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Pork Market Price Transmission During the Covid-19 Pandemic: The Lithuanian Case

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ABSTRACT

The COVID-19 pandemic had a severe impact on the EU economic system and showed the vulnerability of the food system. The paper investigates spatial price transmission patterns of the Lithuanian pork market during the COVID-19 pandemic. The methodological framework of research is based on linear and nonlinear autoregressive distributed lag models, error correction model, and Wald test that allow describing price relations and detecting the asymmetric price behavior. The spatial price transmission analysis is focused on the role of the selected main producing countries (Poland, Germany, France, Denmark, Spain, and the Netherlands) in price development of the small market. Results suggest that the pandemic period does not introduce a fundamental shift in the behaviour of the Lithuanian market and domestic prices are explained by the price evolution in main producing countries. Indeed, the role of foreign markets in price setting differs. In case of Lithuania, the main price leading countries are Poland, Germany, and the Netherlands. During the COVID-19 pandemic, test results for the main producing countries confirm long-term symmetry, but some countries demonstrate asymmetric price behaviour in the short-term dynamics. The dependence of the small market on price changes of countries with lower pork prices than the EU average makes domestic pig farming vulnerable and puts prospects of business development at a disadvantage.

INTRODUCTION

At the end of 2019, global news shows reported a previously unknown and highly infectious disease in China. The local authorities did not manage to control the outbreak in the country of virus origin. As a result, in early 2020, the global society had faced an unprecedented COVID-19 challenge that transformed the functioning of economic systems and changed our social life. Elleby et al. (2020) compares the devastating impact of the global COVID-19 downturn with the Great Depression, while Swinnen and Vos (2021) argue that the introduced pandemic control measures resulted in a deeper recession than the global financial crisis in 2008-2009. However, the most important lessons to be learnt from the global downturn deal with the functioning of food systems and food security. The COVID-19 pandemic became a sophisticated litmus test for the food supply chains that showed vulnerability of global food systems. Lockdowns and subsequent pandemic control measures transformed consumer and business behavior, disturbed the functioning of agricultural markets, and highlighted numerous challenges.

Laborde et al. (2021) describe the changes in behavior patterns introduced by lockdowns and report the pandemic influence on diets, including a shift from meat and other nutrient-dense foods to higher consumption of basic staple food, as an inevitable reaction to income loss. However, only limited research focuses on the price transmission in meat markets (for example, Ramsey et al., 2021; Erol and Saghaian, 2022) during the COVID-19 pandemic. The accumulation of deeper knowledge about this period is critical to improve policy response to similar situations in the future.

This paper sheds light on spatial price behavior of the small EU pork market, namely Lithuania, during the pandemic period. In the EU, pork has the highest per capita consumption level, compared with other types of meat, while the Lithuanian pork market has demonstrated a remarkable shrinking in pig population over the recent decades. The research by Emmanouilides and Proskynitopoulos (2020) suggests that the EU market covers national pork markets with different price-driving power, and high power "hubs" influence the development of prices in countries with lower market power. This knowledge encourages the strong focus of academic studies on price transmission mechanisms of main producing countries that lead prices, while the situation of low power markets attracts less attention. Nevertheless, the knowledge about small markets and price transmission patterns during the pandemic period is important for policymakers that deal with the development of sustainable and resilient food systems at the EU level, while for the academic society this study becomes a contribution to the niche research area.

The paper aims to carry out a spatial price transmission analysis for the Lithuanian pork market during the COVID-19 pandemic period. The further structure of this paper includes generalized results of the literature review on the related price transmission studies. Section 2 provides important reference to data description, introduces the research hypothesis, and the methodological research framework. Section 3 focuses on main results of unit root tests, linear and nonlinear autoregressive distributed lag (ARDL and NARDL) modelling, bounds test, error correction modelling (ECM), while the following section compares empirical results of the study with findings of previous academic papers. Main findings are highlighted in Conclusions.

1. LITERATURE REVIEW ON PRICE TRANSMISSION RESEARCH

Listorti and Esposti (2012) identify two types of academic studies on price transmission, namely vertical and horizontal price transmission research. The first niche sheds light on vertical price passes in value chains and mainly includes farmer, processor, and consumer or retailor levels. The examples of such studies for the EU pork market are provided by Cechura and Sobrová (2008), Capitanio et al. (2019), Rudinskaya (2019). This research area introduces the diversity of challenges that arise from the malfunctioning of domestic supply chains and depicts unique characters of national structures. Meanwhile, a wide range of sophisticated econometric techniques and research periods inconveniences cross-country comparisons and generalizations.

According to Listorti and Esposti (2012), horizontal price transmission studies could be additionally grouped into the cross-commodity and spatial price transmission for the same commodities. The former research investigates how changes in prices of related commodities influence the price evolution of the pork market. For example, Karikallio (2015) studies the integration of the EU livestock markets, Zhou and Koemle (2015) analyse the nexus between price changes in hog and feed sectors. Cross-commodity studies shed light on possible aftermaths of policy interventions and expand the selection of support measures providing a better understanding of food systems. The knowledge about spatial price transmission between the same commodities is important, because it shows the progress towards the well-functioning integrated markets or allows to identify market malfunctioning, investigate and predict the reaction of prices after various shocks. Although most of the conducted studies focus on specific groups of the EU countries (for example, Emmanouilides and Fousekis, 2012; Holst and von Cramon-Taubadel, 2013; Fousekis, 2015), some academics include all member states (Emmanouilides and Proskynitopoulos, 2020).

The academic interest in the COVID-19 impact on the functioning of the pork market around the world was driven by the importance of this meat in diets, but most of the studies omitted price transmission aspect. For example, the impact of the COVID-19 pandemic on the pork market of the United States of America (USA) is analysed by Hayes et al. (2021) who carry out a descriptive analysis of the pork market and Lusk et al. (2021) who focus on spreads of pork prices and marketing margins. The comparative analysis of important indicators is carried out by D'Souza and Dunshea (2021) and by McEwan et al. (2021) who investigate the COVID-19 impact on the Australian and Canadian pork industries. The research on the pandemic impact on price transmission in the pork and other meat sectors is modest and often covers vertical price transmission. For example, Ramsey et al. (2021) investigate vertical pork price transmission and find that the pandemic introduced a price surge in the USA, while the wholesale level reacted to the shock faster than the retail level. Erol and Saghaian (2022) focus on the value chain of beef in the USA and conclude that farmers and consumers had slower adjustments to price changes and experienced the stronger aftermaths of the COVID-19 pandemic.

Although price transmission studies cover three different niches, the same methodological approaches are applied to carry out the research. The in-depth discussion on the evolution of econometric models employed for price transmission analysis is provided by von Cramon-Taubadel (2017). Frey and Manera (2007) also provide a detail list of econometric models, however, they additionally enrich the academic discourse by the list of models that are applied to investigate different types of asymmetric behavior. The aforementioned empirical research helps to assess the research framework based on the available data properties.

2. DATA AND METHODOLOGY

2.1 Data

This research utilizes the secondary data collected in accordance with Regulation (EC) No 1249/2008 (Article 25). Weekly prices for pig carcase (E class) cover price changes from March 2020 to February 2022. EU countries introduced various countermeasures (lockdowns and other movement restrictions, limiting of gatherings, closure of catering establishments and other businesses, mandatory vaccination for the certain activities, etc.) to stop the spread of the virus, while pork markets experienced changes in supply, consumption and consumer behavior during this period. After an outbreak of a war in Ukraine in February 2022 and the following economic sanctions, the war became a dominant explanation of agricultural price surges due to growing input costs and availability of important commodities. Thus, this research focuses on the period with a clear reference to the COVID-19 pandemic.

The previous research suggests that price changes of small markets in the EU are determined by price developments in main producing countries. This paper investigates whether the pandemic-induced market failures and changes influence spatial pork price relations and formulates the hypothesis as follows: *The COVID-19 pandemic period had influenced the price leading role of the main producing countries on the Lithuanian pork market in the long run*.

Table 1. Descriptive statistics for the selected countries and the EU

	DK	*DE*	*ES*	*FR*	*LT*	*NL*	*PL*	*EU*
Min (€/100 kg)	122.71	123.15	123.88	132.00	99.86	110.99	111.53	127.65
Max (€/100 kg)	206.51	207.77	191.64	167.00	198.46	185.76	199.41	195.39
Average (€/100 kg)	153.68	146.03	155.74	146.10	138.21	131.45	139.42	147.01
STDEV	20.53	20.74	19.39	10.86	22.67	17.99	19.71	16.90

Source: author's elaboration is based on data from the Directorate-General for Agriculture and Rural Development of the European Commission

In order to confirm or reject the hypothesis, the study covers Lithuania (LT) and the main EU pork producers, namely Poland (PL), Germany (DE), France (FR), Denmark (DK), Spain (ES), and the Netherlands (NL). The descriptive statistics of the analysed price series is reported in Table 1. During the selected period, the highest price volatility is recorded in Lithuania, while price changes in Germany and Denmark also demonstrate high standard deviation. The comparison of the average prices shows that the Netherlands, Poland, and Germany are highly competitive main producing countries with the lowest average prices.

2.2 Methodological framework

The selection of the appropriate econometric technique starts from the unit root testing that allows grouping data into stationary and nonstationary. Although the previous research employs a wide variety of unit root tests, this study applies Augmented Dickey-Fuller and Phillips-Perron tests (Dickey and Fuller, 1979; Phillips and Perron, 1988), hereinafter referred as the ADF and PP tests. Both tests investigate the null hypothesis (H_0) that the data contain a unit root and the confirmation of the H_0 means that price series are nonstationary. Stationary data reject the H_0 at level (I(0)), while nonstationary data reject H_0 in first difference (I(1)) or after further steps of data processing. If the order of integration is lower than I(2), the appropriate econometric technique for the mixed data is the ARDL model. The ARDL model enables the analysis of the long- and short-term dynamics in price relationships. The adapted for the bipatrtite price analysis Pesaran et al. (2001) model is described in Eq. 1:

$$\Delta LP_t = \gamma_0 + \sum_{i=1}^{p} \alpha_i \, \Delta LP_{t-1} + \sum_{i=0}^{q} \beta_i \Delta \, FP_{t-1} + \rho LP_{t-1} + \varphi FP_{t-1} + \mu \qquad (1)$$

where Δ is referred as the first difference of the variable, LP_t denotes the natural logarithms of prices on the Lithuanian market (t=1,2,...,T), FP_t – the natural logarithms of prices on the investigated foreign market (t=1,2,...,T), γ_0 – constant term, α_i and β_i – coefficients of the short-term dynamics, p and q – lags of dependent and explanatory variables, φ and ρ – coefficients of the long-term dynamics, μ – term of random disturbance.

The selection of lags p and q relies on two steps. First, the bipartite Vector Autoregression (VAR) models that describe price relationships between the Lithuanian and the foreign market are investigated. The VAR lag order selection criteria, namely sequential modified LR test statistic, Schwarz information criterion, final prediction error, Akaike information criterion (AIC), and Hannan-Quinn information criterion, are calculated up to the 8th lag for those bipartite models. The maximum lag for the ARDL modelling is selected as a dominant solution suggested by most calculated criteria. Second, the ARDL models are run starting from the maximum selected lag and reducing it. The appropriate model is selected employing the lowest AIC criterion.

Additional tests on the estimated ARDL models are run to avoid the selection of the alternative that faces serial correlation, heteroscedasticity or stability problems. The outcomes of the Breusch-Godfrey serial correlation Lagrange multiplier test, the Breusch-Pagan-Godfrey heteroskedasticity test (Godfrey, 1978; Breusch and Pagan, 1979), the cumulative sum and cumulative sum of square tests (Brown et al., 1975) empower a proper assessment of the ARDL model, while the consideration of changes in lags allows to overcome the aforementioned problems.

After the selection of the ARDL model, the long-run form of the ARDL model (Eq. 1) allows us to run the bounds test (Pesaran and Shin, 1999) and draw conclusions concerning the presence of the long-term relations between two markets. The H_0 suggests that prices have no level relationships, while the rejection of the H_0 shows the cointegration in the long-term dynamics. The decision is based on the comparison of the calculated *F*-statistic with the lower and upper critical bounds of *F*-test. The presence of the cointegration shows *F*-statistic value that is higher than the upper critical bound level, while the *F*-statistic between bounds provides inconclusive results. If *F*-statistic is lower than the lower critical bound, the data are not cointegrated.

The confirmation of the cointegration between the Lithuanian and the foreign market by the bounds test allows to interpretate short- and long-term coefficients of the ARDL model and run the ECM that provides the error correction term (ECT) or speed of price adjustment to the equilibrium as the most important result of the modelling. The ARDL model is specified as the ECM in Eq. 2:

$$\Delta LP_t = \gamma_0 + \sum_{i=1}^{p} \alpha_i \Delta LP_{t-1} + \sum_{i=0}^{q} \beta_i \Delta FP_{t-1} + \delta_1 ECT_{t-1} + \mu \tag{2}$$

where δ_1 is a coefficient that describes the adjustment towards the long-term equilibrium, *ECT* – error correction term.

However, in some cases the linear ARDL model could hide important differences between the impact of explanatory variable price increases and declines on the development of the dependent variable, but this impact becomes visible in a nonlinear ARDL model. As the COVID-19 pandemic introduced a significant shock on agricultural markets, some evidence of asymmetric price behaviour could be presumed, while NARDL models could have a better explanatory power in such cases. Thus, the research is extended including a NARDL modelling introduced by Shin et al. (2014). NARDL specification is based on the linear ARDL model (Pesaran and Shin, 1999; Pesaran et al. 2001), however, it shows the decomposition of regressors into partial sums of positive and negative price changes. The adapted for the research Shin et al. (2014) model is provided in Eq. 3:

$$\Delta LP_t = \gamma_0 + \sum_{i=1}^{p-1} \alpha_i \Delta LP_{t-1} + \sum_{i=0}^{q-1} \beta_{1i} \Delta FP_{t-1}^{+} + \sum_{i=0}^{q-1} \beta_{2i} \Delta FP_{t-1}^{-} + \rho LP_{t-1} + \varphi_1 FP_{t-1}^{+} + \varphi_2 FP_{t-1}^{-} + \mu \tag{3}$$

where α_i, β_{1i}, β_{2i} – coefficients of the short-run dynamics, FP^+ and FP^- – partial sum processes of price growth and decline in FP_t, φ_1, φ_2, ρ – coefficients of the long-term dynamics.

NARDL model is derived from the selected ARDL model and follows the similar assessment procedure that includes tests for serial correlation, heteroscedasticity, stability, and the bounds test. If the aforementioned tests do not show model's misspecification and confirm the cointegration in the long-term dynamics, the ECM is run for the estimation of bipartite price relations in the short term. NARDL model empowers the analysis of long- and short-term asymmetric behaviour applying the Wald test (see Shin et al., 2014, Rezitis, 2019). The long-term dynamics investigates the H_0 that $-\varphi_1/\rho=-\varphi_2/\rho$, while the H_0 of the short-term dynamics is that $\sum_{i=0}^{q} \beta_{1i} = \sum_{i=0}^{q} \beta_{2i}$. The rejection of the H_0 means the asymmetric price behaviour, while the opposite outcome confirms the symmetric price passes. The comparison of the ARDL and NARDL models shows the importance of asymmetric price behavior in price setting on the Lithuanian market.

3. EMPIRICAL RESULTS

The ADF and PP tests report on conflicting outcomes. The ADF test classifies price movement trajectories in Lithuania, France, and Poland as stationary at 5.00% significance level (Table 2). However, the PP test for the same countries does not allow rejecting the H_0 at 5.00% significance level.

Table 2. Results of the ADF and PP tests with the constant for the selected seven countries

Price series	*ADF test: I(0)*	*ADF test: I(1)*	*PP test: I(0)*	*PP test: I(1)*
LT	-3.0357^{B}	-5.6945^{A}	-2.6947^{C}	-4.7896^{A}
DE	-2.5364	-4.0451^{A}	-2.7242^{C}	-3.9567^{A}
DK	-1.9866	-7.3313^{A}	-1.8618	-8.0480^{A}
FR	-2.9740^{B}	-3.9091^{A}	-2.0777	-3.9091^{A}
ES	-2.9722^{B}	-2.4330	-2.0796	-4.0595^{A}
NL	-2.6141^{C}	-4.7163^{A}	-2.4358	-10.1268^{A}
PL	-3.0334^{B}	-5.3203^{A}	-2.7825^{C}	-4.6928^{A}

Note: the significance level is described by *p*-values, i.e. ^{C} - 10.00%, ^{B} - 5.00%, ^{A} - 1.00%.

Source: own calculations.

The PP test confirms the stationarity of series at I (1), although results for three countries imply that price movements are characterized as stationary at 10.00% significance level. According to tests, prices could be classified as I(0) or I(1), while the conclusion depends on the selected test and the significance level. This important data characteristic is overcome applying ARDL modelling. Bounds test confirms the highest *F*-statistic results and proves 1.00% significance level for the nearest countries, namely Poland and Germany (Table 3). The presence of the long-term relations between the Lithuanian market and those countries remains important for the price setting during the COVID-19 pandemic.

Table 3. ARDL and NARDL bilateral modelling results

	DE–LT		*PL–LT*		*DK–LT*	
	ARDL(3,3)	*NARDL(3,3,3)*	*ARDL(3,1)*	*NARDL(3,1,1)*	*ARDL(4,3)*	*NARDL(4,1,3)*
C	-0.0147	1.0974^{A}	-0.0558	1.2630^{A}	0.1446	0.7195^{A}
LP(-1)^{a}	-0.2093^{A}	-0.2082^{A}	-0.2393^{A}	-0.2374^{A}	-0.1083^{A}	-0.1409^{A}
FP(-1)	0.2100^{A}		0.2502^{A}		0.0770^{C}	
$FP^{(+)}(-1)$		0.2183^{A}		0.2405^{A}		0.1641^{C}
$FP^{(-)}(-1)$		0.2081^{A}		0.2459^{A}		0.1262^{B}
ΔLP(-1)	0.4830^{A}	0.4807^{A}	0.3302^{A}	0.3338^{A}	0.5756^{A}	0.5794^{A}
ΔLP(-2)	0.2706^{A}	0.2834^{A}	0.3143^{A}	0.3133^{A}	0.2686^{B}	0.2698^{B}
ΔLP(-3)					-0.2317^{B}	-0.2177^{B}
ΔFP	0.3814^{A}		0.5698^{A}		0.7582^{A}	
$\Delta FP^{(+)}$		0.3247		0.5184^{A}		0.9256^{B}
$\Delta FP^{(-)}$		0.2839		0.6529^{A}		0.7591^{B}
ΔFP(-1)	0.5078^{A}				0.0031	
$\Delta FP^{(+)}(-1)$		1.0890^{B}				
$\Delta FP^{(-)}(-1)$		0.4308^{B}				0.0698
ΔFP(-2)	-0.4852^{A}				-0.4830^{B}	
$\Delta FP^{(+)}(-2)$		-1.0966^{A}				
$\Delta FP^{(-)}(-2)$		-0.3455^{C}				-0.7536^{B}
Bounds test						
F-statistic	10.5221^{A}	7.6526^{A}	14.4921^{A}	10.8460^{A}	3.7197^{C}	3.6992^{C}
Symmetric price behavior						
Long-term		yes		yes		yes
ARDL Error Correction Regression						
ECT	-0.2094^{A}	-0.2082^{A}	-0.2393^{A}	-0.2374^{A}	-0.1083^{A}	-0.1409^{A}
R^2	0.6758	0.6997	0.7478	0.7503	0.60012	0.6132
Adjusted R^2	0.6589	0.6736	0.7400	0.7400	0.5746	0.5841
AIC	-4.4667	-4.4732	-4.7569	-4.7474	-4.2265	-4.2398

Note: The significance level is described by *p*-values, i.e. ^{C} - 10.00%, ^{B} - 5.00%, ^{A} - 1.00%. ^{a} denotes *p*-value that is not compatible with *t*-Bounds distribution.

Source: own calculations.

The calculated *F*-statistic indicates higher values for the ARDL models, and the decomposition of prices does not show an essential improvement of the model. The stability test for the NARDL(3,3,3) model (DE–LT) shows that CUSUMQ line has minor violations of the lower 5.00% significance boundary, while the linear ARDL(3,3) model passes all tests. According to Table 3, the first lag of prices on the domestic and foreign markets is important explaining the price development on the Lithuanian market in the long-term dynamics. The decomposition of the coefficient describing the long-term dynamics indicates that price declines on foreign markets are associated with positive coefficients. The previous price developments on the Lithuanian market and price level in Poland and Germany are important in the short-term dynamics. The NARDL (3,3,3) model (DE–LT) also includes lagged values of the German price differences as significant explanatory short-term coefficients.

The ECM regression demonstrates the fastest speed of adjustment to equilibrium in case of price relations between Lithuania and Poland (ECT is approx. 24.00%). The models that describe the links between the Lithuanian and German prices also estimate a high speed of adjustment (approx. 21.00%). As ECT must be negative and demonstrate a statistical significance (Rose et al., 2019), the results suggest that the price setting direction is appropriate. Although the price transmission between the Lithuanian and both foreign markets evidence symmetric behaviour in the long-term dynamics, the transmission of the German prices is asymmetric in the short term, while the Wald test for the pair Poland–Lithuania confirms symmetric price movements.

Bounds test for the pair Denmark–Lithuania confirms the cointegration only at 10.00% significance level, while test results at 5.00% level are inconclusive. The ARDL (4,3) model evidences low significance of the long-term coefficient that explains dependent variable based on price changes in the foreign market, while the decomposition of this coefficient demonstrates that positive and negative changes have different significance. In the short-term dynamics, the development of lagged price differences on the domestic market is an important explanatory factor, but lagged price differences' developments in Denmark are also important. The nonlinear model shows higher ECT value than the ARDL; however, the speed of adjustment is lower than 15.00% in both cases. Wald tests suggest the presence of the short-term asymmetry, while the long-term dynamics confirms symmetric price changes.

Table 4. ARDL and NARDL bilateral modelling results

	FR–LT		*ES–LT*		*NL–LT*	
	ARDL (4,3)	*NARDL(4,0,2)*	*ARDL(4,0)*	*NARDL(4,1,0)*	*ARDL(3,4)*	*NARDL(3,3,4)*
C	-0.1098	0.5207^{A}	0.1777	0.5558^{A}	0.0408	1.0810^{A}
LP(-1)^{a}	-0.1078^{A}	-0.1025^{A}	-0.1229^{A}	-0.1111^{A}	*-0.1846*^{A}	*-0.2071*^{A}
FP^{b}			0.0843^{B}			
FP$^{(+)b}$		0.1054				
FP$^{(-)}$				0.0665^{b}		
FP(-1)	0.1281				*0.1776*^{A}	
FP$^{(+)}$*(-1)*				0.0576		*0.2019*^{A}
FP$^{(-)}$*(-1)*		0.1159				*0.2064*^{A}
ΔLP(-1)	0.5231^{A}	0.5553^{A}	0.6298^{A}	0.5866^{A}	0.4235^{A}	0.4551^{A}
ΔLP(-2)	0.2198^{B}	0.2291^{B}	0.2355^{B}	0.2049^{C}	0.3064^{A}	0.3021^{A}
ΔLP(-3)	-0.2060^{B}	-0.2398^{B}	-0.2395^{B}	-0.2273^{B}		
ΔFP	1.3821^{A}				0.4918^{A}	
ΔFP$^{(+)}$				0.6204^{B}		0.5940^{A}
ΔFP$^{(-)}$		2.1062^{A}				0.3262^{B}
ΔFP(-1)	-0.3374				0.2579^{B}	
ΔFP$^{(+)}$*(-1)*						0.2127
ΔFP$^{(-)}$*(-1)*		-1.4089^{A}				0.2147
ΔFP(-2)	-0.5434				-0.2134^{B}	
ΔFP$^{(+)}$*(-2)*						-0.5267^{B}
ΔFP$^{(-)}$*(-2)*						0.0297
ΔFP(-3)					-0.3156^{A}	
ΔFP$^{(-)}$*(-3)*						-0.3841^{B}
Bonds test						
F-statistic	3.4861	2.2305	4.6452^{B}	3.8680^{B}	8.7306^{A}	6.8982^{A}
Symmetric price behavior						
Long-term		-		yes		yes
ARDL Error Correction Regression						
ECT	-0.1078^{A}		-0.1229^{A}	-0.1111^{A}	-0.1846^{A}	-0.2071^{A}
R^{2}	0.5919		0.5472	0.5693	0.6677	0.6576
Adjusted R^{2}	0.5659		0.5332	0.5514	0.6453	0.6234
AIC	-4.2061		-4.1615	-4.1917	-4.3989	-4.3103

Note: The significance level is described by *p*-values, i.e. ^{C} - 10.00%, ^{B} - 5.00%, ^{A} - 1.00%. ^{a} denotes *p*-value that is not compatible with *t*-Bounds distribution, ^{b} means that the outcome is interpreted as Z = Z (-1) + D(Z).

Source: own calculations.

France and Lithuania demonstrate essential price development differences during the COVID-19 period (Table 4). Thus, the bounds test fails to confirm the cointegration between two markets. The comparison of bipartite relations including Spain and the Netherlands allows to observe important differences in estimated models. Although the bounds test confirms the fact of the long-term relations, ARDL (3,4) model (NL–LT) indicates possible stability problems plotting CUSTUMQ line within borders. The NARDL (3,3,4) model is better specified, because it does not face serial correlation, heteroscedasticity, and stability problems. In the long-term dynamics, the main explanatory variables are the first lag of the domestic and foreign prices, while the short-term coefficients of lagged price differences in both countries are significant too. Wald tests do not provide evidence of asymmetric price behaviour in case of the Netherlands and Lithuania.

The comparison of NARDL (4,1,0) and ARDL (4,0) models (ES-LT) implies that for the former model the domestic prices have a higher explanatory power than the changes of prices on the Spanish market in the long term. The short-term coefficients also show lagged domestic price differences as significant explanatory variables; however, the nonlinear model includes positive price changes in the Spanish market as important variable. The investigation of price transmission behavior confirms the symmetric pattens in the long-term dynamics, while NARDL (4,1,0) includes only one significant short-term coefficient related to positive price changes on the Spanish market.

4. DISCUSSION

Results go in line with findings of Emmanouilides and Proskynitopoulos (2020) who argue that pork price changes in Lithuania are mainly driven by the German, Polish, and Dutch markets; however, their study classifies Denmark as a market that could be dependent on the price evolution in Lithuania, while Spain and France are attributed to the same group of power as Lithuania. Econometric modelling suggests that the role of neighbouring Poland is the most remarkable, while this conclusion is supported by Holst and Cramon-Taubadel (2013) finding that price transmission is faster between markets with a common border. This study allows arguing that the aforementioned countries with high market power had maintained their leading position during the COVID-19 pandemic crisis and demonstrated the highest speed of adjustment to the equilibrium. The research hypothesis could be rejected, because there is no empirical evidence of higher price-setting autonomy on the Lithuanian market during the pandemic period, and country retains the long-term dependence on the price changes in main producing countries that played an important role during the pre-pandemic period.

The research reveals that the price evolution trajectory in France differs significantly during the COVID-19 period, and the bounds test fails to confirm the bipartite cointegration. Although bilateral models, including Spain and Denmark, confirm the long-term relations at lower significance levels, the results also imply more individual price trajectories, compared to the Lithuanian market. In fact, the findings touch the issue of the EU market integration efficiency, because a well-functioning integrated market is supposed to transmit price changes and shocks bidirectionally, while individual reactions to crises in Member States and differences in price volatility could be associated with failures of the integrated market. Emmanouilides and Proskynitopoulos (2020) link the existence of market power groups with inefficient EU market too. The previous academic study by Fousekis (2007) also explains the situation in the EU pork market invoking the idea of the "price club" and draws the similar conclusion that the situation in pork market is featured by multiple markets rather than represents the single EU market. Aforementioned studies and the current research show that the "price club" phenomenon survived over decades and bilateral links between club members remain strong even during such crisis as the COVID-19 pandemic. The conducted study found no evidence of asymmetric bipartite price transmission in the long term, but the short-term price dynamics in many analysed bilateral models is characterized by asymmetric price passes.

Indeed, the case of Lithuania shows that such dependence and the competition from the neighbouring main producing countries make small markets more vulnerable. Since Lithuania had joined the EU, the shrinking of the local pig faming was startling. The change of the trade focus from the Russian Federation to the EU market demanded large investments in new breeds and tools that empower the higher productivity, while the high pork price declined and remained below the EU average. Although profit cuts were critical, the situation was exacerbated by periodic animal diseases and other crises. As the Lithuanian pork market is characterized by the relatively low consumer loyalty to domestic agricultural products, it became a place of destination for countries with the high price-setting power that experience overproduction. As a result, the market power and profits of local producers declined, and the EU policy was inadequate to overcome these challenges and protect small markets. Indeed, the further research on the crisis-induced volatility of small markets and impact of main producing countries is critical to understand the short-term responses and ensure viability of pig farming in all Member States by proposing improved policy responses to crises.

CONCLUSIONS

Research results suggest that the COVID-19 pandemic period did not introduce fundamental price transmission changes in the long term. Modelling results also imply that the patterns of price drift in main producing countries differed, however, this feature is hardly an outcome of the COVID-19 pandemic. During the investigated period, the Lithuanian market retains dependence on the countries with high price-setting power and the "price club" membership with Poland, Germany, and the Netherlands. The bipartite models with these countries demonstrate the highest speed of adjustment to the equilibrium after the experienced price shock. In fact, the membership of the small pig producing country in a "price club" of large markets that offer the EU market pork at prices below the EU average introduces negative prospects on the local business development. The Lithuanian market reacts to the dramatic price declines on highly competitive markets and the small market is forced to operate under unfavourable conditions that introduce losses and reduce investment opportunities.

ARDL models show higher F-statistic values of the bounds test, while NARDL models demonstrate symmetric price passes in the long run and do not confirm pandemic-induced impact on symmetric price passes. However, some countries had asymmetric price passes in the short-term dynamics during the COVID-19 period.

Given the fact that the selected research period includes various countermeasures that were applied during different time intervals of the pandemic, the patterns of price transmission could be influenced by the selection of period or econometric technique allowing to investigate more specific research questions. Thus, the promising direction of the research could be the price transmission analysis focused on the application of different countermeasures. The comparison of price transmission patterns during COVID-19 crisis with other types of crises could also improve the knowledge and assist in selecting better-targeted policy measures at the EU level.

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