VERTICAL PRICE TRANSMISSION IN DIFFERENTIATED PRODUCT MARKETS:

A DISAGGREGATED STUDY FOR MILK AND BUTTER

THORE HOLM, JENS-PETER LOY and CARSTEN STEINHAGEN

Department of Agricultural Economics

University of Kiel

Contact: jploy@ae.uni-kiel.de

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Abstract

The retail business is often blamed for employing market power to enforce higher margins. Since 2007 milk markets worldwide have been in turmoil and this public debate flared up again. Only very few papers have addressed the issue by investigating the dynamic pricing process of individual retailers. In this paper variations in vertical price adjustment (cost pass through) between retail and whole sale prices for differentiated milk and butter products (brands) for different (individual) retail outlets in the German market from 2005 to 2008 are analyzed on a weekly basis. The results indicate significant asymmetric price adjustments; however, the starting hypothesis that asymmetric price adjustments are used more excessively by/for stronger brands has to be reconsidered.

1 Introduction

At first glance milk and butter – respectively – appear to be fairly homogenous goods considering their almost normed physical and chemical characteristics; however, these products show significant price differences at the retail level between national brands and/or private labels or between different retail outlets such as supermarkets, consumer markets or discounters. This holds even for prices in the same week at the same store or at stores close by each other. Looking at average prices over the observation period from 2005 to 2008 we find that national brands range from 53 (80) to 106 (239) Eurocents per liter. (per 250 g) for milk (butter). Average private label prices range from 56 (80) to 100 (106) Eurocents per liter (per 250 g) for milk (butter).

Product branding of food processors – mainly dairies – and outlet specific pricing strategies – namely HiLo (high Low) and EDLP (everyday low price) – may serve as arguments to explain the observed price differentials. Dominant brands as well as certain retail chains have some potential to divert from the competitive single market price equilibrium e.g. due to consumer preferences or costs of store switching. Strong brands can generate loyal consumers who do not switch to competing brands before certain price differentials are exceeded. Retail outlets offer a bundle of products to consumers who face store switching costs and therefore often exercise one-stop-shopping. This allows manufacturers and retail outlets to use single product prices strategically.

This potential to manipulate prices might not only result in deviations of average prices but might also lead to differences in the dynamic price adjustments between brands and retail outlets. At the aggregated level many studies for dairy products and other agricultural goods have shown significant asymmetric vertical price adjustments (amongst others PELTZMAN 2000; GOODWIN AND PIGGOTT 2001; BAUMGARTNER 2009). The direction (sign) of price changes or marketing margins therefore leads to different dynamic price reactions with respect to the speed of adjustment and/or the magnitude of the long-run price equilibrium. To what extent and why the dynamic pricing behavior differs between brand and/or retail outlets is the main subject of this study. We analyze the variations in vertical price adjustment (cost pass through) between retail and whole sale prices for the differentiated milk and butter products (brands) and for different (individual) retail outlets in the German market.

The underlying hypothesis is that an increasing potential to manipulate retail prices (market power) goes along with a (positive) dynamic asymmetric price adjustment. Such a behavior is more likely to be observed for strong (national) brands and outlets that serve a wider assortment of goods and more complex or higher quality services such as consumer markets, super- or hypermarkets compared to discounters.

Our study contributes to the literature by adding to the following aspects: First, we present price transmission estimates at the most disaggregated level using specific product prices (EAN-code based) at individual retail outlets to obtain brand (product) specific and store specific price adjustments using an extensive retail scanner data set over a four years period from 2005 to 2008. Second, retail prices often show a high level of rigidity which prevents an efficient estimation of dynamic price adjustment processes; in the sample under study the food crisis in 2007 has caused significant price variation at the wholesale and the retail level. In addition, retail prices are set on a weekly basis which is the frequency of the data under study; the majority of former studies used data at a monthly frequency. Third, we use wholesale prices instead of farm prices as in most of the studies. Wholesale milk prices might better reflect short-run cost changes in the retail market than farm prices. Fourth, a two stage estimation approach is employed to analyze the differences in the price response functions. In the first stage after testing the time series properties we apply a three regime threshold error correction model (TECM) to a wide range of time series (2643) including 71 (90) different brands for milk (butter) and 327 (447) retail stores.[1] In the second stage the estimates of the individual dynamic price adjustment enter an estimated dependent variable regression which uses dummy variables as explanatories to measure and test brand, store type and product specific effects. The estimated dependent variable regression has to our knowledge not been used in this context before, at least for data on the dairy market.

The paper is organized as following. In section two we summarize the empirical literature on vertical dairy product price transmission. In the following section the methodological background of estimating asymmetric price transmission are explained. Section four gives an overview of German dairy product markets at the wholesale and the retail levels. Descriptive statistics and time series properties of the processes under study are described in section five. In section six the estimation results for the threshold error correction model in the first step and the estimated dependent variable regression for different parameters of the dynamic price adjustment in the second step are presented and discussed. In the final section we present our conclusion.

[1] Testing non-linearity and the number of regimes for the threshold model is often ignored in empirical applications. We explicitly consider these issues following the procedure by STRIKHOLM AND TERÄSVIRTA (2006).

2 Literature Review

A great number of studies on asymmetric price adjustments and its implications on the performance of agricultural and food markets have been presented over the past decades; several of these studies have specifically investigated dairy product prices starting with the seminal paper by KINNUCAN AND FORKER (1987) (see Table 1). In particular the recent price volatility in the period between 2007 and 2008 has revived the debate on asymmetric price transmission, e.g. in the US where the "debate over this matter grew more intense when retail prices appeared to change relatively little as farm prices dropped in late 2008" (STEWART AND BLAYNEY 2011).

While according the American Farm Bureau Federation increases of farm prices of milk are quickly passed on to consumers by marketers, farm prices decreases are adjusted much slower to retail prices in order to increase profits mostly in retailing (STEWART AND BLAYNEY 2011). According to MEYER AND CRAMON-TAUBADEL (2004) such a price response is defined as positive asymmetry. The European Commission comes to a similar conclusion: "Since 2007, consumer prices – and to a lesser extent food producer prices – have failed to decrease in line with the decrease in agricultural commodity prices, exhibiting a 'rockets and feathers' evolution pattern in which prices are fast to raise and slow to decrease. The decline in agricultural commodity prices has been passed on up to one year later to the consumers" (EUROPEAN COMMISSION 2009). The German Antitrust Commission has looked at the dynamics of vertical price relationships on domestic dairy markets concluding that the pricing process appears to be efficient; following, they see no need for antitrust policy actions (BUNDESKARTELLAMT 2009). The analysis is based on disaggregated data for national brands and private labels which might explain the differences in the results compared e.g. with other European countries; also, Germany seems to be a special case with a highly competitive retail sector. However, no formal testing is applied; the conclusions are based on graphical analyzes of only a few case studies.

- Insert Table 1 about here -

KINNUCAN AND FORKER (1987) investigate price transmission between retail and farm prices for milk, butter, cheese and ice cream. They find significant positive asymmetries in the price transmission process using the Wolffram-Houck approach. KINNUCAN AND FORKER (1987) argue that governmental price support and industry concentration cause the asymmetric price response; they also discuss the static marketing margin model of GARDNER (1975) and show that farm-retail price transmission elasticities are smaller when price changes are predominantly triggered by cost shifts. However, cost shifters are identified to play only a minor role in explaining the asymmetric price adjustment.

SERRA AND GOODWIN (2003) (milk, cheese, cream caramel), CHAVAS AND MEHTA (2004) (butter), JENSEN AND SKADKÆR MØLLER (2007) (price indexes of different milk products), BAUMGARTNER ET AL. (2009) (milk, butter, cheese, dairy products) and STEWART AND BLAYNEY (2011) (milk, cheese) use (threshold) error correction models. SERRA AND GOODWIN (2003) find positive asymmetries for the Spanish dairy market. The authors relate the asymmetric pricing behavior in the Spanish dairy sector mainly to menu costs, inventory management, search costs and public market intervention. CHAVAS AND MEHTA (2004) find that retail prices respond more strongly to wholesale price increases than to wholesale price decreases; their explanations are consumer search costs, retailers' menu costs and also imperfect competition at the retail level. JENSEN AND SKADKÆR MØLLER (2007) detect weak price transmission especially for milk. In their view asymmetric price adjustment is caused by public intervention and product differences. More value added products show a higher degree of asymmetry. The EUROPEAN COMMISSION (2009) analyzes a range of different milk products (milk, butter, cheese, skim milk etc.) for a variety of EU Member States. Instead of an error correction approach a model in first differences is used to detect asymmetric price responses. In particular for Slovenia, United Kingdom, Denmark and Lithuania significant asymmetries are found. The Commission relates the positive asymmetries to "the limited share of agricultural commodities into final food prices, inefficiencies in the market structure of the chain (either linked to imbalances in bargaining power and/or anti-competitive practices), and some adjustments constraints and costs (e.g. costs of changing prices for both producers and retailers, the slow price transmission due to long-term contracts between economic actors)" (EUROPEAN COMMISSION 2009).

BAUMGARTNER ET AL. (2009) detect positive asymmetries for milk and butter. STEWART AND BLAYNEY (2011) study price transmission over the food crisis from 2007 to 2009 in the US. They analyze the nature of price transmission for whole milk and cheddar cheese, comparing results of different model specifications. Independent of underlying specification they find positive asymmetries. Additionally, STEWART AND BLAYNEY (2011) state for the lower processed product (whole milk) that the price pass-through is larger and that the process of error correction is active in the whole spectrum of observed disequilibria. In contrast the higher processed product (cheddar cheese) shows a band of no error correction.[2]

[2] STEWART AND BLAYNEY (2011) mention some more studies for the US market (LASS AND ADANU 2001; LASS 2005; CAPPS AND SHERWELL 2007; AWOKUSE AND WANG 2009). They conclude: "However, all studies find evidence of some type of asymmetry."

In conclusion, the empirical evidence for statistically significant positive price asymmetries in the dairy sector is overwhelming. However, a few issues need to be resolved before concluding what the main drivers for these phenomena are. First, most studies use farm prices at the upstream level. Dairy farms have contracts with dairies and for cooperative company hold company's shares. Therefore, contract prices might not follow simple market integration rules; for instance, dairies try to use higher prices in the winter season to allocate more milk in that period or some dairies might stabilize prices over the season.[3] In addition, when studying highly processed products such as butter or cheese compared to fresh milk, price transmission might be affected by the importance of processing costs and/or the prices of complements that are not considered. Analyzes of price transmission have to take into account these issues when using farm level instead of respective wholesale prices.[4] Second, all studies discussed here use relatively highly aggregated monthly data. Thus, it might be questioned whether the estimated results indicate an average behavior in the industry. CRAMON-TAUBADEL ET AL. (2006) have shown "that estimation with aggregated data can generate misleading conclusions about price transmission behavior at the level of the individual units (i.e. retail stores) that underlie these aggregates." We also lose the information about variations in individual price responses and about what subsectors are driving the average behavior. Third, many studies focus on statistical significance.[5] It would, however, be important to calculate the economic importance not only in theory by relating coefficients to the scale of respective variables simulating artificial shocks but also to simulate the impact of asymmetry with real data shocks. All these issues are considered in the present study.

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[3] Therefore, imperfect or asymmetric price transmission between farm and retail prices might not indicate imperfect competition and/or inefficient exchange processes. Wholesale prices used here are not directly affected by vertical integration (contracts); for those retailers using contracts wholesale prices still reflect opportunity costs.

[4] At the farm level there is only one price, namely the price of raw milk. The relationship between the farm price of milk and the retail price of butter is likely affected by the price of skim milk powder as it is the complementary product. In this study we use wholesale prices of butter to avoid these problems of model misspecification.

[5] Cramon-Taubadel (1998) presents a simulation to evaluate the economic significance of asymmetric price adjustment. We follow his approach and adopt it for the estimated threshold model.

3 Methodology

A technique to estimate asymmetric price transmission has first been proposed by WOLFFRAM (1971) and later modified by, inter alia, HOUCK (1977). Since then many methodological enhancements have been introduced and a great number of empirical studies e.g. for aggregated data have been presented. A consistent theoretical explanation is still at large (see PELTZMAN 2000). Main arguments for asymmetric price transmission are market or bargaining power, menu costs, inventory management and internalization of price variations. A detailed overview on methodological developments, theoretical justifications and empirical results in this field can be found in FREY AND MANERA (2007) and MEYER AND CRAMON-TAUBADEL (2004).

A major step in developing a methodology to efficiently estimate asymmetric price transmissions is the work by ENGLE AND GRANGER (1987) on cointegration. Most price series indicate non-stationary behavior similar to random walks. Cointegration tests and the error correction representation of co-integrated processes solve the problem of spurious regressions and offer a simple as well as meaningful economic interpretation. GRANGER AND LEE (1989) adopted the concept of asymmetric adjustments to the error correction representation. The basic idea is that the speed of returning back to the equilibrium differs with respect to the sign of the deviation from the long-run equilibrium. Compared to earlier approaches which are based on the signs of price changes, the specification proposed by GRANGER AND LEE (1989) separates positive and negative deviations from the long-run equilibrium. Thereby GRANGER AND LEE (1989) do not only present a statistically consistent specification but also a consistent economic interpretation. This concept can be applied in all fields that rely on an equilibrium concept. While originally developed to analyze the relationship between production, sales and inventories, the specification can also be applied to cost pass through or price integration studies. The following specification illustrates the model. Let p_{1t} be a retail price and p_{2t} be a wholesale price, μ_{t-1} is the deviation from the long-run relationship and I_{t_1} is an indicator variable. I_{t_1} is 1 if $\mu_{t-1} < 0$ and zero otherwise.

$$\Delta p_{1t} = \alpha_0 + \delta^- I_{t_1} \mu_{t-1} + \delta^+ (1 - I_{t_1}) \mu_{t-1} + \varphi \Delta p_{2t} + \sum_{j=1}^{k} \beta_{1j} \Delta p_{1,t-j} + \sum_{j=1}^{k} \beta_{2j} \Delta p_{2,t-j} + \varepsilon_t \qquad (1)$$

Asymmetric error correction models have been applied in different forms, restricted and unrestricted models, with different asymmetric and lag specifications (see CRAMON-TAUBADEL AND LOY 1999, 1996; GRANGER AND LEE 1989).

The two main characteristics of the (asymmetric) price transmission process are the speed of adjustment back to the (linear) long-run equilibrium and its parameters indicating the average margin. For asymmetric processes the speed of price adjustment varies with respect to the sign of the deviation from the long-run equilibrium. Asymmetries are classified into positive and negative. A positive asymmetry implies adjusting retail prices faster when wholesale prices rise compared to when they fall. Negative asymmetries describe the opposite. Traditionally asymmetric models have one threshold (two regimes) which is *a priori* set at zero. In more recent papers the threshold is determined endogenously in a separate procedure. For vertical price transmission models two thresholds (three regimes) are often used to represent the theoretical idea of menu costs that prevent or limit adjustments of small deviations from the equilibrium in the inner regime (BALKE AND FOMBY 1997). In the two threshold model the error correction term is split into three regimes as shown in Equation 2 and 3.

$$\mu_t = \begin{cases} \delta^1 \mu_{t-1} + \varepsilon_{1t} & if \quad \mu_{t-1} > \theta_1 \\ \delta^2 \mu_{t-1} + \varepsilon_{2t} & if \quad \theta_2 \le \mu_{t-1} \le \theta_1 \\ \delta^3 \mu_{t-1} + \varepsilon_{3t} & if \quad \mu_{t-1} < \theta_2 \end{cases} \tag{2}$$

$$\Delta\mu_t = (\delta^1 - 1) I_{t_1} \mu_{t-1} + (\delta^2 - 1)\big(1 - I_{t_1} - I_{t_2}\big)\mu_{t-1} + (\delta^3 - 1) I_{t_2} \mu_{t-1} + \varepsilon_t \qquad (3)^{6}$$

The thresholds are estimated following a procedure by CHAN (1993) who proposes an iterative (grid) search using all potential values for the transition variable and selecting thresholds based on minimizing the residual sum of squares of all potential TAR models. The search is limited to guaranty a minimum number of observations in each regime (HANSEN 1999; HANSEN AND SEO 2002). Threshold values estimated based on CHAN (1993) are super-consistent.[7]

[6] The transformation of (2) into first differences is due to testing convenience similar to the first differencing in linear case applying the ADF-procedure.
The indicator variables are defined according to the regimes separated by the thresholds; for instance, if $\mu_{t-1} < \theta_1$, then $I_{t_1} = 1$ else $I_{t_1} = 0$. If $\mu_{t-1} > \theta_2$, then $I_{t_2} = 1$ else $I_{t_2} = 0$.

[7] A more detailed description on the estimation of thresholds by grid search can be found in CHAN (1993) and STIGLER (2010); ENDERS AND SIKLOS (2001), ABDULAI (2002) and BAUMGARTNER ET AL. (2009) present applications of the procedure.

For every regime a separate autoregressive structure is assumed. Thus, conditions to ensure stationarity of the error term (μ_t), which is a requisite for (threshold) cointegration, are more complex than in the linear case. For multiple regimes there might be a very large number of sufficient conditions to ensure stationarity. Additionally, the number of regimes (thresholds) needs to be confirmed empirically. The threshold parameters are not known a priori and have to be estimated. Standard procedures to test for linearity against non-linearity cannot be applied (HANSEN 1996). For correct inference on threshold cointegration, testing for linearity and the number of regimes need to account for the problem of nuisance parameters under the H_1–hypothesis (ANDREWS AND PLOBERGER 1994; HANSEN 1996).[8] TJØSTHEIM (1990) proves that if the characteristic roots of the autoregressive lag processes in the outer regimes are smaller than one, then the process is stationary; namely, if the outer regimes are stationary, the whole process is stationary. CHAN ET AL. (1985) show sufficient conditions for the three regime model. If $\delta^1 < 1, \delta^3 < 1$ and $\delta^1\delta^3 < 1$, then μ_t is a stationary process.[9]

Following ENGLE AND GRANGER (1987), stationarity of the error term (μ_t) indicates that processes (prices) are threshold cointegrated. Assuming a symmetric lag structure of order k for all prices, threshold cointegration implies the existence of a threshold error correction representation of the following form:

$$\Delta p_{1t} = \alpha_0 + I_{t_1}\delta^- \mu_{t-1} + \left(1 - I_{t_1} - I_{t_2}\right)\delta^0 \mu_{t-1} + I_{t_2}\delta^+ \mu_{t-1} + \varphi \Delta p_{2t} + \sum_{j=1}^{k} \beta_{1j} \Delta p_{1,t-j} + \sum_{j=1}^{k} \beta_{2j} \Delta p_{2,t-j} + v_t \qquad (4)$$

The indicator functions are defined as above. The error correction representation in equation 4 allows for different adjustments of deviations from the long-run equilibrium depending on the size of the deviation. If the inner regime shows no responses (δ_i=0), then the lag polynomial of the error process has a unit root and the process is non-stationary. As long as the outer regimes are stationary, such behavior can be compatible with threshold cointegration.

PIPPENGER AND GOERING (1993, 2000), BALKE AND FOMBY (1997), ENDERS AND GRANGER (1998), ENDERS AND SIKLOS (2001) and LO AND ZIVOT (2001) show that traditional tests do not fail to detect cointegration but they can lose power in presence of threshold (non-linear) effects. Regardless what test is used, e.g.

[8] The problem vanishes if the underlying economic relationship is known a priori.

[9] See BALKE AND FOMBY (1997) for more details on the issue of stationarity, e.g. when the outer regimes indicate non-stationary behavior.

ENGLE-GRANGER Approach (1987)[10] or JOHANSEN trace test (1988), the test power decreases for absolute larger thresholds. Testing directly the null of no cointegration against the alternative of threshold cointegration is a superior alternative. ENDERS AND SIKLOS (2001) propose a non-standard test based on Monte-Carlo-Experiments. They develop two test statistics (t-max- and ϕ-statistic) and simulate critical values.[11] The statistics are then applied to test the null hypothesis of no cointegration against the alternative of threshold cointegration. The hypotheses $\delta^1 < 1,\ \delta^3 < 1$ are tested with the t-max statistic and in addition $\delta^1 = \delta^3 = 1$ is tested by applying the ϕ-statistic. Whenever the test statistics exceed their critical values, the null is rejected.[12]

For testing the number of regimes (thresholds) several approaches are available. A graphical approach is proposed by TSAY (1989) using scatterplots of various statistics versus the specified threshold variables. A formal inference is provided by HANSEN (1996, 1999). HANSEN (1999) proposes a sequential likelihood ratio type test setting the model with the higher number of regimes as the alternative hypothesis. Bootstrapped asymptotic distributions are used to result critical values. The sequential procedure tests the linear model against the one threshold autoregressive model alternative (two regimes) in the first step; then, secondly, a one threshold model is tested against the two threshold alternative and so forth. The procedure stops when the null hypothesis is rejected for the first time. GONZALO AND PITARAKIS (2002) suggest also a sequential test, but based on information criteria. Hansen's test is computational burdensome due to the bootstrapped null distributions. Both sequential methods require the estimation of the model with the higher number of regimes, even if the parsimonious model is the favorable specification. This multiplies again the necessary computational time.[13]

STRIKHOLM AND TERÄSVIRTA (2006) propose another sequential procedure which has two advantages. Firstly, standard inferential methods can be applied and secondly, the higher order threshold alternative needs not to be estimated. The test uses a smooth transition generalization of the TAR model (STAR model) in Equation 3 in order to sequentially determine the right number of regimes. In Equation 5 a three regime STAR model is shown:

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[10] Different tests to detect stationarity in the equilibrium error, such as Augmented-Dickey-Fuller test (ADF), Philips-Peron test (PP) or Kwiatkowski et al. test (KPSS), are considered in the mentioned studies and lead to same loss of test power.

[11] ENDERS AND SIKLOS (2001) simulated their test statistic for a one threshold model; we reexamined their Monte-Carlo-Experiment for a two threshold model. Details on the simulation can be obtained from the authors upon request.

[12] These conditions are sufficient if processes converge, implying that autoregressive coefficients have to be positive. Then these conditions fulfill the first case in BALKE AND FOMBY (1997) mentioned above. Though there might be other conditions to ensure stationarity, rejecting these hypotheses identifies stationary processes. Not rejecting might not necessarily imply non-stationarity.

[13] Computational costs of estimating TAR models rise exponentially with increasing number of thresholds.

$$\Delta\mu_t = \delta^1\mu_{t-1} + \delta^2\mu_{t-1}G_{t_1}(\mu_{t-1},\theta_1,\gamma_1) + \delta^3\mu_{t-1}G_{t_2}(\mu_{t-1},\theta_2,\gamma_2) + \varepsilon_t \quad (5)$$

$G_{t_i}$is a transition function that uses μ_{t-1} as a transition variable, θ_i are threshold parameters which indicate the point of transition. γ_i are slope coefficients which reflect the speeds of the transition between the regimes (1, 2 and 3). If the slope coefficients γ_i tends to infinity, the STAR model in Equation 5 equals the threshold model in Equation 3.[14] If all γ_i are zero, the STAR model equals a simple linear model (TERÄSVIRTA 2006).

The sequential test for non-linearity starts in the first step with comparing the linear representation against a two-regime-STAR-model. The transition function G_{t_1} is replaced by a first order Taylor approximation. Both specifications are linear models. The hypothesis is equivalent to testing $\gamma_1 = 0$ (DIJK ET AL., 2000; STRIKHOLM AND TERÄSVIRTA 2006). For the decision which model is preferred, a simple F-test approximation is used. If the null hypothesis is rejected, one threshold needs to be estimated. According to Chan (1993) the sequential estimation of thresholds results super-consistent estimators; thus for the second step of testing a two- against a three-regime model, the second threshold is again modeled by a Taylor approximation.[15] This procedure is continued until the null hypothesis is rejected for the first time.

[14] Transition function $G_{t_i}(\mu_{t-1},\theta_i,\gamma_i)$ is bound between zero and one. It converges to indicator function as in (3) when γ_i becomes large. For details on the transition function see DIJK ET AL. (2000) or STRIKHOLM AND TERÄSVIRTA (2006).

[15] Estimating the thresholds does not depend on the number of thresholds, meaning if we estimate one threshold for a process that has two, then the estimated threshold equals the one or the other (GONZALO AND PITARAKIS 2002). This is an important requisite for the validity of the sequential testing procedure.

4 Milk Processing and Retailing

German dairies process about 20 percent of the milk produced in the EU-27 (AMI 2010). In 2006 57 of the 198 German dairy companies are cooperatives and 141 are other non-cooperatives (private enterprises). Cooperatives are on average bigger than non-cooperatives and their total share of processed milk is about 50 percent (AMI 2010; BMELV 2008). The market share of the six biggest dairy companies is almost 50 percent, of which four are cooperatives (FRIEDRICH 2010). Cooperatives mostly focus on cost leadership by utilizing economies of scale producing standard products such as milk powder and butter. In comparison, non-cooperatives use more marketing activities and focus on national brands with higher value added (EVERWAND ET AL. 2007; BUNDESKARTELLAMT 2009). 63 percent of the raw milk produced in Germany is processed to cheese (32 %) and butter (31 %). Another 34 percent of the raw produce goes into the production of milk (13 %), cream (12 %) and curdled milk/milk drinks (9 %) (AMI 2010).[16]

Dairy companies directly deal with food retailers. The food retailing sector is even more concentrated than processing. In 2010 the top 6 grocery retailers make more than 75 percent of the sector's turn over. Additionally, food retailers manage most of the dairy product exports (FRIEDRICH 2010; HELLBERG-BAHR ET AL. 2010). The big retailers such as ALDI, LIDL/SCHWARZ, METRO, REWE or EDEKA dominate the negotiations with the processors and can likely exercise market power (BUNDESKARTELLAMT 2009; HELLBERG-BAHR ET AL. 2010). However, this advantageous position might not result in higher margins due to intense competition between retailers and highly price sensitive consumers (HELLBERG-BAHR ET AL. 2010; TWARDAWA 2006; BACHL ET AL. 2010). The retail business in Germany can be differentiated by five formats with respect to store size and store product assortment (A.C. NIELSEN 2006; CLEEREN ET AL. 2010; GIJSBRECHTS ET AL. 2008). Supermarkets sell almost exclusively food items and have a store size smaller than 799 m², small (large) consumer markets sell predominantly food items and have a size above 800 m² and below 1499 m² (> 1500 and < 5000 m²). Hypermarkets sell food and other items such as clothing and have a size bigger than 5000 m² (A.C. NIELSEN 2006). Discounters offer a small assortment of goods (stock keeping units) with a high degree of private labels[17], operate at low costs and low buying-in-prices by realizing huge demand quantities (AGGARWAL 2003; CLEEREN ET AL. 2010; MORSCHETT ET AL. 2006). They use their low cost profile to offer everyday low prices to consumers, using only a small number of price

[16] 44 percent of milk processed by dairies is sold to the retail sector; the remaining products are delivered to large consumers (canteens, restaurants etc.) or the food processing industry (FRIEDRICH 2010).

[17] Discounters can be distinguished into two types. (a) Hard discounters (Aldi and Lidl) offering almost exclusively private labels and (b) soft discounters (Penny, Netto) which offer a limited set of national brands (AGGARWAL 2003, CATALUÑA ET AL. 2005).

promotions (AGGARWAL 2003; HOCH ET AL. 1994). The other store formats use a larger assortment of goods with a higher share of national brands and more fresh and specialty products (GIJSBRECHTS ET AL. 2008). They offer more services and employ a (high-low) promotional pricing strategy (RONDAN-CATALUÑA ET AL. 2005). The concept of private labels has been adopted also by these formats in order to be competitive at a low price level (BRUHN 2006; SCHMALEN AND SCHACHTER 1999). Recently the concept of premium private labels has been developed to compete with (high quality) national brands (BRUHN 2006). Private labels are owned by the retailer who controls all marketing and pricing activities (COLLINS-DODD 2003).

Dairy retail prices are important elements of the marketing policy. Consumers in Germany are highly price sensitive and main dairy products are key items for the consumers' store choice. Thus, dairy products are often used as loss leaders to lure consumers into the store (BACHL ET AL. 2010; RONDAN-CATALUÑA ET AL. 2005).[18] Almost 75 percent of the milk and more than 50 percent of the butter consumed in Germany are private labels (FRIEDRICH 2010). The market share of discounters has significantly increased over the last decades (FRIEDRICH 2010; TITZE 2008). In 2009 discounters hold 56 percent of milk and 50 percent of butter retail sales in Germany. Hypermarkets make 21 percent of milk and 23 percent of butter retail sales (BMELV different volumes).

[18] BACHL ET AL. (2010) rank six dairy products into the group of the most price sensitive 'halo' products. Consumers are most price sensitive in buying coffee, chocolate and butter. 'Halo'-Products are characterized by a high frequency of purchase and good price knowledge. The 'halo'-effect indicates that the store price image is perceived by single product prices.

5 Descriptive Statistics

For this study we use German milk and butter prices at the retail and the wholesale level. Both products are well defined. All butter prices apply to a fat content of more than 82 percent and a package size of 250 g (paper packed). For milk all prices apply to a fat content of 3.5 percent and a package size of 1 liter (cartons). Retail prices cover private labels and national brands. For national brands we can differentiate between cooperative brands and non-cooperative brands. Butter is packed with a standard label or with some extra information (additionally labelled), e.g. showing regional attributes. While butter is the same quality for all brands in the sample, milk is either fresh or ultra-high temperature milk.

The data set includes 919 (1724) individual store retail price series covering 71 (90) brands for milk (butter) in 327 (447) stores belonging to the 5 different store formats. The data are collected weekly starting in the first week of 2005 to the last week in 2008 (n =208) by SYMPHONYIRI GROUP GMBH (SIG, 2011). Table 2 shows the distribution of prices by calculating means, standard deviations (of means), minima (of means), and maxima (of means) for respective sub-groups. Promotional sales are a special feature of retail prices and are used with different weights by store formats. Hypermarkets heavily use this instrument while discounters mainly go without it. This might affect the measurement of price transmission (cost-pass-through) and comparability between store formats. Promotional sales are significant temporary price reductions which are unrelated to cost changes (HOSKEN AND REIFFEN, 2001). According to this definition, price promotions are not part of the cost pass-through or the price transmission between wholesale and retail prices. We therefore exclude all price promotions from the time series. These observations are replaced by the respective last regular price before the price promotion.[19] Price promotions might not lead to biased estimates of the price transmission process, but they likely decrease the efficiency of estimations by adding unexplained price variation.

- Insert Table 2 about here -

Of the 71 (90) different brands for milk (butter) 50 (81) are national brands. For milk (butter) 35 (55) national brands belong to cooperatives, 15 (26) national brands belong to non-cooperatives, 21 (9)

[19] As there is no unique definition of promotional sales, we follow HOSKEN AND REIFFEN (2001) and define sales as significant temporary price reductions that are unrelated to cost changes. More specifically, a product is considered to be on sale if its price is cut by at least five percent for no more than four consecutive weeks. The regular or reference price is defined as the last non-sale price that persisted for more than four consecutive weeks. Sale prices are substituted by the preceding regular price to obtain a regular price series. More details on the procedure and the

brands are private labels. Most retailers offer one private label and more than one national brand. Private labels are generally the low price option. Though we only have a few time series for private labels, the market volume of private labels is significant. 60 percent of the milk and 30 percent of the butter sold carry private labels. More than 50 percent of the milk (butter) is sold in hypermarkets.[20]

The average margin for milk (butter) is 28 (50) Eurocent per liter (250 g). In relative terms the margin is 57 (67) percent for milk (butter). The lowest margins are found for private labels, namely 10 percent for butter and 22 percent for milk. On average private labels are 24 (46) Eurocent per liter (250 g) cheaper than national brands. Discounters and hypermarkets set lower prices than consumer and supermarkets. The size of consumer markets seems to have a small negative effect on average prices. Fresh milk is about 14 cent per liter more expensive than UHT milk. Standard label butter is on average 6 cent per 250 g cheaper than butter carrying additional labels. For cooperative versus non-cooperatives we do find mixed results; while national cooperative brands for milk are cheaper than their private counterparts, national cooperative brands for butter are more expensive. Private labels show less variation of average prices compared to national brands. The variation of average prices in the different store formats appears to be very similar.

In Table A1 in the Appendix we further disaggregate mean prices to analyze potential cross effects. While the general conclusions hold, some deviations catch the eye. Private label milk is cheaper than other brands; however, average prices of private labels are almost the same in all distribution channels. Private label butter is also cheaper than other brands, but the price differences between store formats are smaller than for cooperative and non-cooperative national brands. Also the price wedge between private labels and other brands is less pronounced in discounters than in other store formats.

Though buying-in prices for retailers might differ on average, wholesale prices likely reflect the cost changes or the changes of the buying-in prices for all retailers over time. We work with this assumption and use the same wholesale price for estimating the price transmission for each retailer and each brand.[21] We collect prices for milk from the statistical report of the German Federal Ministry of Food, Agriculture and Consumer Protection (BMELV different volumes) which is based on an extensive survey of the German dairy industry. The prices reflect an average price per liter of pasteurized milk with 3.5 percent of fat in single packaging. The sales price of butter for German dairies is quoted by the butter

[20] Because the data do not cover sales by hard discounters (e.g. Aldi and Lidl), these numbers do not represent the actual market shares on the German food retail market.

[21] Discussions with market experts resulted that the collected wholesale prices are viewed as a cost basis for all retailers. Though there might be some concessions for big retail chains, the dynamic behavior of these prices still correctly reflects cost changes for all chains.

and cheese exchange (SBKB) located in Kempten, Germany. A commission of processors, traders and retailers quote weekly butter prices (SBKB 2010). These quotations reflect average prices for all distribution channels. For all price time series we determine the appropriate lag-length by Akaike Information Criteria (AIC) and log likelihood-ratio tests (LR). For more than half of the series the optimal lag length is two. 75 percent of the series indicates up to five lags. To test for stationarity we use procedures by ADF-test and KPSS-test. The null hypothesis of non-stationarity (ADF-test) is only rejected in five percent of all cases. The null hypothesis of stationarity (KPSS-test) is rejected in nearly 95 percent of all price series. We consider the failure of the test in 5 percent of all cases as the expected type one error. The results for the first differences indicate stationarity for all price series. From this we conclude that the prices under study indicate a unit root and are integrated of order one. For the wholesale price series we arrive at the same conclusion.

Bivariate cointegration between wholesale and respective individual retail prices for milk (919 time series) and butter (1724 time series) is tested by the ENGLE AND GRANGER (1987) Two-Step-Procedure and the JOHANSEN-test (JOHANSEN 1988, 1995). In the case of butter both tests indicate (linear) cointegration for one third of all cases. For milk the Two-Step-Procedure (Johansen-test) indicates cointegration for 67 (15) percent of all cases. For a considerable part of the time series of milk and butter retail prices we find significant evidence against linear cointegration. Therefore, we additionally test for threshold cointegration based on the approach by ENDERS AND SIKLOS (2001). Focusing on the three regime threshold model, the test results indicate significant evidence for (non-linear) threshold cointegration between retail and wholesale prices.[22] Based on ϕ-statistic 96 (82) percent of the time series for milk (butter) indicate a significant threshold error correction mechanism between retail and wholesale prices.

Though a three regime threshold model is used to testing non-linear cointegration, we additionally check this assumption by testing the number of thresholds using the procedure developed by STRIKHOLM AND TERÄSVIRTA (2006). The test results are presented in Table A2. For 40 (50) percent of all retail price series for milk (butter) we receive at least one threshold. And the majority of these processes indicate two thresholds. Thus, the relationships indicate either none or two thresholds. As the two threshold model is

[22] The derived test statistics for unknown thresholds with 208 observations and four lags is 4.84; 5.84 and 8.15 at the 90, 95 and 99 percent significance level for the ϕ-statistic and is -1.37, -1.58 and -2.06 at the 90, 95 and 99 percent significance level for the t-max-statistic (one sided test). We have additionally tested threshold cointegration based on the approach by ENDERS AND SIKLOS (2001) with one threshold. The t-max statistic leads to similar results, while the ϕ-statistic leads to slightly less rejections. Based on joint examination with t-max-statistic, the test leads to similar results. 87 (70) percent of the price series indicate a threshold cointegration relationship with respect to the wholesale price.

the most flexible form, we choose this specification at the cost of losing estimation efficiency in some cases to directly comparing and testing the estimates for the price transmission process.

6 Estimation Results

The analysis of price transmission is based on a three regime threshold error correction model (see Equation 4). The model allows for different decay rates of deviations from the long-run price equilibrium (margins) between wholesale and retail prices. For brands with market power and menu costs we expect positive price asymmetries and a close to zero reduction for inner regimes. Margins above the long-run price equilibrium are reduced more sluggish than margins below the long-run equilibrium; margin deviations within the range of the two thresholds are reduced more slowly or not at all. The wholesale prices are set to be exogenous (p_2). Granger-Causality-tests support this assumption. In more than 90 percent of all cases the wholesale price is found to Granger cause the retail prices. The reverse can be rejected for at least half of the cases.[23]

The estimation of the threshold error correction model starts with estimating the long-run price equilibrium similar to the first step of the Engle-Granger-Two-Step procedure. For the obtained error terms (deviations from the long-run equilibrium) the thresholds θ_1 and θ_2 are determined by a grid search procedure developed by CHAN (1993). The grid search operates over a limited range of the estimated error terms (85 percent of the observations), guarantying a minimum amount of observations of 5 percent in each regime. For 99 percent of the estimated pairs of thresholds the steady state equilibrium (zero) lies between θ_1 and θ_2; thus, in these cases θ_1 is negative and θ_2 is positive. On average the inner regime contains 150 of the 208 observation (75 percent). The estimated thresholds are not affected by the minimum amount of observations in each regime. The inner regime is on average bounded by the lower (upper) threshold at -0.03 (0.05) in the case of milk and -0.10 (0.12) in the case of butter. Thus, in the case of milk (butter) the inner regime ranges from -3 (-10) to 5 (12) Eurocents per liter (250g). The inner regimes include zero and are mostly significantly asymmetric; a higher tolerance towards inclusion of positive deviations is indicated.

The adjustment coefficient estimates (δ^0) for the inner regime ($\theta_1 \leq \mu_{t-1} \leq \theta_2$) are mostly small. In the case of milk (butter) the average parameter is -0.04 (-0.01). 92 percent (80 percent) of the parameter estimates (δ^0) are statistically not significant for the milk (butter) price series. The adjustment coefficients (δ^-; δ^+) for the outer regime are in most cases absolutely bigger than the respective coefficients for the inner regime. And the coefficients for the lower regimes ($\mu_{t-1} < \theta_1$) are bigger in

[23] The threshold error correction model is estimated using a symmetric lag structure with four lags. For this specification we can ensure no autocorrelation in more than 90 percent of all estimated error terms based on an alternative Durbin using the Huber/White robust estimator for the variance-covariance matrix. R-squares for the individual threshold error correction models lie on average at 20 percent for milk and at 40 percent for butter. More details are provided by the authors upon request.

absolute terms than the estimated coefficients for the upper regime ($\mu_{t-1} > \theta_2$). In the case of milk (butter) the average rate of decay for a negative equilibrium error (δ^-) is -0.32 (-0.36) compared to -0.12 (-0.17) for δ^+ in case of positive disequilibria. The estimates of adjustments in the lower regime are statistically significant in 93 percent of all cases for both products. In the upper regime statistical significance is lower; the null hypothesis is rejected in 62 (77) percent of all cases for milk (butter). The adjustment parameters in the lower regime compared to the ones for the upper regime are (statistically) significantly higher in absolute terms for 76 (61) percent of all price series for milk (butter). Considering the fact that we find quite a number of processes that indicate symmetric price adjustment (one regime, see Table A2), the remaining processes clearly indicate positive asymmetries. Ignoring statistical significance, 90 percent of all estimated processes show a higher speed of adjustment in the lower regime (positive asymmetry). Though we have weekly data, we find considerable contemporaneous price adjustments. For milk the average estimated coefficient is 0.1, for butter it is 0.15.

To fully analyze the determinants of the price adjustment processes, we run a dependent variable regression for various coefficients of the adjustment process, namely the estimated average margin (ϕ), the two thresholds (θ_1, θ_2), the adjustment coefficients of deviations from the long-run equilibrium for the three regimes (δ^-, δ^0, δ^+) and the coefficient for the contemporaneous adjustment (φ). As exogenous variables we use dummies for cooperative brands, non-cooperative brands, private labels, additionally labeled butter, fresh milk and dummies for the individual store formats. We run the estimations for milk and butter separately. We use Ordinary Least Squares (OLS) with robust standard errors and Weighted Least Squares (WLS) procedures. OLS is supposed to result unbiased but potentially inefficient estimates. WLS returns possibly biased but efficient estimates (LEWIS 2005).[24] The estimations indicate some small differences but the interpretation and conclusions drawn from it are consistent. The results presented in Table 3 are based on the WLS procedure.

- Insert Table 3 about here -

The reference groups are ultra-high temperature milk and standard butter of cooperative brands sold in all discounters available. For milk we find an average margin of 0.284 Euro per liter, the lower threshold is -0.028, the upper threshold is 0.066 in the reference group. Thus deviations in the range of -10 to +23

[24] Following LEWIS (2005) presenting OLS with robust standard errors and WLS is „good practice“ in estimated dependent variable regressions. In particular when results of both procedures are very close and all parameter estimates are significantly different from zero, alternative methods such as the feasible general least square estimator do not promise any further improvements.

percent of the average margin fall into the inner regime in which deviations are reduced at a rate of only 1.6 percent on average. Low margins (below average) are expanded at a rate of 14.4 percent per period; high margins (above average) are reduced at a rate of 4.7 percent back to equilibrium. The contemporaneous adjustment is rather low at 0.08. For butter we find an average margin of 0.413 Euro per 250 g, the lower threshold is -0.094, the upper threshold is 0.091 in the reference group. Thus deviations in the range of -20 to +20 percent of the average margin fall into the inner regime in which deviations are reduced at a rate less than 1 percent on average. Lower margins are expanded at a rate of 26.6 percent per period and higher margins are reduced at a rate of 12.5 percent. The contemporaneous adjustment is rather low at 0.10.[25]

To illustrate the differences in dynamic pricing process, Figure 1 shows the adjustment path following a change in the wholesale price by one unit for various groups. As the reaction in the inner regime is close to zero for all groups, we only present the adjustment of significant positive and negative shocks (errors terms that fall in the lower or upper regime). If no contemporaneous adjustment would occur, then the Figures would start at zero (in the pre-shock period) and move up to 1 (in shock period) indicating a disequilibrium of one unit. If a contemporaneous adjustment occurs, the shock is immediately at least partially offset. For instance, a coefficient of 0.2 would correct the shock by 20 percent in the same week. Thus, we would find a move from zero to 0.8 for retail prices from period 0 to 1. Besides the reference groups we look at non-cooperative brands and private labels for the same quality at the same distribution channels (standard butter, UHT milk sold in discounters).

- Insert Figure 1 about here -

In all cases except for private labels of butter, the contemporaneous adjustment is found to be comparably low. Private label butter retail prices are adjusted almost instantaneously to correct a wholesale price shock and return to the long-run equilibrium margin. Private label milk show small contemporaneous price adjustments, but lagged responses appears to be quick, however, asymmetric. For milk and butter private labels are offered at very low average margins. Price adjustment processes in the case of milk are slower and indicate more severe asymmetries compared with butter. All asymmetries are of positive nature.

[25] Dependent variable estimation R-squares' are listed in Table 3. In particular for the margins and the adjustments in the lower regime we obtain a very good fit.

Additionally labeled butter is marketed at a higher average margin and the inner regime of the process is even more biased towards positive values (see Table 3). Dynamic adjustments do not significantly change compared with the reference group, but the contemporaneous adjustment for additionally labeled butter slows down considerably. All other retail store types charge a bigger margin than discounters. Hypermarkets are closest to discounters. This holds for milk and butter. In most cases for butter the range for the inner (non-responsive) regime increases for retailers other than discounters. For milk no significant changes in the inner regime can be observed for the different retail outlet formats. There is almost no difference between fresh milk and ultra-high temperature milk.

Finally we simulate the impact of asymmetric price adjustment using real prices by taking a symmetric adjustment as a reference. Following CRAMON-TAUBADEL (1998) we use the minimum of the adjustment coefficients from the lower and upper regime in the reference scenario. In addition we use a symmetric inner regime around zero that is bounded by the minimum of the absolute value of the two estimated thresholds. This procedure assumes that a more competitive price adjustment would indicate the same rate of decay for deviations from the long-run relationship irrespective of the sign. As menu costs might also appear under perfect competition, we keep the inner regime; by forcing symmetry, however, we correct in particular for the tendency that above average margins are if only very slowly reduced.[26] The simulation of the symmetric process is compared to the forecast of the two threshold model.

- Insert Figure 2 about here -

Results for the simulated processes and their differences over the period of observation are presented in Figure 2 for the same groups as in Figure 1. For all groups asymmetric price adjustment has an impact only after the price crisis starting in 2007. Before 2007 price changes and deviations of margins are rather small and lie within the inner regime which uses the same coefficient of price adjustment in both simulations. As we identified mainly positive asymmetries, the effects only occur in times of strong price reductions, for instance in spring 2008. In that period the effects are significant for non-cooperative brands. The differences between symmetric and asymmetric price adjustments account for up to 22 Eurocent per 250 g. The average margin for that group is about 40 Eurocent. Thus, asymmetry can cause a significant increase in profits at least in some periods. For cooperative brands the effects are smaller

[26] Thereby we account for the impact of an asymmetric inner regime which also can indicate a form of positive asymmetric price adjustment when in particular positive deviations are adjusted more slowly compared to their symmetric counterparts in the lower regime.

with 3 Eurocent per 250 g at maximum. For milk we find an effect of about 3 Eurocent per liter at a maximum for private labels and cooperative brands, for non-cooperative brands the impact is negligible. Interestingly there is no positive correlation between the average margin and the impact of asymmetry for the aggregated estimates. If market power is the driving force for asymmetry, then we might expect that it leads to higher margins. However, looking at national brands we find that cooperative brands have the highest margins in butter and non-cooperative brands indicate the highest margins in milk. But these groups show very little impact of asymmetric price adjustment in the price simulation. It appears that groups that operate at low average margins try to use asymmetric behavior to expand it. Exceptions from this rule are private labels for butter which indicate the lowest margin and almost no asymmetries. Butter, however, might be a key product in attracting consumers to the store. Private labels might be used as loss leaders or as a 'halo' item to reinforce the consumers' perception of generally low prices in the store.

7 Conclusions

In this paper the vertical price relationship between the wholesale and retail market for milk and butter in Germany is analyzed at the individual product and store level. The non-linear nature of many of these price relationships is captured by a bivariate three regime thresholds error correction mechanism. We estimate 2633 individual vertical price relationships for butter and milk in Germany including different brands (cooperative national brands, non-cooperative national brands and private labels) and different retail outlets (supermarkets, small and big consumer markets, hypermarkets and discounter).

Private labels are marketed are lower margins and deviations from the long-run price equilibrium (margin) are reduced much faster than for national brands. In particular butter shows an immediate almost one to one response to shocks at the wholesale level. Discounters sell at lower prices compared to other retail formats; however, this holds for national brands rather than private labels. Private labels are priced almost the same in different store types. Though the dynamic price adjustment shows significant asymmetries in the vertical transmission, the economic impact is offset by strong symmetric contemporaneous reactions and large inner regimes of no response. Interestingly, though we find significant asymmetries that might be used to expand margins, strong brands with high margins show less economically significant asymmetric price reactions. The result implies that firms with strong market power (e.g. monopoly) do not use asymmetric price responses to expand their margin. This result makes sense for pure monopolists because in theory it has not been proven yet that monopolists would benefit from asymmetric price response. Firms with less market power might face oligopolistic competition which leads to smaller margins and asymmetric price responses. This observation might also make sense theoretically implying a kinked demand model. Thus, the starting hypothesis that stronger brands or companies with more market power use asymmetric price adjustments to generate higher margins has to be reconsidered. In particular the study shows that strong brands can enforce significant markups (margins) without excessively using asymmetric price adjustment. Instead strong brands apply sluggish symmetric reactions to cost changes.

Asymmetries do not only occur between the upper and lower regimes, but also the range of the inner regimes can be located asymmetrically around zero. In our study we find that the range is most often biased towards positive deviations. Thus, we find some large above average margins in the inner regime and some large below average margins of the same absolute size that belong to the lower regime. While adjustments in the inner regimes are reduced slowly, the response in the lower regime is quickly. Following, some large above average margins are not (or slowly) reduced while the same (absolute) below average margins are expanded quickly.

The impact of range of the inner regime can be ambiguous. A large range of the inner regime reduces the effect of asymmetries that are applied to deviations in the outer regimes. An asymmetric location of the range of the inner regime reinforces the asymmetric effect. A comprehensive interpretation of two threshold error correction models needs to consider the location of the range of the inner regime and needs to look at the level and differences of adjustment parameters between the outer regimes.

Finally, we find significant differences in the marketing margin which can be explained by descriptive factors such as brands, retail outlets, product qualities etc.; however, due to the lack of information the profitability of higher margins and the distribution of profits between retail chains and processors cannot be further evaluated. According to market experts strong brands generate higher profits which are often split by half between retailers and processors. For very strong brands, the profit share of the processor can exceed even an equal share. The increase in retail or processors profits might be disadvantageous for farmers or consumers. Because causality indicate wholesale prices to be exogenous, higher profits are likely caused by increased retail prices.[27] Thus, not farmers but the consumers pay the price.

[27] This result is support by the fact that German wholesale prices for Butter and skim milk powder show a strong relationship to the respective world market prices (see Loy and Steinhagen, 2010).

8 References

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9 *Tables and Figures*

Table 1: Empirical studies of vertical price transmission for dairy products

Author(s)	Kinnucan, Forker	Serra, Goodwin	Chavas, Mehta	Jensen, Møller	Baumgartner et al.	European Commission	Stewart, Blayney
Year	1987	2003	2004	2007	2009	2009	2011
Journal[a]	AJAE	AE	AJAE	WP	WP	RP	ARE
Relationship[b]	Pf ↔Pr	Pf ↔Pr	Pw ↔Pr	Pf ↔ Pw ↔Pr	Pf ↔Pr	Pf ↔Pr	Pf ↔Pr
Product	Milk, Butter, Cheese, Ice Cream	Milk, Cheese, Cream Caramel	Butter	Milk[e]	Milk, Butter, Cheese	Milk, Butter, Cheese and other	Milk, Cheese
Country	USA	Spain	USA	Denmark	Austria	EU-27	USA
Frequency	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly
Result (Asymmetry)	Yes	Yes[d]	Yes	Yes	Yes	Yes	Yes
Form of Asymmetry	Positive	Positive	Positive	Positive[f]	Positive[g]	Positive	Positive[h]
Model[c]	DLM	TECM	ECM	ECM	TVECM	DLM	ECM/TECM/STECM
# Regimes	2	3	2	2	3	2	1/2/3

Legend: a) AJAE: American Journal of Agricultural Economics; AE: Applied Economics; ARE: Agricultural and Resource Economics; WP: Working Paper; RP: Report;
b) Farm gate Price (Pf); wholesale Price (Pw); retail-Price (Pr);
c) Distributed Lag Model (DLM); Threshold (Vector) Error Correction Model (T(V)ECM); Smooth Transition Error Correction Model (STECM);
d) Not in case of milk and cream caramel;
e) Additional investigation of non-dairy products; f) significant asymmetries only found in price transmission between wholesale and retail prices;
g) Negative asymmetries are estimated for cheese and are related to growing international competition;
h) Adjustment to the long run a twofold and show negative asymmetries in case of milk;

Source: Own.

Table 2: Descriptive statistics for weekly German milk (A) and butter (B) prices over the period from 2005 to 2008

A	Milk (in €/liter)					
			Prices			
	Brands (Price Series)	Market Share	Mean	St.Dev.	Min.	Max
Wholesale Price			0.49	0.05	0.44	0.6
Retail Price Series	**(919)**		0.77	0.14	0.53	1.06
Brands	**71 (919)**					
National Brands	50 (633)	41.6%	0.84	0.08	0.53	1.06
Cooperative Dairies	35 (297)	22.3%	0.78	0.08	0.53	0.93
Non-cooperative Dairies	15 (335)	19.3%	0.89	0.07	0.58	1.06
Private Labels	21 (286)	58.4%	0.6	0.03	0.56	1
Type of Milk						
Fresh Milk	35 (320)	23.4%	0.79	0.11	0.53	1.02
UHT Milk	36 (599)	76.6%	0.75	0.14	0.58	1.06
	Stores (Price Series)					
Stores	**327 (919)**					
Supermarket	72 (168)	6.8%	0.76	0.15	0.59	1.06
Small Consumer Market	60 (175)	9.3%	0.77	0.14	0.59	0.96
Large Consumer Market	71 (233)	25.7%	0.78	0.13	0.56	0.97
Hypermarket	83 (276)	50.6%	0.78	0.122	0.53	0.93
Discounter	39 (67)	7.6%	0.65	0.11	0.56	0.9

B	Butter (in €/250 g)					
			Prices			
	Brands (Price Series)	Market Share	Mean	St.Dev.	Min.	Max
Wholesale Price			0.75	0.13	0.64	1.13
Retail Price Series	**(1724)**		1.25	0.2	0.8	2.39
Brands	**90 (1724)**					
National Brands	81 (1581)	68.8%	1.29	0.17	0.8	2.39
Cooperative Dairies	55 (1130)	24.7%	1.32	0.16	0.8	1.72
Non-cooperative Dairies	26 (451)	44.1%	1.23	0.17	0.94	2.39
Private Labels	9 (143)	31.2%	0.83	0.05	0.8	1.06
Type of Butter						
Standard Butter	52 (512)	31.3%	1.21	0.19	0.81	2.39
Additionally Labelled Butter	29 (1069)	68.7%	1.27	0.21	0.8	1.73
	Stores (Price Series)					
Stores	**447 (1724)**					
Supermarket	76 (205)	3.6%	1.32	0.17	0.82	1.73
Small Consumer Market	66 (253)	5.0%	1.34	0.2	0.82	2.39
Large Consumer Market	77 (458)	19.1%	1.3	0.18	0.81	2.05
Hypermarket	83 (570)	53.6%	1.23	0.2	0.8	1.73
Discounter	145 (238)	18.7%	1.09	0.21	0.81	1.48

Legend: Average prices for observations from 2005 to 2008 are calculated for each individual time series. Mean: Average for the respective group. St.Dev.: Standard deviation of average prices. Min.: Minimum average price in the respective group. Max.: Maximum average price in the respective group.

Source: Own calculations based on SIG (2011) with StataCorp. (2011).

Table A1: Average retail milk and butter prices for the period from 2005 to 2008

UHT Milk (in €/liter)

	SM	SC	LC	HM	D
Cooperative Dairies	0.81	0.80	0.80	0.74	0.64
Non-cooperative Dairies	0.93	0.87	0.88	0.90	n.a.
Private Labels	0.60	0.59	0.59	0.59	0.58

Fresh Milk (in €/liter)

	SM	SC	LC	HM	D
Cooperative Dairies	0.79	0.83	0.79	0.78	0.73
Non-cooperative Dairies	0.94	0.94	0.88	0.86	0.87
Private Labels	0.61	0.60	0.60	0.60	0.60

Standard Butter (in €/250 g)

	SM	SC	LC	HM	D
Cooperative Dairies	1.27	1.27	1.24	1.22	1.09
Non-cooperative Dairies	1.19	1.31	1.18	1.03	1.03
Private Labels	n.a.	0.88	0.89	0.83	0.82

Additionally Labelled Butter (in €/250g)

	SM	SC	LC	HM	D
Cooperative Dairies	1.38	1.4	1.39	1.36	1.26
Non-cooperative Dairies	1.30	1.32	1.29	1.25	1.26
Private Labels	n.a.	n.a.	n.a.	n.a.	n.a.

Legend: Average prices for observations from 2005 to 2008 are calculated for the respective group.
SM: supermarket, SC: small consumer market, LC: large consumer market, HM: Hypermarket, D: Discounter.

Source: Own calculations based on SIG (2011) with StataCorp. (2011).

Table A2: The number of regimes according to the test by STRICKHOLM AND TERÄSVIRTA (2006)

Milk

Number of Regimes	SM	SC	LC	HM	D	all
1	51%	58%	61%	72%	37%	60%
2	20%	16%	11%	12%	16%	14%
3	29%	26%	28%	15%	46%	25%

Butter

Number of Regimes	SM	SC	LC	HM	D	all
1	54%	56%	51%	45%	45%	49%
2	8%	7%	6%	11%	2%	7%
3	39%	37%	43%	44%	53%	43%

Legend: SM: supermarket, SC: small consumer market, LC: large consumer market, HM: Hypermarket, D: Discounter
Source: Own calculations based on SIG (2011) with StataCorp. (2011).

Table 3: Dependent variable estimation for average margins, thresholds, adjustment coefficients and contemporaneous adjustment (n = milk and butter)

Milk	ϕ	θ-	θ+	δ-	δ0	δ+	φ
UHT Milk of a Cooperative Dairy at a Discount Store	0.284 *** (0.00)	-0.028 *** (0.00)	0.066 *** (0.00)	-0.144 *** (0.00)	-0.016 * (0.08)	-0.047 *** (0.00)	0.081 *** (0.00)
Brands compared to Reference Group							
Non-cooperative Dairy	0.104 *** (0.00)	-0.016 *** (0.00)	-0.004 (0.19)	-0.018 *** (0.00)	-0.017 *** (0.00)	-0.026 *** (0.00)	-0.023 *** (0.00)
Private Label	-0.191 *** (0.00)	0.002 ** (0.03)	-0.019 *** (0.00)	-0.328 *** (0.00)	-0.041 *** (0.00)	-0.158 *** (0.00)	0.050 *** (0.00)
Fresh Milk compared to Reference Group							
Fresh Milk	-0.006 (0.50)	0.004 *** (0.00)	0.001 (0.51)	0.002 (0.52)	0.001 (0.75)	-0 .003 (0.29)	-0.029 *** (0.00)
Types of Grocery Store compared to Reference Group							
Supermarket	0.040 *** (0.01)	0.000 (0.99)	-0.008 ** (0.01)	0.001 (0.92)	0.023 ** (0.02)	0.016 *** (0.01)	-0.011 (0.31)
Small Consumer Market	0.036 ** (0.03)	0.000 (0.99)	0.002 (0.47)	- 0.005 (0.52)	0.19 ** (0.05)	0.019 *** (0.00)	-0.002 (0.87)
Large Consumer Market	0.019 (0.23)	0.000 (0.77)	0.000 (0.91)	-0.029 *** (0.00)	0.010 (0.28)	0.018 *** (0.00)	0.022 ** (0.38)
Hypermarket	0.005 *** (0.75)	-0.001 (0.27)	-0.002 (0.48)	0.020 (0.80)	-0.005 (0.61)	0.017 *** (0.00)	0.021 ** (0.04)
R-squared[a]	0.81	0.12	0.07	0.55	0.02	0.49	0.08

Butter	ϕ	θ-	θ+	δ-	δ0	δ+	φ
Standard Butter of a Cooperative Dairy at a Discount Store	0.413 *** (0.00)	-0.094 *** (0.00)	0.091 *** (0.00)	-0.266 *** (0.00)	-0.008 ** (0.06)	-0.125 *** (0.00)	0.101 *** (0.00)
Brands compared to reference group							
Non-cooperative Dairy	-0.061 *** (0.00)	0.017 *** (0.00)	0.011 *** 0.00)	-0.032 *** (0.00)	0.003 (0.18)	0.023 *** (0.00)	0.000 (0.97)
Private Label	-0.360 *** (0.00	0.076 *** (0.00)	-0.064*** (0.00)	-0.144 *** (0.00)	0.014 (0.18)	-0.108 *** (0.00)	0.786 *** (0.00)
Additionally Labelled Butter compared to Reference Group							
Additionally Labelled Butter	0.101 *** (0.00)	0.018 *** (0.00)	0.038 *** (0.00)	0.035 *** (0.00)	0.003 (0.29)	-0.016 *** (0.00)	-0.133 *** (0.00)
Types of Grocery Store compared to Reference Group							
Supermarket	0.092 *** (0.00)	-0.038 *** (0.00)	0.010 *** (0.00)	-0.009 (0.12)	-0.010 ** (0.03)	0.024 *** (0.00)	0.080 *** (0.00)
Small Consumer Market	0.115 *** (0.00)	-0.007 *** (0.00)	0.030 *** (0.00)	0.010 (0.09)	- 0.007 * (0.09)	0.017 *** (0.00)	0.080 *** (0.00)
Large Consumer Market	0.089 *** (0.00)	-0.041 *** (0.00)	0.021 *** (0.00)	-0.002 (0.58)	-0.009 ** (0.03)	0.038 *** (0.00)	0.077 *** (0.00)
Hypermarket	0.038 *** (0.00)	-0.043 *** (0.00)	0.011 *** (0.00)	-0.040 *** (0.00)	-0.014 *** (0.00)	0.026 *** (0.00)	0.066 *** (0.00)
R-squared[a]	0.60	0.16	0.15	0.17	0.01	0.04	0.47

Legend: */** denote 5 percent/1 percent significance. ϕ: average marging, Θ-: lower threshhold, Θ+: upper threshhold, δ-: lower regime, δ0: middle regime, δ+: upper regime, φ:contemp. adjustment.
[a]) The R-squared is based on OLS estimation.

Source: Own calculation based on SIG (2011) with StataCorp. (2011).

Table A3: Percentage of cases with significant asymmetries in the adjustment back to the long-run price equilibrium

UHT Milk

	SM	SC	LC	HM	D
Cooperative Dairies	55%	48%	71%	59%	100%
Non-cooperative Dairies	56%	61%	52%	37%	62%
Private Labels	79%	74%	76%	93%	90%

Fresh Milk

	SM	SC	LC	HM	D
Cooperative Dairies	79%	71%	82%	65%	80%
Non-cooperative Dairies	56%	50%	68%	41%	n.a.
Private Labels	54%	80%	57%	100%	89%

Standard Butter

	SM	SC	LC	HM	D
Cooperative Dairies	61%	63%	55%	61%	53%
Non-cooperative Dairies	79%	52%	76%	70%	100%
Private Labels	n.a.	0%	21%	23%	43%

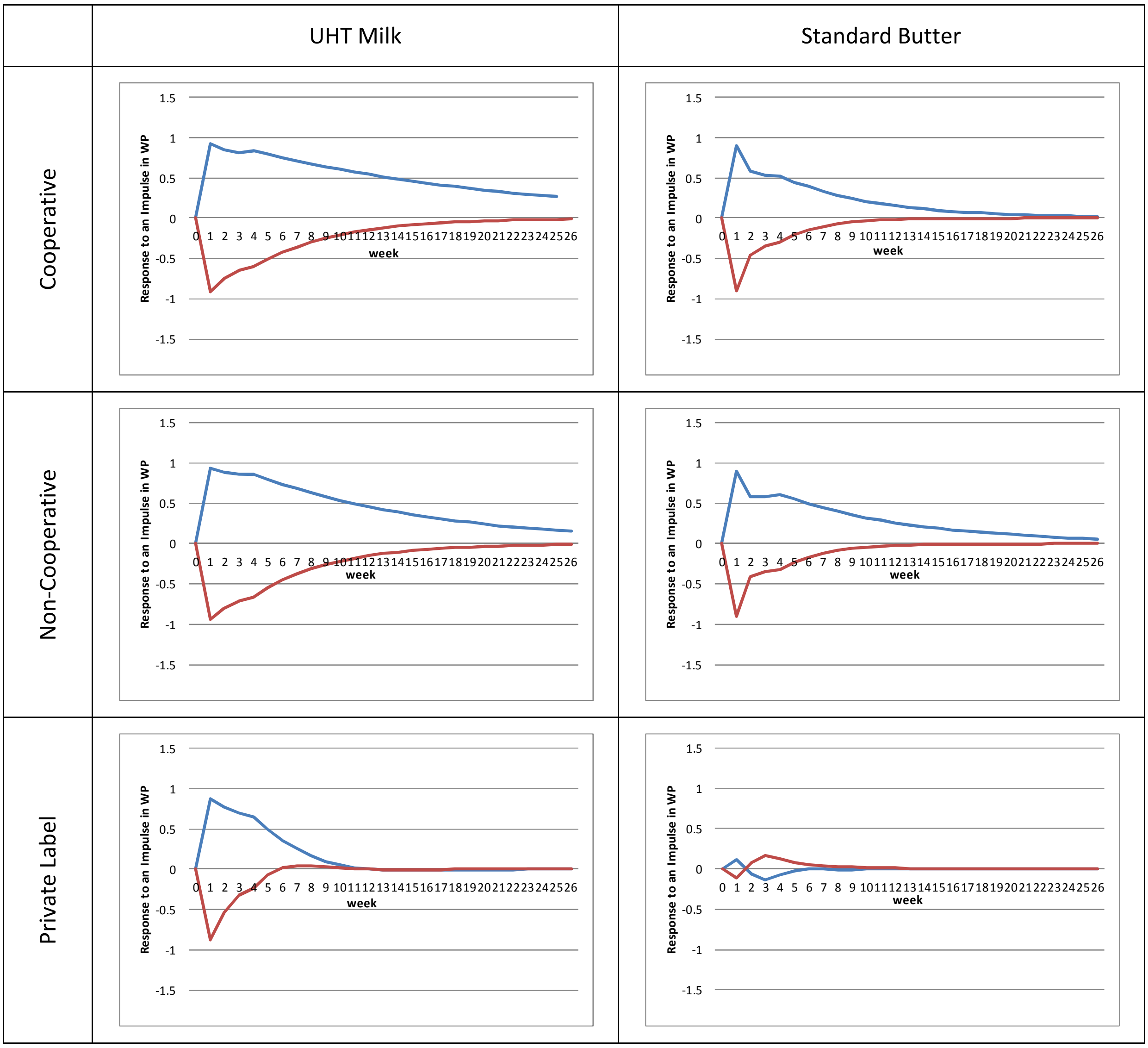
Additionally Labelled Butter

	SM	SC	LC	HM	D
Cooperative Dairies	33%	35%	47%	56%	46%
Non-cooperative Dairies	74%	51%	65%	47%	93%
Private Labels	n.a.	n.a.	n.a.	n.a.	n.a.

Legend: SM: supermarket, SC: small consumer market, LC: large consumer market, HM: Hypermarket, D: Discounter

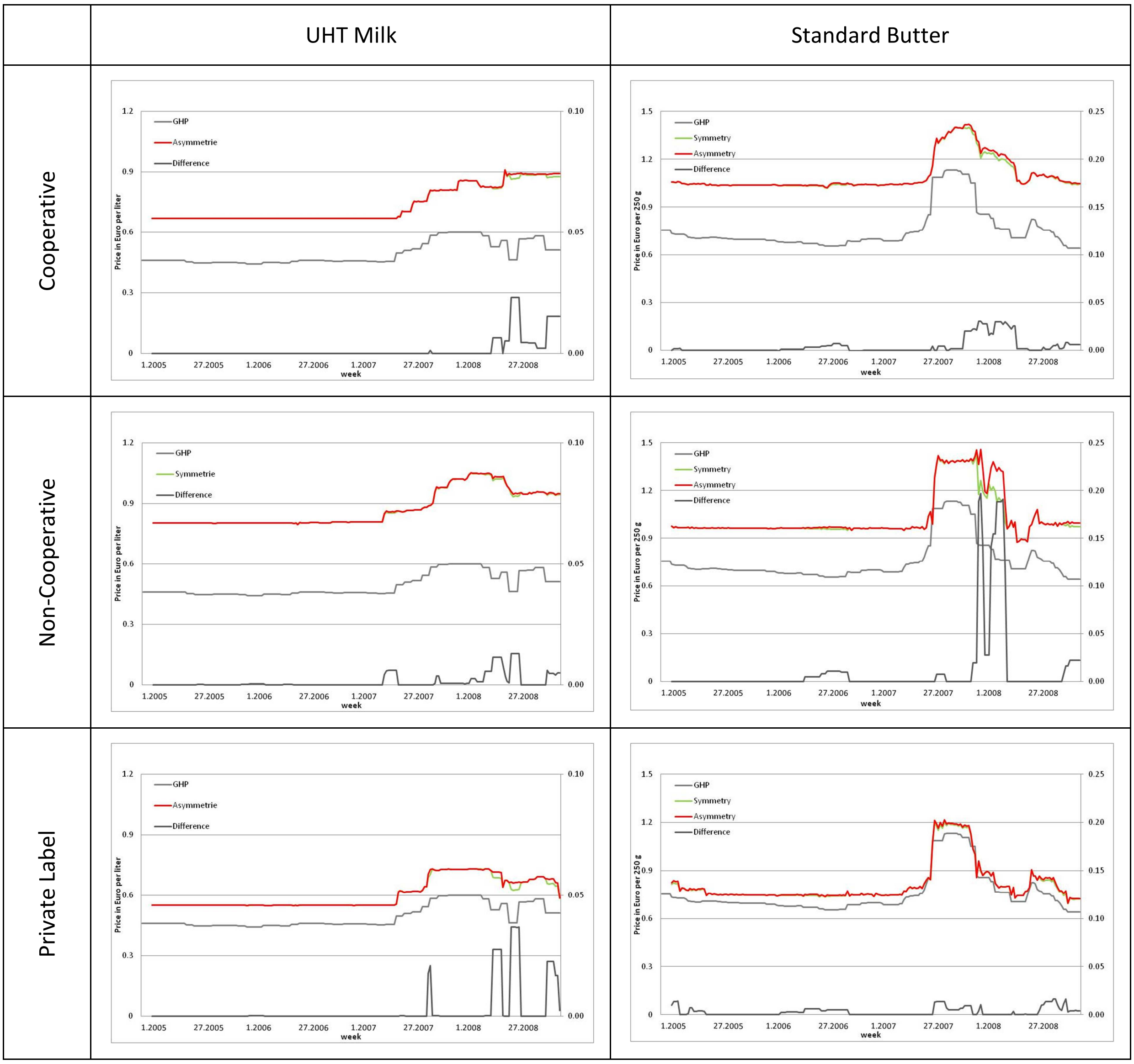
Source: Own calculations based on SIG (2011) with StataCorp. (2011).

Figure 1: Response functions of retail prices to a wholesale price change by one unit



Legend: Week zero is period prior to the wholesale price change.
Source: Own calculations based on estimations results in Table 3 with StataCorp. (2011).

Figure 2: Simulation of retail prices under symmetric and asymmetric price adjustment



Legend: Simulations are based on the individual estimates from threshold error correction representations. After simulating the dynamic processes for each individual time series processes are aggregated for the respective groups shown in the Figure.

Source: Own calculations with StataCorp. (2011)