically once a year would encourage community members to work better, work results of the organisation members would meet their needs, goals and interests of the organisation. *The positive effects of this improvement direction:* efficiency of activities in the organisation would increase.

Due to active volunteers, NGOs achieve good results of the operational efficiency. Volunteers carry out the most suitable work for the society. They have motivation, tolerance and willingness to

work for others. In this way, the organisation fosters motivated, responsible and qualified members of the organisation. *The positive effects of this improvement direction:* volunteers actualize themselves, spread new ideas, work efficiency increases, and goals of the organisation are achieved faster.

Human resources management oriented improvement direction. The education of NGOs members does not directly affect their salary, as they work on voluntary basis. The study revealed that more than a half (75 percent) of organisation members have secondary and vocational education. Acquisition of higher university education would ensure the acquirement of new information, easier communication with authorities would help to develop and implement local projects. More attention paid to the development of competence would ensure training opportunities and implementation of new technologies. *The positive effects of this improvement direction:* higher qualifications of the members, ability to use new technologies, increased work efficiency and productivity.

Non-formal education of adults would allow members to lifelong learning, satisfy cognitive needs, improve qualification, and obtain additional competencies. *The positive effects of this improvement direction:* community initiative for the preparation of projects would increase, effective performance of the organisation would be ensured.

The creation of the motivational environment in NGOs is one of the most important factors of operational efficiency. The quality of work depends on the qualification and motivation of the members. Motivation is a stimulus enabling members of the organisation to achieve better work results, productivity and improvement. An important motivating factor is an opportunity for members to participate in various qualification courses and trainings. *The positive effects of this improvement direction:* higher work efficiency and motivation.

The study found that NGOs face the problem of age: older members are dominant. Even though they are capable of working, they are not active, avoid innovations which leads to the impediment of the work process and decrease of work efficiency.

Attracting young members to the organisations would have a positive impact on the operational efficiency. Such members are perspective, show initiative, they have new ideas and do not avoid innovations, and, therefore, better work results are achieved. *The positive effects of this improvement direction:* higher work efficiency, ability to use technologies.

Manager's competence oriented improvement direction. The operational efficiency of NGOs depends on manager's professional knowledge and competence. The systematic improvement of the competencies would provide new skills of how to motivate members of the organisation, communicate, organise teamwork, inspire members of the organisation to learn and improve. *The positive effects of this improvement direction:* good performance, operational efficiency of the organisation, successful achievement of goals.

Conclusions

1. NGOs management has visibly become similar to business management. NGOs follow the same management principles as applied to the business sector. NGOs which provide services compete with the service providers in business and budgetary sectors. Professionalism is more noticeable in the employment relationship, work processes have become more formal, standardised, and activities are oriented towards measurable results.
2. Factors influencing personal management style can be divided into two main groups: *objective*, which depend on the surrounding environment factors and cannot be affected, and *subjective*, which purely depend on personal qualities of the manager and can be developed and improved (personal features, personality traits, mental characteristics, level of intelligence, education, competence, etc.)
3. Five improvement directions (oriented towards organisation management, collaboration, organisation of activities, human resources management, manager's competence) for NGOs managers' management style, focusing on the elimination of shortcomings of management, have been identified and substantiated.

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COMPARATIVE ANALYSIS OF SUSTAINABLE DEVELOPMENT OF ŠIAULIAI, TELŠIAI COUNTIES AND THE REPUBLIC OF LITHUANIA

Teodoras Tamošiūnas, Raminta Mazajevaitė

Šiauliai University, Lithuania

teo@smf.su.lt

Abstract

The paper analyses sustainable development situation in Šiauliai and Telšiai counties between 2004 and 2013 and compares it with respective situation in the Republic of Lithuania. In order to provide an integrated assessment of the situation, the analysis employed the method of calculating sustainable development indices, close to the Compass method, often applied in research practice all over the world. The calculated indices of economic and social development and environmental state in Šiauliai and Telšiai counties and in Lithuania have shown changes in sustainable development during the period of 10 years. Integrated sustainable development indices, obtained by summing up economic and social development and environmental state indicators demonstrated that sustainable development situation in Šiauliai and Telšiai counties and the Republic of Lithuania between 2004 and 2013 was very similar. Due to the first EU investments between 2005 and 2007, a huge improvement of economic and social situation took place, environmental protection also improved. However, the global economic crisis of 2008 – 2010 decreased the sustainable development of Lithuania and the mentioned counties. In 2011 – 2012, the sustainable development situation started improving again, however, not in such big proportions as in 2005 – 2007. Recession in 2013, in fact, brought the level of sustainable development of Lithuania, Šiauliai and Telšiai counties down to the level of 2004. Conclusions provide generalisation of the research outcomes and possible sustainable development trends for Šiauliai and Telšiai counties.

Key words: sustainable development, county, social, economic and environmental state indicators.

Introduction

The term *sustainable development* was validated in Lithuania in the National Strategy for Sustainable Development approved by the Government of Lithuania in 2003 and renewed in 2009. This term has been known and used in the world since the 50s of the 20th century; however, it was first documented in the Report of the World Commission on Environment and Development *Our Common Future* in 1987.

In 1992, at a UN Conference on Environment and Development in Rio de Janeiro, the heads of 172 states confirmed the provision that sustainable development is the main long-term ideology of the development of society. It adopted *Agenda 21*, encompassing the Global Action Programme on Sustainable Development, Declaration on Environment and Development, and Principles of Sustainable Forest Management. *Agenda 21* defines the hierarchy of implementation: local authority foresees, implements and sustains economic, social and ecological infrastructure; it controls, plans and develops local environment protection policy and sets the order; it helps to implement national and regional environment protection policy (Čiegis, Dilius, & Mikalauskienė, 2014).

In 2001, the European Council adopted the first EU strategy for sustainable development, and renewed it in 2006. The Strategy sets the key goals and policy principles of sustainable development in Europe; it establishes 7 challenges and respective tasks, the aims and objectives of activities.

In 2013, the European Commission confirms already the *Seventh Environmental Action Programme*,

called *Living well, within the limits of our planet* for the period to 2020.

The aim of the paper is to compare the sustainable development situation in Šiauliai and Telšiai counties and the Republic of Lithuania between 2004 and 2013. The period of 10 years has been chosen in order to analyse the sustainable development indicators from the year of Lithuania's accession to EU in 2004 until the end of the second planning period of 2007 – 2013.

The subject of the research is sustainable development in Šiauliai and Telšiai counties and the Republic of Lithuania.

Research problem. Sustainable development indicators and indices that comprise them are meant to define the general sustainability of the country; only a small part of them is provided for the smaller units of the territory – counties and municipalities. Besides, separate indicators do not reflect general sustainable development of the country; that is why researchers group them into indices, which are used to measure and evaluate general sustainability of the development of the country. Not many research works are dedicated to the assessment of the sustainable development of separate territories of the country. The paper assesses the sustainability of the development of two Lithuanian counties (Šiauliai and Telšiai) and compares it with the sustainable development of Lithuania.

The research problem can be generalised by the following *problem questions*: 1) What is sustainable development situation like in Šiauliai and Telšiai counties? 2) How does the sustainable development situation in Šiauliai and Telšiai counties compare

with sustainable development of the Republic of Lithuania?

Theoretical basis of the research. The concept of sustainable development has two main goals: 1) to ensure proper, safe and good life for all the people – the development aim, 2) to live and work with regard to the limits of biophysical environment – the sustainability aim. The concept reflects both anthropocentric and ecocentric views on sustainable development. The essence of the anthropocentric or domination view is an attitude that man is above nature and can rearrange it at his own discretion to make it as much useful to him as possible (Seghezze, 2009). Ecocentric view treats man as an inseparable part of the living nature, in which all kinds of living organisms are important. Here the holistic understanding of the world predominates, when the world and the man are treated as one, when they make integrated wellbeing (Holden, Linnerud, & Banister, 2014; Balsiger, 2011). Blowers, Boersema and Martin (2012) emphasise that society has the duty of taking care of the planet and pass it over to the future generations in a good state.

There are three main dimensions of sustainable development: environmental protection (nature), social environment (society) and economics. Rio de Janeiro Conference in 2012 established the need for the fourth sustainable development dimension – institutional (political), which is understood as the governing one for the other three (Angelevska-Najdeska & Rakicevik, 2012). Institutional dimension encompasses inter-state and inter-governmental activity processes in implementing sustainable development strategies; it expresses opportunities for all the interested parties to be involved in order to implement the sustainable development goals (Szell, 2014). Besides, it is important to decentralise governance and to have institutions creating and helping to implement sustainable development and not only blindly implementing programmes (Kardos, 2012).

Materials and Methods

Integrated measurements of sustainable development. The main idea of calculating the integrated sustainable development indicators is to include all dimensions (environmental, economic and social). The most often used group of such indicators is the ecological footprint. Canadian researchers Rees and Wackernagel (1994) were the first to use the concept of ecological footprint and defined it as the area of land or ocean necessary to provide one person with natural resources, necessary for the production of goods or services and to absorb the resulting pollutants. To establish the ecological footprint area for one person, over 50 kinds of different foods, the demand for energy for the production of 100 most widely used

goods and the area of land necessary to grow forest were assessed. In 2012, the ecological footprint of the countries of North America was 6 ha (in USA – 7.2 ha), in India – 0.9 ha. In European Union countries, the average ecological footprint per person was 4.7 ha, in the Netherlands and Finland it was 6 ha. Lithuanian ecological footprint was 4.4 ha per person. General global ecological footprint should be no more than 2.3 gha by 2030, which means that many countries have to decrease the usage of natural resources for public needs (Holden, Linnerud, & Banister, 2014).

Schmidt-Bleek (1993) suggested using another integrated sustainable development index – material intensity per service unit, which includes dematerialisation of production and consumption. Here the focus is on five categories of resources: water, air, raw materials (minerals, organic fossil fuel), biologic resources (plants and animals) and soil. Evaluation includes not only resources taken from nature but also those returned to it (e.g. pollutants). The analysis of the material flow intensity has demonstrated that developed countries have to reduce their intensity at least 10 or more times by 2050.

The United Nations Development Program Agency has been using the Human Development Index, including economics and society, since 1990. Three key indicators predominate here: average life expectancy, the level of education, and GDP per person. In 2013, the list of 187 countries was led by Norway, Australia, Switzerland, the Netherlands and the USA, while Lithuania occupied the 35th position.

Environmental Sustainability Index, compiled by the researchers of Yale and Columbia universities has 76 indicators, including environmental systems, environmental impact, vulnerability of society, social and institutional potential, and international collaboration. According to the data of 2014, Lithuania occupies the 49th position among 178 countries, Latvia – the 40th, while Switzerland, Luxemburg, and Australia are at the head of the list (Yale university calculations..., 2014).

The Compass method consists of four groups of categories, corresponding to the first letters of the directions on the compass: Nature, Economy, Society, and Wellbeing. Sustainability index is calculated by establishing the average value of each category and calculating their weighted average by providing 0.25 materiality coefficient for the evaluation of every average category (AtKisson & Lee Hatcher, 2005).

There are about 500 ways of calculating sustainable development indicators and indices, we mentioned only the most popular ones here. Although the names of indicators and indices are very different, their essence remains the same; most often they can be consolidated into general systems according to the areas, corresponding to the sustainable development

dimensions (Rasoolimanesh, Badarulzaman, & Jaafar, 2012).

Although the variety of indicators is great, every indicator should be: 1) important; 2) easily understandable; 3) reliable; 4) useful; 5) measurable by conventional units; 6) allowing for changes and supplements (Irimie, Gal, Dumitrescu, 2014). Besides, it has to be universal, sensitive, constant, and to have enough data in terms of time. The improvement of the value of the indicator should be possible to implement in real life and allow using it for public needs (Moldan & Dahl, 2007).

Researchers often encounter the problem that when data is collected at the national level, not all of them are presented also at the regional or municipal level. In such a case, the evaluation becomes less meaningful at the level of local self-government (Graymore, Sipe, & Rickson, 2008).

This problem is also important in Lithuania. The National Strategy for Sustainable Development (2009) allocates 17 indicators for the dimension of environmental protection, 31 are for economic dimension and 27 for social dimension. It singles out the development indicators of 9 territories, showing the situation in counties and municipalities. However, not all indicators can be found on the website of the Department of Statistics or other websites; besides, some indicators are provided only at the national level, without breaking them into those of counties or municipalities.

Selection of indicators. Six experts on sustainable development were given a list of 75 indicators of social, economic and environmental dimensions of sustainable development of Lithuania; they were asked to rate the indicators of every dimension in terms of their importance. According to these ratings, 5 most important indicators were singled out in each dimension.

The 5 most important economic development indicators are as follows: GDP per person (EUR); Material investments per person (EUR); Direct foreign investment per person (EUR); Percentage of the unemployed of the total number of working age population (%); Number of individual cars per 1000

population (units).

The 5 most important environmental state indicators are as follows: The amount of gas and liquid materials, sulphur dioxide, nitrogen oxide, volatile organic compounds per person (t); Emission of atmospheric pollutants from stationary sources per 1 km² (t); Discharges of agricultural, manufacturing and household waste water into surface water (purified according to the norms) (mln. m³); Use of groundwater (mln. m³); Forestation (%).

Calculating sustainable development indices. Indices of all three sustainable development dimensions are aggregated according to the selected 5 most important indicators: $I_m = \sum_{i=1}^5 a_i R_i$, where R_i is 5 indicators making up the respective index, i changes from 1 to 5, a_i is the weight of the indicator making up the respective index, equalizing the dimensions of indicators in such a way that the contribution of every indicator R_i to index I_m makes 20 percent ($m=E, S, N$).

The integrated sustainable development index sums up three sustainable development dimensions – economic, social and natural: $I = I_E + I_S + I_N$, where I_E , I_S and I_N are the indices of economic, social environment and natural state (Čiegis & Ramanauskienė, 2011).

Sustainable development indices in Šiauliai and Telšiai counties and in Lithuania were calculated in the period between 2004 and 2013. Tables 1-3 present examples of calculating the development index when coefficients a_i were chosen in such a way that the basic values of all 5 indicators in 2004 were 6.67, while their total index was 33.33. In the following years, either an increase or a decrease of the basic values of the 5 indicators and index can be observed depending on the actual values of the 5 indicators. Having added up basic values of indices I_E , I_S and I_N in 2004, the value of the integrated sustainable development index $I = 100$ is obtained, the changes of which in the following years show the increase or a decrease of the general level of sustainability. Such methodology of calculating indices essentially corresponds to the conception of the Compass method.

All statistical data have been taken either from the website of the Department of Statistics or websites

Table 1

The Dynamics of the Environmental State Index

Environmental state index	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Šiauliai County	33.33	57.30	25.89	38.40	29.59	36.97	38.45	31.46	40.08	30.53
Telšiai County	33.33	32.08	31.38	37.02	40.99	35.83	33.77	34.34	35.57	35.06
Republic of Lithuania	33.33	35.69	32.22	37.14	32.88	36.10	34.08	32.94	34.40	34.32

Table 2

The Dynamics of the Economic Development Index

Economic Development Index	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Šiauliai County	33.33	40.71	43.50	39.44	34.60	28.51	31.03	40.93	34.20	35.02
Telšiai County	33.33	54.96	45.98	41.27	27.57	31.59	32.29	40.46	35.27	33.36
Republic of Lithuania	33.33	42.61	40.59	39.43	32.84	27.98	30.58	38.12	36.00	34.71

of the respective ministries. The causes of changes in the statistical data have been explained by the six sustainable development experts.

Results and Discussion

Environmental state. Table 1 shows that in 2005 Šiauliai county stands out, with the environmental state index much bigger than that of Telšiai county or Lithuanian average. The greatest influence on the leap of the index was substantial growth of the indicator of discharges of agricultural, manufacturing and household waste water into surface water (purified according to the norms); the same indicator had an impact on the environmental state index in 2010 and 2012. In 2006, the index in Šiauliai county was lowest during the whole period under observation because of the discharge of gases and liquid materials, sulphur dioxide, nitrogen oxide, volatile organic compounds and other pollutants into atmosphere from stationary sources. In 2008, the index of Telšiai county stands out, the increase of which was determined by the figure reflecting discharges of agricultural, manufacturing and household waste water into surface water (purified according to the norms). The comparison of the environmental state index of 2004 and 2013 shows that in Šiauliai county the environmental state substantially worsened (by about 8.4%), while it improved in both Telšiai county (by about 5.2%) and in Lithuania (by about 3%).

Economic development. Table 2 shows that, differently from the environmental state index, in 2005 it is not Šiauliai but Telšiai county that stands out

in economic development. Such a leap was caused by a marked growth in direct foreign investment. After Lithuania's accession to EU, European funds were made use of and more investments were attracted in 2005. Besides, in Telšiai county the greatest part of foreign investment was attracted by Polish oil processing plant AB 'ORLEN Lietuva', operating in Mažeikiai region. From 2008 to 2010 there is a pocket in both counties as well as in Lithuania because Lithuania was part of the global economic crisis and as a result economic development has slowed down. The comparison of the economic development indices of 2004 and 2013 shows that during the decade economic development in Šiauliai county grew a lot (about 5%), while in Telšiai it remained almost the same, and in Lithuania it increased substantially (about 4.1%).

Social development. In Table 3, the increase of the social development index in Telšiai county in 2005 stands out; it was determined by a positive change in the natural demographic trends. In 2009 the same county had the lowest index, caused by the increase of the level of unemployment and a negative change in the natural demographic trends. In 2012, the improvement of these indicators caused growth of the social development index; however, in 2013 a substantial decrease of the indicator of the natural demographic trends determined the decrease of the index of the whole Telšiai county. It can be argued, that social development both in Lithuania and Šiauliai and Telšiai counties during the decade was most consistent, because the values of the social development index did not have such great leaps as economic development

Table 3

The Dynamics of the Social Development Index

Social Development Index	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Šiauliai County	33.33	32.50	34.67	35.66	34.15	30.02	29.46	35.32	33.29	34.42
Telšiai County	33.33	41.35	36.12	34.29	33.15	27.17	30.87	34.58	36.91	30.60
Republic of Lithuania	33.33	33.42	35.09	35.15	32.39	30.13	30.15	35.01	34.76	33.71

and environmental state indices. The comparison of the values of social development indices in 2004 and 2013 shows that during the decade social situation according to the 5 key social indicators in Šiauliai county has improved (by about 3.3%), while in Telšiai county it has substantially worsened (by about 8.2%), and in Lithuania it slightly improved (by about 1.1%).

Figure 1 shows that Šiauliai county integrated sustainable development index fluctuates a lot, especially during the period of 2004 and 2008. Between 2008 and 2010, Šiauliai county as well as Lithuania was affected by the economic crisis, followed by the recovery and the growth of the index, but in 2013 the index plunged again by 7.6%. In 2005, compared to 2004, the integrated index of Šiauliai county increased by even 30.5%, while in 2006 it decreased by 19.8%. In 2007, the index grew by 9.1%, but in 2008 it again fell down by 13.4%. The comparison of the value of sustainable development

index in 2004 and 2013 shows that during the decade the value of sustainable development index in Šiauliai county essentially remained the same.

As can be seen in Figure 2, Telšiai county integrated sustainability index in 2005 in comparison with 2004 (base year) increased by even 28.4%, while in 2006 it decreased by 11.6% and kept decreasing until 2009; after the economic crisis having an impact on the whole of Lithuania it started growing again, however, since 2012 it has been decreasing. In 2013, a sharp drop of 8.8% can be seen again. The comparison of the value of sustainability index between 2004 and 2013 shows that during the decade Telšiai county sustainability index decreased by 1%.

As is demonstrated by Figure 3, the integrated sustainability index of the Republic of Lithuania is fluctuating a lot; an especially sharp fall is noticed during the global economic crisis between 2008 and 2010, which was relatively worse than in Šiauliai and

Sustainability Index of Šiauliai County

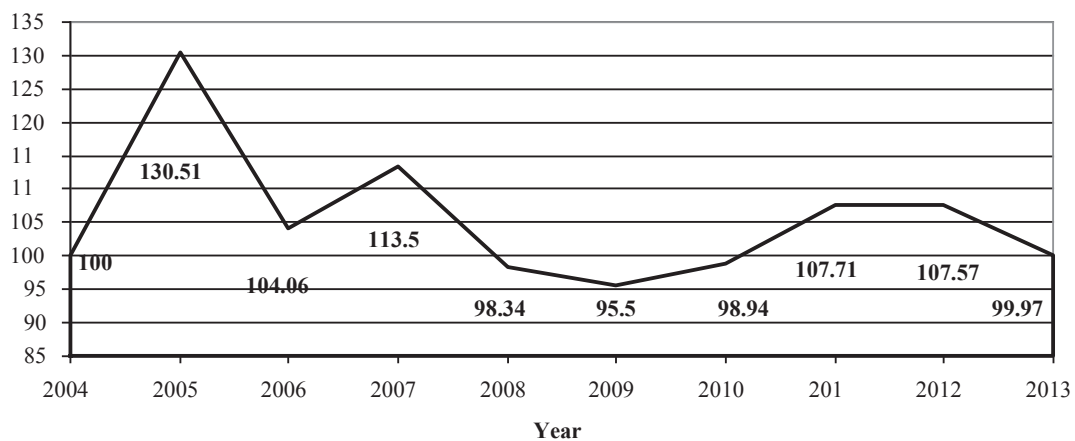


Figure 1. Integrated sustainability index of Šiauliai County in 2004 – 2013.

Sustainability Index of Telšiai County

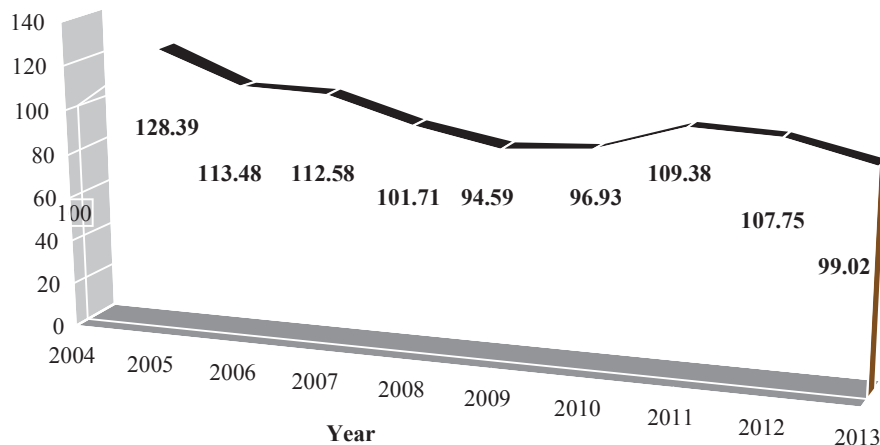


Figure 2. Integrated sustainability index of Telšiai County in 2004 – 2013.

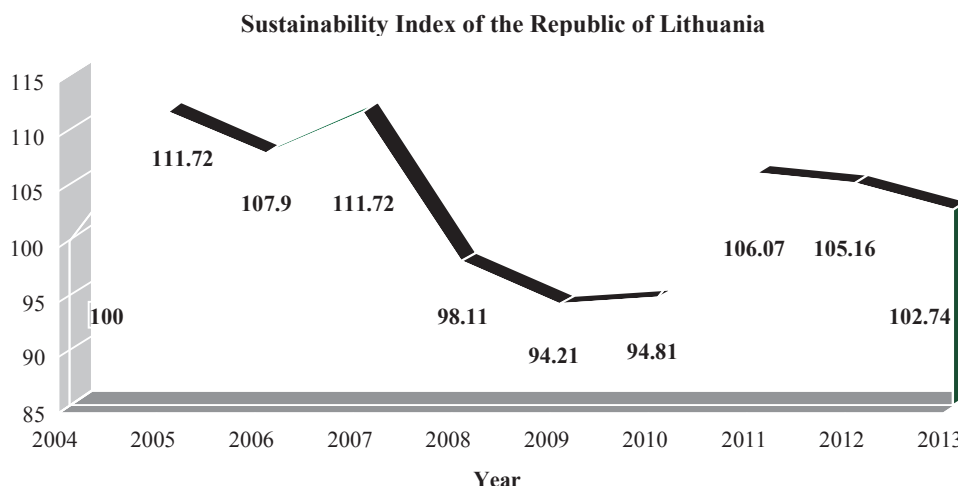


Figure 3. Integrated sustainability index of the Republic of Lithuania in 2004 – 2013.

Telšiai counties. In 2005, the index for the country increased by 11.7%, while in 2008 it decreased even by 12.2%. In 2011, the increase reached 11.9%, but it was followed by a decrease again. The comparison of the values of sustainability index between 2004 and 2013 shows that during the decade the value of the sustainability index of the Republic of Lithuania increased by 2.74%.

Summing up the outcomes shown in Figure 1 – Figure 3, it can be stated that sustainable development of Šiauliai and Telšiai counties and the Republic of Lithuania during the period 2004 and 2013 was very similar. Due to the first EU investments in 2005 – 2007 there was a substantial improvement of economic and social situation, environmental protection was improving as well. However, the global economic crisis of 2008 – 2010 interfered with the sustainable development of Lithuania and mentioned counties. In 2011 – 2012 the situation with sustainable development started improving again, but not as much as in 2005 – 2007. In 2013 the recession in fact brought sustainable development of Lithuania, Šiauliai and Telšiai counties back to the level of 2004.

Conclusions

Sustainability indicators are most often measured at the national level, less often at the level of separate territories of the country. Usually the research literature views it as a drawback and recommends providing more indicators for separate cities and regions of the country. The situation is the same in the Republic of Lithuania: the Department of Statistics of Lithuania provides only a part of values of the indicators for all 60 municipalities of the country out of the list of 84 indicators compiled by the National Strategy for Sustainable Development. Somewhat more sustainability indicators are provided for the ten counties of Lithuania. However, some sustainability indicators are provided by the Department of Statistics

of Lithuania only at the national level. The values of separate indicators for municipalities can be obtained from the information provided by various ministries of the Republic of Lithuania.

The analysis of integrated sustainability indices has shown that sustainable development trends of separate counties (Šiauliai and Telšiai) are essentially the same as those of the Republic of Lithuania. Besides, as has been stated by most of the interviewed experts, measuring some sustainability indicators below the national level is inappropriate because their values in smaller territories are similar to those at the national level. This is typical not only of the environmental state indicators (air, water pollution), but also of some economic and social indicators. That is why it can be concluded that the tradition of measuring sustainability indices and providing information about them in the Republic of Lithuania is optimal and practically justified.

As has been shown by a more detailed statistical analysis of sustainability indicators and expert views, there is a tendency for the air pollution in the form of particulate matter to increase in Šiauliai county, especially during the cold period of the year. While in Telšiai county the indicators of water and forestation are improving due to the new wastewater (sludge) treatment plants and EU investments to increase the area of the forest. Direct foreign investments in Šiauliai county have the tendency to increase, while in Telšiai county they are on the decrease. It is known that export-oriented companies attract most foreign investment. Municipalities can contribute by allocating funds for the improvement of the infrastructure. Material investments in both counties are below the national average. In Telšiai county, road haulage and passenger transport is very low, the number of tourists and accommodation places is also inadequate. The indicator of the natural population replacement is negative not only in the analysed

counties but in the whole country. The number of students in higher or tertiary education in Telšiai county is very low, Šiauliai county also lags behind in these terms from Kaunas and Vilnius counties. These numbers respectively cause the lower level of qualifications of the working population.

The research has shown that the trends for development of sustainability in Telšiai and Šiauliai counties could be as follows: 1) more investments should be allocated for the decrease of air pollution by employing EU investments and municipal funds for the implementation of the projects; 2) it is necessary to perform detailed feasibility studies of the counties in order to attract more investments and tourists by emphasising the originality of the region; 3) it is

important to take good care of the road infrastructure, to provide better conditions for the establishment of more export-oriented companies, to make a more efficient use of internal resources of municipalities for the stimulation of economic processes; 4) to improve the indicators of natural population replacement, more attention should be paid to the development of educational and health care systems, to providing better conditions for living, work, development and making families; 5) to make a more efficient use of the opportunities to train and update professionals in demand for the region; 6) to essentially increase the preparation of projects to attract EU investments in the counties in order to implement the goals set in their strategic development plans of 2014 – 2020.

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THE QUINTUPLE HELIX MODEL: WAY OF REGIONAL DEVELOPMENT CENTRES IN LATVIA TO SMART PUBLIC ADMINISTRATION

Linda Sunina, Baiba Rivza
Latvia University of Agriculture
linda.sunina@talsi.lv

Abstract

People in their lives are divided into different social groups that cooperate with each other; all people are involved in many social groups at one time that may depend and mutually cooperate. The article shows how regional development centres Talsi and Cesis cooperate with other society groups in their territory to develop a smart public administration. The cooperation level was determined by a survey that was provided to the municipality workers, NGO members, and employees in higher education institutions, companies and mass media. The results show that the cooperation is above average, though a lot of work should be done to provide smart public administration in territories. Both municipalities are similar in their size, municipality structure and used cooperation approaches, therefore it is essential to learn from each other to receive greater loyalty from residents and improve cooperation that is significant for smart administration.

Key words: the Helix Model, development centres, smart administration.

Introduction

Individual human beings are, and always have been, completely dependent on the rest of human society and the ecosystem for their economic well-being. Therefore, humans perceive their well-being in reference not only to economic outcomes, but also in terms of changes in their social and natural environments. The expanded interrelationships among people, businesses, organisations, social groups, governmental agencies, and other groups bring about very complex economic and social structures that can generate an almost infinite variety of outcomes (Berg, 2012).

According to forecasts of the World Bank, the number of residents in cities will double by 2050. Already in 2030 six out of ten people will live in cities and towns, and specific weight of city dwellers will increase to seven out of ten by 2050. Such urban globalisation demands new methods in urban planning, innovative solutions for the improvement of infrastructure, as well as the necessity for well-timed prevention of different problems, such as overpopulation, lack of energy, and environment pollution (United Nations, 2014).

In relation to the abovementioned facts, a new term has appeared in Europe – Smart City that is a general strategy, the aim of which is a long-term development and negotiation of such difficulties as social insecurity, lack of working places and low energy efficiency. Currently, there are vast discussions about precise functions and criteria for measuring the ‘smartness’ of cities, as well as a general concept of the smart city that has been based on six basic elements, i.e., smart economy, infrastructure, environment, residents, buildings, and administration.

Latvia as a member state of the European Union follows the current trends and cities and towns already think of being smart, not only providing

smart technologies and buildings, but also starting their way to smart public administration. It cannot be done without residents’ involvement and taking into consideration the fact that residents represent different social spheres and municipality is the joint among those spheres, the direction towards smart public administration could be implemented with a smart cooperation among all spheres.

The aim of the present article is to define whether regional development centres in Latvia provide smart public administration for other society groups defined in Quintuple Helix Model, as well as provide evaluation of both centres to determine the level of current smart public administration.

Materials and Methods

The towns of regional importance, examined in the present article, are Cesis and Talsi, which were chosen due to their similarity in size, number of residents and other indicators. To carry out the present research, the authors used topic-related research papers and information available from the Central Statistical Bureau (CSB). The research methods employed were the monographic and descriptive methods, analysis and synthesis, as well as logical and constructive methods. The main data was collected from a survey that was disseminated both in Talsi and Cesis towns. The survey consisted of different questions concerning municipality cooperation with other spheres of community – higher education institutions, mass media, entrepreneurs, and public organizations (NGOs). The survey was held both in Talsi and Cesis during January and February 2016, questioning 88 units (organizations, companies, municipality deputies and employees) in total and evaluation criteria in points from 1 to 10.

Results and Discussion

The Evolution of Quintuple Helix Model

To describe the communication process in 1967, Frank Dance proposed a communication model called Dance's Helix Model. The word helical derives from 'Helix', which is defined as *an object having a three-dimensional shape like that of a wire wound uniformly around a cylinder or cone*. It shows communication as a dynamic and non-linear process. Frank Dance explains the communication process based on this helix structure and compares it with communication. In the helix structure, the bottom or starting point is very small, then it gradually moves upward in a back-and-forth circular motion, which forms the bigger circle at the top and it still moves further. The whole process takes some time to reach. Just like helix, the communication process starts very slowly and defines a small circle. Communicators share their information only in small portions to their relationships. It gradually develops into the next level, but it will take some time to reach and expand its boundaries to the next level. Later the communicators commit more and share more portions themselves. The main characteristic of helical model of communication is that it is evolutionary (Helical Model of Communication/Communication Theory, 2013).

The helix model system begins from a simple Double Helix Model that includes the contacts between academic circles and entrepreneurs, and establishes a linear relationship. Later, with the development of information and communication technologies, the role of knowledge in society and the need to develop a knowledge-based economy increase. The knowledge base of the economy is thus increasingly a part of the infrastructure of society, and there is the necessity for a proactive role for the state in science, technology, and innovation policies (Leydesdorff & Etzkowitz, 1998).

Afterwards there was a shift from a dominating industry-government dyad in the industrial society to a growing triadic relationship between university-industry-government in the Knowledge Society (Triple Helix Model). This model improves on the non-linear model that replaced linear models based on 'market pull' or 'technology push' (Leydesdorff, 2012). Thus, the Triple Helix Model is closely connected with the conception of innovation and economic development in a knowledge society, and its potential lies in a more prominent role for the university and in the hybridisation of elements from university, industry and government to generate new institutional and social formats for the production, transfer and application of knowledge. Through subsequent development, a significant body of Triple Helix theoretical and empirical research has grown over the last two decades that provides a general framework for exploring complex innovation dynamics and for informing national, regional and international innovation policy-making (the Triple Helix concept).

Quadruple Helix Model is based on the Triple Helix Model and adds as fourth helix the 'public', more specifically being defined as the 'media-based' and culture-based public' and 'civil society'. The Quadruple Helix already encourages the perspective of the knowledge society, and of knowledge democracy for knowledge production and innovation. In a Quadruple Helix understanding, the sustainable development of a knowledge economy requires a co-evolution with the knowledge society (Carayannis, Barth, & Campbell, 2012).

The Quintuple Helix Model is based on the Triple Helix Model and Quadruple Helix Model and adds as fifth helix the 'natural environment'. The Quintuple Helix Model can be proposed as a framework for transdisciplinary (and interdisciplinary) analysis

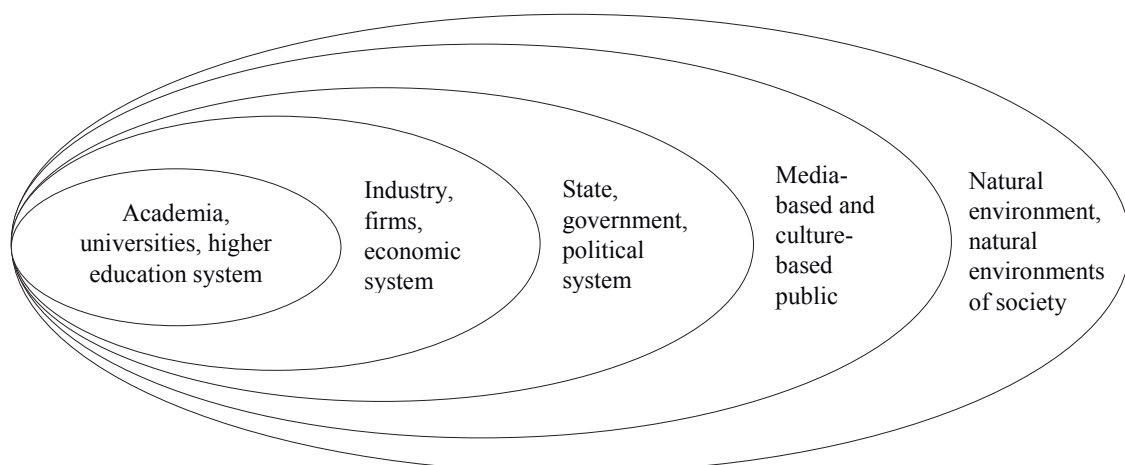


Figure 1. The subsystems of the Quintuple Helix Model (after Carayannis, Barth, & Campbell, 2012).

of sustainable development and social ecology (Carayannis & Campbell, 2010).

The European Commission (2009) identified the 'socio-ecological transition' as one of the major challenges for current and future societies and economies. The Quintuple Helix innovation model offers here an answer that is oriented toward problem-solving and sustainable development, furthermore, indicating how this socio-ecological transition may be mastered in combination with knowledge production and innovation. Therefore, nowadays the concepts of helix models encompass five elements by adding to the Quadruple Helix the natural environment factor as the fifth element in the interaction network - leading to the Quintuple Helix innovation model. The evolution of the helix model is given in Figure 1.

Figure 1 shows the following trend in the evolution of the helix model system.

1. First Helix: Academia / universities. Universities (higher education institutions) of the sciences and of the arts, as well as students, researchers, academic entrepreneurs, etc. which are the resource for creation of new knowledge and technology, the generative principle of knowledge-based economies. (Theoretical framework, 2011)
2. Second – Double Helix: Academia and industry/business. It consists of the creativity economy and the creative industries where it is possible to apply the resource of knowledge and to generate new innovations.
3. Third – Triple Helix: Academia, industry and state/government. The most important helix element for the creation of a knowledge economy is an effective state/government management policy. The maintaining of sufficient institutional capacity, active mobilisation of stakeholders through governance modes and policy coordination shows the states possibility to create a knowledge economy (European Parliament, 2015). The stable and developed economies can ensure the creation, diffusion and usage of ICT, foster investment in human capital as well as in innovations and stimulate knowledge-intensive enterprises.
4. Fourth – Quadruple Helix: Academia, industry, government and media, and culture-based public and civil society: arts, artistic research and arts-based innovation, that have introduced 'knowledge society and knowledge democracy': culture and innovation culture, knowledge of culture and culture of knowledge, values and life styles, multiculturalism and creativity, media, arts and art universities, multi-level innovation systems with universities of the sciences and arts (the Quadruple and Quintuple Helix innovation systems).

5. Fifth – Quintuple Helix that includes: Academia, industry, government, media-based and culture-based public and civil society as well as natural environments of society and economy. The Quintuple Helix finally frames knowledge and innovation in the context of the environment (or natural environments). Therefore, the Quintuple Helix can be interpreted as an approach in line with sustainable development and social ecology, and imply for eco-innovation and eco-entrepreneurship that should be processed in such a broader understanding of knowledge production and innovation. (Carayannis & Campbell, 2010; Carayannis, Campbell, & Orr, 2015)

The basic innovation 'core model' of the Triple Helix focuses on the knowledge society (and on knowledge democracy). From the point-of-view of the Quadruple Helix innovation model, it is evident that there should be a coevolution of the knowledge economy and of knowledge society. The Quintuple Helix finally stresses the socio-ecological perspective of the natural environments of society. Social ecology focuses on the interaction, codevelopment and coevolution of society (Dubina, Carayannis, & Campbell, 2012).

The background of Talsi and Cesis Municipalities

For the current research, the authors chose two towns in Latvia that, despite of the fact that one of the towns is located in Kurzeme region (Talsi, geographic position 57.246351, 22.58769), but the other – in Vidzeme region (Cesis, geographic position 57.313426, 25.266803), are similar in terms of size, number of residents, branches of universities located there, distance to the capital of Latvia etc. Both municipalities are regional centres of development of the Republic of Latvia.

Talsi town is located in the Northern part of Kurzeme, almost in the middle between Ventspils and Riga. The total area of town is 7.8 km², the number of residents – 11 371. Talsi town is the centre of Talsi municipality that is the fifth largest municipality in Latvia. The main decision-making body is Talsi Region Council, consisting of 17 council members, but public administration is implemented by Talsi Region Municipality. Talsi town is well-known for its tourism possibilities and beautiful landscape, as well as with different events and festivals. After the implementation of administrative-territorial reform, Talsi municipality lost direct exit to sea and natural tourist flow in summer decreased; due to global crisis the town experienced massive emigration wave, thus the local government needs to rethink tourist and resident attraction possibilities and implement smart specialization in different fields.

Cesis town is located in the Northern part of Vidzeme; the town also is one of the 21 regional development centres of Latvia. The total area of town is 19.28 km², the number of residents – 15 666. The main decision-making body is Cesis Region Council, consisting of 15 council members, but public administration, similarly to Talsi, is implemented by Cesis Region Municipality. Cesis also experienced the emigration wave during the global crisis, but currently the municipality has worked out re-emigration program with the help of which the municipality will try to return its residents. Cesis is well-known for its nature and various culture and arts festivals, beautiful and interesting architecture, famous people and versatile tourism proposal, therefore it can be defined that Cesis has proven its smart specialization in culture, tourism and arts.

Way to smart public administration

Smart public administration can be defined as a balanced administration that takes into consideration the needs of all community, including four abovementioned environments – higher education institutions, public organizations, companies, and mass media. It is very essential to cooperate among them, since it leads not only to smart public administration, but also to smart economy and smart residents, forming the concept of smart city. The Quintuple Helix Model helps to analyse the current situation and show future trends for improving the cooperation, building stronger and smarter environment and society.

The article further on analyses the current public administration trends according to the Quintuple Helix Model in both municipalities – Talsi and Cesis, showing current situation, similarities and differences between them and stressing further improvements to be done on their way to smart public administration.

Municipality and higher education institution cooperation

Despite extended mobility the municipalities must think of services that can be offered in their territories, and higher education is one of the key factors that will be taken into consideration in time of changing place of settlement, furthermore – a presence of higher education institution (hereinafter – HEI) in a particular territory increases its prestige. Both Cesis and Talsi municipalities have two higher education branches in their territory; the closest HEI is located in 50-80 km area (Valmiera, Ventspils). Every year all programs of these HEIs have students, studying for their degrees, therefore it can be stated that all these HEIs play a significant role in municipalities' life.

In order to evaluate the current cooperation between Talsi and Cesis municipalities and their HEIs both employees of municipality and HEIs were

surveyed and their opinion in five aspects were taken into consideration.

As concerns to publicity in local mass media, responsiveness in different HEI events and projects, Talsi municipality shows more interest, however, Cesis municipality provides more real action, such as guest lectures, material and financial support for HEI. Both municipalities have the same evaluation in implementation of educational projects. Furthermore, it has to be determined that responses from employees in Cesis municipality are more homogenous, which means the activities of Cesis municipality are more visible to others.

There is no single formula that would say that some criteria are better than others for smart public administration, since all criteria are significant, but both municipalities should take into consideration that activities concerning public relations must be closely connected to work and vice versa. Current situation shows that Talsi municipality manages the public relations without any real work, but Cesis municipality, in its turn, provides real projects, gets involved in different activities, but there is no external information to society.

Municipality and public organizations

According to the data of Central Statistical Bureau, there are 152 foundations, societies and associations in Cesis and 227 foundations, societies and associations in Talsi in 2015, respectively. It is a great number of different NGOs, registered in both municipalities, though local authorities of NGOs in both municipalities confirm that only one third of all registered units are economically and socially active. Both municipalities have one or two strong core organizations that are well-known in their field in all Latvia – Talsi County Fund and Kurzeme NGO Support Centre in Talsi Municipality and Science centre Z(in)oo and Cesis Forum in Cesis Municipality. Different other NGOs with delegation contract implement the functions of municipality, for example, Talsi Crisis Centre works with socially vulnerable people etc. It is a quite common situation when different municipality functions are delegated to NGOs that have previous experience and better knowledge of how to provide such services – more often NGOs get involved not only in social field, but also in culture (culture funds), sports (different clubs), education etc., implementing a very important role in society's daily routine.

The cooperation with NGOs has always been quite controversial, since organizations would like to be involved in municipality work to a greater extent than it is, but it cannot be implemented due to laws and regulations restricting that and also because of lack of manpower and experience in a particular field (see Table 1).

Table 1

**Cooperation among municipality and public organizations
(societies, associations, NGOs) in Talsi and Cesis municipalities, points**

Criteria	Talsi			Cesis		
	min	max	mean	min	max	mean
Cooperation of municipality with local NGOs in different fields	4	9	6.53	2	9	6.40
Municipality support (material, financial etc.) for the provision of NGO work	4	8	7.36	4	10	7.20
NGO projects, implemented in cooperation with municipality	5	8	7.37	3	9	6.40
Level of NGO involvement in municipality work (commissions, consultative boards, provision of different functions etc.)	2	8	6.05	1	7	4.90

After the survey it can be seen that, though the results are quite average, the current situation in Talsi municipality is better than in Cesis, especially in NGO involvement in the municipality work, where results of Cesis are below average, showing a low involvement level. Talsi municipality is currently trying to delegate more functions in culture and sports field and encourage people to form clubs for implementing sports activities, tournaments, championships, and survey results show the improvement in cooperation area and the right direction to smart administration.

The results of Cesis municipality are heterogeneous and none of the results are higher than those of Talsi municipality which show that cooperation between the municipality and NGOs in Cesis municipality currently is not developed to a high level and since organizations implement very important actions for the society in total, the cooperation improvement between both sides is highly recommended.

Municipality and companies

It is essential that the development of regional centres are subjected to the number of economically active companies that are not only located in a particular territory, but also have their legal address registered there in order to receive personal income tax, hence municipalities should be closely interested in the establishment and development of companies in their territory. Companies provide working places for local residents, which is the key factor for people when choosing their place of settlement. If NGOs mainly implement social functions and activities, then companies take care of the economic side, consequently.

Both regional centres are struggling to attract companies in their territory due to the proximity of Ventspils and Valmiera, which are cities of national level. Both Talsi and Cesis intensively think of attracting new companies, putting emphasis on small

and medium-sized companies that provide niche production, but also providing vast areas for big companies, establishing industrial areas.

Survey results show controversial attitude and cooperation trends – though all results are above average, the trend is slightly negative (see Table 2).

Cooperation between Talsi municipality and companies is slightly lower than in Cesis municipality despite different cooperation models, such as Talsi Businessmen Club, Entrepreneurship Council, joint seminars and discussions. Survey answers of company representatives show the current cooperation is not so successful as expected and further on municipality must think of new approaches, how to involve companies into municipality's work to give entrepreneurs the possibility to make decisions concerning society and economy on a local level. Cesis municipality, in its turn, should think of common projects in business field, creating new, interesting ideas, and promoting new entrepreneurial ideas.

Municipality and mass media

Mass media and information itself is a new force nowadays, and every society group tries to use it more and more efficiently. If some time ago our only sources of information were radio, TV and newspaper, then now it is possible to receive information in every possible way – there are different social networking possibilities like home pages, Twitter, Facebook etc., as well as newspapers and magazines that are becoming more interesting and approaching all types of target audience.

Municipalities also have their own sources hot to distribute information about events in their territory – Talsi has their own television, two local newspapers (one is owned by the municipality), a home page and active accounts in Facebook, Twitter and in local social media draugiem.lv (social platform for friends). Cesis municipality has one local newspaper with a

Table 2

**Cooperation among municipality and companies
in Talsi and Cesis municipalities, points**

Criteria	Talsi			Cesis		
	min	max	mean	min	max	mean
Municipality support to companies (tax refunds, seminars, technical support, promotion of identification etc.)	3	9	6.48	2	10	6.09
Projects in the field of entrepreneurship, implemented in cooperation with the municipality	4	8	6.10	2	8	5.59
Educational initiative of the municipality to promote mutual cooperation	4	9	6.33	2	10	6.41
Level of company involvement in municipality work (commissions, consultative boards, provision of different functions etc.)	1	8	5.43	2	9	6.00

home page, municipality home page and active social network accounts, which provide information for the Internet users. Broadcasting is performed by regional television and radio in Valmiera.

Cooperation with mass media is good, which can also be seen after the results, though data is comparatively heterogeneous. Currently it can be seen that interest of municipality is comparatively higher to provide and distribute information from mass media, which is a common situation nowadays, when there is much information to choose from. Cesis municipality works with mass media in order to make a good image, but Talsi tries to provide information in regional and national level. Both approaches are good, though they need to be balanced – information provided should be interesting for different target audiences in different places of Latvia and promote a good image of municipality. It can be done with the help of Internet and social networks that are cost-efficient and reach more readers. Both municipalities do not work with mass media frequently, which is one of the greatest mistakes from the viewpoint of territory marketing and on their way to public administration both municipalities must rethink their marketing strategy.

Current cooperation – way to smart public administration

Cooperation is a significant factor in municipality’s way to smart public administration. This article provides analysis of municipality cooperation with different society groups taking into consideration various factors that make the total cooperation index (see Figure 2).

Both municipalities are on their way to smart public administration – they both have strong cooperation with higher education institutions and mass media, though the cooperation with companies should be improved since companies are the economic milestone for every territory. It could be done in different ways by offering tax refunds, making joint seminars, discussions, providing information about companies in their social networks. Cooperation can be also achieved by implementing joint projects in the result of which the true beneficiaries are all members of the society.

The same situation appears in cooperation with non-governmental organizations – although the cooperation level in Talsi municipality is higher than in Cesis, there can be some improvements made.

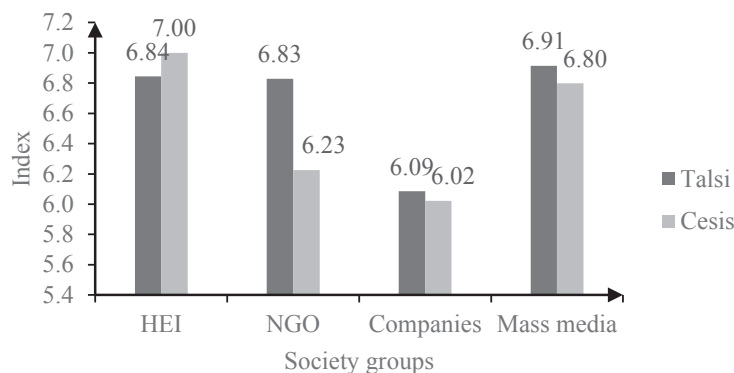


Figure 2. Total cooperation indexes for Talsi and Cesis Municipalities.

Almost all residents are involved in some kind of organizations, which means that cooperation with organizations is indirect cooperation with the society itself. Furthermore, taking into consideration the next planning period of the European Union when a great amount of financing will be provided for organizations, not municipality and state institutions, and cooperation improvement with organizations would give also a financial contribution to the development of the territory.

Conclusions

In order to determine a way to smart public administration cooperation among five groups – municipality, NGOs, mass media, HEIs, and company – were surveyed. During survey, the authors revealed that current cooperation trends in both municipalities are above average, in a range of 5 to 7.

Talsi municipality is more responsive to different HEI events and projects, however Cesis municipality provides more real action, such as guest lectures, material and financial support for HEI.

The cooperation with NGOs is better in Talsi municipality, especially in NGO involvement in the municipality work, where the results of Cesis are below average, showing low involvement level.

The cooperation between Talsi municipality and companies is slightly lower than in Cesis municipality

and survey answers of company representatives show that the current cooperation with Talsi municipality is not so successful as expected and further on municipality must think of new approaches to involve companies into municipalities work.

Cesis municipality works with mass media in order to create a good image, but Talsi tries to provide information in regional and national level. Both approaches are good but municipalities should think of more extensive work in Internet, where they can choose distributable information by themselves.

Both regional development centres have all the conditions to build knowledge economy and knowledge society in their territories that is the key base of smart, skilful and knowledge-based administration, but it cannot be done without involvement and cooperation of the abovementioned society groups.

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CONTENT MARKETING DECISION APPLICATION FOR RURAL TOURISM DEVELOPMENT: CASE STUDY OF 'JLANKOS SODYBA'

Aušra Pažeraitė, Rūta Repoviėnė

Vytautas Magnus University, Lithuania

ausra.pazeraite@lei.lt; ruta.repoviene@gmail.com

Abstract

The paper presents theoretical and practical aspects of content marketing decision application for rural tourism development using a case of a farmstead 'Jlankos sodyba'. The first part of the article deals with theoretical insights into content marketing ability to stimulate rural tourism development. Results of literature review reveal that there are connections between elements of the content marketing and rural tourism development, which means that the use of content marketing can be economically valuable for the wider range of the farmsteads. The second part of the paper focuses on the case analysis of the farmstead 'Jlankos sodyba'. In order to explore how the application of content marketing decisions can impact rural tourism development, an experiment of content marketing usage in search advertisement of selected farmstead was carried out. Separate content marketing elements were involved in search advertisement and changes of advertisement effect upon the customers were measured. The given results show that content marketing elements can improve the chosen advertisement effect upon the customers. This leads to presumption that the wider use of content marketing can improve not only the effect of separate marketing tool, but also can contribute to the development of rural tourism. The paper concludes with findings and discussion; limitations and future research possibilities are given as well.

Key words: rural tourism, content marketing, search advertisement.

Introduction

Rural tourism is a growing and evolving process related to the natural, cultural, social and economic resources for business development. In Lithuania as well as in many other fast developing countries, tourism is becoming a very significant and rapidly growing industry (Gargasas & Veėerskas, 2013; Grigalūnaitė & Pilelienė, 2014). The analysis of rural tourism reveals advantages of this activity: it is a valuable tool for the sustainable development of rural areas and it makes a significant contribution to the rural economy and to the wider tourism (Pena *et al.*, 2014; Haven-Tang & Jones, 2012; Phillips *et al.*, 2011). For this reason, scientific research and development of the valuable methodologies become more and more important in the field of rural tourism development.

One of the main problems for rural farmstead owners is the high level of competition and lack of effective marketing programs. With the increasing competition among the rural tourism destinations, successful marketing actions become very important for the specific rural destinations in order to profitably operate in the market. Consequently, tourism business operators should take advantage of the increasing public interest in rural tourism and its environment. With the aim of attracting potential users and increasing their loyalty, the owners of rural tourism farmsteads should form a positive image of their business in the market (Ramanauskienė & Narkus, 2009). The company's ability to utilize proper marketing tools through the virtual space is extremely important (Išoraitė, 2013; Rose, 2014).

Aggregated results from different studies provide evidence that digital marketing has a great impact on online and offline sales (Khraim, 2015). Therefore, the business and scientific community has begun to discuss about the importance of the content and its quality (Gagnon, 2014; Hanafizadeh & Yarmohammadi, 2015). P. Hanafizadeh & M. Yarmohammadi (2015) mention that content is the origin of communications. Discussions about the content marketing benefits and application to business show the importance of knowing how the content quality affects consumers in different marketing channels and how it can be used for rural tourism development.

Therefore, the scientific problem of this research has been formulated as follows: how the application of content marketing decision can impact rural tourism development. Accordingly, the object of the research is application of content marketing decision impact on the rural tourism development. The aim is to reveal the impact of content marketing decision application on the rural tourism development.

To achieve the aim of the article, the analysis and synthesis of scientific literature have been used. In order to explore the impact of content marketing decision application on the rural tourism development, one-shot experiment has been accomplished and quantitative analysis is given as well.

Materials and Methods

According to A. B. Radac *et al.* (2012), economic benefits from rural tourism can take such forms as employment, increased spending in the community, economic diversification, farmers markets and

infrastructure. Rural tourism is an increasingly important diversification activity for the progress of rural destinations (Brandth & Haugen, 2011). Rural tourism is one of the most fast growing economic segments that deals with challenges and opportunities of global competitive market (Gargasas & Večerskas, 2013; Snieška, Barkauskienė, & Barkauskas, 2014).

However, Lithuanian Department of Statistics data (2016) shows that rural tourism development has not been that intense in recent years and the number of farmsteads has decreased by 1,1 percent. On the other hand, a growing number of guests in rural tourism farmsteads can be clearly seen (Snieška, Barkauskienė, & Barkauskas, 2014). Therefore, the growing consumer interest leads to increasing competition for consumer attention among the farmsteads. Competition fosters companies to think about their marketing activities and to find ways to reach the potential customers. One of the keys of successful tourism business is a high-quality communication with customers. Moreover, it is a key for new opportunities (Radac *et al.*, 2013) as well. Over the years, the communication boundaries and spaces are expanding. Therefore, more and more scientists (Tsekouropoulos *et al.*, 2012; Keramati, Samadi, & Nazari-Shirkouhi, 2013; Andreopoulou *et al.*, 2014) and entrepreneurs pay attention to communication on the Internet. Moreover, according to researchers (Ionel, 2013; Jha, 2012), tourism marketing and efficient advertising of tourism across the region and private firms is one of the main factors of rural tourism development.

The importance of Internet in the tourism industry has increased dramatically in the past decade. Also for rural tourism, virtual space offers huge opportunities for progress and benefit, and new prospects exist for economic growth, better service delivery, social and cultural advances (Tsekouropoulos *et al.*, 2012; Andreopoulou *et al.*, 2014). Internet provides various advantages and benefits by offering a rich, dynamic environment for the exchange of information and resources. For achieving potential benefits such as cost reduction, improved quality of services and access to technological expertise, information technology is a favourable option for many enterprises, including rural tourism (Keramati, Samadi, & Nazari-Shirkouhi, 2013). Customers and potential clients own a leading role in customer-oriented marketing philosophy, and the Internet can fulfil this desideratum with the aid of the technology it uses (Vasilescu & Negrut, 2009). Many tourism enterprises make use of online marketing worldwide as the Internet has been recognized as the most powerful marketing tool. Internet has been extremely important for the promotion and increase in sales of the enterprises (Tsekouropoulos *et al.*, 2012). Therefore, we believe that deeper understanding of online marketing and better application can contribute

to the development of rural tourism and, namely, farmsteads.

Researchers (Pena *et al.*, 2014; Tsekouropoulos *et al.*, 2012) have admitted that the Internet has much to offer to rural tourism companies in terms of promoting their respective service offers, yet, although the online medium enables firms to convey large volumes of information, the user's ability to process that information is limited. This limitation can trigger information overload among users which, in turn, can lead to poor decision-making processes. The efficiency of the promotion activities of rural tourism services can be achieved by using information which is valuable for customers. Thus, when firms use the Internet as a means of promoting their offer, it is vital that they select only the most relevant information pertinent to each client group they wish to reach with their message (Miu, 2012; Pena *et al.*, 2014).

Researchers (Rowley, 2008; Wulf, Schillewaert & Muylle, 2006) concentrate on the content quality as one of the factors determining the attractiveness of virtual information to the consumer that afterwards has influence on consumer confidence, satisfaction and loyalty. Unique and valuable content is becoming a primary goal for companies (Gagnon, 2014; Rose, 2014) that seek to attract consumers. However, a website does not serve only as an informative tool. Many features and capabilities of the website allow a business to actually market a product, and effectively so, as it is able to target and draw customers through expressions unique to the destination product (Srikanth & Liping, 2006). The content of the tourism destination websites and other virtual products is particularly important, because it directly influences the perceived image of the destination and creates a virtual experience for the customer (Andreopoulou *et al.*, 2014). Content quality of tourism enterprise websites is becoming a critical issue for effective online marketing.

Due to the increasing importance of content, new marketing trends appear. One of the most significant among them is content marketing. Authors of this paper believe that content quality takes place of the growing importance in the virtual space, and becomes a weapon helping to earn the sympathy of consumers. As the content marketing is a strategic marketing approach focused on creating and distributing valuable, relevant, and consistent content to attract and retain a clearly-defined audience and, ultimately, to drive profitable customer action (Content Marketing Institute, 2015).

The dialogue between the two parties – the enterprise that offers a service and its customers – represents a vitally important element of relationship marketing which helps to build customer loyalty (Andreopoulou *et al.*, 2014). Although the quality of

information and valuable content is one of the ways to establish a dialogue with the consumer, one can see, that content marketing has an interface with other types of marketing, namely, relationship marketing. The creation of content-based marketing program is more than the creation of virtual promotional advertisement (Gagnon, 2014; Chasser & Wolfe, 2010). Development of valuable content should play an important role in marketing programs and their planning process.

Marketing of rural tourism should be based on principles of mutuality, trust and empathy. It would also involve developing a culture of mutual value sensing, nurturing and process-oriented which is humane and holistic and not excessively 'commercial' outcome focused (Jha, 2012). Creation of the advertising message based on the quality content is the new way of branding. And, as H. Chen & S.H. Mathew (2014) marked, that building a strong brand name has become a critical marketing activity for tourism businesses. A strong brand can help firms in attracting, obtaining, and retaining their customers.

Authors (Ružkevičius & Guseva, 2006; Chasser & Wolfe, 2010; Gagnon, 2014; Abel, 2014; Schuinanii, 2014) mention several features of quality content. These features can be perceived as single content marketing elements. Seven characteristics that should be included in high-quality content are listed below:

- Relevance
- Informativeness
- Reliability
- Value
- Uniqueness
- Emotions
- Intelligence.

Authors of this paper hold the opinion, that the content-based marketing elements are influenced not only by user's perspective, business type, but also by the technology used. Information can be provided for customers in many different feeds, and this variety complicates work of marketing professionals or owners of farmsteads, who intend to use content marketing. As R. Vasilescu & C. Negrut (2009) mentioned, Internet users are one click away from numerous Web pages and software applications which facilitate communication, information and idea exchange. When a site is built, its owner fall prey to the trap of Internet coverage: they believe that the Internet is so extensive that visitors will access the site anyway. This is true, but the visibility of the website is difficult to obtain when search engines index is approximately one billion Web pages. As a result of this, some farmsteads use search advertisement in order to get more visitors for their websites. We believe that content marketing can improve the effect of various online advertising channels and contribute to

the development of rural tourism. Therefore, the next part of this paper deals with the experiment in order to explore how the application of content marketing decisions affects search advertisement effect using the case of a particular farmstead.

Results and Discussion

Experimental designs are the quantitative research designs most closely associated with an action or applied research. An experiment involves the creation of a contrived situation in order to get information about the effect of an independent variable (X) on a dependent variable (Q1). The research will be carried out on the pre-experimental research bases. With this type of experimental project, we aim to check the impact of the independent variable on dependent variable, but not seeking to find out whether there are other secondary factors influencing the outcome.

A farmstead 'Īlankos sodyba' which is located in Lithuania was chosen to perform the pre-experimental research. This farmstead started its business in 1998. The farm stay 'Īlankos sodyba' offers various services and attractions for the customers: water entertainments, a bar, a private beach, hiking tours, ceramic workshops, a ballroom etc. The company also offers services for private celebrations or business meetings. The main target group - people who are looking for a quiet holiday place. Up till now, about 90% of advertising budget are allocated to the online marketing. The farm stay 'Īlankos sodyba' uses communication in social networks, publications in various directories, but search advertisement is considered as the most important marketing tool. Company has used Google AdWords advertising constantly from 2013. However, this type of advertising is very popular in rural tourism sector, and the competition for user clicks is huge. Therefore, the owners of the farmstead are still looking for new ways to improve the advertisement effect upon the customers.

The pre-experimental research was conducted in the spring of 2015 and lasted a month. The spring is quite an intensive period for the summer holidays to plan. During the experiment, Click-through rate (CTR) was measured by using different content marketing elements (X) in a text Ad. CTR is an indicator of Internet user interest on a particular Google AdWords text Ad. Change of CTR (Q1) was measured by comparing previous CTR statistics with the data obtained during the investigation. We aimed to find out the impact of separate content marketing elements on an advertisement. When analyzing the statistics of the past, it was noticed that Google AdWords natural click-through rate (CTR) changes by 10%, so during the experiment CTR change is considered statistically significant only in the case if a change is greater than 10%. In order to check the

validity of the results obtained, the experiment was repeated twice in the same order. Between the first and the second test there was a week-long break. For application of content marketing decision, we selected one Ad group 'Holiday in the countryside' which includes only exact match keywords. In order to get more objective results, no other changes were made during the experiment in the selected Ad group.

Table 1 contains Ad group statistics in both trials and overall results. Although the main focus is on the X (element) impact on the Q1 (click-through rate), other extraneous factors such as cost-per-click (CPC) and the average Ad position (Av. Pos.) were taken into account as well. Actually, the following indicators may also be affected by X. This kind of analysis leads to the practical insights and opens new opportunities for research in the future, because both of the mentioned indicators show the quality of Google AdWords Ad.

Before the experiment, the Ad group 'Holiday in the countryside' had 10.88% CTR, one click cost about 0.22 € and Ad was shown on average 1.9 position. With regard to the effect of content marketing elements, we can see that not all elements made a positive impact on CTR. Four elements had positive, one negligible and two had a negative effect on CTR (see Table 1). The relevance and uniqueness can be distinguished as the most significant elements. Both of them increased CTR almost twice. Relevance of Ad and matching of the user's search query both are inseparable from Google AdWords policy. Therefore, improving the Ad text and connection with keywords has a significant effect on the advertisement impact. As it was mentioned earlier, online communication and advertisement are widely used in rural tourism enterprises. The logic and results of experiment clearly show that the uniqueness is taking an important place.

Table 1

Results of the experiment

Test 1						
Element (X)	Clicks	Impressions	CTR (Q1)	Change (%)	CPC (€)	Av. Pos.
Relevance	9	42	21.43	+ 96.96	0.3	1.4
Uniqueness	8	37	21.62	+ 98.71	0.26	1.4
Reliability	4	27	14.81	+ 36.12	0.21	2.4
Intelligence	4	38	10.53	-3.22	0.2	1.3
Emotions	2	49	4.08	-62.5	0.5	2.0
Value	1	26	3.85	-64.61	0.28	1.8
Informativeness	4	29	13.79	+ 26.75	0.21	1.7
Test 2						
Element (X)	Clicks	Impressions	CTR (Q1)	Change (%)	CPC (€)	Av. Pos.
Relevance	10	48	20.83	+ 91.45	0.29	1.4
Uniqueness	8	41	19.51	+ 79.32	0.28	1.5
Reliability	5	31	16.13	+ 48.25	0.21	2.3
Intelligence	5	42	11.9	+ 9.38	0.2	1.3
Emotions	3	53	5.66	-47.98	0.42	1.9
Value	2	38	5.26	-51.65	0.29	2.9
Informativeness	5	37	13.21	+ 21.42	0.2	1.6
Overall results						
Element (X)	Clicks	Impressions	CTR (Q1)	Change (%)	CPC (€)	Av. Pos.
Relevance	19	90	21.11	+ 94.45	0.29	1.4
Uniqueness	16	78	20.21	+ 88.51	0.27	1.5
Reliability	9	58	15.52	+ 42.65	0.21	2.4
Intelligence	9	80	11.25	+ 0.34	0.2	1.3
Emotions	5	106	4.72	-56.62	0.46	2.0
Value	3	64	4.69	- 56.89	0.29	1.9
Informativeness	9	66	13.64	+ 25.37	0.21	1.7

During the experiment, all advertising positions (total of 11) were occupied. This means that competition for consumer attention is huge among farmsteads. So the use of uniqueness and exceptional features of farmstead gave positive results. The use of intelligence in the first attempt had a negative impact, in the second - positive, but the overall change has not exceeded 10%. Negligible impact could be explained by the popularity of intelligence usage. It could be assumed that advertisement is not standing out from competitors' ads. However, this element has the most positive effect on Ad position and CPC. As it may be seen in Table 1, emotions and value had a negative impact on all three indicators of Google AdWords quality.

Experimental data revealed that Ads with emotional and promotional information had the lowest CTR. This can be explained by the fact that consumers who use search engines expect high-quality, relevant and reliable information. Therefore, the advertisement should not distract them.

In terms of advertisement cost, only three elements reduce CPC, other four have a negative impact on it. The strongest influence on the price of advertisement had the use of emotions, which raised cost-per-click more than twice. Application of content marketing decision in search advertisement is not the cheapest solution for farmsteads that regularly have a strictly limited budget. The first reason is that more than half of content marketing elements had a negative influence on CPC. Another reason is the positive effect on CTR: a higher CTR leads to a bigger number of clicks, more clicks lead to increased advertisement costs.

Regarding the advertising position changes, it is noted that 4 of 7 elements have a positive effect on this. But looking at the overall results, it could be seen that a higher position not always leads to a higher CTR. Therefore, it can be assumed that content quality in advertisement is more significant than technical indicators of the advertisement.

Taking into account all the aforementioned, it could be stated that the research revealed that the application of content marketing decision has an effect on Google AdWords impact upon the customers and can be a great tool for the advertisement campaign, and even improvement of the content of website.

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Conclusions

1. Rural tourism is a valuable tool for the development of rural areas and it is becoming a significant and fast growing industry. With the increasing competition among rural tourism destinations, significance of successful marketing actions is rapidly growing. On the other hand, farmstead owners still lack effective marketing programs.
2. Many tourism enterprises make use of online marketing worldwide, since digital marketing has been recognized as the most powerful marketing tool. Digital marketing is one of the most popular frameworks to spread the message about an organization to the consumers. However, farmsteads are facing a huge competition in virtual space as well.
3. Marketing experts and scientists recognize the importance of quality content and information. Literature review has shown that high-quality content consists of seven separate elements: relevance, value, emotions, intelligence, informative once, reliability and uniqueness. Furthermore, theoretical analysis leads to an assumption that application of content marketing decision may positively affect the development of rural tourism.
4. The results of the experiment show that content marketing elements can improve the efficiency of the Ad. In order to increase Google AdWords impact upon the customer, farmsteads should use content which is relevant and unique. It is worth to note, that separate content marketing elements have an impact not only on the search advertisement effect expressed by CTR, but on other quality indicators as well.
5. Limitations of this study offer opportunities for further research. Keeping in mind that this research has focused on content marketing element influence on the effect of search advertisement, namely, in the farmstead case, for further development and wider practical application it is necessary to expand the field of research. It would be worth to carry out an experiment in the future by testing the influence of elements in different combinations in order to verify the reliability of the pre-experimental project results.

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RESEARCH OF FACTORS INFLUENCING CUSTOMER SWITCHING BEHAVIOUR IN FARMERS' MARKETS IN LITHUANIA

Kristina Zikienė, Lina Pilelienė

Vytautas Magnus University, Lithuania

k.zikiene@evf.vdu.lt; l.pileliene@evf.vdu.lt

Abstract

In recent years, farmers' markets have become one of the most popular places for alimentary shopping. People searching for the alternative and healthier products often choose farmers' markets instead of shopping centres. However, farmers' markets face the same or even tougher competition than the conventional shopping places: farmers not only compete with powerful shopping chains, they have to compete among each other for every single customer. Therefore, customer loyalty becomes inevitable in this industry. Knowing the factors that lead customers to switch to another vendor becomes very important for consumer retention. The aim of the research is to determine the factors influencing customer switching behaviour in farmers' markets in Lithuania. In order to reach the aim, the research was conducted in several stages: 1) the expert evaluation was provided to determine the factors influencing the customer switching behaviour that would be relevant to the industry; 2) a questionnaire survey regarding latter factors was provided; 3) the influence of the factors on customer switching behaviour regarding the different states of customer loyalty was assessed.

Key words: customer loyalty, farmers' markets, Lithuania, switching behaviour.

Introduction

As a consequence of globalization, local agriculture and alternative food systems continue to be a growing topic of discussion in both popular media and academic study (Betz & Farmer, 2016). Increasing consumer awareness of local foods, renewed appreciation for taste and seasonality in produce, a growing willingness by farmers to produce, process and market higher value food products create a foundation for the emergence of farmers' markets (Hamilton, 2005). Moreover, being the places of commerce and social life, farmers' markets have historically been the centres of urban life: some of these markets are much more than outlets for produce, and function as restaurants and grocery stores. (Francis & Griffith, 2011). According to Åsebø *et al.* (2007), one of the reasons why the concept of farmers' market has achieved success in an increasing number of cities is the immediacy between producer and consumer. Being a space for direct marketing, farmers' markets provide agricultural producers with an access to customers without supply-chain intermediaries (Sullivan *et al.*, 2013). According to Vecchio (2011), such direct selling strategies experience a rising usage by farmers due to the fact that they (1) promote and reward non-tangible characteristics; (2) provide a link between urban consumers and rural food producers; (3) allow producers to capture a larger share of the consumers' expenditures by eliminating the intermediaries in the supply chain. Despite all their benefits, farmers' markets face a competition not only from the conventional shops and groceries, vendors in the same markets compete among each other for the same consumers. According to Byker *et al.* (2012), the decision to shop (or not to shop) at the farmers' market is just one of the choices consumers make;

the choice of the vendor is also very important. Thus, the customer loyalty becomes a key success factor for many vendors.

Customer loyalty has been the subject of much research during recent years because of the belief that higher loyalty leads to better results in the marketplace (Lee & Bellman, 2008). The importance of retaining current customers is recognized when markets become more competitive (McMullan & Gilmore, 2008). Curasi and Kennedy (2002) propose that customer loyalty exists when the customer exhibits repurchase behaviour and has a relatively positive attitude or commitment regarding the object (e.g. brand, product, organization, vendor, service provider, etc.). Therefore, one of the key aims of farmers vending in markets becomes gaining and maintaining customer loyalty, which could result in constant sales and positive attitude. Increasing the market share means persuading competitors' customers with weak loyalty-based opinions and beliefs to defect (Fraering & Minor, 2013). Yu *et al.* (2005) argue that as the features, quality, and appearance of products and services become increasingly similar, customers more and more exhibit fickle and non-loyal purchasing behaviours – they switch. Moreover, there is an assortment of complex and interrelated factors that influence an individual's choice (Byker *et al.*, 2012).

Despite the body of literature analysed, the scientific discussion in the area of customer loyalty to the vendor at farmers' markets and factors influencing their switching behaviour is still scarce. Latter insights lead to the consideration of **scientific problem** formulated by a question: what factors influence customer switching behaviour in farmers' markets in Lithuania? To solve the problem of the research, the **aim** of the paper is to determine and assess the

factors influencing the customer switching behaviour in farmers' markets in Lithuania.

Materials and Methods

In order to determine the factors influencing customer switching behaviour in farmers' markets in Lithuania, the questionnaire survey was created. The questionnaire was composed of the three main parts: (1) customer loyalty assessing part; (2) the part related to the factors influencing customer switching behaviour; (3) the demographic part.

The customer loyalty assessing part. The first part of the questionnaire was composed to determine the stage of customer loyalty to the farmers' market and to the particular vendor in it. The model of the determination of customer loyalty stage (Bakanauskas & Pilelienė, 2008) was adapted to reflect the situation. This part contained six questions.

The chosen model for the determination of customer loyalty stage helps in dividing consumers into four segments based on the stages of their loyalty: (1) 'Neutral customer', (2) 'Potentially loyal customer', (3) 'Unconsciously loyal customer', and (4) 'Genuinely loyal customer'. The first two questions in the questionnaire were determining whether the respondent is aware of the existence of farmers' markets and has ever visited any. Considering the problem of the research, those respondents who replied negatively to any of these questions were attached to the first stage of customer loyalty and were eliminated from the further study. The third question enabled the determination of the customers characterised by the second stage of customer loyalty – 'Potentially loyal customers'. Potentially loyal customers were those who indicated that they have purchased products at a farmers' market once. However, considering the limited expertise in the research field, latter respondents also were eliminated from the further research. The fourth question in the questionnaire made it possible to identify the respondents who were not willing to purchase products at farmers' markets in the future. All the respondents who evaluated their purchase intentions in the future negatively were called 'Lost' and were asked to terminate the research.

The fifth and sixth questions were related to a particular vendor at a farmers' market. The fifth question indicated those respondents who had their favourite vendor(s); while the sixth question indicated the genuinely loyal customers. Genuinely loyal customers were those who indicated their total willingness to recommend their favourite vendor to others. The intentions to recommend were measured using 5-point Likert scale; therefore, all the respondents who had not indicated their total willingness to recommend (had not chosen the answer '5') were considered as 'Unconsciously loyal'. Only

those respondents who indicated having a favourite vendor(s) were asked to participate in further research by completing the second part of the questionnaire.

The part related to the factors influencing customer switching behaviour. The second part of the questionnaire was composed with the aim to determine and evaluate factors, affecting loyal customers switching behaviour. Depending on the effect, the factors that affect customer switching behaviour are divided into those supporting (loyalty repressing factors) and repressing switching behaviour (loyalty supporting factors). In the scientific literature, 11 factors supporting customer switching behaviour and 10 factors repressing customer switching behaviour are distinguished (Zikienė, 2012). Firstly, the expert evaluation was provided to determine the factors influencing customer switching behaviour that would be relevant to the industry. After the evaluation, 8 factors supporting customer switching behaviour and 6 factors repressing customer switching behaviour were distinguished. Factors, affecting customer switching behaviour, relevant to the industry and their meanings are presented in Table 1.

To revise the loyal customer specific factors affecting customer switching behaviour in farmers' market, 28 questions were prepared. In order to find out which of them are specific (relevant) for loyal customers, every factor affecting customer switching behaviour was 'converted' into 2 specific situations or examples, directly associated with the farmers' market. 2 specific situations were formulated in order to get more specific and accurate data. The questionnaire used the questions-statements, answers to which have been evaluated using Likert scale. Every question-statement was formulated taking into consideration the nature of the research: as empirical research was used to find out those factors affecting customer switching behaviour that may determine ('form') probable customer switching behaviour, it is true to say that questions used for survey can be attributable to the forecasting type of research questions.

Respondents were asked to evaluate every question-statement in range from 1 to 10 by expressing their agreement or disagreement, respectively. On the basis of evaluations reported by respondents, regression analysis (one variable value prediction by another variable value) was made, in order to find out loyal customer specific factors affecting customer switching behaviour in farmers' market.

Suitability of research data for regression analysis requirements. In order to process the research data using the method of linear regression, it is appropriate to verify whether there is a linear dependency between the factors involved in the formation of loyal customer switching behaviour and factors that support or repress customer switching behaviour. As

Table 1

Factors affecting switching behaviour

Factors supporting switching behaviour	<i>Price issues.</i> The problems associated with a recently raised or a continuously growing price of a product or service, misleading price, taxes, charges, etc.
	<i>Inconveniences.</i> Incidents when customers are kept waiting, inconvenient working hours of the organization, inconvenient location of the organization providing products or services.
	<i>Core service failures.</i> Incidents associated with the mistakes or other technical issues when selling a product or providing a service, mistakes in invoicing.
	<i>Dissatisfactory quality.</i> Quality of the product or service being unacceptable for the customer.
	<i>Service encounter failures.</i> Problems arising during the interaction between a product seller or service provider and customer. Rude or disobliging behaviour of the salesperson or service providing person, lack of knowledge or competency, forcing customers to wait.
	<i>Variety seeking.</i> It is natural for the person to seek for variety, especially if he/she gets bored or 'bellyful' of a particular product or service. Routine and variety-seeking behaviour usually happens cyclically by individual periods replacing each other and gaining dominating features.
	<i>Change of the place of residence of the customer.</i> Change of the place of residence can affect customer switching behaviour if services or products of a particular provider are unavailable near customer's new place of residence. Change of the place of residence can also mean a change in living circumstances and occurrence of new needs of the customer.
	<i>New value.</i> Appearance of a totally new product or service in the market capable of offering an added value for the customer can also encourage him/her to switch to another product/service provider.
Factors repressing switching behaviour	<i>Economic costs.</i> Economic costs are usually treated as costs that can occur when switching to another product/service provider an admission fee must be paid or some benefits available from the former product/service provider are lost.
	<i>Search and evaluation costs.</i> Decision to switch to another product/service provider always requires additional information, search and evaluation of this information. Customer invests his/her time and efforts in information gathering about the competing organizations, its evaluation and making the final decision.
	<i>Perceived risk and uncertainty costs.</i> Customer behaviour is based on the wish to reduce risk, and different strategies are used to achieve this (Sheth ir Parvatyiar, 2000). One of the ways to reduce risk is to become loyal to a particular product, service, organization or brand by reducing choice as well. Becoming a loyal client reduces uncertainty costs (Sheth & Parvatyiar, 2000).
	<i>Lack of perceived available or attractive alternatives.</i> Some non-essential factors influencing relationships between organizations and customers such as market structure or insufficient number of available alternatives can serve as a limitation for customer switching behaviour, and it is particularly likely that if the customer does not notice or simply other alternatives do not exist in the market, he/she will tend to continue relationship with the current organization (Bendapudi & Berry, 1997; Colgate & Lang, 2001).
	<i>Social costs.</i> Social costs are perceived by customers as costs that can be incurred when switching to another organization given the social interaction with the organization is abandoned or with its personnel with whom close relationships have been developed.
	<i>Psychological costs (customer's apathy, passiveness, inertia, behaviour formed by habits, lack of motivation).</i> These character features of customers build particular psychological barriers that prevent switching behaviour. Apathy, passiveness, and inertia are even considered to be characteristic features of loyal customers (Nordman, 2004; Colgate <i>et al.</i> , 1996). Inertia involves customers in a long-term relationship with the organization due to their lack of motivation or low involvement in purchase process. Lack of time, lack of interest, habitude and even laziness become those features that form fake loyalty and prevent customer switching behaviour.

the empirical study was aimed at determining which factors supporting or repressing potential switching behaviour of loyal customers would take part in the formation process of switching behaviour, regression analysis was performed twice. In both cases, factors affecting customer switching behaviour were selected

as dependent variables, and factors supporting or repressing customer switching behaviour were selected as independent variables, respectively.

The suitability of applying the linear regression method for this case was assessed by taking into account the assumptions of linear regression and

verifying whether they have not been violated. Both when factors supporting and repressing customer switching behaviour were selected as independent variables, the coefficients of determination (R) squared in simple linear regression were the same as squared Pearson's correlation coefficient. For the present research, when the factors supporting switching behaviour of loyal customer were selected as an independent variable, the squared determination coefficient was equal to 0.832, and when factors repressing switching behaviour of loyal customer were selected as independent variable the squared determination coefficient was equal to 0.754. According to the requirements applied to regression model, when the squared determination coefficient is greater than or equal to 0.25, the regression model is considered suitable. Suitability of regression model is also determined by p value (when p value is below the level of significance (coefficient of determination) then the theoretical model and observations may be claimed to be matching). In both cases, when the factors supporting and repressing customer switching behaviour were selected as independent variables, p values in the ANOVA table were equal to 0.

The demographic part. The demographic part of the questionnaire was composed of four questions regarding respondents' demographic characteristics: gender, age, place of residence, and average income per person per month.

The research was provided in Lithuania in the winter of 2016. The population of the research was chosen proportionally to reflect all 10 counties of Lithuania. 400 questionnaires were distributed and 349 were returned; 36 men and 313 women participated in the research. The respondent age distribution: 7.2 per cent of respondents were under 25 years old; 48.1 per cent of respondents were 26-35 years old; 30.4 per cent were between 36 and 45 years old; 5.4 per cent of respondents belonged to the age group of 46-55 years; 8.9 per cent of respondents were 56 and over. Considering the respondents' income distribution, the following results were obtained (respondents were asked to indicate their monthly income for one family member): the income of 6.6 per cent of respondents was less than 150 Euros per month; 32.1 per cent of respondents indicated their monthly income to be 151-300 Euros per month; 26.4 per cent of respondents indicated their monthly income for one family member between 301 and 450 Euros; the income of 18.1 per cent of respondents was indicated to be 451-600 Euros per month; and 16.9 per cent indicated their income to be more than 600 Euros per month.

Results and Discussion

In order to reach the aim of the research, the market structure was assessed in accordance with

the customer loyalty. *Stage I.* According to the research methodology, those respondents who have never visited nor have ever purchased a product at farmers' markets were attached to the first loyalty stage. The research results indicating the belonging to the first loyalty stage revealed that only 5.7 per cent of respondents can be attached to the first loyalty stage and called 'Neutral'. After answering the first questions of the questionnaire, all the latter customers were eliminated from further research as having low expertise with the problem.

Stage II. The third question of the questionnaire also was intended to indicate respondent's belonging to the second loyalty stage. Customers belonging to the second loyalty stage can be called 'Potentially loyal', because they had purchased a product at a farmers' market once and hence they had some knowledge about the object. Even 32.7 per cent of respondents indicated that they had purchased a product at a farmers' market once.

Lost. All the remaining 61.6 per cent of respondents indicated that they have performed more than one purchase at farmers' markets; therefore, they can be attached to a higher than the second loyalty stage. However, the filter question was provided to determine respondent's willingness to purchase products at farmers' markets in the future. 12.6 per cent of respondents indicated their doubts of purchasing at farmers' market in the future and 0.6 per cent indicated that they would definitely not buy anything there again. Hence, all the respondents attached to the second loyalty stage and to the 'lost' segment were eliminated from further research for having low expertise or low involvement, respectively.

Loyal. In order to select a more reflective sample, the respondent who had indicated their loyalty to a farmers' market (were attached to the third or fourth loyalty stages) were asked to indicate if they had their favourite vendor there. After answering this question, only 49 per cent of the total sample was considered as a suitable for the further research.

Results of the research of factors influencing loyal customer switching behaviour. With respect to the factors influencing possible switching behaviour of loyal customers that were determined in the research methodology taking into account their relevance in the current industry (farmers' markets), the following independent variables influencing the dependent variable were included into the regression model: factors supporting the switching behaviour – new value, dissatisfactory quality, core service failures, change of the place of residence of the customer, price issues, inconvenience, variety seeking, service encounter failures. In case of the second regression, the dependent variable was influenced by the following independent variables: factors repressing

the switching behaviour – lack of perceived or attractive alternatives, perceived risk and uncertainty costs, economic costs, social costs, psychological costs, search and evaluation costs.

Results of the regression analysis revealed that the potential switching behaviour of loyal customers is formed under the influence of both factors having the potential to support and having the potential to repress the switching behaviour, however their influence differed. Determination coefficient of factors supporting switching behaviour was equal to 0.832, and the determination coefficient of factors repressing switching behaviour was equal to 0.754. Thus, it may be concluded that the influence of factors supporting switching behaviour on the process of loyal customer switching behaviour formation was greater by 9.37%. This suggests that:

- Surveyed customers reported they feel loyal to the chosen vendor for the value they receive rather than for high switching costs; however, the actually small difference denoting the effect of factors supporting switching behaviour, and those repressing switching behaviour on the formation process of loyal consumer switching behaviour demonstrates there are sufficient number of switching barriers, or the switching costs are sufficiently high;

- Loyal customer facing adverse consequences while interacting with certain vendor (or if other factors supporting switching behaviour occur) are tend to switch to another vendor;

- When facing factors supporting switching behaviour, loyal customer's decisions to switch to another vendor are restricted by significantly high switching barriers: customers tend to assess all the possible costs of terminating relations with the regular vendor.

The analysis of the influence of factors supporting or repressing switching behaviour on the formation process of potential switching behaviour revealed that not every researched factor was statistically significant; therefore, their influence regarding the probability of occurrence of switching behaviour among loyal customers was not equal. Regression indicators of factors supporting or repressing loyal customer switching behaviour, i.e. non-standardized coefficients describing each factor (B), and *p* value which is dependent on the selected significance level $\alpha=0.05$ demonstrate that one of the studied factors supporting switching behaviour, i.e. change of the place of residence of the customer, and two of the factors repressing switching behaviour, i.e. social costs and lack of perceived or attractive alternatives, were statistically insignificant. Based on the information revealed by the unstandardized coefficient (B), the following factors affecting switching behaviour demonstrated the greatest influence on the formation of switching behaviour (listed from most to least significant): dissatisfactory quality, inconvenience, new value, service encounter failures, price issues, variety seeking, core service failures). When elaborating the statistically significant factors that repress switching behaviour the following factors repressing switching behaviour demonstrated the largest influence on formation of switching behaviour of loyal customers (listed from most to least significant): economic costs, perceived risk and uncertainty costs, search and evaluation costs, and psychological costs. Coefficients of factors affecting switching behaviour of loyal customers are listed in the Table 2 below.

Based on the results of regression analysis obtained during the study of the factors supporting

Table 2

Coefficients of factors affecting switching behaviour of loyal customers

Factors supporting switching behaviour			Factors repressing switching behaviour		
	Unstandardized Coefficients B	Sig.		Unstandardized Coefficients B	Sig.
(Constant)	.824	.002	(Constant)	1.585	.000
Dissatisfactory quality	.152	.000	Economic costs	.213	.000
Inconvenience	.147	.000	Perceived risk and uncertainty costs	.183	.000
New value	.140	.000	Search and evaluation costs	.155	.000
Service encounter failures	.097	.000	Psychological costs	.133	.000
Price issues	.095	.004			
Variety seeking	.079	.007			
Core service failures	.075	.004			
Dependent variable: Factors affecting switching behaviour					

switching behaviour of loyal customers, the following conclusions can be made:

- The adjusted coefficient of determination describing the influence of factors supporting the formation process of potential switching behaviour of loyal customer was seen to have high significance (0.832), therefore the probability of occurrence of switching behaviour among loyal customers was high;

- Dissatisfactory quality as one of the factors supporting switching behaviour demonstrated the greatest influence on the occurrence of switching behaviour. Product quality remains the product feature based on the assessment of which loyal customers decide whether to buy the product repeatedly or not. Product quality, a widely empirically studied factor supporting product loyalty, is also one of the most significant factors influencing customer loyalty;

- Inconvenience, as a second most significant factor supporting the potential switching behaviour of loyal customers, reveals the importance of both the location of the particular farmers' market and the availability of a certain vendor at the time and place required by the customer. Based on the research results, it may be concluded that in case of circumstances causing inconveniences, loyal customer tends to buy the necessary goods from another vendor;

- New value also demonstrated a significant influence on the formation process of the potential switching behaviour of loyal customers. Based on the research results, it may be claimed that the emergence of a new product in the market potentially providing higher value for the customer would encourage loyal customers to switch to another vendor in the farmers' market. It may also be concluded that the value customer received at the time new product emerged did not fully satisfy loyal customers and the emergence of new value was seen as potentially influencing the switching behaviour;

- Service encounter failures as the fourth most significant factor supporting customer switching behaviour directly influences the growth of dissatisfaction of loyal customers and reveals the negative interaction to encourage loyal customer to switch to another vendor. Research findings deny the assumption that loyal customers are more tolerant to the failures of the selected product seller/service provider. It may be concluded that loyal customers do not tend to forgive product suppliers for their failures, and see negative interaction as a significant reason to switch to another vendor;

- Price with the significance it acquires based on its influence on the formation process of the potential switching behaviour of loyal customers is close to the previously discussed factor – service encounter failures. Despite loyal customers are thought to be less sensitive to the price issues, in the long term, high

or rising prices and cheaper alternatives from other vendors would encourage even a loyal customer to switch to another vendor;

- Variety seeking, as a factor supporting switching behaviour, also takes part in the formation process of the potential switching behaviour of loyal customers. Although loyal customers do not tend to identify variety seeking as one of the most important factors affecting switching behaviour, research data revealed that variety seeking in loyal customers can form naturally (natural demand or striving for variety) or be acquired, i.e. triggered by other individuals, competitive offers, etc. This finding has also been confirmed by the previously stated fact that cheaper offers from other vendors can in the long term encourage loyal customer to switch to another vendor;

- Core service failures as a factor supporting switching behaviour demonstrated the least influence on the potential switching behaviour of loyal customers. The potential of service failure to affect emergence of customer switching behaviour may be interpreted through product seller's/service provider's investments in relations with customers, their experience, and perceived image. Based on the research results, it may be claimed that a certain dependency relationship exists between positive experience, close relations, and approach to the issues arising during the process of selling/purchasing: service errors and failures tend to be seen by loyal customers as not significant for occurrence of potential switching behaviour.

Based on the results of regression analysis obtained during the study of the factors repressing switching behaviour of loyal customer, the following conclusions can be made:

- The influence of factors repressing the switching behaviour of loyal customers on the formation process of switching behaviour was found to be by 9.37 per cent lower compared to that of factors supporting the switching behaviour. The adjusted coefficient of determination for the factors repressing switching behaviour was found to be 0.754 (the higher the adjusted coefficient of determination, the better behaviour of independent variables in regression model describes the values of dependent variable). Based on the value of the adjusted coefficient of determination, it may be claimed that the total influence of all four independent variables (economic costs, perceived risk and uncertainty costs, search and evaluation costs, and psychological costs) on the formation process of the potential switching behaviour of loyal customers is substantial (the closer to 0 is the coefficient, the larger is the influence of the independent variable);

- Of all the statistically significant factors repressing the switching behaviour, economic costs demonstrated the highest impact on the repression of

potential switching behaviour among loyal customers. Economic costs represent high investments by vendors in the development of relations with loyal customers. As a result, customers receive added value or greater value. It is true to state that economic costs potentially incurred by loyal customers are perceived as sufficiently significant: loyal customers appreciate added values received in return for their loyalty;

- Perceived risk and uncertainty costs is the second significant factor repressing potential switching behaviour of loyal customers. The common perception is that perceived risk and uncertainty costs are always higher in the markets of highly differentiated products/services. This leads to the conclusion that loyal customers perceive the range of products offered by vendors as highly differentiated: customers do not expect other farmers' vendors to offer products that provide the same value;

- Search and evaluation costs as a factor repressing switching behaviour are also seen as substantially significant to loyal customers. It may be concluded that loyal customers tend to consider the process of search and evaluation as time-consuming and demanding. As the consumer buying behaviour is based on the willingness to reduce the potential risks, it may be claimed that loyal customers do not tend to risk switching to another unknown vendor.

- Psychological costs have the least influence of all the statistically significant factors repressing customer switching behaviour on the potential switching behaviour of loyal customers, however, the influence is sufficiently significant. Consumer

inertness, passivity, and habitual behaviour are often described as characteristics that repress the switching behaviour. Based on the research results, it may be concluded that these characteristics of loyal customers create certain psychological barriers that repress their switching behaviour.

Conclusions

After performing the research on factors influencing the customer switching behaviour in farmers' markets in Lithuania, it has to be emphasized that the market still has a huge potential to grow. Research results indicated that only half of Lithuanians are loyal customers of farmers' markets. Moreover, the defection rate is quite high. Considering the results of factors influencing the switching behaviour, it can be concluded that customers are loyal to the chosen vendors for the value they receive rather than for high switching costs.

In order to keep the loyal customers and minimize the switching rates, markets' vendors have to consider the improvements of their product quality; also, to keep the variety-seeking customers, regular introduction of new or improved products is necessary to ascertain the new value for customers. Improving the customer perceived value in terms of product and service quality will enhance the effect of the factors repressing the customer switching behaviour in terms of the creation of various switching costs. Moreover, based on the research results it can be suggested for every vendor to perform their own customer analysis in terms of their loyalty structure and defection potential.

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EMPOWERMENT OF INNOVATIVENESS FOR REGIONAL DEVELOPMENT: THE CASE OF ŠIAULIAI REGION

Vita Juknevičienė, Jurgita Bersėnaite

Šiauliai University, Lithuania

v.juknevicene@gmail.com

Abstract

Challenges for modern society encourage the interest of how the regions could increase opportunities to accelerate social and economic development and reach the level of developed regions. Especially it is important for rural areas. There is a search for new answers (ideas and innovations) on creating a competitive advantage of regions. Seeking for a better systematic (not chaotic) result of innovative activities various organizations (even working in different sectors) are tied up with other organisations by tight links in their regional innovation system. The collaboration among different organizations is argued to be the main axis for the stimulation of innovativeness. Besides, all innovative activities must be reinforced by organizations' absorptive capacity (i.e. abilities to access external knowledge, anchor and diffuse it) that leads to innovativeness. This article argues the theoretical and empirical approach of how the regional development could be accelerated by empowered innovativeness as a capacity of participants of a regional innovation system. Lithuania as a modern country and the EU member declares the importance of the reduction of internal regional disparities. Consequently, the analysis of a particular regional innovation system, i.e. Šiauliai region, allows disclosing the regional peculiarities and weaknesses of its innovative activities limiting the development process. The goal of this article is to reveal the current situation of innovativeness in Šiauliai region and draw the directions of its empowerment for further regional development. The article consists of two parts: theoretical insights and explanation of methodological approach; and the presentation and discussion of quantitative research results.

Key words: regional development, innovativeness, regional innovation system, absorptive capacity.

Introduction

Innovativeness and competitiveness are perceived as essential conditions for the survival in a global market. The capacity to innovate, learn, adapt, and use the best international experience is the essential presumption for development in the contemporary global system. Innovation creation, exploitation and diffusion become more important in knowledge economy and provide results, reflecting public expectations – the value for regions and countries. Despite the globalization scale, a lot of efforts are still made in specific locations (regions) to gain their competitive advantage, enabling their ability to attract investments and secure the economic and social well-being. Unbalanced economic and social processes proceeding within regions can reduce their competitiveness, thus affecting wealth creation in the whole country. It is very important for less developed countries and their regions. The essential factor enabling regional competitiveness is the innovativeness determined by the structure of a regional innovation system and its absorptive capacity.

European Union member states (including Lithuania) try to equalize inter-regional differences by implementing the regional policy which supports development processes in the less developed areas, consisting mainly of rural areas (Stawicki, 2015). Despite the implementation of many programs and declared regional dimension in the national policy and strategic decisions, significant economic, social and cultural disparities among and even within

regions still exist in Lithuania (Puidokas & Daukaitė, 2013). The new EU funding period (2014 – 2020), changing EU and national financial instruments and their purposefulness, increasingly highlight capacities and capabilities of a region to adapt and survive in a competitive environment. Innovations are especially important for regions having rural areas, where one of the most important economic activities is agriculture (e.g., Šiauliai region). Such regions must identify their specifics and find the new ways for development.

Regional policy, regional development, regional economic disparities have been analyzed by many authors (among others: Burneika, 2013; Puidokas & Daukaitė, 2013; Kilijonienė, 2010; Abrhám, 2011; Brauers, Ginevičius & Podvezko, 2010; Prokop & Stejskal, 2015), but the aspect of innovativeness for regional development has not been a subject of detailed studies. Consequently, *the goal of this research* was to reveal the current situation with the innovativeness in the Šiauliai region, identifying directions for an empowerment for its development. The first part of the article introduces the theoretical background and methodological approaches of innovativeness as a presumption for regional development. The second part presents results of the research made by analyzing the statistical data of Šiauliai region in the period of 2004 – 2013. Finally, the research is ended by giving some insights and conclusions. Due to format limitations the paper includes only a part of research results, consisting only of the key indicators of innovativeness.

Materials and Methods

Theoretical approach

The analysis of innovativeness for regional development must be started with the understanding that *innovation* is not the self-acting phenomenon, but rather a process requiring ideas, efforts, time and resources. This process becomes more and more collective in the age of knowledge society and surplus information. Therefore, it requires adequate tools and environment, where it can be accelerated, i.e. the innovation system.

Seppänen (2008) identifies four types of innovation systems: national, regional, sectoral and technological. The main links between innovations and dimensions of regional development are highlighted in the conception of a *regional innovation system* (hereinafter referred to as *RIS*), which is understood as a collaboration network of various formal private and public institutions (static elements of a system), based on organizational and institutional agreements, relations and links (dynamic elements of a system), contributing to knowledge generating, i.e. initiation, creation, exploitation (importing and enabling the new technologies and knowledge), and diffusion processes, hereby, increasing regional innovativeness and competitiveness. This institutional network must act and be situated in a particular area, e.g. a region. A few regions can be found in the territory of each country, where acting regional innovation systems can be characterized by the specifics of activity and liaison.

The conception of a region is still a great subject of scientific disputes. So far, the definition of a region (in Lithuanian scientific community) was inseparable from the existing legislation and administrative division. The *region* can be defined as an individual, uniquely combined unit, e.g. a sub-national territorial unit (with clearly determined borders), in which the use of internal and external resources is carried out for socio-economic activities by interactions of natural and social systems (Kilijonienė, 2010; Burbulytė, 2005). Asheim (2011) argues that when analyzing the case of a specific region it is necessary to know which type of the innovation system the particular region could be attributed to:

- territorially embedded regional innovation systems (innovative actions are led only by localized inter-company learning processes, the opportunity for direct interaction with science institutions is underused);
- regionalized national innovation systems (the nature and the level of regional innovations are determined by external actors and relations with them, part of the region's industrial and institutional infrastructure is more integrated into a national innovation system);

- regionally networked innovation system (the nature and the level of regional innovations are determined by favourable institutional and organizational infrastructure, the system includes a localized, two-way learning process, as well as public-private partnerships).

Consequently, the successful performance of a RIS needs more than regional institutions' desire and investments into processes of certain innovations' creation, exploitation and commercialization. The relationship between the RIS, regional environment and the level of economic development of a region is illustrated by Carlsson's (2009) research, which imposed that disparities between regional development (especially, economic ones) are more determined by such indicators as the innovation system and the quality of management, than the nature of political system or the degree of openness in the economy. Competitiveness of a system and economic well-being are determined by the orientation of the interacting participants (i.e. institutions) of a system. Additionally, conducive environmental features of a region are necessary: the dominance of a private funding for research and development (hereinafter referred to as *R&D*), strong and diversified public R&D and consolidating institutions; strong multi-level (business-to-business, business-to-science) communication and interactions with different actors, developed channels, a high level of entrepreneurial, well-qualified workforce and a clear policy, based on social counselling, strategies and innovations, prevailing in a system (Wojnicka *et al.*, 2002). Strengthening all these features of the RIS could lead to the more viable regional development.

Regional development can be seen as a dynamic process that allows meeting changes in the environment, improving the current situation, and contributing to the growth and positive change in a particular area or territory. Development of the RIS (increasing number of innovative companies, investments into R&D, number of patents, licensing returns, etc.) is directly connected with the growth of economic and social indicators, such as *gross domestic product* (hereinafter referred to as *GDP*), foreign direct investment, a level of unemployment, a level of demand of educated workforce, etc., which are essential for the creation of well-being in a region. Under conditions of current operating economic systems, innovativeness is an inherent part of a developing or prosperous region.

Innovativeness as tending to innovate (introduce new or different ideas) can be achieved using region's (as well as persons' and organizations' acting in this region) innovative capacities – absorptive capacity (to access external knowledge, to anchor and diffuse it) and development capacity (to create and exploit innovations). The development capacity is not

possible without the absorptive capacity (Mahroum *et al.*, 2008; Mahroum & Alsaleh, 2012). According to Narula (2004), Rodrik, Subramanian & Trebbi (2002), the development of the regional absorptive capacity needs:

- appropriate basic infrastructure (roads, railways; phones; electricity; the basic qualified human capital, having primary and secondary education; primary and secondary schools, hospitals);
- developed advanced infrastructure (universities, advanced skilled human capital, having higher education; research institutes, banks, insurance companies);
- business companies (local companies with the appropriate human and physical capital, taking over the technology flows; branches of multinational companies, acting as users and creators of technology flows);
- appropriate activity of formal and informal institutions (intellectual property rights, technical standards, weights and measures, incentives and subsidies to promote new technology adoption and development; taxation; competition policy, schemes of investments' promotion and targeting, promotion of cooperation between domestic and foreign economic players; entrepreneurship promotion).

The institutional dimension of a regional innovativeness is very important because effective institutions contribute to the economic development of the region more than territorial dislocation or trade relations, despite the fact that formal institutions create only a minor part of knowledge.

However, it is necessary to emphasize that regional innovativeness is mainly due to the level and efficiency of a regional innovation system as a whole more than to capacities of particular institutions of the RIS. Therefore, two main approaches of *empowerment of innovativeness* should be highlighted: the maintenance (providing human and material resources, creation of favourable legal and institutional environment) and the supervision (monitoring of outcomes and adjustment). According to this theoretical approach, the analysis of Šiauliai region was conducted.

Methodological approach

Large countries have large regions (in the meaning of the geographic scope), where researchers can measure certain statistical indicators important for various economic and social studies. Such data are accumulated in different databases; therefore, new scientific researches occur, analyzing regions' situation of innovativeness, and the level of absorptive capacity. According to the classification of international organizations, smaller countries are considered as indivisible regional units (i.e., in accordance with the

regional classification of European Union, Lithuania is classified as NUTS II type region). With reference to Clemens & Radelet (2003), the development of absorptive capacity and problems of it in some countries, especially smaller ones, are similar. Thus, it can be argued that this attitude is dominating among communities of researchers and practitioners, and creates preconditions for the deficiency of research, carried out in small countries or regions.

Nevertheless, the scope of new value creation (as well as absorptive capacity leading to innovativeness) is different not only in different sectors of the economy, but also in institutions, regions or countries. Regions in small countries differ by social and economic indicators. Furthermore, the ability to absorb knowledge, to use targeted institutional activity and create innovations varies in organizations, operating in the same region. Moreover, each region in a country has a certain established institutional system as its regional innovation system. According to Petraitiė (2009), regional innovation systems are always different, because of different evolutionary, institutional and socio-economic contexts. Therefore, in order to reveal the current situation and to identify the possibilities to empower the innovativeness for regional development, it is essential to examine each case thoroughly and in detail, as it was done in this research, analyzing the case of Šiauliai region.

Under the current legislation, Lithuania has 10 regions (in accordance with EU classification, NUTS III regions), the so called "counties". They are territorial units, but not administrative any more (because of the administrative reform, implemented in the country in 2009 – 2010). However, all statistical data are accumulated for counties (in the regional level), and the institutional structure of Lithuanian regional innovation system can be comprehended easier just by the approach of territorial division.

Šiauliai region is situated in the north of Lithuania, so, it is the peripheral region (has the border with Latvia). Šiauliai region's territory is the second largest area in Lithuania after Vilnius region. It holds the fourth place in the country by population. The centre of the region (Šiauliai city) is the fourth by population as well. The main peculiarities of Šiauliai region are identified according to a very important strategic document 'Development Plan of Šiauliai Region 2014 – 2020' (Šiauliai Regional Development Council, 2013). The document states that an integrated development of urban and rural areas remains one of the essential directions of regional policy (2014 – 2020). According to this document, the main aim of development of Šiauliai region is to become 'a significant place in the country's economic, social and cultural life, where the competitive economy is created and a greater social cohesion of society is achieved'.

Šiauliai region can be characterized by certain socio-economic features perceived as strengths and weaknesses (based on Šiauliai Regional Development Council, 2013). The decision to choose this region for the analysis was influenced by further specifics as well. The region can be identified as rural, because it has the highest area of used agricultural land utilized in the country; gross agricultural production of the region is the highest in the country, and regions' added value, most successfully created in sectors of agriculture, forestry and fisheries, is the biggest in the country as well. Even the largest part of foreign direct investments in the region (according to the dimension of economic activity) goes to manufacturing and agriculture. Lithuania has only four regions with universities (main institutions, initiating and realizing R&D in the RIS) and Šiauliai region is one of them. The main disadvantages as well as challenges for economic development can be identified as low added value of goods and services produced in the region, the lagging behind other three biggest regions in Lithuania (Vilnius, Kaunas, Klaipėda) by such indicators as number of employees, turnover and added value in costs of production, the scale of young people emigration, the percentage of innovating companies is the lowest in the country, the high percentage of innovators, dropping or ceasing innovative activities.

Seeking to draw the directions of regional development in the aspect of innovativeness, it is necessary to perceive the view of the indicators of regional innovativeness and their dynamics. A large research 'Development of regional innovation system's absorptive capacity' was implemented and introduced by Vita Juknevičienė (one of the authors of this article) in 2015. In the light of new data and due to format limitations, the article represents only the key indicators of innovativeness (2004 – 2013; it covers longer period, but because of limitations for data accessibility some meanings are missing). The whole system of indicators was transformed, concluded and presented in the aforementioned research with reference to the main recognized methodologies of innovativeness of countries and regions and particular significant scientific studies in the field: Hollanders & Tarantela (2011), Hollanders *et al.* (2012), Mahroum *et al.* (2008), Mahroum & Alsaleh (2012), Jucevičius *et al.* (2011). The presented indicators are directly connected with three main dimensions of the conception of absorptive capacity as the main presumption for innovativeness, as well as two dimensions of empowerment. Methods of systematization and interpretation are applied for the analysis of quantitative data. Data were renewed in 2016 from databases of two institutions: Statistics Lithuania and The State Patent Bureau of the Republic of Lithuania.

Results and Discussion

As stated above, for the empowerment of innovativeness in a region, appropriate human and material resources must be provided, as well as favourable legal and institutional environment (the maintenance) created and data of innovative activities and indicators of economical situation (the supervision) monitored. But it must be emphasized that good maintenance does not guarantee good final results, therefore, the supervision is needed.

As it was highlighted, empowerment of innovativeness is feasible through maintenance and supervision. The maintenance requires for the favourable legal and institutional environment in the RIS. *Legal system* is in force throughout all the country, therefore, legislation of innovation policy guarantees equal accessibility of consultancy, assisting and financial support instruments (e.g., tax relief for innovative companies), programs and their resources for all regions including Šiauliai (authors would like to emphasize the importance of the gap between accessibility and obtainment or initiative and efforts to obtain). The *institutional structure* of Šiauliai RIS is based on three components (university, business and government). Despite the region's rural profile, too few scientists of Šiauliai University are working on researches, concerned with specifics of agriculture, forestry and fisheries sectors. Though Šiauliai University is a core for scientific activities in the region and it is engaged not only in the development of science, but also implements applied researches for private and public sectors. This presumption helps to explain the fact that marketing innovations takes the largest part of implemented innovations in regional companies (Šiauliai Regional Development Council, 2013). R&D activities are reinforced by regional colleges (they provide higher non-university education in Lithuania as well). Region's business enterprises are specializing in various economic activities; therefore, they become members of different clusters and networks even outside the region. The network of self-government institutions (7 municipalities and 60 neighbourhoods) is located in Šiauliai region, but only a few institutions are working on the regional basis (e.g., The Service of the Government representative of Šiauliai county, Šiauliai Regional Development Council, etc.). A few types of innovation and business support institutions can be identified in the region: regional development agencies, a business incubator, business information centres, specialized innovation centres, a research institute and centres, etc. Unfortunately, Šiauliai region has neither science and technology parks or science and business valleys, nor high-tech science laboratories. The structure of Šiauliai regional innovation system reminds the composition of innovation system in other six less-

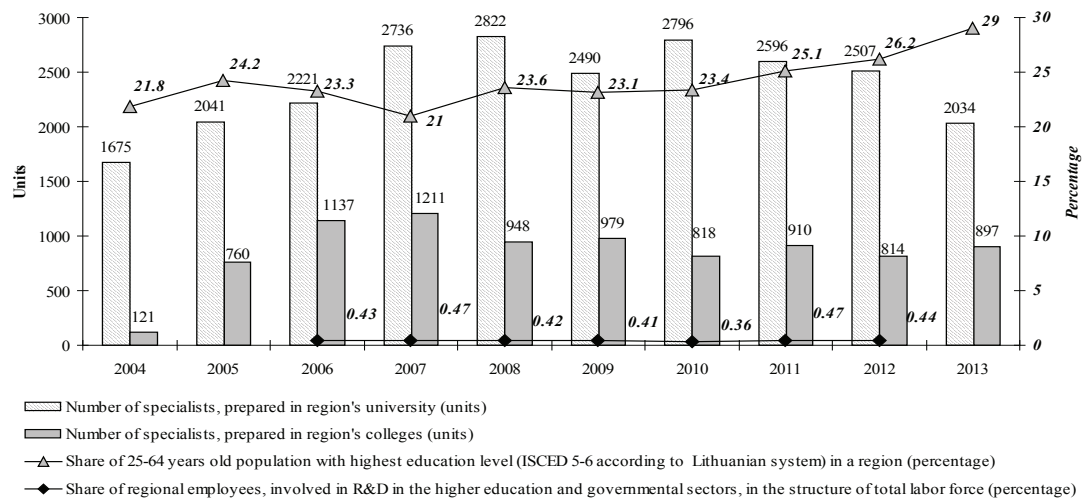


Figure 1. Dynamics of main social indicators of innovativeness in Šiauliai region (2004 – 2013).

developed Lithuanian regions with the exception of regional university factor. To sum it up, the legal and institutional preconditions appeared favourable for development of innovativeness in Šiauliai RIS and it can be empowered through individual organizational activities as well as collaboration between the RIS actors and partners of sectors, clusters and networks. 'Adequate human and financial resources are needed for creation and maintaining of the innovativeness' (Mudrak, van Wagenberg, & Wubben, 2005), consequently, this research represents the provision of adequate resources for Šiauliai RIS and the ensuing socio-economic changes in the region. The most important factor empowering innovativeness is *human potential* as the main input (for maintenance) of innovativeness development. Šiauliai RIS, seeking for regional development, must prepare the necessary qualified specialists (or attract them from other RIS) and has to be able to retain them in the region working in R&D.

Unfortunately, the total number of graduates of higher education institutions (university and colleges) in Šiauliai region has the tendency to

decrease approximately -6.7% per year from 2010 (see Figure 1), what reflects the general tendency for decline in Lithuanian universities and colleges (approximately -5.8%). It is mostly related to the negative demographic changes across the country; the emerging scale of international and internal emigration of young and potential people from region because of new studying and working opportunities, more favourable living conditions, sharpening economic disparities between regions; the impact of economic crisis; and the question of image of higher education institutions of Šiauliai region, created in mass media). Šiauliai RIS lags behind because the labor force (even having enough specialists with higher education – approximately 24% and it is increasing) is not enough involved in R&D activities as the main field to strengthen innovativeness and to gain advantages – this share does not reach even 0.5% (in 2013 in Lithuania there were 35.2% of specialists with higher education, but the share of labor force involved in R&D activities reached only 1.3%).

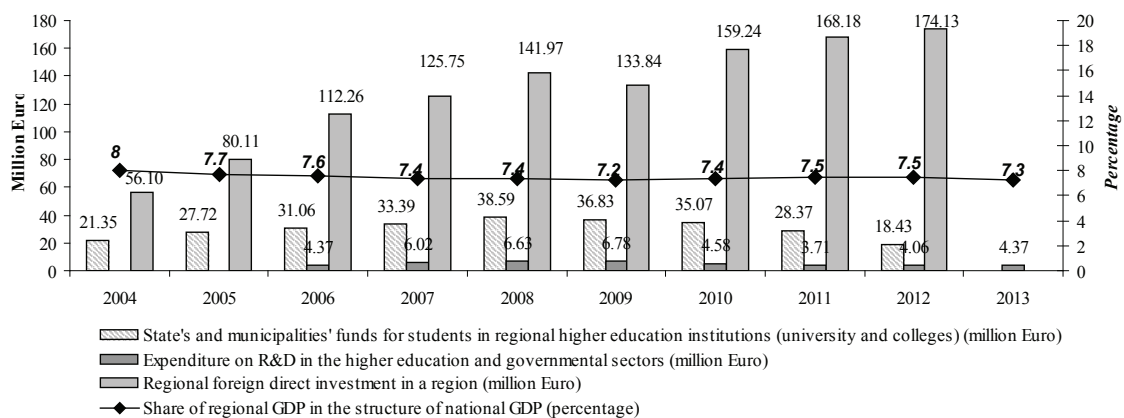


Figure 2. Dynamics of main innovativeness' economical indicators in Šiauliai region (2004 – 2013).

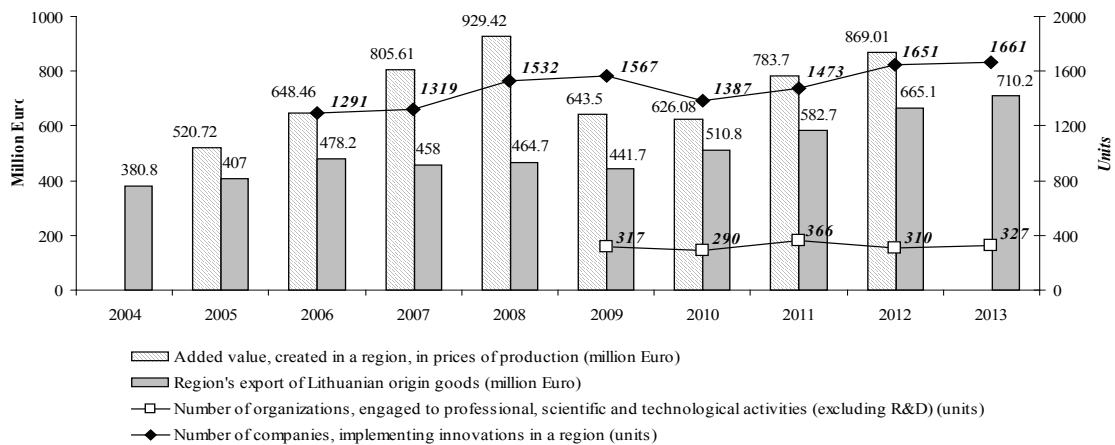


Figure 3. Dynamics of main indicators as a result of innovativeness in Šiauliai region (2004 – 2013).

Innovative activities as an integral part of organizational operations usually require bigger *material resources*. Despite the decline in governmental spending on higher education students (since 2008 approximately -14.7% per year in Šiauliai region and -13.9% in Lithuania) and still low level of investments in R&D (expenditures did not reach 4.5 million Euro in Šiauliai region in 2013, when Lithuanian indicator exceeded 76 times the regional one), the analyzed region has the tendency of growth in regional foreign direct investment, i.e. the indicator tripled in the past 10 years (see Figure 2), as well as the indicator of FDI in Lithuania during mentioned period.

Declining social potential and low investment into it and the search for new solutions lead to a low level of regional GDP share in national GDP (the total amount of regional GDP is not decreasing in recent years, but a decreasing level of the indicator testifies about more accelerated pace of economic development in other regions of Lithuania). Therefore, Šiauliai regional development could be awakened only with the help of targeted national and foreign investment. Especially the investment is needed for supporting and strengthening activities, creating a higher added value, which can be used as one of a few indicators, *measuring and monitoring the output of innovativeness in the region* (see Figure 3).

The economic crisis in 2009 has made an impact on current institutional and economic situation of Šiauliai region. The number of companies, developing human, scientific and technological potential as well as innovative companies is approaching the pre-crisis level in the RIS. The same could be said about the regional capacity to create the added value (especially, when this indicator lags far behind in comparison with more developed regions in Lithuania). The number of registered patents in the region can be included in the supervision of regional innovativeness. But patenting

in Šiauliai region is very poor. Approximately 1-2 patents from this region had been issued in the State Patent Bureau by 2011; 2012 was an exceptional year, when even 5 patents were registered; and there were no patents at all in 2013 (in Lithuania the number of issued patents reaches approximately 68 every year).

Only the growing economic factor of Lithuanian goods export proclaims the bigger exploitation of opportunities of the available potential at the international level (it is 60% greater than in 2009, the time of crisis and almost twice greater in comparison with the beginning of the analyzed period in 2004). It confirms the statements of economists and market analysts about the combination of affordable prices and high quality of Lithuanian goods that generate the confidence in Lithuanian production at the international markets. But at the same time this indicator shows the widening gap between the development of Šiauliai region and Lithuania as a whole: an input of Šiauliai region in total Lithuanian goods export had dropped from 6.34% (in 2004) to 4.78% (in 2013). Such indicators presenting the output of innovativeness indicate various limitations for the development of Šiauliai region and explain main causes of retardation. All three analyzed dimensions are related directly; therefore, strengthening one of the activities could create preconditions for the progress of two others.

Conclusions

The analysis of the innovativeness in Šiauliai region gives some possible directions for empowering all capabilities (including innovativeness) for regional development. The legal and institutional environment is quite favourable to engage the potential and resources into innovative activities. Human resources are ready to face the challenges of modern society and employ their competencies (with a reference to their knowledge and practice gained from their education). Though it should be noted that Šiauliai region should

find the ways not only of how to prepare the necessary qualified specialists in its own or other RISs, but also how to attract and retain the necessary labour force within Šiauliai RIS. That is why *entrepreneurs should be* ready to create friendly environment for non-traditional new activities and decisions and the possibilities to create personal economic stability. The empowerment of innovativeness requires willingness of organizations to change and become more involved in the cross-sectoral collaboration.

Besides, governmental and other institutions in the national innovation system and the RIS must continue the implementation of innovation support policy and more actively apply instruments for the fostering of the innovation culture in the society. Just growing number of conscious, open-minded people can generate innovative ideas and supervise businesses with a higher added value in the RIS, contributing to the regional development and well-being of the whole society.

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THE ANALYSIS OF THE INFLUENCE OF INTERNAL FACTORS ON OUTDOOR ADVERTISING EFFECTIVENESS

Viktorija Grigaliūnaitė, Lina Pilelienė, Arvydas Petras Bakanauskas

Vytautas Magnus University, Lithuania

v.grigaliunaite@evf.vdu.lt; l.pileliene@evf.vdu.lt; a.bakanauskas@evf.vdu.lt

Abstract

The aim of the research is to determine the criteria of internal factors influencing the effectiveness of outdoor advertising. The eye-tracking experiment was conducted in Lithuania in 2016. Consumers' visual attention toward specific criteria of internal factors influencing the effectiveness of outdoor advertising was measured. The chosen criteria were headline font size, the number of elements in the advertisement, and dominating elements in the advertisement (visual or textual). The main results of the research reveal that when the surface size of visual and textual outdoor advertising elements is the same, textual elements attract more visual attention than visual ones and that advertisements containing a large number of elements attract more visual attention than the ones containing a small number of elements. Moreover, when the font sizes of two headlines are both larger than the body text, but those headlines differ in font size one from another, there is no significant difference in consumers' visual attention toward those headlines. Consequently, it is recommended to create outdoor advertisements with a large number of elements, where most of them are textual, in order to attract the consumers' attention.

Key words: outdoor advertising, eye-tracking, visual attention, advertising effectiveness, internal factors.

Introduction

It is well said, 'Where the eye stops, the sale begins' (Pieters *et al.*, 2010), implying that visual attention is necessary, but not a sufficient condition in order for the visual advertisement to become effective. Such a view came out of the information processing aspects. McGuire (1976) broke down the information processing aspects into the steps, of which the most essential are: exposure, attention, comprehension, acceptance, retention, and behaviour. Retention of the advertisement or the behaviour influenced by advertisement is impossible without the exposure and attention to the advertisement. Therefore, the first necessary condition for the advertising to have a possibility to become effective is exposure to it; following exposure, a varying degree of processing capacity – attention – must be allocated to advertisement successfully passing the stage of pre-attentive screening and this step depends on many factors (Walliser, 1997). Attention to advertising then develops into advertising recall and recognition, which form consumers' attitudes, having influence on purchase intentions (see Pilelienė, Grigaliūnaitė, 2015). Furthermore, as Felix and Hinck (2015) stated 'precise knowledge of exposure time and of the exact elements that consumers may actually pay attention to is of significant importance for marketers if they wish to improve advertising effectiveness'. Consequently, consumers' visual attention to the advertising is directly associated with advertising effectiveness.

As mentioned above, there are many factors influencing attention to advertising and its effectiveness. Some authors (Pieters *et al.*, 2002; Pieters & Wedel, 2004; Boerman *et al.*, 2011; Pilelienė & Grigaliūnaitė, 2016) have analyzed the influence of message-related factors on the effectiveness of

print advertising; other authors (Cole *et al.*, 1997) have analyzed the influence of external factors on the effectiveness of outdoor advertising. All of the factors influencing outdoor advertising effectiveness can be classified in two broad categories, each containing more subcategories. The first category is external factors, containing subcategories of outdoor advertising placement and environmental factors (Walliser, 1997; Edegoh *et al.*, 2013; Franch *et al.*, 2013). Nevertheless, the analysis of the influence of external factors on the effectiveness of outdoor advertising is quite limited due to the specificities and regulations in different cities. The second category is internal factors, containing subcategories of personal factors and advertising message-related factors (Walliser, 1997; Franch *et al.*, 2013). As personal factors are hardly controlled by the organizations, the advertising message-related factors are the ones that marketers can gain advantage from, but the research regarding the influence of message-related factors on the effectiveness of outdoor advertising are scarce. Thus, the object of this research is internal factors, referring to message-related factors, which influence the effectiveness of outdoor advertising. Moreover, it is important to know not only the factors influencing the effectiveness of outdoor advertising, but the specific criteria of those factors as well. Consequently, the scientific problem analyzed in the article is formulated by a question: what criteria of internal factors influence the effectiveness of outdoor advertising? The aim of the research is to determine the criteria of internal factors influencing the effectiveness of outdoor advertising. Accordingly, this research fills the gap in scientific literature by determining the criteria of internal factors influencing the effectiveness of outdoor advertising.

Materials and Methods

It is believed (Belch & Belch, 2004; Pieters & Wedel, 2004), that the headline of print advertisement is the most, or at least one of the most important elements of print advertisement. Thus, the importance of headline is proved and the assumption can be made that whether print or outdoor advertisement, it must contain the headline. Despite this, the question rises about the font size of the headline in outdoor advertising. Belch and Belch (2004) argue: ‘Headlines are usually set in larger type’; where ‘larger’ means that the font size of the headline is usually larger than the font size of the body text. Nevertheless, it is unclear how much larger the font size of the headline should be and whether enlarging the font size of the headline leads to more consumers’ attention. Consequently, we hypothesize:

H₁: When the font sizes of two headlines are larger than the body text, but those headlines differ in font size one from another, the headline with a larger font size attracts more consumers’ visual attention than the one with smaller headline font size.

Because of the debates about the influence of pictorial and textual elements of advertisements on consumers’ attention, Pieters and Wedel (2004) analyzed latter influences regarding print advertising. These authors concluded that pictorial elements capture a substantial amount of attention, independent of their surface size, while visual attention to the text element depends on the surface size of the text – the larger surface size of the text, the larger the visual attention. Considering that outdoor advertising is usually presented in the bigger informational clutter, the assumption can be made that the same results obtained by Pieters and Wedel (2004) can be not applicable for outdoor advertising. Therefore, we hypothesize:

H₂: When the surface sizes of visual and textual outdoor advertising elements are the same, visual elements attract more visual attention than textual ones.

Pieters *et al.* (2010) confirmed that print advertising design complexity has a positive effect on the visual attention to the advertisement as a whole. Previous research (see Pilelienė, Grigaliūnaitė, 2016) substantiated these results and stated the fact that the complexity of the advertising layout has a negative influence on the visual attention to the brand presented in the print advertisement. Accordingly, in the case of outdoor advertising, we analyse only one component of advertising complexity – quantity of objects, and hypothesize:

H_{3a}: Advertisements containing a large number of elements attract more visual attention than the ones containing a small number of elements.

H_{3b}: Brand presented in the advertisement containing a large number of elements attracts less visual attention than brand presented in the advertisement containing a small number of elements.

Endeavouring to make a deeper analysis, the assumption is made that the combination of two criteria, namely, the number of elements and dominating elements, can affect consumers’ visual attention to the whole outdoor advertisement. Therefore, the following four hypotheses are made:

H_{4a}: Advertisements containing a large number of elements, where most of them are visual, attract more visual attention than those advertisements containing a large number of elements, where most of them are textual.

H_{4b}: Advertisements containing a small number of elements, where most of them are visual, attract more visual attention than those advertisements containing a small number of elements, where most of them are textual.

H_{4c}: Advertisements containing a large number of elements, where most of them are visual, attract more visual attention than those advertisements containing a small number of elements, where most of them are visual.

H_{4d}: Advertisements containing a large number of elements, where most of them are textual, attract more

Table 1

Advertisement criteria

Criteria	No. of advertisement							
Font	Large	Large	Large	Large	Small	Small	Small	Small
Number of elements	Large	Large	Small	Small	Large	Large	Small	Small
Dominating elements	Visual	Textual	Visual	Textual	Visual	Textual	Visual	Textual
Brand	Same size, same place							

visual attention than those advertisements containing a small number of elements, where most of them are textual.

Considering the hypotheses, authors made the advertisement criteria grid (see Table 1) for the creation of outdoor advertisements containing only the criteria useful for the research in order to minimize the risk of misleading results influenced by factors not analyzed in this research. As it can be seen, eight advertisements were used for the research. Convenience product category was chosen for the research, thus in all of the advertisements, different bread brands were advertised.

In order to eliminate the influence of advertisement layout on the results, all of the advertisements had to maintain the same layout system, created based on the marketing and advertising experts' comments. Latter system is presented below in Figure 1. As it can be seen, the brand is positioned in the left upper corner; in the right upper corner picture is presented only in the advertisements which contain a large number of elements, while headline is presented in the middle of the advertisement. The ratio of paper size to large headline font size is 100:9, while the ratio of paper size to small headline font size is 100:6. At the bottom of the page, visual element is presented in the advertisements, which have to contain visual elements, and the text is presented in the advertisements, which have to contain textual elements (the ratio of paper size to the font size of the body text is 100:3). Consequently, the ratio of small headline font size to body text font size is 2:1; large headline font size to body text font size ratio is 3:1. The advertisement paper size used for the research is A4 (210:297 millimetres), because the participants' walking distance from the advertisements was 1 metre (30 centimetres), due

to the narrow passing. Accordingly, with the bigger distances the advertisement paper size has to be bigger in order to capture the consumers' attention.

All of the advertisements were hung upon the university wall (in the centre of the town) in a random order, in the passing between the bus stop and the entrance to the university. Participants looked (or did not look if did not notice) at the advertisements at their own pace. The experiment was conducted using Tobii Eye-Tracking Glasses – mobile video-based eye tracker recording monocular gaze data from the right eye at a sampling rate of 30 Hz. This eye tracker has an accuracy of 0.5°. The system has a camera to record a scene video with a resolution of 640x480 pixels; maximum recording angles are 56° of visual angle in horizontal and 40° of visual angle in vertical direction.

Each of the participants put on the glasses and performed a standard nine point calibration. All of the participants were volunteers and had not been paid for the participation in the eye-tracking experiment. Before the experiment each of the participants was informed in detail about the experiment and signed the form of information and informed consent. After the experiment, each of the participants filled the advertising aided recall and recognition questionnaire. The experiment was held in Lithuania, Vytautas Magnus University, February, 2016.

Data appropriate for the analysis were obtained from 30 participants' (26 females). All of the participants were right-handed with normal or normal-to-corrected vision. All of the participants were at the age group of 18-29 years.

For the analysis of eye-tracing results Tobii Studio v.3.2.3 software was applied. Pieters *et al.* (2002) stated that consumers extract information

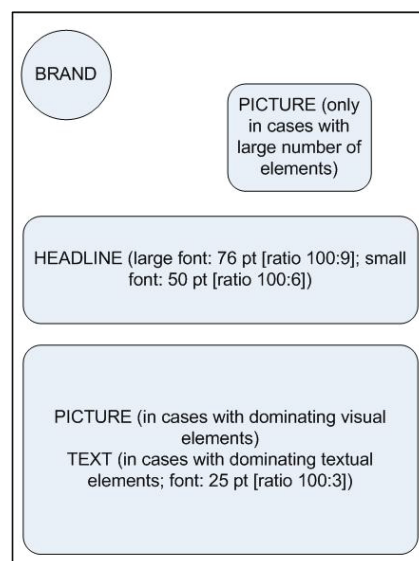


Figure 1. The system of advertisement layout.

from advertisements and their elements during eye fixations, which reflect the moments of visual attention. Meghanathan *et al.* (2015) confirmed that fixation duration is sensitive to the amount of attention deployed to a fixated location. Moreover, the frequency of fixations is a measure of the intensity of visual attention and the information in ads and ad elements (Pieters *et al.*, 2002). Thus, advertisements' and parts' of the advertisements total fixation duration (average duration of all fixations within the specific element) and fixation count (average number of times the participants fixated on the specific element) regarding different criteria were calculated. IBM SPSS

Statistics v.20 and XLSTAT 2014 software packages were applied for the statistical analysis of the results obtained from the Tobii Studio v.3.2.3 software.

Results and Discussion

Participants' total fixation duration (mean viewing time, s) and fixation count (times) are presented in Table 2. All of the results are calculated including zeros (including respondents who did not fixate on the element being analyzed). As it can be seen, the small headline attracts very similar amount and intensity of visual attention compared to the large one. When measuring the factor 'dominating elements', only the

Table 2

Mean viewing time (s) and fixation count for the advertisement elements regarding specific criteria

Criteria	Mean	S.E.	95% C.I. for Mean		Median	S.D.	Minimum	Maximum	Fixation count
			Lower bound	Upper bound					
Headline									
Large font size	3.764	0.444	2.855	4.673	3.575	2.393	0.510	6.690	115.7
Small font size	3.891	0.464	2.941	4.841	3.605	2.500	0.170	7.890	119.2
Domingating elements									
Visual	5.900	0.380	5.122	6.678	5.540	2.047	2.650	9.400	179
Textual	14.755	2.371	9.905	19.605	10.920	12.770	0.500	48.000	444.6
Number of elements									
Large	20.364	1.769	16.745	23.983	17.535	9.528	7.960	42.350	613.2
Small	16.833	1.910	12.927	20.739	15.875	10.285	6.290	45.260	506.8
Brand									
Advertisement with large number of elements	1.756	0.354	1.032	2.480	0.965	1.907	0.000	6.540	59.78
Advertisement with small number of elements	1.846	0.281	1.272	2.420	1.215	1.511	0.140	4.180	56.7
Domingating elements and number of elements									
Large number of elements, dominating visual	7.743	0.569	6.579	8.907	8.225	3.066	2.190	11.650	233.5
Large number of elements, dominating textual	14.023	1.410	11.138	16.908	14.150	7.596	5.200	32.800	422.1
Small number of elements, dominating visual	6.220	0.602	4.988	7.452	6.520	3.244	0.000	13.360	209.22
Small number of elements, dominating textual	10.164	1.502	7.091	13.237	9.275	8.090	3.110	32.480	306.3

bottom of the advertisements with textual or visual parts is analyzed. The analysis reveals that textual elements attract bigger amount and intensity of visual attention. When analyzing ‘number of elements’, the whole advertisements are analyzed and analysis reveals that advertisements with a large number of elements attract bigger amount and intensity of visual attention, though the brand attracts more attention when it is presented in the advertisement with a small number of elements (despite the fact, that the difference is minimal).

When analyzing “dominating elements and number of elements”, the whole advertisements are analyzed. The analysis reveals that advertisements containing a large / small number of elements, where most of them are textual attract more visual attention

than those containing a large / small number of elements, where most of them are visual. Moreover, advertisements containing a large number of elements, where most of them are visual / textual, attract more visual attention than advertisements containing a small number of elements, where most of them are visual / textual.

As the data of eye-tracking experiment are non-normally distributed, Wilcoxon Signed Ranks Test is applied in order to evaluate the difference between two dependent samples (see Table 3). As it can be seen, the difference in visual attention toward a large headline and visual attention toward a small headline is statistically non-significant. On the other hand, the test reveals that the dominating textual elements in outdoor advertising of convenience

Table 3

Wilcoxon Signed Ranks Test

Criteria	Statistics	
	Z	p-value
Large headline font size – Small headline font size	1.113	0.266
Dominating visual elements – Dominating textual elements	3.861	0.000*
A large number of elements – A small number of elements	2.316	0.021*
Brand presented in the advertisement with a large number of elements – Brand presented in the advertisement with a small number of elements	1.144	0.253
Advertisement with a large number of elements and dominating visual elements – Advertisement with a large number of elements and dominating textual elements	3.922	0.000*
Advertisement with a small number of elements and dominating visual elements – Advertisement with a small number of elements and dominating textual elements	2.502	0.012*
Advertisement with a large number of elements and dominating visual elements – Advertisement with a small number of elements and dominating visual elements	3.305	0.001*
Advertisement with a large number of elements and dominating textual elements – Advertisement with a small number of elements and dominating textual elements	2.843	0.004*

*p<0.05.

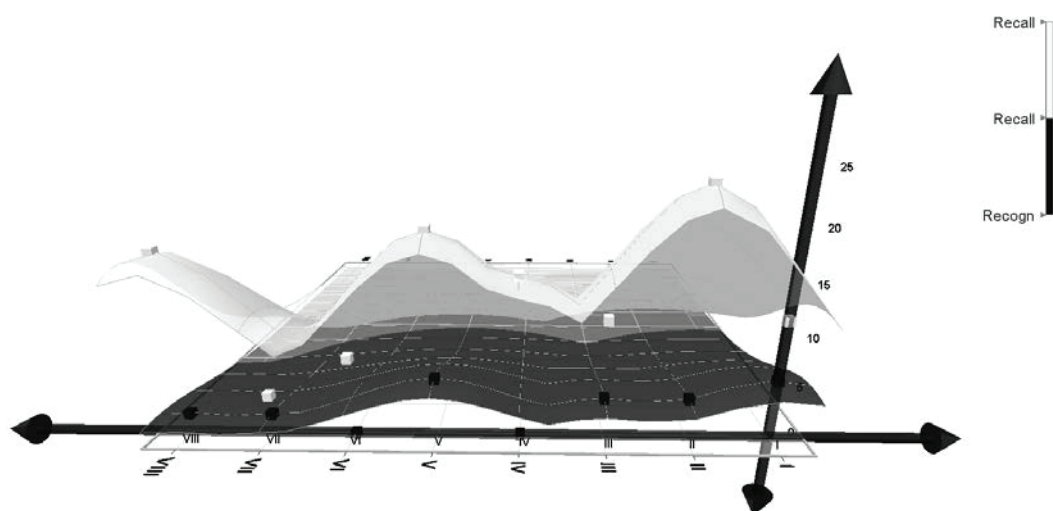


Figure 2. The levels of experiment advertisement recall and recognition, n = 30.

product category attract statistically significantly more visual attention than dominating visual ones. Advertisements containing a large number of elements attract statistically significantly more visual attention than the ones containing a small number of elements. Despite this, the difference in visual attention toward a brand presented in the advertisement with a large number of elements and a brand presented in the advertisement with a small number of elements is statistically non-significant (it is important to mention that in this research only one component of advertising complexity – quantity of objects – is analyzed). Finally, advertisement with either a large or small

number of elements and dominating textual elements attracts statistically significantly more attention than advertisement with either a large or small number of elements and dominating visual elements; moreover, advertisements, where dominating elements are respectively visual or textual, attract statistically significantly more attention when there is a large number of elements, compared to a small number of elements.

It could be stated, that a large number of elements in any case attracts more visual attention than a small number of elements in the outdoor advertisement, and that textual elements in any case attract more

Table 4

Results of hypotheses testing

No.	Hypothesis	Result	Explanation
H1	The headline with larger font size attracts more consumers' visual attention than the one with smaller headline font size	Rejected	The difference is statistically non-significant
H2	When the surface sizes of visual and textual outdoor advertising elements are the same, visual elements attract more visual attention than textual ones	Rejected	When the surface sizes of visual and textual outdoor advertising elements are the same, textual elements attract statistically significantly more visual attention than visual ones
H3a	Advertisements containing a large number of elements attract more visual attention than the ones containing a small number of elements	Supported	Advertisements containing a large number of elements attract statistically significantly more visual attention than the ones containing a small number of elements
H3b	Brand presented in the advertisement containing a large number of elements attracts less visual attention than in the advertisement containing a small number of elements	Rejected	The difference is statistically non-significant
H4a	Advertisements containing a large number of elements, where most of them are visual, attract more visual attention than those advertisements containing a large number of elements, where most of them are textual	Rejected	Advertisements containing a large number of elements, where most of them are textual, attract statistically significantly more visual attention than those advertisements containing a large number of elements, where most of them are visual
H4b	Advertisements containing a small number of elements, where most of them are visual, attract more visual attention than those advertisements containing a small number of elements, where most of them are textual	Rejected	Advertisements containing a small number of elements, where most of them are textual, attract statistically significantly more visual attention than those advertisements containing a small number of elements, where most of them are visual
H4c	Advertisements containing a large number of elements, where most of them are visual, attract more visual attention than those advertisements containing a small number of elements, where most of them are visual	Supported	Advertisements containing a large number of elements, where most of them are visual, attract statistically significantly more visual attention than those advertisements containing a small number of elements, where most of them are visual
H4b	Advertisements containing a large number of elements, where most of them are textual, attract more visual attention than those advertisements containing a small number of elements, where most of them are textual	Supported	Advertisements containing a large number of elements, where most of them are textual, attract statistically significantly more visual attention than those advertisements containing a small number of elements, where most of them are textual

visual attention than visual elements in the outdoor advertisement of convenience product.

Obtained results of eye-tracking experiment are substantiated by the results of advertising recall and recognition questionnaire. The levels of experiment advertisement recall and recognition are provided below in Figure 2. As it can be seen, the best recalled advertisement (24 out of 30 participants) is number two (large headline font size, a large number of elements, dominating textual elements).

Advertisement number eight (with dominating textual elements as well) is recalled by 18 participants; advertisement number five (with dominating visual elements) is recalled by 20 participants. In a common result, the level of advertising recall is better regarding advertisements with dominating textual elements. Nevertheless, the recognition level of the advertisements is very low. The best recognized advertisements are number one (large headline font size, a large number of elements, dominating visual elements) and five, which were recognized by six participants each and advertisement number two, recognized by four participants. These results substantiate Du Plessis (2008) idea, that recognition is an emotional task, thus it is the correct method to use for television, while recall is a logical task, thus a correct method to use for print, outdoor advertising, etc. Consequently, based on the recall test and eye-tracking experiment, a large number of elements and dominating textual elements give the highest possibility to attract consumers' attention and positively influence the effectiveness of outdoor advertising. All of the results of hypotheses testing with the summarized main findings in the explanation column are presented below in Table 4.

Testing the research hypotheses allows to determine the criteria of internal factors influencing the effectiveness of outdoor advertising: headline

larger than the body text, a large number of elements with dominating textual elements, and the emphasised brand.

Conclusions

Visual consumers' attention to outdoor advertising is necessary, but not a sufficient condition in order for advertising to become effective. Message-related factors, as a part of internal factors influencing the effectiveness of outdoor advertising, have a great impact on the consumers' visual attention. Consequently, knowing message-related factors criteria that attract consumers' attention can enhance the possibility for the advertising to become effective.

In the scientific literature, the most discussed message-related factors of print advertising are the headline, dominating elements, and the number of elements. Nevertheless, research regarding the influence of message-related factors on the effectiveness of outdoor advertising is scarce. Consequently, authors of this research analyzed the most discussed message-related factors of print advertising in the context of outdoor advertising.

The analysis of the research results lead to the determination of the internal factors criteria influencing the effectiveness of outdoor advertising: headline larger than the body text, a large number of elements with dominating textual elements, and the emphasised brand. By following these criteria, organizations can improve their advertising campaigns by enhancing advertising effectiveness possibility. Directions for future research are the analysis of the influence of personal factors and external factors on the effectiveness of outdoor advertising.

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FACTORS INFLUENCING CHOICE OF VETERINARY SERVICE

Lina Ašmenskaitė¹, Adelė Astromskienė², Sigita Kerziene¹

¹Lithuanian University of Health Sciences

²Aleksandras Stulginskis University, Lithuania

lina.asmenskaite@lsmuni.lt; adele.astromskiene@asu.lt; sigita.kerziene@lsmuni.lt

Abstract

Increasing competition among health care service providers for pets and constantly growing requirements for the veterinary service quality, force veterinary service providers to search for some possibilities to remain competitive in the market in order to meet both customer needs and expectations, and animal needs best. The aim of the research is – having identified the choice motives for animal health care service, to enumerate the factors, influencing the choice of veterinary service. In order to find the pet keepers' approach concerning the factors, influencing the choice of veterinary service, a pilot research was completed. According to the gained primary data results in the research, it was found that the key factors, influencing the choice of veterinary service are as follows: the service quality of health care, the recommendation of the person responsible for animal care and the price for the delivered service.

Key words: veterinary service, veterinary service provider, customer approach, factors.

Introduction

Currently, in the veterinary sector there are predominant complex and intensive changes, which have some influence on the competitive environment of veterinary service. First, because of the increase in the number of pet health care service providers (Lowe, 2009) and the decrease of veterinary service providers in rural areas (Jensen *et al.*, 2009; Villarroel *et al.*, 2009), as well as the decrease in graduates' opportunities to get employed and entrenched in the labor market (AVMA, 2013), the competition among veterinary service providers, delivering this service, is increasing rapidly.

Another challenge for the veterinary service providers is the constantly growing requirements for the veterinary service quality, changing customer needs, increasing animal owners' insistence for veterinary service providers and all this makes the veterinary service providers search for some possibilities to remain competitive in the market in order to meet both the customer needs and expectations and animal needs best.

It should be highlighted that animal health care service is specific. Differently from human health care, in the animal health care there are distinguished two separate subjects – customer (animal owner) and patient (animal). Veterinary service is provided to animals and the customer is a service purchaser (Ašmenskaitė & Astromskienė, 2015). It should also be emphasized that health care service has to meet not only customer and animal needs, but they also has to comply with clinical standards.

As it has been noted in the literature lately, during the provision of service to customers by veterinary physicians there is predominant insufficient satisfaction of customer needs (Kaler & Green, 2013), distrust to personal abilities and knowledge with the purpose to meet the customer needs (Roshier & McBride, 2013). Besides, there have been indicated

significant differences between pet owner and vet approaches, assessing 'a good vet' qualities (Mellanby *et al.*, 2011). As Lowe (2009) underlines, for veterinary service providers it is a must to improve relationship with farmers, i.e. service receivers. According to the author, farmers insist on veterinary service, which comply with their wider business needs (Lowe, 2009). Lloyd, Harris, & Marrinan (2005) states that in order to maintain the long-lasting relationship with customer, efficient communication with animal owners is one of the assessment indicators of the animal health care service quality. According to Felsted (2012), veterinarians have to pay more attention to the communication of service value to their customers. An animal owner has a right to expect that some attention will be paid to his/her expectations and needs, and as a result the attention to customer as a personality and to his/her animal's problems is a required and very important part for the veterinary service provider's work.

The satisfaction of the veterinary service receivers with the provided veterinary service and the factors facilitating the following that veterinary service providers could foresee animal owners' behavioral peculiarities, is quite a new issue that is little investigated by Lithuanian scientists. The following reveals that the research in veterinary service is carried out assessing it in terms of veterinary medicine approach.

There has been little research conducted by foreign scientists on the given topic. A study of public expectations (MG&A, 2014), carried out by Royal Veterinary College, revealed that it is possible to distinguish the criteria, which have influence on the choice of a veterinary service provider. The key choice factors concerning a veterinary service provider, distinguished by the veterinary service receivers, were the following: territorial convenience (distance to the veterinary service provider), following of professional

standards and personal experience of the service reception. It is worth paying attention to the fact that customer expectations, when choosing a veterinary service provider, differ. Horse owners were likely to reach the veterinary service provider present in a farther distance and pay for the provided service more in comparison to pet owners.

The study, completed in Austria, showed (1285 respondents participated in the survey) that the most significant criteria in the choice of a veterinary physician are the following: friendliness and veterinary physician's consultation and professionalism (competence) (Energy marketing, 2004). It should be stressed that the service price criterion was the least meaningful in the choice of a veterinary physician.

Under the order of the Polish Small Animal Veterinary Association, the Public Relations Agency carried out a study with the aim to indicate the need satisfaction possibilities for dog owners, purchasing the veterinary service. The study results revealed that the most significant motives when choosing the veterinary service provider, are the following: convenient and easily reachable place (54%), veterinary service provider's competence (50%), price (41%) and the range of the provided service (19%) (Walczak, 2012).

The aim of the research – having identified the motives for the choice of animal health care service, to enumerate the factors, influencing the choice of veterinary service.

Materials and Methods

In order to identify the motives for the choice of animal health care service and enumerate the factors, influencing the choice of veterinary service, there was completed a pilot research. In terms of the research completion, for the collection of data the written survey method was used. The data were collected from October to November, 2015.

For the completion of the survey a two-part questionnaire was prepared. The first part contained questions concerning the researched social-demographic data (gender, age, education and income) and the second part – questions with the aim to research the factors that influence the pet owners' choice of the veterinary service.

For the research the non-probability sampling method – convenience sampling - was chosen. It means that there were surveyed those who could be reached most easily. The target research population involved pet owners, who had used animal health care service. The sample, selected for the following research involved different age groups, exceptionally over the age of 18.

During the completion of the research 400 questionnaires were disseminated; 376 of them were

returned, out of them the correctly filled ones were selected. Statistical data analysis was completed applying the software package: IBM SPSS Statistics (21.0 v.). The following methods of statistical analysis were applied: descriptive statistics; and for the assessment of differences related to the statistical significance the nonparametric *chi* square (χ^2) criterion was applied.

Results and Discussion

The majority of the respondents who participated in the research were 18-24 (53.2%) old. There participated more women than men (respectively 81.9% and 18.1%). The greater part of the researched had the higher education of university type or non-completed higher education (53.2%), and almost a quarter – secondary (24.5%), and the least part were those with the advanced vocational education and training (9.6%). During the analysis of the respondent distribution according to the residential area, it was found that more than a half of respondents (69.1%) reside in cities and the remaining 31.6% – in villages. Most respondents (31.9%) indicated that their income was 301- 400 EUR per month, 19.1% of respondents indicated that their income was 401-500 EUR, 30.5% selected the lowest income group – up to 300 EUR, and 8.5% of respondents indicated the highest income group of 701 EUR and more.

First, under the research it was sought to find out the frequency of respondents' visit at the veterinary service provider during the last two years. Over the last two years most pet owners had used the animal health care service at least once. More than a half of respondents (61.7%) indicated that they with their pet visited the veterinary physician 2-5 times, and 20.2% of the surveyed visited the veterinary physician more than 5 times. 18.1% of pet owners had visited the veterinary doctor once during the last two years.

There was indicated statistically significant differences between the frequency of pet owners' visit/attendance and the choice of the veterinary service provider. Most respondents who have a personal veterinary physician first indicated that they have used the animal health care service more than 6 times (Table 1).

During the analysis of the visit/attendance number to a veterinary service provider for one pet owner in two years it was found that on average during the last two years one service receiver had visited the veterinary service provider 4 times. It was also found that women (on average 4.0 times, $p=0.087$) and village residents (on average 4.1 times, $p=0.001$) together with pets more often visited veterinary service providers.

It was found that the number of visits differ depending on the choice of an animal health care provider. Pet owners, who do not have their personal

Table 1

The links between the frequency of pet owners' attendance/visit to the veterinary service provider and the choice of the veterinary service provider, %

Veterinary service provider	Attendance/visit frequency at the veterinary service provider		
	Once	2-5 times	More than 6 times
Ones, who have chosen a personal veterinary service provider	13.2	60.3	26.5
Ones, who have not chosen a personal veterinary service provider	30.8	65.4	3.8

$\chi^2=32.158$, $df=2$, $p=0.000$

veterinary physician, visited animal health care providers more often than those who had chosen the personal veterinary service provider (on average 4.3 times, $p<0.003$). Thus, there can be drawn a conclusion that pet owners do not trust the veterinary service provider and/or the quality of their provided service and, as a result they apply to another service provider expecting a better service quality. The attention should be paid to the fact that pet owners' distrust and disappointment can cause situations when a veterinary service provider starts behaving not as a person responsible for animal health care, but as a businessman. Trust is a very significant aspect for the relationship between service providers (animal health care service providers) and people, using service (pet owners). According to Grand *et al.* (2013), trust in veterinarians is related to professionalism, respectful communication and an ability to deliver information concerning animal diagnostics, treatment methods and treatment prognosis in an open manner and honestly. Consequently, it can be stated that interpersonal relationship between the veterinary service provider and animal owner is impossible with no trust.

Pet owners may apply to any animal health care service provider who provides service and get the necessary help for the pet. Most pet owners who participated in the research (72.3%) indicated that they have a personal veterinary physician who they apply to first in case of animal health problem presence, and only 27.7% of pet owners do not have a veterinary physician and in case of necessity they apply to that animal health care provider who is the most convenient for them. No significant differences between gender, place of residence, age and income were identified. It was determined that the choice of a health care service provider depends on education ($\chi^2=30.815$, $df=4$, $p=0.000$).

The research revealed that the majority of all the surveyed (69.1%) applied to a veterinary service provider because of a dog's health condition, 27.7% – because of a cat's health condition. The minor part (3.2%) of respondents indicated that their animal kind is another, i.e. they applied to the veterinary physician because of exotic mammals' health disorders. No

significant differences between the respondents' gender, age, income education and the most popular kinds of animals were found. The research showed that 47.9% of respondents keep one animal and almost a third (29.8%) keep two pets, 12.8% – 4 and more pets. A trend can be observed that the more pets are kept, the weaker the relationship between the human and animal is.

It should be stressed that it is not sufficient to analyze the demand for animal health care service, based on the statistical change in pet numbers. Analyzing the service demand for animal health care, the regularity of the pet owner visits to a veterinary physician, is particularly significant. The research revealed that almost a half of pet owners (38.3%) visit the veterinary service provider with their pet on a regular basis, and the fifth - irregularly. A third (39.4%) of pet owners indicated that they visit the veterinary service provider very seldom, (i.e. one time totally, one time in 2 years, in the case of the animal's health disorder). No statistically significant differences between the regularity of pet owners' visits and the animal kind have been detected. A presumption can be made that animal owners' behavior and knowledge about animal health care influence the regularity of visits with an animal to a veterinary physician. The results of the study, completed in the USA, showed that the average number of pet owners' visits to a vet was decreasing (Brakke Consulting, 2011). We have distinguished the factors that influence the more seldom visits/attendance to a veterinary service provider: 1) expensive animal health care service is not affordable for pet owners due to its price, 2) pet owners are likely to use the Internet and search for information related to pet health issues – all this has a great influence on the pet owners' decision to visit/attend an animal health care provider more seldom. Scientists draw attention to the fact that the most significant factor influencing the frequency of visits/attendance to a veterinary service provider is a predominant 'false attitude' among most pet owners that regular pet health check-up is not necessary.

The respondents were also asked to indicate the person who takes care of the animal. 42.6% of animal

owners indicated that they take care of their pet. A third of respondents (31.9%) indicated that not only the animal owner takes care of it, but also a spouse/partner. Others pointed out that other family members take care of animals (23.4%). A presumption can be drawn that animal care takes a lot of time, thus it is likely to be shared with other family members and relatives.

In the recent years, more and more attention is being paid to the human and animal emotional relationship that is very significant to human interrelationship (Beck & Meyers, 1996; Bustad & Hines, 1984; Melson, 2003; Serpel, 1999; Šinkariova, Gudonis, & Trakūnaitė, 2008; Tannenbaum, 1985). Human-animal relationship is defined as mutually useful and dynamic human and animal relation that involves the behavior, necessary for both subjects' health and welfare (AVMA, 1998). The following involves emotional, psychological and physical intercourse between a human, animal and environment. A veterinary physician, as a person responsible for animal health care should play a role in human-animal relationship: by aiding the strengthening of the potential of a human-animal relationship. It is universally acknowledged that for a veterinary physician it is useful to know the animal importance in human life, health and welfare (Fraser, 1989; Ormerod, 2008; Timmins, 2008), euthanasia which is related to human and animal feelings of loss (Clements, Benasutti, & Carmone, 2003; Gerwolls & Labbott, 1994; Morris, 2012; Smith, 2012; Weisman, 1991) and about the security of animal welfare (Marder & Duxbury, 2008; Wensley, 2008). The research results have revealed that 73.4% of pet owners keep an animal together with a family member, 23.4% with a friend and only 3.2% indicated that they consider their pet being an animal or work object. Having completed the study in the human and pet relationship, Rislely-Curtisso, Holley, & Wolf, (2006) identified that 97% of pet owners, the majority of which had a dog, consider their animal being their family member. Blacwell (2001) provides similar research data and indicates that 85% of pet owners consider their animal being a family member.

Applying to veterinary service providers, pet owners have their expectations. Veterinary physicians also have a distinctive attitude towards their work duties during the consultation and want to provide the pet owners with a high-quality service. It is very important to estimate if physician and customer expectations are similar as this might have an impact on the usage of the consultation time and the assessment of the service quality. During the research it was sought to find out the reasons for the pet owner application to a veterinary service provider. The respondents could mark all the answer variants suitable for them. During the research there proved to

be two key reasons for the application to an animal health care provider – pet disease / health problems (83.0%) or pet vaccination (69.1%) (Figure 1).

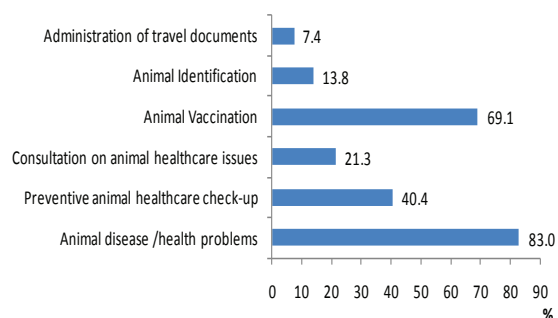


Figure 1. Key reasons for the application to an animal health care service provider.

Volk *et al.* (2011) also identified that only 32% of pet owners considered the necessity visiting a veterinary service provider due to preventive aims, and 36% indicated that it is necessary to apply to a veterinary service provider only for a pet vaccination. On the basis of the following data, a conclusion can be drawn that this determines the decreasing visit/attendance frequency to a veterinary service provider in the recent years (Felsted, 2011). An assumption can be made that animal owners insufficiently comprehend the values of preventive animal health care service.

It has to be stressed that the animal registration and identification obligation is regulated by the Law on Welfare and Protection of Animals in the Republic of Lithuania. Following the above mentioned law, pets (dogs, cats and ferrets) have to be registered and identified. The research results revealed that only 13.8% include the reason related to the pet owners' application to an animal health care service provider for the pet identification. It was determined that the pet owners who are at a younger age (18-24 years) used the pet identification service ($\chi^2=30.685$, $df=4$, $p=0.000$).

The veterinary service receiver has an opportunity to choose the service provider. It is considered that the choice of a veterinary service provider depends on the veterinary service receiver's satisfaction with his/her consultation. Thus it is important for animal health care providers to be aware of the choice criteria because that might help them meet the pet owner's expectations.

Having completed the research, it was determined that the majority of respondents estimated the choice of the criteria for animal health care as significant (Table 2). 97.7% of animal owners indicated that the most significant motive for the choice of a veterinary service provider, was the quality of health care service,

Table 2

Respondent distribution according to the choice of an animal health care service provider, %

Criteria	Not important	Partially important	Important
Service range	7.4	27.7	64.9
Convenient location	14.7	21.3	67.0
Other customers' recommendations	5.3	30.9	63.8
Recommendations of the persons responsible for animal care	10.6	12.8	76.6
Acceptable price for the delivered service	7.4	18.1	74.5
Service quality	1.1	1.1	97.7

63.8% – the recommendations of other persons responsible for animal care, and 74.5% – the price for the delivered service.

In order for the pet owners to apply to service providers, they should have some information about the service provider and the delivered service. Having completed the research, it was determined that 73.4% of pet owners indicated the veterinary physician being as one of the key information sources. Pet owners indicated that they search for the information related to animal health care in the periodical press and informative publications least. Although the social network *Facebook* has turned into the most actively used social network in the whole Europe and the USA during quite a short time (Carlsson, 2012; Li & Sun 2014; Akin & Akin, 2015), however, only 21.3% of respondents search for the information of the following pattern in the social network *Facebook*. The pet owners, who participated in the survey, chose friends and acquaintances, the Internet media and the veterinary service provider's website as information resources (see Figure 2).

Having analyzed the research data it was determined the information presented on the veterinary service provider's website is the most frequently used by the respondents with secondary education ($\chi^2=36.842$,

$df=4$, $p=0.000$). The respondents with non-completed higher education indicated periodical press being as the most significant source of information ($\chi^2=54.339$, $df=4$, $p=0.000$). There has also been noticed a trend that the respondents at a younger age (18-24) had indicated the social network *Facebook* as the most significant source of information concerning animal health care service ($\chi^2=15.503$, $df=4$, $p=0.004$). It should be emphasized that animal health care service providers have to know where their customers get information concerning their pet diseases and their behavior in case of diseases and if that information is secure, as well as to inform customers about the best sources of information.

Summarizing the research results it can be stated that when a need for pet health care service emerges – it is applied for or used. The key motives, influencing the choice of veterinary service are the quality of animal health care service, the recommendations of the persons responsible for animal care and the price for the delivered service.

Conclusions

1. The research in the choice motives for veterinary service providers offers valuable information concerning pet owner needs and expectations that

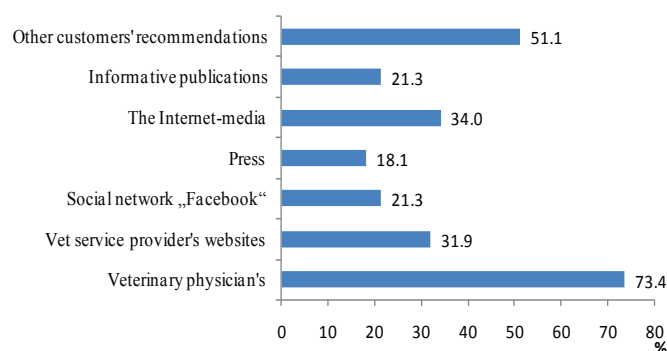


Figure 2. Key information search resources based on animal health care service.

- can be used by the veterinary service providers for the design of the value proposal. It is a required condition for each veterinary service provider's competitiveness.
2. The majority of pet owners applied to a veterinary service provider concerning a dog or cat health condition. Almost a half of the pet owners visit the veterinary service providers with their pets on a regular basis, and the fifth irregularly. The major part of the pet owners has a personal veterinary physician, who they apply to first in case of present animal's health problems. The pet owners who do not have a personal veterinary physician visited an animal health care provider more often than ones who have chosen him/her.
 3. It is purposeful for veterinary service providers to identify the human-animal relationship. The application of the human-animal relationship makes presumptions for the creation of trust between a customer and veterinary service provider and might provide some information concerning the customer. It was determined that the major part of the pet owners consider an animal their family member, and only 3.5% indicated that they consider their pet an animal or work object.
 4. The key reasons for the application to an animal health care provider – pet disease/health problems or pet vaccination. The motive for veterinary service provider's choice by the pet owners involves the quality of the animal health care service, recommendations of the persons responsible for animal care, and the price for the delivered service.
 5. The greater majority of pet owners indicated the veterinary physician being one of the key information sources about the provided animal health care service. The pet owners search for the information related to the animal health care service in periodical press and sources of information least. The choice of information sources by pet owners depends on education. Persons with secondary or non-completed higher education chose the Internet media and the veterinary service provider's website as a source of information more frequently.

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COMPETITIVENESS OF LATVIAN DAIRY SECTOR: PRODUCTIVITY AND EXPORT

Agnese Krieviņa, Juris Hāzners, Ligita Melece

Institute of Agricultural Resources and Economics, Latvia

agnese.krievina@arei.lv; juris.hazners@arei.lv; ligita.melece@arei.lv

Abstract

The objective of the research paper is to explore the competitiveness of Latvian dairy sector from the aspect of productivity and export indicators, as well as to examine some of the possibilities to improve the sector competitiveness. The authors explore the productivity and export indicators of Latvian dairy sector, and the link between productivity and export (within the EU context), as well as analyze the impact of farm investment support within RDP 2007 – 2013. Value added per labour unit has been chosen as the productivity indicator; suitable qualitative and quantitative research methods have been applied to the studies. Based on the introduced indices of relative position of dairy industry productivity and exports, dairy processing in Latvia has strong inter-branch position in the domestic food industry. However, the inter-country comparison shows that Latvian dairy processing is behind the EU average level, when its productivity and export volume are considered. It has been found that productivity and export of dairy processing are positively related; rather strong positive correlation also exists between productivity in dairy farming and dairy processing. Therefore, the development of Latvian dairy sector, which mainly depends on the development of exports, can be more successfully achieved by the increase in its productivity; and relatively the largest productivity gap to close is in the dairy farming in Latvia. The direct investment support effect on NVA/AWU of dairy farms is found to be significant and positive, indicating that farm modernisation support of RDP 2007 – 2013 has facilitated the improvement of overall dairy farm productivity in Latvia.

Key words: dairy sector, productivity, export, Latvia.

Introduction

Raw milk production in Latvia exceeds the domestic consumption needs by almost 40% (CSB of Latvia, 2015) implying that the country's dairy sector is export-oriented to a large extent. In literature, there is an evidence of the link between productivity and export – companies have to be productive to enter export markets (self-selection effect), and vice versa - exporting improves the productivity of companies by gaining experience and learning (learning-by-exporting effect) (Yang & Chen, 2012). There has been an evaluation carried out to analyze the existing relations between exports of goods and services and labour productivity in the economy for Latvia and other European Union (EU) countries. The estimation results confirm that the higher the labour productivity is, the higher the exports will be. Moreover, a higher exporting activity is found to be linked to a higher volume of economic activity, and as Latvia's economy is an import-dependent economy, also a higher import growth rate (Auziņa-Emsiņa & Ozoliņa, 2013). Similarly, it has been found out that exporting enterprises in Latvia are noticeably more productive than non-exporting enterprises, and the most productive are regular exporters (Beņkovskis & Bēms, 2014). This paper, inter alia, contributes to the studies evaluating productivity and the relationship between productivity and export success by focusing on the dairy sector, which is one of the most important agri-food sectors in Latvia and the development of which is to be mainly associated with its competitiveness on export markets.

The objective of this paper is to explore the competitiveness of Latvian dairy sector from the

aspect of productivity and export indicators, as well as to examine some of the possibilities to improve the sector competitiveness. To reach the objective, the following tasks have been set: 1) to explore the productivity and export indicators of Latvian dairy sector, and the link between productivity and export (within the EU context); and 2) to analyze the impact of farm investment support within the Rural Development Programme 2007 – 2013 (RDP 2007 – 2013) to increase the productivity of Latvian dairy farming.

Materials and Methods

Although competitiveness of dairy sector can be evaluated from various perspectives (Viira *et al.*, 2015), this article focuses on productivity and export indicators. Considering the aim of the study and data availability, value added per labour unit has been chosen as the productivity indicator to be analyzed in this paper. Inter alia, indices of relative position of productivity and export of dairy processing have been calculated by the authors, based on the similar approach as used for Balassa index of revealed comparative advantage (RCA) (Balassa, 1965). The index of relative position of dairy industry productivity in Latvia (IRCP) is introduced as follows:

$$IRCP = \frac{\frac{P_{LVD}}{P_{LVF}}}{\frac{P_{EUD}}{P_{EUF}}}, \quad (1)$$

where P_{LVD} - productivity in manufacture of dairy products in Latvia; P_{LVF} - productivity in manufacture

of food products in Latvia; P_{EUD} - productivity in manufacture of dairy products in EU-28 (except Denmark, Luxembourg and Malta); P_{EUF} - productivity in manufacture of food products in EU-28 (except Denmark, Luxembourg and Malta).

Similarly, index of relative position of dairy industry exports in Latvia (IRCE) is defined:

$$IRCE = \frac{\frac{E_{LVD}}{E_{LVF}}}{\frac{E_{EUD}}{E_{EUF}}}, \quad (2)$$

where E_{LVD} - export of processed dairy products in Latvia; E_{LVF} - export of processed food products in Latvia; E_{EUD} - export of processed dairy products in EU-28 (except Denmark, Luxembourg and Malta); E_{EUF} - export of processed food products in EU-28 (except Denmark, Luxembourg and Malta).

The relations regarding productivity and export have been evaluated using analysis of variance (ANOVA) and correlation coefficients. For the calculation of the indicators used in the study, data from Eurostat databases, including Comext, were retrieved for Latvia and other EU countries for the period 2008 – 2013. Correspondence tables between PRODCOM and Combined Nomenclature (CN) (Eurostat, 2016b) have been used to extract and calculate exports of processed food products. Considering the large export of raw milk from Latvia, CN code 04012099 (packed milk >2kg, fat >3%, but ≤6%) has not been counted as export of processed food products.

In order to evaluate the impact of the investment support (i.e., Farm modernisation measure of Latvian RDP 2007 – 2013) on dairy farms, 'naïve' difference-in-differences (DiD) estimator has been used in combination with propensity score matching (PSM). Until recently, the use of 'naïve' estimates was common and widely accepted in the evaluations of policy interventions, which included 'before – after' or 'with – without' approaches (DiD is the combination of these two approaches) along with the comparison with national averages. However, by the use of these methods, the real effects may become understated or overstated, and there can be a potential substantial bias when using the outcomes of non-participants as proxy for the possible outcomes of participants. Therefore, PSM-DiD method is also applied in the study.

PSM-DiD is a rigorous non-experimental method. Data for PSM are usually pooled in a panel from programme participants and non-participants. The non-participating or 'untreated' units constitute the 'control' group, while participants are included in 'treatment' group. Information from the control group

is used to assess what would be the outcome of interest for participants in the absence of the programme. The difference in outcomes for both groups is evaluated by comparing relatively similar units in the groups. The method was developed by Rosenbaum and Rubin (1983). For the implementation of the PSM-DiD method, Imbens (2004) suggests four steps: 1) selection of observational covariates and estimation of propensity scores; 2) stratification of propensity scores and testing of balancing properties in each block; 3) calculation of the Average Treatment on Treated (ATT) by matching; 4) sensitivity test for robustness of estimated ATT effects.

If the balancing properties of covariates are not satisfied in all strata, the test has to be repeated with different number of strata. If the balancing properties are not satisfied again, estimation of propensity scores has to be repeated with a modified list of covariates by adding higher order (squared) covariates. After getting all covariates balanced in every stratum, causal effects can be estimated by the nearest neighbour matching (NNM), radius matching (RM), kernel matching (KM) or stratified matching (SM).

NNM computes the ATT by finding the unit in the control group whose propensity score is the nearest (the value of difference is minimal) for every unit in the treatment group. In RM, the units in both groups are matched when the propensity scores in control group fall in the predefined radius of the units in the treatment group. In KM, all units in the treatment group are matched with the weighted average of all units in the control group. The weights are determined by distance of propensity scores, bandwidth parameter and a kernel function. In SM, for each block the average differences in the outcomes of the treatment group and the matched control group are calculated. The ATT is estimated by the mean difference weighted by the number of treated cases in each block.

The data on participating and non-participating dairy farms of Farm modernisation measure of Latvian RDP 2007 – 2013 were sourced from FADN database, which is not publicly available. Unpublished data of Rural Support Service (RSS) for the identification of supported farms have also been used.

Results and Discussion

Productivity and export competitiveness

Productivity is found to be the ultimate driver of long-run economic growth (EU Membership and..., 2005). Value added per employed person is among the most widely used measures of productivity (OECD, 2001). Along other factors, the reason for its popularity can be related to the fact that labour productivity is regarded to be a revealing indicator of several economic indicators as it offers a dynamic measure of economic growth, competitiveness, and

living standards within an economy (OECD, 2008). Moreover, labour productivity is considered the main factor that explains the dynamics of market shares and thus competitiveness in the Eastern European countries (Beņkovskis & Bēms, 2014).

The obtained results reveal that the productivity of Latvian dairy processors expressed as value added (i.e., value added at factor costs from industry structural statistics) per employee is higher than the average value added per employee in Latvian food industry. In 2013, the productivity of Latvian dairy processing exceeded the same indicator of food industry by about 30%. Likewise, the productivity of dairy processing is higher also in the EU on average, surpassing the value added per employee in food industry only a slightly less than in Latvia – by 28%. Therefore, the calculated index of relative position of dairy industry productivity in Latvia in 2013 was 1.02, indicating that the relative position of dairy processing in Latvia in the context of Latvian food industry is roughly the same as in the EU on average, with a slight comparative advantage.

Processed dairy products (without raw milk) accounted for about 18% of the total exports of processed food products in Latvia in 2013. The same share in the EU on average was smaller – exports of dairy processing made about 15% of the total exports of processed food in 2013. The ratio between these two shares gives the index of relative position of dairy industry exports for Latvia standing at 1.20 in 2013. This implies that in processed food exports Latvia has more specialization in dairy products than it can be observed in the EU on average.

Figure 1 summarizes the calculated indices of relative position of dairy industry productivity and

exports for Latvia and other EU countries in 2013, which are obtained for each EU country applying the same formula as for Latvia. It can be seen that Latvia is positioned in the upper right quadrant, with the values of indices exceeding ‘1’ (axes crossing at the EU average – ‘1’) and representing countries having both a high relative inter-branch productivity and a high relative inter-branch exports of dairy products. Based on the chosen indicators, dairy processing in Latvia has a strong position in the domestic food industry. From its neighbouring countries, only the relative inter-branch position of dairy processing in Estonia is found to be better than in Latvia. At the same time, it has to be mentioned that the analyzed inter-branch position in each country depends on the status of other food industry sectors in a country, and countries with a modest position of dairy processing within its domestic food industry can have a very good competitiveness against dairy sectors in other countries (for example, the Netherlands). Nevertheless, the authors believe that a strong position within domestic food industry generally is a good platform for Latvian dairy processing to develop its competitiveness potential.

When the inter-country comparison of dairy industry is made, the opposite position of Latvian dairy processing can be observed (see Figure 2). Based on the absolute value added per employee and the share of Latvian dairy exports in the total EU exports of processed dairy products, Latvia is positioned in the lower left quadrant, with values below the EU average (axes crossing at the EU average) and representing countries with low productivity and smaller/small export volume of processed dairy products. Latvia shares this quadrant also with Estonia and Lithuania;

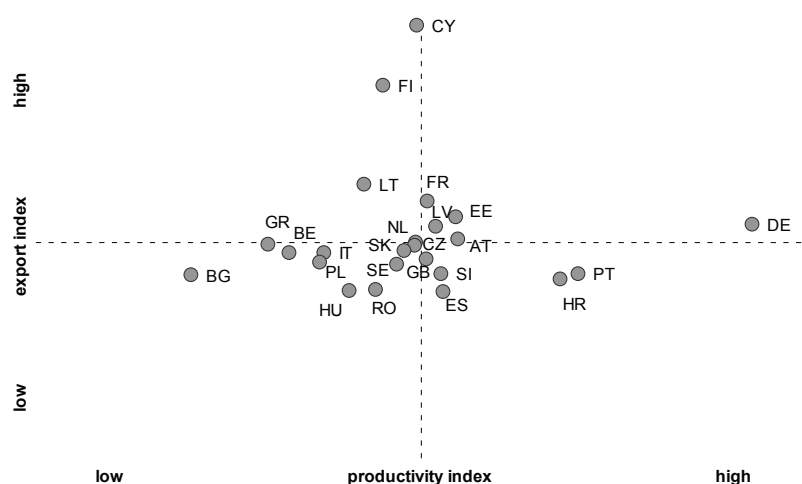


Figure 1. Productivity and export indices of dairy processing in Latvia and other EU countries in 2013*.

*Z-scores used; no productivity data available for IE.

Source: calculations and construction by authors, based on Eurostat data (2016a; 2015a).

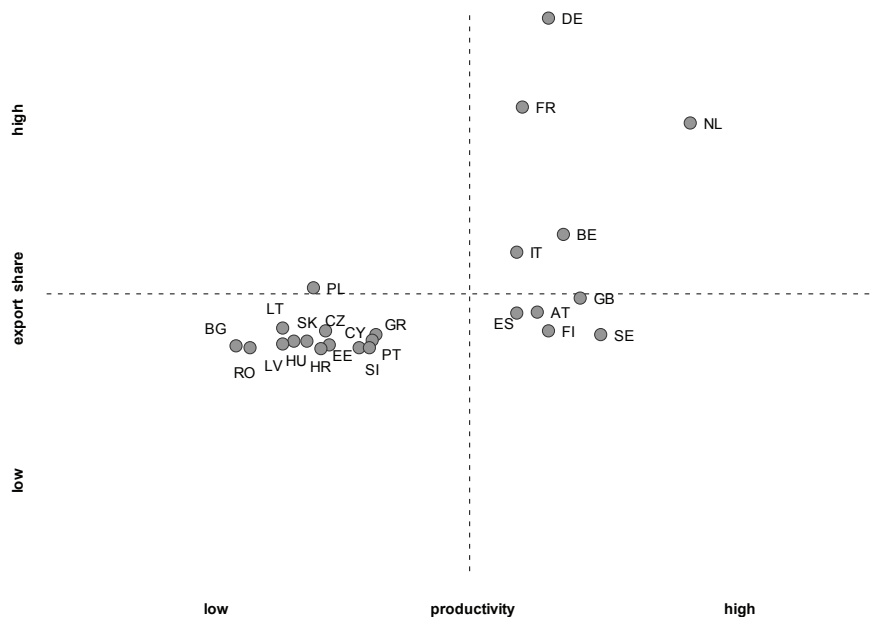


Figure 2. Productivity and export share (EU-28=100%) of dairy processing in Latvia and other EU countries in 2013*.

*Z-scores used; no productivity data available for IE.

Source: calculations and construction by authors, based on Eurostat data (2016a; 2015a).

from so called new EU member states (joining EU from 2004), only Poland is positioned in a different quadrant – upper left, with export volume slightly above the EU average. It can be argued that low value added per employee in these countries is influenced by cheaper labour force and this indicator merely represents the resulting strategies, at the same time, the authors believe that developed and viable dairy industry can not only compete on export markets, but also ensure normal living standards for its employees.

It is also quite obvious that the largest exporters of dairy products are the largest EU countries, at the same time, Belgium and the Netherlands and especially Ireland, with the number of inhabitants being 11.3, 19.9 and 4.6 million accordingly (Eurostat, 2015b), are also positioned in the upper quadrant, and these countries also have a high productivity indicator (Ireland - based on the results of 2012). Figure 2 gives a notion on the relationship between productivity and export, which in more detail is examined further.

When speaking about the competitiveness of the whole dairy supply chain (limiting the concept to its main segments), not only the competitiveness of dairy processing, but also dairy farming has to be considered. Figure 3 shows that, based on the value added per employee in dairy processing and value added (calculated as output less the value of intermediate consumption from FADN) per annual work unit (AWU) in dairy farming, Latvia is positioned in the lower left quadrant, with values below the EU average (axes crossing at the EU average) and representing

countries with low productivity of the whole dairy supply chain.

Although generally the value added per employee in dairy farming is lower than in dairy processing – the difference being 2.7 times in the EU on average in 2013, the gap between the two productivity indicators in Latvia is larger. In 2013, the value added per employee in manufacture of dairy products was 3.7 times the level of value added per annual work unit in dairy farming in Latvia. The gap between productivity in dairy processing and dairy farming was less also in Estonia (1.7 times) and Lithuania (2.1 times). The large difference in Latvia indicates that dairy processing is comparatively more competitive than dairy farming in Latvia and therefore the increase in the productivity in dairy farming is very topical as from the productivity aspect it is relatively the weakest link of the dairy supply chain. Although the production subsidies improve the situation of Latvian dairy farms, net value added per annual work unit (NVA/AWU) in dairy farming in Latvia, which is a farm standard economic result in FADN, still lags the productivity of dairy processing more than in the EU on average.

Link between productivity and export

Having formed data array covering all EU countries in the period 2008-2013 (subject to data availability), the authors further tried to establish the link between productivity (i.e., value added per employee) and export value in manufacture of dairy products. The

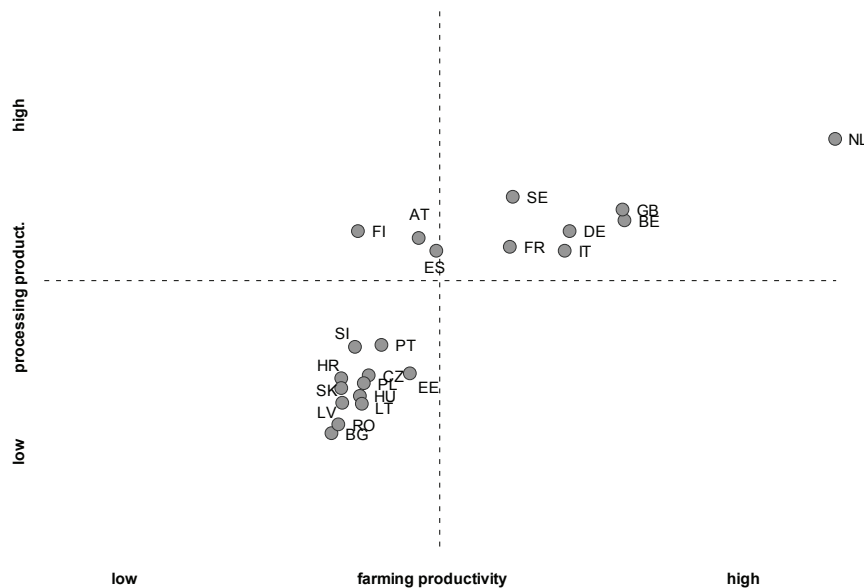


Figure 3. Productivity of dairy processing and dairy farming in Latvia and other EU countries in 2013*.

*Z-scores used; no dairy processing productivity data available for IE; no dairy farming data available for CY and GR. Source: calculations and construction by authors, based on Eurostat (2016a; 2015a), DG Agri (2016) and LSIAE (2015) data.

obtained results by analysis of variance (ANOVA) reveal that there is a difference between the mean productivity of country group having export below the EU average and the country group having export at the EU level and above (see Table 1), pointing to the existing positive link between the productivity and export in dairy processing. Although there are many factors that influence productivity, the authors believe that exports are the preconditions for ensuring the economy of scale effect for such countries as Latvia, whose domestic market is rather small; at the same time, export markets also provide more opportunities for attracting higher product value from the market.

As regards the productivity link within the dairy supply chain, where raw milk constitutes about a half of all purchased materials and services by dairy processing enterprises, rather strong positive correlation ($R=0.819$, $p=7.42E-33$) has been found between the value added per employee in dairy

processing and value added per annual work unit in dairy farming for the EU countries in the period 2008 – 2013. This generally means that a higher productivity in dairy farming is associated with a higher productivity in the dairy processing. The authors believe that both more efficient dairy processors can pay a better price for milk and thus facilitate the increase in the value added in dairy farming; besides, more efficient dairy farming sector reduces different processors' cost related to milk collection and quality etc. thus contributing to higher value added in dairy processing.

Based on the finding, the development of Latvian dairy sector, which mainly depends on the development of export, can be more successfully achieved by the increase in the productivity of Latvian dairy sector; and relatively the largest productivity gap to close is in the dairy farming in Latvia.

Table 1

Results of ANOVA tests for the relation between productivity and export in dairy sector

Variables	Group	Number of cases	Mean	p value
Dependent: Productivity of dairy processing (value added/employee, thsd EUR)				
Grouping: Export value of processed dairy products (as share of the EU average)	1	107	36.9	0.000***
(Group 1- below EU average; Group 2 – EU average and above)	2	41	69.2	

***significant at the 1% level.

Source: calculation by authors, based on Eurostat (2016a; 2016c), DG Agri (2016) data.

Table 2

**Average changes in NVA/AWU of supported (T=1) and non-supported (T=0) dairy farms
obtained by the ‘naïve’ DiD method**

Number of Units	NVA/AWU 2007, EUR	NVA/AWU 2014, EUR	ATT (difference), EUR
T=1 (94)	13,437	16,381	2,944
T=0 (51)	9,267	11,586	2,318
Difference	4,170	4,795	625

Source: calculation by authors, based on unpublished LSIAE (FADN) and RSS data.

Investment support for productivity

Measures of Latvian RDP have been the main support instruments for the facilitation of competitiveness of Latvian dairy sector. In the programming period 2007 – 2013, the investment support for the modernisation of farms and adding value to agricultural products was provided, with the total public funding of EUR 369.5 million granted to farmers and EUR 72.1 million obtained by processors (RSS, 2016). According to the evaluation of the authors from unpublished RSS data, investment support received by dairy farms totalled to about 37% of farm modernisation support, while dairy processors obtained about 31% of the total support for adding value to agricultural products. There is a quite impressive modernisation programme also in RDP 2014 – 2020, which provides EUR 490.0 million for the investments in physical assets, out of which majority (almost 70%) is again targeted at the improvement of the competitiveness of agricultural farms in Latvia (MoA, 2015).

Increase in the productivity of supported farms was the main objective of the Farm modernisation measure of Latvian RDP 2007 – 2013. The contribution of the programme to the restructuring of dairy sector was another important issue, and a growth in productivity is one of the crucial factors behind the improvements in a rather fragmented dairy farming in Latvia. In this paper, the authors tried to evaluate the direct impact of the Farm modernisation measure on supported dairy farms. The economic data in FADN database, which were used for the study, include all relevant information on the programme participants and non-participants regarding their structure and performance

from 2007 to 2014. As the information should cover periods before and after the implementation of the programme, initially 145 dairy farms were selected out of the total number of 943 farms. The possible overlapping was checked, leaving treated units that participated only in the selected measure: there were 94 dairy farms in the treatment group, leaving 51 dairy farms for possible controls.

Firstly, the differences in the farm standard economic result - NVA/AWU - after and before the implementation of the programme were obtained using the ‘naïve’ DiD method by the authors. The values of changes in the analyzed economic variable and the calculated treatment effects are shown in Table 2. According to the results of ‘naïve’ DiD method, the ATT effect (difference) on NVA/AWU both on programme participants and non-participants is positive, being slightly higher for the supported dairy farms.

Further, the authors proceeded by the second evaluation method - propensity score matching (PSM-DiD method). In total 31 variables related to farm structure, considered critical for comparability of economic performance, were initially selected for the use in matching process (i.e., finding matches between treated and control farms). After the repeated Logit regressions with adding of higher order covariates and failed satisfaction of balancing properties in one or more blocks, only 13 variables were retained. These variables include agricultural land; NVA/AWU; gross margins in crop farming; gross margins in livestock farming; gross value added; intermediate consumption; depreciation; buildings; equipment

Table 3

Average treatment effects on NVA/AWU obtained by the PSM-DiD method

Method	Nearest neighbor	Radius matching (0.01)	Radius matching (0.1)	Kernel matching	Stratified matching
Treated	94	55	94	94	94
Controls	22	38	42	42	42
ATT (EUR)	-766	1,785	2,631	214	-1,252
t	-0.20	0.70	1.29	0.05	-0.37

Source: calculation by authors, based on unpublished LSIAE (FADN) and RSS data.

and machinery; fixed assets in crop farming; external costs; labour costs; costs of lease.

After obtaining the propensity scores for all dairy farms, only units satisfying common support condition were selected. Generally, common support restriction is based on 'minima and maxima' comparison, which assumes deletion of all observations whose propensity score is smaller than the minimum and larger than the maximum in the opposite group. With the given specification the balancing property is satisfied. The results of evaluation of average treatment effects with various matching methods and respective test statistics are shown in Table 3.

The average treatment value with the highest test statistics (radius matching, $R=0.1$) was considered the best estimate for the analyzed economic variable. In addition, sensitivity analysis was carried out using the Rosenbaum bounding approach. The results show that the estimated effects of the intervention measure on NVA/AWU are rather sensitive. The sensitivity test shows that a hidden bias, which increases the odds ratio from 1 to 1.05, would make the obtained results statistically insignificant. The relatively high sensitivity could be caused by a relatively small number of observations in the control group. It is recommended to have up to 4 times more observations for potential controls, which is not the case in the study. However, the results of sensitivity tests are providing only additional information with respect to the stability of calculated effects; it does not question the overall validity of the obtained results.

The PSM-DiD method provides a statistically rigorous estimation of the contribution of the analyzed support measure to the growth of NVA/AWU for participating dairy farms at EUR 2,631. The obtained direct programme investment support effect amounts to 16% of the total NVA/AWU of supported farms at the end of the programming period. The value of changes in the economic variable obtained by PSM-DiD method is higher than the value yielded by 'naïve' DiD estimator. This indicates a possible underestimation of programme effects if 'naïve' method is used.

Conclusions

1. Based on the introduced indices of relative position of dairy industry productivity and relative position of dairy industry exports, dairy processing in Latvia has a strong inter-branch position in the domestic food industry. It is characterized by the ratio of dairy processing productivity (value added per employee) against the total food industry productivity slightly above the average EU

ratio, and the share of exports of processed dairy products from the total processed food exports also above the level, which can be observed in the EU on average.

2. According to the inter-country comparison, Latvian dairy processing with low value added per employee and smaller/small share in the total EU exports of processed dairy products, is behind the EU average level.
3. Labour productivity is also low in dairy farming in Latvia, moreover, the gap between the productivity of dairy processing and dairy farming in Latvia is greater than in the EU on average and also in the neighbouring countries, indicating that dairy processing is comparatively more competitive than dairy farming in Latvia and from the productivity aspect it is relatively the weakest link of the main stages in the dairy supply chain.
4. It has been found that productivity and export in dairy processing are positively related. Significant differences in the mean values of productivity for the EU countries have been obtained, when comparing two groups of countries – with export value below and above the EU average level. Rather strong positive correlation ($R=0.819$, $p=7.42E-33$) has been found also between the value added per employee in dairy processing and dairy farming for the EU countries in the period 2008 – 2013, indicating that a higher productivity in dairy farming is associated with a higher productivity in dairy processing. Based on the finding, the development of Latvian dairy sector, which mainly depends on the development of exports, can be more successfully achieved by the increase in the productivity of Latvian dairy sector.
5. When estimating the impact of the Farm modernisation support measure of RDP 2007 – 2013 on dairy farms in Latvia, propensity score matching has to be considered as a more suitable method in establishing a sound counterfactual, as the use of 'naïve' estimators can lead to the underestimation of the support impact. The changes in NVA/AWU estimated by propensity score matching, which can be viewed as a direct investment support effect on the beneficiaries, are significant and positive, indicating that farm modernisation support has facilitated the improvement of overall dairy farm productivity in Latvia.

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PROBLEMS CAUSED BY MASTITIS AND THEIR ASSESSMENT FOR COW HERDS: THE CASE OF LATVIA

Aleksejs Nipers, Irina Pilvere, Anda Valdovska

Latvia University of Agriculture

Aleksejs.Nipers@llu.lv; Irina.Pilvere@llu.lv; Anda.Valdovska@llu.lv

Abstract

The European Union livestock sector is a major player of the agricultural economy and its land use, and livestock is one of the fastest-growing sectors in agriculture, potentially presenting opportunities for economic growth and poverty reduction in rural areas. In Latvia, the year 2014 was quite difficult for the dairy industry both due to Russia's embargo on dairy product import and low milk purchase prices and due to concerns that milk quotas had been exceeded. It is therefore important that cows are healthy and no additional losses are suffered from mastitis. Mastitis is a complex disease involving many factors, which is mainly caused by bacteria and there is no simple model that encompasses different possible aspects. Therefore, the **research aim** is to assess the effects of mastitis in cow herds for farms in Latvia. The research study proceeds in two stages or phases: firstly, to review the scientific literature on mastitis problems and solutions to the problems in other countries, secondly, to survey dairy farms of various sizes in the regions of Latvia in order to examine the real situation concerning mastitis and its effects on the economy of farms. A survey results of 74 farms in Latvia revealed that 90.5% of the farms had problems with mastitis. Consequently, if sick cattle are timely culled, it is possible to keep the herd milk yield without a significant drop. In case of cows with mastitis, farms suffer losses from smaller quantities of milk produced depending on farming intensity and due to cows culled with mastitis.

Key words: cows, mastitis, milk yield, culling, evaluation.

Introduction

The Food and Agriculture Organization of the United Nations (FAO) estimates that the population will grow to 9.1 billion in 2050. Livestock is one of the fastest-growing sectors in agriculture, potentially presenting opportunities for economic growth and poverty reduction in rural areas, though unless carefully managed the main social effects may be negative – if the livestock-dependent poor are squeezed out of markets and are presented with few viable livelihood alternatives (FAO, 2011). FAO (2014) emphasises that livestock production makes an important contribution to economic development, rural livelihoods, poverty alleviation and meeting the fast growing demand for proteins of animal origin.

Throughout the EU the livestock sector is a major player of the agricultural economy and its land use. The relative importance of different subsectors varies enormously among the EU member states, influenced at the same time by cultural values and bio-physical conditions (pork in Spain and beef in Ireland), while economic conditions also interfere (small ruminants are often playing a larger role in more subsistence production oriented economies). Even though a trend has been seen in the last decades to increasing intensification and larger farm units in all member states of the European Union, diversity of farming systems remains large (Leip *et al.*, 2010). In the EU-28 there were 88.4 million heads of bovine animals in 2014. The largest livestock populations were reported in France (19.3 million), Germany (12.7 million), United Kingdom (9.7 million), while the smallest were in Malta (0.01 million), Cyprus (0.06 million) and Luxembourg (0.20 million) (Eurostat, 2015).

Since 2000, the number of cattle has increased by 15% (from 367 to 422 thousand in 2014) in Latvia. However, the number of cows in this period decreased by 19% (from 204 to 166 thousand in 2014) (Central Statistical Bureau, 2015), which indicated the different economic processes in livestock farming. The year 2014 was quite difficult for the dairy industry both due to Russia's embargo on dairy products and low milk purchase prices, and due to concerns that milk quotas had been exceeded. Despite the problems, the total output of milk rose by 6.2% in 2014 compared with 2013. In Latvia, dairy farmers increasingly prefer black and white Holstein cows, and their number increases from year to year (Ministry of Agriculture, 2015).

Under the current circumstances, farmers seek to achieve high milk yields and as low production costs as possible. However, the more productive the cow is, the greater burden is put on the key milk producer – the udder. Cursory care and insufficient knowledge lead to health problems for livestock. Mastitis is an inflammation of the mammary gland (udder), usually caused by infection. Mastitis, inflammation of the mammary gland, can be in clinical or subclinical form and can be caused by various agents, however, the majority of cases are infectious and usually caused by bacteria (Markey *et al.*, 2013). FAO (2014) concludes that mastitis is the most prevalent production disease in dairy herds and it is well documented as disease with a heavy burden in developed countries, while very limited information is available for developing countries. Mastitis is one of the most prevalent production diseases affecting the dairy cattle industry worldwide. Its occurrence is associated with direct and

indirect losses and expenditures (Petrovski, Trajcevič, & Buneski, 2006). In both clinical and subclinical mastitis there is a substantial loss in milk production (Halasa *et al.*, 2007). This opinion is shared by J.K. Holland and co-authors (2015), revealing that reduced milk yield due to mastitis has been estimated. When milk production per cow is decreased by mastitis, less milk will be delivered to the factory and the net return of the farm will decrease. There might also be an association between mastitis and other cattle diseases (Halasa *et al.*, 2007).

The economic impact of mastitis is usually due to increased milk somatic cell count, decreased milk production and selling, increased costs of veterinary treatment, and premature culling of infected animals. Dairy cattle usually catch mastitis from lying in dirty conditions or from poorly clean milking equipment. Cows can be treated using antibiotics. During treatment the milk is withdrawn from human food chain and is either thrown away or given to calves. There are big penalties against farmers that allow treated milk into the bulk tank. For dairy producers worldwide, somatic cell count is not only a measure of herd udder health performance, it is also a determinant of the marketability of their milk (Vavrova, Palik, & Sladek, 2015).

Mastitis is a common disease of dairy cattle causing significant economic loss, which has been estimated to cost the New Zealand dairy industry USD 180 million annually (Ullaha *et al.*, 2013). The dairy producer incurs the cost of these negative outcomes through reduced quality and quantity of milk, as well as increased production costs (Rollina, Dhuyvetter, & Overtona, 2015). Dairy farmers seek to strike an optimal balance between investments into disease management and economic losses due to mastitis. The research studies are mainly popular-scientific and practical, less scientific. Milk quality is mainly researched with regard to factors affecting it (Zagorska, Ciprovica, 2008; Konosonoka, 2005; Cimermanis, 1999), mastitis as a disease of domestic animals is less examined (Gulbe & Valdovska, 2012; Jemeljanovs *et al.*, 2008) and almost no research studies are available on economic effects of mastitis. For these reasons, the **research aim** is to assess the effect of mastitis in cow herds for farms in Latvia. To achieve the aim, two specific **research tasks** were set: 1) to examine the scientific literature on the economic effects of mastitis in cow herds; 2) to analyse the effect of mastitis on milk yield and calculate losses due to lower milk yields and cow culling for farms in Latvia.

The **object of the research** is problems caused by mastitis in dairy cow herds.

Materials and Methods

This research study is part of a broader research study aiming at identifying opportunities for the use

of grassland by livestock industries in Latvia (Latvia University of Agriculture, 2015). The research study proceeds in two stages or phases: firstly, to review the scientific literature on mastitis problems and solutions to the problems in other countries, as a few such research studies are available in Latvia; secondly, to survey dairy farms of various sizes in the regions of Latvia in order to examine the real situation concerning mastitis and its effects on the economy of farms.

In 2014, a survey of dairy farms was conducted in Latvia, acquiring information on 74 dairy farms of various sizes in various regions of Latvia, including 10 farms with less than 20 dairy cows (inclusive), 13 farms with a cow herd ranging from 20 (exclusive) to 50 (inclusive), 17 farms having a herd ranging from 50 (exclusive) to 100 (inclusive), 20 farms with a herd ranging from 100 (exclusive) to 300 (inclusive) and 14 farms having more than 300 dairy cows (Farmer interviews, 2014). Compared with the entire target group of dairy livestock farms in Latvia, the present sample group is mostly represented by large farms and, accordingly, small farms are proportionally less represented.

Various sources of materials and data have been used: the scientific literature, legislation, reports and recommendations, as well as websites, the Internet. Appropriate research methods have been used in the research study, mainly qualitative and also quantitative: monographic; analysis and synthesis, data grouping, abstract analysis, logical construction, etc.

Research limitations: an analysis of the scientific literature on mastitis problems and their economic effects was performed in the broadest aspect; yet, the situation in Latvia was analysed from only two aspects owing to limited availability of information: a) the effect of mastitis on milk yield per cow and losses caused by mastitis; b) losses due to livestock culling.

Results and Discussion

1. Literature review on the economic effects of mastitis on milk production

Literature on mastitis management is quite abundant, but less research has been published regarding the economics of mastitis and mastitis management (Halasa *et al.*, 2007). H. Seegers, C. Fourichon and F. Beaudeau (2003) have made an extensive summary on the economic effects of mastitis finding that the effects of mastitis take the forms of additional costs (extra investment in resources) and losses (revenue decrease). Estimates of the economic effects of mastitis are mainly based on two approaches: analyses based on farm livestock productivity data as well as examinations that add simulation results to the data by means of such methods as partial budgeting and dynamic simulation.

The economic consequences of mastitis (clinical or subclinical) are due to treatment, production losses, culling, changes in product quality and the risk of other diseases. A summary of a number of research studies (Halasa *et al.*, 2007; FAO, 2014; Seegers, Fourichon, & Beaudeau, 2003; Vavrova, Palik, & Sladek, 2015) leads to a conclusion that the majority of the authors, when simulating the economic effects of mastitis, consider that the associated costs can be divided among the following factors: 1) milk production losses; 2) discarded milk; 3) product quality decrease; 4) produced and unsold milk; 5) extra treatment costs; 6) extra drug costs; 7) veterinary services; 8) additional labour costs; 9) additional materials and investments; 10) extra diagnostics costs; 11) lethality and occurrence of other diseases; 12) premature culling and replacement; 13) fines; 14) decrease in feed consumption. There are large variations between studies in the calculations of the economic damage of mastitis and the benefits of mastitis management (Halasa *et al.*, 2007; FAO, 2014; Seegers, Fourichon, & Beaudeau, 2003; Vavrova, Palik, & Sladek, 2015).

Some authors take into account such negative aspects as lower milk prices, poorer sales of meat (euthanized livestock, live weight decreases and lower sale prices) and extra costs to purchase calves for replacing culled livestock. Therefore, the results acquired by various authors differ depending on the methods and the number of indicators employed in their research. Lower milk output is considered to be the key reason of economic losses; yet, depending on the method employed and the research period examined, the results acquired are significantly different. Estimates of average lactational loss due to a clinical case ranged from nonsignificant or very low values to values higher than 700 kg of milk in others. To summarise, a reasonable (and probably underestimated) average cumulated loss of 375 kg (about 5%) can be proposed for a so-called average clinical case, occurring in the second month of lactation in a Holstein cow. However the losses are very variable. To take this variability into account, it can be proposed that out of 10 cases, 4 lead to a quite negligible loss, 5 to an average loss, and 1 case to a very high loss (about 1000 kg) (Seegers, Fourichon, & Beaudeau, 2003).

In her research, Christel Nielsen (2009) estimated economic losses caused by clinical and subclinical mastitis and found that the greatest deal of the losses was incurred by lower milk yield. The research results by various authors in the theoretical discussion of the paper identify the key risk factors of mastitis. Older cows, productive cows as well as cows that had mastitis or other diseases face a greater risk of mastitis. Cows face a greater risk of clinical mastitis (CM) at the beginning of lactation, whereas the risk

of subclinical mastitis (SCM) is faced at the end of lactation; some effect is also made by the season, as a greater number of cases of mastitis are observed in winter months. A cow breed too determines a higher or lower predisposition to pathogens causing mastitis. The development of mastitis is also influenced by the cow farming conditions, pattern of milking, milking equipment, cow diets, feed quality, and cow cleanliness and prevention measures.

To estimate a decrease in milk output caused by mastitis, C. Nielsen (2009) in her doctoral dissertation, employed weekly observation data on cow productivity in a herd of 150 dairy cows (Swedish Red and Holstein cows) on a training and research farm of the Swedish University of Agricultural Sciences. Her research discovered causal relationships between decrease in milk output and the lactation phase; besides, different results were acquired for primiparous cows and groups of other cows. Reduced milk production constitutes the major cost component of the total economic loss caused by mastitis. The magnitude of yield loss is determined by the stage of lactation in which the cow develops mastitis: milk yield is most severely affected when CM occurs in early and when SCM occurs in late lactation. The lactation yield loss associated with CM varies between 0 and 705 kg in primiparous cows and between 0 and 902 kg in multiparous cows, depending on lactation week at clinical onset. Most cases of CM develop in the first week of lactation and results in a yield loss of 578 and 782 kg milk in primiparous and multiparous cows, respectively. The particular research revealed that the average economic loss per case of clinical mastitis and subclinical mastitis were EUR 275 and EUR 60.

E. Cha and co-authors (2011) in their research aimed to estimate the cost of three different types of clinical mastitis (caused by gram-positive bacteria, gram-negative bacteria and other microorganisms) at the individual cow level and thereby identify the economically optimal management decision for each type of mastitis. The average costs per case (USD) of gram-positive, gram-negative and other clinical mastitis causing agents were USD 133.73, USD 211.03 and USD 95.31, respectively. The main contributor to the total cost per case was treatment cost for gram-positive clinical mastitis (51.5% of the total cost per case), milk loss for gram-negative clinical mastitis (72.4%) and treatment cost for other clinical mastitis (49.2%). The model can provide farmers with economically optimal guidelines specific to their individual cows suffering from different types of clinical mastitis.

D. Bar and co-authors (2008) found that the average cost of clinical mastitis per cow and year in these herds was USD 71. The average cost of a clinical mastitis case was USD 179. It was composed of USD

115 because of milk yield losses, USD 14 because of increased mortality and USD 50 because of treatment-associated costs. The estimated cost of clinical mastitis was highly dependent on cow traits: it was highest (USD 403) in cows with high expected future net returns (e.g., young, high-milk-yielding cows), and lowest (USD 3) in cows that were recommended to be culled for reasons other than mastitis.

T. Gröhn and co-authors (2004) aimed to estimate the effects of the first occurrence of pathogen-specific clinical mastitis on milk yield in 3071 dairy cows in 2 New York State farms. The results indicate that milk loss in mastitis cows did indeed vary depending on the pathogen responsible for the mastitis. Among parity 1 cows, *Staph. aureus*, *E. coli*, and *Klebsiella spp.* caused the greatest declines in milk yield. Milk yield also dropped in clinically mastitis cows for whom no pathogen was isolated. Among mastitis parity 2+ cows, *Streptococcus spp.*, *Staph. aureus*, *E. coli*, *Klebsiella spp.*, and *A. pyogenes* were responsible for the largest milk losses. In general, in both groups of cows, the milk yield often began to drop several weeks before diagnosis of clinical mastitis.

E. Rollina, K.C. Dhuyvetter and M.W. Overtona (2015) examined the cost of clinical mastitis during the first 30 days in milk by using recent estimates of its effects and described current market conditions and management practices in the United States. The average case of clinical mastitis resulted in a total economic cost of USD 444, including USD 128 in direct costs and USD 316 in indirect costs. Direct costs included diagnostics (USD 10), therapeutics (USD 36), non-saleable milk (USD 25), veterinary service (USD 4), labour (USD 21) and death loss (USD 32). Indirect costs included future milk production loss (USD 125), premature culling and replacement loss (USD 182) and future reproductive loss (USD 9). As discussed in numerous studies, to be able to consider the real cost of mastitis, the prevalence and incidence should first be established. Then estimation of all relevant costs and expenditures should be made.

2. Problems caused by mastitis and their assessment for cow herds in Latvia

The fact that there were problems with mastitis was admitted by 67 of the 74 surveyed farms, which culled their livestock or bought medicines to treat the disease. However, the scale of this disease on each farm was different, as well as each farm's action to cope with this disease differed.

The analysis of average milk yields for the farms with mastitis problems and no such problems revealed that it was not possible to conclude whether the farms with mastitis problems had lower milk yields (Table 1). A justification for the fact that the data did not allow us to make such a conclusion may be acquired in the following way – a farm with minimum mastitis problems was shifted to a group of farms having no mastitis problems. In this case, the average milk yield for the cow group with “no mastitis problems” increased to 7543 kg, while that for the cow group with “mastitis problems” decreased to 7219 kg. In this case too standard deviations and standard errors were relatively large.

Of the 67 farms having large or small problems with mastitis, 36 performed cow culling operations. The average culling rate was 7.4% a year; yet, the rates differ among the farms – from 1% to 34%.

It has to be noted that in general farms that culled their livestock had higher milk yields. It is interesting that such farms even had higher milk yields than those with no mastitis problems (Table 1). It may be associated with the fact that mastitis problems are specific to intensive farms (yet, the large standard error for the average milk yield on the farms with no mastitis problems does not allow making unambiguous conclusions).

Also, no explicit effects of mastitis on the average number of somatic cells in milk were identified. This may be related to two key factors: the fact that the quantity of milk of sick cows is not significant in the total quantity of milk and the fact that sometimes there are a number of other factors influencing the number of somatic cells in milk (for example, several bacterial

Table 1

Milk yields on the surveyed farms depending on their situation with mastitis in Latvia

Situation on the farm	Number of observations (farms)	Average number of cows on farms	Milk yield per cow (kg year ⁻¹)		
			Average	Standard error	Standard deviation
There are problems with mastitis	67	152	7261	± 200	± 1634
incl. cows are culled because of mastitis	36	156	7615	± 295	± 1769
incl. cows are not culled because of mastitis	31	147	6849	± 247	± 1378
No problems with mastitis	7	179	7191	± 590	± 1562

Source: farmer interviews, 2014; Latvia University of Agriculture, 2015.

Table 2

Losses from lower milk yields due to mastitis problems for the surveyed farms in Latvia

Decrease in milk yield	Decrease in milk yield per cow, kg	Milk price, EUR kg ⁻¹	Decrease in revenue, EUR	Decrease in cost, EUR	Losses per cow per year, EUR
Decrease in milk yield (medium intensive farms)	342	0.3	103	45	58
Decrease in milk yield (intensive farms)	766	0.3	230	101	129

Source: farmer interviews, 2014; Latvia University of Agriculture, 2015.

agents). That is why, the number of somatic cells in milk does not exceed a critical value if cows sick with mastitis do not prevail in the herd.

An analysis of the extent to which grazing contributes to mastitis problems revealed that of 42 farms that grazed their cows, 39 had mastitis problems. At the same time, of 32 farms that did not graze their cows, 28 had mastitis problems. This allows assuming that grazing or no grazing is not a factor promoting mastitis.

A similar situation was observed for cows farmed under tied and loose housing systems. Of 43 farms practising tied housing, 40 had mastitis problems. However, of 32 farms under the loose housing system, 27 had problems with mastitis.

No positive or negative effects of some particular milking technology on mastitis problems were identified empirically.

Losses from mastitis were estimated from the perspectives of lower milk yield and cow culling. Within the present research, the data do not allow us to unambiguously estimate the extent to which mastitis influences milk yield. However, some indicative assessments have been made. Two scenarios were considered: medium intensive farming and intensive farming. In case of medium intensive farming, the effect of mastitis was estimated by comparing the milk yields on farms having no mastitis problems with those on farms having mastitis problems and culling their livestock.

In case of intensive farming, the effects of mastitis were estimated by comparing milk yields on farms

that tackled their mastitis problems through culling livestock (due to which actually or potentially milk yields were lower) with those on farms having mastitis problems and not culling their livestock.

The calculations estimated a decrease in revenue due to milk unsold (because of lower milk yields) and a decrease in costs (sick cows consume less feed).

It was found that in case of medium intensive farming, the losses from unproduced milk were equal to EUR 58 per cow per year. However, in case of intensive farming, the losses from unproduced milk totalled EUR 129 per cow per year (Table 2).

As regards farm losses from culling sick cows, the situation was analysed for the farms culling their sick livestock. Three scenarios were assessed based on the real situation on the analysed farms: medium (at the cow culling rate of 7.4%), minimum (at the cow culling rate of 1%) and maximum (at the cow culling rate of 34%).

It was concluded that at the average cow culling rate (7.4% of the herd a year), the average losses per dairy cow per farm amounted to EUR 74 a year. In case of minimum problems (at a 1% cow culling rate), the average losses per dairy cow per farm totalled EUR 10 a year. In case of maximum problems (at a 34% cow culling rate), the average losses per dairy cow per farm reached EUR 340 a year (Table 3).

Therefore, the knowledge and awareness of risk factors and characteristics of mastitis caused by pathogens involved are essential to control the wide spread of the disease at farm level (FAO, 2014).

Table 3

Losses from culling livestock due to mastitis problems for the surveyed farms in Latvia

Cow culling	Culling rate	Price of a healthy cow, EUR	Price of a culled cow, EUR	Average losses per cow, EUR
Medium	7.4%	1500	500	74
Minimum	1.0%	1500	500	10
Maximum	34.0%	1500	500	340

Source: farmer interviews, 2014; Latvia University of Agriculture, 2015.

Conclusions

1. Mastitis is a complex disease involving many factors, which is mainly caused by bacteria and there is no simple model that encompasses different possible aspects. The scientific literature deals with various factors determining economic effects of mastitis: 1) milk production losses; 2) discarded milk; 3) product quality decrease; 4) produced but unsold milk; 5) extra treatment costs; 6) extra drug costs; 7) veterinary services; 8) additional labour costs; 9) additional materials and investments; 10) extra diagnostics costs; 11) lethality and occurrence of other diseases; 12) premature culling and replacement; 13) fines; 14) decrease in feed consumption.
2. The scientific literature has identified the key risk factors of mastitis: cow age, cow productivity, other cow diseases, lactation period, season, cow breed, cow farming conditions, milking pattern, milking equipment, cow diets, feed quality, cow cleanliness and prevention measures.
3. The survey of dairy farms conducted in Latvia revealed that:
 - 90.5% of the farms had problems with mastitis. Slightly more than half of the farms having mastitis problems performed cow culling operations; in the result, if sick cattle are timely culled, it is possible to keep the herd milk yield without a significant drop;
 - no association was identified between cases of mastitis and grazing or no grazing and tied or loose housing, as well as no positive or negative effects on mastitis problems caused by some particular milking technology were identified;
 - losses from lower milk output ranged from EUR 58 per cow per year in case of medium intensive farming to EUR 129 in case of intensive farming;
 - losses from culling cows due to mastitis differed depending on the cow culling rate: from EUR 10 per dairy cow per year at a minimum rate (1% a year) to EUR 340 at a maximum culling rate (34%).

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ECONOMIC IMPACTS OF SEMI-SUBSISTENCE FARM SUPPORT MEASURE OF LATVIAN RURAL DEVELOPMENT PROGRAMME 2007-2013

Elita Benga

Institute of Agricultural Resources and Economics, Latvia
elita.benga@arei.lv

Abstract

The evaluation of EU Member States' co-founded programmes was assigned particular importance in recent years. The core question to be answered in programme evaluation is whether the stated objectives are accomplished by particular intervention. Until recently, the use of 'naïve' estimates was common in the evaluations of EU Member States Rural Development Programmes. The use of these estimates leads to potentially substantial selection bias resulting from using the outcomes of non-participants as a proxy for the possible outcomes of participants in the case of non-participation. The effectiveness of interventions on outcomes of interest can be better evaluated by propensity score matching (PSM). The objective of the study is to determine the net average effects from semi-subsistence farm support measure of the Latvian Rural Development Programme 2007 – 2013. To reach the research objective, propensity scores based on the most important characteristics were calculated for participants and non-participants of the measure and average treatment effects for gross value added were evaluated by matching methods. The research results show that the positive programme effects evaluated by 'naïve' estimators are overestimated in comparison with the results obtained by more rigorous PSM method.

Key words: policy evaluation, rural development programme, propensity score matching, treatment effects.

Introduction

The evaluation of EU Member States' co-founded programmes was assigned particular importance in recent years. The significance of the monitoring and evaluation has been confirmed in the European Community Agenda in 2000. Periodic evaluation of EU Member States Rural Development Programme (RDP) specific policy interventions is considered crucial in policy development. The main reasons for the evaluation of specific policy interventions are the assessment of the programme's impact, the improvement of programme management and administration, identification of necessary improvements in the delivery of interventions and meeting the accountability. According to the EU definition, programme evaluation is a process that culminates in a judgment (assessment) of policy interventions according to their results, impacts and the needs. In the case of rural development (RDP) programmes, EU regulations distinguish between ex-ante, midterm, ex-post and ongoing evaluations. The existing study is considered a part of an ongoing evaluation which would provide the grounds for the ex-post evaluation of Latvian Rural Development Programme 2007 – 2013. The core question to be answered in programme evaluation is whether the stated objectives are accomplished by particular intervention (support or 'treatment' provided to programme participants). The main problem in the process of evaluation is the assessment of the counterfactual outcome by modelling the situation where treatment is absent. The counterfactual outcome has to be estimated by statistical methods as it is usually not observed, unless there exists a rather costly possibility to use the experimental evaluation

with random treatment assignment. Moreover, a random assignment has to be implemented before the policy intervention.

Until recently, the use of 'naïve' estimates was common in the evaluations of EU Member States Rural Development Programmes. These included "before - after" or 'with - without' approaches along with the comparisons with national averages. The "before - after" approach attributes the entire effect of the observed change in a particular indicator to the programme support. Thus the real effects may become understated or overstated. The "with - without" technique assumes that the outcome indicators will be the same both for programme participants and non-participants in the absence of the programme support. This leads to potentially substantial selection bias resulting from using the outcomes of non-participants as a proxy for the possible outcomes of participants in the case of non-participation. Naïve standard DID (difference-in-difference) estimator compares the before-and-after changes of selected result indicators for programme participants with the before-and-after changes of the same indicators for arbitrarily selected non-participants. The crucial assumption justifying this method is that the selection bias remains time invariant, and this is not often the case. If trends in the outcomes are not time invariant, the estimation is not correct.

Materials and Methods

To measure causal effects of programme or policy intervention, an experiment would be designed in which any unit of observation (farm) has an option to participate or not to participate in a programme. In order to measure an effect (result or impact) of a

given programme, one has to estimate an appropriate counterfactual. As outcomes for participating units only are usually observed by programme monitoring, a way has to be found how to measure what would have happened to the same unit in a situation of its non-participation. For this purpose, a potential outcome model is appropriate. The model was proposed by Roy (1951) and further developed by Rubin (1974) and Holland (1986). Using the potential outcome model, the causal effect of a given programme on unit can be expressed with a basic evaluation formula:

$$e_i = Y_i(1) - Y_i(0), \quad (1)$$

where:

$Y_i(1)$ – potential outcome for unit i in case of participation in RDP (programme participants),

$Y_i(0)$ – potential outcome for unit i in case of non-participation in RDP (counterfactual),

e_i – the effect of programme participation on unit i , relative to effect of non-participation on the basis of a response variable Y .

In evaluation it is relatively easy to obtain for programme beneficiaries the information about $Y_i(1)$ but it is very difficult to estimate $Y_i(0)$ which for programme beneficiaries is not directly observable.

The outcome for a participating unit can be observed directly and it is expressed by formula:

$$e_i = (Y2 - Y1), \quad (2)$$

where:

$Y1$ – value of the outcome variable at programme starting period for a participating unit,

$Y2$ – value of the outcome variable at programme ending period.

The outcome for the same unit without the participation can be interpreted as a result of other factors which may simultaneously affect observable impact variables and it is expressed by formula:

$$e_i = Y3 - Y1, \quad (3)$$

where:

$Y3$ – value of the outcome variable for the same unit without a participation.

The unit can only be observed in one of two possible situations: being supported (participating) or not-supported (without a participation) which means that the real programme effect can be expressed as a

difference between the outcome with a participation and outcome without a participation:

$$e_i = (Y2 - Y1) - (Y3 - Y1) = (Y2 - Y3). \quad (4)$$

Under naïve methodological approaches the whole observed change of a value of a given result indicator ($Y2 - Y1$) is usually attributed to the programme and is erroneously considered to be a programme effect. The real programme effect ($Y2 - Y3$) cannot be directly observed.

The effectiveness of interventions on outcomes of interest can be evaluated either by regression methods or propensity score matching (PSM). Multiple regression is the most common method for estimating the programme support effect. However, regression cannot take into account the distribution overlap on selected covariates. In many empirical studies, the causal effects are estimated by regressing variable of the outcome of interest on binary treatment variable. Thus the adjustment for the distribution between the treatment group and control group is not provided. PSM is a rigorous non-experimental method. The data for PSM usually are pooled in a panel both from programme participants and non-participants. The non-participating or ‘untreated’ units constitute the ‘control’ group while participants are included in the ‘treatment’ group. The information from control group is used to assess what would be the outcome of interest for participants in the absence of the programme. The difference in outcomes for both groups is evaluated by comparison of relatively similar units in these groups. This helps to avoid the potential biases that may arise by comparing the units with substantial differences in their characteristics, as these might affect the participation in the programme and outcomes of interest. A simple comparison of the difference between the averages of the outcome variables in two groups might lead to biased estimation, as the distributions of the covariates in the two groups may differ. A subclassification method was proposed by Cochran (1968). The observation variable is split into a number of subclasses. The treatment effect is then estimated by comparing the weighted means of the outcome variable in each subclass. Cochran’s research suggests that stratifying into five subclasses can remove much of the bias. However, as stated by Rubin (1997), subclassification may turn to be complicated if many covariates exist. To successfully mitigate the potential bias, unit matching has to be based not on a single or a few characteristics but on a full range of available covariates that have potential impact. The propensity score is then defined as the probability of receiving the treatment by the given unit. Thus the

matching is reduced to a single variable, and matching on entire set of covariates is no longer necessary. The method was developed by Rosenbaum and Rubin (1983). They introduced balancing score as a function of covariates that provides the same distributions of covariates in both groups. Furthermore, they also introduced the assumption of strong ignorability, which implies the same distributions of the covariates in both groups given the balancing scores. They proved that treatment assignment is strongly ignorable if it satisfies the conditions of unconfoundedness and overlap. Unconfoundedness means that conditional on observational covariates, potential outcomes for two groups are not influenced by treatment assignment. The overlap assumption means that with the given covariates, the unit with the same covariate values has positive and equal opportunity of being assigned to the treated group or the control group. As stated by Joffe and Rosenbaum (1999), these assumptions eliminate the systematic, pretreatment, and unobserved differences between the units in treatment group and control group. PSM would provide biased estimation of causal effects when assumption of strong ignorability is violated. As suggested by Imbens (2004), if the treatment assignment is strongly ignorable, PSM can be used to remove the difference in the covariates' distributions between the treatment group and control group. He suggests four-step procedure for implementing the PSM:

1. selection of observational covariates and estimation of propensity scores,
2. stratification of propensity scores and testing of balancing properties in each block,
3. calculation of the Average Treatment on Treated (ATT) by matching,
4. sensitivity test for robustness of estimated ATT effects.

If the balancing properties of covariates are not satisfied in all strata, the test has to be repeated with different number of strata. If the balancing properties are not satisfied again, estimation of propensity scores has to be repeated with modified list of covariates by adding higher order (squared) covariates. After getting all covariates balanced in every stratum, causal effects can be estimated by nearest neighbor matching (NNM), radius matching (RM), kernel matching (KM) or stratified matching (SM).

NN matching computes the ATT by finding the unit in the control group whose propensity score is nearest (absolute value of difference is minimal) for every unit in the treatment group. Larger number of comparison units from the control group decreases the variance of the estimator. At the same time, the bias of the estimator increases. Furthermore, one needs to choose between matching with replacement and matching without replacement (Dehejia & Wahba,

2002). When there are few comparison units, matching without replacement will force us to match treated units to the comparison ones that are quite different in propensity scores. This enhances the likelihood of bad matches (increase the bias of the estimator), but it could also decrease the variance of the estimator. Thus, matching without replacement decreases the variance of the estimator at the cost of increasing the estimation bias. In contrast, because matching with replacement allows one comparison unit to be matched more than once with each nearest treatment unit, matching with replacement can minimize the distance between the treatment unit and the matched comparison unit. This will reduce bias of the estimator but increase variance of the estimator.

In RM, the units in both groups are matched when the propensity scores in the control group fall in the predefined radius of the units in the treatment group. The larger the radius is, the more matches can be found. More matches typically increase the likelihood of finding bad matches, which raises the bias of the estimator but decreases the variance of the estimator.

In KM, all units in the treatment group are matched with the weighted average of all units in the control group. The weights are determined by distance of propensity scores, bandwidth parameter and a kernel function. Choosing an appropriate bandwidth is crucial because a wider bandwidth will produce a smoother function at the cost of tracking data less closely. Typically, wider bandwidth increases chance of bad matches so that the bias of the estimator will also be high. Yet, more comparison units due to wider bandwidth will also decrease the variance of the estimator.

In SM, for each block the average differences in the outcomes of the treatment group and the matched control group are calculated. The ATT is then estimated by the mean difference weighted by the number of treated cases in each block. With respect to organizational research, Li (2012) recommends stratified matching as it does not require choosing specific smoothing parameters. The estimation of the ATT then requires minimum statistical knowledge. He regards SM as producing a reliable ATT while being relatively simple. In general, selection of the matching technique is empirical and it largely depends on the results obtained. As proven by Dehejia and Wahba (2002), similar results with most matching methods are obtained when the overlap in the distribution of propensity scores between the treatment group and control group is substantial. After the estimation of the ATT, the sensitivity test is used to investigate whether the causal effect estimated from the matching is susceptible to the influence of unobserved covariates. In detecting the existence of significant unobservables, Rosenbaum (1987) suggested use

Table 1

Average changes in Gross Value Added, EUR of supported (T=1) and non-supported (T=0) units by farm investment support measure of Latvian RDP during the programme period (2007-2013)

Number of Units	Gross Value Added 2007	Gross Value Added 2013	ATT (difference)
T=1 (263)	7 166	8 164	999
T=0 (156)	25 333	19 357	-5 976
Difference	-18 167	-11 193	6 975

Source: research findings, Latvian FADN database.

of multiple comparison groups. Such groups can be used in matching with the treatment group to calculate multiple treatment effects. Comparison of sizes of these effects would provide a sense of the reliability of the estimated ATT. A number of treatment groups can be compared with each other. Comparison of two control groups is possible, too.

The assumption of strong ignorability can be considered violated if causal effects prove to be statistically different between these two control groups. As multiple comparison groups are usually not available, there are three commonly used approaches with respect to sensitivity testing. The first method proposed by Dehejia and Wahba (1999) is changing the specification of the equation by adding or dropping higher order variables. Propensity scores are then recalculated, and newly obtained causal effect is compared to the originally computed effect. Such comparison reveals the reliability of originally computed causal effect. Instrumental variable (IV) method is another technique to assess the bias of the causal effects from original results. However, this method generally reduces the efficiency of the estimator. The bounding approach proposed by Rosenbaum (2002) assumes testing of possible hidden bias in the estimation of treatment effect. The test results would provide the level of sensitivity to hidden biases related to unobserved covariates. Such biases can influence the odds of treatment assignment.

The PSM method first has been empirically applied by Heckman, Ichimura, Smith and Todd (1998) in the estimations of training programmes on future income in the USA labor market. Subsequently, similar studies on the USA labor market were carried out by Dehejia and Wahba (2002), and a few other researchers.

The modules for calculating propensity scores and matching for use in STATA software were developed by Becker and Ichino (2002). Before running the set of necessary modules they recommend to “clean up” the dataset. It is common first to run the *p_score* module which estimates the propensity scores and tests the satisfying of the balancing properties. If the balancing properties are satisfied then ATT can be estimated with one or more of the *att** modules. The modules *attnd* or

attnw, *attr*, *atnk* and *atts* assume the nearest neighbor, radius, kernel and stratified matching, respectively. After the calculation of ATT, the module *mhbounds* developed by Rosenbaum (2002) provides sensitivity analysis with Rosenbaum bounds with Mantel and Haenszel (1959) test statistic.

Results and Discussion

The data on participants and non-participants of Farm Investment Support Measure of Latvian Rural Development Programme semi-subsistence farm support measure are sourced from FADN database which is not publicly available. The economic data in the database include all relevant information on programme participants and non-participants regarding their structure and performance from 2007 to 2013. First, as the information should cover periods before and after the implementation of the programme, 419 units were selected out of total number of 943 units. The possible overlapping was checked, leaving treated units that participated only in selected measure. There were 263 units in treatment group, leaving 156 units for possible controls. For the evaluation purposes differences in values of Gross Value Added after and before the implementation of the programme were obtained using the “naïve” difference-in-differences estimator. The Gross Value Added as the economic variable was selected because of its importance in the evaluation context as it is one of the main economic indicators that measures the impacts of policy interventions on economic performance of single economic units, sectors and national economics in general.

The values of changes in economic variable and calculated treatment effects are shown in Table 1.

The ATT effect on GVA of programme participants calculated by DiD method is positive. For programme non-participants, the ATT effect is negative. Using the “naïve” difference-in-differences estimator would lead to an erroneous assumption that measure contributes to the growth in Gross Value Added for participating units at EUR 6 975.

With respect to propensity score matching (PSM-DiD method), in total, 31 variables related to unit structure which were considered critical for

comparability of economic performance were selected for the use in matching process.

Although only 4 and 6 variables proved statistically significant at 5% and 10% level, respectively, after Logit regression, dropping the variables with lower significance levels caused a loss of balancing

properties in one or more blocks. Similarly, adding of higher order covariates caused the loss of balancing properties. Therefore, the original specification of Logit function was preferred. A list of structural variables with their propensity scores obtained with Logit equation is provided in Table 2.

Table 2

Results of estimation of logit function

Variable	Coefficient	Standard deviation	z	P> z	95% confidence interval	
Organic farming	-0.338324	0.288963	-1.17	0.242	-0.904682	0.228034
Labor inputs	-0.029574	0.159048	-0.19	0.852	-0.341303	0.282155
Agricultural land	0.004518	0.017689	0.26	0.798	-0.030152	0.039189
Livestock units	-0.008048	0.013007	-0.62	0.536	-0.033541	0.017446
Output	-0.000045	0.000049	-0.91	0.361	-0.000141	0.000051
Output in crop farming	-0.000893	0.001155	-0.77	0.440	-0.003157	0.001372
Output in livestock farming	-0.000825	0.001155	-0.71	0.475	-0.003089	0.001440
Total agricultural output	0.000887	0.001154	0.77	0.442	-0.001376	0.003149
Processing	-0.000046	0.000098	-0.47	0.639	-0.000238	0.000146
Net turnover	-0.000059	0.000031	-1.90	0.057	-0.000119	0.000002
Depreciation	0.001603	0.001610	1.00	0.320	-0.001554	0.004759
External costs	0.000063	0.000058	1.09	0.274	-0.000050	0.000176
Gross value added 2007	-0.001615	0.001608	-1.00	0.315	-0.004767	0.001537
Gross value added 2012	0.000044	0.000020	2.19	0.029	0.000005	0.000084
Net value added	0.001624	0.001609	1.01	0.313	-0.001530	0.004777
Gross margins in crop farming	-0.000121	0.000199	-0.61	0.542	-0.000510	0.000268
Gross margins in livestock farming	-0.000816	0.000747	-1.09	0.274	-0.002280	0.000647
Total assets	0.000003	0.000008	0.40	0.690	-0.000013	0.000020
Buildings	-0.000038	0.000019	-2.01	0.045	-0.000076	-0.000001
Equipment and machinery	0.000013	0.000019	0.69	0.493	-0.000024	0.000050
Total liabilities	0.000022	0.000020	1.09	0.277	-0.000018	0.000061
Long-term liabilities	-0.000020	0.000028	-0.72	0.473	-0.000074	0.000034
Gross investments	0.000016	0.000026	0.60	0.549	-0.000035	0.000066
Total state support	-0.001246	0.001601	-0.78	0.436	-0.004385	0.001892
Area payments	-0.001156	0.000697	-1.66	0.097	-0.002521	0.000210
Less favorable area payments	-0.000253	0.000197	-1.28	0.200	-0.000639	0.000134
Crop subsidies	-0.000518	0.000231	-2.24	0.025	-0.000970	-0.000065
Livestock subsidies	-0.000474	0.000166	-2.86	0.004	-0.000799	-0.000149
Compensated excise tax	-0.000547	0.000484	-1.13	0.259	-0.001495	0.000402
Interest subsidies	0.000937	0.000804	1.17	0.244	-0.000638	0.002512
Subsidies for investments	0.001468	0.001602	0.92	0.359	-0.001672	0.004608
Constant	2.287470	0.496222	4.61	0.000	1.314893	3.260047
Logit regression	Observations	LR chi ² (31)	Prob>chi ²	Log likelihood		Pseudo R ²
	419	158.05	0.000	-197.59		0.29

Source: research findings, Latvian FADN database.

Table 3

Blocks of propensity scores

Inferior of block of propensity score	T(0)	T(1)	Total
0.0121553	31	4	35
0.2	23	5	28
0.4	23	28	51
0.6	47	110	157
0.8	11	116	127
Total	135	263	398

Source: research findings.

Table 4

Average treatment effects (EUR) on Gross Value Added by method and test statistics

Method	Nearest neighbor	Radius matching (0.001)	Radius matching (0.01)	Radius matching (0.1)	Kernel matching
Treated	263	64	251	263	263
Controls	69	45	93	135	135
ATT	4 853	3 809	4 523	6 676	5 748
t	1.47	2.28	1.73	1.83	2.33

Source: research findings.

The Table 3 shows the inferior bound, the number of treated units and the number of control units for each of iterated five blocks. As the computed z-value does not exceed the critical value for the 5% confidence interval for all three variables, null hypothesis can not be rejected.

The common support option has been selected. This restriction implies that the test of the balancing property is performed only on the observations whose propensity score belongs to the intersection of the propensity scores in both groups. With the given specification the balancing property is satisfied. The results of evaluation of average treatment effects with various matching methods and respective test statistics are shown in Table 4.

The average treatment value with the highest test statistics (kernel matching) were considered the best estimate for economic variable. Sensitivity analysis was carried out using the Rosenbaum bounding approach. The results show that the estimated effects on Gross Value Added of the Measure intervention are rather sensitive. The sensitivity test shows that a hidden bias which increases the odds ratio from 1 to 1.05, would make the obtained results statistically insignificant. The relatively high sensitivity would have been caused by relatively small number of observations in control group. It is recommended to have up to 4 times more observations for potential

controls which is not the case. However, the results of sensitivity tests are providing only additional information with respect to the calculated effects stability. The overall validity of the obtained results is not questioned.

Using the PSM-DiD estimator provides statistically rigorous estimation of the contribution of a measure to a growth in Gross Value Added for participating units at EUR 5 748. The value of changes in economic variable obtained by PSM-DiD method is slightly lower than yielded by ‘naïve’ difference-in-differences estimator (EUR 6 975). This indicates to a possible overestimation of programme effects if ‘naïve’ method is used.

Conclusions

The use of ‘naïve’ estimators in evaluation of programme effects on economic variables can lead to the overestimation of changes in economic variables attributed solely to the programme. The rather small difference in results obtained by “naïve” difference-in-differences estimator and propensity score matching is purely accidental as the analysis of the other measures of the programme show the effects estimated can be either negative or positive depending upon the method applied. Propensity score matching has to be considered a more suitable method in establishing a sound counterfactual. The changes in Gross Value

Added estimated by propensity score that can be viewed as direct programme effects on beneficiaries matching are significant and positive.

The direct economic impacts of semi-subsistence farm support measure of Latvian Rural Development programme 2007 – 2013 are significant and positive.

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LONG-TERM ELDERLY CARE: QUALITY ASSURANCE CHALLENGES FOR LOCAL GOVERNMENTS

Endija Rezgale – Straidoma, Līga Rasnača

University of Latvia

endiareszgale@gmail.com; liga.rasnaca@lu.lv

Abstract

The purpose of this article is to address the quality assurance challenges for local governments in long-term elderly care. The research is based on the qualitative approach. Theoretical approach is based on active aging ideas and quality assurance principles. Authors have started analysis on how to adapt the quality principles of European Quality Framework for Long-Term Care Services in the Latvian elderly long-term care institutions. The experts' view on evaluation is one of the methods of how to assess the quality principles in long-term care for elderly. The research results show different approaches to quality assurance principles and evaluation at the level of local and central government and the necessity to move towards a unified understanding. Experts emphasised the necessity to discuss quality principles in long-term care institutions and the division of responsibility for elderly care between the local and central government. The main findings are that none of the experts would like to spend the rest of their life, when they reach an old age, in a long-term institution. Principle ranking was successfully used in semi-structured expert interviews. The results show a great extent of variety in evaluating the quality principles of European Quality Framework for Long-Term Care Services in Latvian elderly long-term care institutions.

Key words: long-term care, elderly, active ageing, quality assurance.

Introduction

The fact that people are living longer in the 21st century is bringing new challenges in the elderly long-term care. Ageing society has become a universal concern. Along with the development of medical technology, the health care delivery system, prolonged life expectancy and low birth rate, the proportion of the elderly population in Latvia has increased since regaining the independence in 1991 (CSB, 2016). Increase of ageing population brings the new challenges in long-term elderly care system in the whole world. The number of elderly in need of long-term social care services can differ in various countries but overall tendencies that are sought after are similar. There is a major share of the older population who are in need of care in all of Europe. Some elderly are receiving care from informal carers like spouses, children or other family members. In non-European countries this source of care is used even more. 'The needs and demands of long-term care services have become urgent and significant' (Riedel & Kraus, 2011).

The number of elderly people in need of long-term care and assistance is increasing. Principles and guidelines for the wellbeing and dignity of elderly in need of care and assistance state that most of the elderly people are living at home and only a minority are cared for in a residential care facility. In many countries, care is mainly provided by informal carers. The 'European strategy for wellbeing and dignity of older people in need of care and assistance', 'European initiatives for long-term care' and 'European Quality Framework for long-term care services' are elaborated by social scientists from different countries in the context of EU Strategy 2020 (WeDO, 2012a; WeDO,

2012b). In order to make these changes in long-term care, a proper research must be done in order to identify what the new needs are and how to improve quality in long-term care services. For this purpose there must be done evidence based research of elderly care. The share of elderly population (65+) in Latvia is 17.1% and even older (80+) is 3.4%. Dependency ratio 65+ is 24.8% and 80+ is 4.9% and parent support ratio 80+ is 19.3% (Riedel & Kraus, 2011). Currently there is no separate system for providing long-term care (LTC) in Latvia. LTC is divided between the health and welfare systems (Ilves & Plakane, 2011). A rather high percentage of elderly people in Latvia places an increasing burden on its ability to provide health and social care services (The World Bank, 2015a). In Latvia, about 137 000 elderly people out of half a million are in need of social care. Only 10 000 receive long-term care in institutions and approximately another 10 000 receive care at home (Bērziņš, 2015). According to the World Bank report, about 60 000 people aged 50-64 have a disability and only 1/10 of them receive care in an institution in Latvia (The World Bank, 2015a). The mentioned figures show topicality of elderly long-term care issues and necessity to find the most appropriate solutions for elderly, carers and representatives of local governments.

This study focusses on the quality framework for long-term care services in Latvia. The aim of the study is to disclose quality assurance challenges of long-term elderly care in Latvia. Latvia and the other two Baltic states are not participating in WeDO projects. That could be one of the reasons why quality standards are so different in LTC among the Baltic States and countries in WeDO project. Elderly people in Latvia also deserve a decent attitude towards them

and they have all rights to receive an appropriate long-term care that could meet their needs. The study is built on three main research questions: 1) What is the most important service quality principle in long-term elderly care in Latvia? 2) How to adapt quality principles of European Quality Framework for Long-Term Care Services for Latvian elderly long-term care institutions? 3) What are the biggest challenges for the local government for the elderly long-term residential care? Research tasks are: 1) to characterize EU quality framework for elderly LTC; 2) to develop conceptual framework that justifies the study; 3) analyse quality assurance challenges for local governments such as the financial support and lack of meeting basic needs in long-term care in Latvia.

The practical challenge of this study is to adapt principles of long-term care service quality in EU for Latvia. The quality principles for development of LTC are based on 'EU Quality framework for long-term care services' emphasizing provision of Wellbeing and Dignity of Older people (WeDO, 2012a).

The article begins with a description of elderly LTC issues and topicality in Latvia, and the formulation of programmatic elements. The main theoretical concepts are defined in continuation, the methodological approach described and finally main results characterized and discussed as the basis for conclusions.

Conceptual framework

Care is a diverse and evolving concept. It is taken as a natural part of life yet it is shaped by social and economic situation where and to whom it is provided and funded (Phillips, 2007). Long-term care is 'a system of providing social, personal, and health care services over a sustained period to people who in some way suffer from functional impairment, including a limited ability to perform activities of daily living. The elderly, adults with disabilities, people with mentally and prolonged chronic illnesses are the biggest majority in need for LTC services (Barker, 2003). The LTC provision is impacted by economic, social and cultural resources and traditions. The key aspects of care are cultural and spatial boundaries of care, as well as the ethics of care (Phillips, 2007). The provision of residential elderly LTC could be accepted as social necessity, but not as desirable solution for individual.

The fragmentation of LTC providers (private/public; local/centralised) could have trouble with providing the policy of active ageing. Active ageing 'providing more flexible work arrangements, including increased part-time work, both for workers transitioning to retirement and parents of young children, will be important, enabling longer working lives for an ageing workforce. Elderly employees

are also more likely to remain in the labour force when early retirement options are limited. Moreover, creating affordable childcare and eldercare options can help women stay in work' (The World Bank, 2015a). Active and healthy ageing is crucial not only for active elderly people living independently but also for elderly in LTC institutions.

Quality is 'degree or standard of excellence. Quality improvement in long-term care should be a continuous process by which a service or an activity aims at delivering better results through various means. These include a wide range of quality management tools and other mechanisms such as training for carers, both informal and formal; support for users' fundamental rights; the promotion of an age-friendly and supportive environment including access to services; the definition of quality standards; the assessment of results and outcomes by specific quality indicators' (WeDO, 2012a).

The evaluation of quality demand assessment criteria. The quality principles of European quality framework for long-term care services could be used as such criteria.

The EU Strategy for the wellbeing and dignity of older people in need of care and assistance highlights 11 quality principles for elderly long-term care services. A quality service should be: respectful of human rights and dignity, person-centred, preventive and rehabilitative, available, accessible, affordable, comprehensive, continuous, outcome-oriented and evidence-based, transparent, gender and culture sensitive (WeDO, 2012a). The quality principle respectful of human rights and dignity means that in order to provide a good service, the fundamental rights and freedom of older people, as well as their families and carers, must be respected, too. Person-centred principle means that there are addressed in convenient to client manner the changing needs of each individual.

The main goal is to improve their quality of life and ensure equal opportunities for the elderly. Preventive and rehabilitative principle looks for ways to prevent deterioration, and focuses on restoring the older person's health, wellbeing and ability to live independently as much as possible. A principle that service must be available means that there are broad varieties of care and assistance services to choose for elderly who are in need. Service must be available at the location that is convenient to the elderly person. Accessible means that service must be easy to access to those who are in need. Comprehensive information and advice about the range of available services and providers should be easily accessible not only to the elderly but also to their family members and carers. Affordable service means either service is free of charge or the price for it is so adequate that the elderly

do not have to jeopardise their quality of life, for example, saving on groceries, clothing etc., dignity and independence. Comprehensive means satisfying multiple needs, capacities and preferences of the older person. Also, meet the needs of their families and carers. It aims to improve elderly wellbeing. Continuous means that service is organised so that it ensures clients with continuity of service delivery for as long as it is necessary for them. Outcome-oriented and evidence-based principle focuses primarily on the benefits for the elderly. It is oriented towards improvements in an elderly's health, wellbeing and independence. Transparency principle provides clear and comprehensive information and advice to users and potential users about the services they offer. It includes the cost of services and information about how to access or cancel them. Gender and culture sensitive principle pays attention to gender and culture in care: for example, paying attention to the specific needs of women and men or to cultural differences among both staff and clients (WeDOb). Authors were interested in finding out if all these principles could be appropriate for the evaluation of elderly LTC in Latvia local government LTC institutions.

Materials and Methods

The research is based on the qualitative study with the aim to explore and analyse quality assurance challenges of long-term elderly care in Latvia. The research method of this study is document analysis

and a semi-structured interview (Gochros, 2005). The study includes analysis of EU and Latvian documents on social care.

Additional data was collected through semi-structured interviews which were done in February, 2016. Ten experts were selected for interviews where one out of them was social rehabilitator (SR), five were social workers (SW) and four - the leaders of local governments (LLG) in Latvia (see Table 1.). The social rehabilitator and five social workers were chosen from different elderly long-term care institutions. The interview results were compiled in March.

Considering the fact that quality assurance issue in long-term care institutions is very sensitive, all experts wanted to remain anonymous. While working in the institutional setting, they are afraid to disclose their opinion openly in order to avoid unnecessary contradictions. They also wanted that the names of those institutions where experts are currently working are not mentioned in the research. Leaders of local governments also participated in the research under certain conditions. They also wanted to remain anonymous due to some personal questions in the interview.

For an introduction for the semi-structured interview the experts were asked to rank eleven quality principles of European Quality Framework for Long-Term Care Services in Latvian elderly long-term care.

In order to find out what the most and the least important quality principles in elderly long-term

Table 1

Evaluation of research participants or experts

Expert	Gender	Current job position	Education	Work experience
1.	Female	Social worker	Master in Accounting Bachelor in Social Sciences	Works for two years
2.	Male	Social rehabilitator	First level professional degree in Social Work	Works for two years. Used to work for four years as volunteer in social care services
3.	Male	Social worker	Bachelor in Social Pedagogy	Works for 17 years
4.	Male	Leader of local government	Master in Law Master in Economics	21 year leader of local government
5.	Female	Social worker	Master in Social Pedagogy	Works for 14 years
6.	Female	Social worker	Master of Pedagogy Bachelor of Philology	Works for five years as an interest group manager
7.	Female	Social worker	Master in Law	Works for three years
8.	Female	Leader of local government	Bachelor in Economy Master in Human Resources Management	16 years leader of local government
9.	Male	Leader of local government	Bachelor in Architecture	15 years leader of local government
10.	Male	Leader of local government	Master in Pedagogy Master in Sociology	14 years leader of local government

Table 2

**Ranking table of quality principles for elderly long-term care services
of Latvian local governments**

Quality principle	1. SW*	2. SR*	3. SW	4. LLG*	5. SW	6. SW	7. SW	8. LLG	9. LLG	10. LLG	Total
Respectful of human rights and dignity	2	2	5	10	2	2	2	4	3	3	35
Person-centred	1	4	2	6	1	1	3	1	6	4	29
Accessible	5	9	6	5	9	10	8	6	7	5	65
Available	10	6	4	3	5	9	7	2	4	1	51
Preventable and rehabilitative	7	7	10	9	6	7	4	5	2	7	64
Affordable	9	3	1	1	10	11	9	3	5	2	54
Comprehensive	6	1	3	4	8	5	6	7	8	6	54
Continuous	11	10	8	8	7	4	11	11	10	11	91
Outcome orientated and evidence based	8	5	11	7	4	3	5	9	1	10	63
Transparent	4	8	9	2	11	8	10	8	11	9	80
Gender and culture sensitive	3	11	7	11	3	6	3	10	9	8	71

*SW – social worker, SR – social rehabilitator, LLG – leader of local government.

care services in Latvian case are, one of the ranking methods was used (Smolakova & Sestakovs, 2008). It was the expert evaluating method. This method within itself includes subjective elements and depends on a procedure how the expertise is done. In order to gather variety of expert opinions, 11 cards were used. On each of the cards was written one of the quality principle borrowed from WeDO project. Experts had to rank principles in a hierarchical order according to their answer to one of the research questions - ‘what are the most important service quality principles in long-term elderly care in Latvia?’ The most important principle they had to put as the first, and the least important as the last one in a row. Each quality principle was given a score by the experts. The quality principle that was the most important for the expert was given the lowest score. The highest score received the least important quality principle.

The research is based on qualitative approach by formalizing the experts’ evaluation of each quality assurance principle. Research results do not have a statistical significance but one rather has to pay attention to the validity of them. Validity of the research results was supported by each expert’s interpretation of quality assurance principles. For example, this method is used to make within-group comparison, which foresees ‘conversion of text to at least nominal-level variables’ (Bernard & Ryan, 2010).

Interviews included a control question to all experts: ‘Would you like to spend the rest of your life

in the institution of long-term care when you reached a certain age?’

Criteria selecting experts for the research and overview of them

In order to select the experts for the research, we had to impose criteria for them to qualify for the semi-structured interviews. There were three kinds of criteria: higher education, work experience and the current job position of a potential expert for the semi-structured interview. The education of an expert must be either a professional education by having at least first level professional degree in social work or a degree in any different scientific or professional field. Criteria for current job position must be a social worker, social rehabilitator or a leader of a local government (see Table 1.).

Results and Discussion

Further, the results of this study will be analysed and answers to the main research questions will be clarified. In order to reach the aim of this study and disclose quality assurance challenges of long-term elderly care in Latvia, first of all researchers had to gain answers to the main research results. The results of semi-structured interviews show that there are some differences between answers from leaders of local governments and social workers. The first question was ‘what are the most important service quality principles in long-term care?’ The importance

of quality principles in elderly long-term care in Latvia is portrayed in Figure 1. Using expert ranking method, the research results show that out of eleven service quality principles two stand out as the most important ones in elderly long-term care in Latvia (see Figure 1). They are the person-centred and respectful of human rights and dignity quality principles. The principle that long-term care must be person-centred is evaluated as the most important. The principle covers ideas and practice about individual approach, the main focus being on each person’s needs. However, not all experts ranked these principles as the most important. For example, only one expert, who is a leader of local government, as the most important principle mentioned the principle of affordability of service. He explained in detail his way of ranking the principles. He argued that with sufficient financing everything else would follow. The other leader of the local government outcome-oriented and evidence-based principle put as a priority in long-term care institution.

The least important principles that got the highest score in ranking scale are transparency, gender and culture – sensitive and continuity principles. Gender and culture-sensitive principle was ranked as the

number three by few social workers, though. Experts did not consider transparent and continuous as top priority principles. However, researchers must note that the given scores by experts for each of quality principles (see Table 2) vary quite a lot. For this reason, one cannot evaluate these scores to be the absolute results for this research. This ranking method was used for feasibility to prepare the ground for further qualitative study.

The second research question was ‘is it possible to adopt principles of European Quality Framework for Long-Term Care Services for Latvian elderly long-term care institutions?’ Leaders of the local government were more descriptive and showed bigger competency of how these quality principles could be used in quality assurance. They agreed that in their experience they have not done the quality assurance in long-term institutions in their municipalities by listing quality principles. They also agreed that this method could be used in case of Latvian elderly long-term care, but first of all they have to review and clarify the rules that relate to this group of people.

Getting results for the third research question ‘what are the biggest challenges for the local government

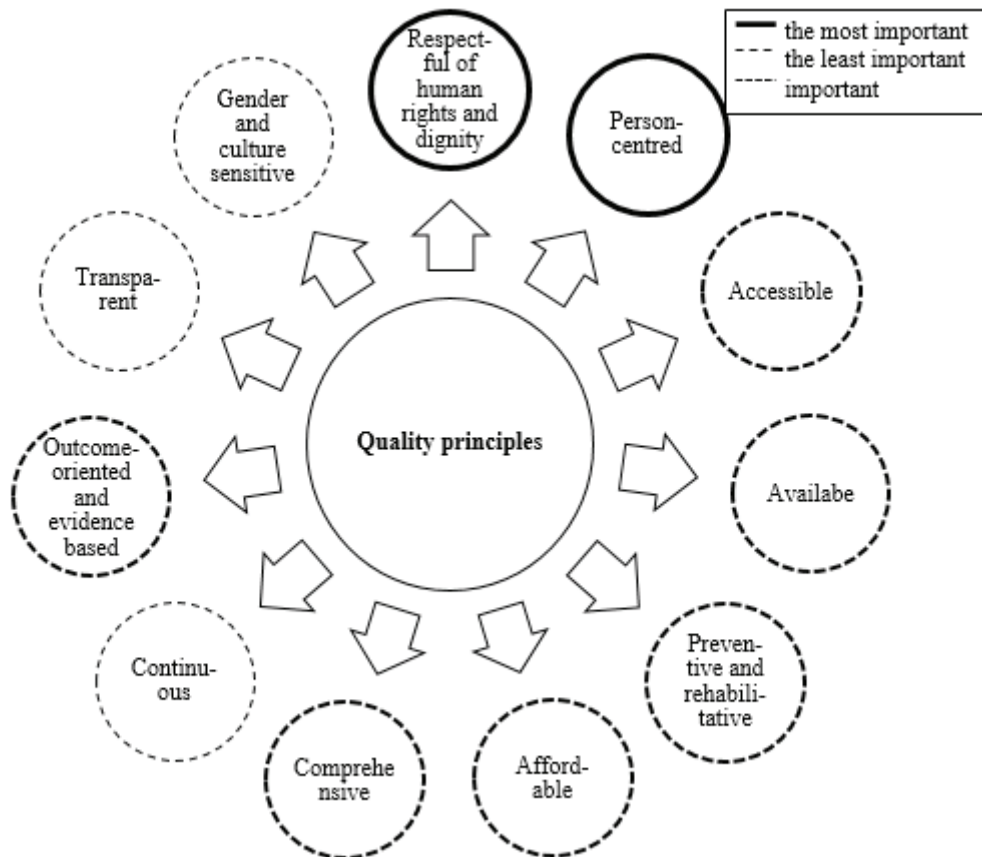


Figure 1. The adoption of the European quality principle framework for long-term care from expert point of view according to the importance of each principle in elderly long-term care in Latvia.

for the elderly long-term residential care?’ local government leaders first of all pointed out financial challenges, but social workers and rehabilitator were putting main focus on lack of meeting elderly basic needs in long-term care institutions. For example, during the interview, the social rehabilitator pointed out that the main challenge in long-term social care institutions is ability to provide elderly with single rooms in long-term institutions. Currently, there is a long waiting list for single rooms and elderly are mainly living in pairs, and it is very inconvenient, because at this age it is very difficult to find roommates of the same age that would be able to share room and not to have conflicts. Another issue that was highlighted was the size of the rooms, which should be bigger giving more space for its residents.

The control question was asked to all experts - whether or not they would like to spend the rest of their life in one of the elderly long-term care institutions. Almost all social workers and rehabilitator answered that they would not want to be residents in one of the long-term care institutions in Latvia when they reach old age. Most of them hope to stay independent as long as possible. They also hope that ‘this day will never come’ to them that they would be in need for long-term care in one of the institutions in Latvia. Their justification is that the current conditions in these institutions are not meeting their basic needs in order to be able ‘to live like a human being when it is nearing to the end of their life course’. One of the experts hopes for her son’s support and in the worst-case scenario hopes that his family will take her to live with them when the time comes. Another expert suggests that those school buildings which are empty after closing down several schools, especially in rural areas, should be turned into social care centres with flats. There elderly would be able to keep up with independent living and each would have an opportunity of having an apartment. In this kind of set up she would agree to live when she reached an old age. In return to that she would agree to give up her previous housing to have an opportunity to live in this centre. Local government male leaders all answered that they would not mind to spend their old age in the long-term care institution. One of them explained

that he has a decent pension fund, which would allow him to afford private long-term care. Another reason mentioned by the expert was a need to socialize and they would not want to stay alone at home in their old age. Long-term institution to their opinion is giving them a chance to be socially active. Perhaps the financial situation and status of each expert influenced their answer to this question.

Some possible questions that could encourage further discussion in the process of the study might occur. For example, how the social work association could be assisted in order to strengthen and support social welfare workforce; how to encourage and support the development of domestic standards and code of ethics; where social service delivery involves non-professionals (providing with a social work professional as a mentor).

Conclusions

The following conclusions can be drawn based on quality assurance challenges for local governments and the results of the conducted research adapting quality principles of European Quality Framework for Long-Term Care Services in Latvian elderly long-term care institutions.

1. Elderly LTC is a topical issue in Latvia due to the social and demographic situation. The LTC faces similar challenges in EU and Latvia.
2. The variety in evaluation of LTC quality principles among social workers, social work specialists and leaders of local government shows necessity for a more detailed analysis and lack of clear vision about the main quality principles.
3. In conclusion, researchers must mention some suggestions on how to improve the quality of social care in Latvia. Firstly, we must support networking and sharing of experiences among social welfare workforce professionals in regions. Secondly, to ensure that the social care workforce teams are visible and audible in the areas they operate.

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SOCIAL SERVICES DEVELOPMENT IN RURAL AREAS DESIGNING DOMESTIC HELP FOR ELDERLY PEOPLE

Sonata Staniuliene, Lina Januleviciene

Vytautas Magnus University, Lithuania
s.staniuliene@evf.vdu.lt

Abstract

Considering the deficiencies of social services for the elderly in governmental institutions and growing demand of ensuring services in rural areas, the paper aims to assess the needs of elderly people for social services in the selected rural areas and to propose the social services' development opportunities in terms of domestic help for the elderly. The social services facilitate support to elderly dependents in their homes, without interrupting their relationships with the family and the community, and improving their quality of life. The survey has shown that the municipality usually satisfies only basic biological needs of old people in rural areas. In order to ensure the well-being of elderly people, a complete cooperation among governmental and non-governmental institutions is required. Development of the services should be focused on the provision of the domestic help services for elderly people who do not receive them, and the diversity of the services for those residents who receive services from the municipality. The implementation of the development project of the domestic help services would enable the elderly residents of the rural municipality to have access to the most necessary services at the required frequency and intensity, considering the recipients' needs, thus improving the quality of life of the elderly people of local community and ensuring their dignified ageing.

Key words: social services, rural areas, domestic help, elderly people.

Introduction

Profound demographic changes are undergoing all over the world; increased life expectancy results in growing number of older people, as well as health, social and economic problems caused by this phenomenon (Šurkienė *et al.*, 2012). Eurostat states that in 2060 37 percent of Lithuanian population will be elderly people (The National Programme of 2012 for Active Ageing and Solidarity between Generations of Europe, 2012). The World Health Organization recommends the retirement threshold for people aged 65 and older (Kanopienė & Mikulionienė, 2006); however, from the socio-economic point of view this is a heterogeneous group: younger elderly people are still quite active, while the older ones are more often or continuously dependent on external assistance (Kanopienė & Dromantienė, 2004). Due to emergence of physiological changes of an old person, there is a need for nursing and care; in the face of psychological changes, there is a need of more attention for an old person, including communication problems; the changes in the socio-economic situation of an old person's life, when his/her needs no longer meet the possibilities, result in numerous other problems (Borisova, 2008).

A large proportion of them live in remote rural areas; therefore, based on the data of the Lithuanian Department of Statistics (2014), the number of elderly people using domestic social services in Lithuania is increasing every year, and the proportion of such people is higher in comparison with the recipients of the stationary care services. The demand for these services is increasing not only because of accelerated ageing process, but also due to the changes in the family structure. For most of the nation's history,

caring for the elderly was a family affair carried out largely by women in the home. In the XXI century, elder care is an increasingly complex enterprise, with much personal care 'outsourced' to paid non-family caregivers (Bookman & Kimbrel, 2011).

However, stationary care services are amongst the most expensive ones, therefore in the context of elder care there is a need for alternative social services, such as, for example, domestic care for the elderly. Considering the growing demand for social services for the elderly and lack of institutions that provide these services in rural areas, there is an urgent problem of ensuring the service development opportunities in rural areas, and designing provision thereof. Therefore, first of all, the paper aims to assess whether there is a need for development of social services for elderly people in the selected rural areas; and upon confirmation of the need for domestic social services, nursing homes or newly established public institutions, as social entrepreneurs, could implement the social service development opportunity in terms of domestic help for the elderly.

The subject of the paper – social domestic help services for the elderly in the rural municipality; the goal of the study - upon examination of the need for social domestic help services for the elderly in the rural municipality, to propose the design options of the domestic help services, ensuring development of the social services system. The objectives of the paper: 1) to analyse the concept and accessibility of the social domestic help services for the elderly in the rural municipality; 2) to examine the need for domestic help services for the elderly in the rural municipality; 3) to propose the design options for development of domestic help services in the rural municipality.

Research methods: analysis of scientific literature, analysis of the documents governing the domestic help services, and survey in writing of the elderly population in the selected rural municipality.

Materials and Methods

Social services are an integral part of the state welfare, helping people of all ages and different social groups (the elderly, the disabled, the disadvantaged, etc.) to ensure the ability to take care of themselves and integrate into society (Bitinas *et al.*, 2010). These services are ever more focused on a person's needs (Johnson, 2003). Katz *et al.* (2011) reveals the personal welfare areas that are closely interrelated: social, psychological and physical. In developing social assistance programs and welfare concepts for the elderly, attention should be paid to ensuring dignity and freedoms of these people (Human Development Report, 2000). Dignity, according to Knechtl (2008), is each person's existential value, independent of his/her status and age, and its maintenance, according to Lohne *et al.* (2010), is still not enough analysed as the configuration of meanings created by groups and individuals.

In foreign countries, a lively debate is held on how to ensure an active, healthy and dignified ageing, making a growing emphasis on an increase of the coverage and quality of social services, particularly improvement of domestic help services (Rosenberger - Spitz, 2013). The main objectives of social services for this age group are to increase the independence and social integration of elderly people. In the modern world, where power is the dominant factor, where the gap between having and not having increases, empowerment is a strategy that helps to support the customer (Johnson, 2003). Studies show that older people are not willing to change the living environment and obtain social services at residential institutions; families and other informal caregivers also prefer domestic care of family members (Lesauskaitė, Macijauskienė, & Širvinskienė, 2009). According to Kybartaitė (2011), it is very important for the elderly to be safe, to feel a caring attitude and respect. They do not need self-sacrifice of neighbours and family, they wish to have a valuable existence that can be ensured by professional staff only. A person feels safe in the home environment and is able to control most of his/her life (Jurkuvienė, Danusevičienė, & Mickevičiūtė, 2007). Studies have shown that an elderly person receiving domestic help services remains more independent for a longer period of time (Žalimienė, 2003), thus reducing social exclusion and stigmatization of the elderly (Stepukonis & Svensson, 2006), improving the quality of life and saving public funds for stationary care (Kudukytė – Gasperė, Jankauskienė, & Štaras, 2012).

European Commission (2008) states that implementation of the main goal of social services – ensuring the opportunities for people to take care of their independence – is related to organization of long-term care services. Today elder care is a multi-sector undertaking with six key stakeholder groups—health care providers, non-governmental community-based service agencies, employers, government, families, and elders themselves (Bookman & Kimbrel, 2011). Nevertheless, provision of public services is a growing challenge in rural areas not only in Lithuania but also in Europe (Kuliešis & Pareigienė, 2015). Public services are one of the aspects of rural vitality, which is widely debated by both scientists and politicians. Especially rural municipalities fail to adapt to the needs of the ageing population; social services in rural areas do not meet the needs of elderly citizens in terms of either quantity or quality (Social Report, 2004). It is noted that in rural areas the greater part of the social services is focused on district centres, so not all residents can benefit from the necessary assistance due to the distance to the service providing institutions, their deficiency, and lack of employees. Social service providers in rural locations, especially those in remote areas, will often find themselves the subject of policy and resource decision-making processes (Turbett, 2009). Demand aspects are debated, new, innovative ways of provision of public services discussed, new service models combining private, public sectors and community resources are sought (Kuliešis & Pareigienė, 2015). Additionally, the development of social services project requires an engagement with multiple levels of practice including individuals, families, groups, organizations and communities (Bisman, Butler, & Kaye, 2003). Provision of effective practice with the rural elderly requires assessments and case studies that reflect sound, knowledgeable, yet creative decision-making (Bisman, Butler, & Kaye, 2003).

In order to identify the need for social domestic help services, the municipality was selected for the case study, which is situated in the rural area, at a significant distance from the metropolitan area; where there are 281 (26 percent) elderly residents and only 4 of them are currently receiving domestic services. There are not full-time employees in the municipality, and social benefit recipients provide domestic help (public work). There is also a small Caritas group working in the area, which provides help to the elderly upon demand; the local primary school organizes public events (e.g., 'Visit a lonely person').

The quantitative method was chosen to determine the residents' opinion in this rural municipality, using the survey method for the collection of quantitative data. The research tool created for the study consisted of two parts: demographic characteristics of the study

Table 1

Distribution of domestic help services by necessity

	Needed and received	Needed, but not received	Not needed
Managing the home environment	8.8	68.4	22.1
Provision of information	11.8	44.9	42.6
Communication	44.1	35.3	20.6
Buying food products	18.4	34.6	47.1
Counselling	16.9	34.6	48.5
Making fire in furnace/carrying firewood	32.4	32.4	35.3
Carrying water	32.4	31.6	36.0
Housework	40.4	31.6	25.7
Looking after oneself	42.6	28.7	28.7
Delivery of hot food/products	33.1	26.5	40.4
Cooking	54.4	20.6	25.0
Managing documents/paying bills	11.0	19.1	69.9
Going to institutions	3.7	17.6	78.7
Buying household goods	11.8	14.0	74.3
Mediation/representation	39.0	14.0	47.1

participants and the questions to identify the need for domestic help services for elderly people (necessity of domestic help services, service providers, service procedures and quality, and the financial ability to pay for domestic services).

The concept of ethics in this study is concerned with the respondents' voluntary consent to participate in the study, upon providing detailed information to them in the language they can understand. The study did not infringe the principles of the research ethics, i.e., the respondents' rights to self-determination and their confidentiality.

The SPSS 17.0 software package was employed for processing of the research statistical data. The data were divided into frequency tables, creating the cross (2x2) interfaces tables to check the correlation between variables, and using chi-square criterion and Spearman correlation coefficient. To assess the reliability of the correlation between variables the significance level $\alpha = 0.05$ was selected.

The survey sample was targeted, i.e., X elderly residents of the rural municipality were questioned, who had been introduced to the researcher by the chief specialist of the X municipality. To establish the study sample size, the formula of Paniott was used, where: n - sample size; Δ - sample error rate = 0.05 (reliability of 95 percent); N - general population size (in this study case – 281). It was estimated that the opinion on the necessity and importance of the domestic help services for the elderly residents of the X rural municipality would be represented by 165 study participants; 166 respondents were questioned (32 percent men and

68 percent women; people aged 67-70 amounted to 26 percent of all the respondents, people aged 71-75 - 23 percent, people aged 76-80 - 20 percent, people aged 81-85 - 19 percent, and people aged 86 and older - 13 percent). Most respondents were people who live alone; they amounted to 57 percent of all the questioned elderly people, while the rest 43 percent of the respondents indicated that they were living with a family member(s).

Results and Discussion

It was revealed that 82 percent of the questioned elderly people needed domestic help services at the time of the survey. Most of the survey participants (46.3 percent) obtained domestic help from neighbours, acquaintances or relatives. A large part (36.8 percent) of the respondents indicated that they got assistance from cohabiting family members. Respectively, 10.3 and 6.6 percent of the respondents used the domestic help services provided by the municipality and non-governmental organizations. It turned out that the respondents living with family members received domestic help mainly from the family members (as reported by 83.3 percent of the respondents) and acquaintances / neighbours (16.7 percent); while single respondents were usually supported by acquaintances / neighbours (65.9 percent); in addition, they also used the domestic help services provided by the municipality (17.1 percent), and received support from the local non-governmental organizations (11.0 percent). The statistical analysis of correlation showed a weak negative (-0.439) statistically significant ($p=0.0001$)

Table 2

Distribution of the necessary domestic help services by the age groups

Age	67-80	81 and >
Going to institutions	17.6	17.6
Carrying water	30.6	33.3
Making fire in furnace/carrying firewood	31.8	33.3
Buying household goods	11.8	17.6
Managing documents/paying bills	16.5	23.5
Looking after oneself	23.5	37.3
Managing the home environment	78.8	51.0
Housework	28.2	37.3

Age	67-80	81 and >
Cooking	15.3	29.4
Buying food products	32.9	37.3
Delivery of hot food/products	25.9	27.5
Mediation/representation	11.8	17.6
Counselling	35.3	33.3
Provision of information	34.1	62.7
Communication	25.5	51.0

correlation between the family composition and the domestic help providers. This means that the lonelier an elderly person, the greater his/her need for the domestic help services provided by the municipality and non-governmental organizations, and vice versa.

During the analysis of variety of the domestic help services provided by the municipality, the services were evaluated as follows: those necessary for the respondents and they received them; those which were necessary, but they did not receive them; and the ones currently not necessary for the respondents (Table 1):

The necessary and received services were defined as assistance in travelling to other institutions (indicated by 78.8 percent of the respondents); assistance in buying household items (74.3 percent); assistance in handling documents and paying taxes (69.9 percent); counselling (48.5 percent); mediation / representation (47.1 percent); assistance in buying food products (47.1 percent).

The respondents needed most help in managing the home environment (digging snow in winter), however they did not get these services (68.4 percent). Based on the answers of the major part of the respondents, the necessary, but not obtained domestic help services included provision of information (44.9 percent), communication (35.3 percent), counselling (34.6 percent), assistance in buying food products (34.6 percent), assistance in making fire in the furnace and carrying firewood (32.4 percent), assistance in carrying water (31.6 percent), assistance in housework (31.6 percent).

The group of people aged 67-80 expressed a need in managing the home environment (78.8 percent). This group of the respondents also indicated provision of information (34.1 percent), counselling (35.3 percent), assistance in making fire in the furnace and/or carrying firewood (31.8 percent), and assistance in carrying water (30.6 percent) as relevant enough. In the meantime, people aged 81 and older highlighted the provision of information (62.7

percent), communication (51 percent), and assistance in managing the home environment (51 percent) as particularly relevant. The respondents of this age group also indicated assistance in looking after themselves, assistance in housework, and assistance in buying food products as quite important (37.3 percent per service). The respondents who did not have centralized water supply and heating indicated assistance in making fire in the furnace and carrying firewood and water as very important as well (33.3 percent per service) (Table 2).

There is a statistically significant correlation between age and the following services: communication (p=0.001); mediation and representation in solving important issues (p=0.0001); assistance in cooking (p=0.0001); assistance in housework (p=0.0001); assistance in looking after oneself (p=0.004); assistance in making fire in the furnace and carrying firewood (p=0.007); assistance in carrying water (p=0.009). The study results show that the need for domestic help differs in various age groups; therefore, it is important to consider the age of the service recipient while planning the domestic help services.

In assessing the amount of the domestic help services provided to the respondents, the study results showed that the services were not sufficient for the majority of the respondents (64.7 percent) or were only partially sufficient (20.6 percent). Merely a small percentage (14.7 percent) of the respondents indicated that the obtained domestic help services were sufficient. After checking the correlation between the family composition and sufficiency of domestic help, no statistically significant difference (p=0.768) was observed. These results show that domestic help services are insufficient both for the respondents living alone and for the ones living with a family member(s).

The analysis of organization of the provided domestic help services aimed at assessing frequency, convenience, duration and quality of service provision. The results showed that the respondents most often

Table 3

Distribution between the family composition and frequency of provision of domestic help

	every day	once per week	once per month
Lives alone	18.03	28.00	15.90
Lives in a family	59.00	5.60	1.90

Table 4

Correlation between family composition and satisfaction with service provision

Satisfaction with provided help	Family composition	
	r	p
Satisfaction with the method of provided help	-0.406	0.0001
Satisfaction with the duration of provided help	-0.406	0.0001
Satisfaction with the quality of provided help	-0.326	0.0001

received domestic help services upon demand (as pointed out by 35.3 percent of the respondents). A large part (34.6 percent) of the respondents received domestic help services on a daily basis. The remaining respondents pointed out that domestic help was provided to them once per week (19.1 percent) or once per month (10.3 percent).

The frequency of provision of domestic help largely depends on the availability of the support sources, therefore it is likely that the respondents who live with family members receive assistance more often than the single ones (Table 3):

The statistical analysis showed that the respondents who live with family members received domestic help on a daily basis (indicated by 59.0 percent of the respondents) or upon demand (32.0 percent). In the meantime, only 18.3 percent of the respondents who live alone indicated that they received domestic help services on a daily basis. The respondents of this group most often received domestic help services upon demand (as pointed out by 37.8 percent of the respondents) or once per week (28.0 percent). Recalculated correlation coefficient showed a very weak negative (-0.289), however, a statistically significant ($p=0.001$) correlation between the family composition and frequency of provision of domestic help. The obtained results show that the lonelier an elderly person is, the less frequently he/she receives domestic help services, i.e., availability of the support sources in the environment of an elderly person ensures more frequent delivery of the necessary assistance.

The study aimed to determine how the respondents evaluated the method, duration and quality of the provided domestic help, as these indicators are very important in planning the procedure on provision of domestic help and its development. The results showed that the respondents were partially satisfied

with the quality (as reported by 44.1 percent of the respondents) and the method (37.5 percent) of provision of domestic help, while the duration thereof was not satisfactory (39.7 percent).

The correlation analysis of variables showed a statistically significant correlation between the indicators of family composition and satisfaction with domestic help (Table 4).

The results suggest that the less relatives are available for an elderly person, the more he/she is dissatisfied with the method, duration and quality of domestic help. This could be explained by the fact that the assistance of family members and relatives is more in line with the expectations of the elderly, and is considered better than the help provided by employees of the institutions.

Since the main objective of the domestic help services is to create conditions for the elderly to remain independent as long as possible, to reduce social exclusion and to improve the quality of life, this study has been aimed to determine whether domestic help meets the essential needs of elderly people and improves their quality of life. The results showed that the domestic help services partially satisfied the essential needs of the respondents, based on the opinion of the majority of them (52.9 percent). A significant number of the respondents (28.7 percent) stated that the provided domestic help had not satisfied their needs at all; and only a small percentage of respondents (17.6 percent) indicated that their basic needs were met in full. A higher proportion of the respondents confirmed that the provided domestic help services had greatly improved their quality of life (60.3 percent), or improved it in part (33.1 percent); and only a small percentage of the respondents (6.6 percent) stated that their quality of life were not improving due to domestic help. The

correlation analysis of the indicators of satisfaction and improved quality of life revealed a weak positive ($r = 0.36$), but not statistically significant ($p=0.0001$) correlation between these indicators. This means that the more satisfied are the basic needs of elderly people, the greater the improvement in their quality of life.

Since the organization procedure and the quality of the domestic help services provided by the municipality do not guarantee the satisfaction of the basic needs of the respondents, a higher proportion of the respondents (55.1 percent) would choose another provider of the domestic services, if that were possible. The majority of the respondents (52.9 percent) would also agree to pay a certain fee for domestic help of high quality that meets their essential needs: 44.9 percent of the respondents are willing to pay up to 3 € per service hour; 7.4 percent - from 3 to 6 €; 8.1 percent - 6 € and more.

Respondents' dissatisfaction with the organization and quality of the domestic help services results in intention to use the services of other providers, even if such services were paid ones. The study results confirm other authors' insights that services meeting users' expectations are valued and viewed with satisfaction, and vice versa (Indrašienė & Katkonienė, 2011). The relevance of the social services recipients' opinion has also been proven in other studies; because only the users can evaluate the final result, revealing whether the services are appropriate for them, satisfy their needs or not (Bitinas *et al.*, 2010).

The study findings suggest that the domestic help services include a relatively narrow circle of users, whose income does not exceed the amount established by the Government. These findings can be explained by M. Kautto's (2001; quot. acc. to Lithuanian Association of Local Municipalities, 2010) two-pronged approach, implying that a person should always be given assistance according to his/her needs, and, on the other hand, applying a realistic approach, based on the available human and material resources. The analysis of the domestic help services rendered by the municipality for elderly people revealed that the municipality had included all the services provided for in The Description of Nursing Services... (2014) into the services list. According to Lithuanian legislation, each municipality is granted the right to develop such a system of social services that best meets the local residents' needs and the capabilities of the municipality, which distinguishes the regional differences of the social services development (Lithuanian Association of Local Authorities, 2010), especially in remote rural areas. Therefore, it is becoming more and more relevant to assess, design and develop availability and quality of social services in rural municipalities. However, the survey results

confirmed that not all elderly persons wishing to receive domestic help were actually receiving it in the rural area under research. The results supported other authors' insights that the largest share of domestic help is provided by the informal sector: family, friends, neighbours, community members (Dunajevs, 2009), while the services rendered by municipalities and NGOs are most frequently used by single people who do not have close family members.

Given the fact that there are no other providers of the domestic help services active in the municipality, there is a need for the establishment of such institutions and development of social domestic services. There are several possible solutions of the problem. The first one - the municipality establishes a branch / subdivision of the social service centre in the rural municipality, which employs professional social workers and caregivers providing domestic help services upon demand of the local population, though in view of the available municipal resources this solution to the problem is likely to be postponed. Then, Caritas group active in the rural municipality is also expanding its activities in attracting volunteers. However, the number of young people is decreasing in the municipality, and in this case, non-professional personnel would provide the services. Finally, the NGO active in the rural municipality is engaged in old people's stationary care development, introducing a new type of services - domestic help for elderly persons, and so far being flexible in funding the development of activities; in addition, the organization employs a number of professional staff who are experienced in working with elderly persons. Therefore, it is this development project of the social domestic help services that should be considered as the optimal solution. On the other hand, the cooperation of various assistance providers (municipalities, non-governmental organizations, family members, neighbours) can ensure a better quality of life for the elderly, enabling them to grow old with dignity.

Conclusions

Various demographic changes (declining birth rates and rising life expectancy) influence the changes in population structure, which results in a more rapid increase of the number of older people. These trends become apparent especially in rural municipalities, where the number of young people is quickly decreasing not only because of the falling birth rate, but also due to the high emigration flows. There is a tendency of declining number of people of different generations living in one family, which results in a lack of assistance required by the elderly family members. This situation increases the need of institutional services, particularly in terms of domestic help.

The domestic help services are considered a priority type of social services, since they facilitate support of elderly dependents in their homes, without interrupting their relationships with the family and the community, and improving their quality of life. However, public institutions providing social services for the elderly in rural municipalities are faced with the lack of financial and human resources; therefore, the residents of districts situated far away from the centres rendering the domestic help services have limited access to the necessary assistance, or such assistance cannot be provided at the full extent.

The survey of elderly people has shown that although the elderly in the rural municipality need social domestic help, the municipality usually provides the domestic help services that mainly meet the basic biological needs of old people. However, the essential objective of assistance for the elderly should be ensuring their well-being, thus it is necessary to pay sufficient attention to the psychological, social and spiritual components thereof. The elderly residents of rural municipality still lack communication, social networking, or just more frequent visits of caregivers.

The survey results of the population of the rural municipality reaffirms that in order to ensure the well-being of elderly people, a complete cooperation between the various service providers is required. In this case, it is very important that public institutions get support from non-governmental organizations, whose activities are generally more flexible, more efficient, and they can obtain additional funds from a wider range of sources. The local care organization has also the opportunity to expand its activities, including provision of the domestic help services.

Development of the services should be focused on the provision of the domestic help services for elderly people who do not receive them, and the diversity of the services for those residents who receive services from the municipality. The implementation of the development project of the domestic help services would enable the elderly residents of the rural municipality to have access to the most necessary services at the required frequency and intensity, considering the recipients' needs, thus improving the quality of life of the elderly people of local community and ensuring their dignified ageing.

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HARMONIOUS MANAGEMENT IN PUBLIC SECTOR

Daiva Urmonienė

Aleksandras Stulginskis University, Lithuania
daiva.urmoniene@asu.lt

Abstract

The article is of a cognitive and application nature. The research objective is to distinguish harmonious management principles applicable to the management of public sector efficiency. Results of the article achieved: 1) The analysis was done of the management principles in social models, as well as between them and harmonious management and its exclusive features. Harmonious management in this article is treated as a continuation of the analysis of the public administration evolution. The extracted specific management principles of conduct can be used for a comparative analysis between the social management models. 2) The analysis was done of harmonious management directions, which may be applied to a public sector organization. 3) The article discusses the process of harmonization and presented stages. Harmonious management process logic diagram integrated exchange organizations into a cohesive process model and principles for promoting efficient activities. 4) The article presents the proposals and conclusions of different options and the need to apply the harmonious management of public sector management to gain efficiency. The aim of the research is to identify the principles of harmonious management applicable to public sector management for the purpose of effectiveness. The paper is based on the scientific literature and document analysis and synthesis, systematization, comparative analysis and case studies. In this article the case study is used by local authorities, which are represented by the public sector. Empirical research is conducted by using the quantitative standardized expert interview method. Visualization method is used, too.

Key words: Harmonious management, harmonization, public sector.

Introduction

Legal acts governing the reformation of public governance as an attempt to harmonise the Lithuanian and EU mechanisms of regional policies fail to comprehensively account for the specific features of the country regions and local self-governance. This suggests that reformation of the public sector administration aimed at increasing economic independence of regions is a relevant issue (Arimavičiūtė, 2009). With the ultimate goal of greater efficiency in governance, Lithuanian researchers (S. Puškorius (2006), K. Masiulis (2007), E. Gaulė (2010)) analyse decisions adopted by the authorities within the context of theories of democracy and rely on the works conducted by world researchers (W. Parsons (2001), H. Fayol (2005), A. Hanberger (2009)) not only to study public governance in general, but also to deal with the issues of improvement of activities by local self-governments, discuss decentralization, partnership between public and private sectors, adequate, sustainable governance, which are some of the key prerequisites of directed and efficient operation of the public sector, and thus of the entire state. Public governance urges for a reform encompassing saving of various types of resources, adoption of rational decisions, framework-based elements of governance, as well as creating bases of new motivating innovations. The ongoing changes must be directed towards contemporary postmodern public governance rather than traditional public administration, reconsidering the traditional normative orientations and dealing with the constantly reoccurring obstacles (Raipa, 2009). With the aim of

achieving efficiency and innovations in public sector management, it would be reasonable to analyse the concept of sustainable management representing the Theory of Harmonious Management (He, António, & Trigo, 2012).

The research object is harmonious management in public sector.

The aim of the research is to identify the principles of harmonious management applicable to public sector management for the purpose of effectiveness.

Materials and Methods

Qualitative research methods have been used for this article. Analysis of the concept of harmonious management in public sector has been performed under the methods of literature and document analysis and synthesis. The method of comparison has been used for identification of the principles of social management models for public sector. Strong and weak aspects of the models have been identified during the analysis of differences between characteristics of the models. The weak aspects have been discussed as the prerequisite for the formation of the subsequent model. The evolution of these models is also relevant for the aforementioned reason. Data for the empirical study have been collected by the methods of semi-standardised expert interview and case analysis. In this article the case study is used by local authorities, which are represented by the public sector. In order to validate the study, proper experts have been chosen according to the guidelines in the scientific literature. Competent people with special experience and expertise in the field directly linked to the object of

examination were involved. The expert competence indicators applied in the paper were the following: position, academic degree, years of the particular research and practical work. Expert characteristics, such as unbiasedness, integrity, ability to analyse a problem without surrendering to the prevailing trends, are particularly important. According to V. Rudzikienė (Rudzikienė & Augustinaitis, 2009), reliability of expert assessment depends on the following: a) number of experts, b) composition of the expert group by areas of specialisation, c) expert characteristics. The selected experts have been grouped into three target groups: researchers analysing the issues of public sector authorities (2 experts), active practitioners working at community organisations (2 experts) and practitioners working at municipal authorities (2 experts). The selection criteria when choosing experts for the study, was that they are relevant opinion practitioners and researchers who globally discuss local self-governance issues. The main keywords used in the expert interview were: harmonisation of functions (transfer, implementation), decentralisation, local authorities, community organisations and their importance. The case of Lithuania is analysed in the discussion of the public sector (organisations) authorities; therefore, local governments, municipal authorities, and community organisations are mentioned.

Results and Discussion

Welfare and image of a state depends on the capability of its public sector to adapt to the processes of change, their ability to plan, adopt decisions, and coordinate their implementation. Nonetheless, introduction of innovative solutions in a public sector is more complex than in the private sector. According to V. Giedraitytė & A. Raipa (2012), innovations influence not only the habits of public servants, nature of work, but also the key public services. Meanwhile the society demands efficiency, new forms of activity, continuously improving qualitative indicators of activity from public authorities (Raipa & Petukienė, 2009). As a result, higher quality-related requirements are inevitably set for the public sector, and more efficient changes in the management system, more effective work organisation and problem solving methods are sought.

Changes in the models of public governance occur as a natural outcome or result of the globalisation processes in social, economic and culture domains rather than for the reason of the 'public' theory of particular importance relevant in policy formation. Three main models of social management are distinguished: traditional hierarchical, the New Public Management (NPM) and New Public Governance (NPG).

The traditional model of public administration (hierarchical). Rationalism is the key idea lying behind the model, directly influencing the practice of public authorities. This, however, has emphasized the main weak aspects of the model. According to R. Vanagas (2006), the traditional model of public administration does not allow for projecting more efficient operation of the public sector. Bureaucracy is good in performing the control functions, but is not successful in dealing with managerial functions and, despite being reliable, opposes innovations. Bureaucrats are not particularly fond of the market demands, attempt to avoid risk and use the available resources improperly.

The new public management. The term was originally used to describe application of methods characteristic of private business to the area of public (social) administration. It also implied the principles of economisation and striving towards efficiency mainly on the basis of quantitative results. Several Nordic countries, the Netherlands and Germany have made attempts to follow the (then) newest fashion of public management, in particular on the municipal level (Guogis, 2012). The new public management is considered to be a more flexible and efficient theory of public administration, with the underlying goal being direction of activities towards a result rather than formal procedures. Client orientation, striving for efficiency, 'juxta positioning', priority planning, global budget, client satisfaction, quality management, 'single window', etc. are set as priorities (Guogis, 2012). Nonetheless, weak aspects have also become evident, e.g.: the market is not suitable for implementation of every area of governance-related activity; effective results that are undefined and subjective are sought; administrators' greater autonomy means vague accountability and higher risk; competition in public sector leads to conflicts between public organisations rather than cooperation, etc.

The New Public Governance pays closer attention to qualitative aspects of social services, emphasizes openness, transparency, polycentric democracy, absence of corruption, and active engagement of non-governmental organisations (Guogis, 2010). A very important component of the new public governance is the component of 'social empowerment', which increases the importance of 'active social policy' (Guogis & Bitinas, 2009). The process of public governance is primarily focused on the process itself rather than only on institutions, structures or public administration actors. The process of governance is mainly of self-organisational character, i.e. implies attempts to abandon centralisation. In this case, governance is performed by shifting the focus from authorities to processes and interactions that cover the civic society as well (Bevir, 2010).

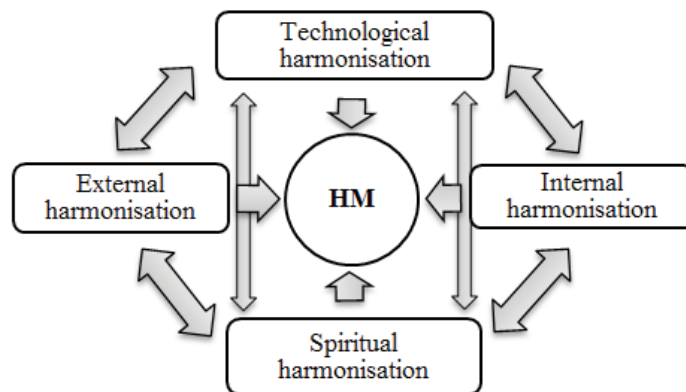


Figure 1. Harmonious management (HV) directions (adopted from He, António, & Trigo, 2012).

Innovation process management as a methodological issue has become particularly relevant in the beginning of XXI century. Under the context of global changes, decisions on innovation, innovative environment, competence of the participants of the innovation process, the culture of development and introduction of innovation, intersectoral nature of the innovative processes, innovative methods, forms and procedures of management of all types of resources of public sector are becoming integral elements of modern public governance (Raipa, 2012).

The concept of harmonious management is characterised by innovative approach towards solutions in governance. In his book 'HeXie (Harmony) Theory and Strategy' (1987), Xi Youming has described the concept of 'HeXie (harmony) Theory' by discussing and comparing the Chinese and Western theories of management. The Chinese harmonious management theory is based on the traditional Chinese culture (consistency between operational effectiveness and spiritual satisfaction) (Xi, Zhang, & Ge, 2012). Harmonious management manifests itself in the context of governance in four directions (see Fig. 1).

The example of organisation could be as follows:

- 'Spiritual harmonisation' in this particular case is explained as consistency between the organisational and individual goals or consistency of individuals' goals.
- 'Technological harmonisation' covers legitimacy of an organisation, effective resource allocation and technological solutions as well as their viability. Moreover, technological and spiritual harmonisation is interlinked. Efficiency of all activities is determined not only by technological decisions, but also by the 'human factor'. Different coherence is developed when other directions of harmonious management (internal and external harmonisation) are considered.
- 'Internal spiritual harmonisation' means sustainable organisational culture, where the

owners, managers and employees all follow the established rules of conduct, consistently working towards the set strategic goals.

- 'External spiritual harmonisation' means compatibility between levels of organisational and social cultures.
- 'Internal technological harmonisation' shows compatibility between technological solutions and management methods for the purpose of efficiency.
- 'External technological harmonisation' is construed as the capability of exchange of information and material resources with external environment of an organisation.

Thus, the key principles of harmonious management could be compared to the models of governance discussed above by means of integration. Summarizing the principles analysed above (strengths and weaknesses), the comparison of social administrative models is provided below (see Table 1).

In general, when changes take place or are initiated in public governance, theories could be claimed to be based on new needs both in practical and in theoretical domains. The differences between the New Governance Model and the traditional public administration are of great importance. The models are different because due to globalization monolithic states are becoming a part of a complex international network and emphasis is placed not on hierarchical but on reticular management style and the priority is given not to the strict form of state regulation but to more gentle management instruments including self-regulation and cooperation with non-state institutions. Therefore, the responsibility of state institutions becomes evident not only to the state institutions of higher hierarchical level but to social partners as well (Domarkas & Juknevičienė, 2007). Under the New Governance Model too much notice is given to ethics. More space is left for social context and the aspects of professionalism, political neutrality, justice

Table 1

Comparison of management principles in social models

Principles	Traditional Public Administration Model	New Public Management Model	New Governance Model	Harmonious Management Model
Accountability of high level officials	Politicians	Customers	Citizens and social partners	Politicians and citizens (the participants of system)
Activity goal	Order consolidation	Provoking changes	Developing social trust	Change of thinking
Activity orientation	Procedures	Results	Needs	Process
Deviation principles	Following rules and regulations	Productivity and results	Accountability, transparency and participation	Compatibility
Major attributes	Objectivity	Regularity	Accountability	Consistency
Management method	Hierarchy	Market equality	Network	System
Normative basis	Administration law	Contracts	Agreements	Common goals (strategy)
Relations between citizens and the state	Subordination	Authorization	Empowerment	Interdependent
Success criteria	Process and outcomes	Outcome	Process	Harmony (dynamic coherence)

Source: adopted from Domarkas & Juknevičienė, 2007; Czaputowicz, 2007; Guogis, Kacevičius, & Stasiukynas, 2010; Schoene, 2014; Lin, 2015.

and avoidance of the clash of public and private interests. Under the New Governance Model it is being assumed that business and public administration spheres are different in principle (Czaputowicz, 2007) and, thus, have to be organized and function in a different way. The harmonious management means, 'a key organizational problem is made by the interaction process between person and material factor in special environment'. Directed by the new methodology, the basis of the harmonious management will originate from three main hypotheses and auxiliary hypothesis, such as 'person is ultimate source of uncertain factor in management action'; 'the uncertainty of material factor can be recognized and controlled ultimately within person cognition' (XI *et al.*, 2005).

In general, it could be claimed that the main idea lying behind harmonious management is harmony and consistency in all activities carried out inside and outside an organisation. The model is construed as a tool for analysis of management and actions that develop the structure for an entire organisation as a whole. The model facilitates problem identification in an organisation, development of strategy and planning of activities for its implementation. This idea reflects the diversity of interrelated elements that define the capability of an organisation to change. The theory brings changes into consideration of possible improvement of organisational management. Development and implementation of a new strategy is not the priority. A new system is rather allowed to

act with the purpose of efficiency (author's remark: to improve 'who will do?' rather than 'what to do?').

Therefore, it could be claimed that where harmonious relationship of management and self-governance between society and authorities exists, these processes reoccur continuously, thus leading to actual development of democracy and national economy as well as progress of the international market (Indriūnas & Makštutis, 2008).

In analysis of harmonious management as a process (or harmonisation), it is important to define the stages (see Fig. 2) that could be applied for the purpose of success criterion in an organisation or interorganisational system. In public sector, harmonisation could be focused on the activities (functions) between separate organisations (e.g. by coordinating inter-agency cooperation) and between separate sectors (e.g. partnership between state and private sectors).

Čiegis and Grunda (2007) have systematized the means of sustainable development of organisations that may be found in literature by whether or not they answer the following questions: 1) What is a sustainable organisation? 2) How could an organisation become sustainable? 3) What indicates sustainability of an organisation (how is it assessed)? The authors have claimed that 'At each stage, an organisation may follow the measures and standards devised by it, the same as it used to do during the development of sustainable development concept;

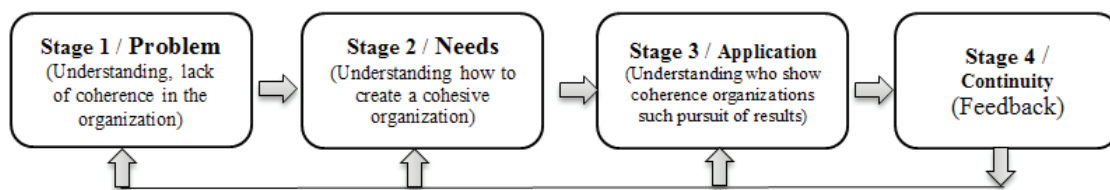


Figure 2. Harmonious management process logical scheme (adopted from Čiegis & Grunda, 2007; Follet, (cited by Gehani & Gehani, 2007)).

however, a number of different definitions of sustainable organisation as well as means intended to assist organisations in working towards sustainability and evaluation of the achieved results have been developed’ (Čiegis & Grunda, 2007). The authors’ model of transformation of an organisation into a sustainable process organisation could be extended by M.P. Follet’s (cited by Gehani, Gehani (2007)) insights, namely, that the management process must involve continuous coordination and harmonisation of the available resources (human, material resources, power structures, communications). The author of this paper has identified 4 principles encouraging more efficient operations: 1. Coordination requires that people be in direct contact with one another, 2. Coordination is essential during the initial stages of any endeavor. 3. Coordination must address all factors in and phases of any endeavor. 4. Coordination is a continuous, ongoing process (Follet (cited by Gehani & Gehani, (2007))).

Contemporary environment of organisations both in private and in public sectors is characterised by 4 components that are difficult to manage, yet highly influential in terms of development of organisations, namely: complexity, changes, ambiguity and uncertainty. Thus, harmonisation is considered to be the prerequisite of improvement of public governance of the Lithuanian local self-government authorities. The process of harmonisation is construed as coordination of the set goals and functions as well as available resources (time, financial, human resources) (i.e. horizontal harmonisation) and compatibility of

functions across the EU, central, territorial and local self-government levels (i.e. vertical harmonisation), with their composition and the anticipated result clearly defined and relevant as well as significant for assuring welfare of the local citizens. The main measures of process harmonisation are the following: law, organisation, finances, knowledge and examples to follow (Kobe, 2014).

In analysis of the results obtained by empirical research, the experts have supported the conclusions provided in the analysed scientific literature, namely, that it would be appropriate to analyse the issues of local self-government and/or community organisations. The respondents have identified the problem of lack of mutual trust, absence of communication between representatives of authorities and/or community organisations or diversity of their approaches towards the information obtained from authorities of national or EU level. The process of cooperation between the authority and community organisations is also mentioned as being important in order to engage the locals into decision making that is necessary for implementation of the set goals. The respondents have specifically named (see Table 2) the public sector institutions, harmonisation of activities between which would be beneficial and efficient.

Respondents’ answers to questions ‘Would it be appropriate to include community organisations into the system of public governance?’ and ‘Are there any activities by the executive municipal authorities that could be implemented by community organisations in a more efficient manner?’ are explicitly positive.

Table 2

Local authorities including effective harmonization of activities *

Institutions representing the public interest	Institutions representing the community interests
Central district government	The local action group
Municipality	Rural community
City municipal government	Local organization
Elderate	Community-based organizations
The lowest-level units - Parish / elderships	Private sector
	Social centre

*Institutional names are non-adjusted.

In terms of activities that potentially be taken over or have already been taken over informally from municipal authorities by community organisations, the respondents have noted that community organisations, to a greater or lesser degree, perform all (majority) of the activities of municipalities, and the list of their functions does not need any extension. According to the respondents, community organisations have already undertaken a considerable number of activities voluntarily. Cooperation between municipal authorities and community organisations is needed. Cultural, leisure, social support provision, employment, education for citizens – development of qualification skills, provision of special (forest) services could be mentioned. There are, however, categorical opinions, such as ‘State is a kind of a large community organisation operating in the specified areas by hiring professionals. Why is it becoming common to think that these functions should be performed by the locals? They would need to be paid anyway. What is the difference then?’

The experts have also asserted that decentralisation is inevitable, and it is important that the locals are involved not only into decision making, but also into more activities which are important to the locals and serve to satisfy their needs. Foreign author A.R. Volmert (2010) has noted that efficient local self-government implies inclusion of a citizen into solution of local tasks, enables adopting decisions adapted to the local conditions and issues and favourable to the citizens. Nonetheless, practitioners representing self-government organisations add that although community or non-governmental organisations may possess sufficient resources for expanding the pool of their activities, monitoring and coordination of all activities, from the decision making to the result phase, must inevitably be performed. This would ensure more efficient saving of resources and progress towards the results.

Hence, public governance should cover saving of various types of resources, adoption of rational decision, framework-based governance elements. In doing this, the focus should be put on contemporary postmodern management of public sector rather than traditional public administration; reconsideration of the traditional normative orientations should be demanded and the continuously reoccurring obstacles must be overcome (Raipa, 2009). The new tasks of public administration of the 21st century require proper and service-minded provision of services to the citizens, efficient financial management, adaptation of experience of business management, adaptation of the services to the increasingly segmented society, active cooperation with citizen communities and active support to the policy area (Smalskys & Skietrys 2014). Application of such principles to the

harmonisation of activities of the local municipal authorities creates prerequisites for introduction of harmonious management into the public sector. The result of harmonisation could be achieved by seeking harmony throughout the system (in the related organisations) under the condition, however, that each subsystem performs its functions properly. This could harmoniously lead to the harmony of the entire system, i.e. help ensure welfare of the entire system.

Conclusions

1. The concept of harmonious management is characterised by innovative approach towards management-related solutions. Harmonious management is the model of management based on philosophies of the East and West and may be applied successfully to public sector as well for the purpose of efficient governance and rational use of resources. The theory of harmonious management is based on the traditional Chinese culture, where operational efficiency and spiritual satisfaction to the one who seeks and/or receives the results are in harmony with each other. In the context of management, harmonious management manifests itself in three directions: spiritual harmonisation, technological harmonisation; internal spiritual harmonisation; external spiritual harmonisation.
2. The following characteristics are identified in harmonious governance. In public governance, liability for the adopted decisions and their results is allocated to both politicians and citizens, viewed as participants of the system. The goal of an activity is the changing way of thinking. Orientation of activity towards a goal as a projected process is the key indicator. The key principle of the model that should be followed is compatibility that is achieved and applied as the main measure, i.e. consistent activities and anticipated results. The model of management should be applied to the entire system that pursues certain common goals (strategy). Relations between the locals and the authorities who are the main participants of public sectors are recognized as being interdependent. The criterion of success and the anticipated results are the harmony that encompasses the entire system and is present in each subsystem.
3. The process of harmonisation is split into four stages that are important to coordinate and may be corrected at any phase: 1. It is important to perceive the existing issue and lack of sustainability in the organisation (system). 2. The needs and possibilities for creating sustainability in the organisation are identified. 3. Application and working towards the results. Continuity. This is the stage, where process continuity must be provided and situations must be dealt with in a

- way that would lead to the search of new issues and their exact designation.
4. For the purpose of efficient and innovative management in public sector, the prerequisite for introduction of the harmonious model of management is created. The success criterion of harmonisation could be achieved by working towards harmony throughout the system (in the related organisations) under the condition that each subsystem performs its functions properly. This would enable achieving harmony throughout the system harmoniously and ensure welfare of the entire system.

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RES UTILISATION DEVELOPMENT IN LITHUANIAN RURAL PLACES

Aušra Pažeraite^{1,2}, Rūta Repovienė²

¹Lithuanian Energy Institute

²Vytautas Magnus University, Lithuania

ausra.pazeraite@lei.lt; ruta.repoviene@gmail.com

Abstract

Energy transition from the fossil fuel dominating to the one based on renewable energy sources (RES) takes acceleration with the internationally recognised need to stabilise the global warming. Therefore, there is a general consensus that the initiative of the wide use of RES is manifold in its nature making an impact not only on the environmental issues, but also adding to the so desired customer involvement and rural development as well. Rural dimension in reaching the EU targets should arguably be a priority as RES utilisation is decentralised in its nature.

Despite the fact that EU with its main strategic documents gives a clear direction on RES utilisation through wider involvement of citizens, especially in rural places, there are certain grounds for stating that a current situation and future insights among EU Member States still differ. Lithuanian case was chosen to explore the sustainability gaps regarding the RES utilisation development in rural places. Literature review is employed to choose the most suitable way aiming to explore and evaluate the RES utilisation development in rural places regarding the sustainability issues. This article adds to understanding and evaluating the main obstacles of the well balanced RES utilisation development in rural places.

Key words: rural development, energy, RES, sustainability.

Introduction

The newest worldwide agreement made in Paris on 12th of December, 2015 leaves no doubt that the world politics turns into a new era of wider utilisation of renewable energy sources (RES) and, consequently, more extensive spread of clean energy technologies. Decisions made in the Paris UN climate conference have to come into effect in the year 2020. It is extremely important that all countries, despite their level of economic development, are involved in and responsible for tackling the climate change. At the core of the agreement is a commitment that the world will aim to stabilise global warming well below two degrees above pre-industrial levels, and even less if possible.

This direction towards the cleaner world development has started with the Kyoto protocol and later on lots of other agreements were made among different and most concerned countries. European Union (EU) arguably takes the leading position regarding the RES utilisation support and spread of clean energy technologies. This unceasing development has started from united political will regarding the perspective on clean development expressed in corresponding strategies followed by the necessary directives, guidelines and corresponding quantitative requirements. It is worth to mention that requirements are only for minimum level to be achieved.

The EU way of RES utilisation had started recognising the need to promote RES as a priority measure in 1998 because their exploitation contributed to the environmental protection and sustainable development. Moreover, it was stated that this spread can also create local employment, have a positive

impact on social cohesion, contribute to security of supply and make it possible to meet Kyoto targets more quickly (the European Parliament and the Council of the European Union, 2001). Furthermore, the European Parliament in its resolution on electricity from renewable energy sources and the internal electricity market (the European Parliament, 2000) underlined that binding and ambitious renewable energy targets set and approved at the national level are essential for obtaining proper results and achieving the EU targets. This inspired to accept the first EU directive on the promotion of electricity produced from renewable energy sources in the internal electricity market. This directive was amended several times and later on in 2010 came into force even more comprehensive document known as 'Energy 2020: A strategy for competitive, sustainable and secure energy' – to reduce greenhouse gas emissions by 20%, rising to 30% if the conditions are right, to increase the share of renewable energy to 20% and to make a 20% improvement in energy efficiency (EU, 2010). Furthermore, European Commission has adopted the Energy Roadmap 2050 where it provides a pattern of energy production and use in order to perform decarbonisation and efficient use of renewable energy (EC, 2011).

There is a general consensus that the initiative of the wide use of RES is manifold in its nature as it makes an impact not only on the environmental issues, but also adds to the so desired customer involvement and smoother regional, in most of the cases, rural, development as well. For instance, rural dimension in reaching the EU targets should be of the highest priority as RES utilisation is decentralised in its nature. Therefore, a great majority of rural areas

have the potential for being self-sufficient in their energy production (Peura & Hyttinen, 2011) through diversity of RES.

Despite the given possibilities and the fact that EU with its main strategic documents gives a clear direction, there are certain grounds for stating that the current situation and future insights in EU Member States still differ. The proportion of gross electricity produced using RES differs widely from one country to another, ranging from 7.3% in Hungary to 70% in Austria, with an average of 27.5% across countries in 2014 (Eurostat, 2016). One of the reasons could be the lack of balance or, more precisely, sustainability regarding the RES utilisation development. Consequently, the main aim of this article is to explore and evaluate the RES utilisation development in rural places regarding the sustainability issues, taking as an example the case of Lithuania. The tasks are the following: to perform literature analysis regarding the evaluation of RES development sustainability, to perform the evaluation of RES development sustainability issues, and to draw conclusions.

Materials and Methods

Sustainability and consequently sustainable development could be understood as a process of achieving a balance between the three most important aspects such as environmental, economic and social ones. Other authors emphasize the link between sustainability and energy sustainability describing it as balance between economic growth and efficient and secure energy supplies together with a clean environment (Hosseini *et al.*, 2012).

Underlying the dynamics of the sustainable development, which allow moving towards a better life (Streimikiene & Siksnielyte, 2016), the economic, social, technological and environmental aspects are analysed. These aspects create the acronym ESTE. The economic aspect is explored using indicators corresponding to the growth of economics and competition; the environmental aspect is evaluated utilising the indicators of impact on the environment and efficient use of resources; and the social aspect is explored using the indicator of social exclusion. It is worth adding that the research was performed with regard to the electricity sector.

The aspect of dynamic corresponds to our day life where huge differences occur even among EU countries. It is clear when comparing socio-economic conditions, despite the efforts of harmonisation, the specific national and regional legislative framework, and the multiple and different point of views of stakeholders (Berardi, 2013; Ruggiero *et al.*, 2014). In other words, authors emphasize the importance of the political (Thygesen & Agarwal, 2014) and legal aspects which clearly can send significant motivation

towards faster spread of RES utilisation. Enrichment of the indicators falls into well known acronym PESTLE, corresponding to the investigation of political, economic, social, technical, legal and, last but not least, environmental aspects.

Investigating the overall countries' energy status, Tofigh and Abedian (2016) as the main aspects distinguish the following four: Social, Technological, Economic, Environmental and Political (STEEP), determining 5 key indicators: Total Primary Energy Consumption per Capita for the Social aspect, Electricity Distribution Losses for the Technological aspect, Energy Intensity for Economic aspect, Carbon Dioxide Emission for Environmental aspect and the Total Renewable Electricity Net Generation as best fitting for Political aspect to be evaluated.

PEST method also serves as one of the instruments characterising the energy systems in terms of policy background, energy use and infrastructure, as well as market behaviour and community attitude for sustainable development (Cosmi *et al.*, 2015). Therefore, having the aim to evaluate the RES utilisation development in rural places with regard to the sustainability issues, the lacking aspect of environmental issues should be added to perform the well balanced evaluation.

The earlier given analysis shows the importance of the political aspect in the spread of RES. When evaluating the overall status of it, the total renewable energy net generation could be the proper indicator. Therefore, taking into account the nature of rural aspect it would be worth to take the indicator of permissions issued to develop the RES excluding the cases of big biofuel generators located in big cities. The number of permissions issued is a result of overall political and legal environment of the country. On the other hand, this indicator is quite easily quantitatively accountable.

Political aspects are tightly related with others, for example, the adequacy of processes in general, and particularly, renewable energy, while they are key in achieving a greater equality, democratic management, quality of life and environmental sustainability, particularly in the rural areas (Belmonte *et al.*, 2015). Therefore, the most influential economic indicator arguably is the tariffs of the power produced using RES. This is the strongest driving force for citizens to take an active role as this is tangibly related with the expanded possibilities for development of well-being in rural places alongside of farming and other activities such as craftsmanship. As it is widely recognised, today we experience an increased need for rural re-development and social innovation (Gobattoni *et al.*, 2015).

As the community position in RES development plays a significant role, it is very important to take

this into consideration when exploring the social aspect of the sustainable development. Most of the social sciences literature on renewable energy and communities is still very much focused on the factors of acceptance and resistance (Delicado *et al.*, 2016). On the other hand, evaluating customer involvement as one of the indicators of the social aspect it is worth to measure an amount of small and medium-sized business ventures as this business in most of the cases is local or even community based. Industrialized countries are implementing various methods to promote polycentric and decentralized energy supply concepts in order to include different options for citizen beneficial participation (Yildiz *et al.*, 2015) in the wider RES utilisation.

Analysing the possible indicators in relation to the technological aspect of sustainability, there are lots of choices, such as adequate technology and resources based on the conditions and infrastructure of the place (Belmonte *et al.*, 2015), losses in the grid while considering technology, as well as innovation, efficiency, research and development (Tofigh & Abedian, 2016). Even having the most advanced, innovative and efficient solution to generate electricity or/and heating or/and cooling, it is still nothing without proper connection to the grid. That is the reason why possibility to connect to the grid is taken as the most significant indicator which could heavily affect the RES development especially in the rural places. In this case, the technical quality is proved in the operation of technology, prior knowledge of users and successful use by other groups (Belmonte *et al.*, 2015).

Often the indicators exploring the impact on the environment are the following: greenhouse gas emissions (Cosmi *et al.*, 2015; Tofigh & Abedian, 2016; Streimikiene & Siksnyte, 2016), and the share of RES in the total energy generated (Streimikiene & Siksnyte, 2016). It is reasonable to assume that the indicators characterising the share of RES in the total amount of energy generated is the right choice as the RES development does not stipulate the greenhouse gas emissions. Moreover, the nature of the long-term trend could bring some valuable insights as well.

Summing up, in order to explore and evaluate

the RES utilisation development in rural places with regard to the sustainability issues, the following aspects should be taken into account: *political* aspect with the indicator of a number of permissions issued to develop the RES, *economic* aspect with the indicator of tariffs of the power produced using RES, *social* aspect with the indicator of amount of small and medium-sized business ventures, *technological* aspect with the indicator identifying possibility of connection to the grid, and *environmental* aspect with the indicator of the RES share in the total amount of energy generated. This kind of exploration and evaluation needs longitudinal data sets as it allows to look at trends and changes of phenomena over time. Consequently, the secondary data analysis (official data from EUROSTAT, Lithuanian National Commission for Energy Control and Prices, and Lithuanian transmission system operator JSC Litgrid) is used and results obtained are later on discussed using systematic analysis, generalization, comparison, and abstraction. The analysis was done using the longest available data time range and including the newest available data as well.

Results and Discussion

The indicator of a number of permissions issued to develop the RES can be explored in two ways: either by taking into consideration the amount of permission units or presenting the amount of capacity allowed to install according to the permissions issued. In order to have an overall picture, a comparison of both kinds of data is given in Table 1 and Figure 1.

In respect of data given in Table 1, the development of a single kind of RES is quite smooth changes except the solar case when a big boom happened in years 2012 and 2013. The amount of permissions issued jumped more than a hundred times from 14 in 2011 to 1462 in 2013. On the other hand, this huge amount of permissions corresponds only to around 60 MW of the capacity installed. In connection with the facts given, it can be assumed that business ventures developing solar energy are really few.

Table 1

Units of permissions issued, 2002 – 2015

Number of units	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Bio	0	1	1	0	0	3	3	2	3	4	5	3	4	8
Hydro	22	6	12	9	8	4	8	3	5	4	14	1	0	3
Solar	0	0	0	0	0	0	0	0	0	14	154	1462	12	64
Wind	1	0	2	1	1	5	9	6	8	27	14	25	37	18

Source: prepared by authors using JSC Litgrid data.

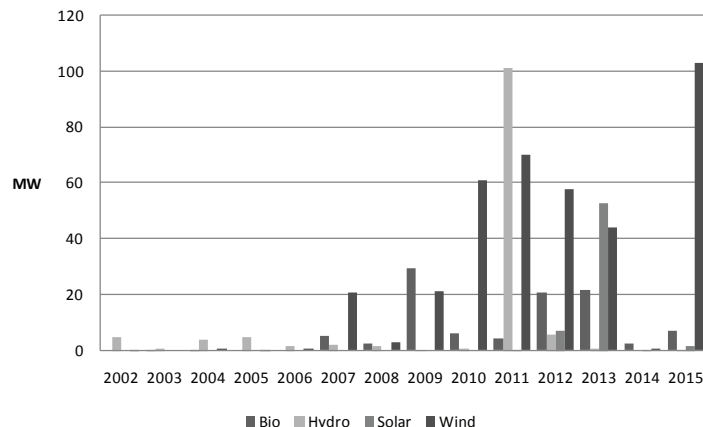


Figure 1. RES capacity installed, 2002 – 2015.

Source: prepared by authors using JSC Litgrid data.

Table 2

Development of tariffs and share of RES in Lithuania, 2007 – 2015

	2007	2008	2009	2010	2011	2012	2013	2014	2015
Bio, ct k ⁻¹ Wh	5.79	6.37	8.69	8.69	8.69	14.50	11.80	8.60	7.00
Hydro, ct k ⁻¹ Wh	5.79	5.79	7.53	7.53	7.53	8.10	8.00	7.00	6.90
Solar, ct k ⁻¹ Wh	0.00	0.00	0.00	47.20	47.20	41.70	21.90	14.50	14.40
Wind, ct k ⁻¹ Wh	6.37	6.37	8.69	8.69	8.69	10.70	10.00	8.00	7.40
RES %	16.7	18.0	20.0	19.8	20.2	21.7	23.0	23.9	25.0

Source: prepared by authors using the data provided by the NCC and Eurostat.

Figure 1 indicates a wavy development of the capacity installed. Solar jump stopped just after the boom period of the years 2012 and 2013. Wind was constantly growing till the year 2011 and later on decreased almost to zero in 2014 and regained in 2015 with 100 MW of capacity installed. It is worth mentioning that there were no significant disturbances regarding the technologies itself. Everything is due to the major changes in legislation and regulation – purchasing tariff for solar power dropped twice, changes occurred in relation to wind quota mechanism etc. The analysis leads to a conclusion that political decisions fail to support sustainability.

Exploring the economic aspect with the indicator of tariffs of the power produced using RES, it is tempting to make it in correlation with development of the share of RES in Lithuania. Data given in Table 2 identifies the constant growing of tariffs for power produced using RES till the year 2012. As it was already mentioned before, tariff setting procedures together with other regulations were changed in 2013. Starting from this year tariffs are getting lower. Despite this fact, the share of RES is constantly growing. Therefore, correlation between bio, hydro and wind purchasing tariffs and the share of RES

could be characterised as positive but only a moderate one (average correlation equals to 0.44). Solar case is so extreme that it should be excluded from the correlation analysis.

The growing share of RES when tariffs took a downward trend could be explained by the depreciation of technologies, namely, wind and solar. One could only imagine how intense could the growth be without regulative intervention which nearly stopped the RES development for a year regarding wind case, and in solar case this suspension continues up to now. Nevertheless, Lithuania is one of nine EU countries fulfilling targets set in Energy 2020 (Figure 2).

It is worth adding that potential of RES utilisation is far bigger in Lithuania (Gatautis *et al.*, 2009) than the level already reached. There are however no reliable statistics about the potential of these sources because they are in principle inexhaustible (Peura & Hyttinen, 2011). On the bases of the above data it is possible to conclude that the indicator of the RES share in the total amount of energy generated is satisfactory and alongside it has opportunities to be improved.

The aim to explore the social aspect with the indicator of amount of small and medium-sized business ventures is not so easy to reach as there is

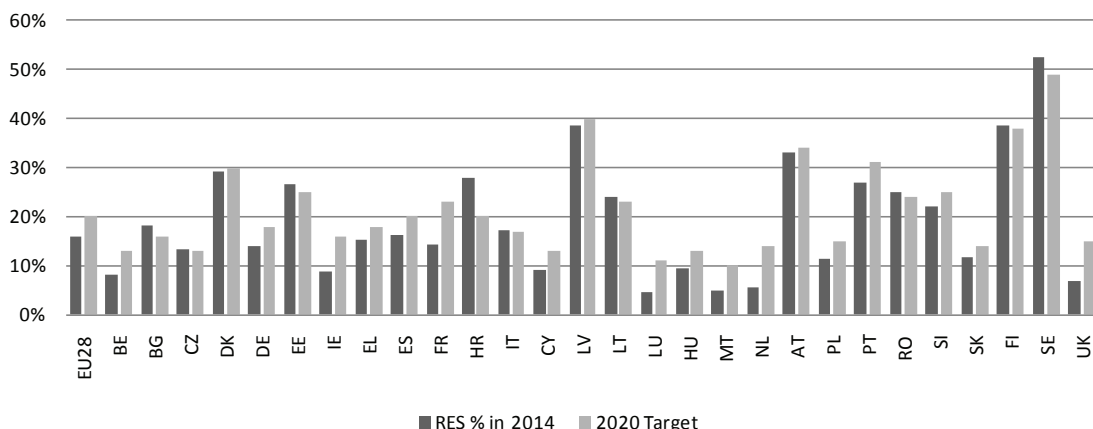


Figure 2. Overall share of energy from RES comparing with 2020 targets.

Source: prepared by authors using Eurostat data.

lack of the data directly attributable to this issue. Arguably small business is the backbone of job creation and extremely important for innovation in the clean energy sector. Small business contributes to social stability and even strengthens the democracy in the country as well (Pažėraitė & Krakauskas, 2012). Moreover, looking to maximize the local value of RES development, economic returns from the local ownership are observed from 1.5 to 3.4 times greater than compared to absentee ownership (Farrell, 2011). Energy sector is by no means capital intensive one and consequently dominated by big companies. RES utilisation development, especially solar technologies, provides real possibilities for the small businesses to take part in the energy sector as well.

According to the Statistics Lithuania, small and medium businesses create nearly two thirds of the country's GDP and employees more than 70% (Statistics Lithuania, 2016). Small and medium-sized businesses in electricity sector, by contrast, comprise only nearly 6% (Table 3). Actually, electricity sector is the one which could explore the situation while production in district heating sector is owned mostly by municipalities and some big companies.

The share of small and medium-sized businesses was extremely small and comprised less than 1% till the year 2010. Actually, subsequent growth is not that big but closure of Ignalina nuclear power plant made changes in the total production amount of the country and correspondingly to the proportional share of RES. However, nowadays the share of small and medium-sized businesses in the field of RES corresponding to 6% looks unsatisfactory in comparison with Germany which has replaced around 31% of its nuclear and fossil fuel generated electricity with green power, produced overwhelmingly from moderately sized onshore wind, solar PV, hydro, and bio-energy installations (Hockenos, 2014).

Possibility of connection to the grid also plays an important role in RES development in rural places. Despite the fact that lots of business entities would like to develop wind generation in the western part of Lithuania, transmission system operator refuses connections because of a weak grid. But there again the expenses assigned to compensate the RES connection to the grid are shrinking (Table 4). Moreover, no single Euro is assigned to grid expansion or strengthening in order to satisfy RES development needs.

Table 3

Share of electricity produced by small energy ventures

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Solar, GWh	0	0	0	0	0	0	0	0.1	2.3	44.8	73
Hydro, GWh	61.5	66.1	55.8	95.9	72.7	74.3	93.2	90.3	96.4	91.9	71.5
Wind, GWh	1.2	1.4	0.5	5.2	13.7	11.3	10.2	43.8	114.4	104.8	115.7
Share from total electricity produced, %	0.3	0.5	0.5	0.7	0.6	0.6	1.8	2.8	4.2	5.1	5.9

Source: prepared by authors using Litgrid data and Energy in Lithuania (2004 – 2005, 2009 – 2014).

Table 4

Amount of expenses assigned to compensate the RES connection to the grid, 2007 – 2015

MEur	2007	2008	2009	2010	2011	2012	2013	2014	2015
RES connection to the grid	11.6	3.9	8.7	0	0.23	0.05	0.13	-0.05	3.06
Expansion of the grid because of RES	0	0	0	0	0	0	0	0	0

Source: prepared by authors using data from Lithuanian National Commission for Energy Control and Prices.

Previous research (Pažeraitė & Krakauskas, 2012) also proves that this unsatisfactory situation has been taking place already for several years. This technological aspect together with the political one and also taking into account the regulatory issues prevent more intense RES development.

Conclusions

1. As the initiative of the wide use of RES is manifold in its nature and it makes an impact not only on the environmental issues, but also adds to the so desired customer involvement and smoother regional, in most of the cases, rural, development as well. For instance, the rural dimension in reaching the EU targets should be of the highest priority as RES utilisation is decentralised in its nature. Therefore, a great majority of rural areas have the potential of wider development because of the RES utilisation.
2. Political aspect of the RES utilisation development in Lithuanian rural places is explored with the indicator of a number of permissions issued to develop the RES, economic aspect with the

- indicator of tariffs of the power produced using RES, social aspect with the indicator of amount of small and medium-sized business ventures, technological aspect with the indicator identifying the possibility of connection to the grid, and environmental aspect with the indicator of the RES share in the total amount of energy generated.
3. RES development lacks the sustainability taking into account political, economic, social, technological and environmental aspects in Lithuania. The evaluation shows that situation is not satisfactory as the political decisions fail to support sustainability; regulative intervention regarding the tariff setting together with quota procedure and unfavourable grid position towards RES seriously injured the RES development. Consequently, the share of small and medium-sized businesses looks unsatisfactory, especially in comparison with more advanced countries. Only the environmental indicator shows a satisfactory situation as in spite of everything Lithuania is one of nine EU countries fulfilling targets set in Energy 2020.

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DECISION MAKING ON THE USE OF CULTURAL HERITAGE IN RURAL TOURISM DEVELOPMENT IN LATVIA

Laura Jeroscenkova, Baiba Rivza, Peteris Rivza

Latvia University of Agriculture

laura.jeroscenkova@inbox.lv

Abstract

The preservation of cultural heritage has become an important component of government policies of the EU and, of course, Latvia. Along with the preservation of cultural heritage, the use of it is also important. The aim of the research is to choose the best scenario for the use of cultural heritage in developing rural tourism in Latvia. The paper focuses on the problem of use of cultural heritage in the rural tourism development. The paper defined three scenarios for the use of cultural heritage in developing rural tourism: the initiative of entrepreneurs, public organisations and residents; the programme funded by national and regional institutions; the EU fund for the preservation of cultural heritage. A decision on the choice of the most appropriate scenario was made based on an expert decision-making method – the Analytic Hierarchy Process (AHP). Out of the three scenarios seven experts: rural craftsmen, a municipality vice leader, a civil servant from the Latvia Ministry of Finance, representatives from rural tourism organisations and the Association of Rural Female organisations, chose the third scenario – the EU fund for the preservation of cultural heritage.

Key words: cultural heritage, rural tourism, the Analytic Hierarchy Process.

Introduction

The advantageous geographical situation of Latvia, its rich historical and cultural heritage as well as the untouched nature are preconditions for developing tourism. Rural tourism is an agricultural industry that enables local residents as well as foreign tourists to view Latvia's beautiful and historically important landscape.

A great deal of farmers less and less benefit from their agricultural land. Therefore rural residents, investing a small amount of capital, enhancing the surrounding environment and reconstructing their premises unused in production, engage in rural tourism activity (Castells, 1997). This kind of economic activity allows gaining revenue all year round, although the amount of revenue earned differs throughout seasons. In this way, funds are invested in the development of a rural municipality. The Sustainable Development Strategy of Latvia until 2030 or Latvia 2030 envisages the development of rural territories – to provide an efficient use of rural resources; it is required to diversify the rural economy through rural tourism, crafts, organic farming, extraction of mineral deposits and production of construction materials, development of transport and other services enterprises and formation of business clusters (Castells, 2000).

Latvia's population shares a common material and non-material cultural heritage, which was accumulated in a long and creative activity over centuries. Culture determines what we are and what we want to be (Grizane, 2013). A common cultural heritage, a common language, common traditions and a common understanding are the key components that ensure the sense of belonging to a certain community and contribute to the solidarity of society. In a broad

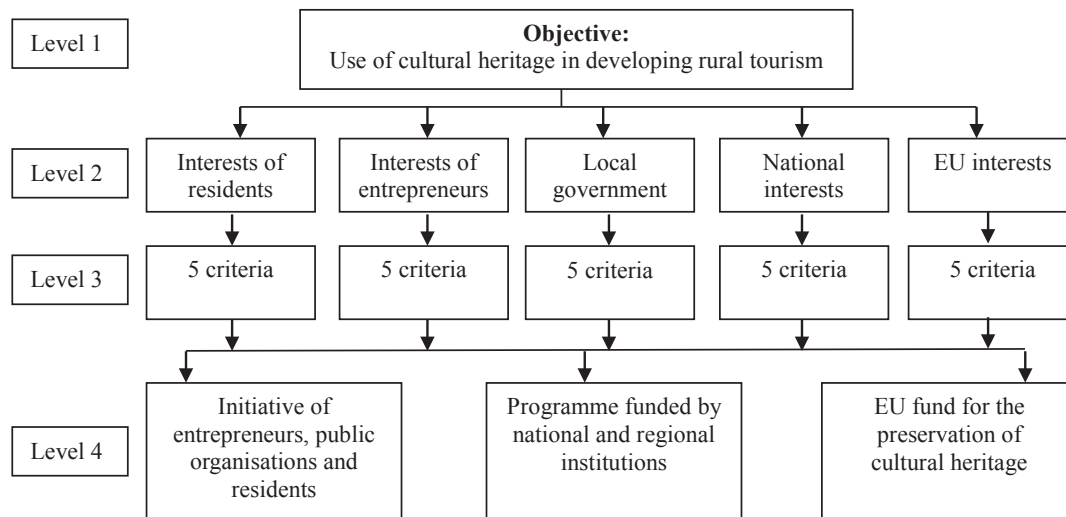
sense, culture is a set of values, which serves as the basis for the identity and the lifestyle of the individual, community and nation. At the same time, culture is also a mechanism shaping, analysing and passing on these values, thereby contributing to the sustainability of Latvia's cultural space (Liscova, 2011).

Tourism, including rural tourism, is one of Latvia's top priority industries whose services represent also exports and have positive social and regional development effects, especially in rural areas.

Tourism services are constantly developing in the world and, of course, in Latvia as well. Cultural heritage tourism is a kind of tourism which, among the other purposes, focuses on getting familiarised with cultural events, cultural heritage and places for sightseeing in one's own or foreign countries (Liscova & Rivza, 2011).

The first priority of the Sustainable Development Strategy of Latvia until 2030 or Latvia 2030 refers to the developing of Latvia's cultural space, as the identity of a strong and creative nation is embedded in its unique, inherited and newly created material and mental values. It unites and consolidates society to create new economic, social and cultural values that are appreciated and recognised in the world.

Significant research studies on the development of rural territories, cultural tourism, the preservation and activation of cultural tourism and rural tourism have been done by both foreign (G. Richards, C. Gratton, W. Munsters, A.M. Hjalager, M. Bauer, P. Roth, A. Langemyer, H. Kalogeropoulou, G.O. Donnchadha, P. Costa, M. Foley, C. Pocock, S. Baum) and Latvian researchers (A. Liscova, T. Grizane, I. Sture, A. Melluma, R. Karnite, M. Pukis, M. Kruzmetra, B. Rivza).



Source: authors' construction.

Figure 1. Scheme for the use of cultural heritage in developing rural tourism.

The aim of the research is to choose the best scenario for the use of cultural heritage in developing the rural tourism in Latvia.

Materials and Methods

To make a decision on the best scenario for the use of cultural heritage in developing rural tourism, the authors employed a multi-criteria decision-making method – the Analytic Hierarchy Process (AHP) (Saaty, 1991). There were engaged seven experts who represented rural craftsmen, municipalities, rural tourism organisations, the Association of Rural Female Entrepreneurs and ministries.

According to the AHP, the 7 experts, first of all, had to design a hierarchy, the first level of which involves a problem. After discussions, the problem was defined: the use of cultural heritage in developing rural tourism (Figure 1). This is Level 1 of the hierarchy.

Further, in developing the hierarchy, criteria groups are defined, which will be Level 2. In our case, there are five criteria groups: interests of residents, interests of entrepreneurs, local government interests, national interests and EU interests (Figure 1) (Rivza, Rivza, & Ramute, 2001).

Further, the 7 experts defined criteria for each criteria group, for example, the criteria group of interests of residents involved five criteria (Figure 1):

- job opportunities at the place of residence;
- preservation of family craft traditions;
- extra revenue;
- preservation of cultural heritage for next generations;
- mentoring of the new generation.

Criteria for the other criteria groups were defined in a similar way (Figure 1). The criteria compose Level 3 of the hierarchy (Figure 1).

However, at Level 4, which is the last one of the hierarchy, there are scenarios to be evaluated by the experts by employing all 25 criteria from all the criteria groups.

Further, the authors described three potential scenarios for the use of cultural heritage in developing rural tourism.

Scenario 1. The initiative of entrepreneurs, public organisations and residents

Its characteristics: entrepreneurs, public organisations and residents take the initiative in identifying and preserving the cultural heritage. It mostly applies to developing crafts as a component of cultural heritage. In a number of Latvia's municipalities, craftsmen groups that contribute to transferring craft skills to the next generation and to participation in fairs and other events have emerged during the last decade. The given scenario characterises the current situation, and its purpose is to activate and develop crafts in municipalities and to actively use it in developing rural tourism.

Scenario 2. The programme funded by national and regional institutions

Its characteristics: the government, in cooperation with regional institutions, establishes a specific programme aimed at preserving cultural heritage and expanding rural tourism. Funding is allocated to the programme, and its operation is governed by a Cabinet regulation. The programme is managed by the Ministry of Environmental Protection and Regional Development (MoEPRD) in cooperation with the Latvian Association of Local and Regional Governments and the Ministry of Agriculture.

Scenario 3. The EU fund for the preservation of cultural heritage

Its characteristics: since the preservation of cultural heritage is a priority of all European countries in the era of globalisation, a proposal on special support to preserve cultural heritage is increasingly voiced. A special ERA-NET project has been launched in the field of science, as well as this research priority is declared in submitting research project proposals. Entrepreneurs also need support. So, the EU establishes a special fund for the purpose of preserving cultural heritage. Its funding is based on a quota system for countries and projects. The preparation, submission, evaluation and implementation of projects are governed by law. The allocation of the fund's funding is controlled by the Ministry of Finance and the MoEPRD.

The 7 experts start their evaluation from the hierarchy's top levels – from Level 2 –, i.e. evaluating the criteria groups. The experts compare the criteria groups in pairs and evaluate their mutual weight relative to the problem, i.e. Level 1. The experts' evaluations are expressed in numbers using a special 9-point scale (Saaty, 2007) and entered into the expert's evaluation table. A priority vector's coordinates and a consistency ratio are calculated for each expert's evaluation table. An algorithm for calculating a priority vector's coordinates may be expressed by the following general formula 1 (Saaty, 2001):

$$x_i = \frac{(\prod_{j=1}^n \frac{w_i}{w_j})^{1/n}}{\sum_{i=1}^n (\prod_{j=1}^n \frac{w_i}{w_j})^{1/n}} = \frac{a_i}{\sum_{i=1}^n a_i} \quad (1)$$

where:

x_i – the coordinate of the priority vector;

$\frac{w_i}{w_j}$ – elements of pairwise comparison matrices;

n – rank of pairwise comparison matrices, i.e. $i=1, 2, \dots, n; j=1, 2, \dots, n$.

A priority vector's coordinates show, for example, in the first table, the relative "weight" of a criteria group in the expert's opinion.

However, an expert's work quality after the matrix is filled in is evaluated by means of a consistency ratio (CR) (Saaty, 2007), which has to be less than 0.20.

After comparing the criteria groups, the experts evaluate the criteria within each group. In conclusion, the experts compare the scenarios relative to each criterion, in our case, 25 criteria.

Afterwards, the results are summarised and the so-called global priority vector's coordinates are calculated. The global priority vector's coordinates are calculated by the following formula 2:

$$X_s = \sum_{j=1}^{25} a_j * x_{sj} = \sum_{j=1}^{25} x_k * x_{kj} x_{sj} \quad (2)$$

where:

X_s – global priority vector's coordinate for the s-th scenario, ($s=1,2,3$);

a_j – global 'weight' of the j-th criterion, ($j=1, 2, \dots, 25$);

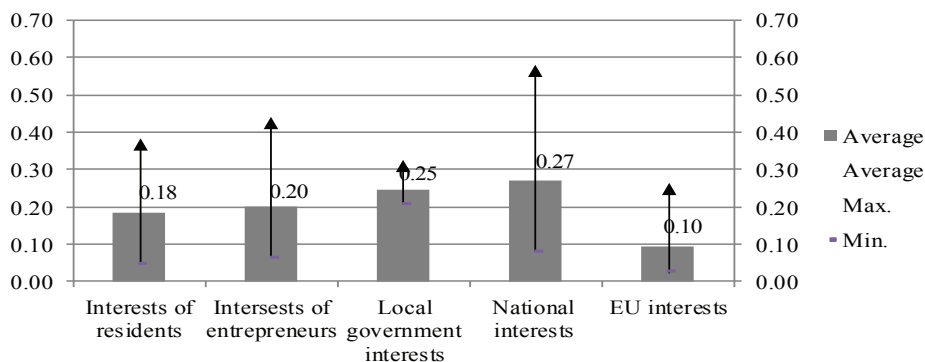
x_{sj} – evaluation of the s-th scenario from the perspective of the j-th criterion;

x_k – 'weight' of the k-th criteria group, ($k=1, 2, \dots, 5$);

x_{kj} – 'weight' of the j-th criterion among the k-th group's criteria (local 'weight').

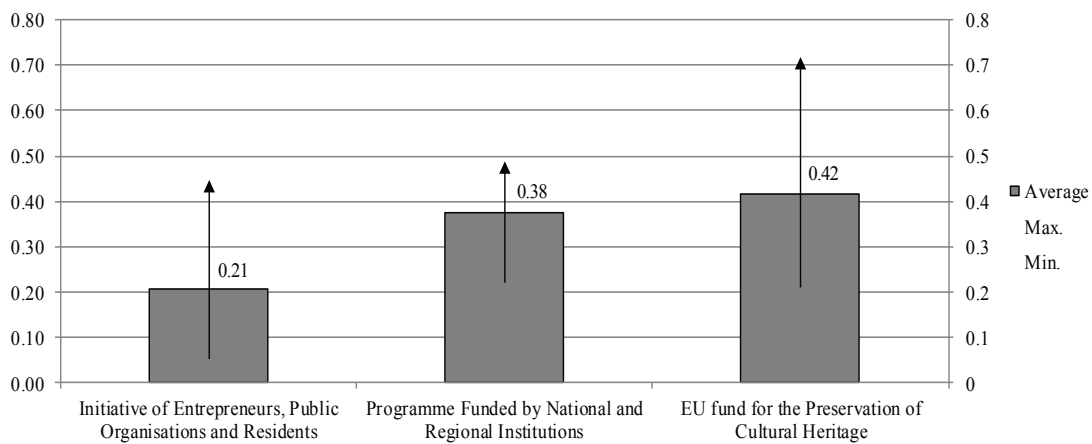
The work of all 7 experts with regard to filling in the tables is organised in the same way, and priority vector coordinates and consistency ratios are calculated for all the tables. In conclusion, each expert's evaluations are summarised and a table of the global priority vector's coordinates is constructed, as well as necessary calculations are performed according to Formula 2.

Evaluations given by the seven experts are processed by calculating the arithmetic mean and dispersion for each evaluation. In charts, the



Source: authors' construction based on the hierarchy analysis.

Figure 2. Evaluations of the criteria groups by the experts for the scenarios for the use of cultural heritage in the development of rural tourism.



Source: authors' construction based on the hierarchy analysis.

Figure 3. Evaluations by the 7 experts for the scenarios for the use of cultural heritage in the development of rural tourism.

dispersion is presented as amplitude, i.e. by means of the minimum and maximum values for each particular evaluation.

Results and Discussion

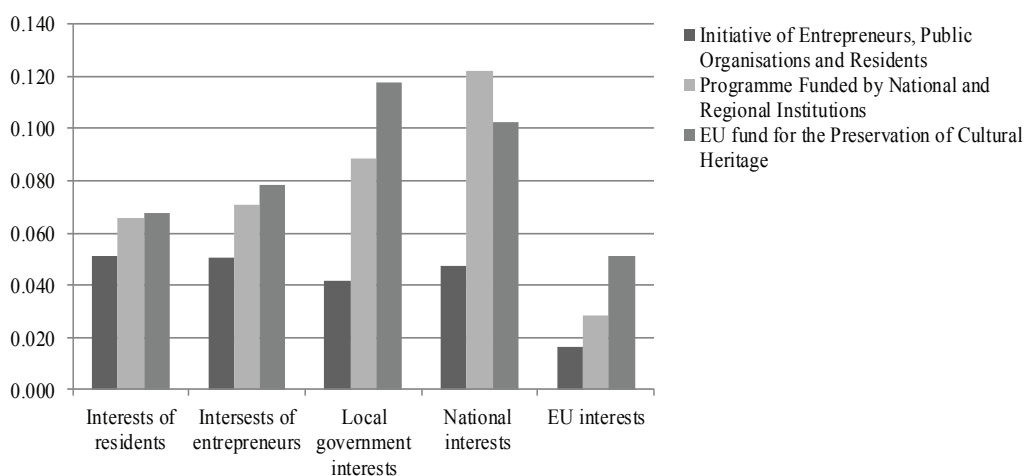
Analysis of the results will start with the assessment criteria groups. The 7 experts evaluated the criteria groups almost equally, giving the priority to national (0.27) and local government interests (Figure 2). The experts were unanimous on the significance of the criteria group for local government interests, which were indicated by the small dispersion, compared with the criteria group for national interests (Figure 2).

Based on the above-mentioned criteria, the third scenario was named the “EU fund for the preservation

of cultural heritage”. The average vector coordinate for the evaluations by the experts was 0.42.

Yet, the expert evaluations have a large dispersion, and it means that the opinions were different. A lower evaluation was given to Scenario 2, the programme funded by national and regional institutions (0.38), while the dispersion was smaller (Figure 3). The initiative of entrepreneurs, public organisations and residents, i.e. the current model, was evaluated the lowest, at only 0.21. The large dispersion in this case too pointed to the difference in the experts' opinions. It means that national and EU financial support is needed in order that a significant change takes place in the use and preservation of cultural heritage.

The final conclusion on the last two scenarios for the use of cultural heritage in the development



Source: authors' construction based on the hierarchy analysis.

Figure 4. Evaluations by the experts for the scenarios for the use of cultural heritage in the development of rural tourism, based on selected criteria groups.

of rural tourism: the programme funded by national and regional institutions and the EU fund for the preservation of cultural heritage have similar evaluations, with the latter one having a slightly greater evaluation. Nothing significantly changes if analysing the evaluations of the scenarios by criteria group (Figure 4).

The scenario EU fund for the preservation of cultural heritage was evaluated the highest for all the criteria groups, except for the criteria group of national interests (Figure 4). This scenario was evaluated much higher both for the criteria group of local government interests and for the criteria group of EU interests (Figure 4).

Conclusions

1. Three development scenarios were put forward for the use of cultural heritage in the development of rural tourism:
 - the initiative of entrepreneurs, public organisations and residents
 - the programme funded by national and regional institutions

- the EU fund for the preservation of cultural heritage
2. Based on the criteria set in the hierarchic analysis, seven experts: rural craftsmen, a municipality vice leader, a civil servant from the Latvia Ministry of Finance, representatives from rural tourism organisations and the Association of Rural Female organisations chose the third scenario – the EU fund for the preservation of cultural heritage. This scenario was evaluated as the most appropriate.
 3. The implementation of this scenario ensures the achievement of EU goals, cooperation among all the stakeholders and faster results.

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EVALUATION OF THE COMPETITIVENESS OF FISHERIES SECTOR CLUSTER

Inese Biuksane^{1,2}, Ilze Judrupa²

¹Institute of Agricultural Resources and Economics, Latvia

²Riga Technical University, Latvia

inese.biuksane@inbox.lv; Ilze.Judrupa@rtu.lv

Abstract

The aim of the research is to elaborate the competitiveness assessment system for fisheries sector cluster, using which it could be possible to assess the competitiveness of fisheries sector cluster in time and space. On the basis of scientific literature study, the authors provide solutions of how to assess the competitiveness of the fisheries sector cluster. As a result of analysis, it was discovered that the best way to assess the competitiveness of the fisheries sector cluster is by using a comprehensive complex indicator – the Index of the Fisheries Sector Cluster Competitiveness. The created Index of the Fisheries Sector Cluster Competitiveness helps the institutions involved in the creation of fisheries policy more successfully elaborate and improve the common policy of fisheries.

Key words: fisheries, fishery, aquaculture, fish processing, index, competitiveness.

Introduction

The world economy faces changes, mostly related to the processes of globalization, uneven development of the countries, as well as the reinforcement of competitiveness. Nowadays the competitiveness of some country's companies more and more determines and influences the development potential of each country. One of the key aims in development strategy of states, spheres and companies has become ensuring competitiveness (Skapars & Sumilo, 2006). Assessment of competitiveness is a significant element in the evaluation of economic performance and sustainability of an industry and its companies.

Peculiarity of competitiveness lies in the fact that it contains social and economic, political and environmental consequences not only of the economic category (product, consumer and environment of rivals, etc.), but also of the non-economic category (systems of education, science, demography, politics and values, etc.), which determine the problems of evaluating thereof.

Various authors' interpretations of competitiveness differ. Some authors believe that companies compete only among themselves, not the countries, consequently, the basis of competitiveness is made by the indicators of entrepreneurship effectiveness, including entrepreneurship strategies, its management skills, marketing, efficiency of prices and costs. However, as we know, entrepreneurship is carried out by a company in a certain region, following the legislation of the area, and consequently many things depend on the measures carried out in the framework of the country and the created environment (Paula & Titarenko, 2009).

The experience of economic development all over the world has proven that competitiveness is influenced by many various factors. For a long time the factors of investments into the capital and infrastructure were the dominating. Later the neoclassical economists

considered directing a resource flow to the "right" fields and "right" companies in the corresponding sphere to be the most important task. In the process of development of the science of economics, scientists supplemented the range of the viewed issues with several factors: human and social capital, technological progress and innovations, business relation to the development of the surrounding environment, nature of demand, diversification of products and market etc. Nowadays scientists working in the field of economics and entrepreneurship believe that the factors influencing the competitiveness are interrelated and should be evaluated in a common context (Kassalis, 2010).

In the development of Latvian economy the fisheries have always played a significant role, especially in the development of the Baltic Sea and Riga Gulf coastline areas. In Latvia, the fisheries sector has not only a long-standing history and traditions, but also an internal potential of self-development. Using the advantage of the support opportunities provided by the EU financial instruments and participating in the EU Common fisheries policy creation, Latvian fisheries sector obtains wide possibilities to facilitate its growth and competitiveness. Consequently, the assessment of the sector cluster competitiveness plays a significant role in facilitation of fisheries sector development.

The aim of the research is to elaborate a complex assessment system through which it would be possible to assess the fisheries sector cluster competitiveness in time and space.

To reach the aim, the following work tasks were set:

- to elaborate the assessment system for competitiveness of the fisheries sector cluster;
- to reflect the results of assessment system for competitiveness of the fisheries sector cluster.

The object of the research is the fisheries sector cluster.

The research reflects the results which are analysed and discussed in detail, more extensively in I. Biuksane's doctoral dissertation 'Evaluation of Competitiveness of Latvian Fisheries Sector Cluster', which was written between 2012 and 2016 (scientific supervisor Dr.oec., assoc.prof. I.Judrupa).

Materials and Methods

On the grounds of the theoretical insights found in the studies of Latvian and foreign scientists, the planning documents and research developed by the EU and Latvian institutions, as well as authors' scientific studies, the definition of sector cluster and sector cluster competitiveness was developed, as well as the Model of the Factors Influencing Competitiveness of the Fisheries Sector Cluster.

To evaluate the competitiveness of fisheries sector cluster, the authors viewed several well-known methods for evaluation and factor groups and indicators used in them. Considering the fact that the analyzed methods incompletely reflect the essence of competitiveness and they cannot be fully used for the evaluation of fisheries sector cluster competitiveness, on the basis of the created evaluation system the authors developed the Index of the Fisheries Sector Cluster Competitiveness.

During the research, the general scientific research methods were used - logically-constructive (induction and deduction), graphical, monographic or descriptive, mathematical-statistical and methods of sociological research (document analysis). In elaboration of conclusions mostly the methods of analysis and synthesis were applied.

Results and Discussion

Assessment system

In order to assess the competitiveness of the fisheries sector cluster successfully and efficiently, first of all, an assessment system must be developed (Figure 1).

In order to assess the competitiveness of the fisheries sector cluster, several globally known models and matrices were reviewed and analysed, for instance, M.E. Porter's five forces analysis model (Porter, 1980), BCG matrix or growth-share matrix (Henderson, 1970), General Electric/McKincey matrix (Udo-Imeh, Edet, & Anani, 2012), SWOT analysis model (Rauch, 2006; Kersan-Skabic & Tijanic, 2009; Sandybayev & Derkan, 2015) and 7S model (Shiri, Anvari, & Soltani, 2014). The following indices were also examined and analysed: Global Gender Gap index (World Economic Forum, 2014b), Business Competitiveness index (World Economic Forum, 2007), Global Competitiveness index (World Economic Forum, 2014a), Travel and Tourism Competitiveness index (World Economic Forum, 2015), Economic Freedom index (Heritage Foundation, 2015), Doing Business index (World Bank, 2014), *Competitiveness Index* (IMG World Competitiveness Center, 2016), World Knowledge Competitiveness Index (Centre for International Competitiveness, 2016), European Competitiveness Index (Centre for International Competitiveness, 2016), Fisheries Competitiveness Index (FCI Team, 2005), Fishery and Aquaculture Competence Index (PrimeFish Team, 2016), Fish Stock Sustainability Index (National Oceanic and Atmospheric

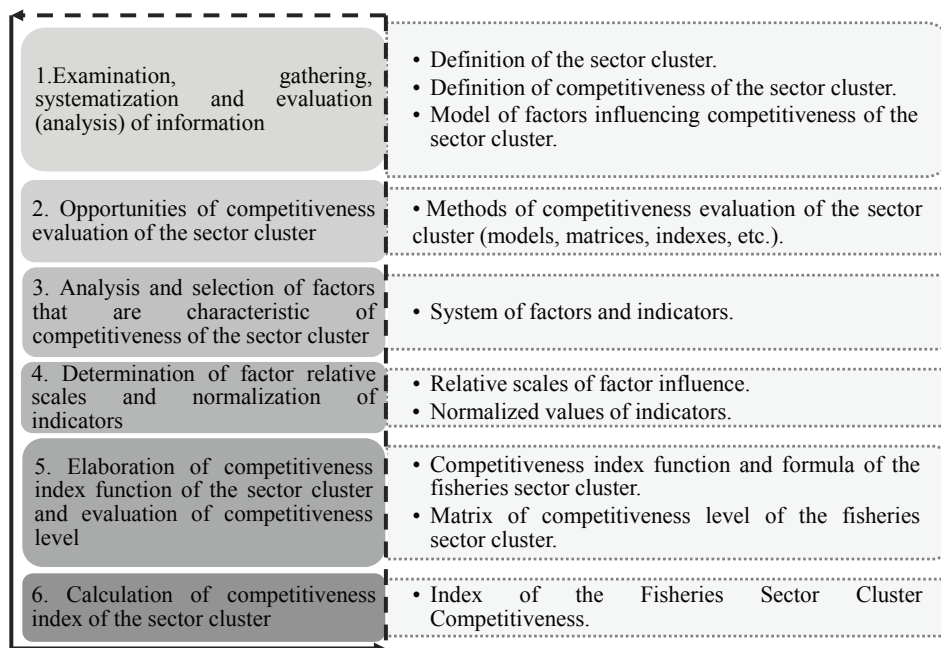


Figure 1. Assessment system of the Fisheries Sector Cluster Competitiveness (Biuksane, 2016a).

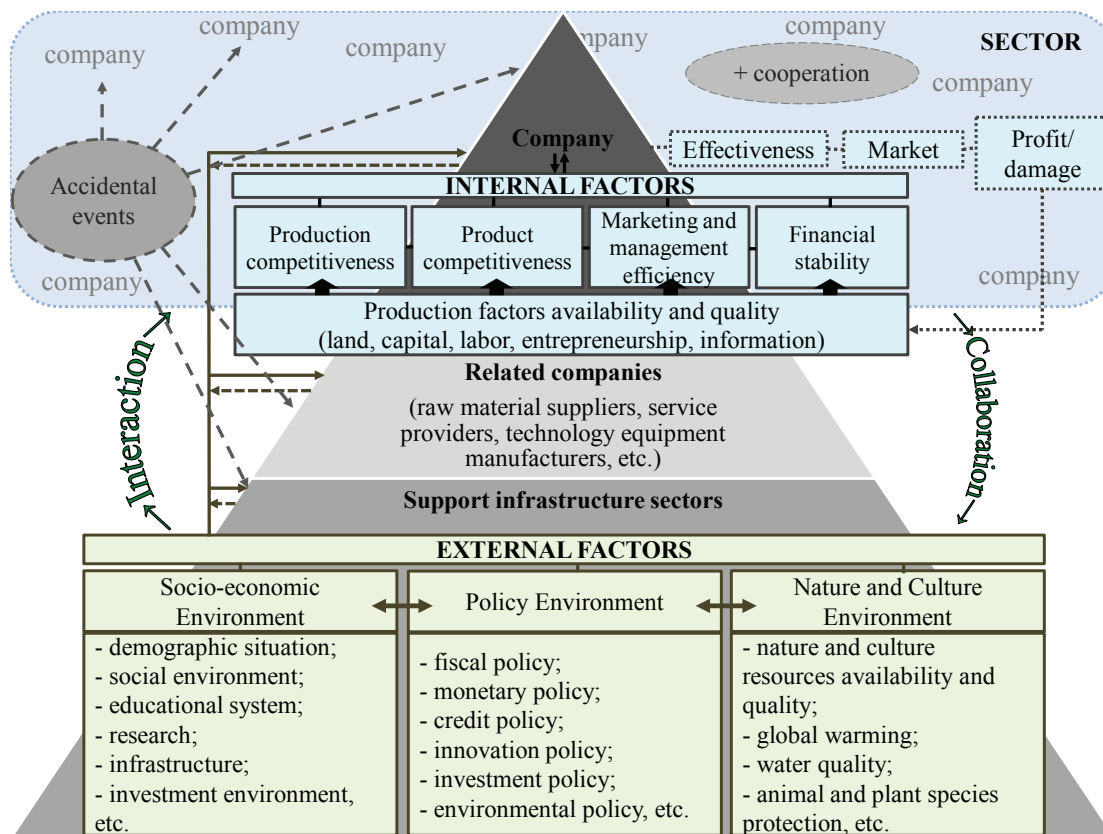


Figure 2. Model of the factors influencing competitiveness of the fisheries sector cluster (Biuksane, 2016b).

Administration, 2015); as well as other significant methods for assessment of competitiveness.

The analysed assessment methods and factor groups and indicators used in them refer only to a specific branch of activity, thus reflecting the essence of competitiveness incompletely. Moreover, the analysed methods cannot be fully used for the evaluation of competitiveness of the fisheries sector cluster.

In order to make an assessment of competitiveness of the fisheries sector cluster possible, a complex indicator – the Index of the Fisheries Sector Cluster Competitiveness should be elaborated. Elaboration of the index will be performed on the basis of assessment system for competitiveness of the fisheries sector cluster.

Outcome of the assessment system

The sector cluster is a cooperation network of similar or associated companies and institutions operating in the sector, which is located in a specific geographic territory. Within the framework of this network, the development and competitiveness of every separate company and, respectively, of all sector is facilitated by common cooperation (Biuksane, 2016a).

The sector competitiveness is the ability to sell a higher quality output (goods and services) in markets

more efficiently than the domestic and international competitors are able to do it (Biuksane, 2015).

Competitiveness of the fisheries sector cluster is influenced by a range of various, interconnected factors of microeconomics and macroeconomics (Figure 2).

Competitiveness of the Fisheries Sector Cluster is influenced by various internal and external social, economical, political, natural and cultural environmental factors (including random events) and the ability to adapt them, as well as the cooperation and formation of mutual interaction and cooperation forms, and the relationship among similar and affiliated companies and support infrastructure spheres (Biuksane, 2015).

Related companies and spheres included in the support infrastructure depend on the development of leading companies in a sphere. When the leading companies of a sphere are developing, both related companies and the spheres included in the support infrastructure benefit. In the environment of the cluster, the integrated long-term development of the companies may be observed at the horizontal and vertical level; as a result, not only competitiveness of the companies in a sphere increases but also competitiveness of a region and country.

The state competitiveness directly depends on the competitiveness of every company working in a

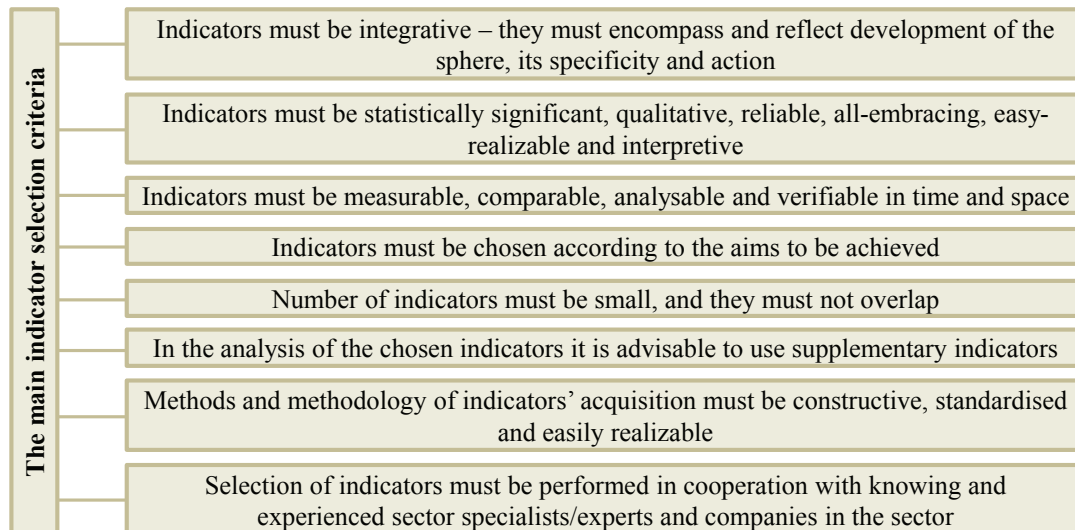


Figure 3. Main criteria of the selection of indicators (Biukšāne, 2016a).

specific economic sector. The more competitive are the companies at a particular sector, the more competitive is the corresponding sphere, and consequently, the state is more competitive at the world level (Skapars &

Sumilo, 2006; Labklājības ministrija, 2007; Denisovs & Judrupa, 2008; Бочкова, 2009).

In order to elaborate the index, indicators describing competitiveness of the sector cluster must

Table 1

Algorithm for determination of relative scales of factor influence (Biukšāne, 2016a)

Factors	Number of respondents				Arithmetic mean value	Factor relative scales (importance)
	R_1	R_2	R_3	R_n		
F_1	b_1	b_2	b_3	b_n	$i_1 = \left(\frac{b_1 + \dots + b_n}{n} \right)$	$\alpha_1 = \frac{i_1}{I_{kop}}$
F_2	b_1	b_2	b_3	b_n	$i_2 = \left(\frac{b_1 + \dots + b_n}{n} \right)$	$\alpha_2 = \frac{i_2}{I_{kop}}$
F_3	b_1	b_2	b_3	b_n	$i_3 = \left(\frac{b_1 + \dots + b_n}{n} \right)$	$\alpha_3 = \frac{i_3}{I_{kop}}$
F_n	b_1	b_2	b_3	b_n	$i_n = \left(\frac{b_1 + \dots + b_n}{n} \right)$	$\alpha_n = \frac{i_n}{I_{kop}}$
Total:	-				$I_{kop} = \sum_{n=1}^{\infty} i_n$	$\alpha_{\Sigma} = \alpha_1 + \alpha_2 + \alpha_3 + \alpha_n = 1$

where:

$F_1 \dots F_n$ - factors influencing competitiveness,

$R_1 \dots R_n$ - number of respondents,

$b_1 \dots b_n$ - influencing values provided by respondents,

$i_1 \dots i_n$ - average influencing value,

I_{kop} - total sum of influencing values,

$\alpha_1 \dots \alpha_n$ - factor relative scales,

α_{Σ} - sum of factor relative scales.

be analysed and selected, taking into account the criteria of the selection of indicators which influence competitiveness (Figure 3).

Relative scales must be determined for the selected indicators describing competitiveness of the fisheries sector cluster, taking into account the opinion of the companies operating in the fisheries sector, as well as the opinion of institution representatives involved in the creation of fisheries policy. Determination of relative scales of factor indicators must be performed using surveys and expert method. Relative scales of factor indicators are determined on the basis of specific algorithm (Table 1).

After determination of factor relative scales, the normalization of factor indicators must be performed. Its main task is to prevent the situation when one or several factors may be dominant. Normalized indicators are calculated on the basis of initial source indicators. As a result of normalization, indicators lose initial units of measure, thus indicators of various factors become mutually comparable.

In order to perform the normalization of factor relative scales indicators, any of normalization algorithms can be chosen:

- normalization by decimal scaling (Patro & Sahu, 2015);
- min-max normalization after linear transformation of data set (Saranya & Manikandan, 2013), in the range of 0 to 1 (Judrupa & Senfelde, 2011) or in the range of -1 to 1 (Judrupa & Senfelde, 2011);
- normalization of Z-evaluation with standard deviation and average absolute deviation (Patro & Sahu, 2015).

Analysing the most popular methods of data normalization, min-max [-1;1] normalization is the most appropriate for the calculation of Index of the Fisheries Sector Cluster Competitiveness due to the following:

- branches of the sector are not compared with the average value of indicators but are compared with the best and worst value of indicators;
- average value of indicators is 0, which is essential for assessment of competitiveness level;
- relations among original source data are maintained;
- normalized values of indicators may be easily comprehended and interpreted.

$$I_F; I_{AQ}; I_{FP} = f(\alpha_1 F_1, \alpha_2 F_2, \alpha_3 F_3, \dots, \alpha_n F_n) \quad (3)$$

where:

I_F - Fishing Competitiveness Index,

I_{AQ} - Aquaculture Competitiveness Index,

I_{FP} - Fish processing Competitiveness Index,

$\alpha_1 \dots \alpha_n$ - relative scales,

$F_1 \dots F_n$ - factors influencing the competitiveness of fishing, aquaculture, fish processing (Biuksane, 2015).

However, in order for the factor normalized values influencing competitiveness not to be too tight on the axle, and not to have several decimal places, which would bother comprehension and comparison of factor values, the offered min-max [-1;1] normalization function is modified transforming it to min-max [-5;5] normalization function (Formula 1).

$$F_{nv} = 5 \frac{f_f - f_{\min}}{f_{\max} - f_{\min}} - 1 \quad (1)$$

where:

F_{nv} - normalized value of factor,

f_f - actual value of factor,

f_{\min} and f_{\max} - minimal and maximal value of factor

(Biuksane, 2016a).

As a result, the Index of the Fisheries Sector Cluster Competitiveness will be analysed and evaluated in the range from -5 to 5, where: -5 is the worst indicator (minimal value of indicator) and 5 is the best indicator (maximal value of indicator).

The Index of the Fisheries Sector Cluster Competitiveness is a complex indicator – it consists of Fishing, Aquaculture and Fish processing Competitiveness Index. (Formula 2).

$$FSCCI = \left(\frac{I_F + I_{AQ} + I_{FP}}{n} \right) \quad (2)$$

where:

FSCCI - Fisheries Sectors Cluster Competitiveness Index,

I_F - Fishing Competitiveness Index,

I_{AQ} - Aquaculture Competitiveness Index,

I_{FP} - Fish processing Competitiveness Index,

n - number of sectors (Biuksane, 2015).

The Competitiveness Index of Fishing, Aquaculture and Fish processing is a function from the factors, influencing the competitiveness of the fisheries sector cluster and their relative weight (Formula 3).

The Competitiveness Index of Fishing, Aquaculture and Fish processing is calculated on the basis of 9 sub-indexes: Sub-index of Availability and Quality of Production Factors, Sub-index of Production Competitiveness, Sub-index of Output Competitiveness, Sub-index of Marketing and

Management Efficiency, Sub-index of Financial Position, Sub-index of Cooperation, Sub-index of Social and Economic Environment, Sub-index of Political Environment, Sub-index of Natural and Cultural Environment, and their relative weight (Formula 4).

$$I_F; I_{AQ}; I_{FP} = (\alpha_1 F_{AQPF} + \alpha_2 F_{PC} + \alpha_3 F_{OC} + \alpha_4 F_{MME} + \alpha_5 F_{FP} + \alpha_6 F_C + \alpha_7 F_{SEE} + \alpha_8 F_{PE} + \alpha_9 F_{NCE}) \quad (4)$$

where:

I_F - Fishing Competitiveness Index,

I_{AQ} - Aquaculture Competitiveness Index,

I_{FP} - Fish processing Competitiveness Index,

$\alpha_1 \dots \alpha_9$ - relative scales,

F_{AQPF} - Sub-index of Availability and Quality of Production Factors,

F_{PC} - Sub-index of Production Competitiveness,

F_{PrC} - Sub-index of Product Competitiveness,

F_{MME} - Sub-index of Marketing and Management Efficiency,

F_{FS} - Sub-index of Financial Stability,

F_C - Sub-index of Cooperation,

F_{SEE} - Sub-index of Social and Economic Environment,

F_{PE} - Sub-index of Political Environment,

F_{NCE} - Sub-index of Natural and Cultural Environment (Biuksane, 2015).

The Index of Fisheries Sector Cluster Competitiveness can be used as an instrument for assessing the fisheries sector cluster (fishing, aquaculture and fish processing) competitiveness in micro and macro level.

Conclusions

The sector cluster is a cooperation network of similar or associated companies and institutions operating in the sector, which is located in a specific geographic territory. Within the framework of this network, the development and competitiveness of every separate company and, respectively, of all sector is facilitated by common cooperation. The sector competitiveness is the ability to sell a higher quality output (goods and services) in markets more efficiently than the domestic and international competitors are able to do it. Competitiveness of the fisheries sector cluster is influenced by a range of

various, interconnected factors of microeconomics and macroeconomics.

The methods for evaluation of competitiveness offered in the literature encompass only a certain field of activity, thus incompletely reflecting the essence of competitiveness, in addition, they can be fully applied for the evaluation of fisheries sector cluster competitiveness, as a result, the authors developed the Index of the Fisheries Sector Cluster Competitiveness.

The Index of the Fisheries Sector Cluster Competitiveness is an instrument offering the opportunity to evaluate and analyse the development of the fisheries sector (fishing, aquaculture, fish processing) in time and space, identifying factors which facilitate and hinder competitiveness at the level of microeconomics and macroeconomics. This index may help institutions involved in creation of fisheries policy to elaborate and improve the common policy of the sector more successfully.

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ROLE OF UNIVERSITY LIFELONG LEARNING PROCESS IMPLEMENTATION

Inguna Jurgelane¹, Tamara Grizane², Liga Jankova³

¹Riga Technical University, Latvia

²School of Business Administration Turība, Latvia

³Riga Teacher Training and Educational Management Academy, Latvia

Inguna.Jurgelane@rtu.lv

Abstract

Nowadays the need for a qualitative, accessible and varied lifelong learning is becoming more and more necessary. In Latvia, different institutions take part in the implementation of lifelong learning; however, in spite of the negative factors of demography and migration, changes of work force supply and demand, investment and information shortage, the role of universities has not been properly investigated. The role of higher education in lifelong learning was studied in 9 state universities of Latvia in the period of 2013 – 2015. Monographic analysis and method of synthesis, data statistical research methods – grouping, comparison, relative and average indicators, as well as dynamics line analysis was used in the article. The study proved that the number of occupied work places has increased in 2015. However, it has not reached the average of ten and seven years since 2006 and 2009. Comparing with the free vacancies, the number of them has increased by 2164, especially in the profession group Specialists and Senior specialists, which as well as Executives, is the target audience of universities, which in its turn is a lifelong learning event insufficiently used potential. The universities have suffered because of demographic and migration factors: the rate of student number increases (-9.4%). In order to reach the goals of education politics, universities try to direct education function from studies to lifelong learning, they try to improve existing lifelong learning courses and programs, as well as to propose new ones in order to offer something for workforce corrections.

Key words: lifelong, higher education, labour market.

Introduction

The middle of the 20th century was the time when the investigation and evaluation of the role of lifelong learning in the world began; in Latvia the work on it has begun relatively recently, especially in connection with universities. Within the work of frame debates with such issues take place: what is lifelong learning, what its goals and implementation options are and what role a university has in this process.

The term lifelong education has transformed from lifelong learning process through whole lifetime (Беляков & Вахштайн, 2006) to recurrent education, permanent education, adult education, but nowadays the term lifelong learning has become consolidated (Schuetze, 2004).

A Memorandum on Lifelong Learning developed by the European Council stresses lifelong learning as the leading power in all fields of education stating employment improvement as one of the main tasks (Commission of European Communities, 2000).

Appropriate workforce preparation for market needs meets several problems in universities of Latvia, and higher education has a crucial role in solving them, and they, from the point of authors, have not been investigated properly: 1) negative factors of demographics and migration; 2) workforce and employers need changes; 3) number of people involved into lifelong learning; 4) extent of staff training.

The demographic structure changes when the number of seniors increases. If in 2013 it was about 28%, then it is expected that it will exceed 36% in

2030. Moreover, since the transformation time of economics in 90ies, the proportion of women with higher education has increased dramatically. They choose to develop careers rather than plan a baby (Mejihovs, 2015). This aspect is very important for those who want to get or who have higher or professional education, because a baby can destroy the chance of career development and possibilities to get higher incomes (Mills *et al.*, 2011).

During the period from 2009 to 2014 Latvia lost 174,911 state inhabitants due to migration. Alarming is the fact that exactly those people, who were at the age of workforce, that is 83.4% of emigrated amount (CSB, 2015) went abroad. That means that the first background of the research problem is the decrease in workforce amount today and in future.

The second background comes into being in the offer and demand of labour market. In Latvia, labour market offer is described by the number of occupied work places, which in 2014 was 932,000. Labour market offer and demand is influenced by the economic crisis, which made remarks in the trade amount changes, as well as in the structure of trade categories. Since 2011 the number of free vacancies has been stable in the interval from 3,006-3,718, despite the fact that in 2014 its increase was observed (CSB, 2015).

The third lifelong learning process influence background, which is highly connected with demography and migration, is the number of people involved in lifelong learning. According to EUROSTAT data, in Latvia the population involved

in lifelong education in 2015 was 5.7%, which in comparison with the European Union – 10.7%, as well as with neighbouring countries Lithuania – 5.8% and Estonia 12.4% – is not a very large number. Furthermore, the numbers of Latvia, which give information about the number of people involved in lifelong learning in 2015 in comparison with 2012, when they were 7.2%, have become even smaller. The states, which have higher indicators of population involvement in lifelong learning and to which we should be similar are Switzerland 32.1%, Denmark – 31.3% and Sweden 29.4% (Eurostat, 2016).

The topicality of lifelong learning in Latvia, the same as in Europe, was promoted by the improvement of education role in economics. That caused changes in the quality of human resources and investment field in human capital (The Republic of Latvia Ministry of Education and Science, 2009).

That is why the fourth lifelong learning problem is investments, which improve the quality of workforce and suitability to the demands of labour market. According to The World Education Forum Global Competitiveness Report data Latvia (in 2012 – 2013) in extent of staff training takes the 47th place out of 148 world countries and the 14th place out of 27 European Union countries (World Economic Forum, 2013).

Despite the lifelong learning and its gained knowledge topicality and previously stated influence factors, the authors concluded that lifelong learning in Latvia has not been studied properly. Researchers take upon interest about higher lifelong learning quality assurance themes (Eglitis, 2003; Jarvis, 2014), their costs and investment stimulation possibilities (Kokosalakis & Kogan, 2001), observance of labour market demands in education and its research (Pavlovskā, 2008; Jaunzems, 2013), securement of lifelong learning and employment (Sannikova, Baltēre 2008), the research of existing situation in lifelong learning field (Jurgelane, 2013; Kapenieks *et al.*, 2014)

and others. *The aim of the study:* investigation of higher education role in lifelong learning in Latvia. In order to reach the aim, tasks as follow were developed: 1) to investigate tendencies of state education institution student number; 2) to clarify labour market demand and offer; 3) to investigate labour market forecasts and actual offer; 4) to develop analysis of lifelong learning processes in order to clarify their role.

Materials and Methods

In the article quantitative and qualitative methods were used – monographic or descriptive method, analysis and synthesis method; data statistical research methods – grouping, comparison, relative and average indicator analysis, development and analysis of time-series. In order to analyse labour market ten and seven year occupied work places and vacancy average indices were compared with the year 2015. Calculations and data processing was made using computer programme Microsoft Excel. Restriction of the research: in order to evaluate the role of universities in lifelong learning, available data of 9 universities (overall there are 17 universities in Latvia), which was given by The Latvian Association of Higher Education Institutions for Lifelong Learning (LAKMA) and from the universities themselves. Data included information about the number of people involved in lifelong learning in 2013 – 2015. The largest universities and universities from all regions of Latvia were represented. The research was made during the period 2013 – 2015. As the sources of information were previously developed researches, world, Europe and Latvian institution documents, statistical data and publications about the specific theme.

Results and Discussion

Demographic structure as well as migration described in introduction leaves a trace to student number (Table 1) in educational institutions in Latvia.

Table 1

The number of students in educational institutions in Latvia 2012 – 2015 (CSB, 2016a)

Educational institutions	Years			Underlying growth in 2014 – 2015 to 2012 – 2013
	2012 – 2013	2013 – 2014	2014 – 2015	
	The number of students			Growth rate %
Preschools	93,293	93,533	92,219	-0.01
Comprehensive schools	212,433	209,130	209,686	-0.01
Vocational schools	32,086	31,055	29,855	-0.07
Higher education institutions and colleges	94,474	89,671	85,881	-0.09
Total	432,286	423,389	417,761	-0.03

Table 2

**Number of occupied work places according to trade categories in Latvia from 2006 to 2015 (thousands)
(CSB, 2016b)**

Occupational group	Year									
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
	Occupied work places									
Executives	109.2	122.0	106.6	89.1	76.6	76.1	79.8	84.1	88.9	90.1
Senior specialists	150.3	157.0	157.0	136.3	118.4	124.4	129.6	141.3	150.8	158.3
Specialists	143.9	169.4	175.7	147.1	151	159.7	163.9	162	154.2	155.2
Clerks	67.5	67.4	62.5	48.7	44.2	42.2	42.0	44.8	43.3	43.8
Service and sales workers	151.5	159.9	160.6	131.5	123.3	127.4	130.9	135.5	143.3	149.0
Skilled agricultural and fishery workers	6.1	8.1	6.4	5.0	5.9	6.5	6.8	6.8	6.5	6.5
Skilled workers and craftsmen	129.3	136.9	132	93.8	86.5	93.3	103.5	100.6	93.6	92.7
Equipment and machine operators and assemblers	89.6	90.3	85.6	69.5	66.9	69.1	69.1	75.3	76.8	74.0
Simple professions	112.0	121.9	124.7	100.0	99.4	102.3	108.7	110.2	115.8	109.4
Total	964.7	1,038.3	1,016.6	826.1	776.7	805.5	839.1	865.1	877.9	883.8

Base growth speed in 2013 – 2014 against base period in 2012 – 2013 in all positions is negative, which confirms the student number decrease. Higher education institutions and colleges are the places where student number decreases fastest. That shows a negative tendency – work force with higher education decreases. A contradiction with labour market demands occurs, because employers want competent employees, who have the latest knowledge in specific work field.

In order to investigate labour market tendencies in Latvia from the year 2006 to 2015, authors summarized statistical data about occupied and free job places according to occupational groups (Table 2, Table 3), that is – labour market offer and demand. Comparing ten (2006 – 2015) year period average with the year 2015, that is -5.5 thousand occupied places, but seven (2009 – 2015) years – is an increase 44.4 thousand. After comparing occupied job places in occupational groups in analogical time cut, the authors ascertained the largest increase within ten years in profession Senior specialists 15.96 thousand. Comparing 10 years – Clerks (6.84 thous) and what is more – Skilled agricultural and fishery workers in 2015 could not catch up – occupied job places were 13.82 thousand less. Comparing seven year period average with the year 2015, dramatically increased Senior specialists up to 21.3 and Service and sales workers 14.6 thousand occupied places.

At the same time the authors concluded free vacancies (Table 3) in all trade categories; comparing ten year period average with the year 2015, there is a shortage of 1753 more vacancies, but seven year

period average – has increased and are 2164 more. In a ten year cut the largest number of free vacancies in comparison with the average of the year 2015, is in profession Skilled agricultural and fishery workers – 615 and Senior specialists – 466, but the average of seven years with 2015 showed a free vacancy place growth Specialists 721, Service and sales workers 362 and Senior Specialists 236.

Authors state that workforce occupational groups Executives, Senior specialists, Specialists, Service and sales workers are the target audience of universities, which is a lifelong learning event insufficiently used potential. As well as if a Bachelors' or Masters' degree is obtained, not always it is necessary to enter or continue education in a universities professional or academic study programme just in order to improve professional competence, which corresponds to labour market needs and a person could react to latest tendencies in the World. It would be natural and logical to divide roles of university and professional educational institutions not only within the context of formal education, but also lifelong learning, as well as to cooperate within the processes of lifelong learning in universities and professional educational institutions. The authors consider that university role in the implementation of lifelong learning must be connected exactly with the education of executive and senior level employee lifelong learning, or with those employees, who have a desire to learn only specific (necessary for his job) courses, seminars, lectures.

The European Council pointed out that the education system must be more open and flexible; at the same time it must be suitable for individual needs

Table 3

The number of vacancies in Latvia from 2006 to 2015 (CSB, 2016c)

Occupational group	Year									
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
	The number of vacancies									
Executives	912	1,016	580	176	179	194	242	211	216	257
Senior specialists	3,436	3,578	2,046	525	585	809	819	588	524	917
Specialists	2,445	3,251	2,160	558	516	769	829	1,345	1,290	1,726
Clerks	1,229	1,034	839	199	49	77	190	197	208	323
Service and sales workers	2,805	2,491	1,231	316	255	569	607	847	729	976
Skilled agricultural, fishery workers	68	154	44	9	8	4	6	32	3	16
Skilled workers, craftsmen	3,613	3,807	1,402	202	164	244	247	211	197	437
Equipment and machine operators	2,580	2,540	1,048	187	146	164	166	192	156	351
Simple professions	1,991	2,097	1,046	204	96	176	244	309	395	585
Total	19,157	20,231	10561	2,377	2,001	3,008	3,351	3,934	3,719	5,589

and interests, leaning on gradual formal education environment integration and a desire to make available a qualitative education for all (Commission of the European Communities, 2000).

The authors concluded that not always individual desires correspond to labour market demand forecasts. In 2015, Ministry of Economics (MoE) of Latvia developed a forecast of the labour market up to 2030 and it showed a labour surplus in the group of higher education for people with education in fields of humanitarian and services, that according to the MoE data in 2020 could exceed 20%. A similar situation can also be in social, commercial and law sciences and for the citizens, who have obtained a higher education in pedagogy. According to the given information, it is possible to predict a dangerous trend – in 2020 about 6 – 8% of young specialists with relevant qualifications will work in a workplace that is inadequate to their education. However, the labour market and educational staff agree that young people with tertiary education are more flexible in labour market, and they have more opportunities to work in professions that do not correspond to their qualification. The opposite trend can be observed in the natural sciences, in the group of mathematics and information technology, which, without a change in the educational structure, until 2020 can form the lack of specialists with higher education in engineering, manufacturing and construction, agriculture. The same situation is also in health care and social welfare (MoE, 2015). Authors observed this tendency already in the research in 2015 when analysing the statistics of free vacancies (Table 3).

Considering the fact that major challenges for the future labour market will be associated with an aging of employees, migration and demographic impact, the assurance of the balance of skills demand and supply will be important (Sannikova & Baltere, 2008). Emphasis is put exactly on such skill acquisition that improves even more complicated skill acquirement. As a result, manufacturing efficiency, competence and productivity are improved (Kumar, 2004).

According to data collected in 2015, the expected appropriate education level necessary for profession in 2020 unfortunately shows higher levels of education than is required by the relevant profession to low and medium-skilled workers. However, high-skilled workers have a lower level education than it would be necessary in accordance with the position (MoE, 2015).

The authors consider that particularly higher education institutions are those who could change the situation, by offering employers lifelong learning courses for their employees. As long there is such a trend, labour productivity may decline, and in result those employees who carry out highly qualified work with an inadequate level of education can be pushed out of the labour market. There are opportunities for close development of the cooperation between the employer and universities, especially in the development of specific skills in a lifelong learning context.

The objective is to increase the proportion of the adult education of 25 – 64 year-olds to 15% by 2020 (The Republic of Latvia Ministry of Education and Science). However, in 2015 the lifelong

Table 4

**Number of individuals involved in lifelong learning in 9 Universities of Latvia from 2013 to 2015
(LAKMA)**

University	2013	2015	Growth rate %
	The number of students		
Daugavpils University (DU)	906	896	-1.1
Latvia University of Agriculture (LUA)	1,200	1,192	-0.7
Latvian Academy of Sport Education (LASPE)	578	1374	+137.5
University of Latvia (LU)	887	244	-72.5
Liepaja University (LiepU)	598	805	+34.6
Riga Stradins University (RSU)	4,033	3,012	-25.3
Riga Technical University (RTU)	1,274	1,898	+50.0
Ventspils University College (VeA)	414	212	- 48.8
Vidzeme University of Applied Sciences (ViA)	644	95	- 85.3

learning activities involved only 6% (MoE, 2016). The dynamics of lifelong learning shows that it is necessary to implement adult education activities more purposefully. Such a rapid development of lifelong learning offer can only be made by higher or vocational education institutions, where professional teaching staff, laboratories, equipment, infrastructure are available. The average professional educational institution transformation into competence centres also requires the support of universities.

Citizens with higher education more actively choose to participate in lifelong learning. In 2014, 9.4% of inhabitants with higher education were involved, but with elementary education only 1.9% (European Commission Report, 2013).

Participation in lifelong learning depends also from the employee. Unfortunately, in Latvia more than 35% of employers do not provide further education of employees on the grounds of the existing staff sufficient work qualifications (European Commission's report, 2013). Universities must justify the need for employees to take part as the cooperation partners of lifelong learning.

The wide lifelong learning institutionalization (background, infrastructure) unfortunately cannot overstep life obstacles of an individual – incomes. It could be possible to comprehend young people form age 15-19, who state that shortage of money (59%) is the barrier of entering lifelong learning; however, shortage of money to people able to work in the age of 41 – 50 (38%) causes concern (Jurgelane, 2014).

In Sweden, Lithuania and Estonia lifelong learning activities are funded by the state, local government, as well as additional funding is obtained from the European Union funds. A relatively small number of trainees pay for training activities themselves (Jurgelane, 2014).

The authors state that there exists a heightened risk for further lifelong learning events, because EU Structural fond financing shift structures or suspensions can occur. In most cases inhabitants themselves pay for lifelong learning events. Exception is European Union Structural fond financed and State Employments Agency organized events for unemployed learning and qualification improvement for employed ones.

In order to investigate the role of higher education in lifelong learning, the authors developed a survey in nine state universities of Latvia and they concluded that lifelong learning events organized by LASPE, LiepU in 2015 were those universities who were visited most frequently. There budget ways of means are attached in order to pay totally or partially for student programmes or courses.

Riga Technical University (RTU) uses a new offer – Open approach university, new professional completion and further education course. Decrease is observed in University of Latvia (LU) – state funded teacher courses ended in 2014. Growth rate in amount of -85.3% is observed in Vidzeme University of Applied Sciences (ViA), because the university changed the lifelong learning structure strategy and basic activities. They chose to concentrate on science integration in order to develop business, not on further education and training. The largest student number decline since 2013 has experienced Daugavpils University (DU) with an increase rate (-17.0%) and LU (-17.9%) and Liepaja University (LiepU) – (14.0%). Overall, all universities included in the research have suffered from demographic and migration factors: increase rate (-9.1%).

The authors' opinion is that due to the decrease of the student number the infrastructure and associate professor workload is decreasing, research libraries and modern technologies are not used

properly. Summing up the situation in the previously described labour market and the need for professional development and student population trends, the authors recommend universities to start actively engaging in the implementation of life-long learning processes. After analysing the existent situation in universities, it has been concluded that in each of them (however, differently) there is a department responsible for the realization of lifelong learning process. The best positions have those universities which offer specific courses through lifelong learning – programs that are not offered in other universities (eg. Latvia University of Agriculture – agricultural programs, Riga Stradins University – medical programmes, etc.).

In order to achieve the indicators on lifelong learning, universities need to shift the gravity centre of educational function from studies to lifelong learning. In order to ensure this shift and realize functions of lifelong learning, the number of employees has to be increased, as well as opportunities for lifelong learning from distance using an organized electronic studying environment have to be created. The need for gravity centre shift is shown by the facts of change in the number of students in Latvia (Tab. 4).

In order to support university lifelong learning process, universities of Latvia have to join a lifelong learning association (The Latvian Association of Higher Education Institutions for Lifelong Learning) (LAKMA). The aim of it is to promote lifelong learning in universities and cooperate in order to solve important lifelong learning questions with The Republic of Latvia Ministry of Education and Science, Rector Council, Higher education council, Employers' Confederation of Latvia and other institutions. That is why the authors consider – it has been proved that the role of higher education is crucial for lifelong learning process realization.

Conclusions

1. The student number in state educational institutions from 2013 – 2015 has decreased, because of demographic and migration factors. The fastest student declining number is in higher educational institutions and colleges – growth rate -0.07%.
2. Latvia's labour market offer in 2006 – 2015: in 2015 comparing with seven (2009 – 2015) year period

average occupied position amount has increased to 44.4 thousand. Particularly in profession group Senior specialist – 15.96 and Service and sales workers – 14.6 thousands; the demand, that is – free vacancies, in ten years has increased up to 1753, but in seven years – 2164. Vacancies are free in all workforce profession groups starting from Executives, Senior specialists up to Service and sales workers, which is a university lifelong learning event insufficiently used target audience potential.

3. In 2015, a conclusion was made that 2020 forecast has an inappropriate necessary educational level for a profession. It stated that high qualification profession representatives have a lower education level, inappropriate for the position; furthermore, work force structural disparity was observed.
4. In the period of 2013 – 2015 LSPA, LiepU experienced the highest number of people involved in lifelong learning due to state investment assets. RTU was successful because of Open approach university, new professional completion and further education course.
5. In order to stop student number decline in universities and to reach lifelong learning indicators stated by education politics, the university role is the education process reorientation in formal and informal education offer. It should be done in order to develop specific skills. Role of universities is also to create possibilities to study lifelong learning from distance, promote financial support in order to provide lifelong learning activities.
6. The Latvian Association of Higher Education Institutions for Lifelong Learning (LAKMA) as the voice of higher education role in the realization of lifelong learning promotes universities to cooperate with The Republic of Latvia Ministry of Education and Science, Rector Council, Higher education council, Employers' Confederation of Latvia and other institutions in order to solve important lifelong learning questions. That is why the authors consider – it has been proved that the role of higher education is crucial for lifelong learning process realization.

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SUPPORT IN THE JOB SEARCH FOR LONG TERM UNEMPLOYED SOCIAL BENEFIT RECEIVERS

Anna Bičkovska, Jānis Pāvulēns

Latvia University of Agriculture

annabickovska@inbox.lv; pavulens@inbox.lv

Abstract

Nowadays, when the general rate of unemployment in Latvia is not that high anymore, there are still a lot of people who are unemployed for many years and during all those years they are abusing the budget of municipality by receiving social benefits. The aim of the article was to examine the way how the long-term unemployed social benefit receivers assess the meaning of support in job searching. On the basis of The Theory of Planned Behaviour a questionnaire was developed by the authors, 37 long-term unemployed social benefit receivers registered in Riga Social Service were asked to take part in the survey and gave informed consent. The results show that the respondents who are longer unemployed receive more support from their families. Statistically significant correlations ($p=0.03$) were found between the duration of unemployment and person's determination to search a job, the unemployed who are longer without a job are less active in job searching process. Direct support in the job searching process is deeply connected with the possibility to share individual's thoughts and emotions with the family. There is no statistically significant correlation between men and women responses.

Key words: planned behaviour, job searching, long-term unemployed social benefit receivers.

Introduction

The level of unemployment is decreasing in the capital of Latvia - Riga; in December 2015 the level of unemployment was 5% (Reģistrētais bezdarba ..., 2016). The number of social benefit receivers are decreasing as well in Riga – in 2015 there were 42 253 social benefit receivers in Riga (6% from total number of inhabitants) (Rīgā turpina samazināties..., 2016).

Unfortunately, there is no research carried out about long-term unemployed social benefit receivers and how support can impact their ability to find and keep the job. The amount of that target group is not big, but for Riga Social Service it is important to know why clients are not getting a job if it is possible and what should be done to prevent it.

The long-term unemployed social benefit receivers are able-bodied persons who have received benefits more than 12 times within the last three years and were jobless at least 9 months (Pētījums par..., 2007), and have been receiving social service support at least for the last six months.

The long-term unemployed social benefit receivers are the clients of Riga Social Service and State Employment Agency – there they are able to receive institutionalised support from professionals, but it is important to receive support from family members as well, because time they spend together has more effect than a few appointments with specialists. In Riga Social Service only the client itself gets direct supervision in process of searching a job, the client's family is not involved in this process.

Authors decided to do a research on how the long-term unemployed social benefit receivers evaluate the support that they receive from their families (emotional support), because receiving formal support (from social workers, career counsellors etc.)

is not enough for managing successful career, but for professionals it is important to evaluate support clients receive from families, so they can or can't take it into the consideration while working with clients. Family is one part of the successful career, and it is important to maintain positive relationships and receive the support from family members (Kas ir karjera, 2016).

The aim of the research is to examine the way how the long-term unemployed social benefit receivers assess the importance of support in job searching.

Materials and Methods

The theoretical part of the research consists of the study and theoretical analysis of the scientific and methodological literature on job search, planned behaviour and perceived support.

To assess importance of support in job search, the empirical part of the research was provided.

Research questions:

1. How do the long-term unemployed social benefit receivers assess support received from Riga Social Service and State Employment Agency?
2. Do the long-term unemployed social benefit receivers consider their job searching as purposeful, planned process?
3. How do the long-term unemployed social benefit receivers assess the support received from their family members?
4. How do the long-term unemployed social benefit receivers assess the impact their social status has on their families?

The current empirical research was carried out in Riga Social Service in November 2015. There were 37 long-term unemployed social benefit receivers

participating in the research, all of the participants gave informed consents. The participants of the research were as follows: 30 females (81.8%) and 7 males (19.2%) between the age of 26 to 59 (Mean (M) = 43.97, Standard Deviation (SD) = 9.76), the age distribution of the respondents is normal (The Shapiro–Wilk $W = 0.95$; $p = 0.12$). Eight respondents have higher education (7 women and 1 man), 24 (19 women and 5 men) – secondary education, 4 women and 1 man have only primary education. Distribution differences of the attained educational level among the genders were not statistically significant (Chi-square criterion $\chi^2 = 0.28$; $p = 0.87$). In the study sample statistically important positive correlation exists between the age of unemployed and their duration of unemployment (Spearman's rho (r_{sp}) = 0.47, $p = 0.004$), elderly unemployed are longer without a job.

The survey developed by the authors consists of 12 questions based on the Theory of Planned Behaviour and The Reasoned Action Approach (Ajzen & Fishbein, 2005; Ajzen, 2012). According to the theoretical approach, the aim of the survey was to define the long-term unemployed social benefit receivers' ideas about the support they receive.

The participants were also asked to specify their gender, age, and duration of unemployment and the level of education.

MS Excel and R 3.2.3 (The R Project, 2016) have been used to process the research data.

The descriptive statistics indicators (Mean, Standard Deviation, Median, Quartiles, Range and Interquartile Range) were calculated. The Shapiro–Wilk W was calculated testing for normality of the distribution of participants' age, the non-parametric criteria – Kruskal–Wallis χ^2 , Spearman rho (r_{sp}) and Pearson Chi-squares were calculated analysing differences of distribution among the subgroups.

Results and Discussion

In 1930 – 1931 in Austria a research about the community of unemployed living in a small village was carried out, where all inhabitants were employed at one factory and after it collapsed all of them became unemployed. Austrian researchers Maria Jahoda and Paul Lazerfeld figured out that village inhabitants described their life as life without a goal, dreams and future plans, they still were trying to maintain family life, but they were feeling guilty, because they were not able to provide all the necessities for their families. Generally, the atmosphere in the village was depressive, negative and passive in all the ways (McLaughlin, 1992).

That research shows us that for an individual it is very important to work not only because of money or opportunity to achieve some goals, but to work because they want to supply their families, to receive

acceptance and support. That means that the status of unemployed means a lack of support and unfulfilled hopes from the side of the family members. For long-term unemployed social benefit receivers it might be hard to realise that society expects them to search and find a job and leave social security system, that is why they are able to receive institutional support (Reardon & Lenz, 1999).

In the process of finding and keeping job not only support of family members is important – it is important to be determined and have reasons for all the actions that will be needed to be done in the field of job search. While searching for a job and trying to manage career in the best possible way for long-term unemployed social benefit receivers, it is important to analyse their level of determination and their behaviour according to it (Kulkarni & Gopakumar, 2014).

R. Kanfer, C.R. Wanberg & T.M. Kantrowitz (2001) define that job searching is not only a process that brings important results, but it is also self-regulative and full of outcomes process. During the job searching process an individual turns on his creative part and brings out some personal resources that were not used for many years if employment goal is not accomplished new resources and features of personality are discovered. Working with the long-term unemployed social benefit receivers it is important to research and use the antecedents of job searching behaviour. Job searching antecedents include personality traits, motives, self-evaluation, social context, biographical variables and generalized expectations. These entire individual features create a unique job searching behaviour for every individual, employment outcomes depend on it - status, time of searching and number of job offers (Kanfer, Wanberg, & Kantrowitz, 2001).

In difficult situations, e.g. during job search, two types of behaviour can occur according to the type of the individual's personality. For approach-oriented individuals that might be additional motivation to act more effectively and be more creative in job searching. For avoidance-oriented individuals every failure of additional difficulty is a sign to leave it. Long-term unemployed social benefit receivers are considered to be the second type of individuals (Wanberg *et al.*, 2012).

In 1985, Icek Ajzen invented the Theory of Reasoned Action and defined determination. Determination is an individual ability to be active and creative that activates under changes of attitudes, behaviour intentions, subjective and social norms as well as perceived power and perceived behavioural control (Ajzen, 1985). Determination includes many factors, which interact between themselves, it creates individual –if he is determined and fields this

determination includes, because in many different fields of life level of determination differs.

In the Theory of Planned Behaviour developed from the Theory of Reasoned Action individual's actual control over the behaviour is represented by:

1. Attitudes – how individual judge behaviour and outcomes he is interested in;
2. Behavioural intention – factors of determination, which affect individual learning to be active and create new situations;
3. Subjective norms– includes socially acceptable norms and how they affect individual;
4. Social norms – socially acceptable norms for concrete community, place;
5. Perceived power – strengths which are used for perceiving behaviour and reflecting it;
6. Perceived behavioural control – how easy individual perceives and reflects behaviour (The Theory of Planned Behavior, 2016).

According to the Theory of Planned Behaviour, people's behaviours are the results of behavioural intentions, 'behavioural intentions are assumed to follow reasonably from their beliefs about performing the behaviour' (Ajzen & Fishbein, 2005). Therefore, a set of specific purposeful actions (e.g., job searching) has to be considered as an embodiment of specific (job search) intention, which in turn follows reasonably from individual's beliefs about performing job searching. I. Ajzen and M. Fishbein found three antecedents of behavioural intention: behavioural beliefs, normative beliefs and control beliefs. These beliefs may be irrational or inaccurate, but they provide cognitive basis for attitudes towards behaviour, subjective (i.e., perceived social) norms, and perceived behavioural control (self-efficacy). The relative weight or importance of each antecedent 'vary as a function of the particular behaviour and the population under consideration' (Ajzen & Fishbein, 2005). Behaviour may be influenced primarily by attitudinal considerations, normative or control factors which are conceptually independent; however, these factors can correlate with each other, e.g., attitude toward behaviour can be influenced by normative beliefs. For example, if people infer that their spouses or other relevant referents would want them to perform job searching behaviour, they may form a positive attitude toward this behaviour. The Social Identity Theory developed by H. Tajfel also argues that perceived norms in relevant social contexts influence individual beliefs and behaviour (Tajfel & Turner, 1979).

It was found out in the empirical part of the research that more than half of respondents (18 women and 4 men) estimate support they receive from Riga Social Service and State Employment Agency as sufficient; almost third part of respondents

(9 women and 2 men) estimate received support as not efficient; 4 respondents (3 women and 1 man) consider that they do not receive any support from Riga Social Service and State Employment Agency. Distribution differences of the perceived support from Riga Social Service and State Employment Agency among the genders were not statistically significant ($\chi^2 = 0.11$; $p = 0.94$). Statistically significant differences were not found among the age distributions in fore-mentioned subgroups (Kruskal-Wallis $\chi^2 = 1.39$, $p = 0.50$). It means that estimation of received support is not related to respondents' sex or age.

Estimation of received support is connected with the respondents' level of education, but distribution differences of the perceived support from Riga Social Service and State Employment Agency among the subgroups of attained educational level were not statistically significant ($\chi^2 = 2.12$; $p = 0.35$). More than a half of the respondents with higher education claim that received support is not enough, 2/3 of respondents with secondary education consider it as sufficient.

More than 2/3 of respondents (26 from 37) consider, that they often or always are searching for a job purposefully, the biggest part of them (20 respondents – 17 women and 3 men) claim that they always are searching for a job purposefully, six women are doing that often, 1/4 of the respondents (9 respondents – 7 women and 2 men) are doing it rarely. Two men claim that they are not searching for a job purposefully. Because of the small number of men participating in the survey, the differences of the purposefulness of job searching process among the genders are not statistically significant ($\chi^2 = 3.11$; $p = 0.07$), but there is a tendency that women consider themselves more purposeful in job searching process, more than 3/4 (23 from 30) women claim that they always or often are searching for a job purposefully, men consider it rarely (only 3 from 7).

Statistically significant differences were not found among the age distributions in fore-mentioned subgroups (Kruskal-Wallis $\chi^2 = 0.98$, $p = 0.80$). It means that assessment of job searching purposefulness is not connected with respondent's age.

Statistically significant differences were not found in the purposefulness of job searching process among the subgroups of attained educational level ($\chi^2 = 2.54$; $p = 0.28$). In the group of respondents with primary education 3 from 5 respondents consider that they are rarely searching for a job purposefully, 3/4 of respondents with higher education are often (2 respondents) or always (4 respondents) searching for a job purposefully. In the group of respondents (24) with secondary education 2 respondents consider that they are not searching for a job purposefully, 4 consider that they are rarely doing it, 3 – often and 15 – always. General secondary education connection

with lower job searching intense is mentioned also in the research carried out in 2006 'Regional research about unemployed psycho-social portrait' (Reģionālie pētījumi..., 2006).

Statistically important negative correlation between the period of unemployment and job searching activities (purposefulness) exists ($r_{sp} = -0.38$; $p = 0.02$). It means that the unemployed who are longer without a job are less active (purposeful) in job searching.

A bit less than half of the respondents (17 respondents; 14 women and 3 men) consider that they never receive direct support from their relatives and family members, 14 respondents (10 women and 4 men) consider that they rarely receive it and 6 women consider that they often receive direct support in job searching process. Differences between respondents' gender in receiving direct support are not statistically significant ($\chi^2 = 2.27$; $p = 0.32$), relatives are showing or not showing signs of direct support to men and women equally.

Received direct support in job searching is not connected with job searching purposefulness. From 17 respondents who never received direct support from relatives, almost 2/3 (11 respondents) consider that they are often (2 respondents) or always (9 respondents) searching for a job purposefully. From 20 respondents who rarely or often receive direct support from family members, 3/4 (15 respondents) are often searching for a job purposefully (4 respondents) or are always doing that (11 respondents). Two men who consider that they are not searching for a job purposefully, they rarely receive direct support from family members, which may confirm that relationships in families of long-term unemployed social benefit receivers are complicated.

Between groups of unemployed in the context of receiving direct support from family members, there is no statistically significant differences in age groups (Kruskal-Wallis $\chi^2 = 1.91$; $p = 0.38$), but statistically significant differences were found in the length of unemployment among the subgroups of perceived direct support in job searching (Kruskal-Wallis $\chi^2 = 7.20$, $p = 0.03$). Those respondents, who are longer without a job, more often receive direct support from family members in job searching process (Table 1).

Direct support from family members is closely connected with the opportunity to freely express thoughts and emotions in the family. 24 respondents (almost 2/3 from all respondents, 18 women and 6 men) consider that they are able to express their thoughts and emotions freely in the family, 18 respondents (3/4 from all respondents) consider that they are able to do so at least rarely. Between 13 respondents (12 women and 1 man), who consider that they are not able to share their thoughts and emotions in the family, only two of them consider that they rarely receive direct support from family members in job searching process. Differences between groups are statistically significant ($\chi^2 = 12.07$; $p < 0.001$).

Opportunity to share thoughts and emotions in the family is not statistically significant connected with receiving condemnation about being unemployed ($\chi^2 = 1.90$; $p = 0.39$). Only one man considers that he often receives condemnation and is not able to share thoughts and emotions in the family; 19 women and 5 men consider that they never have received condemnation about being unemployed; 11 women and 1 man rarely receive condemnation. Eight respondents consider that they are not able to share their thoughts and emotions, but they have never received condemnation about being unemployed, eight other respondents consider

Table 1

Duration of unemployment in subgroups of unemployed, months

Statistical indicators* of duration of unemployment	Unemployed, who do not receive direct support from family members, n=17	Unemployed, who rarely receive direct support from family, n=14	Unemployed, who often receive direct support from family, n=6	Sample of unemployed, n=37
Median (M_c)	33.0	43.0	85.5	42.0
Min value	18	23	27	18
Max value	123	100	156	156
1st Quartile (Q_1)	25	37	63.8	32
3rd Quartile (Q_3)	50	78.3	115.5	79
Range	105	77	129	138
Interquartile Range	25.0	41.3	51.8	47.0
* Duration of unemployment does not fit into normal distribution (Shapiro-Wilk $W = 0.88$, $p < 0.001$), that is why nonparametric indicators are used.				

that they sometimes do receive condemnation about being unemployed, but that does not stop them from being open and share their thoughts and emotions in the family; 5 respondents avoid being open and share their thoughts and emotions in the family, and they do receive condemnation in the family about being unemployed.

Although 24 respondents have not received condemnation about being unemployed, problems and conflicts in the family are statistically significant connected between them ($\chi^2 = 18.65$, $p < 0.001$), 14 respondents consider that sometimes they have conflicts and problems in the family about being unemployed, but they are not connected with condemnation from family members and relatives. Two respondents consider that they receive condemnations, but it is not the reason of conflicts in the family.

A small number of respondents (5 from 37 respondents, 2 women and 3 men) consider that their status of unemployed has no impact on their families; one woman confirms that she has no family. Thirty from 36 respondents consider that their unemployment has a significant impact on their families (financial impact), that confirms that 25 women and 4 men distribution differences of the impact of respondents' social status on their families among the genders are not statistically significant ($\chi^2 = 2.30$; $p = 0.13$), 3 women and 1 man from them mention that their status of unemployed has not only financial impact on their families, but also emotional. Almost all respondents with higher education (7 from 8) mention that their families have financial problems because of them being unemployed, almost half of the respondents with primary education (2 from 5) and 4/5 of respondents (19 from 24) with secondary education. Only 1/4 of respondents with higher education (2 from 8) mention emotional impact on their families because of them being unemployed; 1/8 of respondents with secondary education (3 from 24) consider the same. Between respondents with primary education no one mentioned emotional impact on their families because of them being unemployed. Because of too small number of

respondents with higher and secondary education distribution differences of the impact of respondents' social status on emotional climate in their families among the subgroups of attained educational level are not statistically significant ($\chi^2 = 1.70$; $p = 0.43$), but there is a tendency in the results - the higher is the level of education the more critically the respondent judges about the impact on the family.

Conclusions

- More than half of respondents (22 from 37) consider the support they are receiving from Social Service and Employment Agency as adequate; only 4 respondents (from 37) consider that they are not receiving support from Social Service and Employment Agency being clients of these institutions. That means that the services institutions are providing are adequate to the needs of long-term unemployed social benefit receivers.
- More than 2/3 of respondents consider their job searching as purposeful, but they are still staying long-term unemployed social benefit receivers, which means that they are not able to evaluate themselves and their own actions in adequate way.
- Almost half of the respondents consider that they never receive any direct support from their family members in the process of job searching. That depends on the way how respondents understand the term 'direct support', as well as it shows that relationships in the families of long-term unemployed social benefit receivers are complicated.
- The largest part of the respondents (30 from 37) considers that their status of unemployed has a huge impact on their families; most of them mentioned financial problems as most important, only few of them are speaking about emotional problems that may appear in the family. That means that long-term unemployed social benefit receivers are more focused on searching for the money source and not on the career building, improving career managing skills and working for the perspective.

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