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Asymmetric price transmission analysis in the Czech pork market

Analýza asymetrické cenové transmise na českém trhu vepřového masa

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ABSTRACT

The paper examines the characteristics of farm, processor and consumers (retail) price relationship within the Czech pork market. Last years the farm prices of pork meat are volatile comparing to processors and consumers (retail) prices. In these conditions the analysis of the character of price transmission becomes an actual issue. The paper employs the pre-cointegration, cointegration approach and the coefficients of price transmission elasticity for testing asymmetry in the transmission of farm pork price changes to changes in the processor and retail price. In this analysis monthly farm, processor and retail prices of pork and pork products encompassing the period from January 2006 to September 2017 were used. For the analysis the products with low value added (pork meat) and higher value added (pork ham and pork salami) were investigated. Empirical results of applicated approaches suggest that in the short-run, the processor's and consumer's price responds differently to the increase and decrease of farm price and processor's price, accordingly. Moreover, the evidence of different speed of price long-run adjustment was proved. The results proved the existence of price transmission asymmetry, and besides, this fact is pronounced more significant in the second stage of agri-food chain, i.e. in the processor-retailer relationship.

Keywords: error correction model, pork products, price asymmetry, price transmission elasticity

ABSTRAKT

Článek se zabývá analýzou charakteru cenového přenosu mezi cenou zemědělských výrobců, cenou potravinářských výrobců a spotřebitelskými cenami na trhu s vepřovým masem v České republice. V posledních letech jsou ceny zemědělských výrobců vepřového masa více volatilní ve srovnání s cenami zpracovatelů a spotřebitelskými cenami. Za těchto podmínek se analýza charakteru cenového přenosu stává aktuální. V článku jsou využity předkointegrační a kointegrační přístupy k testování asymetrického cenového přenosu. Dalším nástrojem testování cenové asymetrie jsou koeficienty elasticity cenové transmise mezi zemědělskými podniky, zpracovateli a obchodními řetězci. Analýza využívá měsíční ceny zemědělských výrobců jatečných prasat, ceny potravinářských výrobců a spotřebitelské ceny vepřového masa a výrobků z vepřového masa za období od ledna 2006 do září 2017. V rámci analýzy byly zkoumány produkty s nízkou přidanou hodnotou (vepřové maso) a vyšší přidanou hodnotou (vepřová šunka a vepřový salám). Empirickými výsledky bylo prokázáno, že v krátkodobém časovém horizontu cena zpracovatelů a spotřebitelská cena reaguje odlišně na zvýšení a snížení cen zemědělských výrobců a zpracovatelů. Navíc byl prokázán rozdíl v rychlosti při návratu ceny k rovnovážnému stavu. Výsledky naznačují existenci asymetrie v přenosu cen mezi jednotlivými úrovni vertikály, přičemž, tato skutečnost se projevuje výrazněji na druhé úrovni zemědělsko-potravinářské vertikály, tj. ve vztahu mezi zpracovatelem a obchodníkem.

Klíčová slova: cenová asymetrie, elasticita cenové transmise, model korekce chyby, vepřové maso

INTRODUCTION

The analysis of price transmission in the pork market has not been given sufficient attention. Abdulai (2002), using the cointegration threshold test, analyzed the transfer of prices between the producer and retailer on the pig meat market in Switzerland. The author found the presence of asymmetric transmission between these two levels. Using the endogenous break date estimation procedure, Adachi and Liu (2009) identified four breakpoints in the retail-farm price relationship in the pork market in Japan. Similar empirical results have been demonstrated in the U.S. pork market (Boetel and Liu, 2010; Gervais, 2011). Farm-retail price transmission in the Hungarian pork market was found to be asymmetric in the long term (Bakucs and Ferto, 2005), but asymmetric in the short term (Bakucs and Ferto, 2009).

Market power is one of the major factors causing asymmetric transmissions in the pork market. For example, Gervais (2011) showed that the oligopsonic power of processors is the main cause of asymmetric price transmission in the agri-food chain. The long-term asymmetric transmission of Swedish meat industry prices is also caused by market power (Karantininis at al., 2011). Other factors, related to asymmetric price transmission, include adjustment costs, inflation, state intervention and inventory management (Bakucs, 2013).

For the Czech Republic Lechanová (2006) in the market of meat (pork, beef and poultry), Lechanová and Novák (2006) in the market of milk, yogurt and cheese, and Dudová and Bečvářová (2015) in the market of milk and butter, proved market power existence on the level of processors and retailers using multiple-equation specification and coefficients of price transmission elasticity. These studies used pre-contegration approach to asymmetric price transmission analysis. Cointegration methods (Vector Error Correction model-VECM) was applied by Čechura and Šobrová (2008) in the market of pork meat and Rumánková (2016) in the market of soft wheat. Although there are few studies focused on analysis of asymmetry of price transmission in the pork agri-food chain in the Czech Republic, only one of them deals with testing of price time series and apply cointegration approach to price asymmetry analysis.

The objective of this paper is to analyse the character of price transmission and to identify the presence of price transmission asymmetry among the individual segments of the pork agri-food chain in the Czech Republic. The analysis is divided up into three partial chains, specifically the following:

- slaughtering pigs (farmers price - FP) – pig ham (processor price - PP) – pig ham (consumers price - CP)
- pork salami (PP) – pork salami (CP)

The research questions to be addressed are:

(1) What is the character of price time series for pork and pork products market?

(2) Are there any inequalities in the nature of vertical price transmission among the different levels of agri-food chain in the pork market?

This paper compares the differences in retail price changes from the magnitude perspective. Price adjustment are supposed to be asymmetric in the sense that responses to price increases are different than responses to price decreases. Monthly data of slaughtering pigs' prices (FP), and processor and retail pig ham (PP and CP), and pork salami prices (PP and CP) over the January 2006 to September 2017 for the CR was used. First, the main econometric methods used to test for the presence of asymmetry were introduced. Then several tests are conducted to determine the specific econometric model for each commodity based on time series properties. Third, the estimated regression coefficients associated with processor and retail price increases vs. decreases to investigate whether price asymmetry exists at pork market were compared.

MATERIALS AND METHODS

Asymmetric Price Transmission (APT) evaluation methodologies

Following Meyer and von Cramon-Taubadel (2004), methods for identifying asymmetric price transmission

can be divided into pre-cointegration and cointegration approach. There have been a variety of modeling techniques used to test for the presence and degree of asymmetric price transmission. In this section, the methods used in this paper are introduced.

In the following, P_t^{out} is a firm's output price in period t. Furthermore, P_t^{out} is caused by P_t^{in}, the input price at time t. Assuming symmetric and linear price transmission, the following equation can be used:

$$P_t^{out} = \alpha + \beta_1 P_t^{in} + \mu_t \quad (1)$$

In the case variables are not cointegrated, VAR model for the APT testing can be used:

$$\Delta P_t^{out} = \alpha + \beta \Delta P_{t-1}^{out} + \sum_{j=1}^{K} \left(\beta_j^{+} D^{+} \Delta P_{t-j+1}^{in}\right) + \sum_{j=1}^{L} \left(\beta_j^{-} D^{-} \Delta P_{t-j+1}^{in}\right) + \gamma_t \quad (2)$$

where D_t^+ and D_t^- are dummy variables with $D_t^+ = 1$ if $P_t^{in} \geq P_{t-1}^{in}$ and $D_t^+ = 0$ otherwise; $D_t^- = 1$ if $P_t^{in} \geq P_{t-1}^{in}$ and $D_t^- = 0$ otherwise. By means of these dummy variables, the input price is split into a variable, that includes only increasing input prices and another variable that includes only decreasing input prices. Thus, two input price adjustment coefficients are estimated, that is β_1^+ for increasing input price phases and β_1^- for the decreasing input price phases. Symmetric price transmission is rejected if β_1^+ and β_1^- are significantly different from one another, which can be evaluated using F-test.

In the paper of Hanh (1990) the former approach was generalized as one of the family of pre-cointegration approaches. Following cointegration approach moreover includes so-called error correction term (ECT). One of the conditions using cointegration methods is that non-stationary price variables P_t^{out} and P_t^{in} are cointegrated.

Von Cramon-Taubadel and Loy (1996) suggest the model where ECT and ΔP_t^{in} can be split into positive and negative components to allow for more complex dynamic effects:

$$\Delta P_t^{out} = \alpha + \sum_{j=1}^{K} \left(\beta_j^{+} D^{+} \Delta P_{t-j+1}^{in}\right) + \sum_{j=1}^{L} \left(\beta_j^{-} D^{-} \Delta P_{t-j+1}^{in}\right) + \phi^{+} ECT_{t-1}^{+} + \phi^{-} ECT_{t-1}^{-} + \gamma_t \quad (3)$$

where ECT is split into positive and negative components (i.e. positive and negative deviations from the long-term equilibrium - ECT^+ and ECT^-.

For the numerical expression of the intensity of price transmission, the coefficient of elasticity of price transmission is most often used (EPT). EPT between two levels of food chain can be defined (Mc Corriston, 2002):

$$EPT = \frac{\frac{\partial P^{in}}{pin}}{\frac{\partial P^{out}}{pout}} = \frac{\partial P^{in}}{\partial pout} \cdot \frac{pout}{pin} \quad (4)$$

As mentioned above, market power in individual food chain level may influence price transmission, as a result of the existence of market power, when there is no complete transfer of price changes from the level of agricultural markets to the final consumer. Using the price transmission elasticity coefficient, it is possible to assess the market power in individual markets of a given food chain.

Description of the pork price data

The section provides an overview of price developments along the food supply chain, i.e. the agricultural sector (farm-gate price), the food industry (food processor price, factory-gate price) and the retail industry (food consumer price).

The data used in the analysis are monthly price data for pork and pork products covering the period January 2006 – September 2017 with the distinction on pork products with lower (slaughtering pigs, pig ham) and higher (pork salami) value added. Farmers price is represented by the price of slaughtering pigs paid to farmers (CZK/t). Processor and consumer prices are represented by ham (hind legs, CZK/kg) and pork salami (CZK/kg) price. The figures come from Czech Statistical Office.

The analysis of visual price development, made in the first step of the research, carried the following results (Figure 1, Figure 2):

- Agricultural prices are volatile: over the period considered, slaughtering pig prices have experienced seasonal cycles and two 2-3-year cycles of price increase and price decrease with significant magnitude – the maximum price in the cycle being almost 42% higher than the minimum price. The volatility at the farm level has raised the concern as to the existence

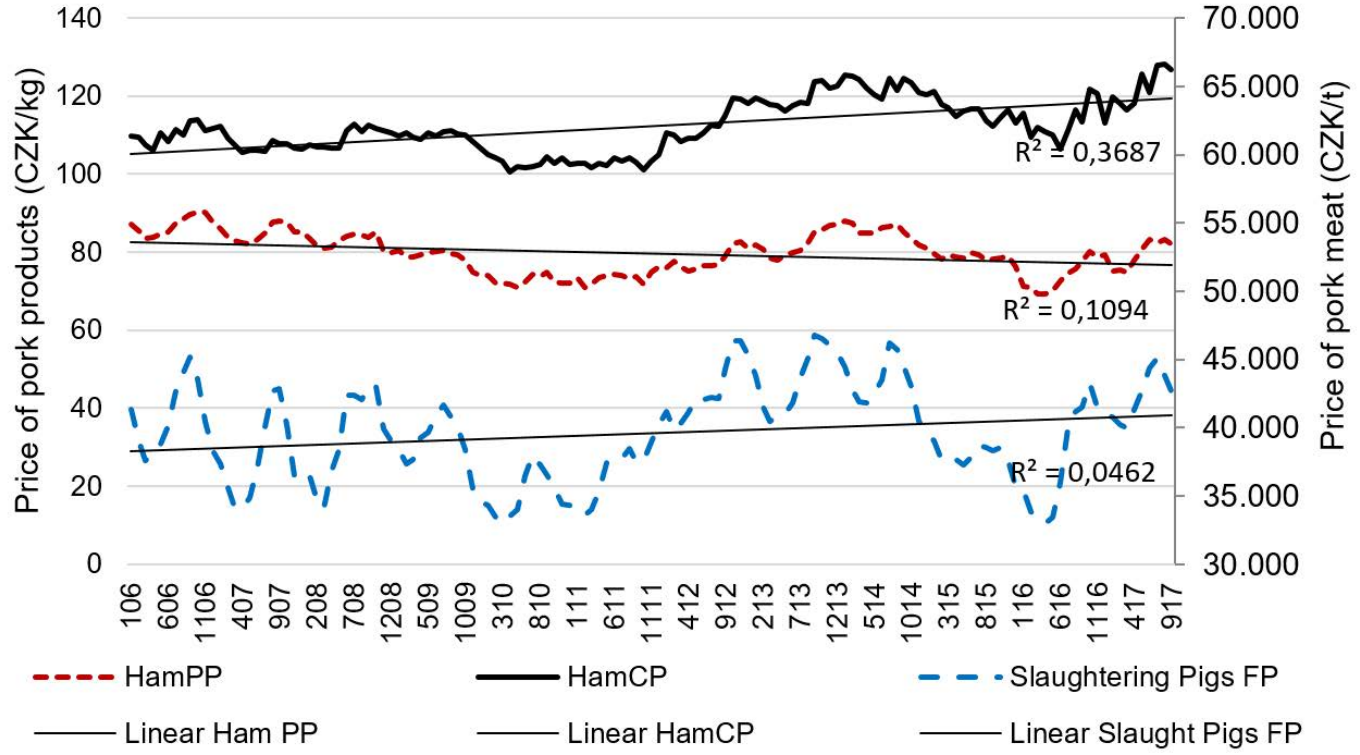

Figure 1. Price development of slaughtering pigs and pork ham (Source: Czech Statistical Office)

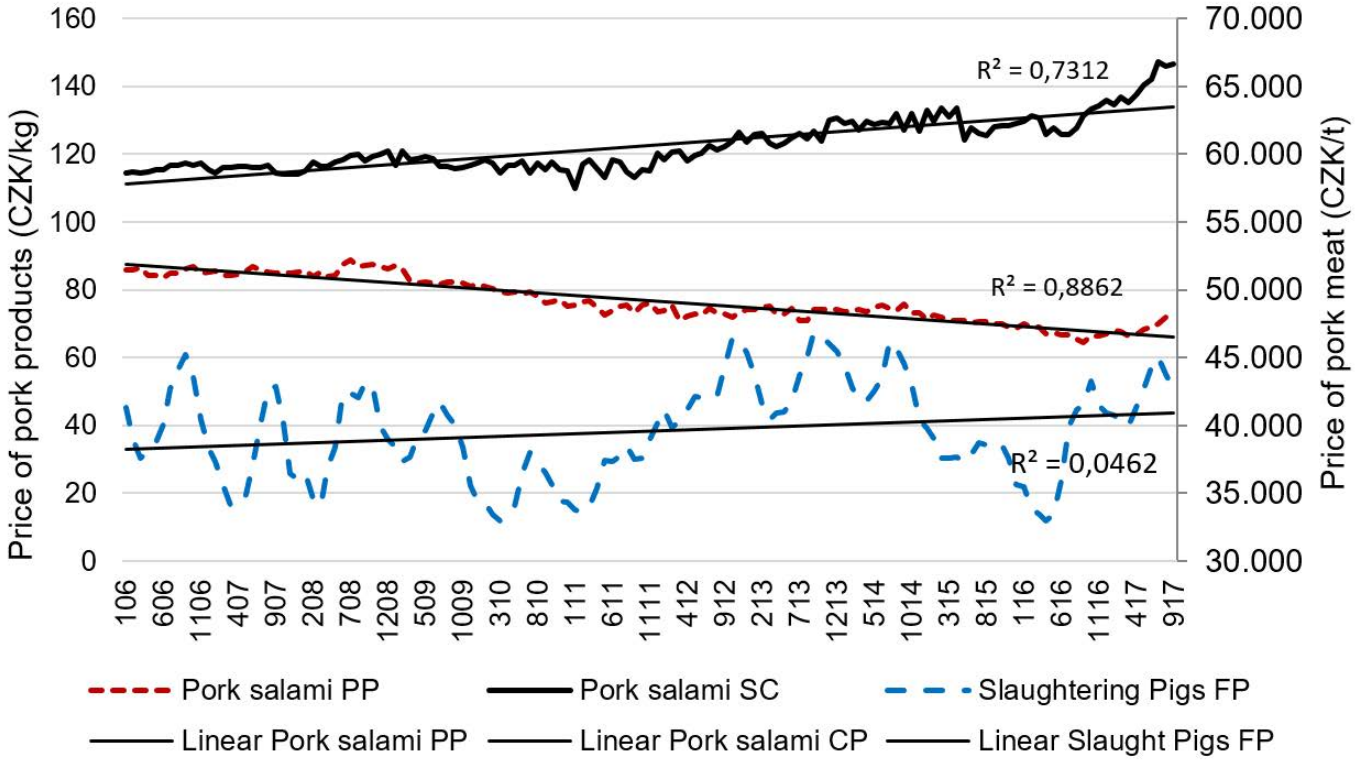

Figure 2. Price development of slaughtering pigs and pork salami (Source: Czech Statistical Office)

of asymmetric transmission between retail and farm price changes and the possible relative welfare impacts on consumers, pig farm, processing firms, and retailers.

- Processors and consumers prices of ham (hind legs) are more stable comparing to farm prices: over the same period, variations in processor and consumer prices have been much smoother. Consumers prices have an increasing total trend comparing to processors price. Processor prices have slightly decreasing trend within the analysed period.
- Processor and consumer prices of pork salami have different linear trends. The increase of consumers price within the analysed period is more pronounced comparing to processors price, and the gap between these two prices are growing in course of time.

RESULTS AND DISCUSSION

Time series testing

Following statistical tests were applied to identify the specification of the model for asymmetric price transmission testing.

The Augmented Dickey-Fuller (ADF) Test

The Augmented Dickey-Fuller (ADF) test was used to check on the stationarity of P_t^{out} and P_t^{out} price series. Under the ADF test the null hypothesis is that the price series are non-stationary. If a variable is stationary, it is integrated of order zero, *I(0)*. Similarly, if its first difference is stationary, then the variable is integrated of order one, *I(1)*. The final lag-length is determined via Akaike Information Criterion (AIC) values. In most cases the optimal leg-length is 1 (1 lagged variable is included into the model).

For all variable stationarity condition is not hold. However, variables are stationary in their first differences, i.e. all variables are *I(1)*.

Johansen Cointegration Test

The concepts of cointegration and the error correction mechanism are very closely related. Error correction terms are included if P_t^{out} and P_t^{out} are cointegrated. Johansen's test to check for cointegration was used. The number of cointegrating vectors between two variables can be at most one. The null hypothesis under the Johansen test is that the rank (*r*) of cointegrating vectors between retail and farm prices is zero (i.e. r = 0), which implies non-cointegration.

The results of Johansen's cointegration tests show that only farm price of slaughtering pigs and processor price of pig ham were found to be cointegrated. The relationships between analysed prices have different behaviour. According to the results of cointegration test, different methods for the relationships must be applied. For the relationship with cointegration analysis can be applied, whereas in the case of absence of cointegration pre-cointegration approach must be used. However, for unification of the methodology, both approaches, asymmetric VAR model as well as asymmetric VECM, were estimated for analysed relationships.

Testing for price asymmetry

Testing for APT based on pre-cointegration analysis

For VAR models the response of PP of pig ham to the growth of FP of slaughtering pig price is more pronounced than the response to the decrease of FP of slaughtering pigs price (Table 1). Is the case of the delayed variables the response to price decrease is more pronounced than the reaction to price growth? For the processor and consumer price of pork ham was found the higher scope of the reaction of consumers price to the growth of processor price comparing to the reaction to price decrease. In the case of ham salami for all estimated models, there is a significant reaction of CP to the increase in PP of pig ham. However, the reaction to the decline is negative, that can be explained by the different developments in these two prices. This finding means that in the case of decreasing of processor price of pork salami a retailer does not incline to reduce the price.

Table 1. Estimation results of asymmetric VAR model

Relation	Coefficient	Relation	Coefficient
Slaughtering pigs			
Regression of Processor price and Farm price			
Positive change in FP	0.0006007***	Positive change in FP L1	0.0003378***
Negative change in FP	0.0004694***	Negative change in FP L1	0.0004346***
Pig ham			
Regression of Consumer price and Processor price			
Positive change in PP	0.6151943***	Positive change in PP L1	1.137468***
Negative change in PP	0.0636769	Negative change in PP L1	0.2478333
Pork salami			
Regression of Consumer price and Processor price			
Positive change in PP	0.5761365*	Positive change in PP L1	0.2085557
Negative change in PP	-0.1092555	Negative change in PP L1	0.3931072***

***, * denotes significance at the 1% and 10% level, respectively. Source: own processing

Testing for APT based on cointegration analysis

Coefficients of ECM proved long-run and short-run adjustment in most products cases (Table 2). Error Correction Term (ECT) displays speed of adjustment towards equilibrium. Negative and significant ECT parameters indicate a long-run causality running from P_t^{in} to P_t^{out}. In the case of negative ECT change its parameter is positive. It implies that the process is not converging in the long run. Thus, there are some instabilities. On the one hand, it could have meant that there are some specification problems with the model itself, or maybe there are some data issues. On the other hand, it could also be an indication of structural changes during the analysed period. In the case of estimated models not all coefficients have correct sign, that can be explained by the absence of cointegration relationship. Nevertheless, the results of the parameters estimation bring interesting findings.

The reaction of pig ham PP to the increase of slaughtering pigs FP is more pronounces comparing to price decrease. The ECT has no right sigh in the case of price increase and insignificant in the case of price decrease.

The CP response to a change in the PP of pig ham in the ECM model also shows more significant scope of reaction to price increase. The response to price decrease, in opposite, is negative and insignificant (as in the case of VAR mode). The ECT is significant only in the case of a positive price variation from the equilibrium price.

In the case of pork salami for all estimated models, there is a significant reaction of CP to the increase in pork salami PP. However, the reaction to the price decrease is negative, that can be explained by the different development of these two prices. Hence there is an evidence of positive asymmetric price transmission (following a convention employed by Peltzman, 2000) between the level of agri-food chain exist.

Table 2. Estimation results of asymmetric VEC model

Relation	Coefficient	Relation	Coefficient
Slaughtering pigs			
Regression of Processor price and Farm price			
Positive change in FP	0.0007026***	Positive ECT	0.0245019*
Negative change in FP	0.0006518***	Negative ECT	-0.0860556
Pig ham			
Regression of Consumer price and Processor price			
Positive change in PP	1.099512***	Positive ECT	-0.2446869***
Negative change in PP	-0.2209242	Negative ECT	0.1298284
Pork salami			
Regression of Consumer price and Processor price			
Positive change in PP	0.2212175	Positive ECT	-0.0343229
Negative change in PP	-0.2294632	Negative ECT	-0.1307215*

***, * denotes significance at the 1% and 10% level, respectively. Source: own processing

Elasticity of price transmission

The problem of elasticity estimation in the chain of pork meat is that pork products are not 100% composed of pork meat. Costs of other materials as well as costs of energy and labour have impact on pork products price. Nevertheless, coefficients of elasticities bring their input to asymmetry analysis because they let to assess the direction of price formation.

The results of the part of the analysis of price transmission in the supply (above the diagonal) and the demand (below the diagonal) direction, where the intensity of the price transmission is expressed by the coefficient of elasticity of the price transmission, bring the following findings.

In the first stage of the pork chain in the producer (farmer) – processor relationship the inelastic price transmission of the pig ham can be identifies, which means that the change in the input price is not fully transmitted to the output price (Table 3). On the second stage the elastic price transmission (EPT = 1.06) between the processor and retailer exists, which means that the change in output price is transferred by more than one unit to the price in the previous stage of pork chain. Appears, that retailer has an impact on the producer's price, apparently through the processor. On both levels of pork chain slaughtering pigs – pork salami, EPT is negative for most relations, i.e. the prices move in different directions that is consistent with previous results.

These results are partially supported by the results of other authors in the Czech Republic for pork and other products. For pork Lechanová (2006) found different results based on price transmission elasticity coefficients. However, the inconsistency can be explained by different time periods analysed. The situation on the market of pork meat has changed after the EU accession. In the analysis of Dudová and Bečvářová (2015) different reaction of downstream market to positive and negative

Table 3. Hydrochemical parameters in aquaponics system

	Slaughtering pigs	Pig ham PP	Pig ham CP		Slaughtering pigs	Pig salami PP	Pig salami CP
Slaughtering pigs	x	0.878	1.055	Slaughtering pigs	x	-0.139	0.596
Pig ham PP	0.447	x	0.509	Pork salami PP	-0.122	X	-1.013
Pig ham CP	0.467	0.439	x	Pork salami CP	0.267	-0.519	x

Source: own processing.

milk and milk products price changes was proved. Novák (2007) verified asymmetric price transmission for milk and yoghurt. For cheese unequal reaction to positive and negative price change was not evidenced.

Most publications on asymmetric price transmission (APT) refer to non-competitive market structures as an explanation for asymmetry. Particularly in agriculture, where farmers are at the beginning and consumers are at the end of the marketing chain, it is often supposed that imperfect competition at the processing and retailing level allows to practice market power (Kinnucan and Forker, 1987; Miller and Hayenga, 2001; McCorriston, 2002; Lloyd et al., 2003). It is generally expected that this will result in positive APT. Scherer (1980) argues that price inflexibility may exist in industries characterized by nonprice competition, high market concentration ratios, and large advertising expenditures. Price transmission elasticity implies that the processing stage may exercise oligopsonic power (Čechura and Šobrová, 2008).

On the one hand, in most cases, the assumption of market power existence is presented as obvious, without rigorous theoretical and practical support (Meyer and von Cramon-Taubadel, 2004). On the other hand, it is not clear a priori whether market power will lead to positive or negative asymmetry (Bailey and Brorsen, 1989).

CONCLUSIONS

One of the major features of price transmission along the pork food supply chain is the apparent stability of processor's and consumer's price changes compared to the volatility of prices of slaughter pigs. Processor's prices and consumer's prices exhibit diverging trends. While consumer's prices principally showed relatively continued increase, processor's prices exhibited either less significant increase or even tended to decrease in the long run, widening the gap between agricultural and food prices.

According to price determination theory, processor's prices define the consumer's (retail) prices; that is price transmission flows downward along the supply chain and the direction of causality runs from upstream to downstream sectors. However, there are evidences in the literature, that this development can be different.

Empirical results of applicated approaches, pre-cointegration and cointegration, suggest that in the short-run, the processor's and consumer's price responds differently to the increase and decrease of farm price and processor's price, accordingly. Moreover, the evidence of different speed of price long-run adjustment was proved. The price asymmetry can be explained by the measure of market power. These results are consistent with results of previous studies (Čechura and Šobrová, 2008; Dudová and Bečvářová, 2015). Coefficient of price transmission elasticity is elastic only on the level of processor-consumer relationship.

With respect to the fact that evidence of asymmetric price transmission was found, further investigations need to be done about detection the reasons of inequalities and asymmetries. The reasons can be related to market power, inefficiencies in the market structure of the chain, specific adjustment costs, perishable character of food products, imperfect market information and public intervention.

This points towards some policy issues, notably the fact that governments should be aware of the effect of market power of intermediaries and the role they play in influencing the price received by farmers, and therefore the gains from trade liberalization in agricultural markets. Abuse of monopsony power by large intermediaries in agricultural markets can be particularly harmful for perishable agricultural commodities when farmers have no enough time and bargaining power to find more advantageable sales channel and market for their production.

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