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THE INVESTIGATION OF THE LITHUANIAN BEEF MEAT SUPPLY CHAIN

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Abstract

This paper aims to investigate the transmission of beef meat prices along the supply chain in Lithuania. A set of econometric techniques allows studying relationships between prices on the farm and at the retail store level during the period from 2010 to 2017. The Johansen co-integration test confirms the presence of the long-run co-movement of prices on upstream and downstream levels of the beef meat supply chain. In the short-run, the price on the farm Granger causes the development of prices on the downstream level and findings suggest an evidence of the price-setting leadership on the upstream level. The error correction model shows the adjustment of the analysed prices towards the equilibrium with a rate of speed 25%.

Key words**:** *beef, market, meat, price transmission, supply chain*

INTRODUCTION

During the period from 2010 to 2017, the Lithuanian cattle sector survived dramatic transformations, while the development direction of the same sector in the European Union (EU) differed. According to Eurostat, during the above-mentioned period, the number of live bovine animals in Lithuania decreased from 748.0 to 676.9 thousand heads, while the situation in dairy sector was even more dramatic: the population of dairy cows fell from 359.8 to 272.8 thousand animals.

However, according to Eurostat data, in EU-27 the opposite development direction was obvious and the number of live bovine animals increased from 87,387.2 to 88,367.8 thousand heads. It should be noted that the growth rate in EU-15 was slower and the number changed from 74,898.5 to 75,197.5, i.e., in fact, the growth rate in EU-12 was higher than in EU-15. The EU dairy sector also showed signs of the moderate enlargement, but the contribution of EU-15 countries was more significant. Over the period 2010–2017, the number of dairy cows in EU-15 increased from 17,552.5 to 18,188.8, while in EU-27 from 23,107.4 to 23,171.8. Thus, the shrinking of dairy sector in Lithuania goes in lines with a common development trend for EU-12 countries.

Although Lithuanian cattle sector is shrinking, the switch from dairy to meat production is obvious. The driving forces of this transformation become an important research objective. In fact, many important factors influence farmers' decision to stay in, start up or exit this business, for example, the outbreak of animal diseases, changes of business environment after access to the EU market, trade bans or restrictions, changes in the support model, input of food price spikes in growth of production cost, unfair purchase prices, and etc.

An important factor is a functioning of domestic supply chains. Although it covers many components, this paper focuses on vertical price transmission issues that could contribute to market efficiency problems and encourage exit from livestock production if farmers believe that other agricultural niches are more attractive.

The conducted literature review shows a huge academic interest towards research on vertical price transmission in dairy sector [22], while the research on beef meat price behaviour is not covered sufficiently.

The academic research on vertical beef meat price changes mainly targets the investigation of the situation in individual countries and evidences quite diverse situation around the world. The most recent research on beef meat price transmission covers studies of domestic chains in Costa Rica [14], Ireland [15], Hungary [1], France [15], Germany [15], Netherlands [15], Poland [13], Slovenia [3], Finland [16], Iran [18], the United Kingdom [15], USA [7, 8, 23], Australia [10], and etc.

A separate research direction covers studies that investigate the impact of particular factors on price behaviour. For example, [2] and [21] pay special attention to aftermaths of diseases on vertical price transmission and market efficiency failures, [17] investigates links between export price volatility, cattle prices paid to farmers, and marketing margins of exporters.

Studies on horizontal price transmission also bring valuable knowledge and contribute to the understanding of beef price development on regional level. The example of such studies is the analysis of price transmission between Chinese, Australian, and Southeast Asian markets [6].

The aforementioned research on price transmission covers quite diverse methodological frameworks allowing to investigate short- and/or long-run price behaviour (for instance, the Johansen co-integration and the Granger causality tests, autoregressive distributed lag models, different types of error correction models (ECM), including Bayesian multiple-regime vector ECM, and etc.). It should be pointed out that the most recent study on the evolution of methods is represented in [24].

This paper contributes to scientific studies adding the Lithuanian case of price transmission along the beef meat chain. It is important to note that previous Lithuanian case studies on beef meat supply chains mainly focused on the structure of supply chain and driving forces of changes, while the investigation of relations between prices on different chain levels was not covered.

Thus, the paper aims to investigate the transmission of beef meat prices along the supply chain in Lithuania. The results of this study create an important knowledge for policy makers constructing both national agricultural policy and the Common Agricultural Policy that provides the general framework for the EU agriculture.

The remainder of this paper is organized as follows. In the next section, we describe data and explain the methodology. Then, we discuss the empirical results. In the final section, we provide some conclusions, policy implications, and suggestions for the further research.

MATERIALS AND METHODS

Data. The estimation of vertical price transmission relies on weekly producer and retailer prices collected by SE 'Agricultural Information and Rural Business Centre' (AIRBC). Retail prices show an average price of ham with bones for the main supermarket networks in Lithuania, while the assessment of producer price relies on an average purchase price of bovine (young bulls) carcasses at enterprises for the conformation classes S–P. This paper investigates the period from January 2010 to December 2017 (Fig. 1).

Fig.1. Producer and retailer prices, Euro/kg
Source: AIRBC, own calculations.

Fig. 1 demonstrates that price fluctuations on retail level are more visible during the periods 2010–2011 and 2013–2015, while price changes on producer level are less dramatic. Although some periods with visible changes of the gap between producer and retailer prices could be identified, the overall development of price series, on the long term, does not show dramatic changes on the Lithuanian market.

Methods. Price transmission is analysed employing a set of econometric methods. Natural logarithms are used to overcome common statistical problems [4]. A first compulsory step is to examine whether the series are stationary or not. The Augmented Dickey-Fuller (ADF) test [5] allows judging about stationarity of price series and their position around the mean [19].

The next step examines the long-run relation (or the absence of co-movements) between beef meat prices on different supply chain levels. The absence of the co-movement alarms about possible market efficiency problems and reports about the deviation from the traditional price mark-up concept presuming that price changes at any level must be transmitted along the supply chain. The Johansen co-integration test [11, 12] verifies the co-integration or the absence of the long-term relation between producer and retailer price series. In this regard, the results of Trace and Maximum Eigenvalue tests are combined to draw conclusions.

The third step employs the Granger causality test [9] allowing to explore the direction of causality between examined series. The results of this test allow identifying a price-leading stakeholder or confirming the presence of the bidirectional causality when all stakeholders have similar impact on market in the short-run.

Finally, vector ECM is estimated in order to examine the speed of adjustment of producer and retailer prices on the Lithuanian market. The most recent developments of ECM types and their applications for price transmission estimation are described in [13, 24].

RESULTS AND DISCUSSIONS

Results. This section provides the main results of the conducted study on vertical beef meat price transmission at the Lithuanian market. The discussion on the main issues of the Lithuanian market efficiency and results of other studies related to the similar topic is provided.

First, the ADF test investigates the presence of unit root in beef meat producer and retailer price series. The results (Table 1) show that the analysed beef meat price series are non-stationary in levels; however, both producer (LPP) and retail (LRP) prices are stationary in first difference.

Table 1. Results of ADF tests for beef meat price series

Null hypothesis:		**LPP has a unit root**		**D(LPP) has a unit root**	
	Level	*t*-stat	Prob.	*t*-stat	Prob.
ADF test statistic		-0.1480	0.6321	-30.6176	0.0000
Test critical values:	1%	-2.5705		-2.5705	
	5%	-1.9416		-1.9416	
	10%	-1.6162		-1.6162	
		Lag Length: 1 (SIC, maxlag=17)		Lag Length: 0 (SIC, maxlag=17)	
Null hypothesis:		**LRP has a unit root**		**D(LRP) has a unit root**	
	Level	*t*-stat	Prob.	*t*-stat	Prob.
ADF test statistic		0.2390	0.7551	-7.7959	0.0000
Test critical values:	1%	-2.5712		-2.5712	
	5%	-1.9417		-1.9417	
	10%	-1.6161		-1.6161	
		Lag Length: 11 (SIC, maxlag=17)		Lag Length: 10 (SIC, maxlag=17)	

Source: Own calculations.

Secondly, the Johansen co-integration test without deterministic trend is run in order to verify the presence or absence of long run relationship between the investigated beef meat price series. The results of Trace and Maximum Eigenvalue tests complement each other and support the same conclusion (Table 2).

Table 2. Results of the Johansen co-integration test for beef meat price series

Null hypothesis	**Eigenvalue**	**Statistic**	**Critical Value (0.05)**	**Prob.**
	Trace test			
No CE*	0.0395	16.4140	12.3209	0.0098
At most 1 CE	8.89E-05	0.0361	4.1299	0.8764
	Maximum Eigenvalue test			
No CE*	0.0395	16.3779	11.2248	0.0057
At most 1 CE	8.89E-05	0.0361	4.1299	0.8764

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

According to the results of both tests, the null hypothesis of no co-integrating equations (CE) between producer and retailer price series can be rejected and *p*-values are significant at 1.0% level. In the longer term, both tests support the conclusion that beef

meat prices on upstream and downstream levels move together.

Thirdly, the horizon for the short-term relations of the investigated beef meat price series is studied applying the Granger causality test (Table 3).

Table 3. Results of the Granger causality test for beef meat price series

Hypothesis	F-Statistic	Prob.
LPP does not Granger cause LRP	7.5325	0.0006
LRP does not Granger cause LPP	2.6353	0.0729

Lags: 2
Source: Own calculations.

Based on the outcomes of the test, in the short term perspective, the causality goes from the farm to downstream beef meat supply chain level, while the leading stakeholder is producer.

Finally, the ECM is estimated to demonstrate the relations between retailer and producer prices.

Table 4. Estimation of ECM for beef meat price series

Co-integrating equation for Lithuanian case	
LRP(-1)	1.0000
LPP(-1)	-0.3803 (0.0644) [-5.9018]
Error Correction:	D(LRP)
ECT	-0.2468 (0.0462) [-5.3443]

Source: Own calculations.

The estimated Error Correction Term (ECT) value shows that retailer price adjusts to the equilibrium at the speed of adjustment 24.7%.

Discussion. The cross-country comparison of achieved research findings with other countries identifies both similarities and differences; thereby the price behaviour in individual countries, such as Lithuania, makes results a valuable contribution to academic discussion.

In Lithuania, as in the case of most studies the unit root test on raw data evidences that beef meat prices are not stationary. The similar results were found for the Australia, China, Costa Rica, Indonesia, Hungary, Finland, Vietnam, and the USA [1, 6, 14, 16, 23]. However, the Slovenian case [3] provides an interesting outlook on the issue of stationarity. The study identifies both stationary and non-stationary beef meat price series during the selected periods and argues that in case of price transmission analysis the stationarity is not a feature of price variable, but rather an attribute of the sample selected for the current research. Thus, it underlines the significance of data properties and justifies differences in findings of individual studies.

During the period from 2010 to 2017, the Lithuanian beef meat price series are co-integrated in the long-term perspective. The similar behaviour was found in [3, 16]. Hence, the case studies in other countries show that the longer research period could result in higher number of co-integrating equations. For example, the study of the USA identifies even three vectors over the investigated period from 1974 to 2001 [23]. The absence of the co-movement or multiple breaks and co-integrating equations within a relatively short period show possible market efficiency problems that could alarm about failures of mark-up concept leading to the serious damage of welfare on the certain beef meat chain levels. The aforementioned structural breaks could be an outcome of different factors, for example, [21] and the case of the United Kingdom in [15] put stress on the influence of mad cow disease on the appearance of such breaks in beef meat price series.

Results of the Granger causality test allow focusing on the nature of the short-term relation between beef meat prices on different supply chain levels. In case of Lithuania, in the short run, producers are responsible for price changes. This finding goes in lines with previous research for beef sector [1, 10] and an argument that farm prices should lead the changes of retail prices [10].

According to the conducted literature review, the selection of the research model depends on the nature of investigated data and research objectives. Different types of error correction models remain among the most common econometric techniques applied in price transmission studies. Autoregressive distributed lag models [8, 13] and relatively new and promising copula-based analysis [7] are also widely applicable techniques allowing to investigate the behaviour of price series. Yet this list of methods is not final.

The more detail description of wide range of applied models and their application peculiarities is provided in [13, 24].

Lithuanian study relies on ECM; however, the cross-comparison of the analysed case studies [1, 3, 13, 14, 15, 16, 18, 23] with the results of the previously conducted research shows that the models established for individual countries differ significantly. Even results for the same country will strongly depend on the selected time period, data frequency, and included into analysis framework stakeholders.

CONCLUSIONS

The results of the Johansen co-integration test do not highlight serious market efficiency problems, because Lithuanian beef meat prices on producer and retailer levels move together in the long term.

However, in the shorter term, the Granger causality test does not confirm the bidirectional beef meat price movement between upstream and downstream levels. In the Lithuanian case, the one-way causality comes from the farmer that produces beef meat to the downstream level of the supply chain, while the hypothesis of absence of Granger causality for the opposite movement is not rejected. This result does not challenge for any particular action protecting the upstream level of the supply chain, because the welfare of farmers is not violated.

ECM estimation shows that the beef prices on domestic market returns to the general equilibrium at the speed rate of 24.7%.

Hence, some notes concerning the further necessary academic research could be done. According to the previous studies, the number of stakeholders included into the analysis of the supply chain is an important factor improving the knowledge about the situation. Consequently, a more detailed investigation could capture the hidden problems of the market. For example, [20] link market efficiency with price transmission asymmetry. Furthermore, studies on (a)symmetric behaviour along the beef meat supply chain or policy-orientated regimes-dependent price behaviour investigations with a focus on the impact of particular factors could assist in the development of the well-functioning cattle sector and beef meat supply chains in the EU.

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