VERTICAL PRICE TRANSMISSION ANALYSIS: THE CASE OF MILK IN THE SLOVAK DAIRY SECTOR

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Abstract: Testing for nature price transmission and calculating elasticities of price transmission are important areas of research for providing insights into market efficiency issues. Symmetric or asymmetric price transmission has been the subject of considerable attention in agricultural economics. The concept of the price transmission is an important area of the research particularly in relation to the assessment of impact on the welfare of the vertical entities. The main goal of the paper is an analysis of the price transmission and its exploitation in case of price elasticity estimation in dairy sector. Work investigates vertical price transmission of milk in the Slovak agri-food chain. The research is based on Vector Error Correction Model (VECM) of the selected commodities at producer, processor and consumer level and the estimation of the parameters specified in the model. Moreover the paper determines the coefficient of elasticity of price transmission (EPT).

Key words: dairy sector, elasticity, milk, price transmission

Introduction

Price transmission in agricultural markets has been a subject of numerous studies and asymmetry in price transmission has been detected in most of agricultural products markets.

Bakucs et. al. (2012) explains that there is some evidence that asymmetries are found more often for livestock rather than crop products. Also Popovics (2008) confirms and quantifies that the Hungarian dairy market is under an oligopoly and asymmetric price development prevails in the whole chain and in the specific stages as well, but the appearance of these effects is different in the specific stages. Furthermore, the effects of price increases are more intense in the retail than in the processing stage. Similar results were found by Matulová et. al. (2010), where due to the oligopsonistic dairies market structure the dairies transfer mainly the negative price changes to the farmers and the asymmetric price transmission is cause by the existence of imperfect market competition within the Czech dairy sector. They also supposed the influence of producer price on agricultural price is driven mainly by the relationship between the dairies and the wholesalers. An analysis made by Jaffry and Grigoryev (2011) came up to conclusion that DEFRA (average UK farm-gate prices) and AMPRE had a long-run relationship. Another interesting finding is that the adjustment from farm-gate (DEFRA) prices to the AMPE prices was symmetric but adjustment from AMPE to farm-gate prices was asymmetric. In the liquid milk market, an important finding was that the wholesaler's response was shifting towards an asymmetric response against the farmers as well against the retailers for certain chains. Houck's method applied by Kinnucan and Forker (1987) revealed asymmetry in the farm-retail price-transmission process in the dairy industry. Results indicated that retail dairy product prices adjusted more rapidly and fully to increases in the farm price of milk than to decreases. The reasons suggested for the observed price asymmetry include: industry concentration; government price support activities; and/or whether marketing margin changes are due to retail-level demand shifts or farm-level supply shifts. Jensen and Møller (2007) found out that from wholesale to retail, the price transmission is strong and symmetric in the long run (80–85%) for milk, however in the short run, price transmission is asymmetric. Relationships and patterns of transmission among farm and retail markets were analysed by Serra and Goodwin (2002), using both weekly and monthly price data of dairy products in Spain. They found out that, the transmission of shocks appears to be largely unidirectional when weekly data is used: retail prices adjust to farm level shocks to the raw milk price, but the milk price only modestly responds to retail market shocks. On the other hand, farm prices appear to be more elastic to shocks to retail prices with monthly data, indicating that milk prices require a considerable long period to adjust. Additionally, when weekly data are used, formal testing suggests the presence of asymmetries in vertical price transmission patterns for some manufactured dairy products with a relatively long shelf life. However, they concluded that asymmetries are not present in the price transmission of highly perishable dairy products.

Over the last three decades surveys for analyzing price transmission have been mainly based on variable-splitting technique developed by Wolfframand whose technique was later adapted by Houck and Ward (Maghaddasi, 2009). In Houck´s method asymmetric price transmission is examined by price variables divided into decreasing and increasing stages (Shadmehri Ahmadi and Ahmadi, 2010). Vavra and Goodwin (2005) explain that Houck's method was extended by Ward (1982) who included lags of exogenous variables variables such that the delay in effects and the length of lags can differ depending on whether the causal price is increasing or decreasing. Boyd and Brorsen (1988) were the first to use lags to differentiate between the magnitude and the speed of transmission. These techniques were called the pre-cointegration techniques. Von Cramon-Taubadel and Fahlbusch (1994) pointed out that an asymmetric error correction model (ECM) based on the work of Granger and Lee (1989) could be used to test for asymmetric price transmission. Cramon-Taubadel and Loy (1999) also came to conclusion that this method was more appropriate than using the Houck approach if the price data were co-integrated. This method allows for asymmetric adjustments by distinguishing between positive and negative shocks to error correction terms (Capps and Sherwell, 2007). An alternative error correction specification is threshold autoregressive (TAR) model that recognizes the fact that a shock may have to reach a critical level before a significant response is done (Jeffry and Shabbar, 2004).

Materials and methods

The aim of this paper is to investigate and analyze the nature of price transmission mechanism between farm-processor and processor-retail marketing channels in the Slovak dairy market. Vertical price transmission analysis is performed in order to identify important features of the market functioning and potential market failures. More specifically, the paper describes the relationship between prices (Hupková-Bielik-Turčeková, 2009), calculates the long-run elasticity of price transmission (Lechanová-Bečvářová, 2006; Šobrová, 2009), focuses on the speed of the adjustment process, tests the direction of causality (Palkovič-Sojková, 2012) and provides evidence of symmetric or asymmetric price transmission in the dairy sector.

With respect to the main goal, the paper analyses the behavior of variety of common tests for evaluating vertical price transmission. Firstly, the descriptive statistics is applied in order to describe the main features of a data collection and examine the relationship between farm-gate and processor prices and on the other hand between processor and consumer prices. Prior to ensure that estimation of the price relations is not miss-specified, it is important to test stationarity of the selected time series by the Augmented Dickey-Fuller test (ADF). Therefore, for each pair of prices the analysis consists of the following steps:

1. The Augmented Dickey-Fuller (ADF) test is done in order to test the price variables to see if they are non-stationary (I (1)). The number of lagged difference terms is chosen based on Akaike information criterion (AIC), Schwartz-Bayesian criterion (SBC) or Hannan-Quinn information criterion (HQC) (Šobrová-Čechura, 2009),
2. The standard Engle-Granger and Johansen test is applied to determine whether the two series are co-integrated, meaning that each variable is non-stationary (I(1)) and a linear combination of the two variables is stationary (I(0)) (Ferto and Bakucs, 2005).
3. If the presence of a long-run relationship between variables is detected, then the Vector Error Correction model (VECM) is estimated. According to Mazur (2006), standard co-integrated VECM model for p variables with k lags in the original VAR model and normal errors can be written as:

$$\Delta x_t = \Pi x^*_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \Delta x_{t-i} + \Psi g_t + \varepsilon_t, \quad \varepsilon_t \sim iiN(0,\Omega)$$

where:

$$\Pi = \alpha\beta', \; x^*_{t-1} = (x_{t-1}', d_t')', \; rank(\Pi) = r, \; 0 < r < m,$$

and d_t are deterministic terms restricted to the co-integration space, whereas g_t represents unrestricted deterministic components; α and β are assumed to have full column rank equal to r. In the setting it is assumed that all variables in x_t are I(1) non-stationary, so I(2) and seasonal non-stationarity and co-integration are ruled out for simplicity. Ω is assumed non-singular, initial condition matrix X_0 is assumed non-random. Elements of α and β represent long-run dynamics of the system: columns of β are interpreted as co-integrating vectors, whereas elements of α transfer impact of deviations from long-run equilibrium onto current dynamics of the variables. Long-run weak exogeneity of variables in the system results in zero restrictions on the corresponding rows of α. Long-run exogeneity is tested by the significance of the error correction terms in the equations. Since 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.

Based on LLOYD et al., (2004) the market structure is competitive if and only if the price transmission elasticity is equal to 1. Oligopoly power is exercised if the price transmission elasticity is higher than 1 and oligopsony power is present if the price transmission elasticity is less than 1. There could also be the possibility of both oligopoly and oligopsony power.

Modeling oligopsony can supply unique results about the nature of relations in agri-food chains that help to understand, among other issues, how the markets are pushed into equilibrium states, what is the position of single elements in the chain, what is the competitiveness of farmers, what is the effect of agricultural policy and how is this effect in the chain distributed (Čechura 2006).

4. Vector Autoregressive approach (VAR) is performed to detect if one price does not Granger cause other price.
5. Dummy variable technique is used in order to find out symmetry or asymmetry of the selected time series. The results with a statistically insignificant (p>0.05) coefficient for the dummy variable indicate the asymmetric price transmission.

The data set covers the time period from January 2004 to December 2011. The time series for econometric research are analyzed after the Slovakia's accession to EU due to consistency of data and avoiding misleading interpretations which might occur in case of different nature of series, structural breaks and other factors. The monthly data were collected from The Research Institute of Agricultural and Food Economics online database www.vuepp.sk and from an online statistical database SLOVSTAT. The vertical price transimission analysis was performed by Gretl software.The following prices are used: farm-gate price of raw cow milk I. class (FPI), farm-gate price of raw cow milk Q class (FPQ), processor price of semi-fat milk in PE bags excl. VAT (PP), consumer price of pasteurized semi-fat milk incl. VAT (CP); (EUR/l).

Results and discussion

In this chapter the price transmission analysis will be taken between FPI and PP of semi-fat milk in PE bags, between FPQ and PP of semi-fat milk in PE bags, between PP of semi-fat milk in PE bags and CP of pasteurized semi-fat milk.

Figure 1 shows the development of producer price (FP) of raw cow milk I. class and Q class (EUR/l), processor price (PP) of semi-fat milk in PE bags(1l; excl. VAT) and consumer price (CP) of pasteurized semi-fat milk (1l; incl. VAT) in Slovak Republic (SR) during the period 2004–2011.

According to the main statistical characteristics of the analyzed time series shown in *Table 1,* the mean value of farm-gate price of raw cow milk I. class equals 0,28 EUR/l and price of raw cow milk in quality class Q equals 0,31 EUR/l. On the other hand the average value of processor price equals 0,43 EUR/l and approximately 0,66 EUR/l in case of consumer price. Based on the table it is clear that the relative variation in FPI is the highest comparing to other price time series. More specifically, the variation coefficient (C.V.) of farm-gate price of raw cow milk I. class reaches 16,95 per cent in case of monthly data, FPQ reaches 10,74 per cent, processor price time series equals 11,30 per cent and the variation coefficient of the consumer price series reached value of 7,49 per cent. The minimal value of FPI equals 0,18 EUR/l and 0,21 EUR/l in case of FPQ, while the maximal value of FPI reaches 0,36 EUR/l and FPQ equals 0,38 EUR/l. The extreme values of processor price show larger differences than extremes of farm-gate prices. The minimal value of processor price equals 0,33 EUR/l, while its maximal value equals 0,54 EUR/l. The minimum of consumer price equals 0,54 EUR/l whereas the maximum equals 0,75 EUR/l. Moreover, these extremes values- were not reached in the same periods. The minimum value of FPI was recorded during the period May-September 2009, while the minimum of processor price was reached in July and August 2009. Regarding to FPQ the minimum value was reached during the period August-September 2009. The minimum consumer price was reached in September and October in 2009. The maximum of farm-gate price in quality class I. was experienced from February 2008 to April 2008 as well as for farm gate price of raw cow milk Q. class. On the other hand, the maximum was recorded only in February 2008 in case of processor price. Regarding to consumer price, the maximum was reached from January 2008 to May 2008.

There is a high and positive correlation between producer and processor prices according to results from correlation analysis. Correlation between FPI and PP was 90,49% and between FPQ and PP was 88,00 %. Additionally, there is also positive correlation between processor and consumer prices (72,58%).

Table 1: Summary statistics, using the observations 2004:01–2011:12

Variable	Mean	Median	Minimum	Maximum	St. Dev.	C.V.
FPI	0,28448	0,31000	0,18000	0,36000	0,048229	0,16953
FPQ	0,31021	0,32000	0,21000	0,38000	0,033308	0,10737
PP	0,42656	0,44000	0,33000	0,54000	0,048184	0,11296
CP	0,65938	0,65000	0.54000	0,75000	0,049392	0,074908

Source: own calculations; http://vuepp.sk; http://www.statistics.sk/; FPI/raw cow milk I. class (EUR/l), FPQ/ raw cow milk Q. class; PP/semi-fat milk, in PE bags (1l); CP/pasteurized semi-fat milk (1l)

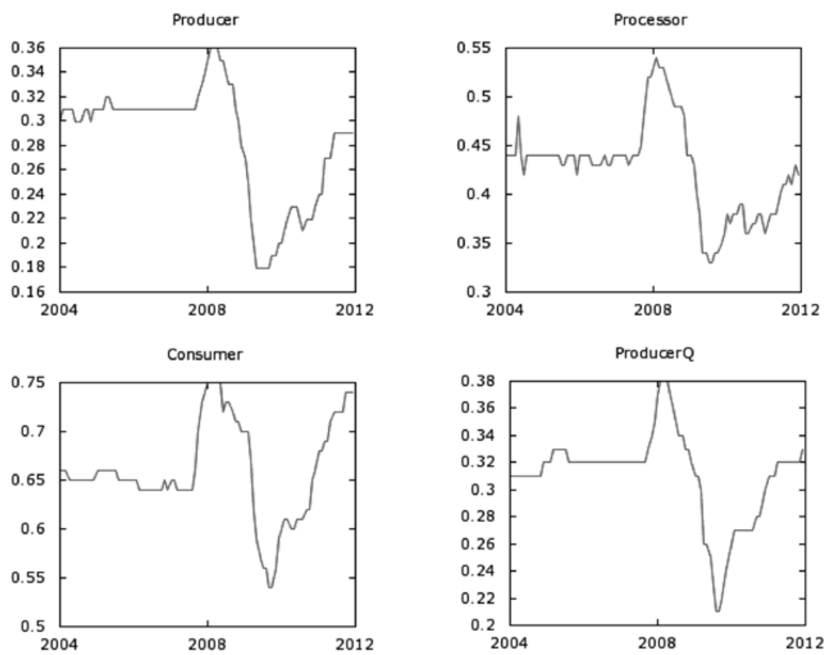

Figure 1: Development of FP, PP and CP prices of cow milk in SR (2004–2011)
Source: Own calculations; Producer/raw cow milk I. class (EUR/l), ProducerQ/raw cow milk Q class; Processor//semi-fat milk, in PE bags (1l); Consumer/pasteurized semi-fat milk(1l)

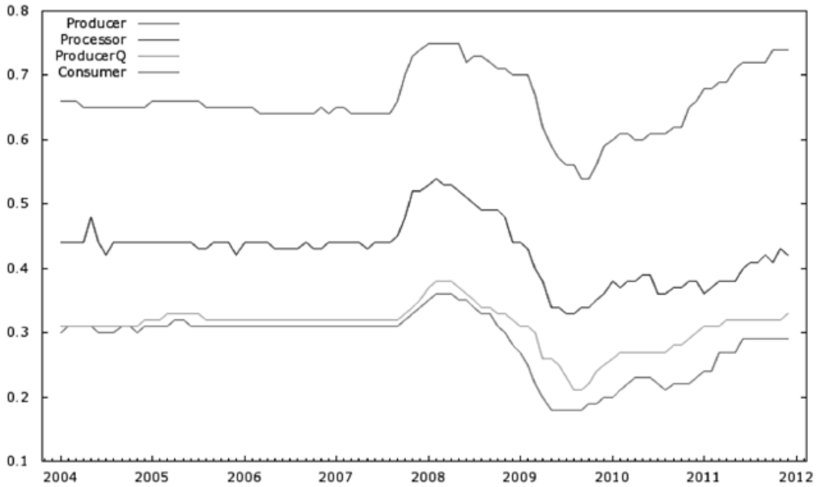

Figure 2: Development of producer, processor and consumer prices in SR (2004-2011)
Source: own calculations; producer/price of raw cow milk I. class (EUR/l), producerQ/price of raw cow milk O class; processor/ price of semi-fat milk, in PE bags (1l excl.VAT); consumer/ price of pasteurized semi-fat milk (1l) incl. VAT

As shown in *Figure 2,* all variables are clearly related (move together through examined time) and their means are not constant and seem to be not stationary, meaning that they appear to be I(1) and the test for unit roots was done to clarify this statement. The time series of monthly data were analyzed on 2 significant lagged values. Reports on estimated autocorrelation coefficient for the errors were small and revealed that the correct number of lags in the ADF was chosen based on Akaike criterion (AIC) and Hannan-Quinn criterion (HQC) and Schwartz Bayesian criterion (BIC). The null hypothesis of the ADF test is as follows:´The time-series have a unit root and are not stationary´. The hypothesis was not rejected and ADF test confirms all selected time series to be non-stationary and integrated of the first order I(1) whereas their first differences were stationary at both 1 and 5 per cent significance levels, except first difference of FPI that was stationary only in test without constant. Rregarding to FPQ, the first difference was not stationary in test with constant and trend, see results in *Table 2.* Afterwards, Johansen and Engle Granger co-integration test were carried out for the time series which have unit roots.

Table 2**:** ADF test

Variable	Augment Dickey Fuller test		
	without constant	with constant	with constant and trend
	p-value*	p-value*	p-value*
FPI	0,5103	0,2901	0,504
dif FPI	0,008297	0,08948	0,2714
FPQ	0,6802	0,2216	0,5139
dif FPQ	0,001396	0,02154	0,09093
PP	0,5753	0,4629	0,7031
dif PP	5,668e-005	0,001355	0,009037
CP	0,7388	0,1989	0,4742
dif CP	7,247e-005	0,001545	0,009378

Source: own calculations; lag length for ADF test =*2lags; FPI (farm-gate price of rawcow milk I. class); FPQ (farm-gate price of raw cow milk Q class); PP (producer price); CP (consumer price)

According to results obtained by ADF test, all the original time series were non-stationary and therefore they could be used for co-integration test. Based on Johansen test, variables FPI and PP are co-integrated. One lag order was chosen for the co-integration analysis and co- integration analysis discovered one co-integrating vector in the analyzed relationship, thereby verifying and demonstrating the long run relationship between the processor price and farm-gate price of cow milk I. class during the analyzed period. As shown in *Table 3* the trace statistics rejects the null hypothesis of no co-integration among the variables and does not reject the null hypothesis that there is one co-integration relation between variables. The final number of co-integrated vectors with one is equal to one; therefore the estimation of VECM model will be applied in order to find out the long-run relationship. In case of FPQ and PP of semi-fat milk, Johansen test confirmed the existence of long-run relationship in test with unrestricted constant *(Table 4).*

Table 3: Johansen co-integration test (FPI and PP of semi-fat milk)

Hypoth-esized No. of CEs	Eigen-value	Trace test	p-value	Lmax test	p-value
0	0,15347	17,304	0,0247	15,828	0,0260
1	**0,015417**	**1,4760**	**0,2244**	**1,4760**	**0,2244**

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

Table 4: Johansen co-integration test (FPQ and PP of semi-fat milk)

Hypoth-esized No. of CEs	Eigen-value	Trace test	p-value	Lmax test	p-value
0	0,17392	18,244	0,0172	15,314	0,0220
1	**0,023287**	**2,0028**	**0,1570**	**4,9639**	**0,1570**

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

Based on Engle-Granger test, the model that contains constant was selected and test down for maximum lag order was chosen testing FPI and PP *(Figure 3).* However, it failed to reject the null hypothesis (the Engle-Granger test is often thought by econometricians to have low power and it means that is sometimes fails to reject the null hypothesis even though it is false). Concerning the ADF test on residuals, the unit root null hypothesis is not rejected at 5 per cent significant level, as well as not rejected for the individual variables in case of FPI and PP. The conclusion is that there is no evidence for a co-integrating relationship. On the other hand, Engle-Granger test without constant confirmed the evidence for a co-integration relationship in case of FPQ and PP *(Figure 4).*

Dickey-Fuller test on residuals
p-value **0,4807**
There is evidence for a cointegrating relationship if:
(a) The unit-root hypothesis is not rejected for the individual variables.
(b) The unit-root hypothesis is rejected for the residuals (uhat) from the co-integrating regression.

Figure 3. Engle-Granger test of FPI and PP
Source: own calculations

Dickey-Fuller test on residuals
p-value **0,03001**
There is evidence for a cointegrating relationship if:
(a) The unit-root hypothesis is not rejected for the individual variables.
(b) The unit-root hypothesis is rejected for the residuals (uhat) from the co-integrating regression.

Figure 4. Engle-Granger test of FPQ and PP
Source: own calculations

Based on Johansen test shown in *Table 5,* variables PP and CP are co-integrated regarding to case of cow milk price. Co-integration analysis discovered one co-integrating vector in the analyzed relationship, thereby verifying and demonstrating the long run relationship between the processor price and consumer price of cow milk during the analyzed period. Regarding to Engle-Granger test *(Figure 5),* the model that contains constant and quadratic trend was selected and a test down for maximum lag order was chosen due to the fact that only this way specified model confirmed co-integration. The model with different attributes failed to reject the null hypothesis. Concerning the ADF test on residuals, the unit root null hypothesis is rejected at 5 per cent significant level whereas not rejected for the individual variables. The conclusion is that there is an evidence for a co-integrating relationship.

Table 5. Johansen co-integration test (PP and CP of semi-fat milk)

Hypothesized No. of CEs	Eigen-value	Trace test	p-value	Lmax test	p-value
0	0,18070	16,790	0,0300	16,742	0,0179
1	**0,0005724**	**0,048096**	**0,8264**	**0,048096**	**0,8264**

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

As shown in *Table 6,* casual relationship was found between processor price of semi-fat milk and producer price of row cow milk I. class and Q class. There is a bi-directional causal relationship between farm-gate and processor prices. On the other hand, there is an evidence of causal relationship between processor and consumer prices of semi-fat milk. As expected, the processor price does not Granger cause consumer prices of semi-fat milk.

Dickey-Fuller test on residuals
p-value **0,03015**
There is evidence for a cointegrating relationship if:
(a) The unit-root hypothesis is not rejected for the individual variables.
(b) The unit-root hypothesis is rejected for the residuals (uhat) from the cointegrating regression.

Figure 5. Engle-Granger test (PP and CP of semi-fat milk)
Source: own calculations

Table 6. Granger causality (PP and CP of semi-fat milk)

	No. of lags	F- test	p-value	H0
FPQ → PP*	2	5,4687	0,0058	Reject (causality)
PP* → FPQ	2	7,3806	0,0011	Reject (causality)
FPI → PP*	2	12,026	0,0000	Reject (causality)
PP* → FPI	2	4,0598	0,0205	Reject (causality)
PP* → CP*	2	2,7041	0,0724	Do not reject
CP* → PP*	2	9,3989	0,0002	Reject (causality)

Source: own calculations; FPQ/farm-gate price of raw cow milk Q class; FPI/farm-gate price of raw cow milk I. class; PP*/processor price of semi-fat milk; CP*/consumer price of semi-fat milk

The VAR model was computed in order to find out the optimal lag according to Akaike information criterion (AIC), Schwarz-Bayesian criterion (SBC) and Hannan and Quinn information criterion (HQ). On the basis of optimal lag order according to the VAR model which was set to two by SBC and HQC, VECM consists of 2 lag order, two endogenous variables (l_producer, l_processor) and constant was not included while testing farm-gate price of raw cow milk I. class and processor price of semi-fat milk. According to *Figure 6 and 7,* VECM form with unrestricted constant and two endogenous variables (l-producer, l-processor) was used in both cases and endogenous variables are transformed variables into natural log form. The Beta transported vector shows the nature of the long term relationship between FP and PP. Co-integration vector expressing the long-term relation has a following form in case of FPI and PP: (1,0000; –1,4852). The value of 1,4852 expresses price transmission elasticity. The value is higher than 1 and therefore an imperfect market structure is considered; more specifically oligopoly or oligopsony power is presented meaning that the market power is on the demand side according to Lloyd et al. (2004); this means that processors have a stronger power than producers. The price elasticity says that increase in PP price by 1,00 per cent results in rise of FPI by 1,49 per cent. Concerning FPQ and PP, co-integration vector has a following form: (1.0000; –0,87426). The value is lower than 1 but also indicates imperfect market structure and the price elasticity says that rise in PP price by 1,00 per cent results in rise of FPQ by 0,87 per cent. The results also show that the processor and farm-gate price margin is going up in the long run. Alfa parameters show how fast each variable reaches equilibrium- the higher the value the faster the reaction. The Alfa parameter is significant only in case of processor price. Therefore the relationship between FPI and PP is not simultaneous and FPI is considered to be weakly exogenous. However, adjustment coefficients do not have the expected sign. On the other hand, the alfa parameter is significant just in case farm-gate price of raw cow milk Q class, meaning that the relationship between FPQ and PP is not simultaneous as well, moreover the coefficient of FPQ has the expected sign and processor price is weakly exogenous variable.

DW statistics confirmed that unnecessary lags were included in both models and the models are efficient and does not include autocorrelation according to Breusch-Godfrey test too. Null hypothesis (homoscedasticity) is not rejected while testing ARCH test. On the other hand, the null hypothesis in case of the test for normality of residual was rejected; however, this might be due to the fact that all variables were transformed by taking a natural logarithm *(Figure 6, Figure 7).*

VECM system, lag order 2 Maximum likelihood estimates, observations 2004:03-2011:12 (T = 94)	
beta (cointegrating vectors, standard errors in parentheses) l_Producer 1,0000 (0,00000) l_Processor –1,4852 (0,032526) alpha (adjustment vectors) l_Producer 0,044414 (p-value 0,29075) l_Processor 0,10580 (p-value 0,01083)	Test for ARCH: Equation1 p-value= 0,276457 Equation2 p-value= 0,207209 Test for Autocorrelation Breusch Godfrey Equation1 p-value= 0,273 Equation2 p-value= 0,589 Test for Normality test p-value= 2,18145e-006

Figure 6: VECM (FPI and PP of semi-fat milk)
Source: own calculations

VECM system, lag order 2 Maximum likelihood estimates, observations 2004:03–2011:12 (T = 94)	
beta (cointegrating vectors, standard errors in parentheses) l_Producer 1,0000 (0,00000) l_Processor –0,87426 (0,16823) alpha (adjustment vectors) l_Producer -0,097670 (p-value 0,03064) l_Processor 0,068182 (p-value 0,26309)	Test for ARCH: Equation1 p-value= 0,064831 Equation2 p-value= 0,683741 Test for Autocorrelation Breusch Godfrey Equation1 p-value= 0,461 Equation2 p-value= 0,915 Test for Normality test p-value= 3,90681e-012

Figure 7: VECM (FPQ and PP of semi-fat milk)
Source: own calculations

According to Figure 8, VECM form with unrestricted constant and two endogenous variables (l-processor, l-producer) was used and the optimal lag order was selected according to the VAR model which was set to two by AIC, HQC and BIC. Co-integration vector expressing the long-term relation has a following form: (1,0000; –1,3099). The Beta transported shows the nature of the market structure. The value is higher than 1, therefore an imperfect market structure is considered; more specifically, oligopoly and oligopsony power can be found in the market according to Lloyd et al. (2004). The price elasticity says that increase in consumer price by 1,00 per cent results in increase of processor price by 1,3099 per cent. Alfa parameters show that the speed of adjustment is not significant in both cases and confirmed that the relationship between processor and consumer price is not simultaneous.

DW statistics confirmed that unnecessary lags were included in the model. The model is efficient and does not include autocorrelation according to Breusch-Godfrey test too. Null hypothesis (homoscedasticity) is not rejected while testing ARCH test. On the other hand, the null hypothesis in case of the test for normality of residual was rejected; however, this might be due to the fact that all variables were transformed by taking a natural logarithm. In addition, the specification for the model can be considered appropriate. The results are shown in *Figure 8.*

VECM system, lag order 2 Maximum likelihood estimates, observations 2004:03–2011:12 (T = 94)	
beta (cointegrating vectors, standard errors in parentheses) l_Processor 1,0000 (0,00000) l_Consumer –1,3099 (0,25779) alpha (adjustment vectors) l_Processor -0,079311 (p-value 0,18314) l_Consumer 0,056511 (p-value 0,07793)	Test for ARCH: Equation1 p-value= 0,153102 Equation2 p-value= 0,218273 Test for Autocorrelation Breusch Godfrey Equation1 p-value= 0,673 Equation2 p-value= 0,934 Test for Normality test p-value= 7,80601e-005

Figure 8: VECM (PP and CP of semi-fat milk in PE bags)
Source: own calculations

Testing for symmetry or asymmetry in price transmission was done by dummy variable technique in VECM. The dummy variable that allows for positive and negative disequilibria is different from zero. The results indicate that PP reacts differently to changes in CP in case of examined long-run relationships and vice versa. However, the presence of symmetry was revealed while testing the adjustment from PP of semi-fat milk to FPQ. On the other hand, PP of semi-fat milk reacts again differently to changes in FPQ *(Table 7).*

Table 7. Dummy variables

Dummy variables (FPQ and PP semi-fat milk)				
Variable	Coefficient	Std. Error	t-statistic	p-value
D	0,000133816	0,0129162	0,0104	0,99176
Variable	Coefficient	Std. Error	t-statistic	p-value
D	0,0593341	0,0158135	3,7521	0,00034
Dummy variables (PP and CP of pasteurized semi-fat milk)				
Variable	Coefficient	Std. Error	t-statistic	p-value
D	0,0514616	0,0149727	3,4370	0,00095
Variable	Coefficient	Std. Error	t-statistic	p-value
D	0,0159552	0,00869682	1,8346	0,07038
Dummy variable (FPI-PP of semi-fat milk)				
Variable	Coefficient	Std. Error	t-statistic	p-value
D	-0,0262489	0,0153145	-1,7140	0,09045
Variable	Coefficient	Std. Error	t-statistic	p-value
D	0,0263494	0,0144162	1,8278	0,07136

Source: own calculations

Conclusion

Firstly, the main features and desriptive statistics of the selected time series were examined. The Johansen co-integration test and Engle-Granger test were conducted in order to clarify the long-term co-integration. The results provided an evidence of co-integration relationship between the raw cow milk prices and processor prices of semi-fat milk as well as between processor prices of milk and consumer prices of milk. However, the simultaneous relationship between prise series was not confirmed in any case. The Granger causality tests suggest that there is bilateral causality in almost all examined cases, however, PP of semi-fat milk does not (Granger) caused CP. Based on the results of VECM, FPI is exogenous while observing its relationship with processor price, meaning that the processor prices are influenced by FPI in the long-run. On the other hand, it can be stated that producers of raw cow milk in quality class Q are price takers. An explanation behind this is a share of FPQ on the total purchase of raw cow milk that increases in case of supply scarcity and diminishes due to market surplus of raw cow milk. Additionally, retail prices have an impact on processor prices in the long-term. The analysis also detected the imperfect market structure and confirmed the fact that was expected: market power is on the demand side. Asymmetric price transmission was found to be evident in the chain. However, the adjustment from PP of semi-fat milk to FPQ revealed symmetry in price transmission.

The empirical analysis confirmed the inefficient market functioning characterized by the dominant position of retailers. Moreover, we can conclude that market environment is being deformed and retailers are able to abuse their market power in the vertical dairy chain. The mark-up pricing model is in direction from retailers-to-processors-to-producers, meaning that the retailers have the major impact on price determination in the dairy chain. This is very common since they are also able to place imported dairy goods at competitive prices on the market. These market circumstances trigger the wrong functioning and poor distribution of margins in the Slovak dairy sector. Producers are very fragmented, their willingness to cooperate together is weak and their impact on price decisions is low which also rise from the fact that milk is a perishable commodity. Due to the evidence of market failure we recommends closer cooperation of producers by establishing associations that might help them to achieve better position and strengthen their negotiation power in vertical linkages. Regarding to processors, there is also a scope for mutual cooperation based on establishment of their own retail networks.

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