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"Ineffective" competition: a puzzle?

Andrey V. Ivanov*
Florian Mueller**

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*Andrey V. Ivanov, Chair for Applied Microeconomics, Department of Economics, Mannheim University, D-68131 Mannheim, Germany, aivanov@rumms.uni-mannheim.de
**Florian Mueller, Chair for Applied Microeconomics, Department of Economics, Mannheim University, D-68131 Mannheim, Germany, f.mueller@econ.uni-mannheim.de

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“Ineffective” competition: a puzzle?*

Andrey V. Ivanov † Florian Mueller ‡

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Abstract

Conventionally, we think of an increase in competition as weakly decreasing prices, increasing the number of consumers served, thus increasing consumer surplus, decreasing firms profits, etc. Here, we demonstrate that, under some tame circumstances, an increase in competition may lead to a price increase in a horizontally differentiated market. We show this relationship for the petrol market in German cities.

1 Introduction

Increased competition between firms in a market can be defined as an increase in the number of firms present or, alternatively, as a decreased horizontal differentiation between a constant number of firms in a fixed market. Standard thinking about these two kinds of competition in an oligopolistic market would suggest that an increase in competition may lead to weakly lower prices in this market.

In contrast, oligopoly models with additional features like repeated interactions, collusion, threats, or taste for variety, eventually produce a countervailing effect. But even these models in general display the conventional competition effect as described above. So will, for example, more competition in equilibrium also lead to a decreased propensity of collusion and thus lower prices.

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†Chair for Applied Microeconomics, Department of Economics, Mannheim University, D-68131 Mannheim, Germany; aivanov [at] rumms.uni-mannheim.de

‡Chair for Applied Microeconomics, Department of Economics, Mannheim University, D-68131 Mannheim, Germany; f.mueller [at] econ.uni-mannheim.de

We show in this contribution, that even in a simple setting of horizontally differentiated goods increased competition[1] may in fact lead to higher prices without explicit communication amongst the players.

We use a one stage standard model of horizontal differentiation as introduced by Hotelling (1929) and Salop (1979) to lay out the theoretical grounds. The existence of this effect has in principle been mentioned (in particular in Salop (1979) and Economides (1989)) before, but has never been appreciated as reasonable strategic behaviour of the players. However, we find empirical evidence, that this effect exists in reality.

We analyze the comparative statics of the model in depth in section 3. Subsequently in section 4, we find evidence for a positive relationship between prices and the density of firms in a market of petrol stations in German cities.

Our theoretical model closely follows the basic setup and equilibria of the pricing game as introduced by Salop (1979). Readers familiar with this work are welcome to skip section 3 completely, or go to sections 3.4 and 3.5 for a review of the best response strategies of the firms and the resulting equilibria before continuing with section 4.

2 Literature

To a large extent, the post-Hotelling (1929) literature on horizontally differentiated products concerned itself with finding the existence of an equilibrium in a Hotelling model of positioning and pricing, ever after d'Aspremont, Gabszewicz, and Thisse (1979) have shown that the original specification of Hotelling (1929) did note have a pure strategy Nash equilibrium in the pricing subgame for firm locations that were too close to each other. Also, for example, Anderson (1986; 1988) and Osborne and Pitchik (1987) investigate mostly the existence of equilibria. Those from this group that report the pricing behaviour as a function of distance all have a monotone positive relationship between the two.

On the other hand, Salop (1979) and Economides (1989) are two works that do report the non-monotone price behaviour that we investigate here, although these authors seem to have believed the effect to be strange and difficult to see in reality. These papers differ from the first group in one critical point: their models have an outside option for consumers to choose, while the former models forced all consumers to participate in the market. In our model—which is a direct descendant of Salop (1979)—if all consumers were made to buy at least from one firm, the pricing behaviour would also be monotone.

[1] Here, the two kinds of increased competition coincide in terms of optimizing behaviour of the firms.

There exists other work that also derives seemingly counter-intuitive (at least from traditional point of view) results about the behaviour of the firms in horizontally differentiated marketplaces, but these papers have different settings. For example, Stahl (1982) and Schulz and Stahl (1996) study externalities from many firms in one marketplace, which may lead single-product firms in one marketplace to charge higher prices than a multi-product monopolist. They do not look at competing marketplaces, which makes their results different to our paper.

3 The Model

Our goal is to investigate the pricing of a duopoly in a differentiated goods market, where the degree of differentiation is given by a transportation cost à la Hotelling. As reference cases, we use the pricing strategies in two monopoly settings.

3.1 Set-up

The market is given by a Salop circle[2] of circumference $2 \cdot s$. Each point on the circle represents a differentiated good that is most preferred by a consumer occupying that point. Consumers are uniformly distributed along the circle, with density $1/s$, which results in a constant consumer mass of 2. There are two identical firms, positioned exactly opposite each other at 0 and s. Like Salop (1979), we are interested in the analysis of the short term behaviour in the pricing game and thus we also assume that the firms' positions are fixed exogenously. We normalise marginal costs of production to zero. When a consumer x consumes a good offered at $y \neq x$, he incurs a disutility or transportation cost, $t \cdot |x - y|$, according to the shortest arc-length distance between x and y. Consumption of either good delivers to the consumer a pure utility of $a > 0$ in monetary terms, which is then adjusted for the price paid and the transportation cost.

Earlier work was concerned with the non-existence of pure strategy equilibria in similar Hotelling settings. We choose our set-up in a simple way, such that typical problems pertaining to pure strategies[3] do not occur, in order to allow for clear presentation of our case. This relates to the amount of firms and their symmetric position, given which, it is impossible to obtain the *hinterland* of your competitor. Take firm i, which prices such that the consumer at location of its rival, $-i$, just prefers $-i$ to i. Lowering its price by a small amount, firm i does not gain all of the consumers *on the other side* of $-i$, because it has already been serving those consumers from the other side of the circle. The *hinterland* does not exist.

[2] cf. Salop (1979)

[3] e.g., jumps in demand due to undercutting the rival's price, leading to non-existence of pure strategy equilibria.

Due to the same reasoning and for simplicity of exposition we can cut the circle in half and obtain our market as a line from 0 to s with firms positioned on the opposite sides and consumers uniformly distributed with density $1/s$ and a total mass of one.

3.2 Consumption decision

Consumers are utility maximizers and buy one or zero units of a good from at most one of the companies present. This decision is summarised in the conditions (1) and (2) below. If they buy zero units from the firms in question, they buy some homogeneous outside good, which costs 0 and delivers 0 utility to every consumer, irrespective of location.

Definition 1 (Utility form) *Let $a, s, t \in \mathbb{R}_+$. For the person located at an address x between 0 and s (at a distance $z_0 = x$ or $z_1 = s - x$ from firm 0 or firm 1 respectively), when buying a good from firm i at price p_i, the indirect utility is given by the additive separable function*

$$u_x(p_i, z_i) = a - p_i - t \cdot z_i \ .$$

Thus, given firms' prices $p_i, p_{-i} \in [0, a]$, the consumer located at x buys product i if and only if: (a) he prefers good i to good $-i$,

$$u_x(p_i, z_i) \geq u_x(p_{-i}, z_{-i}) \tag{1}$$

and (b) he prefers good i to the outside option,

$$u_x(p_i, z_i) \geq 0 \tag{2}$$

3.3 Aggregate demand and firms' profits

As the consumers do not act strategically, we can map their decisions directly into the (piece-wise linear) demand function for the firms. The firms can capture the market from their position up to an indifferent consumer. This consumer is either indifferent between buying the firm's product and buying the other product (fulfilling (1) with equality)or he is indifferent between buying the product and not buying (fulfilling (2) with equality). Consumers further away from the firm than the indifferent consumer either buy the other product or do not buy at all. There either exists one indifferent consumer, if all consumers are served or there are two indifferent consumers, if some consumers in the middle of the market are not served.

Firms set prices $p_i \in [0, a]$—a compact, convex set. Setting any price equal to or above a would lead to demand of zero for firm i. Therefore, we establish the upper bound a on the price set. Relaxing this assumption does not change the results.

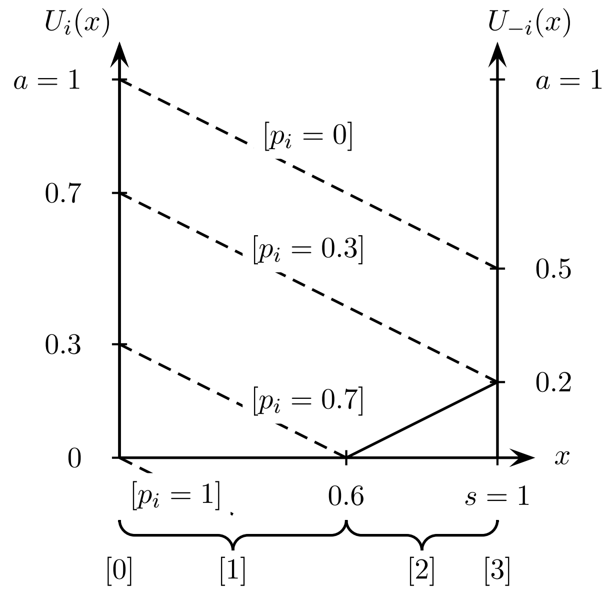


Figure 1: Example consumer utility levels for different prices p_i with fixed parameters $p_{-i} = 0.8$, $a = 1$, $t = 0.5$ and $s = 1$

The piece-wise demand equation for firm i is then given by the distance from that firm to the closest indifferent consumer weighted with the density of consumers $1/s$ on that part of the market.

$$D_i(p_i, p_{-i}|a, s, t) = \max\left\{ \underbrace{\ 0\ }_{[0]}, \min\left\{ \underbrace{\frac{a - p_i}{st}}_{[1]}, \underbrace{\frac{1}{2} + \frac{1}{2st}(p_{-i} - p_i)}_{[2]}, \underbrace{\ 1\ }_{[3]} \right\} \right\} \quad (3)$$

The piece-wise linear parts of the demand can be associated with regions of demand patterns, which are described below. An example for the demand for firm i's product depending on its price p_i is shown in figure 1.

[0] Demand is zero if a firm prices higher than the price of its competitor at the firm's location $\big((p_i \geq p_{-i} + st) \wedge (p_{-i} \leq a - st)\big)$ or too high for all consumers at $(p_i = a)$

[1] The first interesting part of demand corresponds to firm i being a local monopolist. A small decrease in price leads to engaging previously idle consumers in trade; a small increase leads to him losing customers to the outside option.

[1]-[2] The kink between parts [1] and [2]. If the firm lowers its price, it steals the customers from the competitor; if it increases its price, some customers switch to the outside option—*not* to the competitor.

[2] This part corresponds to competitors being in "effective" competition: the market is covered, and any change in prices leads to stealing consumers from—or driving your consumers to—the competitor. This occurs for prices $p_i \in (p_{-i} - st, 2a - p_{-i} - st)$.

[3] This part corresponds to firm i capturing the whole market, which occurs at prices $p_i < p_{-i} - st$, or $p_i < a - st$ if firm $-i$ prices itself out of the market.

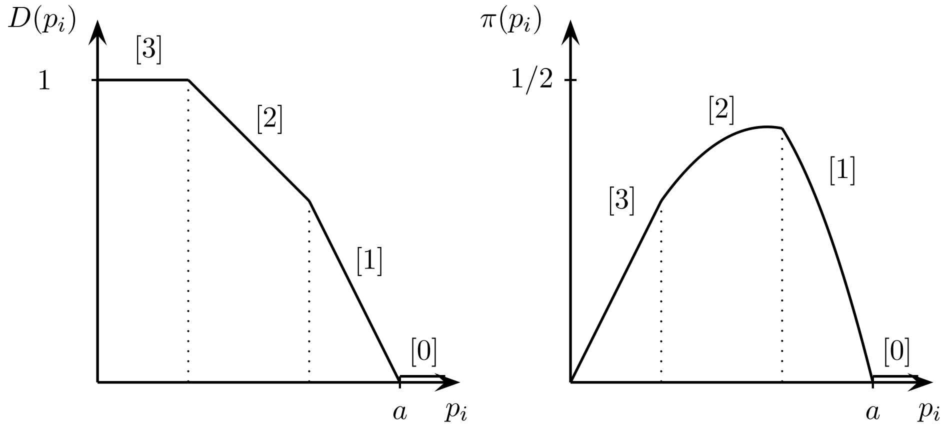
Of course, depending on the competitor's price p_{-i} and the parameters a, s, and t, some of these regions may not exist at all:

- If there is no competitor (or $p_{-i} > a$), then part [2] collapses.
- If $p_{-i} < a - st$ (low enough) and $st > a$, there is no part 1: even for very high p_i firm i would "effectively" compete with firm $-i$.
- If $p_{-i} < st$ or $st > a$, there is no (profitable) part 3: even for very small $p_i > 0$ firm i cannot capture the whole market from firm $-i$, either because firm $-i$ prices too low or the transport across the whole market is too expensive.

From the demand equation (3) we get the profit function by multiplying by the price p_i: $\Pi_i(p_i, p_{-i}|a,s,t) = p_i \cdot D_i(p_i, p_{-i}|a,s,t)$. We write out the profit function covering the full space of $p_{-i} \in [0, a]$ and the parameters a,s,t $\in \mathbb{R}_+$.

$$\Pi_i(p_i, p_{-i}|a,s,t) =$$
$$\begin{array}{ll} [0] \\ \\ [1] \\ \\ [2] \\ \\ [3] \\ \\ \end{array} \begin{cases} 0 & \big((p_i \geq p_{-i} + st) \wedge (p_{-i} \leq a - st)\big) \\ & \vee (p_i \geq a) \\ \frac{a-p_i}{st} \cdot p_i & (2a - p_{-i} - st \leq p_i \leq a) \\ & \wedge (p_{-i} \geq a - st) \\ \left[\frac{1}{2} + \frac{1}{2st}(p_{-i} - p_i)\right] \cdot p_i & (p_{-i} - st \leq p_i \leq 2a - p_{-i} - st) \\ & \wedge (p_{-i} \leq a) \\ p_i & \big((p_i \leq p_{-i} - st) \wedge (p_{-i} \leq a)\big) \\ & \vee \big((p_i \leq a - st) \wedge (p_{-i} \geq a)\big) \end{cases} \tag{4}$$

Function $\Pi_i(p_i, p_{-i}|a,s,t)$ is quasi-concave and continuous in p_i. The positive part is strictly concave. Therefore, the function has a unique maximum above zero. In fact, given any quadruplet (p_{-i}, a, s, t), the maximiser lies either in the interior of one of the non-zero piece-wise components [1] or [2] of the profit function, or in one of the corners of part [2]. One example for the demand and profit function for a parameter set at which all regions exist is depicted in figure 2.



(a) Demand (b) Profit

Figure 2: Demand and profit regions at fixed parameters p_{-i}, a, t, and s as in the example in figure 1

3.4 Best responses

Maximising the profit from equation (4) with respect to p_i, we get firm i's continuous best response function $p_i(p_{-i}|a, s, t)$. For discussion, we name the areas of the best response function. The pieces span the space for all parameters as shown in figure 3.

$$p_i(p_{-i}|a,s,t) = \begin{array}{r} \text{GM} \\ \text{CM} \\ \text{EC} \\ \text{IC} \\ \text{LM} \end{array} \begin{cases} a - st & (p_{-i} \geq a) \wedge (st \leq \frac{a}{2}) \\ p_{-i} - st & (p_{-i} \leq a) \wedge (p_{-i} \geq 3st) \\ \frac{st + p_{-i}}{2} & (p_{-i} \leq 3st) \wedge (p_{-i} \leq \frac{4}{3}a - st) \\ 2a - st - p_{-i} & (p_{-i} \leq \frac{3}{2}a - st) \wedge (p_{-i} \leq a) \wedge (p_{-i} \geq \frac{4}{3}a - st) \\ \frac{a}{2} & (st \geq \frac{a}{2}) \wedge (p_{-i} \geq \frac{3}{2}a - st) \end{cases} \tag{5}$$

The parameters for the market size s between the firms and for the relative transportation cost t always enter in the same way as a product for the total transportation cost across the whole market st, such that we don't need to treat them separately from now on. We discuss the firms' rationale behind this best response function by letting st increase and thereby taking us through the different regions of the best response function.

GM Global monopoly—occurs when the competing firm has totally priced itself out of the market ($p_{-i} \geq a$) and the total transportation cost is so low, such that the firm finds it optimal to set a price to just serve the whole market (region [3] of the demand and of the profit equation).

CM Capturing the whole market—also corresponds to part [3] of the demand function. Here the competitor is active in the market ($p_{-i} < a$), but charges too high a price ($p_{-i} \geq 3st$) such that firm i maximises profit in this region by charging the highest price that allows it to capture the whole market against the price of the competitor.

EC Effective competition—the best response refers to an inner maximum over the part [2] of demand and of profit equation. Here, the total transportation cost is low enough relative to the reservation utility, such that the firm engages in competition that serves every consumer at positive utility.

IC Ineffective competition—refers to the kink [1]-[2] in the demand function and in the profit function. The firm prices such that the indifferent consumer is just indifferent between buying from either firm or not buying at all. Note that the prices in this region are strategic substitutes: $\partial p_i(\cdot)/\partial p_{-i} < 0$.

LM Local monopoly—refers to inner maximum over part [1] of the demand and profit function. The total transportation cost here is high enough, such that the firm can ignore the presence of the competitor and set prices in a local monopoly. Consumers in the middle remain unserved.

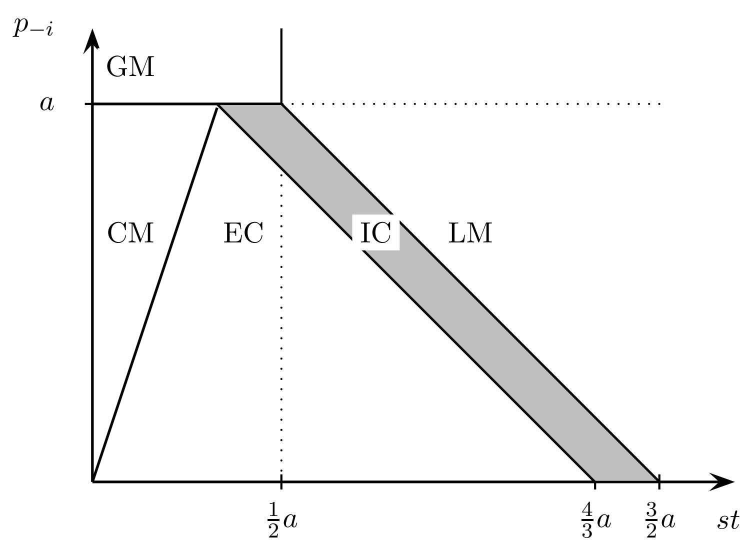


Figure 3: Areas of the best response function p_i in p_{-i}–st space

3.5 Equilibrium

Solving the system of best response functions, we find that there is a unique pure strategy symmetric Nash equilibrium, with an equilibrium price p_i^* for any parameter tuple (a, s, t). We characterise our equilibrium in terms of st's relation to a as we are interested in the comparative statics with respect to the level of the exogenous parameters st.

$$p^* = \begin{cases} st & \text{if } st \leq \frac{2}{3}a \\ a - \frac{st}{2} & \text{if } \frac{2}{3}a < st \leq a \\ \frac{a}{2} & \text{if } st > a \end{cases} \tag{6}$$

These equilibrium prices lie in three different regions of the best response function (EC, IC, and LM)—corresponding to three different rationales for the behaviour of the firms—depending on the transportation cost and the distance between the firms, st. The equilibrium price of the duopoly case is pictured with a solid line in figure 4. As reference cases we use the pricing of the one-product monopolist (dotted line) and of a two-product monopolist (dashed line).[4] For small st, the firms engage in effective competition and their behaviour corresponds to standard understanding of lower prices at lower levels of transportation cost or distance. The limit (as $st \to 0$) of this case is marginal cost pricing in a Bertrand competition with a homogenous good. For very high st values, the firms maximize profits by acting as local monopolists and setting the monopoly price $a/2$.

In the middle region ($st \in [a/2, a]$)we see the price first overshoot the one-product monopoly price and then return to the one-product monopoly price with higher st.

For $st \in [\frac{2}{3}a, a]$, the equilibrium lies in the region of "ineffective" competition and the duopoly firms act as a two-product monopolist without explicit communication or coordination through repeated games. They are led solely by profit maximization through setting prices. Notably, at all of these st, the firms price such that the indifferent consumer is exactly indifferent between the two goods and the outside option. The firms decide not to engage in competition, instead they evade competition by jointly exploiting the consumers as long as all consumers participate.

3.6 Discussion

We argue, that this equilibrium behaviour reflects a reasonable strategy in practice. The rigidity of the partitioning of the market and the adjustment over prices is directly driven by the different price elasticities of demand for the firms. In this equilibrium, they face a discretely higher elasticity of

[4]Please refer to Appendix A for the computation of the reference cases.

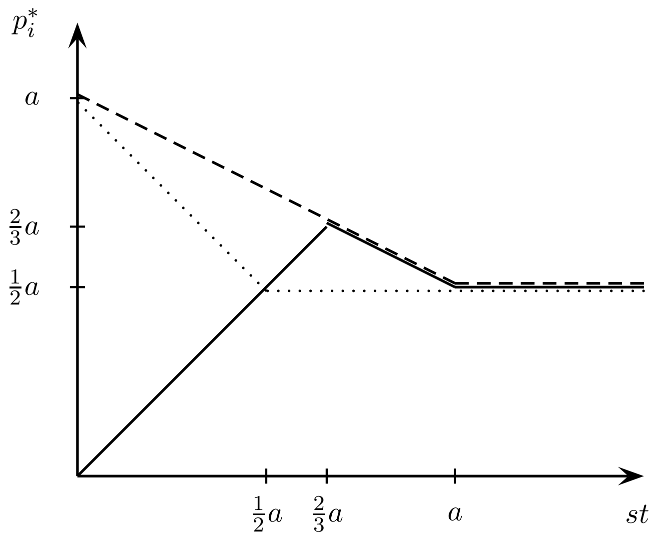


Figure 4: Equilibrium prices in the duopoly, and the 1-product and 2-product monopoly reference cases

demand for price increases than for price decreases because they lose more customers to the outside option when increasing the price, than they gain consumers from the competitor when lowering the price.

Similarly, we can assess the effects of ineffective competition in the comparison of the duopoly setting to the two-product monopoly setting. In the region of $st \in [\frac{2}{3}a, a]$, the firms in the duopoly set prices like a two-product monopolist, although they could engage in competition. Here, the market is in fact less than twice the size of the market a one-product monopolist would deliberately decide to serve at its profit-maximising price for the same set of parameters. However, the mere increase in the number of firms at the positions as described in the model on this specific st-range does not decrease the equilibrium prices. As compared to the one-product monopolist, we shall even see a price increase. This effect needs to be considered, when judging on firm concentration in such markets. The effect will be prevalent in markets that at the same time are horizontally differentiated, show limited market expansion as reaction to lower prices in the market, and have an outside option for the consumers.

4 Empirical model

In this section, we examine the prediction of our model that the relationship between the equilibrium market price and the distance between the firms is not monotonic across all distances—in particular, that it is not always positive. We do this by analysing the pricing behaviour of petrol stations along the station density in different city districts in Germany, where a district is an administrative unit at the level of a county ("Landkreis" or "Kreisfreie Stadt" in German), between a community and a state.[5]

We believe that this petrol market corresponds closely to the spatial competition as presented in our model, despite some problems discussed briefly below. We take the station density, denoted as ζ, as a proxy for the inverse of the distance between the firms ($1/s$) and we assume that the per distance transportation cost t is equal in all cities. Thus, we look at an equilibrium price in our model as a function of the station density ζ, together with the two kinks at ζ' and ζ'' as depicted in figure 5.

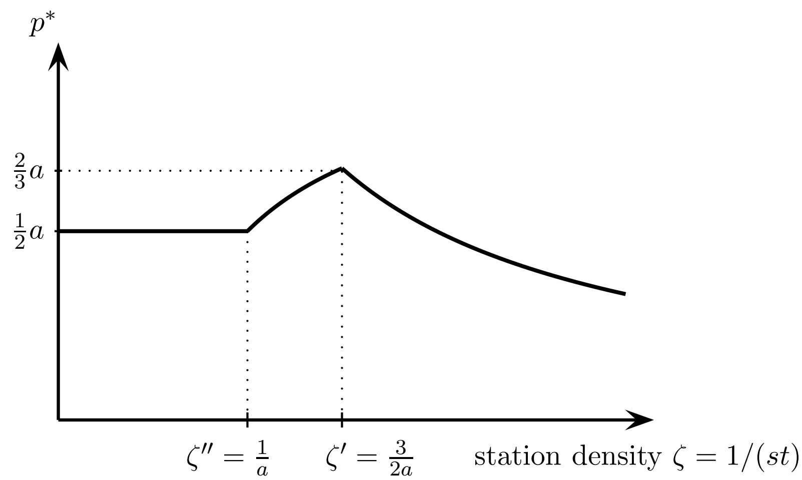


Figure 5: Equilibrium price prediction for station density

It is clear that effective competition (to the right of ζ') is abundant, and this has in fact been shown in Karle (2005), for this particular data set. We do not believe that local monopolies exist in the market for petrol in German city districts, which is why we do not expect to find the part of the curve that is to the left of ζ'' in figure 5.

What we add to the discussion is the identification of the middle section of "ineffective competition": we first reject the hypothesis that the prices are a downward-sloping function of station density across *all* station densities, then we find a suitable value for a kink point ζ', and estimate a two-part connected linear curve around this kink.

To bridge the gap between the model of section 3 and our empirical work, we need to assume that consumers and stations are in fact distributed

[5]City districts therefore contain a large city and its closest surroundings.

uniformly within the district, that consumers do frequent the closest station, *ceteris paribus*, and that districts have zero interaction with each other. Of course, these are strict assumptions. For one, consumers' locations are typically not given by their physical address, but rather by their every-day route to and from work (which furthermore may be in a different district). On the other hand, we believe that any distortion from these problems should enter in the same way irrespective of the observed station density. Therefore, these distortions should at worst hinder our analysis and at best have no effect, but they should not help us identify the upward-sloping part of the curve around the kink ζ' in figure 5.

4.1 Data

We use daily German petrol station price data collected for 78 days starting April 13, 2005, from a service website for retail petrol price comparisons.[6]

Some of the original sample entries had missing observations for our variables of interest. For example, Sunday and Saturday prices were largely not reported by the stations, so we only include weekday prices in the sample. While there were some observations from the rural districts, only the city districts ensure that the sample observations are representative of all the petrol stations in a district. At the end, we are left with a consistent subsample of the original data that contains daily price observations for 807 petrol stations in 93 major German city districts for 63 days.

The stations are divided into brand types: Premier-brand or A-type (e.g., Shell, BP), second-tier or B-type, and independent or C-type, according to their differentiation in the eyes of consumers.

We treat the districts as markets in the sense of section 3. Our dependent variable is the average retail price of one litre of petrol in a district, for each day and brand type, which gives us $14,984$ observations. We need to control for the changes in variables that may influence consumer preferences (the brand type, income) and marginal cost (local wholesale price per litre), as these are held constant in the model of section 3. In fact, the local wholesale price changed dramatically during the sample period, while income is different across the districts. We thus consider as independent variables: station density in a district, income per capita in a district, the brand type and the local wholesale price.

The income is measured as local GDP per capita in a city; the local GDP is taken from "Volkswirtschaftliche Gesamtrechnungen der Länder 2003". The wholesale price is the daily price reported for the petrol spot market in Rotterdam, by Energie-Informationsdienst; we take a 5-day moving average of this price to capture the adjustment lag of the retail price to the wholesale price changes. The local wholesale price is then the moving average of the

[6] For a detailed data description, see Karle (2005).

Rotterdam price adjusted for time-persistent local differences, which are reported weekly by Europe Oil-telegram. The station density, ζ, is measured as the average number of stations per square kilometre in a district.

4.2 Testing for negative relationship between prices and station density

Suppose we know the value ζ' in figure 5. In order to test for negative price–station density relationship, we first partition the 14,984 observations into two parts according to the kink station density, $\bar{\zeta} = \zeta'$: with $n_1(\bar{\zeta})$ observations to the left of $\bar{\zeta}$, and $n_2(\bar{\zeta}) = 14,984 - n_1(\bar{\zeta})$ to the right. We then use OLS to estimate a two-part connected linear curve with a kink at $\bar{\zeta}$, which gives us two slope parameters for the curves on the right and left partitions. Last, we test the equality of these two parameters using a Chow test, which is stated formally below.

Of course, we cannot compute ζ'. Instead, we repeat our estimation and test pragmatically for different assumed values of $\bar{\zeta}$. We start with $\bar{\zeta} = 0.25$ and move down in increments of 0.005 until $\bar{\zeta} = 0.09$.

To estimate the two curves with the constraint that they meet at $\bar{\zeta}$, we transform the station density to be around 0 with:

$$\text{adjusted station density} = \text{station density} - \bar{\zeta}, \tag{7}$$

which permits us an estimation of one intercept for both parts of the curve in a single OLS regression. Now we can fit the two-part connected linear model, which allows for different parameters in different partitions:

$$\begin{bmatrix} p_1 \\ p_2 \end{bmatrix} = \begin{bmatrix} i & X_1 & 0 & Z_1 & 0 \\ i & 0 & X_2 & 0 & Z_2 \end{bmatrix} \cdot \begin{bmatrix} \alpha \\ \beta \\ \gamma \\ \delta_1 \\ \delta_2 \end{bmatrix} + \begin{bmatrix} \epsilon_1 \\ \epsilon_2 \end{bmatrix}, \tag{8}$$

where p_1 and p_2 are the $n_1 \times 1$ and $n_2 \times 1$ vectors of the dependent variable observations (the average retail petrol prices in a district, for each day and brand type) in the left and right partitions, respectively; i is a vector of 1's; X_1 and X_2 are respectively $n_1 \times 1$ and $n_2 \times 1$ (left and right partition) matrices of station density observations; Z_j is an $n_j \times 4$ matrix of control variables for two partitions (with $j = 1, 2$ and the controls being: moving average of the Rotterdam wholesale price adjusted for local differences, income, and two dummies for brand types A and B); α is the price at the connection of the two lines (corresponds to the intercept since X_1 contains only negative values after the transformation); β and γ are the slope coefficients for the left and right partitions (X_1 and X_2, respectively); δ_j is the 4×1 vector of coefficients for Z_j, $j = 1, 2$; and $\epsilon_{1,2}$'s are the disturbances (assumed i.i.d.).[7]

We allow for different effects of the Z control variables in different partitions, by partitioning all the Z control variables according to the same kink station density $\bar{\zeta}$. Our hypothesised relationship between the station density and price is different for different partitions, but the model of section 3 is silent about the effects of independent variables other than station density. There is no reason to assume that the effect of, for example, marginal cost on price is the same in the ranges of effective and "ineffective" competition, since in the latter part the pricing is driven by the kink feature of the demand curve.

Given the empirical model in equation (8), our testable hypothesis is

$$\mathbf{H_0} : \beta = \gamma. \tag{9}$$

The data analysis shows that at any $\bar{\zeta}$, the right partition has a negative relationship between the price and station density. If the data can identify the part of the curve that is between ζ'' and ζ' in Figure 5, then our test will reject the equality of slopes for the right and left partitions around $\bar{\zeta} = \zeta'$. Furthermore, the slope of the left partition should be positive.

We assume that the disturbances have a zero mean and are uncorrelated with any of the regressors.

To cope with potential heteroscedasticity, we calculate the standard errors using the White covariance matrix, such that our estimation and tests are heteroscedasticity-robust.

4.3 Results

For all tested kinks points $\bar{\zeta} \leq 0.14$, we can reject the null hypothesis of equal slope coefficients in both partitions with at least 98% confidence. Furthermore, the slope in the left partition is positive and significant at a 1% level for all kink points $0.105 < \bar{\zeta} \leq 0.135$, and positive and significant at a 10% level for all kinks $\bar{\zeta} \leq 0.105$ and at a 5% level for $\bar{\zeta} = 0.14$. The model fits equally well for all the tested kink points (R^2 is slightly above 56%).

For large values of $\bar{\zeta}$, we cannot reject the null. Both slope coefficients are negative and significant and cannot be said to differ. The F-statistics and the associated p-values of the above tests for all $\bar{\zeta}$ are given in Table 2 in the appendix B.

Thus, we have shown that the relationship between station density and prices is not monotonic. In particular, the relationship is positive for low station density, and becomes negative after a certain kink point. We conclude that this turning station density is around $\bar{\zeta} = 0.135$ (the highest tested potential kink point to deliver positive and significant slope of the left partition and still leave many observations to the left).

[7]Our estimation and tests are robust to exclusion of the Z controls. We do not report the results here, but they can be obtained directly from the authors.

Finally, we fit the curve in equation (8) for $\bar{\zeta} = 0.135$. The results of the regression are given in table 1. To illustrate the relationship, we picture the fitted price curve against station density in figure 6.

Table 1: Estimation results of equation (8) with $\bar{\zeta} = 0.135$

Variable	**Coefficient**	**(Std. Err.)**
station density$\leq \bar{\zeta}$	0.102**	(0.012)
station density$> \bar{\zeta}$	-0.008**	(0.002)
marginal cost_1	0.965**	(0.008)
marginal cost_2	0.953**	(0.007)
income_1	0.000**	(0.000)
income_2	0.000**	(0.000)
A_1	0.020**	(0.001)
A_2	0.016**	(0.000)
B_1	0.013**	(0.001)
B_2	0.006**	(0.000)
Intercept	0.886**	(0.002)
N	14984	
R^2	0.566	
$F_{(10,14973)}$	2218.716	

Significance levels : † : 10% $*$: 5% $**$: 1%

5 Conclusion

In this contribution we showed that increased competition may lead to higher prices in a simple model of horizontal differentiation. We especially analysed the comparative statics of this effect and we argued that it represents a rationalisable strategy of firms. Furthermore, we showed its existence in the retail gasoline market in Germany.

The set of markets in which this effect surfaces is, as usual, limited but exists, as we have shown in the empirical section. The market needs to be horizontally differentiated, it needs to have an outside option for all potential buyers, and its expansion due to lower prices needs to be limited. A strictly kinked demand curve, as in our simple example, is in fact not a necessary prerequisite, as one can show for a family of locally smoothed-out demand curves. Clearly also this model is only powerful with restricted entry and exit to the market, as we have for example in the short term examination that is done in the empirical part of the paper.

The model is general enough in its description of consumers and producers that it can also be applied to increased integration of international producer-supplier markets, which occurs when improved communication

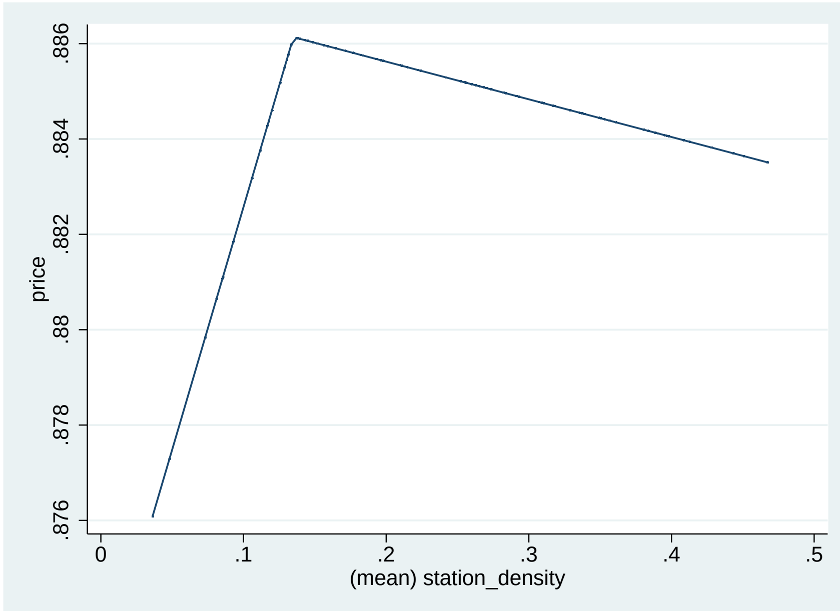


Figure 6: Predicted prices

technologies and opening of the local markets reduce the perceived transportation costs[8] between previously distant agents. Take the product to be an intermediate input, the two producers to be the suppliers of this input, and the consumers as the manufacturers of a final good. As long as this producer-supplier market fulfils the conditions described in the previous paragraph, one of the model's predictions is that for a certain exogenous fall in the perceived transportation costs (i.e., more world integration) the manufacturers experience higher costs of intermediate inputs in the short run.

From a competition policy point of view, for the relevant markets with features as above, competition authorities need to consider this behaviour when judging on market concentration as classical concentration measures might be misleading, if they purely measure market share ratios of the participating firms.

Furthermore, the firms' strategy of 'evading competition' and accommodating to a shared market even without explicit communication needs to be appreciated as a reasonable and profit maximizing strategy of players in markets, that seemed to follow standard intuition of competition.

[8]These can include real transportation costs plus information costs, etc.

A Reference cases

We compare the equilibrium price of our duopoly game to two reference cases: A one-product monopoly and a two-product monopoly.

A.1 One-product monopoly

One way to look at one-product monopoly is to fix the price of firm $-i$ in the duopoly profit equation (4) so as to price it out of the market: $p_{-i} = \hat{p}_{-i} > a$. Then, the regions [0] and [2] will disappear from the demand function (for prices $0 < p_i < a$), and we are left with

$$\Pi_i^M(p_i|a,s,t) = \begin{matrix} [1] \\ [3] \end{matrix} \begin{cases} \frac{a-p_i}{st} \cdot p_i & p_i > a - st \\ p_i & p_i \leq a - st \end{cases} \tag{10}$$

Solving the maximisation problem for the monopoly, we get the equilibrium prices as

$$p^{M*} = \begin{cases} a - st & \text{if } st \leq \frac{a}{2} \\ \frac{a}{2} & \text{if } \frac{a}{2} < st \end{cases} \tag{11}$$

A.2 Two-product monopoly

The two-product monopoly can be computed in the same framework, as one firm setting prices p_i and p_{-i} simultaneously. The firm will use symmetric prices as, without fixed cost for the second product, it is always better to supply the upper half of the market line with the product located at the upper end than to supply it from the lower end of the market and vice versa. This leaves more utility with the consumers, which can be extracted through higher prices. Thus we get the symmetric prices $p_i = p_{-i}$ and the profit is given by

$$\Pi_i^{2M}(p_i|a,s,t) = \begin{matrix} [1] \\ [3] \end{matrix} \begin{cases} \frac{a-p_i}{st} \cdot 2 \cdot p_i & p_i > a - \frac{st}{2} \\ p_i & p_i \leq a - \frac{st}{2} \end{cases} \tag{12}$$

Solving for the equilibrium prices yields

$$p^{*2M} = \begin{cases} a - \frac{st}{2} & \text{if } st < a \\ \frac{a}{2} & \text{if } a \leq st \end{cases} \tag{13}$$

B Chow Test results

Table 2: The F-statistic and the associated p-values for the Chow test for the parameter stability at different $\bar{\zeta}$'s

increment	F	p	R^2
.25	2.218132	.136419	.5654151
.245	2.094088	.1478908	.5654117
.24	2.280698	.131014	.564586
.235	2.1578	.1418687	.5645825
.23	2.038049	.1534272	.564579
.225	1.921477	.1657146	.5645757
.22	2.729819	.0985114	.5672181
.215	2.879594	.0897294	.5672224
.21	2.79763	.0944247	.5656854
.205	1.596892	.2063639	.5622169
.2	1.499953	.2206978	.5622142
.195	.1695287	.6805369	.56202
.19	.0887485	.7657784	.5620067
.185	.0685921	.7934014	.5620061
.18	1.978202	.1596008	.5626864
.175	2.476331	.1155927	.5624058
.17	2.615331	.1058565	.562429
.165	2.786674	.0950722	.5624336
.16	3.745212	.0529778	.5608998
.155	2.042018	.1530274	.5609509
.15	5.64495	.0175182	.5626013
.145	2.282735	.1308421	.5620812
.14	9.525839	.0020297	.5621582
.135	79.31693	5.89e-19	.5661687
.13	82.42374	1.23e-19	.5652712
.125	53.00962	3.48e-13	.5628271
.12	52.13296	5.44e-13	.5628073
.115	40.56149	1.96e-10	.5638012
.11	12.34939	.0004424	.5638718
.105	6.764859	.0093062	.563678
.1	6.484803	.01089	.5636718
.095	6.206994	.0127354	.5636657
.09	15.73746	.0000731	.5644021

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