

VERTICAL PRICE TRANSMISSION ALONG THE POTATO SUPPLY CHAIN IN LITHUANIA

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Abstract

Potato sector is one of the competitive areas of the European Union (EU) agriculture. Although Eurostat declared that in 2015 Lithuanian share in the EU-28 harvested production was modest and composed only 0.7%, according to Food and Agriculture Organization of the United Nations (FAOSTAT), this crop remained on the list of top 10 commodities by net production value in Lithuanian agriculture. However, over the past decades the Lithuanian potato sector survived undesired transformations. The aim of this paper is to analyse the changes of the main indicators, related to the potato sector, and vertical price transmission among the chain of potatoes in Lithuania. The conducted research indicates the most important development trends of the potato sector and applies econometric techniques to investigate if there is any long-run relationship between the farm and retail prices of potatoes for the period of 2010 to 2016. Although the statistics show the shrinking production and domestic consumption of potatoes in Lithuania, the analysis of the vertical price transmission does not provide evidence of market inefficiencies. The Johansen cointegration test confirms the existence of a long-run relationship between the farm and retail prices, while the Granger causality test shows that there is a bidirectional causality between the examined series. The M-TAR model does not provide evidence of the farm and retail price asymmetry in the long run.

Key words: agriculture, supply chain, cointegration, potato, price transmission.

Introduction

Over the past decades, global markets of agricultural commodities survived several crises, accompanied by significant food price shocks peaked in 2008 and 2010 – 2011 (Islam, 2011). Previous dynamic changes of prices often resulted in market inefficiencies and led to the undesired impact on the welfare of farmers and consumers, and determined the changes in the crop structure in the EU member states. The aforementioned situation encouraged scientists to focus on the research explaining vertical price transmission mechanisms of agricultural and food products.

During the previous decades research on price transmission of fruit and vegetable markets was fragmentary and often led to the contradictory findings, which were mostly based on the case studies of selected agricultural markets in different countries. One of the most cited contributions to this research area investigating price transmissions of seventeen fresh vegetables (including potatoes) belongs to Ward (1982). The findings confirmed the relevance of asymmetry for the USA markets of fresh vegetables and allowed to identify a wholesale market as an actor with the major pricing power, while changes of retail and shipping prices lagged. Ward (1982) made an assumption that perishability could be a major determinant of price asymmetry among the supply chain of fresh vegetables and initiated the scientific discourse on vertical price transmission based on different estimation techniques.

Important contributions to this discourse were made by the studies of selected agricultural commodities in the USA (Brooker *et al.*, 1997;

Girapunthong, VanSickle, & Renwick, 2003; Acharya, Kinnucan, & Caudill, 2011; Li & Sexon, 2013), Brazil (Aguilar & Santana, 2002), France (Hassan & Simoni, 2002), Hungary (Bakucs, Fertő, & Szabó, 2007), Greece (Rezitis & Pachis, 2013), Slovakia (Pokrivcak & Rajcaniova, 2014; Rajcaniova & Pokrivcak, 2013), Dutch (Assefa, Kuiper, & Meuwissen, 2014; Verreth *et al.*, 2015), the United Kingdom, Germany, Denmark, the Netherlands and Spain (London Economics, 2004), Turkey (Aysoy, Kirli, & Tumen, 2015), Malaysia (Zainalabidin & Iliyasu, 2017). An essential conclusion emerges from the aforementioned research with conflicting results – every study brings valuable knowledge about supply chain management and critical market efficiency factors in the particular country. Generalizations and applications of research results to other industries and time periods often fail to explain the situation in the supply chain of the particular agricultural commodity (Aguilar & Santana, 2002).

The paper contributes to this scientific discourse exploring vertical price transmission along the supply chain of potatoes. Despite the importance of this crop in the EU, only few researchers carried out a more comprehensive research on the situation of the vertical price transmission along the supply chain in Hungary (Bakucs, Fertő & Szabó, 2007), Slovakia (Rajcaniova & Pokrivcak, 2013; Pokrivcak & Rajcaniova, 2014), Dutch (Assefa, Kuiper, & Meuwissen, 2014; London Economics, 2004), the United Kingdom, Denmark, Germany and Spain (London Economics, 2004). Rajcaniova & Pokrivcak (2013), Pokrivcak & Rajcaniova (2014) found strong evidence of asymmetry in the vertical price transmission of

Slovakian potato chain. In both research cases consumer prices reacted to the decrease in producer prices more rapidly than to the growth of price and were determined at the producer level. Assefa, Kuiper & Meuwissen (2014) studied the Dutch ware potato sector and the linkage of retailer oligopsony power with asymmetric behaviour. They found that price decreases on farms were transmitted partially while the increases almost fully and concluded that farmers' oligopoly power did not improve price transmission and could worsen the market situation.

Bakucs, Falkowski & Fertő (2007) investigated the transmission of producer and retail prices in Hungary and did not confirm findings about the price transmission asymmetry in the potato chain. The Hungarian potato sector was affected by seasonality and the price level determination came from the producer to retail. However, the long-run and short-run vertical price transmissions were symmetric. The results of the Hungarian case corresponded to the previous findings of London Economics (2004) final report for Department for Environment, Food and Rural Affairs (DEFRA) covering research of the potato sector in six EU member states and reporting about symmetric farm-retail price transmissions. Peculiarities of national potato markets were noticed: the United Kingdom, Denmark and Spain markets had a long-run symmetric transmission, Germany had a short-run, the Netherlands potato sector had a long-run symmetric transmission for the producer-retail direction and a short-run symmetric transmission for the retail-producer direction. The speed of price adjustments in the selected countries differed; however, the proportion of the adjustment was higher for the producer price changes than for the retail (except in the Denmark case).

The aim of this paper is to analyse the changes of the main indicators related to the potato sector and vertical price transmission among the chain of potatoes in Lithuania. Though some researchers reported on the structural transformations of the potato sector in Lithuania during the recent decades (Lukošiūtė, 2009;

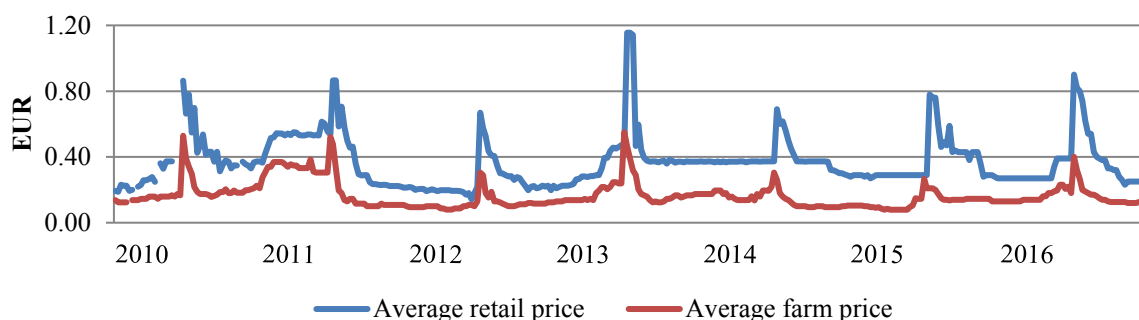
Melnikienė, 2017), the research on vertical price transmission of the EU countries omitted Lithuanian case as the reliable statistics was not available. The paper covers this gap and provides empirical evidence on the price transmission among the chain of potatoes, contributing to a better understanding of the potato sector development trends and market functioning issues. The conducted research provides a comprehensive view on the situation of vertical price transmission along the potato chain utilising different techniques to show multiple aspects of market inefficiency for the same period.

Materials and Methods

The paper covers two objectives, which are implemented applying different methodological approaches: 1) to analyse the main indicators of the potato sector's development, 2) to study vertical price transmission along the chain of potatoes in Lithuania.

The first objective – the analysis of the main indicators of the potato sector's development – employs methods of graphical and comparative data analysis. This task investigates changes for the period from 2010 to 2016 and relies on the secondary data from Statistics Lithuania. The results identify main development trends related to potato production, domestic consumption, and self-sufficiency.

The second objective – the study of vertical price transmission along the chain of potatoes in Lithuania – also covers the period from 2010 to 2016 and analyses the relationships between the average selling prices on commercial farms and the average retail prices for fresh potatoes of Lithuanian origin. The research of vertical price transmission of the potato sector relies on a weekly data collected by the state enterprise 'Agricultural Information and Rural Business Centre'. The price on farm is set as the average of minimum and maximum price; the retail price shows the average price in the main network supermarkets of 7 counties. Figure 1 illustrates changes of the aforementioned average farm and retail prices. The second objective employs different econometric techniques applied



Source: SE 'Agricultural Information and Rural Business Centre' and authors' calculations.

Figure 1. Average potato prices: farm and retail levels.

for the analysis of time series compiling a 4-stage methodological research framework in order to explain the relationships between the farm and retail prices of potatoes. The econometric tests were run employing Eviews software.

The methodological 4-stage research framework for the investigation of the vertical price transmission is based on the analysis of the aforementioned literature on research of vertical price transmission in fruit and vegetable markets. The structure of the framework is set as follows: 1) ADF test; 2) Johansen cointegration test; 3) Granger causality test; 4) M-TAR model.

Stage 1: the augmented Dickey-Fuller (ADF) test (Dickey & Fuller, 1979). The non-stationary data can lead to a 'spurious regression' (Brooks, 2008). In this case, the empirical results of the research could be in accordance with the theory and the hypothesis, but the regression, indicating the relationship between prices, has no meaning. The series of the farm and retail prices are tested for the unit root employing the ADF test. If the null hypothesis (H_0) is not rejected, it is presumed that the analysed sample of price series contains a unit root. The alternative hypothesis is in favour of stationary price series without a unit root. The results of the ADF test make an impact on the selection of the further econometric analysis techniques. The proposed methodological research framework is applied only if the H_0 is rejected.

Stage 2: the Johansen cointegration test (Johansen, 1991; 1995). Cointegration analysis is an empirical technique used to establish the degree to which variables are related in the long run. The introduction of cointegration was due to the realisation that most of the financial data is non-stationary. Curbertson (1996) implied that regression models from non-stationary time series variables cause spurious regressions. However, when cointegration deals with data with stochastic trends, the problem of spurious regression is avoided.

Johansen developed a methodology for the analysis of the cointegration between the selected variables and common trends in vector autoregression (VAR) models with Gaussian errors and seasonal dummies (Johansen, 1991). This test is used to identify the existence of the long-run relationship between the farm and retail prices. It allows testing more than one cointegration relationships and includes two types of tests: trace and eigenvalue. The Johansen trace test examines the H_0 that the number of linear combinations r is equal to a given value, while the alternative hypothesis is in favour that the number of linear combinations r is greater than a given value. The rejection of the H_0 means that there is a long-run relationship between the farm and retail prices. Maximum eigenvalue allows testing for the existence of more than one combination ($r + 1$) of the price

variables. The rejection of the H_0 allows stating that the certain number of possible linear combinations exists.

Stage 3: the Granger causality test (Granger, 1969). Granger causality tests for the short-run relationship between the farm and retail prices. This stage assists in defining empirically the direction of causality between the farm and retail prices, and exploring the feedback situation. The Granger causality test studies whether the farm price causes the retail price and how much of the current selected price variable could be explained by its values in the past and by values of the second price variable. Granger causality exists if one price helps to predict another or if the coefficients on the lagged second price variable are statistically significant. Test runs two-way causation investigating if the farm price causes the retail price, and vice versa. However, the Granger causality test does not assure that one price is causing another; the results only confirm that the price series of one variable helped to predict another.

Stage 4: the momentum threshold autoregressive (M-TAR) model (Enders & Granger, 1998; Enders & Silkos, 2001). The M-TAR model for unit roots extends standard cointegration analysis and allows investigating nonlinear adjustment mechanisms and identifying asymmetry. The asymmetry could demonstrate that time series is 'more 'momentum' in one direction than the other (Enders & Silkos, 2001), i. e. positive and negative price shocks in the long run are transmitted with different intensity. The two-step procedure is followed. The first step tests the H_0 that there is no cointegration between prices in the long-run relationship. The second step tests the H_0 that there is a symmetric adjustment mechanism between the farm and retail prices in the long-run equilibrium.

Results and Discussion

Main indicators of potato sector development in Lithuania

The potato sector, especially potatoes for human consumption, is one of the competitive areas of the EU agriculture. Though in 2015 Lithuanian share in the EU-28 harvested production was modest and composed only 0.7% (De Cicco & Jeanty, 2017), this crop remained on the list of top 10 commodities by net production value in Lithuanian agriculture (FAOSTAT., 2017). In 2016 this specialization remained unpopular at agricultural companies and enterprises, and 97.3% of Lithuanian potatoes were harvested at farmer and family farms (Melnikienė, 2017).

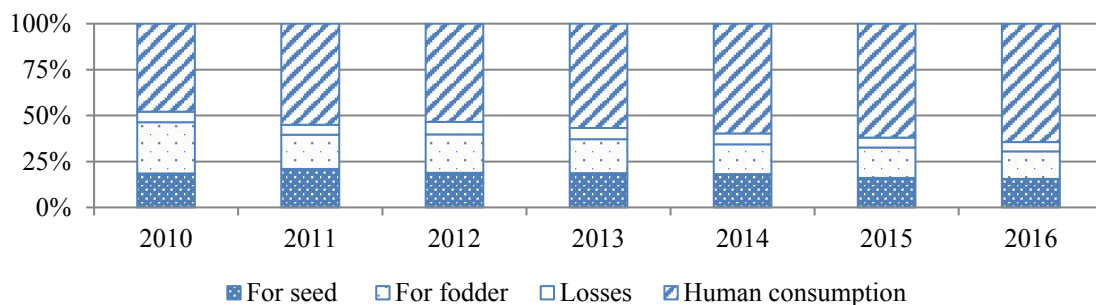
The comparison of the most important indicators of potato sector identifies undesired development trends (Table 1). The harvested area fell by 39.6% from 2010 to 2016. During the same period, the harvest of potatoes decreased from 476.6 to 351.5 thousand

Table 1

Main indicators of the potato sector in Lithuania

	2010	2011	2012	2013	2014	2015	2016	2016 compared with 2010 (2010=100%)
Harvest, thou t	476.9	587.7	549.9	426.5	468.5	399.2	351.5	73.7
Average yield, 100 kg ha ⁻¹	130.0	156.0	171.0	148.0	172.0	170.0	159.0	122.3
Harvested area, thou ha	36.6	37.7	32.2	28.7	27.3	23.5	22.1	60.4
Production per capita, kg	154.0	194.0	184.0	144.0	160.0	137.0	123.0	79.9
Consumption per capita, kg	94.0	99.0	95.0	93.0	96.0	94.0	94.0	100.0
Self-sufficiency, %	79.0	107.0	103.0	88.0	100.0	90.0	84.0	106.3
Domestic consumption, thou t	607.5	547.2	532.6	485.2	470.6	442.9	416.7	68.6

Source: Lietuvos..., 2015; Lietuvos..., 2017; authors' calculations.



Source: Lietuvos..., 2015; Lietuvos..., 2017.

Figure 2. Structure of potato total domestic consumption.

tons. The average yield increased, but the results showed significant fluctuations and varied from 130.0 to 172.0 kg ha⁻¹. The indicator of potatoes per capita fell by 20.1%. However, consumption per capita remained almost stable since 2010 with a moderate increase from 2011 to 2014. Despite the decline in the production observed in 2010 – 2016, the indicator of self-sufficiency improved. The annual indicator of self-sufficiency demonstrated significant fluctuations: in 2011, 2012 and 2014 the figure exceeded 100.0%, but since 2015 the dependence on imported potatoes increased. Import of potatoes is mostly orientated for the periods of early harvests in countries with warmer weather.

Domestic consumption of potatoes fell by 31.4% from 2010 to 2016. The annual decrease of this indicator was accompanied by the transformation of domestic consumption structure (Figure 2). Over the analysed period, the domestic consumption of potatoes for agricultural purpose fell (seed had a drop of 15.7%, fodder – 46.2%), but the share of human consumption in the structure increased by 34.4%.

The consumption of processed potatoes is increasing, while the consumption of fresh potatoes demonstrates a decrease trend. Melnikienė (2017) argues that the indicator of human consumption

for Lithuania is higher than the EU average and the further decrease of the consumption is possible in the immediate future. The unfavourable demand trends affect the supply of potatoes and the structure of agricultural crops gradually transforms.

The vertical price transmission among the potato chain

The shrinking of the potato sector in Lithuania could be influenced by the inefficiency of vertical supply chain. The paper investigates the relationships between the farm and retail prices applying the 4-stage research framework for the identification of different chain inefficiency aspects.

The first step of the empirical analysis is the ADF test, which examines the stationarity of the farm and retail price series. Table 2 presents the results of the ADF test on the examined series and the results show that for both prices the *t*-statistic is greater than the critical value at 5% level of significance when prices are expressed in levels. This is also supported by the *p*-value of probability which is less than 0.05. Thus, the series of the farm and retail prices does not have a unit root, the H₀ is rejected and the examined series can be characterized as stationary and integrated of order zero.

Table 2

Results of the ADF unit root test for the farm and retail prices

Variables	<i>t</i> -statistic	<i>p</i> -value	Critical value (5%)
Farm price (0*)	-3.51	0.01	-2.86
Retail price (0)	-4.42	0.00	-2.86

Note: * Parentheses in the ADF test indicate the lag length based on Schwarz information criterion.

Table 3

The Johansen cointegration test results for the farm and retail prices

Hypothesized No. of CE(s)	Unrestricted cointegration rank test (Trace)			Unrestricted cointegration rank test (Maximum Eigenvalue)			Prob.**
	Eigenvalue	Trace statistic	Critical Value (5%)	Eigenvalue	Max-Eigen statistic	Critical Value (5%)	
$r=0^*$	0.12	43.20*	12.32	0.12	42.62*	11.22	0.00
$r=1$	0.00	0.58	4.13	0.00	0.58	4.13	0.51

Note: * indicate rejection of the H_0 at the 5% level of significance. **MacKinnon-Haug-Michelis (1999) *p*-values.

The second step is the Johansen cointegration test. This approach uses the maximum likelihood estimation in a VAR model. There are two statistics reported using this test: the trace and maximum eigenvalue. We found evidence from the ADF test that all the series are integrated of order zero. The results of the Johansen approach indicate that there is one cointegration vector between the tested price series (Table 3). The *p*-value 0.00 is lower than 0.05. The comparison of trace statistic and maximum eigenvalue

statistic to critical values allows rejecting H_0 ($r = 0$) at the 5% significance level. The Johansen cointegration test demonstrates a long-run relationship between the farm and retail prices of the potato chain.

The Granger causality test is the third step in order to ensure that residuals are uncorrelated. The second step shows that there is one cointegration vector for the examined price series, so the Granger causality test can be defined as a joint test (*F*-tests) for the significance of the lagged value of the assumed exogenous variable

Table 4

The Granger causality test results for the farm and retail prices

H_0	<i>F</i> -statistic	Prob.
Retail price does not Granger cause farm price	6.74*	0.00
Farm price does not Granger cause retail price	35.19*	0.00

Note: * indicate rejection of the H_0 at the 5% level of significance.

Table 5

The threshold autoregressive model for farm and retail prices

Variable	Coefficient	Std. Error
Above Threshold (ρ_1)	-0.19	0.04
Below Threshold (ρ_2)	-0.05	0.04
Threshold Value	0.00	
<i>F</i> -equal ($\rho_1=\rho_2$)	5.25	(3.07)*
<i>T</i> -max value	-1.34	(-2.07)*
<i>F</i> -joint (Φ) ($\rho_1=\rho_2=0$)	9.24	(5.78)*

Note: * simulated critical values for 5% significance level.

and for the significance of the error correction term. The results are reported in Table 4. The p -values are lower than 0.05 and the comparison of F -statistic to critical values indicates that there is a bidirectional causality between the farm and retail prices, and both variables cause each other simultaneously.

The fourth step tests for the asymmetry between the farm and retail prices. Threshold autoregressive models are used to determine whether asymmetry is present within the chain. The results for the farm and retail price threshold autoregressive models can be found in Table 5. The results suggest that there is a cointegration but the hypothesis of asymmetry is rejected, thus, positive and negative shocks from the retail prices affect the farm prices with the same magnitude.

To test for asymmetry, we separate the residuals obtained from the long-run equation into positive and negative with a zero threshold. The positive residuals (above threshold) are named as ρ_1 and the negative (below threshold) – ρ_2 . The $\rho_1=\rho_2=0$ represents the result for cointegration under asymmetry. In Table 5 it is named as F -joint (Φ) and amounts to 9.24. The H_0 means that there is no cointegration and the alternative hypothesis states that there is a cointegration. The comparison of F -joint (Φ) with the critical value F -stat (9.24 > 6.07), provided in Enders & Siklos (1998), allows to reject H_0 . The alternative hypothesis means that there is a cointegration under asymmetry.

The $\rho_1=\rho_2$ represents the result for asymmetry. In the Table 5 it is named as F -equal. The H_0 presumes symmetry and the alternative hypothesis is in favour of asymmetry. The comparison of the F -equal with the critical value F -stat (5.25 < 6.07) does not allow to reject the H_0 and they witness in favour of symmetry.

The results of the Lithuanian case correspond to Bakucs, Falkowski & Fertő (2007) findings for the Hungarian potato chain. The long run symmetric farm-retail transmission was also found in some countries included into London Economics (2004) final report

for DEFRA. The Lithuanian case of the potato chain does not witness serious issues of market inefficiency as both farmers and retailers influence market prices.

Conclusions

Analysis of the main indicators for the period 2010 – 2016 shows the shrinking of the Lithuanian potato sector. The harvested area fell by 39.6%, the harvest reduced by 26.3% (though the average yield increased by 22.3%). The situation in the potato sector is determined by changes in the structure of domestic consumption, e. g. declining use of agricultural commodity for agricultural and human consumption.

The econometric analysis of vertical price transmission among the chain of potatoes does not indicate serious problems which could result in market inefficiencies. The Johansen cointegration test confirms that there is a long-run relationship between the farm and retail prices. The Granger causality test shows the evidence of two-way causality and confirms that in the short-run the changes of prices are influenced by both the producer and the retailer. The M-TAR modelling allows stating that in the long run increases and decreases of prices are transmitted with similar intensity and shocks are fully transmitted between the farmer and retailer.

The conducted research allows to make an assumption that the shrinking of potato sector could be better explained by changes in the consumption than by market inefficiency issues. Though the results of the empirical research do not show obvious evidence of market inefficiency, the conclusions can be influenced by research limitations determined by available statistics. The current research draws attention to the farm and retail prices, however, some researchers provide an evidence of market inefficiencies between different stakeholders along the chain, while the empirical research on the farm and retail prices does not show serious problems. The further research could investigate the price transmission situation within a chain with more stakeholders.

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