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Jurkėnaitė, N. and Paparas, D. 2020. Price transmission along the Lithuanian pigmeat supply chain. *Ukrainian Food Journal*, *9*(1), pp. 240-251.

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Abstract

Introduction. The paper analyses structural changes of pig farming in Lithuania and explores price behaviour along the Lithuanian pigmeat supply chain.

Materials and methods. The conducted study uses annual indicators collected by Statistics Lithuania and weekly prices published by SE 'Agricultural Information and Rural Business Centre' (AIRBC). Methods of comparative analysis and graphical representation allow investigating the most important changes of Lithuanian pig farming. Price behaviour is studied employing econometric tests showing the characteristics of the analysed pigmeat price series and different aspects of price relations in the short- and long-term perspective.

Results and discussion. The share of small and medium-sized farms with less than 10 pigs is decreasing in the structure of pig farms, while farmer and family farms have lost their key role in pig farming, in particular between 2004 and 2018. This development direction of pig farming was caused by multiple factors, including the change of business environment after 2004, transformation of agricultural support model and aftermaths of price hikes, the impact of governmental intervention due to the integration into the Eurozone, as well as animal health issues.

Price transmission analysis demonstrates that pork market had faced several critical shocks that had an impact on price behaviour and stakeholders' welfare. Granger causality test shows price setting direction from retail to farm, while, in the long run, the hypothesis of asymmetric behaviour is not supported.

Conclusions. The study confirms dramatic change of Lithuanian pig farming sector and the need of additional support mechanism to foster a structure of pig farming that allows the co-existence of different types of farms. A price transmission study shows market efficiency problems in the short-run that could have a negative impact on farmers' welfare.

Keywords: Agriculture, Market**,** Pig farming**,** Pork, Price transmission, Supply chain

Introduction

According to OECD-FAO Agricultural outlook [OECD/FAO. (2019], in Europe, pork meat consumption per capita was the highest among all meat varieties since 1990. However, on a global scale this trend had changed in 2007 and poultry became the most popular globally consumed meat variety, while pork meat was the second most important meat in the world.

Thus, the topic of pigmeat price transmission attracted a huge attention from academic society around the world. The most recent research covers studies of domestic supply chain of Australia [Griffith G.R., Piggott N.E. (1994], Czech Republic [Čechura L., Šobrová L. (2008), Rudinskaya T. (2019], China [Zhou D., Koemle D. 2015, Dai J., Li X., Wang X. (2017, Dong X., Brown C., Waldron S., Zhang J. (2018], Denmark [London Economics. (2004], Finland [Luoma A., Luoto J., Taipale M. (2004], France [London Economics. (2004], Germany [Von Cramon-Taubadel S. (1998, London Economics. (2004], Hungary [Bakucs L. Z., Fertõ I. (2005),], Ireland [London Economics. (2004], Italy [Capitanio F., Adinolfi F., (2019)], Netherlands [London Economics. (2004], Poland [Kufel-Gajda J., Figiel S., Krawczak M. (2017], Slovenia [Bojnec Š., Peter G. 2005], Switzerland [Abdulai, A. (2002),], the United Kingdom [London Economics. (2004, Paparas D., Pickering T., 2018], the USA [Goodwin B. K., Harper D. C. (2000, Miller D. J., Hayenga M. L. (2001], and etc. The findings of these studies imply that price behaviour and relevant market efficiency challenges depend on the country. It should be noted that even the common market of the EU is rather a set of sufficiently diverse supply chains reflexing market peculiarities of the countries.

This fact makes the study of the Lithuanian pigmeat supply chain an interesting topic, because the previous research on price transmission in this country is scarce due to data availability. It is important to note that since Lithuania had joined the European Union (EU), domestic pig farming sector got through the serious structural transformations. The overall population of pigs reduced, while the dominant share of animals on farmer and family farms was replaced by the leading role of agricultural companies and enterprises. The aforementioned changes could have a significant impact on price behaviour along the pigmeat supply chain and influence the welfare of stakeholders along the pigmeat supply chain.

The paper is aiming to analyse the structural changes of pig farming in Lithuania and explore the price behaviour along the Lithuanian pigmeat supply chain. The study identifies the main factors that had an impact on pork sector evolution and focuses on prices as an important component that could have an impact on pig farming development trends in Lithuania.

Four sections compile this paper. Introduction rationalizes the importance of the current study. Materials and methods section includes the main information about the investigated data and selected research techniques. Results and discussion section

identifies main factors that led to structural changes in the Lithuanian pig farming and gives the most important findings of the price transmission study, discusses the results of the previous research. In Conclusions main findings are summarised.

Materials and methods

Materials

The study relies on main annual indicators of pig farming collected by Statistics Lithuania and weekly upstream and downstream prices of pigmeat published by AIRBC. The upstream level is measured by the average purchase price of pigs (confirmation class E) collected from the Lithuanian enterprises on weekly basis. The downstream price level is measured by the average retail price of ham without bones calculated from retail prices of the main network supermarkets in Lithuania. The price transmission study is carried out for the period 2010–2017.

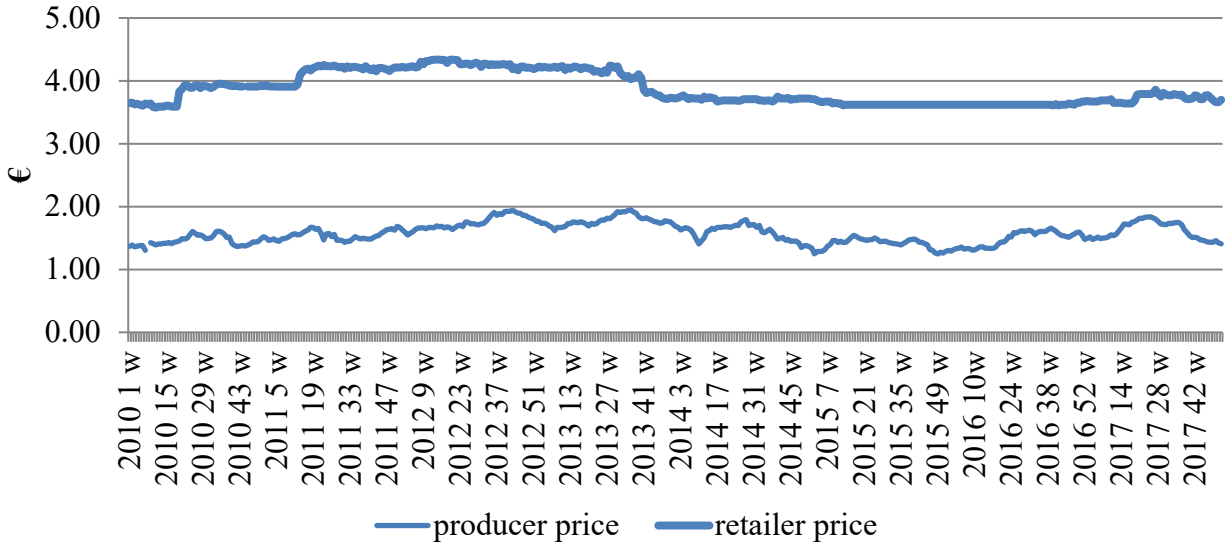

Figure 1. Pigmeat prices on producer and retailer levels

Source: AIRBC, own calculations.

According to Figure 1, the gap between upstream and downstream prices is changing during the analysed period. Downstream prices are less volatile than the prices on upstream level. Starting from 2014, an interesting behaviour of the price on downstream level is observed. Retail price stabilizes for the long period and does not respond to price fluctuations on producer level, while starting from 2017 it becomes more dynamic. This situation could be a result of couple inter-related factors. For example, the influence of the legislation controlling price hikes before and after the entrance to the Eurozone, as

well as the reaction of retailers to the threat of African swine fever on domestic market and the change of the situation after the Russian ban.

The investigated Lithuanian pigmeat supply chain demonstrates a higher price volatility on producer level, while retail prices are more stable. In fact, the analysed case is similar to the functioning of pigmeat supply chains in Czech Republic [Rudinskaya] and Poland [Kufel_Gajda], while the opposite price development trend is evidenced in Slovenia where retail prices demonstrate higher volatility than prices on farm [Bojnec Š., Peter G. (2005]. However, some studies provide examles of quite similar volatility on both levels of the country, for example, price development in China [Dong 2018], Italy [Capitano 2019], and Finland [Luoma 2004]. Hence, not only at a global level but also within EU market the behaviour of prices on different supply chain levels of the same commodity is country-specific.

Methods

At the first stage the study applies methods of comparative analysis and graphical representation to investigate changes on the Lithuanian pig farms. The findings are drawn on the basis of the analysis of main indicators published by Statistics Lithuania.

At the second stage the price transmission along the pigmeat supply chain is explored. Firstly, the nature of data is investigated in order to characterize price series as stationary or non-stationary. For this purpose, Augmented Dickey Fuller (Dickey D. A., Fuller W.A., (1979)) test is run.

At the second step the Johansen co-integration test (Johansen S. (1991), Johansen S. (1995) is carried out to answer the question if there is a co-integrating vector or vectors between downstream and upstream pigmeat prices. The second step reveals if prices on different levels of the pigmeat supply chain repeat the movements related to price hikes and reductions in the long run. The absence of co-integrating vector alerts about possible problems in price transmission resulting in market inefficiency issues. If results of the Johansen test do not confirm co-integrated behaviour between prices, the Bai-Perron multiple break test (Bai-Perron, 1998) will be run to investigate the presence of breaks in price series. The results of the Bai-Perron multiple break test are applied to repeat the Johansen co-integration test with structural breaks.

At the third step the Granger causality test (Granger C.W.J. (1969),) is carried out. The results of this test allow to identify the direction of price running causality in the short-term perspective. The efficient market could be characterised by the two-way causality, while in case of price setting leadership on downstream or upstream level the welfare of farms or consumers could be violated.

At the fourth step The relations between upstream and downstream prices are described by vector error correction model (VECM). Caracteristics of this model and application issues are described in (Von Cramon-Taubadel 2017).

TAR

Results and discussion

Structural changes of pig farming in Lithuania

Over the last decades, the structure of the pig population on Lithuanian farms overcame a significant transformation. According to Statistics Lithuania, when Lithuania entered the EU in 2004, the share of pigs that were grown of farmer and family farms accounted for 56.78% of the population, while in 2018 a drop to a critically low 24.92% level was demonstrated. For the investigated period 2010–2018, the gradual increase of the share of animals at agricultural companies and enterprises and the corresponding changes of pig farming structure are demonstrated in Figure 2.

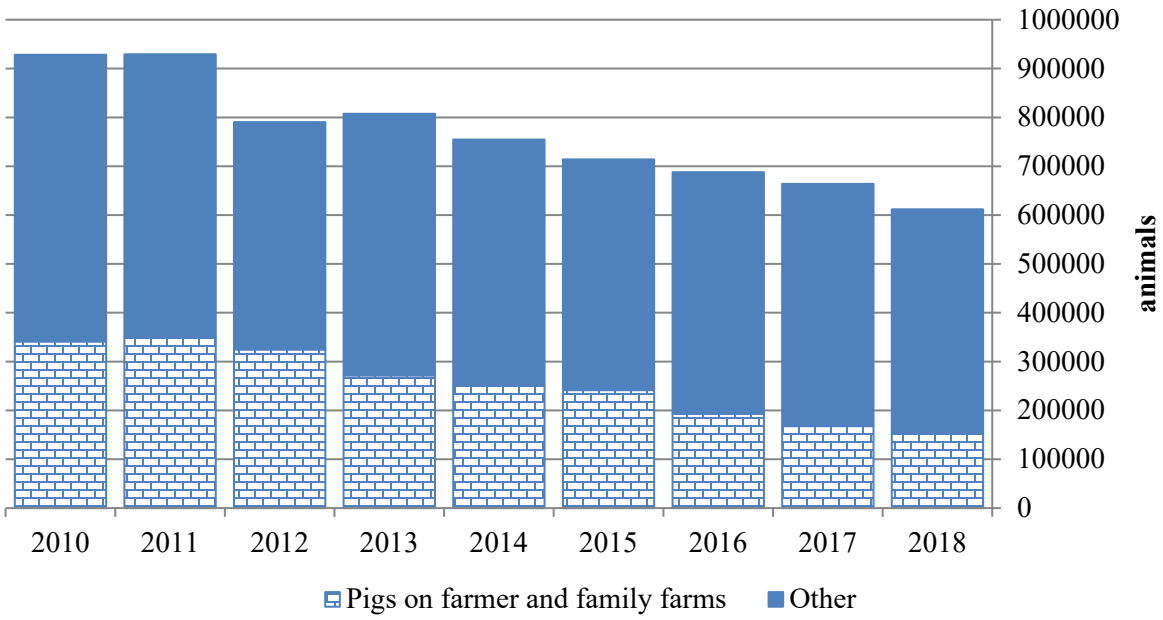

Figure 2. Structure of pig population by farm type in Lithuania for the period 2010–2018

Source: Statistics Lithuania [(2019), Animal production].

Another important characteristic is the structure of pig farming by herd size. The share of farms that have 1–2 pigs decreased very sharply from 8.14% in 2007 to 3.47% in 2016 [(2019), Farm structure. Farm animals]. At the same time, the share of farms with the herd size from 3 to 9 pigs dropped from 11.57% to 8.28%, while the share of farms with 10 pigs and more increased from 60.36% to 70.29% [(2019), Farm structure. Farm animals].

During the period 2010–2018, domestic production was growing until 2013, later, the Russian ban and African swine fever had an impact on the produced amounts of pigmeat and foreign trade. In 2018, both import and export of meat products (estimated in meat equivalent) increased, as compared to the year 2010. Total domestic uses also showed a

sign of moderate increase and statistics reacted to embargo and animal health problems (Table 1).

Table 1

Main indicators of supply balance sheets for pigmeat, thou tonnes

	2010	2011	2012	2013	2014	2015	2016	2017	2018	Change (2010 = 100%)
Produced	73,3	74,9	79,4	86,9	84,9	84,3	74,0	71,5	72,0	98,2
Import	78,5	83,2	85,4	90,6	84,1	91,8	83,8	89,0	92,1	117,3
Export	15,3	23,2	27,6	35,7	22,3	27,6	17,0	19,7	23,3	152,3
Total domestic uses	136,9	136,7	135,4	141,9	147,0	147,6	141,3	141,0	140,7	102,8

Source: Statistics Lithuania [(2019), Supply balance sheets for agricultural products for the crop year], own calculations.

Hence, the current situation of the Lithuanian pig farming was determined by multiple factors inside and beyond pork sector. A crucial aspect was the change of the farming environment after the integration into the EU in 2004. Representatives of pig farming quickly realized that they could not compete with the leading pigmeat producing countries that were equipped with modern material facilities allowing to offer their product at a better price. The first years of competition within the common market started from the clear understanding of two serious problems. First, there was a need to invest in modernisation of farms that produced pigmeat. Second, a change of traditional breeds of pigs to the new breeds, preferred by European consumers, was compulsory. However, the national agricultural support model did not spend a decent attention to this situation.

The introduction of the Common Agricultural Policy determined the establishment of the novel support model and gave another signal for the development of the national agriculture creating more favourable conditions for crop production. Global price hikes for agricultural commodities in 2007–2008 and 2010–2011 contributed to the growth of pig farming costs bolstering pig feeds. Direct payments and the growth of crop prices made crop production a more attractive farming niche.

In 2015, Lithuania became a member of the Eurozone and farmers faced a new dilemma. On the one hand, the prices for the related services were rising, on the other hand, the competition on the EU market did not allow to follow the general price development direction. Hence, for smaller farmers, the choice between generously supported crop production and unprofitable pig farming became more obvious. The exit of small farms from pig farming often resulted in land rent and its futher use for crop production on larger farms.

Another important aspect that contributed to the structural changes in pig farming was animal health. The outbreaks of classical swine fever in 2009 and 2011 had a significant impact on export restrictions of live pigs and the transformation of the foreign trade structure. At that time, the Russian Federation was the main trading partner for the Lithuanian pork sector; however, the outbreak of the classical swine fever in 2011 had stopped the export of live pigs until the second half of 2013. Hence, this situation encouraged farmers to look for new markets and switch from export of live animals to pigmeat products.

The subsequent opening of the Russian market was short, because in January 2014 the first outbreak of African swine fever was confirmed in Lithuania. This outbreak led to the confusion and the disturbance of the foreign trade. The strength of the common market became the weakness as the European Commission could not quickly respond to a new challenge and propose the zoning, while a free cross-border movement within the EU became a threat. Later, the Russian market was closed due to import ban on EU agricultural commodities.

Nevertheless, the impressive geographical spread of African swine fever virus in wild nature and on Lithuanian pig farms was reported until 2018, while only in 2019 the figures started to fall down. As a comparison, according to statistics of the State Food and Veterinary Service [(2019), AKM atvejų statistika], 1,446 spots in a wild nature and 3098 infected wild boars were found in 2018, while by November 26th, 2019 only 430 infected places and 644 wild boars were documented.

The aforementioned disease led to the polarization of pig farming society in Lithuania, because a huge number of small farms were represented as a serious threat for commercial farms. The detection of virus on a small farm resulted in an export ban for larger commercial farms belonging to the same zone. It is argued that the spread of this virus in pig farming is rapid in countries that have a significant share of small farms [Schulz et al 2019]. The vulnerability of small farms was widely recognized due to careless implementation of biosafety measures on those farms. However, the proposals to slaughter pigs and prohibit pig farming on small farms did not achieve enough support in Lithuanian agriculture.

Finally, a political decision to keep a diverse farming structure was made. On the one hand, the larger farms were proposed to get funding for farm modernization and improvement of biosafety measures. Small and medium farms with less than 100 pigs, located in districts with African swine fever spots, were offered two types of compensationary support from autumn 2018. The first type of support assisted in improvement of biosafety measures on farms, while the second measure compensated a switch from pig farming to other livestock farming activities.

Pigmeat vertical price transmission in Lithuania

ADF test show that pigmeat raw prices on downstream and upstream levels are not stationary, because the absolute value of ADF test statistic is lower than critical values (Table 2). However, pigmeat prices at both levels of the supply chain become stationary in first difference and it could be concluded that pigmeat prices are integrated in order one.

Table 2

Results of unit root test for pigmeat prices

H_0: has a uni root		**lproducer**		**D(lproducer)**		**lretailer**		**D(lretailer)**	
	Level	*t*-stat	Prob.	*t*-stat	Prob.	*t*-stat	Prob.	*t*-stat	Prob.
ADF test statistic		-2.166	0.219	-16.681	0.000	-1.239	0.659	-20.199	0.000
Test critical values:	1%	-3.446		-3.446		-3.446		-3.446	
	5%	-2.868		-2.868		-2.868		-2.868	
	10%	-2.570		-2.570		-2.570		-2.570	
Lag Length: 1 (SIC, maxlag=17)				Lag Length: 0 (SIC, maxlag=17)					

Source: own calculations.

In Lithuania, the investigated raw pigmeat price series are non-stationary; however, prices become stationary in first difference. According to the previous studies, the similar price behaviour is documented in studies on price series in Switzerland [Abdulai, A. (2002)], Czech Republic [Rudinskaya], China [Dong 2018], the United Kingdom [Paparas 2018]. Nevertheless, some studies evidence that data stationarity issues depend on supply chain level and pigmeat product, for example, case studies of Polish [Kufel_Gajda], Slovenian [Bojnec 2005], and Czech [Cechura 2008] supply chains. It is not often the case that price series confirm an assumption of data stationarity, for instance the USA case study [Miller].

The Johansen co-integration test on variables in first difference for the pigmeat price series does not indicate co-integrating equation and states that in the long run pigmeat prices do not move together. The results show that market face efficiency problems, however, in some cases the explanaition of such problems could be structural breakes that allow to find co-movements between breakpoints.

It should be noted that some researchers identify structural breaks and split price series analysis into sub-periods [Bojnec 2005, Dong 2018] or integrate structural breaks into research [Bakucs L.Z., Fertõ I. (2006), Paparas 2018]. The majority of the cases justifies the presence of such breaks in price series by crises [London Economics 2004, Dong 2018], animal diseases [Abdulai, A. (2002, Bojnec 2005, Paparas 2018], governmental interventions [Bojnec 2005], and other factors.

Thus, Bei-Perron test is run to investigate pigmeat prices for the presence of structural breaks. Bai-Perron test applies the break specification method 'L+1 vs L sequentially determined breaks' and identifies five breaks for the investigated period: 1) 4/01/2011, 2) 7/27/2012, 3) 10/04/2013, 4) 2/20/2015, 5) 10/21/2016. During the period 2010–2017, the Lithuanian pigmeat supply chain faced shocks of various origins, i.e. change of business environment, entrance to Eurozone, price hikes, swine fever outbreaks, and change of foreign trade partners as well as main trading commodities. The aforementioned factors influenced price development and efficiency of the Lithuanian pork market and contributed to the aprisal of the identified structural breaks.

Further, the Johansen co-integration tests show that the most significant structural break was in 2013 and inclusion of this dummy into estimation process allows to receave meaningful results.

Table 3

Results of the Johansen co-integration test with linear deterministic trend and break in 2013 for pigmeat prices

H_0	Eigenvalue	Statistic	Critical Value (0.05)	Prob.
	Trace test			
No CEs*	0.059	35.950	29.797	0.009
At most 1 CE	0.022	11.445	15.495	0.186
At most 2 CEs	0.006	2.545	3.841	0.111
	Maximum Eigenvalue test			
No CEs*	0.059	24.506	21.132	0.016
At most 1 CE	0.022	8.900	14.265	0.295
At most 2 CEs	0.006	2.545	3.841	0.111

* rejects the null hypothesis at the 0.05 level. Lags interval (in first differences): 1 to 4.

Source: own calculations.

The Johansen test allows rejecting hypothesis that pigmeat prices on both levels are not co-integrated in the long-term perspective (Table 3). However, the hypothesis of one or two co-integrated equations cannot be rejected. Thus, the conclusion could be drawn that prices along the pigmeat supply chain are co-integrated.

Summarising previous finding, it could be concluded that studies apply specific tests for co-integration or the co-integration becomes an initial step of tests for symmetric price behaviour. The absence of co-integration in Swiss pork sector is found by [Abdulai, A. (2002)] applying the Engle-Granger test, however, tests for asymmetry finds co-integration. One co-integrated equation is found in the United Kingdom [Paparas 2018], or couple cointegrating vectors for the investigated periods in China [Dong 2018], while in

case of Slovenia the split of time seried into sub-periods allowed to find only one co-integrating equation instead of two [Bojnec 2005]. Thereby, the situation on the Lithuanian market is not unique and previous research shows quite different situation for the countries.

The next step to explore if prices on different levels help to explain price behaviour on opposite supply chain level in the short run. Table 4 introduces results of the Granger causality test. According to estimated values, the Lithuanian pigmeat market demonstrate features of one-way causality that runs from retailer to producer.

Table 4

Results of the Granger causality test for pigmeat prices

H_0:	F-Statistic	Prob.
'lproducer' does not Granger Cause 'lretailer'	0.179	0.67
'lretailer' does not Granger Cause 'lproducer'	3.673	0.05

Lags: 2

Source: own calculations.

It should be noted that previous research also found evidences of one-way causality, however, the more often direction runs from farm to retail level (Harper 2000, Bakucs, Ferto 2006, Goodwin, Harper 2000, Miller 2001) and correspond to price determination theory argueing that causality should run from upstream to downstream sectors.

The VECM is assisting in describing the Lithuanian pigmeat market. The estimated VECM includes a structural break in 2013 as an addition parameter (Table 5). The estimated error correction term shows that after shocks pigmeat prices return to the described equilibrium with a speed 3.6% for the analysed period.

Table 5

Estimation of VECM for pigmeat prices

Co-integrating equation for Lithuanian case	
lretailer(-1)	1.0000
lproducer(-1)	-0.221564 (0.09883) [-2.24180]
D2013(-1)	0.124768 (0.02065) [6.04136]
C	-1.330823
Error Correction:	D(LRETAILER)
ECT	-0.035729 (0.00835)

	[-4.27857]

Source: Own calculations.

The main results of TAR model with constant and structural break for 2 lags are provided in Table 6. The selected threshold value is zero. The comparison of F-joint (6.45) with the critical value 5.81 allows rejecting the H0 of 'no co-integration' and accepting the alternative that the series are co-integrated. Moreover, the H0 of the symmetric price behaviour is not rejected, because F-equal (0.53) is lower than the critical value (2.88). This means that increases and decreases of the prices are transmitted from the retailer to the producer – in the long run – with the same intensity.

Table 6

Results of TAR with D2013 for pigmeat prices: threshold value – zero

Variable	Coefficient	Std. Error
Above Threshold	-0.040	0.0180
Below Threshold	-0.060	0.021
Differenced Residuals(t-1)	0.040	0.050
Differenced Residuals(t-2)	0.039	0.050
F-equal:	0.537	(2.882)*
T-max value:	-2.199	(-2.094)*
F-joint (Phi):	6.445	(5.811)*

Source: own calculations.

It is true to note that different tests for presence of asymmetry is one of the most often investigated issues. Academic studies show that different countries demonstrate both symmetric (Bakucs, Ferto 2005, Griffith, Piggott 1994) and asymmetric (Abdulai, A. (2002), Rudinskaya, Kufel-Gajda 2017, Dai, Wang 2018, Goodwin Harper 2000,) behaviour or combine both types in a longer period (Dong 2018) or in a long- and short-term perspective (Bakucs, Ferto 2006), on different levels of supply chain (Miller 2001)

Conclusion

Over the period from 2010 to 2018, significant structural changes in the Lithuanian pig farming took place. The overall population of pigs has decreased, while the dominant share of pigs on farmer and family farms in 2010 was replaced by predominance of agricultural companies and enterprises. Small farms are disappearing from Lithuanian pig farming, because farmers exit pig farming or switch to other farming types, while the share of medium-sized pig farms in the country is not remarkable.

Other important factors, contributing to structural changes and demotivating to run medium-sized farms, are the growth of farming costs, animal diseases, and disturbances

of foreign trade. The current negative trends could be changed introducing specific support measures targeting at fostering a specific pig farming structure.

The empirical research on price transmission along the Lithuanian pigmeat supply chain demonstrates that pigmeat market experienced several critical shocks over the investigated period. Those shocks had different nature (governmental intervention due to entrance to the Eurozone, animal health issues, global price hikes) and made an impact on price behaviour and co-movements. Tests suggest that in the short-run the leading price setter is retailer, while in the long-run prices do not demonstrate asymmetric behaviour.

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