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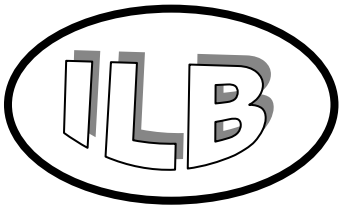

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Policy Impacts in the Dairy Supply Chain: The Case of German Whole Milk Powder

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1 Introduction

The dairy sector is one of the most important agro-food markets in the European Union (EU). In addition to the fresh dairy products, cheese and butter considerable amounts of other dairy products with long sell-by dates are produced like skimmed milk, semi skimmed milk and whole milk powder. These products have some advantages in longer storage periods and easy transportation and thus they are often designated not only for domestic storage but also for international markets. As other internationally traded dairy products milk powders depict remarkable price variations in the last years which do find good matches in the domestic markets. Despite these variations the German industry regards milk powder as an interesting product for further investments driven by luminous international demand prospects. So the likely impacts between the international and the domestic prices movements are an important topic for the German dairy industry as well as German milk producers.

In the past, the EU dairy market has been highly supported by the Common Market Organization (CMO) while, at the same time, milk supply has been restricted by the milk quota regime. High administrative price for dairy products were protected by significant import tariffs isolating the EU dairy sector from international trade. In addition, exports subsidies allowed successful competition with exports from third countries, not only for intervention products but also for other dairy products like whole milk powder. However, with the restructuring of the support starting with the Agenda 2000, the coupled market price support in form of intervention prices of butter and skimmed milk powder were stepwise reduced in favour of decoupled payments. Also invention purchases were restricted and the abolition of the milk quota regime was announced for 2014/15 and phased in by yearly increases of the national quotas. At the same time applied export refunds were suspended for most dairy products.

Despite EU exports subsidies the milk quota system hindered growth of EU exports to third countries. Thus, the EU share in international trade of dairy products declined while export share of grassland bound producers like New Zealand and Australia, Southern American countries or the US increased. With a global economic growth, and an enhanced growth in emerging countries world market prices have been increased. Thus, the gaps between the EU domestic prices driven by reduced intervention price and rising international prices have been diminished. As international import demand increased considerably, especially for cheese, skimmed milk and whole milk powder. Due to the higher share of grassland based milk production adverse weather conditions affect international prices to depict high price fluctuations compared to earlier periods. In consequence, price fluctuations spill over to the domestic market unless the prices undercut significantly intervention prices.

Since then prices vary considerably. 2013 was an all-record year for dairy prices. Milk producers' revenues on average were highest ever, outdating the previous records of 2008 and 2011. But, however, the milk price crisis of 2009/10 was also a result of this process. Therefore the question how prices changes may be transmitted within the supply chain is important and will be studied. As in the German market the interest in milk powder is high the paper puts a focus on milk powder and here especially on whole milk powder because this product contains the main components of milk, namely protein and fat likewise.

The paper is structured as follows: Section 2 deals with the market prices. Section 3 briefly discusses the theoretical background of the test techniques used in the analysis. The empirical results and limitations are presented and discussed in Section 4. The paper ends with concluding remarks in Section 5.

2 The market for whole milk powder

Analysing developments of raw milk producer prices, wholesale prices of whole milk powder in Germany and international prices of whole milk powder including export refunds, if applicable, reveals fundamental changes in the price movements over time (see figure 1). Not only the gap between wholesale prices and international prices are diminishing since the implementation of the Agenda 2000, but also price variation increased dramatically. Decreasing intervention price levels now allow dairy product prices and producer prices to fluctuate in a broader range. Price extremes (upward and downward) increase in number and scale as stocks in the EU are historically low, whilst at the same time grassland based milk production, susceptible to weather, increased worldwide. Although 70% of world whole milk powder production is exported prices are highly vulnerable to small changes in basic conditions as dairy products are characterized by tight substitutive and coupled-product relationships. This because less than 7% of total world milk production is internationally traded. Consequences of that interlinked relationship can be seen in the sharp price decline in 2009/2010 where a negative demand shock as a consequence of the financial crisis conflicting with an ample supply induced by high market prices in 2007/2008. Granting of export refunds prevented EU dairy prices to decrease more and, thus, helped to stabilize raw milk producer prices in 2010.

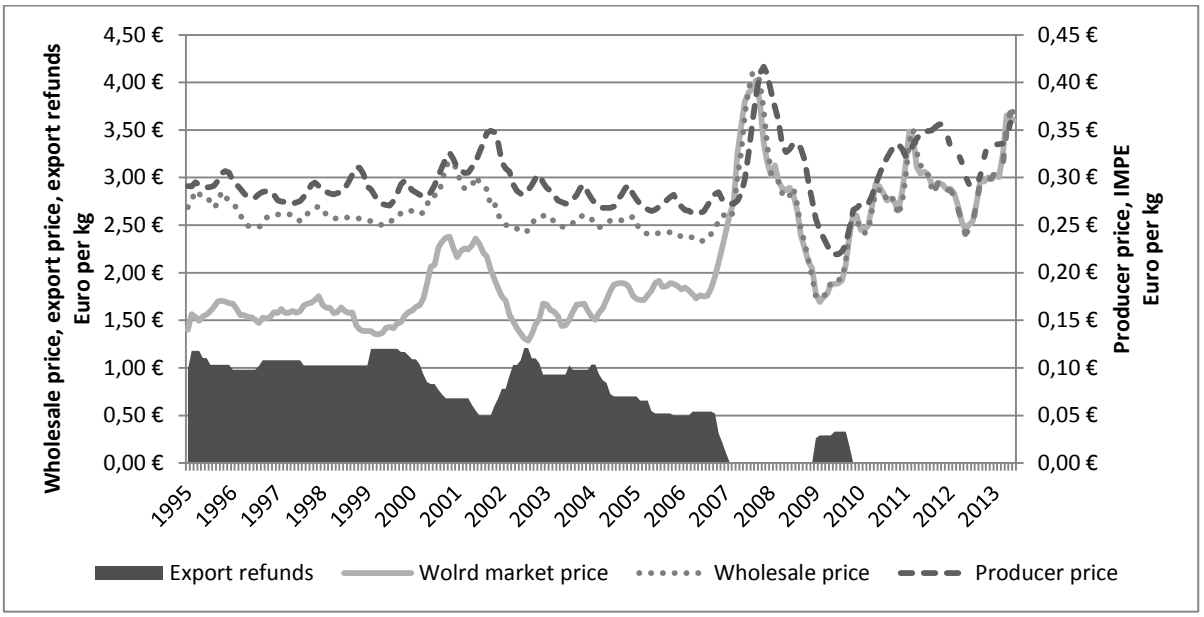

Figure 1. Market prices and EU export refunds of whole milk powder
Source: Own illustration; Data: BMEL, USDA, ZMP, AMI, CAP Monitor.

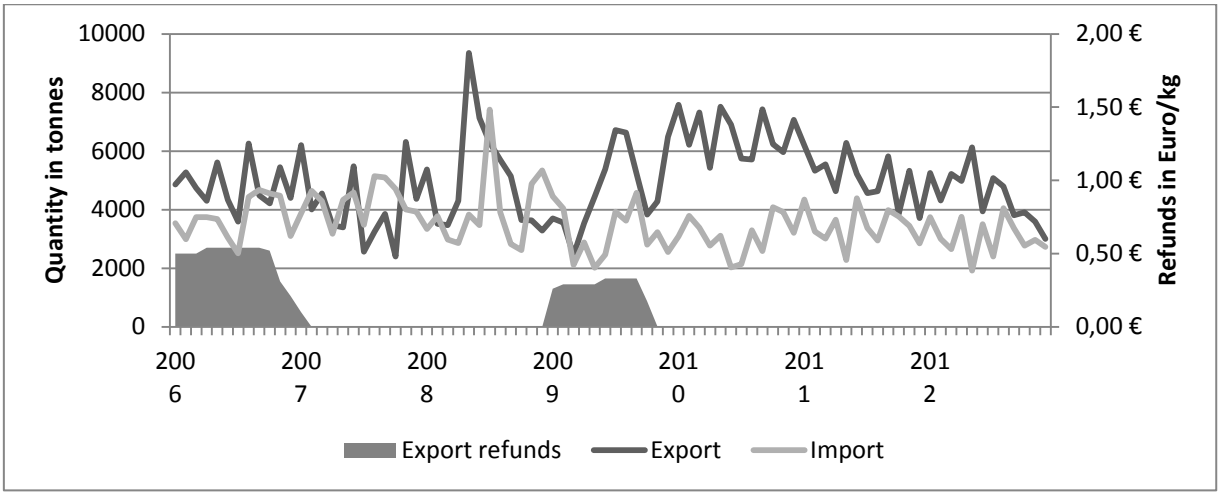

Figure 2. Foreign trade of whole milk powder in Germany (2006-2012)

Source: Own illustration; Data: BMEL, USDA, ZMP, AMI, CAP Monitor.

Nevertheless, the partial liberalization of the EU dairy market led to wholesale prices and world market prices nearly at same levels. Temporarily increasing exports reveal that the international competitiveness of the German dairy supply chain is indicated. Moreover, it has to be noted that intra-EU trade traditionally had a strong importance. Over time intra-EU trade gains even more relevance for German exports of whole milk powder as its share increases from 78% in 2006 to 84% in 2012. Interestingly, since 2011 whole milk powder exports drop again. This because German dairy processing focuses more on cheese as margins are higher and international competition for cheese is less intense from the EU/German perspective as product differentiation is higher with cheese. Additionally, raw milk supply in the EU is still limited by the milk quota regime and any production increase of one processed dairy product is at expenses of others.

3 Data and preparatory steps

In this chapter data and first analysing steps are briefly discussed for the observation period covering January 1995 to June 2013. The regarded supply chain of whole milk powder comprises production, processing and trade of whole milk powder whereas, due to a limited availability, the focus is put on whole milk powder not including cream powder, semi-skimmed powder or other whole milk powder with additives Thus, producer prices of raw milk[1] and wholesale prices of whole milk powder[2] in Germany are used. For international prices Oceania export prices[3] are used. To consider prices relevant for German exporters EU export refunds, if applicable, are added. Both, the graphical analysis of price developments (see figure 1) and theoretical considerations regarding the evolution of EU dairy market organization (see chapter 1), lead to the consideration of splitting up the observation period in several subsamples. Therefore three subsamples are built covering January 1995 to March 2000, April 2000 to March 2007 and April 2007 to June 2013. These subsamples now allow filtering out EU dairy policy effects' on price formation within the supply chain of whole milk powder.

Before starting the actual analysis some preparatory steps concerning the original time series are applied. Detailed test statistics are not presented here[4].

Seasonality

Economic price series often include a seasonal component which has to be eliminated. In this analysis, for example, monthly producer prices are expected to exhibit strong seasonal price movements driven by a production pattern. Seasonality is tested for and, if needed, removed by the Census X-12-ARIMA procedure. This seasonal adjustment program is produced, distributed, and maintained by the U.S. Census Bureau and is widely used by a large number of national authorities. In applying moving average filters the main components of the series (trend and seasonality) are estimated (Findley and Hood, 1999) and then removed from the original data series.

Affected by seasonality is the raw milk producer price in the periods 1995-2000 and 2000-2007 as well as the German wholesale price of whole milk powder in the periods 1995-2000 and 2000-2007. In the last observed period (2007-2013) the seasonal component of the price series is not significant anymore. In contrast, the export price shows a seasonal pattern in neither period.

Stationarity

Price series do often not only include a seasonal component but also exhibit strong trends. If this is the case, then the series are called non-stationary and, thus, they are not suitable for economic comparisons (Green, 2008: 739). This is because possible relationships between two series cannot be properly identified and the danger of spurious regression is present.

[1] Prices of raw milk containing 3.7% fat and 3.4% protein. Since 2010 the fat content is 4.0%.

[2] Prices for edible whole milk powder containing 26% fat.

[3] Prices for edible whole milk powder containing 26% fat.

[4] Detailed results can be obtained on request from the author.

A series is called stationary if the mean and autocovariances of the series do not depend on time. In other words, the correlation between a series and its lagged values has to depend only on the length of the lag and not on when the series started (Ramanathan, 2002: 472). From this follows that the process generating a stationary time series is time-invariant. A stationary time series is referred as integrated of an order zero or I(0). Non-stationary time series can be transformed into a stationary series by differencing, for example. The formal method to test for stationarity is the Dickey and Fuller (1979) unit root test.

All most all considered price series have a unit root and are integrated of order one. The only exception represents the export price. In period 1995-2000 export prices contain no significant trend, thus, beeing integrated of order zero.

Cointegration

In general, economic time series do not develop independently from each other. With the concept of cointegration equilibrium relationships between economic series can be illustrated. This concept is closely related to stationarity. Firstly, because if in both time series a trend is present there is the danger of spurious correlation. Secondly, time series have to be of identical integrated order to perform a test of cointegration. Johansen (1988) developed a test procedure to test time series for cointegration. If there exist parameters of α and β so that ε_t is stationary, then both series are called to be cointegrated (Engle and Granger, 1987). In the short run deviations from the equilibrium are possible but in the long run the cointegrated series do not drift significantly apart. These short run deviations from the identifiable long run relationship can be modelled with error correction models (Kraft and Schneider, 2004: 1548).

The Johansen test reveals that in period 1995-2000 cointegration between producer, wholesale and export prices is limited. More specifically, world market prices and producer prices were not cointegrated, an outcome to be expected as international prices including export subsidies were meant to separate price movements on the international markets from the domestic markets. In both other periods regarded long run relationships between the prices existed. That in turn determines that the error correction model is only permitted between producer and wholesale prices in period 1995-2000 and world market prices have to be excluded from the analysis for that period. In both other periods the observed series show significant cointegration behaviour.

Error correction model

The idea of error correction modelling is that there exists a long run relationship between two or more variables where a portion of disequilibrium from one period is corrected in the next period (Greene, 2008: 689; Engle and Granger, 1987). This is why error correction is closely related to the concept of cointegration. A simple error correction model is:

$$\Delta y_t = \alpha[y_{t-1} - (\beta_1 + \beta_2 x_{t-1})] + \sigma \Delta x_t + \epsilon_t,$$

where α and δ are regression coefficients und ε_t is a disturbance term.

In this simple error correction model the change in one variable is related to past equilibrium errors, as well as to past changes in both variables (Engel and Granger, 1987). The relationship between changes, hence first differences, is called short run. α is the correction factor of the error correction term. A real error correction effect requires, beside cointegration, that the coefficient α is negative and in absolute values not greater than one. If y_{t-1} should be exceed the equilibrium relationship then Δy_t will be reduced by an amount that is proportional to this excess but not exceeding it. Thus, after every adjustment an approximation to the long run relationship is achieved (Strohe and Nastansky, 2010).

4 Empirical results

In this chapter the results of the error correction models are presented and discussed. From the necessary prerequisites of this model approach as discussed in chapter 3 follows that only in the first period (1995-2000) a restricted model can be calculated where the world market price is excluded because of lacking cointegration behaviour.

As described in chapter 3 the error correction model approach allows distinguishing between short-run and long-run relations. The results for the short-run causality are presented in table 1 whereas the long-run error correction coefficients (*α-coefficient*) are displayed in the tables 2 – 4 in the annex.

Table 1.
Short-term causality - Wald-Test results

5	1995 – 2000			2000 – 2007			2007 - 2013		
	Producer	Wholesale	World	Producer	Wholesale	World	Producer	Wholesale	World
Producer	-	0.3038	-	-	**2.3529***	1.2381	-	0.6099	0.9658
Wholesale	0.5199	-	-	**2.8308***	-	1.6619	0.3317	-	**3.6366****
World	-	-	-	**2.7258***	0.8075	-	0.9537	**2.3233#**	-

Level of significance: *** 99;9%, ** 99%, * 95%, # 90%.
Source: Own computations

1995-2000

The results do yet not give a comprehensive picture in relation to expectations. Although α-coefficient has the expected negative sign for both cointegration equations but regarding the wholesale price the error correction coefficient has an absolute value greater than 1 indicating that the speed of adjustment is faster than one month which is not economically appropriate. However, with regard to the producer price the α-coefficient means that a shock in the period before, ceteris paribus, will be adjusted for in approx. 8 months. This is an appropriate outcome if one bears in mind the contractual relationships between dairies/wholesalers and customers of whole milk powder as well as the price formation model of many German cooperative dairies[5].

In this period neither price series has significant short-run causal effects on each other indicating that in this period price formation is based rather on long-run relationships between milk producers and dairies/wholesalers.

2000-2007

Johansen test indicated 2 cointegration equations. But the results for the α-coefficient show also values with a positive sign indicating that both series do not converge in the long run and drift apart. That is, the series might not be stationary and or cointegrated. This contradicts the test results on stationarity and cointegration performed before.

For producer prices (cointegration-equation 1) the error correction coefficient shows the expected negative sign meaning that a shock will be corrected for after approx. 4 months. In cointegration-equation 2 of wholesale prices the error correction coefficient is also significant and has the correct sign indicating that a shock is corrected for after approx. 2 months. With regard to contractual relationships between the actors within the supply chain this time frame appears to be very short and ambitious. A time frame of at least 4 months would have been expected and, thus, would have been more plausible.

In addition to these long-run relations between producer prices, wholesale prices and world market prices also short-run relations do exist (see table1). Both lagged values of wholesale prices and lagged values of world market prices each jointly causally affect producer prices. Wholesale prices in turn are jointly causally affected by lagged values of producer prices in the short-run.

2007-2013

As already described in the afore-mentioned period the problem of significant error correction coefficients with a positive sign does exist for wholesale prices, too, preventing an economically meaningful interpretation. For producer prices the α-coefficient is negative and in absolute values less than one. It says that for producer prices a shock will be corrected for, ceteris paribus, after approx. 6 months. This result is economically appropriate. Comparing this result with results of the first period contract durations between dairies and traders/retailers have been shortened as price fluctuations increased in speed and magnitude.

In this period two significant short-run causal relationships are identifiable. First, the lagged values of the wholesale price jointly causally affect world market prices. Second, lagged values of world market prices jointly causally affect

[5] Cooperative dairies have a significant market position in Germany as more than two third of cow milk production is delivered to and processed in cooperatives (Bundeskartellamt, 2009: 31). Many German cooperative dairies are calculating the producer price of raw milk only after raw milk has been processed and milk products have been sold. The valuation of raw milk then depends on the utilization capability of a dairy and its product mix.

German whole sale prices. These bilateral causal relationships indicate that German wholesalers are integrated in international markets and that German whole milk powder supply has an influence on international markets.

Explanation and Qualification

Although the tests revealed cointegration between the series within the periods the results of error correction models depict some inconsistencies. This outcome may be driven by the fact that the periods chosen are relatively short, so that the long term equilibrium is difficult to establish. Further analysis should put a focus on the generation of longer periods and good option in this respect might the use of two corresponding with the main shift in the policy regime instead of three periods.

However, also other problems may embed in the time series which underwent some structural adjustments in the data compilation namely the official price calculation of whole milk powder. Prices of whole milk powder at the level of wholesale used in this analysis may be biased due to their survey method. Official prices are based on notifications of companies relating to quantities of whole milk powder sold at certain prices. From this information an aggregated wholesale price is calculated and, thus, which might not correctly display the real market developments.

Yet another aspect needed to consider is the fact that although exports of the product group whole milk powder have increased this might not be true for the product category of standard whole milk powder for which the export prices are compiled. A glance in the production statistics displays an growth in the production of whole milk powder but driven in particular by the subcategory other milk powder with additives whereas also exports hereof significantly increased. In that case the used prices might not be the relevant one which needs to be covered in furthers analysis.

Related to the quality question are the issues that whole milk powder and skimmed milk powder are quite interlinked in their usages and, thus, can often be used as substitutes. This, in turn, leads to spill-over effects between skimmed milk and whole milk powder which might distort the formation of a long-run equilibrium in the supply chain of whole milk powder, in particular when one takes into account that production and export of skimmed milk powder are about twice the size of the whole milk powder market. So in future research this aspect requires to be studied more deeply.

5 Concluding remarks

The analysis deals with the interactions of prices concerning different marketing levels in the German dairy sector with regard to effects of changing politic framework in the period January 1995 to June 2013. A focus is put on whole milk powder. Marketing levels studied comprise producer prices of raw milk, wholesale prices of whole milk powder, and international prices of whole milk powder including EU export refunds. To analyse price cointegration and causality significant seasonality was removed. And more, price series were tested for stationary. On the adjusted series the Johansen test for cointegration was applied and Granger causality was tested. If the prerequisites were complied error correction models were estimated.

This paper provides a first step in studying price formation along the whole supply chain and across milk and dairy products in Germany. Aim is to quantify the effects of price signals in this quite interlinked market.

Although the analysis provides some interesting results some limitations have to be considered: results of error correction models ocasionally contradict tests on stationarity and cointegration performed before. Several factors could be responsible for the outcome. First, the periods chosen are relatively short. Second, inadequate data quality may also bias model results and third, not observing the tight substitutive relationship between other milk products, in particular skimmed milk powder, could also explain unexpected model results.

However, the analysis enables to draw a number of conclusions. Indeed, the market forclosure of EU dairy marktets as well as the effects of the stepwise market liberalization are reflected by the results. In the first period no cointegration did exist between the world market and the following steps of the supply chain of whole milk powder. Only after EU dairy market organization is stepwise adjusted the world market price gains influence on producer and wholesale prices and vice versa. Also short-term as well as long-term relationships in the error correction model develop and strenghten with the evolution of EU dairy market organization in later periods.

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Annex

Table 2.
Error correction model results for period 1995 - 2000

Cointegration Equation	**CoIntEq 1**	**CoIntEq 2**
$Producer_{-1}$	1.0000	-
$Wholesale_{-1}$	-0.0391	-
$Export_{-1}$		-
C	-0.2114	-
Error Correction	**Producer**	**Wholesale**
CointEq 1	**-0.1305****	**-1.4368***
CoIntEq 2	-	-
$D(Producer_{-1})$	**0.5020*****	-0.0153
$D(Producer_{-2})$	0.0640	-1.8183
$D(Wholesale_{-1})$	-0.0056	-0.0384
$D(Wholesale_{-2})$	-0.0031	-0.0424
C	-0.0002	-0.0036
Adj. R^2	0.3323	
F-statistic	6.8720	

Level of significance: *** 99;9%, ** 99%, * 95%, # 90%.
Source: Own computations

Table 3.
Error correction model results for period 2000-2007

Cointegration Equation	**CoIntEq 1**	**CoIntEq 2**	
Producer$_{-1}$	1.0000	0.0000	
Wholesale$_{-1}$	0.0000	1.0000	
Export$_{-1}$	-0.1550	-1.1300	
C	0.1038	0.2940	
Error Correction	**Producer**	**Wholesale**	**Export**
CointEq 1	**-0.2498*** **	**1.8970***	0.01600
CoIntEq 2	**0.0606****	**-0.5618#**	**0.6534#**
D(Producer$_{-1}$)	-0.2152	-0.2947	1.9161
D(Producer$_{-2}$)	**0.29888***	0.9836	**-4.0773#**
D(Producer$_{-3}$)	0.1184	**-5.4114****	**-9.1628*****
D(Producer$_{-4}$)	-0.0973	2.4739	2.3385
D(Producer$_{-5}$)	0.0132	-1.7935	0.5900
D(Producer$_{-6}$)	0.2141	0.609	-4.2262
D(Producer$_{-7}$)	-0.1456	0.5607	-0.7653
D(Producer$_{-8}$)	**-0.3673****	1.4646	2.0754
D(Producer$_{-9}$)	-0.1833	2.3646	1.7082
D(Wholesale$_{-1}$)	-0.0261	**0.6279***	-0.4374
D(Wholesale$_{-2}$)	**-0.0527****	0.2233	-0.1946
D(Wholesale$_{-3}$)	-0.0080	**0.5739***	-0.1051
D(Wholesale$_{-4}$)	**-0.0349***	0.0035	-0.2719
D(Wholesale$_{-5}$)	**-0.0368***	0.1752	-0.0732
D(Wholesale$_{-6}$)	-0.0213	**0.3376#**	0.1807
D(Wholesale$_{-7}$)	0.0022	0.0174	-0.0367
D(Wholesale$_{-8}$)	0.0061	0.1330	-0.1003
D(Wholesale$_{-9}$)	-0.0045	0.0862	0.0864
D(Export$_{-1}$)	**0.0281#**	-0.1611	**0.5769***
D(Export$_{-1}$)	**0.0254#**	0.0272	**0.5486***
D(Export$_{-1}$)	**0.0269***	0.0043	**0.5613***
D(Export$_{-1}$)	0.0174	-0.1341	**0.3982#**
D(Export$_{-1}$)	0.0023	-0.1667	0.0822
D(Export$_{-1}$)	**0.0166#**	0.0872	**0.3801***
D(Export$_{-1}$)	0.0090	0.0376	0.1437
D(Export$_{-1}$)	0.0025	-0.0015	**0.3323***
D(Export$_{-1}$)	0.0020	**0.2066#**	**0.3666***
C	**-0.0007#**	0.0078	0.0097
Adj. R^2	0.4898		
F-statistic	3.3881		

Level of significance: *** 99;9%, ** 99%, * 95%, # 90%.

Source: Own computations

Table 4.
Error correction model results for period 2007-2013

Cointegration Equation	**CoIntEq 1**	**CoIntEq 2**	
$Producer_{-1}$	1.0000	0.0000	
$Wholesale_{-1}$	0.0000	1.0000	
$Export_{-1}$	-0.1348	-1.3039	
C	0.0701	0.9083	
Error Correction	**Producer**	**Wholesale**	**Export**
CointEq 1	**-0.1688****	-0.1570	-1.8518
CoIntEq 2	0.0223	0.2111	**1.1463****
$D(Producer_{-1})$	**0.6010*****	-0.3357	0.13799
$D(Producer_{-2})$	-0.0292	1.9338	1.0266
$D(Producer_{-3})$	-0.1115	-1.5085	1.0500
$D(Producer_{-4})$	0.0152	-1.9637	-4.2969
$D(Producer_{-5})$	-0.0376	2.6141	**5.4592***
$D(Wholesale_{-1})$	-0.0004	-0.3042	**-0.9159***
$D(Wholesale_{-2})$	-0.0147	**-0.6596***	**-0.8165***
$D(Wholesale_{-3})$	0.0071	-0.4507	**-0.8556****
$D(Wholesale_{-4})$	-0.0023	-0.3173	**-0.5448#**
$D(Wholesale_{-5})$	-0.0106	-0.2990	**-0.5259#**
$D(Export_{-1})$	0.0163	**1.0637*****	**1.5308*****
$D(Export_{-2})$	0.0007	**0.6285***	**0.7894***
$D(Export_{-3})$	-0.0055	**0.4541#**	**0.8061****
$D(Export_{-4})$	0.0028	**0.4557***	**0.8150****
$D(Export_{-5})$	0.0093	**0.4953***	**0.7772****
C	0.0006	-0.0038	-0.068
Adj. R^2	0.8201		
F-statistic	20.84		

Level of significance: *** 99;9%, ** 99%, * 95%, # 90%.
Source: Own computations