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Volatile world market prices for dairy products - how do they affect domestic price formation: The German cheese market

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Abstract

Since the stepwise reduction of intervention prices combined with watered down conditions and suspended export refunds, respectively, the EU dairy industry faces new challenges regarding wild price fluctuations originally caused in third countries. In the past, the EU domestic market was insulated as far as possible from world markets. However, today global prices could affect prices even at the level of consumers, but more directly at the level milk producers. Volatility noticeable increased with the price peak in 2007, followed by the drop in 2008, and a new price boost in 2010. Additionally, reduced security in marketing of butter and skimmed milk powder led to higher processing share of cheese which is not only exported but also increasingly consumed within the EU.

Analyzing time series data of dairy products' prices illustrates price fluctuations at different levels of the supply chain. Particularly, retail prices are less volatile than milk producer prices. Therefore, it is often assumed that retailers do not completely pass on downward movements of producer prices to consumers or, vice versa, and assumption encouraging debates on market power, margins and price transmission in the supply chain. German retailing is characterized by a high of market concentration and by a predominance of discounters, displaying a leading position in price negotiations with dairies or wholesalers. Thus, it can be argued that retailers adversely affect dairies who, in turn, affect milk producers. From this follows price transmission asymmetries differ across different levels of the supply chain, and volatile world market prices induced may affect the lower part of the supply chain negatively.

However, price transmission has been analyzed in various studies before, mostly analyzing price transmissions between retailing and consumer level. Thus, they abstract from effects of intermediate levels (wholesale, world market). Therefore, the objective of this paper is to investigate the transmission of milk prices from the farm to the retail level and to detect possible asymmetries, leading in the case of world market price fluctuations to additional problems in the German supply chain. The focus is on the German cheese market whereby regime specific effects are tested e.g., the reduction of EU market support which has major impacts on price transmission. Additionally, the change in the product mix and the increased export orientation of German dairies also affect price transmission. In the analysis monthly data from January 1990 to October 2011 for producer prices of raw milk, wholesale and consumer prices for cheese as well as prices in international trade with cheese are considered. Institutional prices were generated on a monthly basis, thus, capturing dates of change in intervention prices and of export refunds. Applying a subset of model specifications based on error-correction representation asymmetries are studied, whereby the seasonal pattern of data is filtered out.

Keywords: Price transmission, Cointegration, Granger-causality, Dairy

JEL classification: C1, E3, E6, F3, Q1

1. INTRODUCTION

As one of the prominent agri-food markets in the EU the dairy sector has been highly protected and supported by the Common Market Organisation (CMO), while, at the same time milk supply has been restricted by the milk quota regime. From international trade the EU sector has been isolated by relatively high import tariffs, while exports have been cheapened by the application of exports subsidies set by administration to allow successful competition with exports from third countries. Starting with the Agenda 2000, like in other sectors, support was restructured. In principle, 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 buyings 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. First cuts in the intervention prices occurred in 2005.

Although EU exports were subsidised 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 and the international prices have been diminished. As international import demand increased it has been increasingly satisfied by grassland based milk production which is much more subject to adverse weather conditions so that international prices also depict high price fluctuations. In consequence, price fluctuations are spilled over to the domestic market unless the prices undercut significantly intervention prices.

On the German market reduced support for the intervention products led to a shift in processing trends in recent years. While under the ample intervention system for butter and skimmed milk powder any foreseen milk surplus was processed into those two intervention products, the fundamentals have changed, and now, in principle, a very stable cheese production, also capturing surplus milk, can be observed. In Germany, this development is driven by a high and growing domestic consumption for cheese and limits in the seasonality of milk supply. Thus, the cheese price drew more focus; more than one third of the available milk is processed into cheese. So the price formation for cheese has an enduring impact on the producer prices of milk; however, wholesale cheese prices depict higher fluctuations than in the past. When the whole processing chain is regarded, retail prices are less volatile than milk producer prices. Therefore, it is often assumed that retailers do not completely pass on downward movements of producer prices to consumers or, vice versa, and assumption encouraging debates on market power, margins and price transmission in the supply chain.

German retailing is characterized by a high share of market concentration and by a predominance of discounters, displaying a leading position in price negotiations with dairies or wholesalers. Thus, it can be argued that retailers adversely affect dairies who, in turn, affect milk producers. From this follows price transmission asymmetries differ across different levels of the supply chain, and volatile world market prices may affect the lower part of the supply chain negatively. However, price transmission has been analyzed in various studies before, mostly analyzing price transmissions between retailing and consumer level with a special emphasis on whole milk[1]. Thus, they abstract from effects of intermediate levels (wholesale, world market). Therefore, the objective of this paper is to investigate the transmission of milk prices from the farm to the retail level and to detect possible asymmetries, leading in the case of world market price fluctuations to additional problems in the German supply chain.

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

2. GERMAN CHEESE PRICES

In this section the development of the cheese market and the regarded data are briefly discussed. As the paper deals with relationships and correlations between different levels of monthly prices for milk and milk products one product is considered in particular, namely cheese.

Figure 1 shows the development of world market, wholesale, consumer, and producer prices for cheese and raw milk as well as for EU export refunds for Gouda, respectively. Considered prices comprise data from the period January 1997 to October 2011 which are currently the latest available price information. In addition to international prices the analysis covers the level of wholesale, consumers and milk producers to illustrate fundamental marketing levels in the cheese supply chain.

The data originates from different sources as described in the following. Time series for world market prices of cheese in reasonable quantity traded for a longer time period are only available for Cheddar produced in Oceania[2]. Hence, this international price may not be relevant for EU processors if they like to export. To receive world market prices comparable to the domestic price level of the European Union, EU export refunds for cheese[3] are added to the price of Cheddar. This additional calculation is necessary because intra-EU prices are separated from the world market level either by import tariffs when imports are regarded or reduced to world market price levels by export refunds when exports are considered. The EU is a net-exporter of cheese; therefore the export prices consisting of the world market price plus refunds are relevant.

In Germany, however, Cheddar is not a common type of cheese and, thus, not officially noted. In Germany Gouda besides Emmentaler are more important types of cheese in production

[1] See Kunnican and Forker (1987), Serra and Goodwin (2002) or Capps and Sherwell (2005) for example.
[2] Prices are monitored by Gould of the University of Madison and are provided on the homepage ‘understanding dairy markets’.
[3] Historic time series of EU export refunds can be found in CAP monitor (2011) for example.

as well as in consumption. Prices of both types of cheese are officially monitored. But in the case of Emmentaler there is a break in the data series in 2004. From this point in time there is no single price series available anymore. The official quotation is divided into prices of Emmentaler at the service counter and prices of Emmentaler in pieces. Values of both new series do not correspond to values of the former time series. Additionally, Emmentaler is a type of hard cheese and more often used in further processing[4]. In contrast, Gouda is a typical semi-soft type of cheese and is more often demanded for direct consumption by consumers. Therefore, Gouda has been chosen to illustrate correlations and causal relationships of cheese prices at the level of wholesale and consumers in Germany. At the level of wholesale prices for Gouda are officially noted at the cheese exchange in Kempten. Consumer prices of Gouda and raw milk prices are published by ZMP and AMI, respectively. All prices used are noted monthly in Euro per kilogram or are converted to Euro with officially monthly exchange rates, respectively.

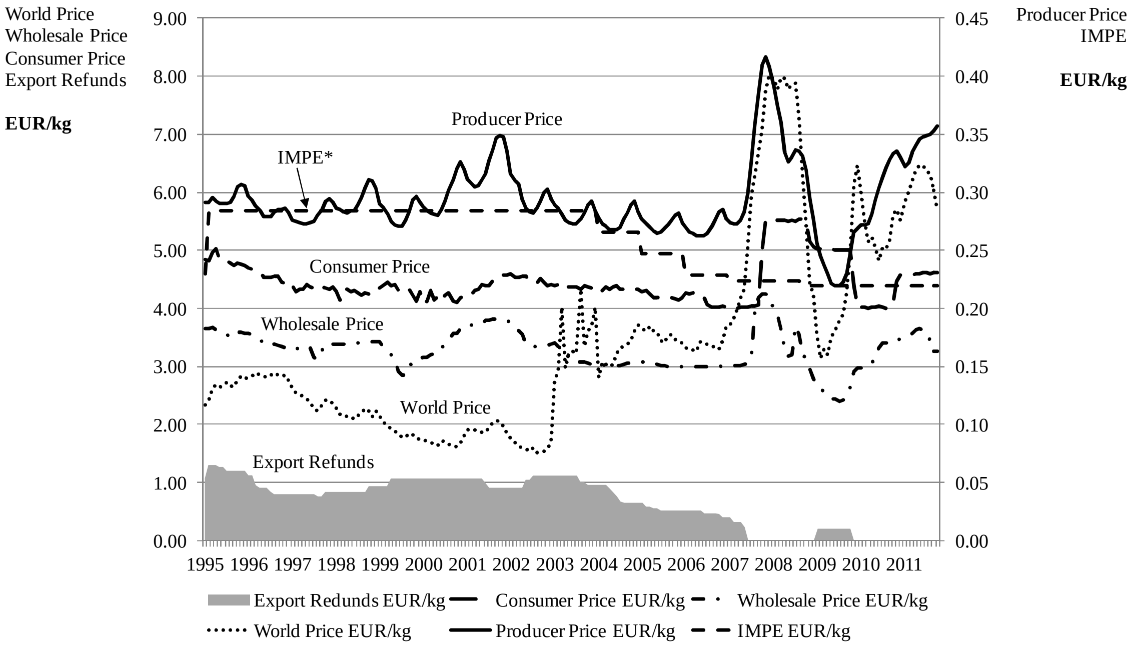
Since 2005 major structural changes have influenced the development of the price series (see also Figure 1) within the European Union. So, the development of wholesale, consumer and producer prices reflects besides other factors amendments in the EU dairy market regulation. In 2003, for example, the Luxembourg Agreement resulted in substantial changes for the EU dairy market by cuts in the market support measure like export refunds and the intervention prices for butter and skimmed milk powder. In Addition, intervention sales were limited. The milk quota abolition was decided on accompanied by a phasing-out with an annual stepwise increase of the national quota levels. As compensation for milk producers the EU introduced the dairy premium which was quite quickly integrated in the decoupled payments.

Those fundamental changes in policy measures had far-reaching implications for the market participants. While in the period before 2004 no high prices fluctuations have been observable not even for the world market prices the situation changed substantially in the period beginning in 2004. As a consequence of the cut in the support level of the EU world market and EU market are stronger linked and domestic prices are allowed to fluctuate more broadly. Nevertheless, the price peak starting in 2007 has its origin to a lesser extent in EU policy changes but to a higher extent in insufficient global supply. Main drivers were decreasing production quantities in Oceania and South America due to unfavourable weather conditions and low stock quantities of butter and skimmed milk powder around the world, especially in the EU. In consequence, a decreased milk supply met an unrestrained or even growing demand for milk and milk products causing the observed price increases. But due to the meanwhile decreased protection levels these market signals could more directly influence domestic prices in the EU. The recovered supply and the decreased demand for milk products – not only because of the high prices but also due to the financial crisis – caused the sharp price decline in 2009 again. As can be seen in figure, price developments at the world market not really resulted

[4] Emmentaler for direct consumption generally originates from Switzerland.

in corresponding changes of downstream marketing levels until 2007. In the following period until 2011 demand for milk and milk products was stimulated again by low product prices on the one hand and on the other hand by a recovering global economy and, thus, strong increasing demand for processed milk products in emerging countries.

Figure 1 Development of cheese prices at different market levels and of raw milk producer prices between 1997 and 2011measured logarithmically



* IMPE: Intervention milk price equivalent of the European Union.
Source: Own illustration.

Based on the changes in the CMO, it seems to be plausible to split up the observation period in two subsamples. The first subsample covers the period from January 1997 to December 2004 and the second subsample comprises the period from January 2004 to October 2011.

3. THEORETICAL BACKGROUND

In this chapter information about the different analysing steps and their underlying theory are briefly discussed. Before starting the actual analysis some preparatory steps concerning the original time series had to be applied.

3.1. 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.

The model structure within the observed price series is assumed to be multiplicative. This means that the magnitudes of the seasonal movements change proportionally with the level of the series (U.S. Census Bureau, 2011: 193). Thus, the trend (C_t), the seasonal (S_t) and the irregular components (I_t) of a time series (X_t) are represented by a multiplicative function of the form[5]:

1. $X_t = C_t \bullet S_t \bullet I_t$

The irregular factor (I_t) may be decomposed into its sub-components: changes in the number of trading days and festival dates (the calendar effects) (P_t) and the remaining irregularity (E_t) caused by all other influences (CBS, n.d.):

2. $I_t = P_t \bullet E_t$

from this follows

3. $X_t = C_t \bullet S_t \bullet P_t \bullet E_t$

To qualify the adjustments provided by the Census-X-12 procedure a control statistic *Q* has been developed. It is the sum of eleven relevant statistics. Each statistic is assigned a weight according to its relative importance to the overall quality of the adjustment. If *Q* is greater than 1, the adjustment is declared to be unacceptable. This is also true if the test for identifiable seasonality fails (Lothian and Morry, 1978) and implies that there is no significant seasonality measurable within the data series.

3.2. Stationarity

Price series do often not only include a seasonal component but also exhibit strong **trends**. If this is the case, then the series is called **nonstationary** and, thus, is 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.

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)*. Nonstationary time series can be transformed to a stationary series by differencing, for example. If the series is stationary after constructing *d* differences then the original series is integrated of order *d* or *I(d)*, respectively. A

[5] Method details are given in Shiskin, Young and Musgrave (1967).

common example of a nonstationary series is the random walk (see Cuthbertson, Hall and Tylor, 1992: 3):

4. $X_t = X_{t-1} + \varepsilon_t$

where ε_t is a stationary random disturbance term. This type of series is clearly *I(1)*. The order of integration is the number of **unit roots** contained in the series, or, as already mentioned, the number of differencing operations it takes to make a time series stationary (Greene, 2008: 740). The formal method to test for stationarity is the unit root test. Dickey and Fuller (1979) were the first presenting a test applicable to *AR(1)* processes. The unit root test of Dickey-Fuller can be applied to time series with drift

5. $\Delta X_t = \alpha + \delta X_t + \varepsilon_t$

and to time series with drift and linear deterministic trend

6. $\Delta X_t = \alpha + \beta_t + \delta X_t + \varepsilon_t$

The advantage of the augmented Dickey-Fuller test is that this test, in contrast to the standard Dickey-Fuller test, can accommodate higher-order autoregressive processes in ε_t (Greene, 2008: 751). The relating regression equation takes the canonical form:

7. $\Delta X_t = \alpha + \beta_t + \delta X_t + {}_{j=1}\Sigma^{p}\, \delta_j \Delta X_{t-1} + \varepsilon_t$

where *p* is the preselected order of lags for the residuals[6]. As the t-distribution for the t-statistic of *δ* is not appropriate, however, Engle and Granger (1987) have provided critical values.

3.3. 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.

Two time series, both nonstationary, could have a particular **linear combination** that is stationary:

8. $Y_t = \alpha + \beta X_t + \varepsilon_t$

After transformation it becomes apparent that the random disturbance term ε_t is a linear combination of two integrated and nonstationary series Y_t and X_t:

9. $\varepsilon_t = Y_t - \alpha - \beta X_t$

This implies that, in general, ε_t is integrated, too. But 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 will 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).

[6] For more details on the underlying theory of the test see Dickey and Fuller (1979).

Johansen (1988) developed a test procedure to test time series for cointegration[7]. The basis of this method of testing is a multivariate vector autoregressive model (Johansen, 1988: 234).

3.4. Granger Causality

From the identification of cointegration between two time series one cannot conclude how these two series causal affect each other. However, Granger (1969) was the first to attempt a test for the **direction of causality**. Granger questioned whether *X* causes *Y* and how much of the current *Y* can be explained by past values of *Y* and then to see whether adding lagged values of *X* can improve the explanation. If *X* helps in the prediction of *Y* then *Y* is said to be **Granger-caused** by *X*. It is important to note that two-way causation is often the case: *X* Granger-causes *Y* and vice versa. However, this doesn't mean that *Y* is the result of *X*.

Normally, the following bivariate regressions are run for all possible pairs of (*X*, *Y*) series

10. $Y_t = \alpha_0 + \alpha_1 Y_{t-l} + ... + \alpha_l Y_{t-p} + \beta_1 X_{t-1} + ... + \beta_l X_{t-q} + \varepsilon_t$
11. $X_t = \alpha_0 + \alpha_1 X_{t-l} + ... + \alpha_l X_{t-q} + \beta_1 Y_{t-1} + ... + \beta_l Y_{t-p} + \mu_t$

where ε_t and μ_t are white noise and *p* and *q* are the order of the lags for *X* and *Y*, respectively. The null hypothesis is that *X* does not Granger-cause *Y*, so that $\beta_j = 0$ for $j = 1, 2, ..., q$. The restricted model is therefore:

12. $Y_t = {}_{i=1}\Sigma^p \alpha_i Y_{t-i} + \nu_t$

The test statistic is the standard Wald F-statistic:

13. $F_c = [(ESSR – ESSU)/q] / [ESSU/(n – p – q)]$

where *n* is the number of observations used in the unrestricted model in *equation (10)*, *ESSU* is the error sum of square for *equation (10)*, and *ESSR* is the error sum of squares for the restricted model in *equation (12)* (Ramanathan, 2002: 476). The lag length is arbitrary but should be chosen to be large. Nevertheless, the selected length should correspond to reasonable beliefs about the longest time over which one of the variables could help predicting the other. Alternatively, the determination of the lag length could be made with the **Lagrange multiplier test**.

Once Granger published his test procedure, a variety of alternatives have been developed[8].

4. EMPIRICAL RESULTS

In this chapter descriptive results of the used data set is briefly presented followed by the discussion of test results testing for seasonality, stationarity, and causality. To give a general overview of underlying market relationships for the total period of 1997 to 2011 a correlation analysis of the world market prices plus export refunds if applicable, wholesale, consumer, and

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[7] For more details see Johansen (1988) and Johansen and Juselius (1990).
[8] For example see Pierce and Haugh (1977), Sims (1980), or Geweke, Meese and Dent (1983).

producer price series is carried out and this analysis reveals some interesting findings (see Table 1). First, the correlation between the world market price plus export refunds and the German wholesale price is lower than the correlation between the world market price plus export refunds and the consumer as well as the producer price in Germany. This is a remarkable finding as one would expect the relationship between the world market level and the wholesale level to be closer than to the consumer level. This observation can be explained with i) the high market foreclosure caused by the EU dairy market organization, ii) the (partially) fixation of export refunds to counteract domestic price fluctuations and additionally with iii) the high degree of intra-EU trade of dairy products. i) and ii) cause wholesale prices not to follow every movement of world market prices and iii) implies a relatively independence of intra-EU prices from the world market level.

Second, wholesale prices are stronger correlated to producer prices than to consumer prices. This finding significantly depends on the price formation mechanism of raw milk used by most German dairies in which the final price is determined after products are sold. This means that the raw milk price co-operative dairies[9] are paying their milk producers depends on the utilization of dairies' milk in their respective milk processing and the prices of their milk products achieved in the marketing channel. After raw milk is processed and milk products are sold the generated revenue is used for calculating the raw milk price to be paid.

Table 1 Correlation matrix of logarithm of price series (1997-2011)

	World market price	Wholesale price	Consumer price	Producer price
World market price	1.0000	0.0418	0.3824	0.3898
Wholesale price	0.0418	1.0000	0.1410	0.8324
Consumer price	0.3824	0.1410	1.0000	0.2518
Producer price	0.3898	0.8324	0.2518	1.0000

Source: Own computations.

Table 2 summarises main results of the seasonality test with the Census-X-12 procedure. From this follows that significant stable seasonality is present only in wholesale and producer prices during the whole observation period. In contrast, world market prices include only from 2005 to 2011 a stable seasonal component whereas consumer and world market prices exhibit no seasonality between 1997 and 2004. This result may be driven by the fact that export share of dairy products from regions with grassland based milk production was significantly higher in the period 2005 to 2011 than in the 1997 to 2004.

Table 2 Summary of selected results of test for seasonality

	World market price		Wholesale price		Consumer price		Producer price	
Period	1997-2004	2005-2011	1997-2004	2005-2011	1997-2004	2005-2011	1997-2004	2005-2011
Number of observations	96	82	96	82	96	82	96	82

[9] Nearly 70% of German raw milk is processed by co-operative dairies (Bundeskartellamt, 2009: 31).

Stable seasonality†	0.564	5.712***	24.194***	7.983***	1.515	1.182	472.2***	56.090***
Moving seasonality†	4.310**	3.966**	3.742**	7.673**	3.577**	3.005*	2.354*	5.836**
Q-value	1.20	0.73	0.41	0.53	1.18	1.12	0.12	0.28

† F-value and level of significance: *** 99.9%, ** 99%, * 95%.
Source: Own computations.

Series with significant seasonality are adjusted for. Additional tests on trading day effects show that these are only relevant for producer prices in period II and, therefore, are corrected.

After adjusting price series for seasonality, if necessary, they are tested for stationarity (Table 3). We used the augmented Dickey-Fuller test instead of the standard Dickey-Fuller test because it allows higher orders of autoregressive processes in the disturbance term. In the test equation a constant and a linear trend as exogenous variables are included. Additional test with the KPSS-test[10] confirmed the findings. All observed time series are nonstationary, thus, showing trend behaviour and are of integration order *I (1)* at least the 95%-level of significance.

Table 3 Summary of the augmented Dickey-Fuller test for stationarity

	World market price		Wholesale price		Consumer price		Producer price	
Period	1997-2004	2005-2011	1997-2004	2005-2011	1997-2004	2005-2011	1997-2004	2005-2011
Number of observations	96	82	96	82	96	82	96	82
Unit root	I (1)	I (1)	I (1)	I (1)	I (1)	I (1)	I (1)	I (1)
F-value	-12.75***	-3.80*	-4.37**	-5.78***	-10.31***	-5.49*	-3.53*	-3.2539(*)

Level of significance: *** 99.9%, ** 99%, * 95%, and (*) 90%.
Source: Own computations.

After controlling for the basic requirements in a next step of the analysis it is interesting to know whether these nonstationary price series show some common movements. Thus, a Johansen test of cointegration is performed to answer this question. The results are summarized in Table 4. From 1997 to 2004, linear combination could only be proven to be significant between the following combinations: wholesale prices and consumer price, wholesale and producer price, and consumer and producer prices. Between world market prices and the other price series no cointegration behaviour could be identified. This is plausible, because the market foreclosure of the EU dairy market regulation (like intervention price, export refunds, etc.) separated intra-EU prices as strongly as possible from developments on international markets.

Only when the EU started with the stepwise liberalization of the dairy market regulation, intra-EU prices became more and more connected to world market developments as the results confirm for the period between 2005 and 2011. Within this period all series are significantly cointegrated at least at the 95%-level. The only major difference is in the lag length. From 1997 to 2004 the lag length is shortest between consumer and producer prices with three months and longest between wholesale and producer prices with nine months. The lag length depends

[10] For details on the test see Kwiatkowski et al. (1992).

mainly on the contract duration between dairies and retailers or exporters, respectively. As already seen the market liberalization process in the EU has some major implications for some of the price series and caused their lag length to decline. In the period lasting from 2004 to 2011 the lag length is shortest between world market and wholesale prices with two months and longest between consumer and producer prices with six months.

Table 4 Results (Trace Statistics) of the Johansen test of cointegration

	World market price	Wholesale price	Consumer price
1997-2004			
Wholesale price	0.8597 (3)		
Consumer price	1.8853 (3)	7.0762** (4)	
Producer price	0.9414 (3)	5.6719* (9)	9.1230** (3)
2005-2011			
Wholesale price	5.3859* (2)		
Consumer price	6.2211* (3)	9.0258** (4)	
Producer price	4.8878* (6)	4.0502* (4)	6.5105* (2)

Length of lag in parentheses. Level of significance: *** 99.9%, ** 99%, * 95%.
Source: Own computations.

However, after identifying correlated movement the causal relationship has to be tested. In doing so Granger's causality test is applied on the price series. The main results for both subsamples are presented in the Table 5. Between 1997 and 2004 the world market price Granger-caused the wholesale price at a 90%-level of significance with a delay of one month. These results indicate to a high degree of integration of German wholesale prices in world markets; however, these results contradict somewhat the results of the Johansen test of cointegration as those test results were not significant for a lag length of one month.

Wholesale prices significantly Granger-cause consumer prices as well as producer prices with a lag length of three and two months, respectively. These results are in line with the outcome of the Johansen test. Lag-lengths of two to three months seem also plausible to explain price movements to ripple up- and down-stream in the supply chain. And more, producer prices also Granger-cause wholesale prices with a delay of two months and consumer prices with a delay of three month. That producer prices Granger-cause wholesale prices and in turn consumer prices are the consequence of increased costs of production of milk producers and appear to be plausible as well.

In the current period the picture has changed somewhat. Between 2005 and October 2011 world market prices Granger-cause prices on all other marketing levels; however, with varying lag lengths ranging from two to six months. This reflects the impact of the reduced price gap between world market and domestic market. But in this period now, wholesale prices only Granger-cause consumer prices and have no Granger-effect on producer prices anymore. This outcome is quite astonishing as, normally, producer price formation is based on the prices received by the dairies. Possible explanations might be that German dairies increasingly dependent on international export markets in the case of cheese, raw milk production costs depict a decreasing share in total cost of the final processed product, declining share of cooperative dairies, dairies may try to avoid paying price extremes and compensate on longer terms, or combinations thereof.

Consumer prices have only at a 90-significance level a Granger-causal effect on producer prices. Compared with this, the causal effect of producer prices on the wholesale level and the consumer level is rather stable in this period. The decrease of causal relationship of the downstream marketing levels among one another may be caused by the stronger dependency of prices on international market developments.

Table 5 Results of Granger's causality test

	World market price		Wholesale price		Consumer price		Producer price	
	F-value	Lags	F-value	Lags	F-value	Lags	F-value	Lags
1997-2004								
World market price			0.5722	1	0.3154	3	0.5435	3
Wholesale price	3,9375$^{(*)}$	1			3.0160*	3	7.6209***	2
Consumer price	0.1546	3	4.1592**	3			4.4370**	3
Producer price	0.8533	3	7.0200**	2	3.6040**	3		
2005-2011								
World market price			1.2869	2	1.1112	6	1.8750	2
Wholesale price	7.6519***	2			2.7310	2	17.5803***	2
Consumer price	2.3795*	6	3.9741*	2			4.4444*	2
Producer price	4.9236**	2	1.5405	2	2.4589$^{(*)}$	2		

Level of significance: *** 99.9%, ** 99%, * 95%, and $^{(*)}$ 90%.
Source: Own computations.

5. CONCLUDING REMARKS

Our paper deals with the interactions of prices concerning different marketing levels in the German dairy sector whereas here, a focus is put on cheese. Marketing levels studied comprise producer prices of milk, wholesale and consumer prices of Gouda, and international cheddar prices including EU export refunds. To analyse price cointegration and causality significant seasonality was removed applying the Census-X-12 procedure. And more, price series were tested for stationary. On the adjusted series the Johansen test for cointegration was applied and Granger causality was tested. 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: In the paper the focus is on cheese and it is abstracted from any interactions with other dairy products although prices of all products are linked. This fact is even more accentuated by the quota system still limiting available milk quantities for processing allowing certain quantity adjustments. Another problem is arising from the price data. Comparable price series are difficult to achieve; so the use of the international cheddar price plus export refunds in comparison to the Gouda prices may provide some disadvantages and may hinder a generalisation. Thus the outcome may be different when more homogenous products are regarded. Other limitations concern the procedure applied. Cointegration and granger causality lead to some contradicting results. Here, further and deeper analyses are required.

Nevertheless, some first conclusions can be provided: While producer and wholesale prices are subject to seasonality, consumer prices do not reflect any seasonality. Thus, the likely seasonality is counterbalanced by retailers and wholesalers. This is confirmed by other studies showing that prices at the point of sale are quite rigid (Weber, 2009; Herrmann, Möser and Weber, 2005). In contrast, the outcome of the international price indicates an increased seasonality which may be driven by the growing export share of grassland based production. With the implementation of the Luxembourg Agreement, indeed, the market features of the German cheese market have changed significantly, as was to be expected. While in the period 1997 to 2004, the domestic prices were quite unrelated to the international prices including export refunds, the period 2005 to 2011 depict granger caused price relations for all three regarded marketing levels. Wholesale prices and consumer prices are granger causing each other with different lags in both periods regarded. Hence, while the producer price granger affects the wholesale price via increased production cost, the other way round does not hold true any longer in the second period 2005 to 2011. This comes as a surprise as at least cooperative producer prices are based on the wholesale prices. And although, there are several explanations are possible, a deeper analysis of this result is required.

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