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Potato price transmission in a small producing country: Does the neighbourhood of the main producing country matter?

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Abstract

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This paper investigates price transmission on the potato market of a small producing country, namely Lithuania, and the influence of the neighbouring main producing country (Poland) on the price setting over the period of 2017–2023. The research framework includes the following coherent and interconnected steps that allow to investigate relationships between potato prices: unit root tests, the Toda-Yamamoto test, the Autoregressive Distributed Lag (ARDL) modelling and the Bounds test for the co-integration, the Error Correction Term (ECT) estimation applying the ARDL Error Correction Regression. The Toda-Yamamoto test demonstrates a bidirectional movement between producer and retail prices on the Lithuanian potato market, while, in Poland, the price setting moves from producer to retailer. Bounds tests confirm the presence of the long run relationships for vertical and horizontal potato price transmission of the small producing country. However, the ECT coefficient for the domestic supply chain is 1.63 times the ECT coefficient for horizontal potato price transmission. Results confirm that the main producing country influences the price setting of the investigated small producing country. Thus, individual case studies of member states are important to understand potato price setting mechanisms and the EU market functioning.

Keywords: potato market; price; supply chain

Introduction

Potato is a well-known important food security crop (Devaux et al., 2021) and agricultural commodity included in a diet of many Europeans. Over the past two decades, the European Union (EU) demonstrates a drop in potato production (Thorne, 2012). According to Eurostat and FAOSTAT data (Eurostat, 2023; FAOSTAT, 2023a), in 2022, the harvested area decreased by 41.52% compared to 2004. Countries that joined the EU in 2004 and later observed a steep decline (71.44%) in potato cultivation areas during the same period. In fact, the share of those countries in the EU potato cultivation area dropped from 54.41% in 2004 to 26.58% in 2022. This situation represents an interesting topic for the academic research, because the knowledge about driving forces of changes allows us to move towards a desired structure of the EU's agriculture.

The academic research suggests that the shrinking of potato sector is an outcome of many inter-related factors. Potato use reducing factors include the growing welfare and the changing lifestyle of consumers (Thorne, 2012; Kowalska & Gurkowa, 2019; Stańko & Mikuła, 2021) and switch to processed food (Kowalska & Gurkowa, 2019; Piwowar, 2021) as well as the increased access to competitive substitutes

(Thorne, 2012; Kowalska & Gurkowa, 2019; Louwaars, 2023), changes in popular diets (Kowalska & Gurkowa, 2019; Devaux et al., 2020; Devaux et al., 2021; Goffart et al., 2022), including lower potato consumption among young people (Gustavsen, 2021), changes in animal feed production (Devaux et al., 2020; Devaux et al., 2021; Piwowar, 2021; Stańko & Mikuła, 2021; Goffart et al., 2022), including the growing role of wheat use for fodder in the EU (Klimek-Kopyra et al., 2023), and other potato production-related industries, price fluctuations (Dogbe & Revoredo-Giha, 2021).

Nevertheless, the most recent research has a strong focus on the main producing countries and potato sector development trends (Kowalska & Gurkowa 2019; Chiurciu et al., 2020; Devaux et al., 2020; Devaux et al., 2021; Piwowar, 2021; Stańko & Mikuła, 2021; Goffart et al., 2022), while the situation in small producing countries is not sufficiently addressed. This paper builds a deeper knowledge about the EU potato market providing an analysis of the situation in a small producing country, namely Lithuania, with a particular interest on one factor that has an impact on potato use.

According to Kowalska & Gurkowa (2019), price fluctuations could be an important factor that influence potato consumption. On the one hand, price fluctuations change human consumption, on the other hand, skyrocketing potato prices force to look for substitutes that ensure business profitability in animal production and other industries that use potato as a raw material. In fact, market functioning failures could motivate farmers to select a more profitable crop and encourage changes in the national structure of agriculture.

The most recent studies that deal with different aspects of potato prices include price transmission studies for Hungary (Bakucs et al., 2007), Greece (Rezitis & Pachis, 2016), and Italy (Santeramo & Von Cramon-Traubadel, 2016), the application of the ARCH model to analyse the nexus between price, its volatility and the selected demand and supply factors in Ireland (Thorne, 2012), the application of Gini coefficient for the investigation of trade situation in Romania (Zapucioiu et al., 2023). The previous research suggests that each country establishes individual price transmission patterns that evolve over time and highlights the importance of the individual case studies for the understanding of the EU market functioning.

This study contributes to the academic discussion providing the case of the small producing country that has a common border with the main producing country. The paper aims to investigate vertical potato price transmission in Lithuania and to analyse the influence of the neighbouring main producing country, namely Poland, on the price setting of the small country.

The research is aiming to answer two questions. How does vertical price transmission influence potato market functioning in Lithuania? What influence has the neighbouring main producing country, Poland, on potato price setting in Lithuania? The previous research results allow us to set two hypotheses. Hypothesis 1: Changes in Lithuanian potato producers' prices lead price changes at the downstream level. Hypothesis 2: Potato producer price changes in Poland lead potato price setting in Lithuania.

Materials and Methods

The analysis is based on the monthly potato prices received from the State Enterprise Agricultural Data Centre (SEADC) and Statistics Poland (CSO). The SEADC publishes average potato prices at farm and retail levels, while Statistics Poland provides average retail prices in PLN. Retail prices from Statistics Poland are converted into EUR applying the monthly currency rate reported by the National Bank of Poland. This study covers the period from January 2017 to August 2023.

The methodology relies on three main stages. First, the Phillips-Perron (PP) and the Augmented Dickey-Fuller (ADF) unit root tests (Dickey & Fuller, 1979; Phillips & Perron, 1988) are applied to investigate the characteristics of potato price series. These tests confirm data (non-)stationarity and define order of integration *I(d)*. A confirmation of the null hypothesis (H_0) shows that price series are non-stationary, while the alternative hypothesis (H_A) classifies potato price series as stationary. Potato price series that are stationary at level are referred as *I(0)*, while the rejection of the H_0 in the first difference classifies price series as *I(1)*.

Second, the Toda-Yamamoto test (Toda & Yamamoto, 1995) based on the augmented Vector Autoregression (VAR) model is applied. According to Umar & Dahalan (2016), this test circumvents the limitations of the Granger causality test (Granger, 1969) related to the order of integration. The Toda-Yamamoto test adds the maximum order of integration $I(d_{max})$ of the investigated potato price series to the optimal lag number (p). The ADF and the PP tests are employed to estimate $I(d_{max})$, while p is set estimating and comparing the Akaike information criterion (AIK) for the generated VAR models including up to 8 lags. VAR models, selected for the Granger causality test, satisfy the requirements for the absence of serial correlation (the residual serial correlation Lagrange Multiplier test) and stability condition (the Roots of Characteristic Polynomial test).

After the appropriate VAR models are selected, the Granger (non-)causality is investigated applying the Wald

test. This study tests six H_0 of the Granger non-causality that cover two vertical bivariate VAR models and one horizontal bivariate VAR model, i.e. investigates casual relationships between potato prices in domestic supply chains of Lithuania and Poland and between markets at the producer level (Table 2). The rejection of the H_0 of the Granger non-causality shows that changes of one potato price series (explanatory variable) could be useful predicting changes of another potato price series (dependent variable) in the past. The rejection of both H_0 for the bivariate VAR model reports on the bidirectional price movement, while the confirmation of both H_0 for the bivariate VAR model does not allow to prove the presence of the Granger causality.

Third, the Autoregressive Distributed Lag (ARDL) model (Pesaran & Shin, 1999; Pesaran et al., 2001), where price series are related both contemporaneously and across historical values, is applied. The modelling employs logarithmic transformations of potato prices per tonne. The selection of the ARDL model is explained by the results of unit root tests. The ARDL model allows to investigate the relationship between *I(0)*, *I(1)* or a mix of those orders of integration (Nkoro & Uko, 2016) and to confirm or reject the co-integration between time series applying the Bounds test (Pesaran et al., 2001), while traditional methodologies mostly rely on the same order of integration of the investigated variables.

According to Nkoro & Uko (2016), the selection of lag lengths for the ARDL model could rely on the AIC. This study sets the maximum number of lags for the dependent and explanatory variables ($p_{max} = q_{max} = 4$) and estimates all combinations of ARDL models that go in lines with this condition. The comparison of the AIC values for the generated models allows to select the optimal lag lengths' combination for the reported ARDL model. The selected ARDL models are serially uncorrelated and homoscedastic as they satisfy requirements of the Breusch-Godfrey serial correlation Lagrange Multiplier and the Breusch-Pagan-Godfrey heteroscedasticity tests.

This study provides short- and long-run coefficients of the long run form of the ARDL models with restricted constant (classified as case II in Pesaran et al., 2001), results of Bounds tests, and error correction terms (ECT) for the reparametrized ARDL-ECM models (Pesaran et al., 2001). The Bounds test relies on the Wald test to investigate the presence of the co-integration between potato price series in the long run. The rejection of the H_0 allows to state that potato price series are co-integrated. The ECT parameter refers to a speed of adjustment of short-term dynamics to the co-integrated relationship between the investigated potato price series.

Results and Discussion

In 2022, Poland was the 3rd in terms of its share in the EU potato cultivation area (196.110 ha). Lithuania had the 14th position and utilised 15.180 ha for potato production, while the contribution to the overall EU harvested production allowed country to occupy the 17th position in 2022 (Eurostat, 2023). Nevertheless, FAOSTAT (2023) shows potatoes on the list of top 10 agricultural commodities in both countries.

The comparison of standard deviations of the monthly potato prices per kg in Lithuania and Poland allows us to state that the potato market of the small country demonstrates higher volatility than the main producing country (Figure 1). Although producer prices show similar patterns during the period of 2017–2022, the situation at retail level differs. In Lithuania, retail prices skyrocket with the start of a new harvest, while the market of the main producing country is less sensitive to seasonal peaks.

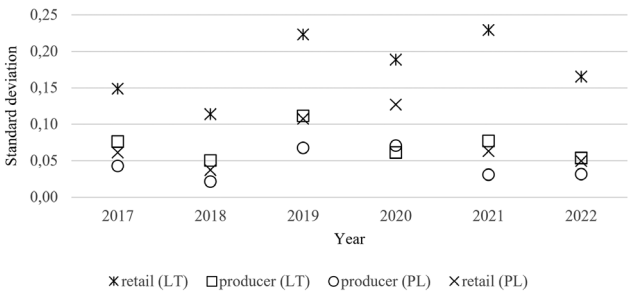

Fig. 1. Standard deviations of the monthly potato prices in Lithuania and Poland

Source: own calculations based on the monthly prices provided by the SEADC and CSO

The further econometric analysis of price transmission patterns requires knowledge about characteristics of price series. The discrepant results of the ADF and the PP tests prevent from a clear identification of the order of integration (Table 1). In fact, the analysis allows us to classify series as I(0) or I(1) and justifies the application of the ARDL model dealing with time series that have the mixed order of integration. However, the ADF test confirms I(2) for retail prices in Poland, while the PP test classifies the same data as I(1). Data properties in Table 1 suggest that the Toda-Yamamoto approach (Toda & Yamamoto, 1995) allows to overcome limitations of the traditional Granger causality test (Granger, 1969).

The Toda-Yamamoto test for producer and retail prices in Lithuania shows bidirectional price change movements (Table 2). Results suggest that price fluctuations at upstream and downstream levels assist in predicting of price changes in the supply chain and the test does not identify price

Table 1. Properties of potato price series: unit roots tests

	ADF test I(0)	ADF test I(1)	PP test I(0)	PP test I(1)
Retail price (LT)	-3.166(0)**	-3.092(11)**	-3.127(3)**	-13.455(12)***
Retail price (LT) after logarithmic transformation	-2.732(0)*	-8.267(0)***	-2.623(5)*	-10.475(13)***
Producer price (LT)	-3.002(0)**	-8.212(1)***	-2.992(4)**	-8.445(18)***
Producer price (LT) after logarithmic transformation	-3.623(1)***	-1.723(11)	-2.790(4)*	-6.805(15)***
Producer price (PL)	-1.773(0)	-8.109(0)***	-1.888(1)	-8.075(5)***
Producer price (PL) after logarithmic transformation	-2.061(1)	-7.140(0)***	-1.630(0)	-7.008(5)***
Retail price (PL)	-2.183(0)	-1.1421(11)	-2.255(2)	-8.101(8)***
Retail price (PL) after logarithmic transformation	-2.175(0)	-1.195(11)	-2.235(3)	-7.584(8)***

Note: values show *t*-statistic (lag length/bandwidth) and significance at *10.00%/**5.00%/***1.00% levels.
Source: own calculations based on the monthly prices provided by the SEADC and CSO

leading stakeholders. This situation differs from Jeder et al. (2017) findings for the Tunisia potato market where causality runs from producer to retail price. The study by Thorne (2012) reports on the opposite situation in Ireland where the concentration on the downstream level weakens the bargaining power of farmers. In fact, the Granger causality results for the Lithuanian potato chain demonstrate a case that is closer to the well-functioning market compared to the aforementioned two cases. The bidirectional price causality does not witness in favour of the market power concentration and welfare violation.

In Poland, the leading role of producer in local supply chain is confirmed at 10.00% significance level. Although a bidirectional Granger causality is associated with a well-functioning market, the price leading at producer level is widespread in different sectors of agriculture. In fact, this causality allows producers to secure better welfare, protect their incomes and farm viability in case of steep price declines on retail level.

Given the importance of Poland on the EU potato market, the horizontal Granger causality between producer prices in Poland and Lithuania is an interesting aspect. The analysis of Eurostat data confirms that the EU potato market is highly concentrated. In 2022, the largest contribution of the EU's harvested production of potatoes (66.74%) came from Germany, France, the Netherlands, and Poland. Belgium and Denmark represented 7.53% and 5.51% in the structure of the harvested production, while the individual contribution of other countries was lower than 5.00% (Eurostat, 2023).

Although the Law of One Price theory and spatial arbitrage concept suggest that a well-functioning market explains price differences between countries by transaction costs (Listorti & Esposti, 2012), the most recent research shows that the EU main producing countries exercise market power in individual agricultural commodity markets and lead price setting of small producing countries. Thus, Listorti & Esposti (2012) recognise market power as one of the factors that could infringe the validity of Low of One Price theory. For example, Emmanouilides & Proskynitopoulos (2020) argue that the concentrated EU pork market developed influential markets and formed clusters of countries with stronger interaction. The study by Roman & Roman (2020) also suggests that the EU milk market is still on its way towards integration, while individual countries form groups with the stronger inter-connections in price setting.

Results of the Granger causality test go in lines with the previous research and confirm that price changes in the main producing country, namely Poland, could be employed as an explanatory variable of producer price changes in Lithuania. Nevertheless, results confirm the bidirectional price setting at 5.00% significance level, while the rejection of the H_0 at 1.00% significance level shows the

Table 2. Results of the Toda-Yamamoto test: vertical and horizontal Granger causality of potato price series

H_0	Optimal lags	F-Statistic	Granger causality
Retail price (LT) does not GC producer price (LT)	2	10.822***	bidirectional***
Producer price (LT) does not GC retail price (LT)	2	78.410***	
Producer price (LT) does not GC producer price (PL)	2	6.058**	bidirectional** or from Poland to Lithuania***
Producer price (PL) does not GC producer price (LT)	2	17.447***	
Producer price (PL) does not GC retail price (PL)	1	3.145*	from Producer to Retail*
Retail price (PL) does not GC producer price (PL)	1	0.040	

Note: GC means Granger cause. *** corresponds to 1.00% significance level, ** – 5.00% significance level, * – 10.00% significance level.
Source: own calculations based on the monthly prices provided by the SEADC and CSO

leading role of Poland. These findings allow us to presume that the highly concentrated EU potato market could face the same challenge of the market fragmentation that distorts the integration of the common market in case of other agricultural commodities.

ARDL modelling results allow to investigate the presence of the long run relationship between potato prices on the domestic market or between markets. The vertical price transmission in Poland is removed from the analysis, because ARDL models do not deal with I(2) time series. Table 3 shows the long run form of the ARDL (1,4) model that describes relations between producer and retail prices on the Lithuanian market. Retail price is selected as the dependent variable, while the model investigates whether historical producer and retail prices are useful explaining price changes at downstream level. Long run coefficients suggest that both retail and producer price changes are significant and could be used to explain the development of retail prices. However, the short run coefficients highlight only the importance of producer price changes as an explanatory variable. The F-Bounds test shows that potato prices at upstream and downstream levels are co-integrated in the long run during the period of 2017–2023. The transformation of the ARDL model into the ECM allows us to estimate a speed of adjustment to the equilibrium. For the vertical potato price relationships on the Lithuanian market, the ECT is significant and accounts for -0.44.

The long run form of the ARDL (4,2) model describes relationships between potato producer prices in two countries. The model relies on the results of the Toda-Yamamoto test and sets producer prices in Lithuania as the dependent variable. Long-run coefficients suggest that the trajectory of price changes on farms in Lithuania could be explained by price changes on farms in both countries. Short-run coefficients show that the most recent development of the price trajectory on Polish farms is a highly statistically significant explanatory variable, while the lagged prices at producer level in Lithuania take a longer delay interval and the significance level is lower in the short run dynamics. The F-Bounds test confirms that potato producer prices are co-integrated and price changes in Poland could be useful explaining the producer price trajectory in Lithuania. This finding goes in lines with the previous research that confirms the co-integration between main producing countries and smaller markets. It should be noted that the analysed period covered several crises (for example, COVID 19, droughts), but long run potato price relationship patterns remained. The ECT is -0.27 and it shows that the speed of adjustment to the long-term equilibrium describing relations between two markets is slower than in vertical price relations on domestic market.

In conclusions, results of the Toda-Yamamoto test and coefficients of the short- and long-run dynamics of the ARDL (4,2) model confirm that the role of the main producing country is critical for the price setting in Lithuania (Hy-

Table 3. Results of the ARDL modelling for potato price series

ARDL Long Run Form			
	Variable	ARDL(1,4) Dependent variable: lnRPLT	ARDL(4,2) Dependent variable: lnPPLT
Constant	C	-0.236	0.789***
Long-run coefficients	lnRPLT(-1)*	-0.440***	
	lnPPLT(-1)*		-0.269***
	lnPPLT(-1)	0.534***	
	lnPPPL(-1)		0.135**
Short-run coefficients	D(lnPPLT)	0.216**	
	D(lnPPLT(-1))	0.582***	0.283**
	D(lnPPLT(-2))	-0.292***	-0.106
	D(lnPPLT(-3))	0.259**	0.167*
	D(lnPPPL)		0.599***
	D(lnPPPL(-1))		0.320**
ARDL ECM Regression			
ECT		-0.440***	-0.269***
F-Bounds Test			
F-statistic		5.296**	4.075*

Note: RPLT corresponds to retail price in Lithuania, PPLT – producer price in Lithuania, PPPL – producer price in Poland. *** corresponds to 1.00% significance level, ** – 5.00% significance level, * – 10.00% significance level.

Source: own calculations based on the monthly prices provided by the SEADC

pothesis 2). Although the analysis of the Granger causality between producer and retail prices shows the bidirectional price movement causality in Lithuania and the Hypothesis 1 cannot be confirmed by the Toda-Yamamoto test, the ARDL (1,4) model demonstrates the importance of producer prices as an explanatory variable.

Conclusions

Over the period of 2017–2023, potato price changes on the Lithuanian domestic market demonstrated the bidirectional Granger causality, while in Poland price changes on farms determined the trajectory of retail prices. Results of the Toda-Yamamoto test and the ARDL modelling suggest that the development of producer prices in Poland influenced potato price changes in Lithuania. However, the speed of adjustment to the long-term equilibrium on the Lithuanian domestic market was faster than between markets.

Our findings allow us to presume that the highly concentrated EU potato market faces the same problems of market integration as other agricultural commodities, i.e. the price setting power is concentrated in main producing countries and the EU market becomes an interaction of clusters with different price setting roles within and between groups. Results underline the importance of individual case studies for the better understanding of the EU potato market and highlight the modest attention of academic society to this research area. The situation of the potato market is changing due to impact of different crises and the further EU-wide research is critical, because potato is an important crop that contributes to the maintaining of the well-functioning food security system in member states.

References

Bakucs, L. Z., Fertő, I. & Szabó, G. G. (2007). Price transmission in the Hungarian vegetable sector. *Studies in Agricultural Economics*, *106,* 23-39.

Chiurciu, I., Cofas, E. & Dragomir, V. (2020). Study on the production and marketing of potatoes in the European Union. *Romanian Agricultural Research*, *37*, 243–251.

Devaux, A., Goffart, J. P., Petsakos, A., Kromann, P., Gatto, M., Okello, J., Suarez, V. & Hareau, G. (2020). Global food security, contributions from sustainable potato agri-food systems. In: *The Potato Crop: Its Agricultural, Nutritional and Social Contribution to Humankind*. Springer Nature Switzerland AG, Switzerland, 3-35. https://doi.org/10.1007/978-3-030-28683-5.

Devaux, A., Goffart, J. P., Kromann, P., Andrade-Piedra, J., Polar, V. & Hareau, G. (2021). The potato of the future: opportunities and challenges in sustainable agri-food systems. *Potato Research*, *64*(4), 681-720. https://doi.org/10.1007/s11540-021-09501-4.

Dickey, D. A. & Fuller, W. A. (1979). Distribution of the estimators for autoregressive time series with a unit root. *Journal of the American Statistical Association*, *74*(366a), 427-431.

Dogbe, W. & Revoredo-Giha, C. (2021). Nutritional implications of trade-offs between fresh and processed potato products in the United Kingdom (UK). *Frontiers in Nutrition*, *7*, 614176. doi: 10.3389/fnut.2020.614176.

Emmanouilides, C. J. & Proskynitopoulos, A. (2020). Spatial integration of pig meat markets in the EU: Complex network analysis of non-linear price relationships. In: *Theory and Applications of Time Series Analysis: Selected Contributions from ITISE 2019, 6*. Springer Nature Switzerland AG, Switzerland, 81-97.

Eurostat (2023). Crop production in EU standard humidity. https://ec.europa.eu/eurostat/databrowser/view/apro_cpsh1__custom_8903417/default/table?lang=en (cit. 17-11-2023).

FAOSTAT (2023). Commodities by country. https://www.fao.org/faostat/en/#rankings/commodities_by_country (cit. 17-11-2023).

FAOSTAT (2023a). Crops and livestock products. https://www.fao.org/faostat/en/#data/QCL (cit. 17-11-2023)

Goffart, J. P., Haverkort, A., Storey, M., Haase, N., Martin, M., Lebrun, P., Ryckmans, D., Florins, D. & Demeulemeester, K. (2022). Potato production in northwestern Europe (Germany, France, the Netherlands, United Kingdom, Belgium): characteristics, issues, challenges and opportunities. *Potato Research, 65*(3), 503-547. https://doi.org/10.1007/s11540-021-09535-8.

Granger, C. W. (1969). Investigating causal relations by econometric models and cross-spectral methods. *Econometrica: Journal of the Econometric Society*, *37*(3), 424-438.

Gustavsen, G. W. (2021). Sustainability and potato consumption. *Potato Research*, *64*(4), 571-586. https://doi.org/10.1007/s11540-021-09493-1.

Jeder, H., Naimi, A. & Oueslati, A. (2017). Transmission between retail and producer prices for main vegetable crops in Tunisia. *International Journal of Food and Agricultural Economics (IJFAEC)*, *5*(1), 19-28.

Klimek-Kopyra, A., Bacior, M. & Neugschwandtner, R. (2023). Hybrid rye (*Secale cereale* L.) as a good crop component to enhance yield stability in a winter cereal mixture. *Acta Agrobotanica,* 76, 1-17. DOI: 10.5586/aa/172670.

Kowalska, A. S. & Gurkowa, K. (2019). Changes in potato production and consumption in Poland in 2001-2019. *Problems of World Agriculture*, *19*(3), 46–56. DOI: 10.22630/PRS.2019.19.3.45.

Listorti, G. & Esposti, R. (2012). Horizontal price transmission in agricultural markets: fundamental concepts and open empirical issues. *Bio-based and Applied Economics*, *1*(1), 81-108.

Louwaars, N. P. (2023). Chapter 4. Potato in the Netherlands–a remarkable story. In: *Impact of Hybrid Potato: The Future of Hybrid Potato from a Systems Perspective*. *Wageningen Academic Publishers,* Netherlands, 45-58. https://doi.org/10.3920/978-90-8686-946-6_4.

Nkoro, E. & Uko, A. K. (2016). Autoregressive Distributed Lag (ARDL) cointegration technique: application and interpretation. *Journal of Statistical and Econometric Methods*, *5*(4), 63-91.

Pesaran, M. & Shin, Y. (1999). An Autoregressive Distributed-Lag Modelling Approach to Cointegration Analysis. In: *Econometrics and Economic Theory in the 20th Century: The Ragnar Frisch Centennial Symposium*. *Cambridge University Press*, Cambridge, 371-413.

Pesaran, M. H., Shin, Y. & Smith, R. J. (2001). Bounds testing approaches to the analysis of level relationships. *Journal of Applied Econometrics*, *16*(3), 289-326. doi: 10.1002/jae.616.

Phillips, P. C. & Perron, P. (1988). Testing for a unit root in time series regression. *Biometrika*, *75*(2), 335-346.

Piwowar, A. (2021). Potato market. In: *Selected markets of agri-food products after Poland's accession to the European Union,* Rynek ziemniaków, In: *Wybrane rynki produktów rolno spożywczych po wejściu Polski do Unii Europejskiej*. Wydawnictwo Uniwersytetu Ekonomicznego we Wrocławiu, Poland, 80-92 (Pl).

Rezitis, A. N. & Pachis, D. N. (2016). Investigating the price transmission mechanisms of Greek fresh potatoes, tomatoes and cucumbers markets. *Journal of Agricultural & Food Industrial Organization*, *14*(1), 91-108.

Roman, M. & Roman, M. (2020). Milk market integration between Poland and the EU countries. *Agriculture*, *10*(11), 561. doi:10.3390/agriculture10110561.

Santeramo, F. G. & von Cramon-Taubadel, S. (2016). On perishability and vertical price transmission: empirical evidences from Italy. *Bio-based and Applied Economics Journal*, *5*(2), 199- 214. DOI: 10.13128/BAE-18043.

Stańko, S. & Mikuła, A. (2021). Changes in the production, foreign trade and domestic consumption of potatoes in Poland in 2001-2019. *Problems of World Agriculture, 21*(1), 33–51. (Pl) DOI: 10.22630/PRS.2021.21.1.3.

Thorne, F. S. (2012). Potato prices as affected by supply and demand factors: an Irish case study. In: *European Association of Agricultural Economists (EAAE)123rd Seminar*, February 23-24, 2012, Dublin, Ireland. https://ageconsearch.umn.edu/record/122473.

Toda, H. Y. & Yamamoto, T. (1995). Statistical inference in vector autoregressions with possibly integrated processes. *Journal of Econometrics*, *66*(1-2), 225-250.

Umar, M. & Dahalan, J. (2016). An application of asymmetric Toda-Yamamoto causality on exchange rate-inflation differentials in emerging economies. *International Journal of Economics and Financial Issues*, *6*(2), 420-426.

Zapucioiu, L. F., Sterie, M. C. & Dumitru, E. A. (2023). Economic analysis of potato and tomato trade in Romania: The Gini coefficient. *Western Balkan Journal of Agricultural Economics and Rural Development (WBJAERD)*, *5*(1), 15-28. doi: 10.5937/WBJAE2301015Z.

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