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Postprint / Postprint
Zeitschriftenartikel / journal article

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Empfohlene Zitierung / Suggested Citation:
Grzybowski, L. (2010). Screening Competition in Mobile Telephony. *Applied Economics*, 2155-2163. https://doi.org/10.1080/00036840903153788

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https://nbn-resolving.org/urn:nbn:de:0168-ssoar-242764

Screening Competition in Mobile Telephony

Journal:	*Applied Economics*
Manuscript ID:	APE-07-0663.R1
Journal Selection:	Applied Economics
Date Submitted by the Author:	22-Jan-2009
Complete List of Authors:	Grzybowski, Lukasz; UK Competition Commission
JEL Code:	L40 - General < L4 - Antitrust Policy < L - Industrial Organization, L41 - Monopolization|Horizontal Anticompetitive Practices < L4 - Antitrust Policy < L - Industrial Organization, L96 - Telecommunications < L9 - Industry Studies: Transportation and Utilities < L - Industrial Organization
Keywords:	

Screening Competition in Mobile Telephony *

Lukasz Grzybowski[†]

Abstract

This paper presents a simple method for screening competition in differentiated products oligopoly with a small number of competitors. In many situations, estimation of price elasticities of demand may be impossible due to difficulties in defining demand or missing data on sales. However, even without information on price elasticities, in certain situations it is possible to test for the static non-cooperative Nash-Bertrand equilibrium, which in the case of rejection, may be important screening information for antitrust authorities. The static non-cooperative Nash-Bertrand equilibrium may be rejected when demand is linear and in the estimation of best-response functions, the coefficients on the competitors' prices are statistically greater than 0.5. The application of this method is illustrated by the example of German mobile telephony using monthly data between January 1998 and December 2002. According to the estimation results, the observed prices in the segment of low-users cannot be the outcome of a static non-cooperative Nash-Bertrand equilibrium.

Keywords: collusion; best-response functions; mobile telephony.

JEL Classification: L13, L41, L96.

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[*] The opinions expressed in this article reflect only the author's view and in no way bind the institution to which he is affiliated.

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1 Introduction

This paper is concerned with competition in the mobile telecommunications industry. A simple method for testing static non-cooperative Nash-Bertrand equilibrium is presented and applied to mobile telecommunications industry in Germany using monthly data between January 1998 and December 2002.

In general, mobile telecommunications industries are oligopolies with a small number of competitors and institutionally regulated entry. Mobile telephony seems to be also characterized by other necessary and important ingredients for collusion to be sustainable (see Rey (2000)). Firms interact frequently and may react quickly to changes in competitors' prices, i.e. a new tariff may be marketed within a very short period of time, probably even a month. The innovation, which is observed in mobile telecommunications industry, such as the introduction of pre-paid cards, SMS, MMS, etc. can be very quickly imitated by competitors. Furthermore, there are structural links between network operators, because they have to sign bilateral interconnection agreements. In many countries we may also observe symmetry of market shares. However, the asymmetry of shares is not uncommon and network operators may significantly differ in cost structure, which may disturb incentives for collusion.[1] Because of these structural characteristics the mobile telecommunications industry is perceived as an industry in which tacit or explicit collusion may be suspected.[2]

Detection of collusion and cartels is one of the critical issues in antitrust and there is an overwhelming number of theoretical and empirical studies on this subject. This paper presents a simple method for testing static non-cooperative Nash-Bertrand equilibrium. It is based on a stylized framework for differentiated products competition with linear demand functions and uses market level data.[3] When there is a change from competition to collusion, the slopes of

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[1] Other factors which influence incentives to collude are: market transparency, product differentiation, demand growth and fluctuations, buying power of consumers, multimarket contacts, network effects, etc.

[2] In France, for instance, the Competition Authority found written evidence on information sharing and on market shares fixing agreement. The Competition Authorities in Spain and Ireland found collective dominance in their mobile telecommunications industries.

[3] Since competition and collusion are not contrasted directly this method may be classified as screening, see discussion in Harrington (2005).

best-response functions become steeper and the intercepts move towards the origin. The non-cooperative Nash-Bertrand best-response functions should not in general be too steep and, in particular, their slopes cannot be greater than 0.5. When firms jointly maximize their profits, in certain situations, best-response functions may have slopes greater than 0.5.[4] Therefore, when in the estimation of best-response functions the coefficients of competitors' prices are statistically greater than 0.5, one may state that the observed prices do not result from the static non-cooperative Nash-Bertrand equilibrium. Importantly, this framework does not require estimation of price elasticities of demand, which in many situations may be impossible due to difficulties in defining demand or missing data on sales. If information on diversion ratios is not available and the estimates of the coefficients on competitors' prices are smaller than 0.5, static non-cooperative Nash-Bertrand equilibrium cannot be rejected. However, if it is possible to estimate demand functions or get information on diversion ratios from elsewhere, a particular market equilibrium could be tested. This method is then an alternative to the estimation of a structural model of demand and supply.

The application of this method is illustrated on the case of mobile telephony in Germany using monthly data between January 1998 and December 2002. According to the estimation results of the best-response functions, the observed prices cannot result from a static non-cooperative Nash-Bertrand equilibrium.[5]

The remainder of this paper is organized as follows. Section 2 presents a literature review. Section 3 introduces the empirical framework. Section 4 provides an overview of the German mobile telephony and presents the data and estimation results. Section 5 contains the conclusions.

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[4] This method is applicable to markets with a small number of competitors, in which demand is well approximated by a linear function. It should be possible to estimate best-response functions in these markets and the diversion ratios for some products must take particularly large values, i.e. products of colluding firms must be relatively close substitutes.

[5] The German Competition Authority has not raised any concerns regarding competition in mobile telecommunications industry.

2 Literature Review

This paper refers to studies on competition in the mobile telecommunications industry and detection of cartels. There is a large body of literature on estimation of demand for telecommunications services but studies which assess the degree of competition either by estimating structural models of demand and supply or in other ways are rather scarce. For instance, Grzybowski and Pareira (2007) estimate nested logit demand for aggregate data and simulate a merger in mobile telephony in Portugal. Kim (2006) uses aggregate data on Korean mobile telecommunications industry to estimate a dynamic structural model of switching decisions between tariff plans and network operators. She finds that the magnitude of switching costs varies across networks and that a change in the variety of optional plans and plan characteristics play a role in the consumer switching decision.

Recent reviews of economic research on the detection of cartels may be found in Porter (2005) and Harrington (2005). In general, collusion may be detected if there are structural breaks in the market data. For instance, sharp changes in the price cannot be typically explained by changes in cost and demand. They are inconsistent with competitive theory but consistent with theories of collusive pricing under imperfect monitoring (see Green and Porter (1984)).

According to Harrington (2005) the empirical methods for cartel detection may be classified as screening and verification methods. Screening methods provide evidence that firms do not behave competitively but do not provide evidence of collusion. Verification methods directly contrast competition and collusion as alternative explanations for the observed behavior of firms. There is a large body of empirical studies of both types. In particular, screening methods were developed and applied for empirical analyses of procurement auctions. These studies commonly estimate reduced form bidding equations by regressing price on cost and demand shifters. Bidding equations for suspected cartel members should be statistically different from bidding equations for non-colluding firms. Afterwards, one may check whether bidding by non-colluding firms is consistent with a competitive model and bidding behavior of colluding firms is consistent with a model of collusion. Examples of such studies are: Porter and Zona (1993) on the procurement auctions for high-way-paving jobs, Porter and Zona (1999) for school milk, Bajari and Ye (2003) for seal coating.

Many other studies, reviewed in Harrington (2005), try to screen industries for the presence of cartels by analyzing the patterns of prices and market shares. In particular, under certain conditions, the variance of price is lower for collusion. Abrantes-Metz et al (2005) develop a screening method in terms of price variance. Moreover, parallel price movements are commonly perceived as a collusive marker, which, however, may not be true, as illustrated by Buccirossi (2006).

The literature mentioned above and others suggests that detecting collusion is very difficult. The empirical methods at hand are data demanding and often limited.

3 Empirical Model

A differentiated products industry is considered, in which firms strategically choose prices and play static Nash-Bertrand game. The profits of a single product firm j in period t may be written as:

$$\Pi_{jt}(p_{jt}, p_{-jt}) = (p_{jt} - mc_{jt}) D_{jt}(p_{jt}, p_{-jt}) - F_{jt}, \tag{1}$$

where p_{jt} represents price, mc_{jt} is marginal cost, $D_{jt}(.)$ is the demand, F_{jt} represents fixed cost of firm j and p_{-jt} is a vector of prices of competitors.[6] The first order condition may be written as:

$$D_{jt}(p_{jt}, p_{-jt}) + (p_{jt} - mc_{jt}) \frac{\partial D_{jt}(p_{jt}, p_{-jt})}{\partial p_{jt}} = 0. \tag{2}$$

Demand functions are assumed to be linear:

$$D_{jt}(p_{jt}, p_{-jt}) = a_{jt} + \sum_{k=1}^{J} b_{jk} p_{kt}, \tag{3}$$

for which $\frac{\partial D_{jt}(p_{jt}, p_{-jt})}{\partial p_{kt}} = b_{jk}$. For given demand function, the system of FOCs (3) may be written as a system of j Nash-Bertrand best-response functions in the form:

$$p_{jt} = -\frac{a_{jt}}{2b_{jj}} + \frac{mc_{jt}}{2} - \frac{1}{2b_{jj}} \sum_{k \neq j} b_{jk} p_{kt}, \tag{4}$$

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[6] If the price elasticities may be estimated in a trustable way, the main problem remains lack of information on marginal costs. However, when the determinants of marginal costs are observed, markups may be estimated and a collusive market conduct can be tested against the competitive one (for a literature review and discussion see Bresnahan (1987) and Reiss and Wolak (2006)).

In the case of an industry in which some firms collude, the best-response functions for colluding firms may be written as:

$$p_{jt} = -\frac{a_{jt}}{2b_{jj}} + \frac{mc_{jt}}{2} - \frac{1}{2b_{jj}} \sum_{k \in cartel} (b_{jk} + b_{kj}) p_{kt} - \frac{1}{2b_{jj}} \sum_{k \notin cartel} b_{jk} p_{kt} + \frac{1}{2b_{jj}} \sum_{k \in cartel} b_{kj} mc_{kt}, \quad (5)$$

while the best-responses for non-colluding firms are given by equation (4). Once, firms start colluding, their best-response functions become steeper and the intercepts move towards the origin.

The coefficients of the competitors' prices $\frac{b_{jk}}{2b_{jj}}$ in the non-cooperative best-response equation (4) represent a diversion ratio divided by 2, which in theory must be smaller than 0.5.[7] For an industry with a small number of competitors it should be possible to estimate a system of best-response functions given by (4) or (5), or a mixture of these two. If the coefficient of the prices of competitors is statistically greater than 0.5, then a static non-cooperative Nash-Bertrand equilibrium may be rejected. Thus, observed prices can be generated by the steeper cooperative best-response functions given by equation (5).

Mobile telecommunications services are commonly perceived as horizontally differentiated products. Empirical studies typically model demand for mobile access using discrete choice framework. In this study, a stylized linear differentiated products demand functions are used. The assumption of the functional form of demand is critical for the validity of the test. It is responsible for the appearance of a 2 in the denominators of equations (4) and (5), which results in a boundary value for the estimates of coefficients on competitors' prices, based on which competition and collusion may be distinguished. The consequence of the assumption of the functional form of demand on testing for market power in homogenous products framework is discussed by Bulow and Pfleiderer (1983). They show that a monopolist facing a linear demand curve will pass to consumers 50% of cost changes, while in general pass through rates can be higher or lower depending on the shape of the demand curve. The other underlying assumption is that cross-price effects are smaller than own-price effects, which is a common premise in theoretical models.

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[7] As in Shapiro (1996), diversion ratio from product A to product B is the fraction of sales lost by product A which is captured by product B due to a price increase of product A. It may be also interpreted as the proportion of people buying product A who consider product B as their second choice.

4 Empirical Implementation

4.1 Mobile Telephony in Germany

In 1992, Telecom Mobilnet and Mannesmann Mobilfunk started to provide mobile telecommunications services in Germany using digital networks. The first one was a subsidiary of state-owned telecommunications incumbent Deutsche Telekom, which was later privatized and transformed into T-Mobile. The second one was a private company, which was later taken over by Vodafone. In 1993 a third license was granted to E-plus, which began to provide mobile telecommunications services one year later. Another license was granted in 1997 to Viag Interkom (later called O2) which started providing mobile telecommunications services in November 1998.

In 2000, six companies received licenses to develop UMTS networks: Group 3G (Quam), T-Mobil, Mannesmann-Vodafone, Auditorium, Mobilcom Multimedia and O2.[8] One of the license winners, Quam, entered the market in November 2001 by signing roaming agreements with active network operators. It acquired about 200,000 consumers but subsequently went bankrupt one year later.

Network operators may sell services to consumers directly or indirectly through independent service providers (ISPs). In general an ISP resells airtime on a third party's mobile telecommunications network by providing billing and customer care services under its own brand name. In Germany network operators can commercially decide whether to sign an ISP agreement. According to the German Telecommunications Act the agreements between network operators and ISPs have to be non-discriminatory and assure fair competition between retailers. Typically, the tariffs offered by ISPs reflect tariffs of the network carriers.

In 2003, there were four network operators – T-Mobile, D2 Vodafone, E-Plus and O2 – and about twelve ISPs. Only O2 did not reach any agreement with ISPs. Out of these firms, only eight had significant market shares – network operators: T-Mobil (29.9%), D2 Vodafone (27.7%), E-Plus (9.3%), O2 (6.3%) and ISPs: Debitel (12.7%), Mobilcom (6.5%), Talkline (3.2%), Drillisch (2.4%). The remaining ISPs accounted for only about 2.0% of subscribers.[9] Be-

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[8] This technology allows data to be transferred at much higher rates in order to satisfy the demands of multimedia applications.

[9] Source: www.RegTP.de

cause of the market structure and pricing dependence, it is assumed that only network operators compete with each other.

4.2 Data

The estimation of best-response functions requires data on firm-specific prices, marginal costs and demand factors, as given by equations (4) and (5). Such a detailed firm-level information is not available publicly. The Federal Statistical Office (FSO) in Germany provides separate CPI indices for fixed line and mobile telephony. Four different price indices are computed for mobile telecommunications services – three different user profiles: infrequent, average and frequent users, and an aggregate index.

Firm-specific price indices used in this study are computed based on user profile methodology, which is similar to the one used by the FSO (see Beuerlein (2000).[10] Tariff information for Germany was collected from the price listings published in telecommunications magazine "Connect" and on the Internet in the time period January 1998 – December 2002. The price indices are computed for a consumer who uses mobile telecommunications services infrequently so that he is interested in purchasing a pre-paid tariff rather than a contract. The number and length of phone calls, as well as distribution of calls among destination networks and time-zones are randomized. Moreover, the simulation accounts for price discrimination between on-net and off-net calls.

The following algorithm is used for the calculation of firm-specific price indices. An infrequent mobile telephony user is assumed to make on average 15 calls per month (uniform distribution from the interval [10,20]). An average length of a call is 2 minutes (Poisson distribution with $\lambda = 20$ seconds multiplied by 6). The distribution among destination networks is proportional to the market shares. The peak time is assumed to be the same for all tariffs, between 8am and 8pm on weekdays. The distributions over days and hours of the day are uniform. Then, for the first draw, for all tariffs available on the market in a given month, the expected bill value

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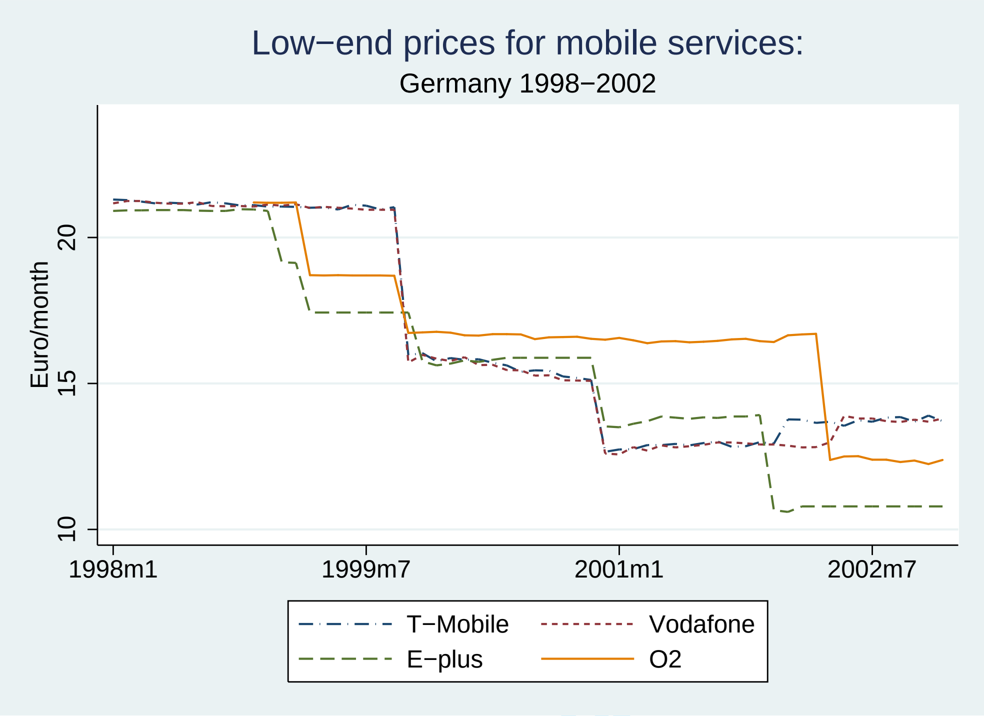
[10] A similar approach was also used by the Irish Commission for Communications Regulation in its analysis of wholesale mobile access and call origination. This analysis was a basis for the assessment of collective dominance in mobile telecommunications industry in Ireland. See Commission for Communications Regulation (2004) "Market Analysis - Wholesale Mobile Access and Call Origination."

is computed. The simulation of monthly calls is repeated 1000 times and an average bill value is calculated. The cheapest tariffs offered by each firm constitute firm-specific price indices (see Figure (1)).

Figure 1:



The FSO provides also country-level information on potential marginal cost factors, such as the cost of labor, capital and electronic equipment (see Table (1)), which are used as exogenous explanatory variables in the regression of best-response functions. Moreover, the time trend may be a component of the cost function and could be interpreted as technological innovation. As described in the previous section, two market entries took place in the time period of this analysis. The first one, of O2, took place in November 1998 and the second one, of Quam, in November 2001. Prices of these firms are not used in the regressions but instead, the best-response functions are allowed to react to entries through parallel shifts.[11]

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[11] As can be seen on the Figure (1), prices of T-Mobile and Vodafone did not react to these entries, while E-plus reacted by price decreases.

Apart from cost determinants, the regressions should also include demand factors. Demand for mobile telecommunications services may depend on the network quality, i.e. reception quality and coverage. By January 1998 all three network operators: T-Mobile, Vodafone and E-plus were on the market sufficiently long to provide coverage for the whole country area. Thus, it may be expected that there were no significant changes in the network quality between January 1998 and December 2002. Other important issues are handset subsidies and advertising. Unfortunately, due to lack of data on these factors, they cannot be accounted for in this analysis. Potentially, the improving quality of handsets may show up in the time trend as stimulating demand. On the other hand, firms tend to reduce their subsidies over time, which may have a negative impact on the demand.

A number of empirical studies suggest the presence of network effects in mobile telecommunications industry. The demand for mobile telecommunications services could be stimulated by the number of current users. In particular, consumers may value to subscribe to a larger network more than to a smaller one. Thus, lagged own network market shares are used in the regressions as a proxy for firm-specific network effects. Since network effects are supposed to stimulate demand, they should show up with a positive sign in the regressions of best-response functions. Moreover, if there are high switching costs in mobile telecommunications industry, greater market shares may induce firms to charge higher prices to exploit locked-in consumers. The information on market shares in terms of subscriptions was provided by the Federal Network Agency.

The best-response prices are regressed on the variables discussed above and the prices of competitors, which are endogenous and require instrumental variables estimation method. The exogenous explanatory variables from the model are used as instrumental variables. Cost factors are commonly used instrumental variables for prices. Entries of O2 and Quam were regulated and may be considered as exogenous. Price index for fixed line services is assumed to be exogenous. Fixed line markets in Germany were liberalized on January 1st, 1998. There has been an increasing number of entries and competition in the national and international markets, in particular. Moreover, lagged penetrations for mobile telecommunications services in Germany and dummies for third and fourth quarters are used as instruments. We also use the average price for mobile telecommunications services in France as an instrument for prices in Germany.[12] Prices of mobile telecommunications services in France and Germany may follow a common trend due to similarity of cost structures.

4.3 Estimation

Figure (1) shows that prices of mobile telecommunications services set by T-Mobile and Vodafone are almost identical with correlation of 0.998. Only between January 2002 and April 2002 prices differed by a negligible value. This means that these firms were able to form perfect conjectures about the prices set by the competitor in the next month. They lowered prices exactly in the same month and by the same value. The prices set by E-plus also match perfectly the prices of competitors for most of the time but, in addition, E-plus reacted to entries of O2 and Quam by lowering prices. The prices set by the entrant O2 also do not differ significantly from the prices of competitors. The differences visible in prices of E-plus and O2 in the form of a parallel shift upwards are partly due to differences in on-net and off-net prices and the distribution of calls according to market shares.[13]

The observed parallelism and the coordination in lowering prices by T-Mobile and Vodafone looks suspicious and may potentially indicate coordination of strategies. However, based on equation (4), one cannot exclude that identical prices result from a static non-cooperative Nash-Bertrand game. We may observe that two networks set identical non-collusive prices when demand factors, marginal costs, and own and cross-price elasticities with the other networks are very similar. T-Mobile and Vodafone have almost identical market shares since the startup of mobile telecommunications industry in Germany, which may be due to similar cost structure. The collusive best response prices given by equation (5) may be similar under the same conditions.

Also, lack of reaction of T-Mobile and Vodafone to the entry of O2 and Quam does not allow to distinguish collusive and non-collusive price setting. Entry has no effect on the best-response

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[12] First, price indices for the network operators in France are computed in an analogous way as for Germany. Then, industry-level price is constructed by weighting the individual prices by market shares.

[13] List prices in these periods may be the same for all four network operators but, for instance, in 2003, the share of E-Plus was 14.3% and of O2 only 6.3%.

function when it does not change own-price elasticity and the cross-price elasticity with the entrant is close to zero, i.e. the diversion ratio is almost zero. Basically, a non-collusive entry has the same effect on collusive and non-collusive prices. Therefore, in general, it is not possible to distinguish between collusive and non-collusive best-response prices as long as information on own and cross-price elasticities is not available.

The network operators T-Mobile, Vodafone and E-plus are numbered by 1,2 and 3, respectively. Since the observed prices of T-Mobile and Vodafone are basically the same, we may substitute $p_{2t} = p_{1t}$ in the FOCs. In the case of competition we have a system of FOCs given by equation (4). In the case of collusion among all three network operators we use equation (5). When only T-Mobile and Vodafone collude and E-plus maximizes profits non-cooperatively we have a system of equations (5) for the first two operators and equation (4) for E-plus.[14] Thus, in a general form, we have a following system of three equations to estimate:

$$\begin{cases} p_{1t} = \alpha_1 x_{1t} - \beta_1 p_{3t} + \varepsilon_{1t} \\ p_{2t} = \alpha_2 x_{2t} - \beta_2 p_{3t} + \varepsilon_{2t} \\ p_{3t} = \alpha_3 x_{3t} - \beta_3 p_{1t} + \varepsilon_{3t} \end{cases} \tag{6}$$

where x_{it} are the vectors of demand and cost factors and ε_{it} represent normally distributed error terms.[15] The slopes in these three situations take the following values:

$$\begin{cases} \beta_1 = \frac{b_{13}}{2b_{11}+b_{12}}, \beta_2 = \frac{b_{23}}{2b_{22}+b_{21}}, \beta_3 = \frac{b_{31}}{b_{33}} & \text{all compete;} \\ \beta_1 = \frac{b_{13}}{2(b_{11}+b_{12})}, \beta_2 = \frac{b_{23}}{2(b_{22}+b_{21})}, \beta_3 = \frac{b_{31}}{b_{33}} & \text{only T-Mobile and Vodafone collude;} \\ \beta_1 = \frac{b_{13}+b_{31}}{2(b_{11}+b_{12})}, \beta_2 = \frac{b_{23}+b_{32}}{2(b_{22}+b_{21})}, \beta_3 = \frac{b_{31}+b_{13}}{b_{33}} & \text{all collude.} \end{cases}$$

When demand functions are not estimated and information on diversion ratios is missing, it is not possible to test which equilibrium fits best the data. However, as already discussed, if in the estimation of best-response functions, some slopes on competitors' prices are greater than 0.5,

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[14] It is assumed that mobile network operators set their prices independently to the prices of fixed-line services. In the case of a price increase by one network operators, the second choice would be almost certainly subscription to another network. There are very few consumers who completely give up the usage of mobile telecommunications services. Also the European Commission in a number of decisions has established that mobile telecommunications services cannot be regarded as a substitute to fixed line telephony services.

[15] Given that $p_{2t} = p_{1t}$, the first two equations are the same. Nevertheless, both equations are estimated.

then the cases of non-cooperative Nash-Bertrand equilibrium and collusion between T-Mobile and Vodafone can be rejected.

The estimation results are presented in Table (2) for SURE estimation and in Table (3) for GMM estimation. According to the Hausman J test the exogeneity of the prices of competitors may be rejected. In the regression of prices of T-Mobile and Vodafone on the prices of E-plus, the coefficients are significantly greater than 0.5, which rejects the static non-cooperative Nash-Betrand equilibrium and the case of collusion between T-Mobile and Vodafone only. This may be an important screening information for the German Competition Authority. In fact, these coefficients should be smaller than 1. In all three regressions in Table (3) their equality to values smaller than 1 cannot be rejected.

The regressions show some dependence of the best-response prices on the cost factors: the cost of labor and electronic equipment, in the case of T-Mobile and Vodafone. Pricing by E-plus seems not to be determined by the cost factors. There is even a negative dependence, which is counterintuitive. Greater lagged market share leads to lower current period prices in the case of T-Mobile and Vodafone, but higher for E-plus. The entry of Viag and Quam was basically ignored by T-Mobile and Vodafone, while E-plus reacted with price decreases. Finally, prices of fixed line services are insignificant in the GMM estimation and time trend is significant in the case of T-Mobile and Vodafone.

5 Conclusions

This paper presents a simple method for testing static non-cooperative Nash-Bertrand equilibrium and illustrates its application to mobile telephony in Germany.

In many situations estimation of price elasticities of demand may be impossible due to difficulties in defining demand or missing data on sales. However, even without information on price elasticities, in certain situations it is possible to test for a static non-cooperative Nash-Bertrand equilibrium.

When there is a change from competition to collusion and demand functions are linear, the slopes of best-response functions become steeper and the intercepts move towards the origin. The non-cooperative Nash-Bertrand best-response functions should not in general be too steep and, in particular, their slopes cannot be greater than 0.5. Therefore, if in the estimation of best-response functions the coefficients on the competitors' prices are statistically greater than 0.5, it may be definitely stated that the observed prices do not result from a static non-cooperative Nash-Bertrand equilibrium. Moreover, when it is possible to estimate demand functions or get information on diversion ratios from elsewhere, a particular equilibrium can be tested. This method is then an alternative to the estimation of a structural model of demand and supply.

The application of this method is illustrated on the example of German mobile telephony using monthly data between January 1998 and December 2002. According to the estimation results, observed prices for the segment of low-users cannot be the outcome of static non-cooperative Nash-Bertrand equilibrium. This may be important market screening information for the German Competition Authority.

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6 Appendix

Table 1: Simple Statistics

Variable	Obs	Mean	Std	Min	Max
price T-Mobile (Euro/100)	60	0.1656	0.035	0.126	0.213
price Vodafone (Euro/100)	60	0.1647	0.035	0.125	0.212
price E-plus (Euro/100)	60	0.1565	0.035	0.106	0.209
price fixed (index)	60	1.0741	0.129	0.958	1.297
electronic	60	0.9223	0.035	0.866	0.983
labor (index)	60	1.1808	0.044	1.097	1.263
lagged share T-Mobile	60	0.2306	0.123	0.064	0.393
lagged share Vodafone	60	0.2255	0.115	0.060	0.362
lagged share E-plus	60	0.0778	0.039	0.018	0.122
time	60	0.3050	0.174	0.010	0.600
Quam dummy	60	0.2166	0.415	0.000	1.000
Viag dummy	60	0.8500	0.360	0.000	1.000
avg.price Germany (Euro/100)	60	0.1623	0.034	0.121	0.211
avg.price France (Euro/100)	60	0.0629	0.013	0.042	0.089

Table 2: Estimates of Best-Response Functions (SURE)

Variable	Est.	z	$P > \|z\|$	[95% Interval]
T-Mobile				
price E-plus	.931	6.56	0.000	[.653, 1.210]
price fixed	-.069	-1.81	0.070	[-.144, .005]
Quam dummy	.023	4.63	0.000	[.013, .032]
Viag dummy	.046	7.67	0.000	[.034, .059]
lagged share	-.094	-2.05	0.041	[-.185, -.004]
time	-.143	-2.01	0.045	[-.283, -.003]
labor	.679	5.02	0.000	[.414, .945]
electronic	.568	3.00	0.003	[.197, .939]
intercept	-1.196	-5.13	0.000	[-1.654, -.739]
Vodafone				
price E-plus	.949	6.65	0.000	[.669, 1.229]
price fixed	-.049	-1.25	0.211	[-.127, .028]
Quam dummy	.023	4.82	0.000	[.014, .033]
Viag dummy	.041	6.51	0.000	[.028, .053]
lagged share	-.095	-2.05	0.040	[-.186, -.004]
time	-.159	-2.30	0.022	[-.295, -.023]
labor	.742	5.38	0.000	[.471, 1.013]
electronic	.477	2.51	0.012	[.104, .851]
intercept	-1.207	-5.14	0.000	[-1.668, -.746]
E-plus				
price Vodafone	.540	6.14	0.000	[.368, .713]
price fixed	.068	2.18	0.029	[.006, .129]
Quam dummy	-.017	-4.20	0.000	[-.024, -.009]
Viag dummy	-.033	-6.72	0.000	[-.043, -.024]
lagged share	.094	0.65	0.516	[-.190, .379]
time	.049	0.80	0.425	[-.071, .170]
labor	-.357	-2.76	0.006	[-.610, -.103]
electronic	-.233	-1.49	0.136	[-.539, .073]
intercept	.630	3.06	0.002	[.227, 1.034]

Table 3: Estimates of Best-Response Functions (GMM): Equation by Equation

Variable	Est.	z	$P > \|z\|$	[95% Interval]
T-Mobile				
price E-plus	1.202	7.36	0.000	[.882,1.522]
price fixed	-.055	-1.44	0.149	[-.130, .019]
Quam dummy	.028	4.48	0.000	[.016, .041]
Viag dummy	.052	10.48	0.000	[.042, .062]
lagged share	-.053	-1.05	0.296	[-.153, .046]
time	-.100	-1.42	0.156	[-.238, .038]
labor	.506	3.51	0.000	[.224, .789]
electronic	.489	2.83	0.005	[.150, .828]
intercept	-1.005	-4.06	0.000	[-1.491,-.520]
Hansen J test		22.82	0.001	
Centered R2		0.93		
Vodafone				
price E-plus	.871	4.48	0.000	[.490,1.252]
price fixed	-.013	-0.36	0.716	[-.083, .057]
Quam dummy	.022	4.06	0.000	[.011, .033]
Viag dummy	.035	6.36	0.000	[.024, .045]
lagged share	-.099	-2.19	0.028	[-.187,-.010]
time	-.133	-2.10	0.036	[-.258,-.008]
labor	.689	5.24	0.000	[.431, .947]
electronic	.429	2.65	0.008	[.112, .746]
intercept	-1.131	-5.16	0.000	[-1.560,-.701]
Hansen J test		23.23	0.001	
Centered R2		0.95		
E-plus				
price Vodafone	.464	3.72	0.000	[.219, .709]
price fixed	.040	1.12	0.261	[-.030, .111]
Quam dummy	-.020	-4.08	0.000	[-.030,-.010]
Viag dummy	-.033	-13.06	0.000	[-.038,-.028]
lagged share	-.052	-0.44	0.658	[-.285, .179]
time	.040	0.89	0.374	[-.048, .129]
labor	-.247	-1.99	0.046	[-.491,-.003]
electronic	-.178	-1.55	0.120	[-.403, .046]
intercept	.508	2.73	0.006	[.143, .874]
Hansen J test		12.058	0.017	
Centered R2		0.97		