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The evidence of asymmetric price adjustments

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Abstract: The paper provides insights into the price transmission of dairy sector in Slovakia and examined the nature of price adjustments and market efficiency along the vertical chain. The results were based on monthly prices covering the time period 2004–2012. The farm gate prices of raw cow milk Q class and I. class were distinguished and the comparison was made also between the prices of semi-fat milk and durable semi-fat milk. The methodological approach called the Vector Error Correction model (VECM) was applied in the paper due to the fact that the Johansen co-integration test revealed that the time series were co-integrated, meaning that the long run relationship existed between them. The obtained results were in line with the recent empirical findings that have shown that the market power on the demand side, the imperfect market structure existence and also the fact that milk is a highly perishable commodity might be the explanations for the revealed asymmetric price adjustments.

Key words: asymmetry, co-integration**,** milk, price transmission, VECM

Matošková (2011) stated that price refers to a motivation power of the supply and demand development in the world markets. The low demand elasticity of agri-food products causes that the small production volume variability might result in significant changes (shocks) in supply and demand and thus also in the price levels. Additionally, the degree of the price transmission influences the price volatility. The empirical studies on price transmission measure the degree to which commodity prices at the geographically separated markets or at different levels of the value chain share common long-run price information (Amikuzuno and Ogundari 2012). According to Matriz (2008), the interaction of prices along the supply chain (vertical price transmission) provides insights into the efficiency of a commodity's market structure, the welfare distribution in an industry, as well as the existence of the market power among the key players. Vavra and Goodwin (2005) indicated that typical features of the vertical price relationships are the magnitude, speed and nature of the adjustment through the supply chain to market shocks generated at different levels of the marketing process.

Bakucs et al. (2013) explained several reasons for the existence of the asymmetric price transmission and stated that the price transmission asymmetries are more likely in the presence of the retailers' market power. Additionally, they demonstrated that asymmetries are present in sectors with a higher number of fragmented farm producers and less likely to exist with a more concentrated farm structure. Distortions in the price relationship between retailers and suppliers are more likely to appear in the presence of the regulations limiting the price competition between retailers. Their results also revealed that the more balanced is the bargaining power of farmers and retailers, the more likely one should observe the symmetric price transmission. Cutts and Kirsten (2006) determined that the presence of search costs in local imperfect markets, and a faster response of firms to decreases the profit margins than they do in the case of increases are the reasons for the asymmetric price adjustments.

To illustrate the above, Kinnucan and Forker (1987) found that the retail prices were more sensitive to increases in the farm prices than to decreases in the farm prices. Falkowski (2010) detected that the price transmission between the farm and retail levels was affected by both the short-run and long-run asymmetries and the behaviour of prices in the fluid milk sector in Poland is consistent with the use of market power by the downstream sector. Opposite results were investigated in the case of milk prices in Hungary, where no asymmetry was

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found in either the long- or short-run. The differences between Poland and Hungary might be due to the differences in the local sector's development during the transition. The other explanations supporting the empirical results are considered to be the differences between the dairy chain structures (market structure at the processing level) and the role of the FDI (Bakucs et al. 2012). Capps and Sherwell (2005) showed the evidence of asymmetry in the farm-retail price transmission and concluded that the price transmission elasticities in conjunction with the raising farm prices generally are larger than the corresponding elasticities associated with the falling farm prices in the US. Additionally, Stewart and Blayney (2011) studied the price transmission of the whole milk and cheddar cheese over the food crisis from 2007–2009 in the US and found out that the farm and retail prices moved together on a long run relationship in both cases. They detected that the milk price shocks were transmitted asymmetrically to the retail store prices; therefore, the profits might be gained or lost in the short run. Holm et al. (2012) analysed the vertical price relationship between the wholesale and retail market for milk and butter in Germany and their research indicated significant asymmetric price adjustments.

The aim of this paper is to investigate the price transmission along the marketing chain in the milk sector. The analysis of the vertical price transmission will be applied on the farm gate (FP), processor (PP) and retail milk prices (CP). With respect to the aim of the paper, the following hypotheses were formalized and reviewed:

(1) There is an evidence of a long-term simultaneous relationship between the farm-gate price and the processor price in the selected agri-food chain;
(2) It can be assumed that the chain is demand driven, meaning that the processors have a stronger position in the market and the bargaining power compared to producers;
(3) It can be stated that the chain is demand driven, meaning that the retailers have a stronger position and the bargaining power than processors;
(4) There is an evidence of the asymmetric price transmission in the dairy sector.

MATERIALS AND METHODS

The paper examines the existence of the asymmetric price transmission across market levels in the Slovak dairy sector. The monthly price data of Slovak farm, wholesale, and retail markets were collected for milk from the Research Institute of Agricultural and Food Economics online database www.vuepp.sk and from the online statistical database SLOVSTAT (www.statistics.sk). The following data cover the time period from January 2004 to December 2011:

– the farm-gate price of raw cow milk I. class (FPI), the farm-gate price of raw cow milk Q class (FPQ), the processor price of semi-fat milk in PE bags, the consumer price of pasteurized semi-fat milk; (EUR/l)
– the farm-gate price of raw cow milk I. class (FPI), the farm-gate price of raw cow milk Q class (FPQ), the processor price of durable semi-fat milk (1l box), the consumer price of durable pasteurized semi-fat milk (1 l); (EUR/l).

There are several different methods that could be performed for testing the asymmetric price transmission. The time series model refers to the most widely used method for testing the market power and the asymmetric price transmission in the agricultural economics literature and it is based on the assumption that the agricultural product included in the production process is the largest cost component of the final consumer good (Cutts and Kirsten 2006). The methodological approach called the Vector Error Correction model (VECM) is applied in the paper due to the fact that the co-integration has been detected between the examined time series, meaning that there exists a long-term equilibrium relationship between them (Čechura and Šobrová, 2008; Lajdová, 2013). Based on the Johansen test, two series are co-integrated, meaning that each variable is I(1) and a linear combination of the two variables is I(0) (Minot 2010). Jacobs and Wallis (2010) defined the VECM model as a convenient alternative form of the VAR model which provides an easy interpretation of and differentiation between the short-run and long-run implications of the model. Hassouneh et al. (2012) defined the following form of the bivariate VECM while analysing the two commodity prices P_{1t} and P_{2t}:

$$\Delta P_{1,t} = \alpha_1 + \alpha_{P1}\left(\alpha + P_{1,t-1} - \beta P_{2,t-1}\right) + \sum_{i=1}^{n} \alpha_{11}(i)\Delta P_{1,t-i} + \sum_{i=1}^{n} \alpha_{12}(i)\Delta P_{2,t-i} + \varepsilon_{P1,t}$$

$$\Delta P_{2,t} = \alpha_2 + \alpha_{P2}\left(\alpha + P_{1,t-1} - \beta P_{2,t-1}\right) + \sum_{i=1}^{n} \alpha_{21}(i)\Delta P_{1,t-i} + \sum_{i=1}^{n} \alpha_{22}(i)\Delta P_{2,t-i} + \varepsilon_{P2,t} \quad (1)$$

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Table 1. Johansen co-integration test (semi-fat milk)

	Hypothesized No. of CEs	Eigenvalue	Trace test	*p*-value	Lmax test	*p*-value
FPI-PP	1	0.015417	1.4760	0.2244	1.4760	0.2244
FPQ-PP	1	0.023287	2.0028	0.1570	4.9639	0.1570
PP-CP	1	0.0005724	0.048096	0.8264	0.048096	0.8264

Source: own calculations; trace test indicates 1 co-integrating equations at 5% level

where α and β are the parameters of the co-integration vector $\varepsilon_{P1,t}$ and $\varepsilon_{P2,t}$ are the white noise disturbances that may be correlated with each other, α_1, α_2, $\alpha_{11}(i)$, $\alpha_{12}(i)$, $\alpha_{21}(i)$ and $\alpha_{22}(i)$ are the dynamic short-run parameters, and α_{P1} and α_{P2} are the parameters that measure the rate at which the prices adjust to disequilibria from the long-run co-integrating relationship. This long-run relationship is given by the expression $(\alpha + P_{1,t-1} - \beta P_{2,t-1})$. The VECM indicates the speed of the adjustment parameters from the factor loading matrix (α) demonstrating the weakly exogenous prices and fundamentally the direction of the long run causality (Bakucs et al. 2012). The long-run exogeneity is tested by the significance of the error correction terms in the equations. The prices are expressed in logarithms for the price transmission analysis; the co-integration factor (β) is the long-run elasticity of the one price with respect to the second price. Thus, β is the long-run elasticity of price transmission. Kisaka et al. (2014) explained the method used by Prakash et al. (2001) that involves the assignment of a dummy variable, $d = 0$ if there is a positive disequilibrium and $d = 1$ if there is a negative disequilibrium. The asymmetric adjustment to the long-run equilibrium is then tested by imposing and testing zero restrictions on the dummies´ parameters.

The deviation of the markets from a state of equilibrium is examined by the application of the impulse-response analysis and the VECM model alpha vectors (Rumánková 2014). The evolution of economic impacts through the system is detected by an impulse response analysis. According to Saghaian et al. (2014), this function traces the effect of one standard deviation shock to one of the innovations on current and future values of the endogenous variables.

RESULTS AND DISCUSSION

This section focuses on the empirical analysis of the price transmission, thus the main interest is placed on the coefficient of the price transmission and identification of asymmetry in price adjustments. We present the Johansen co-integration test and the VECM approach and sum up the results related to the stated hypotheses.

Based on the Johansen test (Table 1), the variables FP of milk and PP of semi fat milk are co-integrated. The co-integration analysis discovered one co-integrating vector in the analysed relationships, thereby verifying and demonstrating the long run relationship between the processor price and the farm-gate price of raw cow milk in both quality classes during the analysed period. The trace statistics rejects the null hypothesis of no co-integration also between the PP and CP of semi fat milk and does not reject the null hypothesis that there is one co-integration relation between the variables. In this test, H_0: $r = 1$ is not rejected at the 5% significance level.

The Johansen test revealed that the variables FP and PP are co-integrated in the case of the durable semi-fat milk price. The co-integration analysis discovered one co-integrating vector also in the relationship between the PP and CP of the durable semi fat milk, thereby verifying and confirming the long run relationship between them (Table 2).

Table 2. Johansen co-integration test (durable semi-fat milk)

	Hypothesized No. of CEs	Eigenvalue	Trace test	*p*-value	Lmax test	*p*-value
FPI-PP	1	0.060479	5.7395	0.2194	5.7395	0.2190
FPQ-PP	1	0.068509	6.6711	0.1493	6.6711	0.1491
PP-CP	1	0.058962	3.7071	0.0542	3.7071	0.0542

Source: own calculations; trace test indicates 1 co-integrating equations at 5% level

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The hypothesis "There is an evidence of a long-term simultaneous relationship between the farm-gate price and the processor price in the selected agri-food chain" was not accepted. The analysis confirmed the long-term co-integration between the producer price of the raw cow milk and the processor prices. However, the relationship between the FPI and the processor price of the semi-fat milk is not simultaneous and the FPI price is weakly exogenous. The results also confirmed that there is no simultaneous relationship in the case of the FPQ and PP of the pasteurized semi-fat milk, meaning that the PP prices are weakly exogenous. Considering an analysis between the farm gate prices and the PP of the durable semi-fat milk, the results confirmed that the relationship is again not simultaneous. On one hand, the FPI was weakly exogenous, whereas the processors of the durable semi-fat milk seemed to have an impact on the producers of the raw cow milk in quality Q, while evaluating the relationship between the FPQ and PP of the durable semi-fat milk. Based on the results, the FPI is exogenous in both cases, meaning that the processor prices are influenced by the FPI in the long-run. Additionally, it can be also stated that the producers of the raw cow milk in the quality class Q are price takers (Table 3).

The alpha values show the speed of the reaction of the individual prices upon the deviation of the system from the state of equilibrium (Rumánková 2014). Concerning the speed of the convergence of the FPQ to the long-run equilibrium as a result of the price shock, about 9.7% of the disequilibrium is corrected within one month. The error correction coefficient shows that 5.6% in the CP of the semi-fat milk is corrected in one month. 10.6% of any price shock in the equilibrium is corrected in case of the processor prices of the semi-fat milk; however, the adjustment coefficient does not have an expected sign. Additionally, about 20.7% of the disequilibrium is corrected within one month due to the unexpected price movements in the case of the FPQ while testing the price transmission between the FPQ and PP of the durable semi-fat milk. Regarding the PP of the durable semi-fat milk, the ECT has a wrong sign (positive), meaning that that the short run price movements along the long-run equilibrium might not be stable even though the parameter is significant. The speed of the adjustment of 5.6% for the CP of the semi-fat milk is the weakest. To conclude, the corrections of prices indicate that the adjustment process is rather slow and the significant disruptions of the long-run equilibrium exist due to the fact that milk is a perishable commodity and spoils very easily and the costs of collecting, transporting and storage have an impact on the market situation. The lack of sufficient forage production, the state and the EU support measures may cause a slow adjustment process back to the equilibrium. A significant influence on the consumer prices of milk has also the economic crisis which leads to a slow-down of the consumption of milk and dairy products and the increasing import volumes (Table 3).

Table 3. VECM model

	Beta	Alpha	*p*-value for alpha
l_FPI	1.0000	0.044414	0.29075
l_PP (semi fat milk)	–1.4852	0.10580	0.01083
l_FPQ	1.0000	–0.097670	0.03064
l_PP (semi fat milk)	–0.87426	0.068182	0.26309
l_PP (semi fat milk)	1.0000	–0.079311	0.18314
l_CP (semi fat milk in PE bags)	–1.3099	0.056511	0.07793
l_FPI	1.0000	–0.071745	0.14679
l_PP (durable semi fat milk)	–1.5261	0.18611	0.00113
l_FPQ	1.0000	–0.20703	0.0002
l_PP (durable semi fat milk)	–0.80459	–0.059160	0.39041
l_PP (semi fat milk)	1.0000	0.28218	0.00040
l_CP (durable semi fat milk)	–2.4223	0.056366	0.22998

Source: own calculations

The results in Table 3 depict that the processor price of the semi-fat milk and the farm-gate prices have a positive relationship in the long run, meaning that 1% per cent change of the PP will lead to 1.49% per cent change in the FPI and to 0.87% cent change in the FPQ. The coefficients of the consumer price of the semi-fat milk show that for 1% change in the CP, the PP of the semi-fat milk will increase by 1.31%. The processor price of the durable semi-fat milk and the farm-gate prices show a positive relationship in the long-run as well. More specifically, 1% increase in the PP of the durable semi-fat milk will lead to 0.80% increase of the FPQ and 1.53% increase in the FPI in the long-run. The coefficient of the consumer price of the durable semi-fat milk determines a positive relationship with the processor prices of the durable semi-fat milk indicating that 1 per cent increase in the CP will lead to 2.42% increase in the PP of the durable semi-fat milk in the long term.

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The Beta transported vector in Table 3 also shows the nature of the long term relationship. The hypothesis "It can be assumed that the chain is demand driven, meaning that the processors have a stronger position in the market and the bargaining power comparing to producers" was accepted. The analysis detected an imperfect market structure, meaning that the oligopoly power is presented. The market power is on the demand side and the processors have a stronger position and bargaining power in comparison to the producers in both cases. Additionally, the hypothesis " It can be stated that the chain is demand driven, meaning that the retailers have a stronger position and bargaining power than the processors" was accepted in the case of the pasteurized semi-fat milk in the PE bags as well as the durable semi-fat milk. The imperfect market structure was specified; more specifically, the oligopoly power can be found in the market. Additionally, there is evidence that the retailers abuse their stronger market power.

According to the results obtained by including the dummy variable in the VECM, the vertical dairy sector chain showed the evidence of a symmetric and also asymmetric price transmission. The dummy variable technique was applied and the asymmetry was revealed between the PP and CP in all examined cases. Concerning the FP and PP prices, the dummy variable was not significant while testing the FPQ and PP of the semi-fat milk and the FPI and PP of the durable semi-fat milk, meaning that the adjustment from the PP prices to FP prices is symmetric. Regarding other cases of the FP and PP, the asymmetry was detected (Table 4).

The Impulse-response function was performed in order to illustrate the dynamics of the system and to determine the speed and the way of reaction of one variable if one standard deviation shock is given to the other variable. Concerning the one standard deviation positive shock which is given to the PP of semi-fat milk in the PE bags, the reaction of the FPI, FPQ and CP of the pasteurized semi-fat milk is positive to this shock in all examined periods. The same positive respond of the PP of the semi-fat milk is also illustrated if one standard deviation shock is given to the FPQ, FPI and CP of the semi-fat milk.

Table 4. Dummy variables

Variable	Coefficient	Std. Error	*t*-statistic	*p*-value
PP and CP of durable semi-fat milk				
D	0.0453382	0.0230798	1.9644	0.05985
D	0.0159552	0.00869682	1.8346	0.07038
FPQ and PP of durable semi-fat milk				
D	0.0225156	0.0117391	1.9180	0.05877
D	0.0468559	0.0147626	3.1740	0.00215
FPQ and PP semi-fat milk				
D	0.000133816	0.0129162	0.0104	0.99176
D	0.0593341	0.0158135	3.7521	0.00034
PP and CP of pasteurized semi-fat milk				
D	0.0514616	0.0149727	3.4370	0.00095
D	0.0159552	0.00869682	1.8346	0.07038
FPI-PP of durable semi-fat milk				
D	0.00541662	0.0141586	0.3826	0.70315
D	0.0243854	0.0143251	1.7023	0.09296
FPI-PP of semi-fat milk				
D	–0.0262489	0.0153145	–1.7140	0.09045
D	0.0263494	0.0144162	1.8278	0.07136

Source: own calculations

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Likewise, a positive response is measured in the FPI and FPQ if there is a shock given to the PP of the durable semi-fat milk. One standard deviation shock in the FPI will positively affect the PP of the durable semi-fat milk. On the other hand, the initial PP of the durable semi-fat milk will positively respond to a sudden change in the FPQ up to 7 months followed by a negative reaction in the long-run. The effect of a sudden shock in the CP of the durable semi-fat milk will cause a negative response of the PP of the durable semi-fat milk in all periods. There is an evidence of a positive effect on the CP of the durable semi- fat milk up to 15 periods while one deviation shock is given to the PP of the durable semi-fat milk. Afterwards, CP of durable semi-fat milk reacts again positively from 34 months. The most volatile reaction to shocks is experienced in the case of the durable semi-fat milk; mainly the PP and CP of the durable semi-fat milk (Annex).

CONCLUSION

The vertical price transmission analysis was undertaken based on the monthly data of the farm-gate prices of the raw cow milk in the quality class I., the farm-gate prices of the raw cow milk Q class, the processor prices/consumer prices of the pasteurized semi-fat milk in the PE bags, the processor prices/consumer prices of the durable semi-fat milk. The Johansen co-integration test revealed that the examined time series were co-integrated, meaning that there existed long run relationships between them. Based on the results of the VECM, the processor prices were influenced by the farm gate prices of the raw cow milk I. class and the retail prices had an impact on the processor prices in the long-term. On the other hand, the producers of the raw cow milk in the quality class Q were price takers. This could be explained by the difference in the share of the FPQ in the total purchase of the raw cow milk which increases in the case of the supply scarcity and diminishes due to the market surplus of the raw cow milk (Lajdová and Bielik 2013). The impulse-response analysis showed the reactions of the system to shocks. The negative response to shock was experienced mainly in the case of the processor and consumer prices of the durable semi-fat milk. Likewise, the farm-gate price of the raw cow milk Q class responded negatively to the shocks of the processor prices of the durable semi-fat milk. In other cases, the analysis confirmed that the impact of one shock had a more or less similar effect on the other variables, meaning that they became steady in the long-run. Testing for the symmetry or asymmetry in the price transmission was done by the dummy variable technique in the VECM. The results indicated asymmetric price adjustments in the majority of cases. However, the presence of symmetry was revealed while testing the adjustment from the PP of the semi-fat milk to the FPQ and from the PP of the durable semi-fat milk to the FPI. This study can be extended by threshold models of the dynamic economic equilibrium (TAR, M-TAR) to gain a more complete picture about the examined issue.

The empirical analysis confirmed the evidence of the asymmetric price adjustments in the Slovak dairy sector. The reasons of this asymmetry are in line with empirical findings presented by Bakucs et al. (2013). The main problem of the inefficient functioning of the vertical chain in the dairy sector is the high number of fragmented farm producers and their lack of willingness to cooperate together. Furthermore, similar results were found by Matulová et al. (2010), where due to the oligopsonic dairies market structure, the dairies transfer mainly the negative price changes to the farmers and the asymmetric price transmission was caused by the existence of the imperfect market competition within the Czech dairy sector. The Slovak dairy sector is also characterized by the imbalances of power related to price negotiations in the chain. We assume that the lack of transparency and monitoring systems of margins plays also a significant role in the farm-processor-retail price transmission. A closer cooperation of producers in the established associations might help to maintain the production and processing of milk and withstand the pressures from the foreign competitors and retailers. It will be one of the most necessary steps towards strengthening of the producers´ position in the vertical chain if we take into consideration ending of the milk quotas in 2015 and its possible consequences such as a decrease in the milk prices and the termination of farms that will fail to anticipate or react to the competition.

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ANNEX

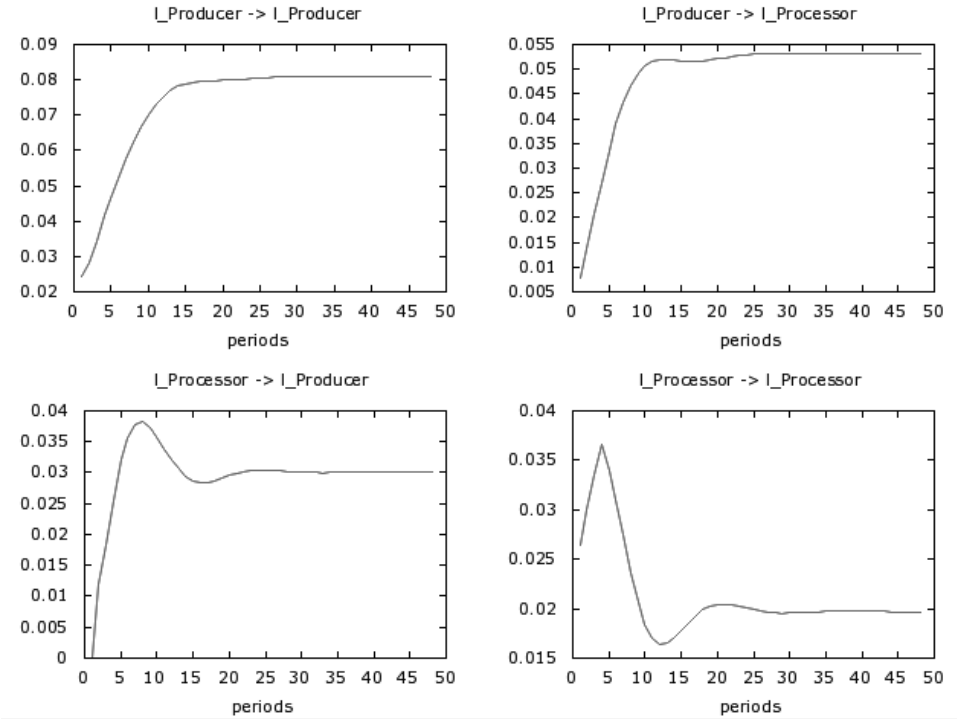

Figure 1. Impulse-Response analysis (FPI and PP of durable semi-fat milk)

Source: own processing

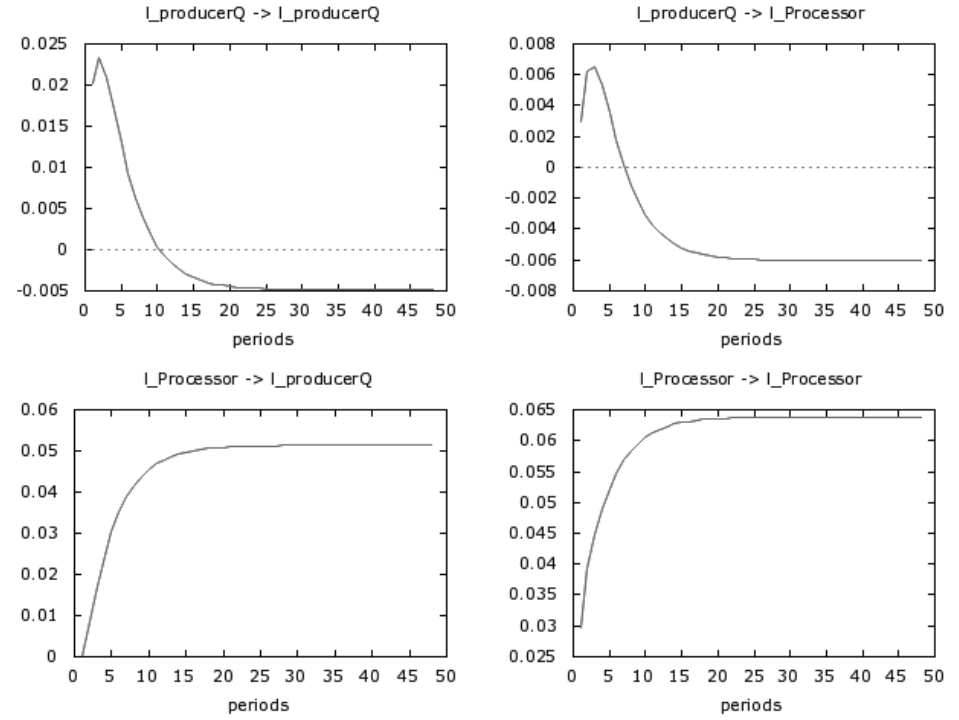

Figure 2. Impulse-Response analysis (FPQ and PP of durable semi-fat milk)

Source: own processing

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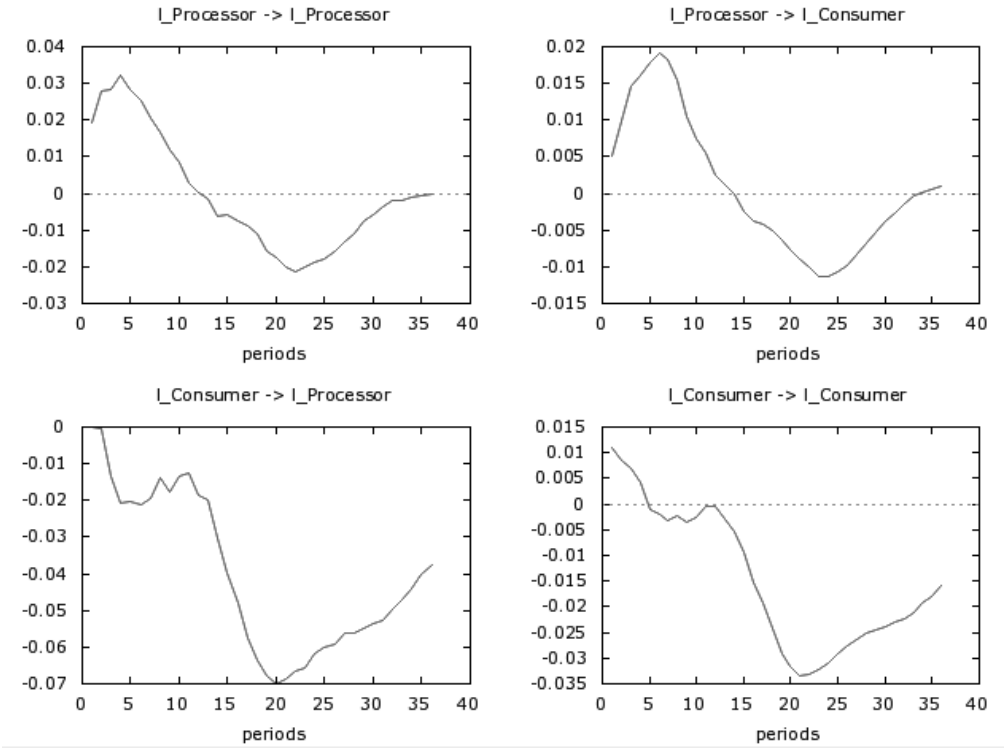

Figure 3. Impulse-Response analysis (PP and CP of durable semi-fat milk)

Source: own processing

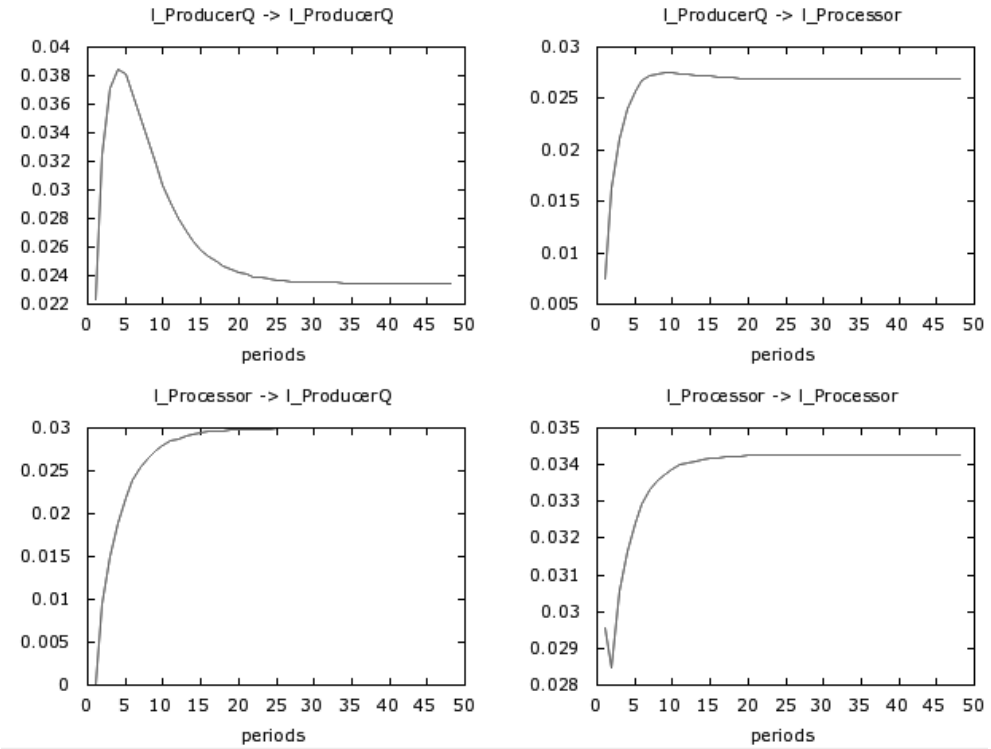

Figure 4. Impulse-Response Analysis (FPQ and PP of semi-fat milk)

Source: own processing

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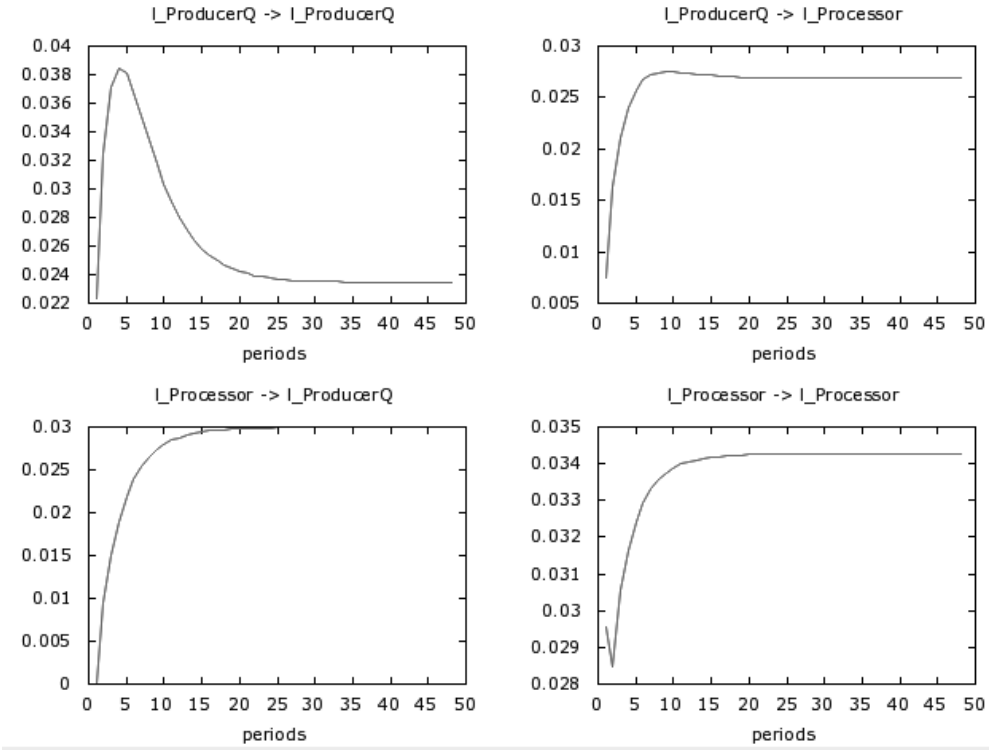

Figure 5. Impulse-Response Analysis (FPI and PP of semi-fat milk)

Source: own processing

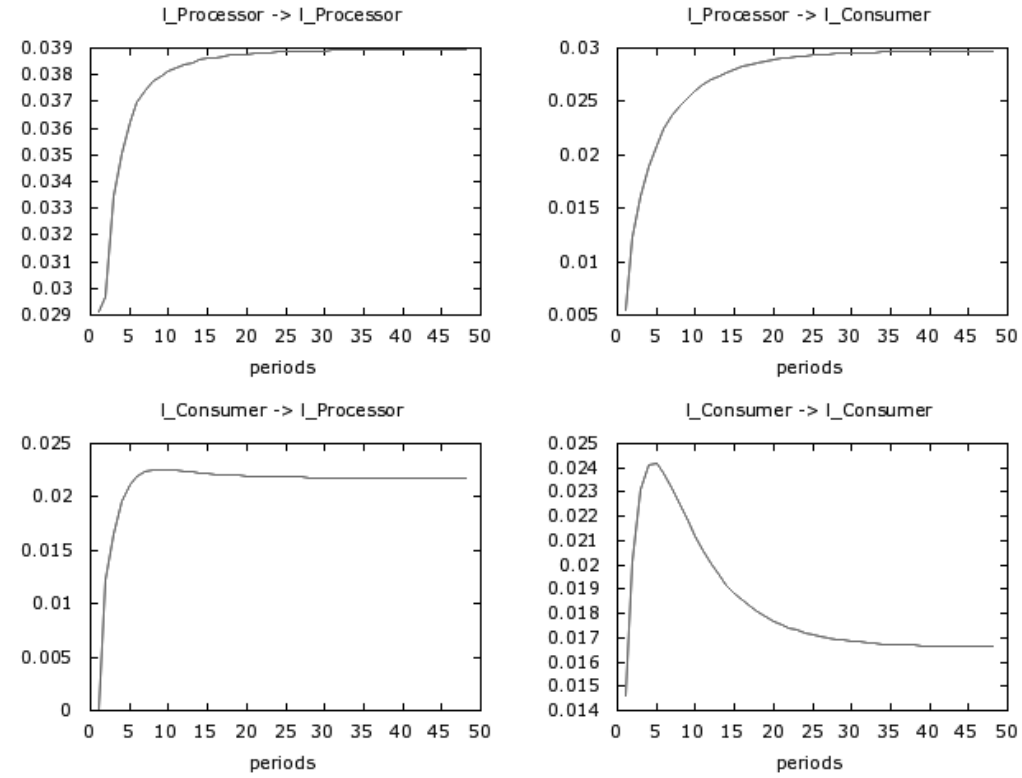

Figure 6. Impulse-Response Analysis (PP and CP of pasteurized semi-fat milk)

Source: own processing

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