COST PASS-THROUGH IN DIFFERENTIATED PRODUCT MARKETS: A DISAGGREGATED STUDY FOR MILK AND BUTTER

Jens-Peter Loy, *Thore Holm, Carsten Steinhagen und Thomas Glauben**

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Abstract

In food retailing a high degree of static price dispersion between and within stores and between brands has been documented, but at the brand and/or retail outlet level the dynamic behaviour of prices, as well as its causes, have not been analysed in the European food market context. In this paper we estimate the dynamic pricing behaviour of brands at various retail outlets to identify the role of private (low-price brands) and national (high-price brands) labels to explain the dispersion of retail price dynamics. The results indicate significant asymmetries in cost pass-through processes, which vary between brands and outlets. In particular, private labels (low-price brands) adjust prices faster than national labels (high-price brands). Moreover, cost pass-through is slightly more (positive) asymmetrical for private labels than for high-price national brands.

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Keywords: Cost Pass-Through, Panel Threshold Error Correction Model, Dairy, Retail Market, Germany

*Thore Holm and Carsten Steinhagen are research associates and Jens-Peter Loy (corresponding author: jploy@ae.uni-kiel.de) is Professor at the Department of Agricultural Economics at the Christian-Albrechts-Universität Kiel, Germany. Thomas Glauben is Professor at the Leibniz-Insititute IAMO in Halle. We gratefully acknowledge financial support by "Zukunftsprogramm Wirtschaft Schleswig-Holstein" co-financed by the European Union (European Regional Development Fund) and by the German Research Foundation (Project DFG LO 655/6-2). We also acknowledge support by the EU-Project TRANSFOP.

1 *Introduction*

At first glance milk and butter 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. Even prices during the same week at the same store, or at nearby stores, show persistent variations. For example, average weekly milk retail prices of national brands range from 53 to 106 Eurocents per litre. 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 (national) brands and 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 react to certain price changes of their preferred brand. Retail outlets offer a large assortment of products to consumers who face store-switching costs and therefore often engage in one-stop-shopping. Therefore, manufacturers and retail outlets can use single-product prices strategically, which may not only result in significant price heterogeneity, but also in heterogeneity of dynamic price adjustments or cost pass-through between the various food manufacturers, retail outlets and brands. At the aggregated level, many studies for dairy products and other agricultural goods have shown significant asymmetric cost pass-through (amongst others PELTZMAN 2000; GOODWIN AND PIGGOTT 2001; BAUMGARTNER ET AL. 2009). This particular pricing behaviour is also known as "rockets and feathers", that is, prices rise like rockets but fall like feathers (TAPPATA 2009). The direction (sign) of price changes or marketing margins therefore leads to various dynamic price reactions with respect to the speed of adjustment and/or the magnitude of the long-run price equilibrium. The extent to which the dynamic pricing behaviour differs between brands and/or retail outlets is the main subject of this study. Further, we explain the variations in the cost pass-through by considering processor, retailer and brand characteristics on parameters of the dynamic cost pass-through process. One underlying hypothesis is that national (high price) brands have the potential to manipulate retail prices by adjusting asymmetrically to cost changes. Also, such behaviour is more likely to be observed in stores that offer a large assortment of goods and more complex or higher quality services.

Our study contributes to the literature by furthering aspects of the following issues. First, we present cost pass-through 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 cost-price adjustments using an extensive retail scanner data set from 2005 to 2008. This is not the first such study, but to our knowledge it is the first that uses data for the European market. Second, retail prices often show a high level of rigidity, which prevents the 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 previous studies, particularly on milk markets, employ data at a monthly frequency. Third, in contrast to other studies on milk and milk products, we use wholesale instead of farm prices because they better reflect cost changes at the retail market level than do farm prices. Fourth, we use and compare two estimation approaches—a traditional two-stage and a panel threshold error correction model approach.[1]

The paper is organised as follows. In section two we briefly summarise theories explaining asymmetric vertical cost pass-through and derive some hypotheses. In the following section we address some methodological issues on estimating pass-through. Section four provides an overview of German dairy product markets at the wholesale and retail level. 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. At the end of this section the results of the panel threshold error correction model are presented and compared to the results for the two-stage approach. In the final section we summarise the paper and draw conclusions.

2 Theory and Hypoteses

Based on TIROLE (1988), BORENSTEIN ET AL. (1997: 324) present a theory that "prices are sticky downward because when input prices fall the old output price offers a natural focal point for oligopolistic sellers." Many authors also claim that market power is one of the most important reasons for asymmetric cost pass-through or price adjustment; VAVRA AND GOODWIN (2005: 8), for instance, assume that "[…], it is the presence of non-competitive behaviour in the market place that is often identified as, or claimed to be, the culprit for asymmetric price transmission." MEYER AND CRAMON-TAUBADEL (2004: 586) provide another example: "Two main proposed causes of APT dominate the literature: non-competitive markets [market power] and adjustment [menu] costs". In particular, governments and the media associate asymmetric cost pass-through with collusive behaviour (TAPPATA, 2009: 673). The main alternative arguments for asymmetric cost pass-through are menu costs (BALL AND MANKIW, 1994), inventory management (e.g. REAGAN AND WEITZMAN, 1982), and consumer search costs (TAPPATA, 2009).[2] TAPPATA (2009) argues that consumers have limited (no) information about cost shocks; thus, they use the price level as an indicator for input costs. In periods of high costs, firms have little room for price setting. Therefore, consumers expect low profits from searching in periods with high input

[1] We also test the number of regimes extending the procedure by STRIKHOLM AND TERÄSVIRTA (2006).
[2] Asymmetries in menu or other costs following an input cost-based contraction or expansion of production can lead to asymmetric price adjustment, even under perfect competition (MEYER and CRAMON-TAUBADEL, 2004). AZZAM (1999) shows that a concave demand can also cause incomplete and asymmetric cost pass-through.

costs. The search decision is based on information from the previous period. When prices are high, consumers decide to search less in the next period. If prices fall, firms anticipate that consumers will search less and keep high prices. When (output) prices are currently low, consumers search more. If prices rise, firms quickly adjust output prices to prevent losses. We briefly test this aspect of consumer search theory following CHANDRA AND TAPPATA (2011) by relating measures of price dispersion to the price level for competing retailers. Our results indicate no negative correlations between price dispersion and price level.[3] [4]

MEYER AND CRAMON-TAUBADEL (2004) point out the major difficulties of providing evidence on the determinants of the (asymmetric) cost pass-through. The examined studies either present only one pair of time series (prices and costs) with likely no change in the market conditions over time, or use a cross-section panel that fails to account for differences between products and/or countries (see PELTZMAN, 2000). In our study we follow PELTZMAN (2000) and circumvent these problems by using a panel for nearly the same products in the same country over the same period of time.

The empirical evidence for positive asymmetric cost pass-through appears to be overwhelming for the dairy sector (see HOLM ET AL. 2012 for a review). Most studies use farm prices at the upstream level. Dairy farms have contracts with dairies, while in cooperative companies farmers hold the companies' shares. Therefore, contract prices might not follow simple market integration rules; for instance, dairies use higher prices in the winter to balance the seasonal pattern of milk deliveries, or some dairies stabilise prices over the season.[5] In addition, when studying highly processed products such as cheese or milk chocolate compared to fresh milk, price transmission may be affected by the importance of processing costs and/or the prices of complements that are not considered. Analyses of price transmission (cost pass-through) have to account for these issues when using farm level instead of respective wholesale prices.[6] Most empirical studies discussed here use relatively highly aggregated monthly data. Thus, it might be questioned whether the estimated results indicate average behaviour in the industry. CRAMON-TAUBADEL ET AL. (2006: 505) have shown “that estimation with aggregated data can generate misleading conclusions about price transmission behaviour at the level of the individual units (i.e. retail stores) that underlie these aggregates.” We also loose the information about variations

[3] We used retailers located within a region with the same first two digits in their postal code to calculate weekly price variations and the average price level. Correlations for milk retail prices between the two measures are all positive. Thus, for the indirect test the search cost hypothesis of TAPPATA (2009) is rejected.
[4] LEWIS (2011) develops an alternative search cost-based theory, in which consumers search less when prices fall.
[5] 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.
[6] At the farm level we only have the price of raw milk. The relationship between the farm price of milk and the retail prices of butter is likely affected by prices of skim milk powder. In this study we use wholesale prices of butter; thus, cross product effects can be ruled out.

in individual price responses and about which subsectors are driving the average behaviour. The above mentioned issues are considered in the present study. Further, we use additional information on food processors, retailers and brands to explain the heterogeneity of individual cost pass-through processes. We especially differentiate between cooperative and non-cooperative dairies, supermarkets and discounters, and private label (low price) brands and national (high price) brands. We thus propose the following hypotheses:

(1) Non-cooperative dairies produce more and higher-priced national brands compared to cooperative dairies. Strong brands have a higher potential to deviate prices from marginal costs. Cost pass-through is expected to be slower and more asymmetric. Cooperative dairies focus on low-cost bulk products and low-price private labels (OBERSOJER AND WEINDLMAIER 2006).
(2) Discounters mostly employ an everyday low pricing strategy (HOCH ET AL. 1994; GONZÁLEZ-BENITO ET AL. 2014); they offer a limited amount of services, advertise price fairness and promise their consumers to pass on cost savings. We expect discounters to quickly and symmetrically adjust to cost changes. Other store formats offer a wider range of products and services, and search costs for consumers are higher in these outlets. Thus, cost pass-through is slower and less symmetric.
(3) By offering private labels, retailers circumvent double marginalization. The retailer has full control over the cost pass-through process (MILLS 1995 and HOCH, 1996). In particular for low price private labels we expect a quick and symmetric pass-through. National brands' processors try to impose higher prices and use more (price) promotions following a HiLo-strategy. Adjustments of regular prices, therefore, are likely to be slower and less symmetric for high price national brands. HONG AND LI (2013) present some first empirical evidence for a large US retailer supporting these hypotheses.
(4) Search costs limit the consumer's efforts to find the lowest price. High search costs allow retailers to impose higher price dispersion. We follow RICHARDS ET AL. (2012) and measure search costs by the number of SKU (stock keeping units) in a store. Stores with higher consumer search costs are expected to pass-through costs more asymmetrically.

3 Methodology

For the first approach we apply bivariate threshold error correction models to estimate the cost pass through for very retail price time series. We test the number of regimes and for threshold co-integration. The indicator functions (I_t) define the three regimes.

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

$$+ \sum_{j=1}^{k}\beta_{2j}\Delta p_{2,t-j} + v_t. \quad (1)$$

The error correction representation in equation 1 allows for different adjustments of deviations from the long-run equilibrium depending on the size of the deviation represented by the three regimes.

In the second step we use a dependent variable regression to analyse the determinates of the estimated coefficients of the threshold error correction models, particularly the adjustment parameters $\delta^{-}, \delta^{0}, \delta^{+}$. The specification of the model is presented in the results section.

Instead of modelling each cost pass-through of retailers separately, panel models can be employed to increase the efficiency of the estimation and to simultaneously estimate potential determinants of differences in the price adjustment. Also, the basic time series properties can be tested by panel techniques. Here we employ the IPS-test to test for unit roots, which is particularly suited for heterogeneous panels (IM ET AL., 2003). A critical assumption underlying the IPS-test is that the cross-sectional observations are independent. The Hadri-test considers cross-sectional dependencies and is applied here as well.[7] PEDRONI (1999) developed two classes of tests for panels with heterogeneous co-integration vectors using a residual-based approach. Residual-based co-integration tests, however, often fail to reject the null hypothesis of no co-integration due to the common-factor restriction (WESTERLUND 2007; KREMERS ET AL. 1992). To overcome the common-factor restriction, we also apply the panel co-integration tests by WESTERLUND (2007).

The threshold error correction representation in Equation 1 can be extended to a panel model. By this we assume all panel members to follow the same cost pass-through process, for example the same error correction mechanism (see Equation 2).[8] To allow for individual variations of the error correction mechanism or the short term dynamics, the model can be extended by panel member dummies that are multiplied with respective variables such as for the short term dynamics shown in Equation 4. If the cause for the individual variation is known, another interaction term can be added (see RICHARDS ET AL. 2012). For example, if individual variations of the error correction mechanism are caused by the relative average margin (M = 1 – average retail price / average wholesale price), then the error correction term (μ_{it-1}) multiplied by the relative average margin (M_i), is added to the model specification (see Equations 3 and 4):

$$\Delta p_{1_{it}} = \alpha_i + I_{t_1}\delta^{-}\mu_{it-1} + \left(1 - I_{t_1} - I_{t_2}\right)\delta^{0} \cdot \mu_{it-1} + I_{t_2}\delta^{+}\mu_{it-1}$$

[7] BREITUNG AND DAS (2008) show that all tests may be biased when the common component indicates a unit root. To our knowledge, this problem has not yet been solved.

[8] A fixed effect model allows only the constant term to vary between panel members.

$$+\sum_{j=1}^{k}\beta_{1,j}\Delta p_{1_{it-j}}+\sum_{j=1}^{k}\beta_{2,j}\Delta p_{2_{it-j}}+v_{it} \quad (2)$$

$$\Delta p_{1_{it}}=\alpha_i+I_{t_1}\delta^-\mu_{it-1}+\left(1-I_{t_1}-I_{t_2}\right)\delta^0\mu_{it-1}+I_{t_2}\delta^+\mu_{it-1}$$

$$+I_{t_1}\delta^{*-}M_i\cdot\mu_{it-1}+\left(1-I_{t_1}-I_{t_2}\right)\delta^{*0}M_i\cdot\mu_{it-1}+I_{t_2}\delta^{*+}M_i\cdot\mu_{it-1}$$

$$+\sum_{j=1}^{k}\beta_{1,j}\Delta p_{1_{it-j}}+\sum_{j=1}^{k}\beta_{2,j}\Delta p_{2_{it-j}}+v_{it} \quad (3)$$

$$\Delta p_{1_{it}}=\alpha_i+I_{it_1}\delta^-\mu_{it-1}+\left(1-I_{it_1}-I_{it_2}\right)\delta^0\mu_{it-1}+I_{it_2}\delta^+\mu_{it-1}$$

$$+I_{it_1}\delta^{*-}M_i\cdot\mu_{it-1}+\left(1-I_{it_1}-I_{it_2}\right)\delta^{*0}M_i\cdot\mu_{it-1}+I_{it_2}\delta^{*+}M_i\cdot\mu_{it-1}$$

$$+\sum_i\ \sum_{j=1}^{k}\beta_{1,i,j}D_i\Delta p_{1_{it-j}}+\sum_i\ \sum_{j=1}^{k}\beta_{2,i,j}D_i\Delta p_{2_{it-j}}+v_{it}\ . \quad (4)$$

For all panel models we assume individual long-term relationships and therefore individual error terms, μ. RICHARDS AT AL. (2012) only consider one set of common thresholds. We also introduce individual sets of thresholds by introducing the estimates for the thresholds from the individual TECMs (I_{it_1},I_{it_2}). To interpret the panel results, RICHARDS ET AL. (2012) suggest calculating an average speed of adjustment by cumulating the effects of a change in the error correction term as follows. The average speed of adjustment back to the equilibrium for a unit shock in the lower regime is $\delta^-+\delta^{*-}*\emptyset M$.[9]

The two-stage approach and the panel procedure have advantages and limitations in this application. The two-stage procedure does not place any restrictions on the individual cost pass-through processes besides the general structure of the TECM. All coefficients are separately estimated for each individual retail price series. The panel approach is more efficient because it places various restrictions on the individual cost pass-through processes. In the extreme, all parameters of the TECM are assumed to be the same for the panel members. However, these restrictions can be partly lifted by introducing further auxiliary variables as done in Equation 4.[10] The actual advantage of the panel approach is that the determinants for the variations in the cost pass-through parameters can be modelled simultaneously as in Equations 3 and 4. In theory it is possible to allow for all kinds of individual variations in the panel model, but computer costs and software limit the lifting of restrictions. For the data under study, a fully flexible panel model could not be estimated because of matrix limitations for the panel procedure in STATA Version 12. Thus, we apply the flexible two-step procedure and the presented panel model specifications to test the robustness of our results.

[9] The mean value for the relative average margin is used in this calculation (see RICHARDS ET AL. 2012).

[10] By lifting restrictions, the number of estimated coefficients increases and the efficiency gain is reduced. This process can be limited by the power of the software package. For the data under study a fully flexible panel model could not be estimated due to matrix limitations of the panel procedure in STATA Version 12.

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 were cooperatives and 141 were non-cooperatives (private enterprises). Cooperatives are on average larger than non-cooperatives and their total share of processed milk is about 50 percent (AMI 2010; BMELV 2008). The market share of the six largest dairy companies is almost 50 percent, and four of them are cooperatives (FRIEDRICH 2010). Cooperatives often focus on cost leadership by utilising economies of scale when producing standard products such as milk powder and butter. In comparison, non-cooperatives show more marketing activity by focussing on national brands with higher added value (EVERWAND ET AL. 2007; BUNDESKARTELLAMT 2009). Fully 63 percent of the raw milk produced in Germany is processed to cheese (32 %) and butter (31 %), while another 34 percent is used for milk (13 %), cream (12 %), and curdled milk drinks (9 %) (AMI 2010).[11] Dairy companies deal directly with food retailers, a sector that is even more concentrated than processing. In 2010 the top six grocery retailers provided more than 75 percent of the sector's turnover. 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 negotiations with processors (BUNDESKARTELLAMT 2009; HELLBERG-BAHR ET AL. 2010). However, this advantageous position might not result in higher margins due to intense competition between retailers and price sensitive consumers (HELLBERG-BAHR ET AL. 2010; TWARDAWA 2006; BACHL ET AL. 2010).

The retail business in Germany is differentiated by five formats with respect to store size and store product assortment (NIELSEN 2006; CLEEREN ET AL. 2010; GIJSBRECHTS ET AL. 2008). Supermarkets almost exclusively sell food items and are smaller than 799 m², while small (large) consumer markets sell predominantly food items and are between 800 m² and 1,499 m² (> 1,500 and < 5,000 m²). Hypermarkets sell food and other items such as clothing and are larger than 5,000 m² (NIELSEN 2006). Discounters offer a small assortment of goods (stock keeping units) with a high degree of private labels,[12] and operate at low costs and low buying-in-prices by realising huge demand quantities (AGGARWAL 2003; CLEEREN ET AL. 2010; MORSCHETT ET AL. 2006); discounters use their low cost profile to offer everyday low prices to consumers, using only a small number of price 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).

[11] 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).

[12] 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, RONDÁN-CATALUÑA ET AL. 2005).

Dairy products are key items that influence consumers' store choices. Thus, dairy products are often used as loss leaders to lure consumers into the store (BACHL ET AL. 2010; RONDAN-CATALUÑA ET AL. 2005).[13] 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 recent decades (FRIEDRICH 2010; TITZE 2008). In 2009 discounters accounted for 56 percent of milk and 50 percent of butter retail sales in Germany, while hypermarkets accounted for 21 percent of milk and 23 percent of butter retail sales (BMELV different volumes).

5 Descriptive Statistics

For this study we use German milk and butter prices at the retail and wholesale levels. 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), while for milk, all prices apply to a fat content of 3.5 percent and a package size of 1 litre (cartons). Retail prices cover private labels and national brands. For national brands we can differentiate between brands produced by cooperative and non-cooperative dairies. 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 (1,724) individual store retail price series covering 71 (90) brands for milk (butter) in 327 (447) stores belonging to the five discussed store formats. The data were collected weekly starting in the first week of 2005 through the last week in 2008 (n =208) by SYMPHONYIRI GROUP GMBH (SIG, 2011). Table 1 shows the distribution of prices by calculating means, standard deviations (of means), minima (of means), and maxima (of means) for the respective sub-groups. Promotional sales are a special feature of retailing mainly used by non-discounters. Sales' prices may affect the measurement of cost pass-through and comparability between store formats. Promotional sales are significant temporary price reductions that are unrelated to cost changes (HOSKEN AND REIFFEN 2001). According to this definition, price promotions are not part of the cost pass-through between wholesale and retail prices. We therefore exclude all price promotions from the time series.[14] These observations are replaced by the respective last regular price before the price

[13] BACHL ET AL. (2010) rank six dairy products into the group of the most price sensitive 'halo' products. Consumers are most price sensitive when buying coffee, chocolate, and butter. 'Halo' products are characterised 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.

[14] Following the comment of an anonymous reviewer, we checked the impact of excluding sales' prices by running the models with the original series. The results are documented in Table A4 in the Appendix. The results show only slight differences compared with the results in Table 3. In addition, the number of promotional sales is neither correlated with the parameters for the cross section analysed in Table 3, nor with the price or cost level in time.

promotion.[15] Price promotions might not lead to biased estimates of the cost pass-through process, but they likely decrease the efficiency of estimations by adding unexplained price variation.

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, and 21 (9) brands are private labels. Most retailers offer one private label and more than one national brand, with private labels generally being the low price option. Though we only have a few time series for private labels, their market volume is significant. Sixty 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.[16] The average margin for milk (butter) is 28 (50) Eurocents per litre (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 litre (250 g) cheaper than national brands. Discounters and hypermarkets set lower prices than consumer and supermarkets, but the size of consumer markets seems to have a small negative effect on average prices. Fresh milk is about 4 Eurocent per litre more expensive than UHT milk. Standard label butter is on average 6 Eurocent per 250 g cheaper than butter with an additional label. Comparing cooperatives and non-cooperatives, we find mixed results. While national brands of cooperative dairies for milk are cheaper than non-cooperative brands, national brands of cooperative dairies for butter are more expensive. Compared with national brands, private labels show less price variation.

To analyse cost pass-through, we measure costs by the wholesale price for milk and butter. We interviewed a dozen market experts (CEOs of major dairy companies in the German market) who confirmed that whole prices indicate production and transportation costs of milk and butter, respectively. The wholesale prices reflect the minimum revenue received by dairies selling standard milk products such as butter and skim milk powder for export, and include transportation costs to the retailer. These prices also cover production (processing) costs, including the farm price of milk and costs of collecting the raw milk. Variations in production costs between dairies are negligible in terms of this study. Though buying-in prices might differ for retailers and/or brands, wholesale prices still reflect the (opportunity) costs or minimum revenues that the processor faces over time. We work with this assumption and use the same wholesale price for estimating the cost pass-through for each retailer and each brand. The differences between the retail and wholesale prices indicate extra

[15] Because 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 5 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.

[16] 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 retail food market.

margins, which go to the processor (dairy) and/or the retailer.[17] The division depends on the strength of the (national) brand and/or the product and the negotiation power of the processor (dairy) and/or the retailer.[18] We collect wholesale prices for milk from the statistical report of the German Federal Ministry of Food, Agriculture and Consumer Protection (BMELV, various volumes), which is based on an extensive survey of the German dairy industry. The prices reflect an average price per litre of pasteurised milk containing 3.5 percent of fat in single packaging. The sales price of butter for German dairies is quoted by the butter and cheese exchange (SBKB) located in Kempten, Germany. A commission of processors, traders, and retailers quote weekly butter prices (SBKB 2011). 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. Seventy-five percent of the series indicate up to five lags. To test for stationarity we use procedures from the ADF test and KPSS test. The null hypothesis of non-stationarity (ADF test) is only rejected in 5 percent of all cases, while 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 to be the expected type one error. The results for the first differences indicate stationarity for all price series. We thus 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. The panel unit root test by HADRI (2000) rejects the null hypothesis of stationarity for the original retail price panel. Thus, some panel member retail price series contain a unit root. For the first differences, all series are stationary.

Bivariate co-integration between wholesale and respective individual retail prices for milk (919 time series) and butter (1,724 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) co-integration for one-third of all cases. For milk (butter), the two-step procedure (Johansen test) indicates co-integration for 67 (15) percent of all cases. For a considerable part of the time series for milk and butter retail prices, we find significant evidence against linear co-integration. Therefore, we additionally test for threshold co-integration 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 co-integration between retail and wholesale prices. Based on a ϕ-statistic, 96 (82) percent of the time series for milk (butter) indicate a significant threshold error correction mechanism

[17] As a reviewer correctly pointed out, the margin does not cover retailing marginal cost. Thus, the measure is an upper bound.

[18] Our interpretation is similar to CONNOR AND PETERSON (1992) and BARSKY ET AL. (2003), who use private label brand prices as marginal cost indicators to calculate markups over marginal costs.

between retail and wholesale prices.[19] All WESTERLUND (2007) tests indicate panel co-integration between retail and wholesale prices for milk and butter.

Though a three-regime threshold model is used to test non-linear co-integration, 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 90 (94) 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. Because the two threshold model is the most flexible form, we choose this specification at the expense of losing estimation efficiency to directly compare and test the estimates for the pass-through process.The panel based tests for unit roots by Hadri (2000) and for co-integration by Westerlund (2007) result that times series contain a unit root and the retail price time series are co-integrated with the wholesale price series. First differences of the times series are tested stationary. The results are similar for milk and butter.

6 Estimation Results

The analysis of the cost pass-through is based on a three-regime threshold error correction model (Equation 1). The non-linear model has three different decay rates for deviations from the long-run price equilibrium (margins) between wholesale and retail prices. We expect national (high price) brands and large supermarkets with significant consumer search costs to asymmetrically pass through costs. Margins above the long-run price equilibrium due to marginal cost reductions are reduced more sluggishly than margins below the long-run equilibrium caused by increased costs. Due to retailers' menu costs, a slow or zero reduction of deviations from the long-run margin is expected for the inner regime. Thus, margins in the range between the lower and upper thresholds are expected to be reduced slowly or not at all. The wholesale price is set to be exogenous. 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.[20] For 99 percent of the estimated pairs of thresholds, the steady state equilibrium (average margin or a zero deviation from it) lies between θ^- and θ^+; values for θ^- are negative, and values for θ^+ are positive. On average,

[19] 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 levels for the ϕ-statistic and is -1.37, -1.58, and -2.06 at the 90, 95, and 99 percent significance levels for the t-max-statistic (one-sided test). We also tested threshold co-integration 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 the t-max-statistic, the test leads to similar results. Eighty-seven (70) percent of the price series indicate a threshold co-integration relationship with respect to the wholesale price.

[20] 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 test using the Huber/White robust estimator for the variance-covariance matrix. The 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.

150 of the 208 observations (75 percent) belong to the inner regime. The estimated thresholds are not affected by the procedure of setting a minimum amount of observations of 5 percent in each regime. On average, the inner regime is bounded by a lower threshold of -3.5 (-10.4) and an upper threshold of 5.8 (12.6) Eurocent per litre (250 g) for milk (butter).

The adjustment coefficient estimates (δ^0) for the inner regime ($\theta^- \leq \mu_{t-1} \leq \theta^+$) are predominantly small. In the case of milk (butter), the average parameter estimate is -0.04 (-0.01). Fully 92 (80) percent of the estimates (δ^0) are statistically insignificant for milk (butter). The adjustment coefficients for the outer regimes ($\delta^-;\ \delta^+$) are in almost all cases absolutely larger than the coefficients for the respective inner regime. Further, the estimates for the lower regimes (δ^- for $\mu_{t-1} < \theta^-$) are larger in absolute terms than the estimates for the upper regime (δ^+ for $\mu_{t-1} > \theta^+$). In the case of milk (butter) the average rate of decay (δ^-) for a below average margin[21] is -0.32 (-0.36) compared to 0.12 (-0.17) for δ^+. Further, δ^- is statistically significant in nine out of ten cases, while δ^+ is statistically significant in 62 and 77 percent of all cases for milk and butter. We also find significant contemporaneous price adjustments in 39 percent of all cases. For milk the average estimate is 0.1; for butter, average φ is 0.15. All estimated coefficients of the individual cost pass-through process show significant variations across the sample.

To analyse the determinants of this variation of the price adjustment processes, we run a dependent variable regression for the main indicators (coefficients) of the cost pass-through process, namely the estimated average margin (ϕ)[22], the two thresholds $(\theta^{-/+})$, the adjustment coefficients of deviations from the long-run equilibrium (margin) for the three regimes ($\delta^-,\ \delta^0, \delta^+$), and the coefficient for the contemporaneous adjustment (φ). For exogenous variables we use dummies for non-cooperative dairies, private labels, additionally labelled butter, fresh milk, and dummies for the individual store formats. The control group includes national brands of ultra-high heated milk (standard butter) produced by cooperative dairies and sold by discounters. The estimators for the control group can be interpreted directly; the estimators for the dummies such as non-cooperative dairy or private label present the deviations from the control group. We use ordinary least squares (OLS) with robust standard errors and weighted least squares (WLS) procedures for milk and butter separately. Ordinary least squares is supposed to result in unbiased but potentially inefficient estimates, while WLS provides possibly biased but efficient estimates (Lewis and Linzer 2005).[23] The estimations indicate only some

[21] This refers to margins that are smaller than the lower threshold.

[22] The average margin is calculated from the difference between average retail and average wholesale prices over the period of observation.

[23] Following Lewis and linzer (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.

small differences. The interpretation and conclusions drawn from both estimations are consistent. The results in Table 2 show the WLS estimates.

For milk we find an average margin ($\emptyset$) of 28.4 Eurocent per litre for the control group; the lower threshold (θ^-) is -2.8, while the upper threshold (θ^+) is 6.6 Eurocent per litre. Deviations from the average margin in the inner regime range from -10 to +23 percent with respect to the average margin. The deviations are reduced at a rate of 1.6 (δ^0) percent per week. Lower margins are expanded (δ^-) at a rate of 14.4 percent per period and higher margins are reduced at a rate of 4.7 (δ^+) percent back to the equilibrium. The contemporaneous adjustment (φ) is 0.08; 8 percent of a wholesale price change is transmitted immediately to the retail price.

For butter we find an average margin of 41.3 Eurocent per 250 g. The lower threshold is -9.4 and the upper threshold is 9.1 Eurocent per 250 g for the control group. Thus, deviations in the range of -23 to +22 percent of the average margin fall into the inner regime in which deviations are reduced at a rate of less than 1 percent for the average process. 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 at 0.10; thus, 10 percent of a shock is adjusted in the same period.

For private label milk the average margin is 19 Eurocent (70 percent) lower than in the control group. The range between thresholds is smaller, and deviations from the long run price equilibrium are reduced much more quickly than in the control group. The same holds for private label butter, except the magnitude of the change in the average margin and the contemporaneous adjustment appear to be even more distinctive than for milk. For instance, private label butter retail prices almost completely reflect wholesale price shocks during the same week.

Average margins for supermarkets and small consumer markets are higher than for the other retail formats. The average margins for hypermarkets are closest to margins of discounters. The inner regimes (menu costs) are wider (higher) for supermarkets, consumer markets, and hypermarkets for butter compared to the control group, while this effect is not observed for milk. Below average margins are corrected at almost the same speed in all retail formats; above average margins are reduced more sluggishly by all non-discount retail formats. Supermarkets and small consumer markets in particular charge higher prices; they indicate higher menu costs (in the case of butter) and react more asymmetrically to cost changes.

Finally, we employ a panel threshold error correction model. Instead of separating brands by private labels and national brands, here we use the relative average margin (average retail price minus average wholesale price, divided by the average retail price) to classify brands. As private labels are mostly low-priced, and high-priced brands are almost exclusively national brands, this measure is strongly correlated with the private label dummy variable used before. Search costs can be approximated by the number of stock-keeping units in the respective store following RICHARDS ET AL. (2012). This measure is added to the model specification in the same way as the relative margin (see Equation 4).[24] We use individual threshold estimates, and the results of the two-step procedure indicate significant variations of individual thresholds (see Table 3). We estimate two specifications that differ in the flexibility of individual cost pass-through processes. In one specification we model common price dynamics as in Equation 3; in the other specification we use flexible price dynamics as shown in Equation 4. RICHARDS ET AL. (2012) use a common set of thresholds and common price dynamics as in Equation 3; we also estimate this specification to directly compare our results with RICHARDS ET AL. (2012). Further, we run the two-stage approach for this specification to compare the panel and the two-stage approach. The results of all estimations and some statistics are presented in Table 3.

We again find significant positive asymmetries for the cost pass-through. The adjustment is faster in the lower regime compared to the upper regime (positive asymmetry), while the inner regime indicates the slowest reductions of deviations from the average margin. For comparing the estimates of the cost pass-through, we follow the procedure used in RICHARDS ET AL. (2012) and evaluate the estimates at averages of the relative margin and averages of search costs (number of stock keeping units). The averages for the relative margin are 0.43 for milk and 0.38 for butter, while the average stock keeping units are 3.6 for milk and 5.7 for butter. For milk the calculation return δ^- is equal to -0.17, δ^0 is -0.02 and δ^+ is -0.05. For butter we obtain -0.31 for δ^-, 0.03 for δ^0 and -0.13 for δ^+. The coefficients almost match the estimates for the control group in Table 3.

The coefficients for the relative average margin show positive signs, indicating that the cost pass-through becomes slower for products with higher margins. This finding supports the results by BORENSTEIN AND SHEPARD (2002), who show that cost pass-through slows down with market power. However, the asymmetry between the adjustment coefficients of the outer regimes (δ^-, δ^+) becomes smaller with increasing relative margins, indicating that brands with higher margins pass through costs more symmetrically or less asymmetrically. This result is robust for all estimation procedures and model specifications; results are also very similar for milk and butter (see Table 3). Testing the different panel specifications implies that the more flexible specification is favoured. The impact of search cost measures is statistically significant but comparably small compared to the effect of the relative margin. The impact of the search costs on the speed of cost pass-through is about one-tenth of the effect of the relative margin. The obtained signs are mixed to some extent between specifications and/or products. For milk, search costs slow down the speed of the cost pass-through, no matter whether

[24] As noted before, a fully flexible panel model for the data sets under scrutiny cannot be estimated with the STATA 12 software. We limited the flexible model to the level of the EAN, implying that we assume that all cost pass-through processes are assumed to be the same for the same products (EAN code) irrespective of the store the product is sold at.

margins are above or below average. The results for butter indicate that the positive asymmetry is increasing with search costs, implying that the rocket and feathers phenomenon becomes more pronounced for higher search costs. Search costs seem to reduce competition. RICHARDS ET AL. (2012) find the same effect on the ready-to-eat cereal market in Los Angeles (USA); they also find that cost pass-through becomes more symmetric or less asymmetric for brands with higher margins (prices).

7 Conclusions

In this paper the cost pass-through between the wholesale and retail market for milk and butter in Germany is analysed at the individual product (brand) and store level. The non-linear nature of many of these price relationships is modelled by bivariate and panel three-regime thresholds error correction models. We use 2,643 individual vertical price relationships between wholesale and retail level for milk and butter including different brands (national brands of cooperative and non-cooperative dairies and private labels) and different retail outlets (supermarkets, small and large consumer markets, hypermarkets, and discounters).

We find significant (static) price dispersion in the German milk and butter retail market, which is mainly explained by the co-existence of national brands and private labels. Retail outlet formats, product differentiation (e.g. additional labels), and the organisational structure of the processor (cooperative versus non-cooperative dairies) also play a role in explaining the observed price dispersion. As expected, private labels indicate lower prices than national brands. Discounters set lower prices than supermarkets, etc., and additional labels reward higher prices. These results mainly support the theory and the empirical evidence in the literature.

The dynamics underlying the static price dispersion, namely the cost pass-through mechanisms between brands, retail outlets, etc., also indicate significant variations. In general, the cost pass-through indicates significant positive asymmetries, implying that increasing costs are adjusted quicker than decreasing costs (wholesale prices). The theory predicts that at least national (high price) brands more extensively use asymmetric cost pass-through to maintain high prices. Private label (low price) brands are supposed to practise price fairness by quickly and symmetrically transmitting cost (wholesale price) changes. Discounters exercise an everyday low price strategy which implies that cost changes are passed on evenly to the consumer. Other retail formats mainly employ HiLo pricing strategies. When consumer search costs are low (high), retailers are expected to pass on cost changes quickly (slowly) and symmetrically (asymmetrically).

For the data under study we find that costs are passed on to consumers more quickly for private label (low price) brands than for national (high price) brands. However, cost pass-through is asymmetric and is even slightly more asymmetric for private label (low price) brands than for high-priced national brands. Discounters indicate a fast but also asymmetric cost pass-through; as expected, supermarkets, consumer markets and hypermarkets pass on costs slightly more asymmetrically than discounters. Cooperative dairies are supposed to produce lower price brands and pass through costs more symmetrically. Cooperative dairies receive lower prices for milk; however, the cost pass-through is more (positive) asymmetric than for the respective non-cooperative brands. For butter, the situation is reversed, since most of the non-cooperative brands use additional labels that indicate higher prices, but more symmetric cost pass-through mechanisms. Search costs appear to have an impact on the cost pass-through process; the direction of the impact is ambiguous and rather small compared to the effect of the average margin and/or the brand (private label or national brand). Private-label butter indicates the fastest and most symmetric cost pass-through at very low margins, indicating that such brands are used as loss leaders and/or to generate a 'halo' effect on the store's price image.

Our study faces some limitations. Most retail prices indicate some non-continuous time series behaviour, which may be modelled more adequately by some form of jump processes. Even though the threshold error correction model allows different regimes to mimic some features of jump processes, its underlying assumptions are still based on continuous processes for the different regimes. Exploring alternative processes to model the data generating process of retail prices more adequately might offer some new insights and interpretations of the cost pass-through mechanism. Also, considering more detailed brand information may be worthwhile to further enlighten the role of brands beyond the differentiation between national brands and private labels. Finally, the availability of buying-in prices for the individual retailers may allow researchers to identify the role of processors and retailers in the joint cost pass-through process. Some recent studies with access to such data in other markets indicate the potential for future research in this direction.

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8 Tables

Table 1: Descriptive statistics for weekly German milk (Eurocent per litre) and butter (Eurocent per 250 g) prices over the period from 2005 to 2008

Milk			Prices			
	Brands (Price Series)	Market Share	Mean	St.Dev.	Min.	Max
Wholesale Price			49	5	44	60
Retail Price Series	**(919)**		77	14	53	106
Brands	**71 (919)**					
National Brands	50 (633)	41.6%	84	8	53	106
Cooperative Dairies	35 (297)	22.3%	78	8	53	93
Non-Cooperative Da	15 (335)	19.3%	89	7	58	106
Private Labels	21 (286)	58.4%	60	3	56	100
Type of Milk						
Fresh Milk	35 (320)	23.4%	79	11	53	102
UHT Milk	36 (599)	76.6%	75	14	58	106
	Stores (Price Series)					
Stores	**327 (919)**					
Supermarket	72 (168)	6.8%	76	15	59	106
Small Consumer Marke	60 (175)	9.3%	77	14	59	96
Large Consumer Marke	71 (233)	25.7%	78	13	56	97
Hypermarket	83 (276)	50.6%	78	12	53	93
Discounter	39 (67)	7.6%	65	11	56	90

Butter			Prices			
	Brands (Price Series)	Market Share	Mean	St.Dev.	Min.	Max
Wholesale Price			78	13	64	113
Retail Price Series	**(1724)**		125	20	80	239
Brands	**90 (1724)**					
National Brands	81 (1581)	68.8%	129	17	80	239
Cooperative Dairies	55 (1130)	24.7%	132	16	80	172
Non-Cooperative Da	26 (451)	44.1%	123	17	94	239
Private Labels	9 (143)	31.2%	83	5	80	106
Type of Butter						
Standard Butter	52 (512)	31.3%	121	19	81	239
Additionally Labelled B	29 (1069)	68.7%	127	21	80	173
	Stores (Price Series)					
Stores	**447 (1724)**					
Supermarket	76 (205)	3.6%	132	17	82	173
Small Consumer Marke	66 (253)	5.0%	134	20	82	239
Large Consumer Marke	77 (458)	19.1%	130	18	81	205
Hypermarket	83 (570)	53.6%	123	20	80	173
Discounter	145 (238)	18.7%	109	21	81	148

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 2: Dependent variable estimation for milk and butter respectively

Milk	ϕ	θ-	θ+	δ-	δ0	δ+	φ
Control Group[a]	28.40 *** (0.00)	-2.76 *** (0.00)	6.63 *** (0.00)	-0.144 *** (0.00)	-0.016 * (0.08)	-0.047 *** (0.00)	0.081 *** (0.00)
Non-Cooperative Dairy	10.40 *** (0.00)	-1.64 *** (0.00)	-0.39 (0.19)	-0.018 *** (0.00)	-0.017 *** (0.00)	-0.026 *** (0.00)	-0.023 *** (0.00)
Private Label	-19.10 *** (0.00)	0.17 ** (0.03)	-1.89 *** (0.00)	-0.328 *** (0.00)	-0.041 *** (0.00)	-0.158 *** (0.00)	0.050 *** (0.00)
Fresh Milk	-0.56 (0.50)	0.37 *** (0.00)	0.11 (0.51)	0.002 (0.52)	0.001 (0.75)	-0 .003 (0.29)	-0.029 *** (0.00)
Supermarket	4.05 *** (0.01)	0.000 (0.99)	-0.77 ** (0.01)	0.001 (0.92)	0.023 ** (0.02)	0.016 *** (0.01)	-0.011 (0.31)
Small Consumer Market	3.63 ** (0.03)	0.000 (0.99)	0.22 (0.47)	- 0.005 (0.52)	0.19 ** (0.05)	0.019 *** (0.00)	-0.002 (0.87)
Large Consumer Market	1.93 (0.23)	0.000 (0.77)	0.00 (0.91)	-0.029 *** (0.00)	0.010 (0.28)	0.018 *** (0.00)	0.022 ** (0.38)
Hypermarket	0.51 *** (0.75)	-0.11 (0.27)	-0.22 (0.48)	0.020 (0.80)	-0.005 (0.61)	0.017 *** (0.00)	0.021 ** (0.04)
R-Squared[b]	0.81	0.12	0.07	0.55	0.02	0.49	0.08

Butter	ϕ	θ-	θ+	δ-	δ0	δ+	φ
Control Group[a]	41.30 *** (0.00)	-9.38 *** (0.00)	9.06 *** (0.00)	-0.266 *** (0.00)	-0.008 ** (0.06)	-0.125 *** (0.00)	0.101 *** (0.00)
Non-Cooperative Dairy	-6.12 *** (0.00)	1.73 *** (0.00)	1.08 *** 0.00)	-0.032 *** (0.00)	0.003 (0.18)	0.023 *** (0.00)	0.000 (0.97)
Private Label	-3.60 *** (0.00	7.60 *** (0.00)	-6.39*** (0.00)	-0.144 *** (0.00)	0.014 (0.18)	-0.108 *** (0.00)	0.786 *** (0.00)
Additionally Labelled Butter	10.10 *** (0.00)	1,79 *** (0.00)	3.77 *** (0.00)	0.035 *** (0.00)	0.003 (0.29)	-0.016 *** (0.00)	-0.133 *** (0.00)
Supermarket	9.19 *** (0.00)	-3.81 *** (0.00)	1.04 *** (0.00)	-0.009 (0.12)	-0.010 ** (0.03)	0.024 *** (0.00)	0.080 *** (0.00)
Small Consumer Market	11.5 *** (0.00)	-0.72 *** (0.00)	2.97 *** (0.00)	0.010 (0.09)	- 0.007 * (0.09)	0.017 *** (0.00)	0.080 *** (0.00)
Large Consumer Market	8.91 *** (0.00)	-4.06 *** (0.00)	2.12 *** (0.00)	-0.002 (0.58)	-0.009 ** (0.03)	0.038 *** (0.00)	0.077 *** (0.00)
Hypermarket	3.77 *** (0.00)	-4.25 *** (0.00)	1.13 *** (0.00)	-0.040 *** (0.00)	-0.014 *** (0.00)	0.026 *** (0.00)	0.066 *** (0.00)
R-Squared[b]	0,60	0,16	0,15	0,17	0,01	0,04	0,47

Legend: */**/*** denote 10 percent/5 percent/1 percent significance; ϕ: average margin; $Θ^-$: lower threshold, $Θ^+$: upper threshold; $δ^-$: adjustment in the lower regime; δ0: adjustment in the middle regime, δ+: adjustment in the upper regime; φ: contemporaneous adjustment.

[a]) The control group for milk is UHT milk of a cooperative dairy national brand sold at a discount store. For butter the control group is a standard butter of a cooperative dairy national brand sold at a discount store.

[b]) The R-squared is based on OLS estimation.

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

Table 3: Results of different panel error correction representations and the two stage dependent variable estimation

Milk	PTECM 1 - Eq. 13 (common Thresholds)	PTECM 2 - Eq. 13 (individual Thresholds)	PTECM 3 - Eq. 14 (idividual Thresholds)	Dependent Variable Estimation
δ-	-0.559***	-0.542***	-0.554***	-0.77***
δ0	-0.261***	-0.031***	-0.039***	-0.148***
δ+	-0.151***	-0.198***	-0.2121***	-0.287***
L_i*δ-	0.899***	0.811***	0.8414***	1.24***
L_i*δ0	0.491***	-0.013	0.0157	0.128*
L_i*δ+	0.216***	0.307***	0.339***	0.486***
SKU_i*δ-	0.005***	0.0064***	0.006***	0.011***
SKU_i*δ0	0.0046***	0.004***	0.0039***	0.015**
SKU_i*δ+	0.003***	0.004***	0.0037***	0.0054***
R-squared				
overall	0.084	0.091	0.1	δ- = 0.57
within	0.085	0.093	0.11	δ0 = 0.01
between	0.86	0.14	0.14	δ+ = 0.43
Log-Likelihood	527452.96	528222.62	529464.89	
Likelihood-ratio test (H0: PTECM2 is nested in PTECM3): p-value = 0.00				

Butter	PTECM 1 - Eq. 13 (common Thresholds)	PTECM 2 - Eq. 13 (individual Thresholds)	PTECM 3 - Eq. 14 (idividual Thresholds)	Dependent Variable Estimation
δ-	-0.985***	-0.868***	-0.825***	-0.315***
δ0	-0.209***	-0.482***	-0.399***	-0.075***
δ+	-0.364***	-0.321***	-0.300***	-0.260***
L_i*δ-	1.78***	1.517***	1.333***	0.582***
L_i*δ0	0.503***	1.255***	1.02***	0.201***
L_i*δ+	0.607***	0.444***	0.369***	0.640***
SKU_i*δ-	-0.017***	-0.021***	-0.016***	0.0058***
SKU_i*δ0	-0.0132***	-0.021***	-0.018***	-0.008***
SKU_i*δ+	0.002***	0.003***	0.003***	-0.002***
R-squared				
overall	0.25	0.25	0.28	δ- = 0.47
within	0.26	0.26	0.29	δ0 = 0.05
between	0.08	0.002	0.004	δ+ = 0.33
Log-Likelihood	511003.92	511139.91	518251.58	
Likelihood-ratio test (H0: PTECM2 is nested in PTECM3): p-value = 0.00				

Legend: */**/*** denote 10 percent/5 percent/1 percent significance; δ-: adjustment in the lower regime; δ0: adjustment in the middle regime, δ+: adjustment in the upper regime; L_i: Lerner-Index, SKU_i: stock keeping units

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