Spatial Competition in Milk Processing Industry

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Summary.

A model of uniform spatial pricing with Löschian conduct as developeded by Alvarez et al. is tested for the milk processing industry in Germany. Results confirm some oligopsony power in this spatial markets and a low pass-through of a retail price change to the farm.

Keywords: spatial competition, ologopsony, milk processing

1. Introduction

Rising concentration in food processing industries is evident in most countries. This might imply market power of processors as a seller of food products and/or as a buyer of agricultural raw products. While geographical markets for finished products are often relatively large, markets of some agricultural products are limited to a small geographical area because of high transportation costs. A good example might be raw milk which is usually not transported over long distances. Hence, concentration in milk processing might be a more serious problem for farmers than it might be for consumers.

The aim of the paper is to answer the question whether milk processors are able to exert market power in a spatial market setting. We provide empirical results for two very different regions in Germany (Bavaria, Former Eastern Germany) and Germany as a whole. In Bavaria milk production is a very important source of farm revenues, though milk production units are quite small (around 30 cows per farm on average) and the density of milk processors is still high (average distance between processors is 28 kilomtres). In Former Eastern Germany milk production is less important, the average milk production unit has about 140 cows, and the average distance between milk processors ist about 55 kilomtres.

In the theoretical part in section 2 we repeat a duoply spatial competition model as developed by Alvarez et al (2000). However, we illustrate their model graphically and derive more intutive geometric areas of firms profits. In the empirical model in section 3, like in Alvarez et al. (2000), we estimate a reduced form model where the price paid to farmers is explained by distance, transportation costs, the price of milk at the consumer level and the number of relevant rivals. Section 4 represents the estimation results.

2. Graphical description of the Alvarez et al. model

Alvarez et al. (2000) employ a spatial competition model with two processors, located in a fixed distance d on a linear, unbounded line. Processors have identical constant processing costs c (not including the raw material milk), and they get the same price p for processed milk. Thus, $\rho = p\text{-}c$ is their gross margin.

The two processors compete for the raw products produced by a continuum of farmers distributed along the line. Farmers supply curve $x^s(u)$ is linear in price u:

$$(1)\quad x^s(u)=u$$

The pricing scheme employed is UDP, i.e. the processors bear shipping costs. Shipping costs are linear in distance and quantity; $t*r$ are the costs to transport one unit of raw material r miles. Thus, given ρ, t and u and neglecting competition, each processor chooses a market area as large as possible - without generating negative net margin, i.e.[1]:

$$(2)\quad \check{r}\,(u)=(\rho\text{-}u)/t$$

Due to competition a processor might not obtain the total supply within this market area. Assuming that processors set the same purchaser price *u* and their market areas overlap, they share the supplied quantity 50:50 (in the overlapping region).

To derive the equilibrium, an assumption has to be made about price reactions or market boundary reaction. Alvarez et al. (2000) assume Lösch competition, i.e. if one processor changes his UDP *u*, the competitor will react 1:1. With Lösch competition changes in own market area translate into synchronous changes in the market area of the competitor.

Due to the fact, that both processors have to set the same price in equilibrium, there are three cases of an equilibrium:

- Local monopoly
- Plain overlapping of market areas in-between locations
- Spacious overlapping of market areas beyond competitors locations

Figure 1- 3 depict the three cases; *A* and *B* mark the two processors locations and R^*_i the particular market boundary, $i = A, B$:

While Alvarez et al. use integrals to describe processors profits for the three different cases, we provide more intuitive formulas. In the case of local monopoly profit is given by

$$\begin{aligned} &\Pi_{\text{local monopoly}}(u) = 2 * \left(\rho - u - \frac{1}{2} * t * r\right) * u * r, \quad \text{with} \quad r = \frac{\rho - u}{t} \quad \text{one gets:} \\ (3) \quad &\Pi_{\text{local monopoly}}(u) = 2 * \left(\rho - u - \frac{1}{2} * t * \frac{\rho - u}{t}\right) * u * \frac{\rho - u}{t} = \frac{1}{t}(\rho - u)^2 * u \end{aligned}$$

Figure 4 depicts the processors' situation in the case of a local monopoly in two dimensions.[2] Profits are given by the gross margin ($\rho = p - c$) minus purchaser price u minus transportation cost (1/2*t*r where ½*t is the average transportation cost). This unit net profit is multiplies by the supply of a single farmer u times the number of farmers in the processors market r. In addition we have to multiply it by 2 because of the symmetric nature of the model (processor picks up milk to his left and right)

In both cases of overlapping markets – meagre or spacious – three zones have to be considered, i.e. there are three summands within the profit formula. For meagre overlapping, the zones can be described as follows:

- There is no competition in one's backyard:

$$\Pi_1(u) = 1 * \left(\rho - u - t * \frac{r}{2} \right) * u * (r) \tag{4.a}$$

- Between locations there is an area without competition - it is placed next to the own location:

$$\Pi_2(u) = 1 * \left(\rho - u - t * \frac{d-r}{2} \right) * u * (d - r) \tag{4.b}$$

(*d-r*) is the width of this area and *½*(d-r)*t* are the average shipping costs within this region.

- And last but not least, there is an area adjoined to the latter one. It is where the market areas overlap:

$$\Pi_3(u) = \frac{1}{2} * \left(\rho - u - t * \frac{d}{2} \right) * u * (2 * r - d) \tag{4.c}$$

This time the width is *2*r-d (=r-(d-r))* and the average transportations costs are the transportation costs for the center of this region, i.e. at *d/2*. That is because the area spreads symmetrical around *d/2* with a radius of *r-d/2*.To get the whole profit all three summands have to be added up.

For the case of an overlapping of market areas beyond competitors' locations profit again consists of three summands:

- First of all, there is no competition in the remote part of the backyard.

(5.a) $$\Pi_1(u) = 1*\left(\rho - u - t*\frac{2*r-d}{2}\right)*u*(d)$$

The width is *d*, and the center ½*(*2*r-d*).

- Second, there is competition in the part of the backyard next to one's own locations.

(5.b) $$\Pi_2(u) = \left(\frac{1}{2}\right)*\left(\rho - u - t*\frac{r-d}{2}\right)*u*(r-d)$$

Here, width is *r-d*, and the center lies at ½*(*r-d*).

- In-between locations, 'competition land' continues to exist all over the place. Thus, the own market share is ½. 'Competition land' comes to an end at distance *r*, i.e. beyond competitors' location.

(5.c) $$\Pi_3(u) = \left(\frac{1}{2}\right)*\left(\rho - u - t*\frac{r}{2}\right)*u*(r)$$

Again, to get the whole profit all three summands have to be added up.

For each case described above, the equilibrium price is the one maximizing the total profit. It is calculated by differentiating *Π* with respect to *u*; at *u** the partial derivative diminishes and the second order condition is fulfilled, too.[3]

The equilibrium milk price, deduced from profit maximization, is given by:

(6) $$u^* = \begin{cases} \dfrac{\rho}{3}, & \text{for } \dfrac{t*d}{\rho} \geq \dfrac{4}{3} \\ \dfrac{\rho}{2} - \dfrac{t*d}{8}, & \text{for } \dfrac{4}{3} \geq \dfrac{t*d}{\rho} \geq \dfrac{4}{7} \\ \dfrac{4*\rho - \sqrt{4*\rho^2 - 6*t^2*d^2}}{6}, & \text{for } \dfrac{4}{7} \geq \dfrac{t*d}{\rho} \geq 0 \end{cases}$$

Its essential features are:

- If the distance is small[4], competition beyond locations emerges. Only 1/5 to 1/3 of the changes in the retail price p, expressed by changes in the gross margin ρ, will be transmitted to the purchaser price.
- In case of a medium distance – competition in-between locations[5] – price transmission is 50 %. And finally, in local monopoly price transmission again decreases to 1/3. All together, price transmission stays far below 100 % or 1, respectively.
- The equilibrium purchaser price schedule – expressed as a function of t^*d – looks like the one shown in 7.

Due to the formulas and chart 10 the essential findings from theory are:

- Price transmission $\in$ [1/5; ½]
- Before reaching the local monopoly, the milk price schedule looks like a upside down hyperbole[6]. This can be re-interpreted as: the milk price is a increasing function of t^*d and a decreasing function of $(d^*t)^2$.

These findings are to be tested with data for the German milk processing industry.

3. Empirical Model

Based on the theoretical model a reduced form model of the following form is estimated:

$$(6)\ \mathrm{u}_{\mathrm{i,j,k}} = \alpha_{\mathrm{i}} + \lambda_{\mathrm{j}} + \gamma_{\mathrm{k}} + \beta_1 \mathrm{S}_{\mathrm{i,j,k}} + \beta_2 \mathrm{S}^2_{\mathrm{i,j,k}} + \beta_3 \mathrm{P}_{\mathrm{j,k}} + \beta_4 \mathrm{N}_{\mathrm{i,j,k}} + \mathrm{e}_{\mathrm{i,j,k}}\,.$$

The price per litre paid to farmers $u_{i,j,k}$ by each firm i in each month j, in each year k is explained by $S_{i,j,k}$, $S^2_{i,j,k}$, $P_{,j,k}$, $N_{i,j,k}$, and three sets of dummies, where α_i accounts for firm level fixed effects (i = 1, …, 183 for whole Germany), λ_j for monthly differences (j = 1,…, 11) and γ_k for yearly differences (k = 1, … ,3). $S_{i,j,k} = D_{i,j,k}{*}F_{j,k}$ is the empirical counterpart of $s = t^*d$

and is calculated in the following way. $D_{i,j,k}$ is constructed as the sum of distances from firm i to its nearest rivals such that the combined volume of the rivals at least equalled the volume of firm i. We utilised price per litre $F_{j,k}$ of diesel fuel to approximate shipping costs t. Since price changes with s as depicted in Figure 4 β_1 is expected to have a positive sign while β_2 is expected to have a negative sign. $P_{j,k}$, is the empirical counterpart of p. Since we lacked data on wholesale prices received by processors, $P_{j,k}$, represents the national average price per litre for bottled milk. Similar to Alvarez et al. we include $N_{i,j,k}$, the number of rivals whose combined volume equals at least the volume of firm $_i$.

Data consisted of monthly observations of prices paid to farmers and milk quantities shipped to 183 milk processors (about 97% of all milk processors) between 1999 and 2003 as gatherd by the Zentrale Preis- und Marktberichtsstelle (ZMP).

We run regressions for all processors in Germany as well as separately for two distinct areas. Bavaria is a very dense though small structured milk producing area. On average there are about 20 cows per hectare. Also milk processing is small structured with an average distance between milk processors of 28 kilometres. In contrast to Bavaria in former Eastern Germany milk production is less important (8 cows per hectare), but and milk processing firms are more widespread (55 kilometres). The average milk quantity a truck collects per stop is 414 litres in Bavaria and 2580 litre in former Eastern Germany.

Table 1 presents statistical information for the data used for whole Germany.

4. Results

Regression (6) is carried out using fixed effects unweighted. OLS and weighted GLS estimation procedures in Eviews 3.1. The results for Bavaria, Eastern Germany and whole Germany are illustrated in Table 2 - 4. The results are similar for all three regions. S, S2, and P have the expected signs. However S^2 is much larger for Bavaria. The parameter of P is about 0.38 implying imperfect price transmission between the consumer price and the price for raw milk. Only 38 % of changes of the consumer price are forwarded to farmers.

For all three regressions coefficient connected to N (the number of competitors used to calculate d) has an unexpected sign. Intuition suggests an increase in u caused by a growing number of competitors.

Looking at the dummies for January till November, milk price is above average from October till March and below average from April till September. A big milk supply during summer time-feeding and a small milk supply during winter time-feeding is likely to cause the seasonal changes.

Dummies for the years 2001 and 2002 indicate, that the years both presented above average-milk prices. Most likely, they are the result of increased consumer demand due to BSE-crisis.

References

Alvarez, A. M. ; Fidalgo, E. G ; Sexton. R. J. ; Zhang, M. (2000): Oligopsony power with uniform spatial pricing: theory and application to milk processing in Spain, European Review of Agricultural Economics, 27(3); 347 – 364

Footnotes

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[1] At the boundary $\check{r}$ the net margin diminishes, i.e. $0=\rho - u - t * \check{r}$. The interpretation of the expression $\rho - u - t * \check{r}$ is: *gross margin – purchaser price – shipping costs*.

[2] 3-dimensional illustrations are provided in the Appendix.

[3] The partial derivative is of order two. Thus, there are two candidates for maximizing □, but only one of them fulfills the second order condition (second derivative negative).

[4] The lower line of the formula is the relevant one.

[5] The middle line of the formula has to be examined.

[6] A downward open hyperbole.

Appendix:

Three-dimensional figure of local monopoly:

At the x-axis, we see the distance *d* between the locations of the two milk processors. The y-axis is applied for all cost elements, as there are the milk price *u* and the shipping costs, and last but not least, the z-axis measures the milk quantity per spatial unit. All together, we quantify: *milk quantity per spatial unit* , *market area* and *net margin*

The volume of the "wedge" is identical to profit. The product of the first factors measures the total quantity processed by a firm. Net margin is generated as difference of gross margin and total costs; latter are milk price *u* plus shipping costs.

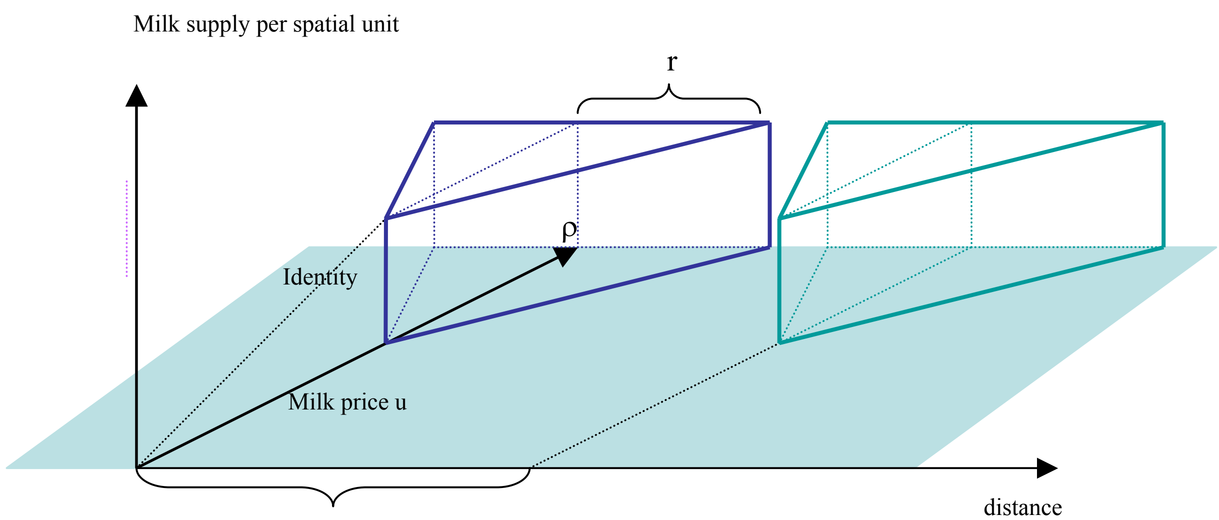


Chart 1: 3-dim. figure of local monopoly

Three-dimensional figure of <u>‘overlapping in-between locations’</u>:

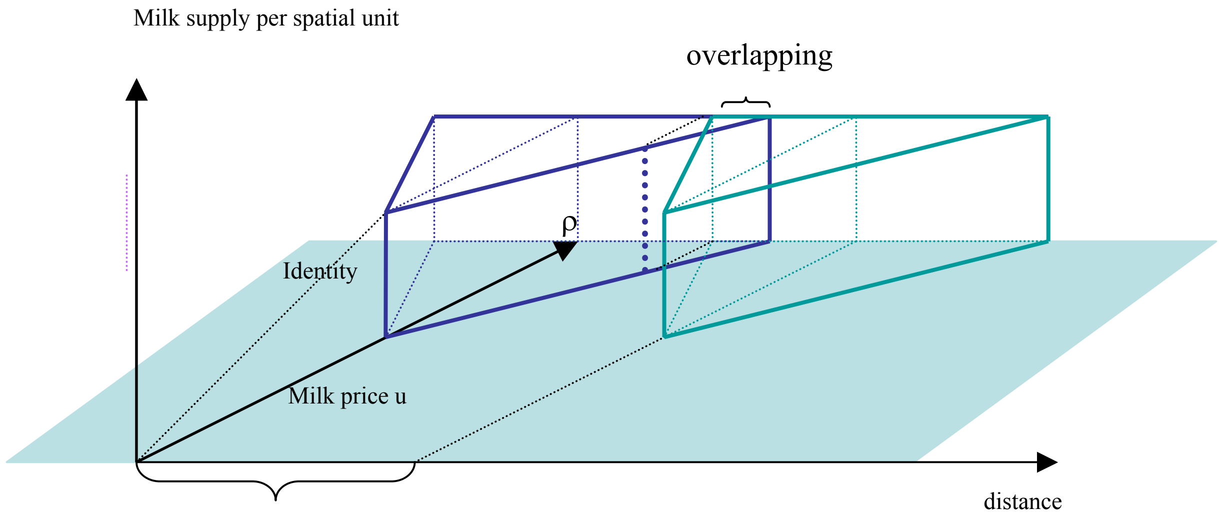
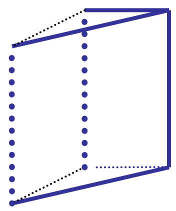
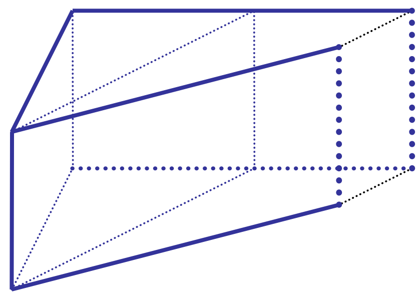


Chart 2: 3-dim. fugure of ‚overlapping in-between locations’

The volume, which the LHS processor has to share 1:1 with the RHS processor, looks like this:



and the volume, he keeps totally for his own, looks like:



Three-dimensional figure of <u>‘overlapping beyond competitors’ locations’</u>:

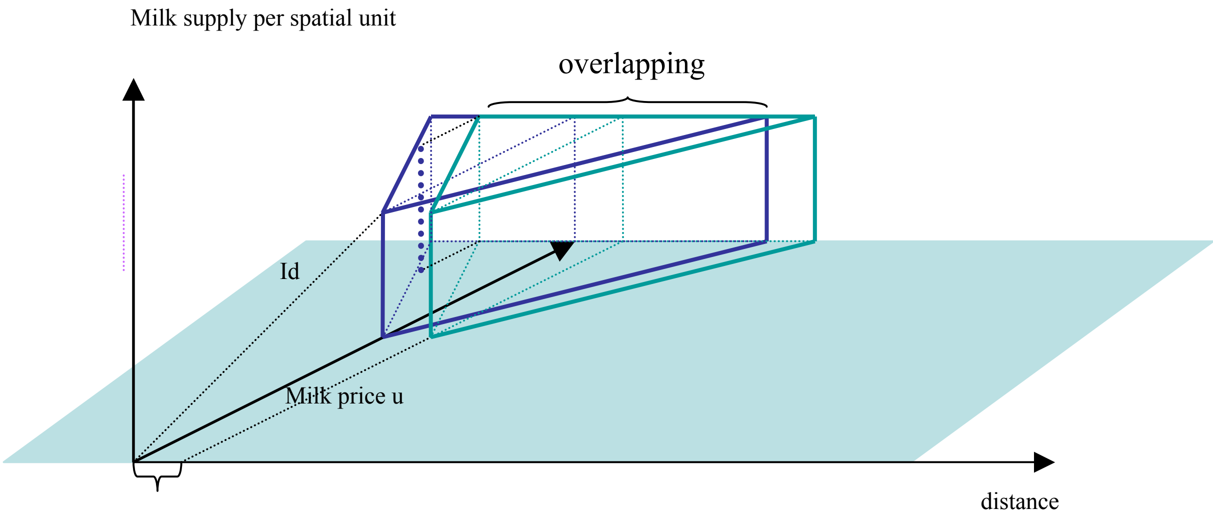
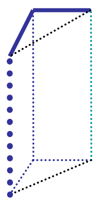
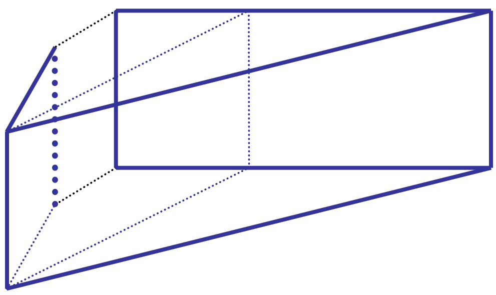


Chart 3: 3-dim figure of ‚overlapping beyond competitors’ location’

The small fraction, the LHS processor calls ‘his own’ is represented by the following ‘edge’:



and the fragment, the LDS processor has to share 1:1 with the RHS competitor, is given by:



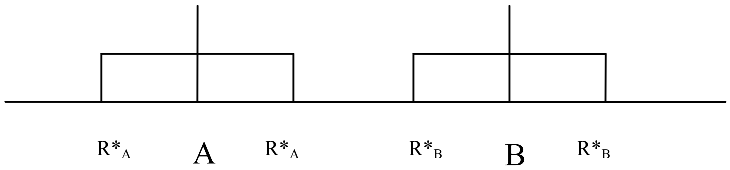


Figure 1: Local monopoly

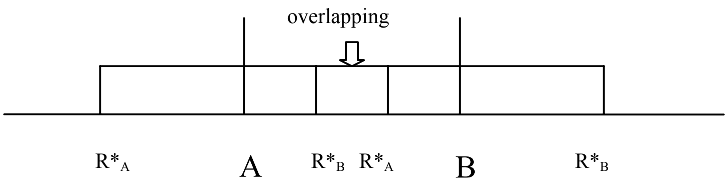


Figure 2: overlapping in-between locations

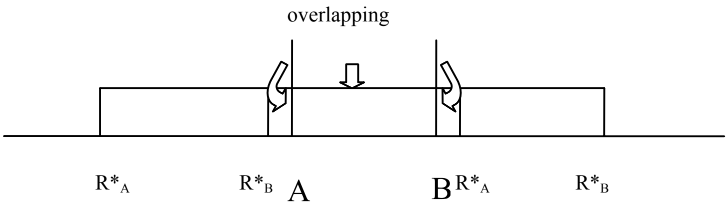


Figure 3: overlapping beyond competitors' locations

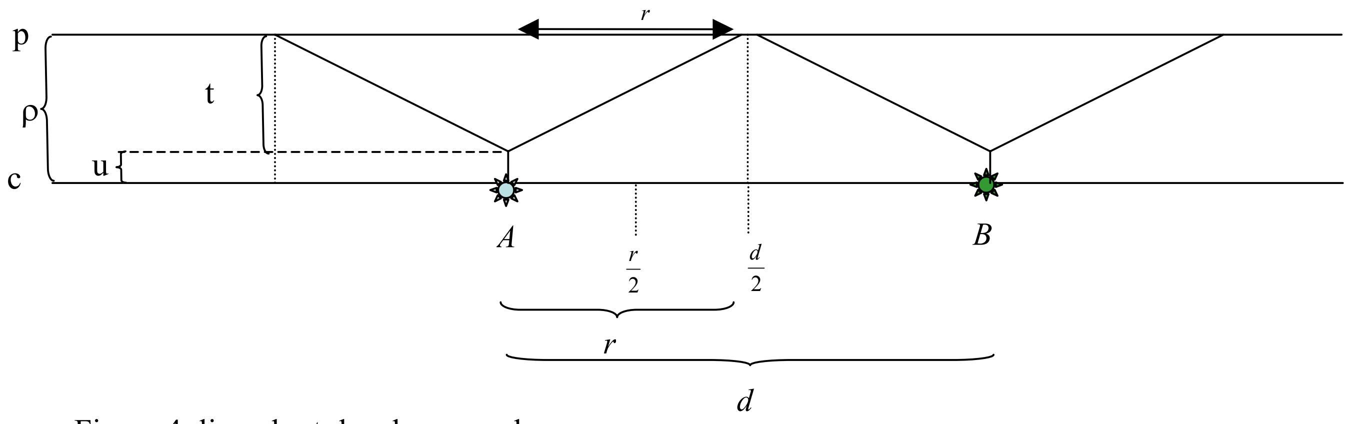


Figure 4: line-chart: local monopoly

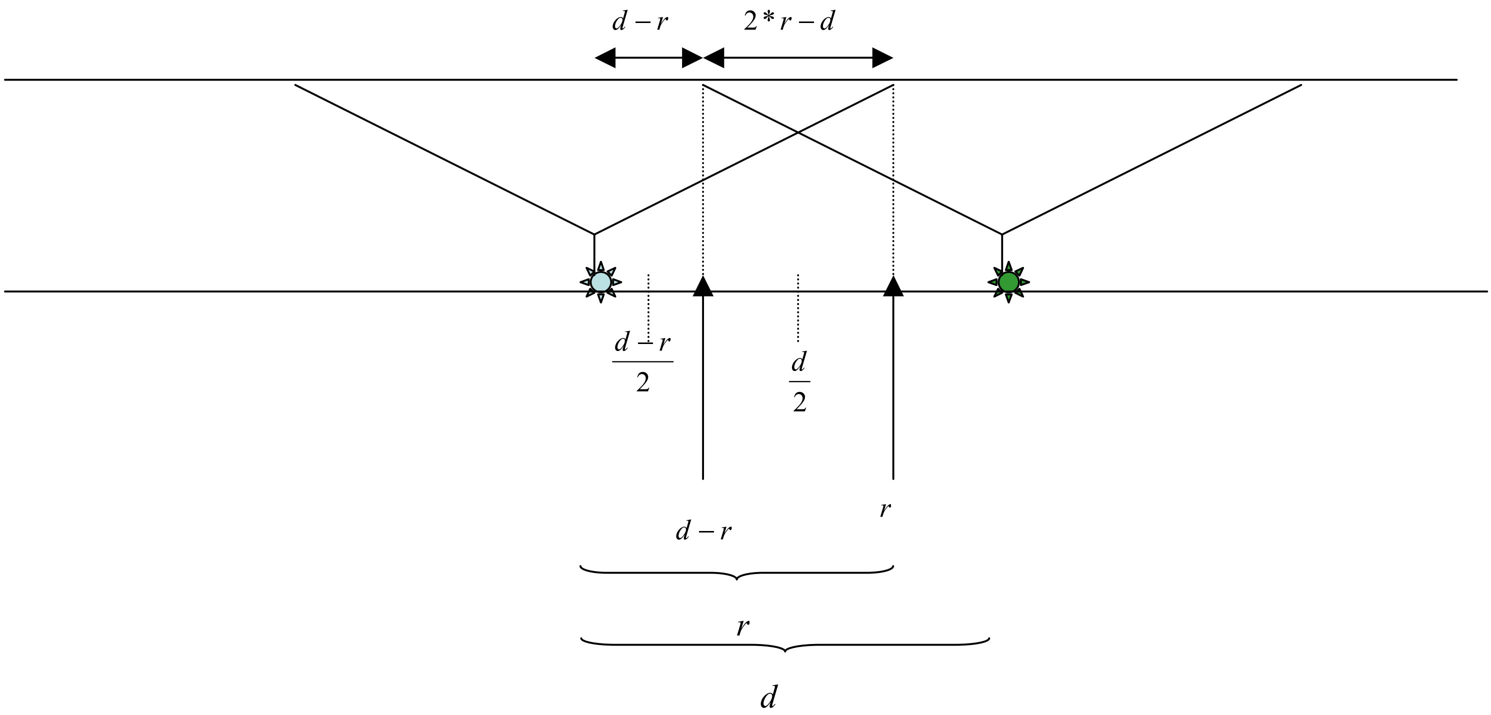


Figure 5: line-chart: overlapping in-between locations

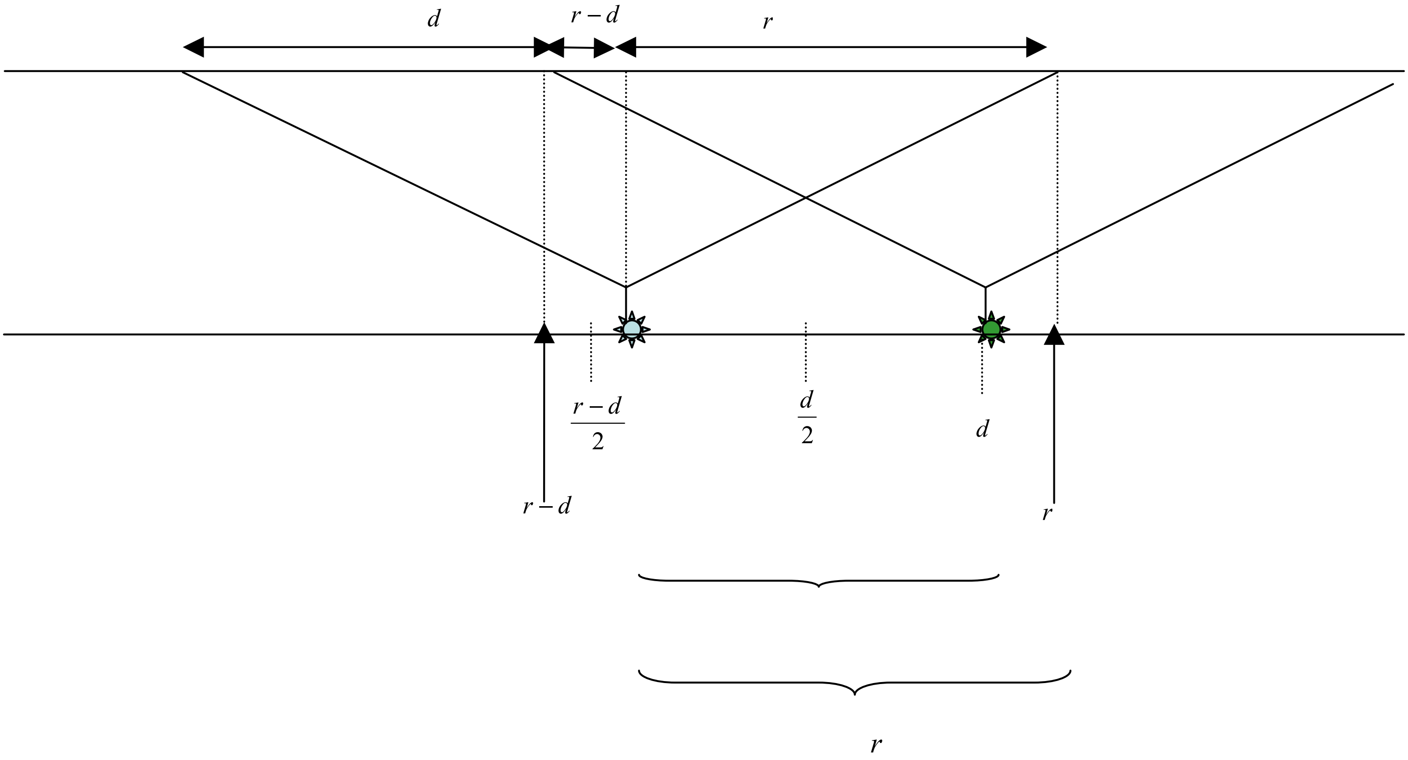


Figure 6: line-chart: overlapping beyond competitors' location

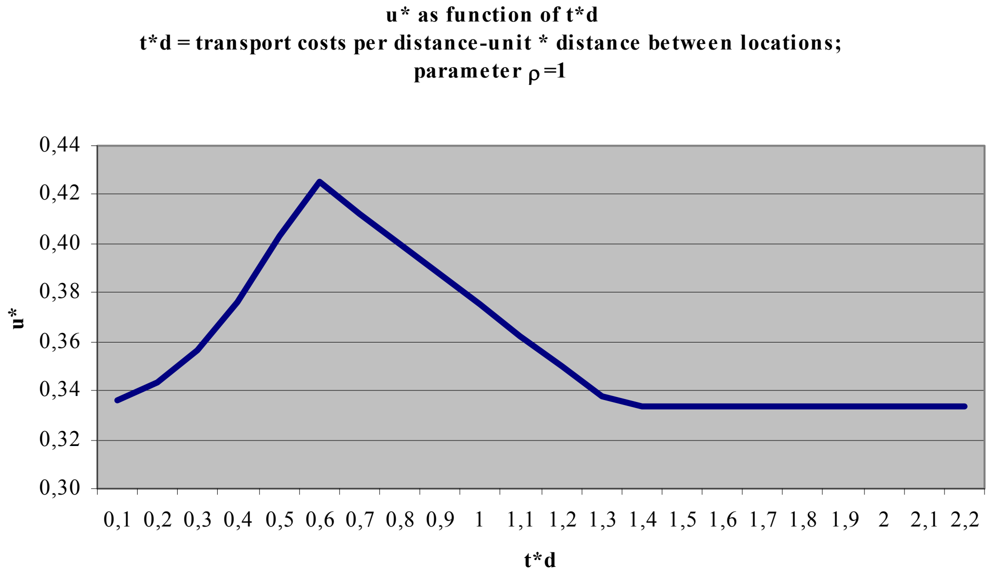


Figure 7: milk price schedule for varying *t*d* (transport cost rate*distance)

Dairies in Germany (fiscal data in Cent)				
Variable	Mean	Deviation	Minimum	Maximum
U	32,12	2,33	26,92	40,26
P	47,27	3,44	42,50	53,28
N	1,90	1,57	1,00	10,00
S	19,11	27,94	0,99	159,91

Table 1: Statistical KPIs for regression variables

Dependent Variable: u
Method: GLS (Cross Section Weights)
Date: 05/12/04 Time: 16:24
Sample: 1999:01 2002:12
Included observations: 48
Number of cross-sections used: 62
Total panel (unbalanced) observations: 2928

Variable	Coefficient	Std. Error	t-Statistic	Prob.
S	0.045540	0.007776	5.856210	0.0000
S2	-0.000152	4.52E-05	-3.366285	0.0008
N	-0.371941	0.068814	-5.405004	0.0000
P	0.381202	0.006490	58.73243	0.0000
M1	0.360315	0.062616	5.754398	0.0000
M2	0.197969	0.062583	3.163315	0.0016
M3	0.284296	0.062683	4.535475	0.0000
M4	-0.228940	0.062448	-3.666074	0.0003
M5	-0.610849	0.062432	-9.784208	0.0000
M6	-0.445290	0.062417	-7.134133	0.0000
M7	-0.634787	0.062306	-10.18820	0.0000
M8	-0.412358	0.062282	-6.620860	0.0000
M9	-0.225386	0.062200	-3.623551	0.0003
M10	0.038896	0.062204	0.625295	0.5318
M11	0.116911	0.062227	1.878771	0.0604
Y00	1.847036	0.040033	46.13788	0.0000
Y01	2.293928	0.054793	41.86517	0.0000
Y02	-0.468459	0.052438	-8.933549	0.0000

Weighted Statistics

R-squared	0.986528	Mean dependent var	34.88338
Adjusted R-squared	0.986154	S.D. dependent var	6.335428
S.E. of regression	0.745476	Sum squared resid	1582.730
F-statistic	12267.85	Durbin-Watson stat	0.779716
Prob(F-statistic)	0.000000		

Unweighted Statistics

R-squared	0.870248	Mean dependent var	32.57492
Adjusted R-squared	0.866648	S.D. dependent var	2.050583
S.E. of regression	0.748818	Sum squared resid	1596.956
Durbin-Watson stat	0.675999		

Table 2: Estimation results for Bavaria

Dependent Variable: u
Method: GLS (Cross Section Weights)
Date: 05/12/04 Time: 16:31
Sample: 1999:01 2002:12
Included observations: 48
Number of cross-sections used: 31
Total panel (unbalanced) observations: 1428

Variable	Coefficient	Std. Error	t-Statistic	Prob.
S	0.041839	0.013289	3.148290	0.0017
S2	-9.28E-05	4.15E-05	-2.235500	0.0255
N	-0.806086	0.253155	-3.184163	0.0015
P	0.372491	0.015777	23.60934	0.0000
M1	-0.677506	0.151195	-4.481005	0.0000
M2	-0.902517	0.151089	-5.973399	0.0000
M3	-1.016175	0.151130	-6.723837	0.0000
M4	-1.587782	0.150397	-10.55729	0.0000
M5	-2.062136	0.150396	-13.71136	0.0000
M6	-1.783336	0.150161	-11.87616	0.0000
M7	-1.621106	0.149852	-10.81803	0.0000
M8	-1.089365	0.149702	-7.276872	0.0000
M9	-0.551893	0.149331	-3.695765	0.0002
M10	0.078521	0.149342	0.525784	0.5991
M11	0.397264	0.149405	2.658967	0.0079
Y00	1.840993	0.093003	19.79496	0.0000
Y01	2.339782	0.137877	16.97009	0.0000
Y02	-0.638136	0.134275	-4.752449	0.0000

Weighted Statistics

R-squared	0.973168	Mean dependent var	33.77882
Adjusted R-squared	0.972234	S.D. dependent var	7.604790
S.E. of regression	1.267199	Sum squared resid	2214.388
Log likelihood	-2263.537	F-statistic	2942.034
Durbin-Watson stat	0.581174	Prob(F-statistic)	0.000000

Unweighted Statistics

R-squared	0.727300	Mean dependent var	31.31627
Adjusted R-squared	0.717808	S.D. dependent var	2.403284
S.E. of regression	1.276667	Sum squared resid	2247.603
Durbin-Watson stat	0.550504		

Table 3: Estimation results for Eastern Germany

Dependent Variable: ul
Method: GLS (Cross Section Weights)
Date: 05/12/04 Time: 16:39
Sample: 1999:01 2002:12
Included observations: 48
Number of cross-sections used: 183
Total panel (unbalanced) observations: 8508

Variable	Coefficient	Std. Error	t-Statistic	Prob.
S	0.015554	0.003859	4.030982	0.0001
S2	-2.07E-05	8.32E-06	-2.494073	0.0126
N	-0.211091	0.059917	-3.523062	0.0004
P	0.376166	0.006702	56.13035	0.0000
M1	-0.516185	0.064169	-8.044171	0.0000
M2	-0.844820	0.064137	-13.17220	0.0000
M3	-0.991470	0.064292	-15.42129	0.0000
M4	-1.526173	0.064062	-23.82337	0.0000
M5	-1.913026	0.064008	-29.88739	0.0000
M6	-1.595975	0.064026	-24.92679	0.0000
M7	-1.432700	0.063919	-22.41415	0.0000
M8	-0.743115	0.063912	-11.62723	0.0000
M9	-0.043788	0.063857	-0.685728	0.4929
M10	0.573786	0.063860	8.985017	0.0000
M11	0.799541	0.063881	12.51610	0.0000
Y00	1.882268	0.038996	48.26879	0.0000
Y01	2.236613	0.055307	40.44018	0.0000
Y02	-0.620485	0.053978	-11.49510	0.0000

Weighted Statistics

R-squared	0.976106	Mean dependent var	35.79299
Adjusted R-squared	0.975531	S.D. dependent var	8.837995
S.E. of regression	1.382494	Sum squared resid	15877.08
F-statistic	19962.07	Durbin-Watson stat	0.529454
Prob(F-statistic)	0.000000		

Unweighted Statistics

R-squared	0.708689	Mean dependent var	31.86682
Adjusted R-squared	0.701676	S.D. dependent var	2.590524
S.E. of regression	1.414921	Sum squared resid	16630.62
Durbin-Watson stat	0.467708		

Table 4: Estimation results for Germany