Cooperative vs. Non-Cooperative Spatial Competition for Milk in the Presence of Farm Marketing Cooperatives

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Abstract. Although important, the spatial dimension is often neglected in studies of market power and competition in agricultural markets. This paper investigates spatial competition for raw milk between dairies under the presence of marketing cooperatives. Since observed in reality, our model is based on uniform delivered pricing and overlapping market areas. We compare spatial cooperative price matching with non-cooperative Hotelling-Smithies conduct. Utilizing a vector error correction model we show that the observed low price transmission in Germany is in line with cooperative behaviour. This seems rational since it increases processors profits. The abolition of the quota system may increase price transmission.

Keywords: spatial competition, uniform delivered pricing, price transmission, horizontal cooperation, VECM

JEL classification: C32, D43, Q11, Q13, R32

1. Introduction

Two major characteristics of agricultural production are a strong dependency on land and a low product value per unit of weight and/or volume. This is particularly true for milk where scattered production of raw milk at the farm level and centralized processing in dairies is linked by costly shipping. Hence, incorporating a spatial dimension is important in the analysis of such agricultural markets. This is even more true given an increasing concentration within the processing sector. For example, the number of milk processing facilities decreased by approximately 21% in Germany between 1997 and 2006, whereas the processed quantity remained at a constant level (ZMP, 2008). As a consequence, the average distance between production and processing of milk has increased. High shipping cost and the unequal distribution of suppliers and demanders have crucial implications - most important that processors are able to exert spatial market power.[1]

Although there is an extensive literature on spatial monopoly (e.g. Beckmann, 1976; Phlips, 1983; Greenhut *et al.*, 1987) and spatial competition between suppliers (e.g. Capozza and Van Order, 1978; Gronberg and Meyer, 1981), there are few studies analyzing spatial market power within an input market framework. Notable exceptions are Löfgren (1985, 1986) and Zhang and Sexton (2001). Löfgren (1985) empirically analyzes the price list of the Swedish pulpwood market with respect to spatial price theory while Löfgren (1986) investigates different pricing policies of a spatial monopsonist. Zhang and Sexton (2001) examine a firm's decision with respect to the pricing policy in a duopsony market.

One important pricing strategy often applied in agricultural markets in general and for milk in particular is a uniform delivered (ud) price. Under ud pricing (udp) producers receive the same price from the processor independent of their relative location to the processing facility. Whereas prices are seemingly independent from the distance, differences in transportation costs imply net prices to be a function of distance. Since local prices do not reflect transportation costs, udp is a price discriminating strategy and an indicator of local market power (Phlips, 1983). Moreover, udp can facilitate overlapping market areas among competing firms, something that we frequently observe in reality for milk, but also for other agricultural products like tomatoes (Durham *et al*., 1996). Taking this into account Alvarez *et al*. (2000) in their seminal work in the *European Review of Agricultural Economics* develop a spatial duopsony model of milk processors using udp. Their study is the first attempt to explicitly consider spatial aspects of market power in overlapping markets with udp. A key result of their study is that firms may set prices above the monopsony level to minimize direct competition among them. Hence, firms act cooperatively or collusively. However, their result is based on the conjecture of price-matching (PM) behaviour, i.e. each processor assumes that its rivals will match any proposed price change.

The aim of this paper is threefold: First, we will present a model which includes also the alternative non-cooperative Hotelling-Smithies (HS) conjecture, i.e. that a firm expects no change of the competitor's price in response to a variation of its own price. Second, we account for additional features important in the raw milk market as the presence of marketing cooperatives and the European quota system. In regard to the latter, instead of a linear or inelastic supply function as usual in spatial competition models, we introduce a more flexible function to capture both, supply under a quota and without a quota system. Third, based on our theoretical findings we empirically test whether milk processors in Germany follow a cooperative (PM) or non-cooperative (HS) pricing strategy. In particular, utilizing time series econometrics we test whether the observed price transmission is consistent with PM or HS conjectures.

The rest of the study is organized as follows. The next section represents our theoretical model and derives comparative statics for PM and HS competition. Section 3 represents a vector error correction model to test empirically whether price transmission in the German raw milk market is consistent with PM or HS conjectures. Section 4 describes utilized data and Section 5 represents empirical results. We draw conclusions in Section 6.

2. Theoretical Model

2.1. General Model

To highlight the alternative assumptions of firms' spatial competitive behaviour, we follow Capozza and Van Order (1978) and Gronberg and Meyer (1981) by using a conjectural variation term θ. In the case of two firms (A and B) and an ud price u, $\theta = \partial u_B/\partial u_A$, i.e. the response in price firm A expects from firm B given an own-price variation. In line with Gronberg and Meyer (1981) one can distinguish 3 different conjectures in spatial udp models:[2]

1. *Hotelling-Smithies* (HS): The firm expects no change of the competitor's price in response to a variation of its own price ($\theta_{HS} = 0$). If so, the firm can increase its market radius R and $\partial R/\partial u > 0$.
2. *Lösch* (L): The firm expects the competitor will exactly match any price variation ($\theta_L = 1$) and suppliers choose to trade with the closest firm. The market radius is fixed ($\partial R/\partial u = 0$).
3. *Price-matching* (PM): The modified Lösch-assumption for ud pricing ($\theta_L = 1$), where suppliers choose the firm randomly. Markets overlap and the radii depend on the price ($\partial R/\partial u < 0$).

L-competition does not allow for overlapping market areas. Because the price has to be the same at each point in the market, firms either have to commit to fixed and exclusive market regions or suppliers always have to deliver to the closest processor. Since this is hardly observed in reality, we do not pursue this conjecture here. The PM-conjecture is based on the same competitive conduct, but as introduced by Gronberg and Meyer (1981) allows for overlapping market areas.[3] Exclusive market areas are usually also derived in a HS competition framework (Schuler and Hobbs, 1982; Zhang and Sexton, 2001). Moreover, according to Dasgupta and Maskin (1986) or Beckmann (1973) a price equilibrium in pure strategies does not exist under HS competition. However, we will below show that both findings are not necessarily true if marketing cooperatives exist.

Our spatial economic model is based on common assumptions (see e.g. Capozza and Van Order, 1979;

Löfgren, 1986; Zhang and Sexton, 2001): a single homogeneous input is produced in a line market by equally distributed suppliers. With no loss of generality the supplier density is set equal to one. As illustrated in Figure 1 two processors *A* and *B* are located at the end points of the line (Kats and Thisse, 1989; Zhang and Sexton, 2001). The distance between the processing firms (and at the same time the market size) is $d = 1$. The distance from processor *A* and *B* to a farmer is measured with *r* and 1 - *r*, respectively. The transport rate *t,* which represents the cost of transporting one unit per distance, is constant and identical at any point *r* in the market. The price received by a supplier (at its location *r*) is the uniform delivered price *u*. We assume a supply function of the form $q(r) = w(u) = xu^y$ with *q* is the quantity produced, *x* is a constant and *y* the elasticity of supply. For simplicity and with no loss of generality we can set $x = 1$ and $y \geq 0$. Hence, our input supply function is more flexible than in most previous studies and can gasp a quota system ($y = 0$ or close to 0), but also situations with higher price elasticity ($y > 0$). Beside the raw milk price *u*, other processing costs *c* are assumed to be constant. Hence, the net product price *p* is $p = P - c$, with *P* being the price received by the processor for the finished product.[4]

Let's now first assume that processor *A* has a monopsonistic position. The "local" profit of *A* at any point *r* is:

$$\Pi(r) = (p - u - tr)q(r) \qquad (1)$$

Under udp, local prices as well as the local supply are equal at any point in the market. However, since transport costs increase with distance local profits decrease. The monopsonist's profit is given by:

$$\Pi(R,u) = u^y \int_0^R (p - u - tr)dr = \frac{1}{2}u^y R(2p - 2u - Rt) \qquad (2)$$

Maximizing equation (2) with respect to *R* and *u* yields first order conditions

$$u'(R) = \frac{y(2p - tR)}{2(1+y)} \qquad (3)$$

and

$$R'(u) = \frac{p-u}{t}. \qquad (4)$$

Hence, we can solve for the optimal market radius *R** and the optimal ud price *u** and get

$$u^* = \frac{yp}{2+y} \qquad (5)$$

and

$$R^* = \frac{2p}{(2+y)t}. \qquad (6)$$

According to equation (4), firms do not serve a location *r* where local profits are negative, i.e. at distances where input price *u* plus the transport costs *tr* exceed net revenues *p*. This is a common assumption in udp models where the market radius *R** is defined by zero profits at this location (Schuler and Hobbs, 1982; Alvarez *et al*. 2000; Zhang and Sexton, 2001). However, due to exogenous restrictions or competition, the firm may not be able to choose the optimal market radius. In this context, a particular characteristic of the (German) raw milk market is important: farmers may cooperate to concentrate raw milk supply. Such *marketing cooperatives* are a form of horizontal integration and are common for certain agricultural goods (e.g. cereals or milk) or production techniques (e.g. organic farming). In 2007, 139 marketing cooperatives are registered in the German milk sector (BMELV, 2008). The share of processed milk delivered by marketing cooperatives was for example 34 % in Saxony for the year 2005 and 20 % in Bavaria in 2008.[5] Formation of such cooperatives is supported by law (Marktstrukturgesetz). For instance, subsidies to support foundation can be received in the first 5 years after approval. Additionally, marketing cooperatives are eligible to apply for investment grants.

The introduction of marketing cooperatives has important consequences for the spatial competition model.

Members of marketing cooperatives may be (arbitrarily) distributed over the market region. Processors competing for marketing cooperatives' supply have to accept to collect milk from some locations where it is not profitable. If a processor is not able to reject single members of a cooperative, the market radius *R* of a firm is fixed to the interfirm distance *d*, i.e. replacing *R* in equation 6 with *d*. In this case, our spatial model is comparable to a framework studied by Kats and Thisse (1989) or Iozzi (2004). Both investigate a spatial udp duopoly where the firms do not ration supply.[6] Consequently, the processor buys from all points inside the interfirm distance *d*. An exogenous market radius is a common condition in spatial economics, e.g. to compare the properties of spatial price strategies in a monopolistic framework (Beckmann, 1976). Nevertheless, under competition this assumption is critical if transport costs (or distances among neighbouring processors) are so high that locally separated monopolies (monopsonies) could exist. However, this is unlikely for the (German) raw milk market with still a sufficiently large number of processors in business.

Based on this framework, we can now compare the PM with the HS conjecture. Both represent extremes settings of spatial competition. While the firm under PM internalizes the decision of the competitor to maximize overall profit, the HS firm aims to benefit from outbidding the competitor. Hence, PM represents cooperative and HS non-cooperative competitive behaviour.

2.2. Price-matching (PM) conjecture

Since firms assume that every price change will be answered by an equal adjustment of the competitor's price, the rational choice is to maximize the cumulative profit over the whole market. Consequently, both firms set the same ud price. Assuming that input suppliers have no preference for distance, we can assume that they choose a processor with equal probability. This is called the random tie breaking rule (RTBR) (Iozzi, 2004). Accordingly, the market profit with PM processors is:

$$\Pi_{PM} = u^y \int_0^d (p - u - tr)dr = \frac{1}{2} u^y d(2p - 2u - dt) \cdot \qquad (7)$$

At all locations *A* and *B* share supply equally. Therefore, $\Pi_A = \Pi_B = ½\, \Pi_{PM}$. Because of the existence of marketing cooperatives, processors have to serve the whole market area ($R = d$). Processors' optimal price u_{PM}^{opt} is derived by the differentiation of equation 7 with respect to *u*:

$$u_{PM}^{opt} = \frac{y(2p - td)}{2(1 + y)} \qquad (8)$$

Not surprisingly, the result for the cooperative PM conjecture is the price of a monopsony with exogenous market radius (compare with equation 3 in the case of $R = d$).

2.3. Hotelling-Smithies (HS) conjecture

Iozzi (2004) shows, that under the RTBR a price equilibrium in pure strategies exists. Basically, the firm may capture a location with the highest price or share the location if the prices are equal. The processor operating under this framework faces three options: setting a higher (+), a lower (–) or the same price (=) as the rival. If the competitor's price is *u'*, the processor's profit is given by

$$\Pi_{HS}^{(+)}(u,u') = u^y \int_0^d (p - u - tr)dr \qquad \text{if } u > u', \qquad (9a)$$

$$\Pi_{HS}^{(=)}(u,u') = \frac{1}{2} u^y \int_0^d (p - u - tr)dr \qquad \text{if } u = u', \text{ or} \qquad (9b)$$

$$\Pi_{HS}^{(-)}(u,u') = 0 \qquad \text{if } u < u'. \qquad (9c)$$

Given the presence of marketing cooperatives and $R = d$, the processor with a lower price will not be able to capture any location. This is in contrast to standard udp competition models (Beckmann, 1973; Schuler and Hobbs, 1982; Zhang and Sexton, 2001). Since these models assume exclusively positive local profits inside a firm's market radius, a residual market may exist. For example, if B's price is sufficiently high and B is free to choose R (see equation 4), all locations r in $[0, 1 - R_B]$ will not be served by B. Consequently, it can be profitable for firm A to use a low (monopsonistic) ud price in this (proximate) region and $\Pi^{(-)}{}_A > 0$ if $u < u'$. However, in our model including marketing cooperatives we may observe negative local profits if u is sufficient high (see Figure 1).[7] Therefore, distant locations can lower the overall profit of the processor. Given this, profits under $u > u'$ (equation 9a) are always higher than under $u = u'$ (equation 9a) and $u < u'$ (equation 9a), unless all alternatives yield zero profits. Hence, a price equilibrium exists. Solving the zero profit condition

$$\Pi_{HS} = u^{y} \int_{0}^{d} (p - u - tr) dr = 0 \tag{10}$$

leads to

$$u_{HS}^{opt} = \frac{1}{2}(2p - td)\cdot \tag{11}$$

According to equation (10) at u_{HS}^{opt} both firms earn zero profits. Particularly, A (B) yields positive (negative) profits at all locations r in $[0, d/2]$ and negative (positive) profits for $r=[d/2, d]$.

Comparing these results with the case of PM conjecture, we notice that the ud-price is higher and profits are lower under HS.[8] Optimal prices, profits and comparative statics are compared in Table 1. Regarding the spatially related variables t and d we follow Alvarez *et al*. (2000) by defining $td = s$ to measure the absolute importance of space. As shown in Table 1 the effect of s on the ud-price is negative for HS and PM-conduct. However, if space becomes more important the optimal price will decrease less under HS than under PM.

Additionally, the optimal ud price under HS-competition (equation 11) is independent of the price elasticity of supply and the price transmission is always ($\partial u/\partial p = 1.0$). Perfect price transmission is an indicator that HS competition corresponds to non-cooperative behaviour.[9] Under PM conduct the price and price transmission depend on y. Since $s \leq 2$ under spatial competition, both relations are positive. The dependency between price transmission and y is illustrated in Figure 2. Given a quota system, the supply elasticity for raw milk can be assumed to be inelastic. In this case, the price transmission under PM conjecture is less than 0.5. Both firms set prices believing that the competitor will set the same ud price. The competitive conduct is cooperative. In this way, firms can (more efficiently) exploit their local market power by means of both lower prices and lower price transmission.

3. Empirical model

To test empirically whether price transmission in the German raw milk market is consistent with PM ($\partial u/\partial p \leq 1.0$) or HS ($\partial u/\partial p = 1.0$) conjecture we utilize a vector error correction model (VECM) (Saghaian, 2007; Rojas *et al.*, 2008; Kirchgässner and Kübler, 1992; Chavas and Mehta, 2004).

$$\Delta P_t = \sum_{i=1}^{p-1} \Gamma_i \Delta P_{t-i} + \Pi\, P_{t-1} + \varepsilon_t \tag{12}$$

where ΔP_t is a (2×1) vector of the first differences of the producer price (price of raw milk; u_t) and the wholesale price (price of processed milk; p_t); Γ is a (2×2) matrix of coefficients representing short-run relationships between variables; Π is a (2×2) matrix of long-run and speed of adjustment coefficients; P_{t-1} is a (r×1) vector of the cointegrating relation, with r being the number of cointegrating relations; and ε_t is a white noise process. Matrix Π can be decomposed into two matrices α and β, where $\Pi = \alpha\beta'$. Matrix α characterizes the speed of adjustment, i.e. the coefficient shows how fast the variables move back to the long-run relationship after a shock or a change of the equilibrium. Matrix β is labelled cointegrating coefficient and represents the long-run relationship (Lütkepohl, 2005; Hamilton, 1994). Hence, a VECM is a first-differenced vector autoregressive (VAR) model incorporating cointegration. As such, it accounts for interdependences between producer and wholesale prices upstream and downstream. In addition, the model analyses the long-run relationship as well as the short-term dynamics between both prices.

Prior to estimating the VECM some tests have to be carried out. First, all prices are tested for stationarity and their integration order using an augmented Dickey-Fuller (1979) test:

$$y_t = \delta + \rho y_{t-1} + \zeta_1 \Delta y_{t-1} + \zeta_2 \Delta y_{t-2} + ... + \zeta_{t-s} \Delta y_{t-l} + \varepsilon_t \text{ with } \rho = 1 - \delta, \quad (13)$$

Where y_t is a price series and δ, ρ, ζ_1, … ζ_{t-s}, are coefficients to be estimated. The null hypothesis is nonstationarity (H_0: $\rho = 0$). The alternative hypothesis H_1 is $\rho < 0$. The number of lagged differences *s* is derived based on the Akaike information criterion.

Second, Johansen's (1988, 1991; Johansen and Juselius, 1990) test on cointegration is carried out to test whether there exists a long-run relationship and to derive the number of cointegrating relations (Granger, 1981; Engle and Granger, 1987). We carry out two likelihood ratio (LR) tests: the trace statistic and the maximum-eigenvalue statistic. The trace statistic is defined as:

$$LR(r_0, k) = -T \sum_{i=r_0+1}^{k} ln(1 - \lambda_1) \quad (14)$$

Where r_o is the assumed number of cointegrating relations (r = 0, 1, …, k-1), k is the number of endogenous variables, λ is the *i*-th largest eigenvalue of the Π matrix and T is the number of time periods. At the most there are k-1 cointegrating vectors. The null hypothesis is H_0: $rk(\Pi) = r_0$, i.e. the cointegrating rank rk is r_0 (H_1: $r_0 < rk(\Pi) \leq k$). The maximum-eigenvalue statistic is:

$$LR(r_0, r_0 + 1) = -T\ ln(1 - \lambda_{r_0+1}) \quad (15)$$

The null hypothesis is H_0: $rk(\Pi) = r_0$ versus H_1: $rk(\Pi) = r_0 + 1$. For both statistics we test the null hypothesis of no cointegration (H_0: $rk(\Pi) = 0$) as well as the null hypothesis of one cointegrating relation (H_0: $rk(\Pi) = 1$). Cointegration between two variables can only exist if the variables have the same order of integration.

Third, causality between variables is determined using a Granger (1969, 1988) causality test. We test for both, if *p* Granger causes *u* and vice versa. To test whether *p* causes *u* we estimate a regression with *u* as dependent variable and lagged *u* as well as lagged *p* as independent variables:

$$u_t = \eta_0 + \sum_{i=1}^{n} \eta_i u_{t-i} + \sum_{j=1}^{m} \gamma_j p_{t-j} + \varepsilon_t \quad (16)$$

The null hypothesis is given by $\gamma_1 = \gamma_2 = ... = \gamma_m = 0$ (H_1: $\gamma_j \neq 0$ for at least one $j \leq m$). If the null hypothesis is rejected, i.e. *p* gives additional explanatory power for *u*, *p* Granger causes *u*. The same but reversed regression is utilized to test whether *u* causes *p*.

4. Data

To estimate the VECM monthly price data for raw milk at the producer level and for dairy products at wholesale level are utilized. The data are collected for Germany from January 1997 to December 2006. The producer price for raw milk is in Cent per kilogram and compiled by ZMP (1998-2007). The wholesale price is the weighted average wholesale price of fresh milk, cheese, butter and milk powder in Cent per kilogram (based on data from ZMP, 1998-2007) taking into account the quantity of raw milk contained in each kilogram of the product.

Descriptive statistics for both prices are provided in Table 2. The mean producer price is 28.77 Cent per kilogram and fluctuates between 26.23 and 34.79 Cent per kilogram. The mean wholesale price is 41.26 Cent per kilogram and ranges from 37.54 to 46.84 Cent per kilogram. Standard deviations between prices are not significantly different.

5. Empirical results

Based on visual inspection and analysis of the data (Hamilton, 1994, p. 501 et seq.) we carry out an ADF test including a constant and no time trend. The Akaike information criterion (AIC) is used to determine the appropriate lag-length. For both price series at the level the null hypothesis of a unit root is not rejected at the 10% significance level, but rejected at the 1% significance level for the first difference (Table 3). Therefore, all producer and wholesale prices are integrated of order one.[10]

To determine the number of lags in the VECM we use two lag length criteria, Akaike information criterion (AIC) and the final prediction error (FPE). Several VAR models with different lag lengths – from zero to twelve lags – are estimated and analyzed regarding their AIC and FPE values. The model with the lowest AIC respectively FPE has the optimal lag length for a VAR (Yang *et al*., 2006; Holtemöller, 2004; Brüggemann, 2006). For a VECM, the optimal lag length is the chosen lag length of a VAR model minus one lag (Lütkepohl, 2007). The AIC and FPE results report four lags for Germany as optimal choice for a VAR model. Therefore, we use three lags for the VECM.

Table 4 shows the results of the Johansen's cointegration test. The precondition for cointegration that both variables have the same order of integration is fulfilled. Each cointegration equation includes an intercept and the price variables. The null hypothesis of no cointegrating equation is rejected at the 5% significance level based on both, the trace and the maximum-eigenvalue statistics. In both cases, we failed to reject the null hypothesis of one cointegrating equation. Therefore, the results indicate that there is one cointegrating relation, i.e. a long-run relationship between the producer price and the wholesale price exists.

Results of the Granger causality test are described in Table 5. They confirm a bidirectional relationship between producer and wholesale price, i.e. the causality relationship goes downstream and upstream.

Based on all test results we estimate a VECM with three lags:

$$\Delta P_t = \sum_{i=1}^{3} \Gamma_i \Delta P_{t-i} + \Pi P_{t-1} + \varepsilon_t \tag{17}$$

Estimated coefficients of the cointegrating equation and their t-statistics are represented in Table 6. The alpha coefficient is significant at the 1% level for the producer price. The speed of adjustment coefficient for the wholesale price is not statistically significant. The beta coefficients are significant at the 1% level. Hence, there is a long-run relationship between the producer and wholesale price.

Table 7 presents the estimates of the VECM. The results show the long-run relationship and the short-run dynamics. As the long-run relationship is already explained above we analyze now the short-run dynamics.

As we can see the VECM clearly shows the upstream and downstream relationship. The second column Δu_t represents the transmission from downstream prices (= wholesale price) to upstream prices (= producer price). The third column Δp_t demonstrate the converse relationship, i.e. the influence of upstream prices on downstream prices. The short-run dynamics for each dependent variable Δu_t and Δp_t include three periods. Therefore three lagged variables of the producer price as well as the wholesale price are used as independent variables.

To analyze empirically if price transmission is in line with PM or HS competition we investigate the impact of the lagged wholesale price on the current producer price. All three lagged wholesale prices are positive and statistically significant at least at the 5% level. Adding up price transmission over all three periods we get a quite low value of 0.312. Hence, a change of the wholesale price of one Cent per kilogram will result in a change of the producer price of 0.312 Cents per kilogram. This value is within the interval of 0.0 and 0.5 as predicted by the PM model. Additionally, we carry out a Wald test with the null hypothesis that the added lagged wholesale prices are equal to one (H_0: $\Delta p_{t-1} + \Delta p_{t-2} + \Delta p_{t-3} = 1$ and H_1: $\Delta p_{t-1} + \Delta p_{t-2} + \Delta p_{t-3} \neq 1$; H_0 implies Hotelling-Smithies competition). The null hypothesis is rejected at the 1% significance level. Hence, upstream price transmission in the German milk market is far away from being perfect and supports the existence of PM competition and collusion.

Downstream price transmission from the producer price to the wholesale price is only significant for the second lagged producer price. Added up price transmission over all three periods is 0.545.

6. Conclusion

While agricultural production is highly scattered, food processing becomes more and more concentrated. Moreover, agricultural products suffer from high transportation costs compared to their product value. Therefore, farmers easily face market power from input buyers. As a counter strategy, farmers often horizontally cooperate via marketing cooperatives. In Germany, such cooperatives are frequently established by milk producers and they hold a significant share of overall raw milk production. Another characteristic of agricultural markets in general, and for the raw milk market in particular, is uniform delivered pricing (udp), i.e. input buyers absorbing transportation cost. Alvarez *et al*. (2000) developed a spatial duopsony model with ud pricing and showed that price-matching (PM) behaviour of processors matches up with the real world observation of overlapping, and hence inefficient, markets in milk procurement. In this paper we demonstrate that given the existence of marketing cooperatives, one may also observe overlapping market areas under the contrary Hotelling-Smithies (HS) assumption. Technically, this means that price equilibrium in pure strategies exists. However, while PM is in line with cooperative behaviour among food processing firms, HS competition represents non-cooperation, i.e., under HS there is fierce price competition. This is supported by our theoretical finding that price transmission is perfect under HS, but imperfect under PM.

In addition, our spatial competition model incorporates a more flexible input supply function than usually utilized in spatial models. An interesting result derived from this feature is that price transmission under PM competition rises with increasing supply elasticity. This finding is of particular interest in regard to the process of abolishing the quota system in the EU. Since we can expect that the abolition will increase supply elasticity at the farm level, this may increase price transmission and may have a positive impact on producer prices.

Empirically, we test whether price transmission between milk processors and producers in Germany is in line with PM or HS competition. Based on a vector error correction model we find a price transmission of 0.31. This strongly points to PM conduct and cooperative behaviour between processors. Hence, our results support the PM assumption in Alvarez *et al*. (2000). However, additionally we provide an explanation why firms may compete according to this conjecture. In the presence of marketing cooperatives, HS implies lower profits than PM competition. If both firms behave according to PM, this results in a Pareto optimal outcome. Nevertheless, HS is a dominant strategy in the static game. Hence, a static Nash equilibrium exists where both firms assume HS. However, our empirical results suggest that milk processors are able to overcome this prisoner's dilemma. One intuitive explanation could be that price interactions among dairies can be interpreted as supergames. According to Friedmann (1971), the equilibrium of such a game is non-cooperative and Pareto optimal.

Our empirical result is also in line with a low, but not zero, individual milk supply elasticity as expected under the presence of a quota system. In fact, under a quota system milk supply is not fixed at the individual farm level, but the costs of expansion at the individual level increase by the need to acquire extra quota. For our theoretical duopsony model, a price transmission of 0.31 corresponds to a milk supply elasticity of 0.45 (with $\partial u/\partial p = y/(y+1)$. This seems to be in line with further studies: for example, Colman *et al*. (2005) apply different regression techniques to data of specialized milk producing farms in two regions of the U.K. between 1991 and 1995, a time during which the milk marketing quota of the U.K. was almost constant. With one exception all their estimates are in a range from 0.27 to 0.63 depending on the estimation technique. Bouamra-Mechemache *et al*. (2008) utilize Theil–Goldberger mixed estimation method and time series data for EU member states. They derive medium supply elasticities for the EU-15 countries between 0.3 and 0.5. Komaki and Penzer (2005) estimate price elasticities under a quota system for two different regions in Japan of 0.12 and 0.24.

Endnotes:

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[1] A comprehensive discussion regarding the introduction of space in neoclassical theory is e.g. Eaton and Lipsey (1977).

[2] Prior to Gronberg and Meyer (1981), Capozza and Van Order (1978) identified three different conjectures under the fob (free on board) regime: HS, L and Greenhut-Ohta (GH). Under GH competition, each firm assumes that the price at the market border is fixed. This leads to an increasing (decreasing) own price if the rival decreases (increases) its price. ($\theta_{GO} = -1$). However, this is not applicable under udp since prices have to be equal at each point of the market to be equal at the market border. Thus, it is not feasible to keep the price at the market border constant if one firm increases and the other firm decreases its ud price.

[3] In fact, Avarez et al. (2000) name their assumed conjecture Löschian competition, but their model makes clear that it is the same as PM in our terminology which follows Gronberg and Meyer (1981).

[4] With P being constant, we implicitly assume perfect competition in the final good market, which is the common assumption for a spatial oligopsony (Löfgren, 1986; Alvarez *et al.*, 2000; Zhang and Sexton, 2001).

[5] Data are published online at http://www.statistik.sachsen.de, www.lfl.bayern.de, http://www.bayern-meg.de, and http://www.interessengemeinschaft-ige-sachsen.de/.

[6] To justify the no rationing assumption Dixon (1990) introduced costs of turning down customers in terms of loss of goodwill, reputation or offence caused. The author's conclusion is that firms are willing to meet demand in excess of their profit-maximizing supply to avoid these costs. Baye and Morgan (2002) argue that many price setting oligopoly environments have the feature to award the whole production on a winner-take-all basis. In this case again firms need to deviate from the profit-maximizing supply since rationing is not feasible. Iozzi (2004) states that firms may be also prevented from rationing by regulatory requirements to satisfy all the demand (e.g. electricity markets in the UK or car insurance in Germany). The existence of marketing cooperatives with members distributed across land is a further argument in favor of the no rationing assumption.

[7] A major characteristic of udp is cross-subsidization of distant suppliers by customers which are close to the processor. The possibility of negative local profits is just an extension of this feature.

[8] This is true over the economic reasonable range of $0 \leq td/p \leq 2$ where spatial competition occurs. If $td/p \geq 2$, we have to consider spatial monopsonies instead of competition because $2R \leq d$ (with R defined by equation 4). Moreover, the assumption of $R = d$ would yield neither positive profits nor positive prices if $td/p \geq 2$.

[9] If markets are perfectly competitive or in the case of fierce price competition (e.g. under the classical Bertrand competition) we find the same result regarding price transmission as under the described HS scenario.

[10] For comparison and completeness we also carried out an ADF test for all other options (no constant and no time trend; constant and time trend) The results are equal to the case presented here (a constant only) except for the case of no constant and no time trend where the null hypothesis of a unit root for the producer price at level is not rejected at the 5% significance level.

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Table 1: Summary of the theoretical findings regarding Hotelling-Smithies (HS) and Price-Matching (PM) behavior

	HS	PM
u^{opt}	$\frac{1}{2}(2p-s)$	$\frac{y(2p-s)}{2(1+y)}$
$\Pi(u^{opt})$	0	> 0
$\partial u / \partial p$	1	$y/(y+1)$
$\partial u / \partial y$	0	$\frac{2p-s}{2(1+y)^2}$
$\partial u / \partial s$	-1/2	$-\frac{y}{2(y+1)}$

Table 2: Descriptive Statistics of Producer and Wholesale Prices

	Producer Price	Wholesale price
Mean	28.77	41.26
Median	28.44	40.87
Maximum	34.79	46.84
Minimum	26.23	37.54
Std. Dev.	1.83	1.82
Observations	120	120

Table 3: Augmented Dickey-Fuller (ADF) Test Results (with constant)

	u_t	p_t
	Test results for variable in levels	
ADF t-statistic	-1.90	-1.65
p-value	0.33	0.46
	Test results for first-differenced variable	
ADF t-statistic	-4.83	-9.95
p-value	0.00	0.00

Table 4: Johansen's Cointegration Test Results

Null hypothesis	Eigenvalue	Trace statistics	Max-Eigenvalue Statistic
r = 0	0.14	21.89*	16.97*
r ≤ 1	0.04	4.93	4.93

* Significant at the 5% level. Critical values: 20.26 and 9.17 at the 5% level for the trace test; 15.89 and 9.17 at the 5% level for the maximum eigenvalue test.

Table 5: Granger Causality Test Results (with three lags)

Null hypothesis	F-Statistic
Producer price does not Granger cause wholesale price	4.59*
Wholesale price does not Granger cause producer price	4.86*

* Significant at the 1% level.

Table 6: Estimated Speed of Adjustment Coefficients (α's) and Cointegrating Coefficients (β's)

Independent Variable	u_t	p_t
Alpha	0.0070	0.0055
	(4.1370)	(1.1401)
Beta	1.00†	-6.8537
	(---)	(-4.5294)

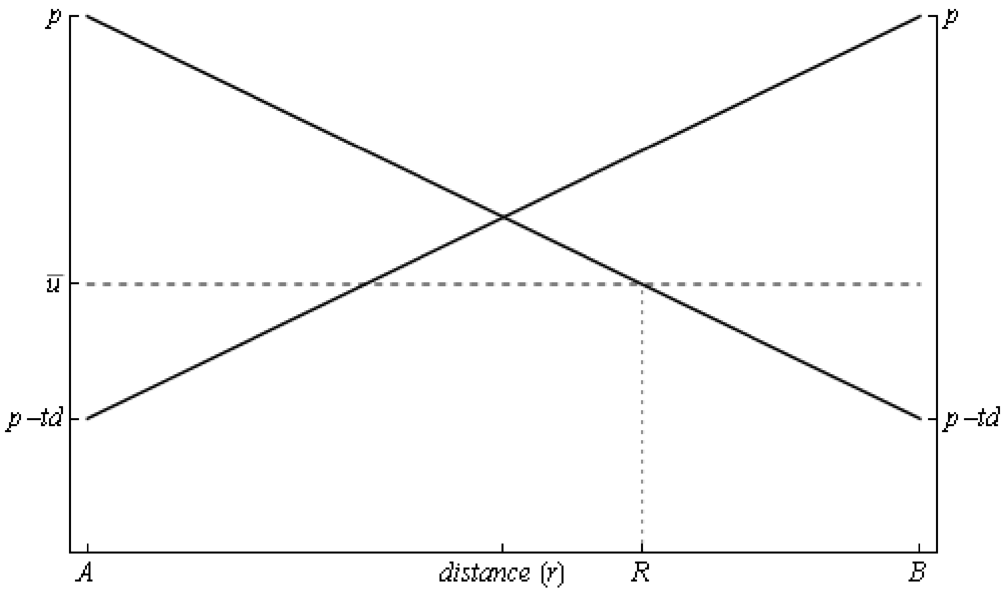
T-statistics are in brackets.
†The cointegrating equation is normalized by setting the cointegrating coefficient β of the producer price equal to one.

Table 7: Estimates of the VECM (dependent variables are Δu_t and Δp_t, t-statistic in brackets)

	Δu_t	Δp_t
P_{t-1}	0.0070***	0.0055
	(4.1370)	(1.1401)
Δu_{t-1}	0.461***	0.323
	(4.826)	(1.180)
Δu_{t-2}	0.004	0.614**
	(0.039)	(2.067)
Δu_{t-3}	-0.165*	-0.392
	(-1.861)	(-1.547)
Δp_{t-1}	0.114***	0.011
	(3.206)	(0.110)
Δp_{t-2}	0.118***	-0.065
	(3.361)	(-0.646)
Δp_{t-3}	0.080**	0.052
	(2.204)	(0.507)

* Significant at the 10% level. ** Significant at the 5% level. *** Significant at the 1% level.

Figure 1: A spatial duopsony line market



Notes: Firm *A* (*B*) is located at $r = 0$ ($r = d$). The distance between *A* and *B* is $d = 1$. The solid black lines (downward sloped from the processors location) highlight the price *u* where local profits are zero ($p\text{-}u\text{-}tr = 0$). If say A sets $\bar{u}$, the local profits are positive for all *r* in [0, *R*] and negative for r=[*R*, *d*]. Hence, for all prices u=[0, p/2] there is a market profit $\Pi(u) \geq 0$.

Figure 2: Price transmission depending on the price elasticity of supply *y*