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Working Paper #07-24

September 2007

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Competition in Mobile Telephony in France and Germany*

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Abstract

This paper provides an insight into the antitrust investigation initiated by the French competition authority, which found that mobile operators exchanged strategic information and agreed to fix market shares in years the 2000-2002. The empirical analysis is based on the comparison of mobile markets in France and Germany and uses aggregate industry-level data on subscriptions and prices. The penetration of mobile phones at the end of 1999 was higher in France than in Germany, but this situation was reversed by the end of 2002. In the same time period, minimum prices of mobile services in France, computed for a defined low-usage basket, were on average by about 58% lower than the corresponding prices in Germany. The results of binomial logit demand estimation suggest two explanations for this situation. First, there is a significant difference between price elasticities of demand in these two countries. Second, consumers seem to perceive mobile telephony as a substitute to fixed-line connection in France and as a complement in Germany. However, in a separate reduced-form estimation we do not find a significant effect of prices for fixed-line services on mobile prices in either country. Furthermore, the estimation results suggest that the share-fixing agreement in France could have slowed down subscriptions, but we fail to find that it had an adverse effect on prices.

Keywords: mobile telephony, binomial logit, reduced-form, share-fixing.

JEL Classification: L13, L96.

*Financial support from the NET Institute, www.NETinst.org, is gratefully acknowledged. The opinions expressed in this article reflect only the authors' views, and in no way bind the institutions to which they are affiliated.

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1 Introduction

Mobile telecommunications markets in the European Union are oligopolies with a small number of competitors, ranging between 2 and 4, and regulated entry. In recent years, in a few countries, national competition authorities raised concerns about collective dominance and the potential for tacit or explicit collusion in mobile industries. For instance, the Irish and Spanish competition authorities found that there was collective dominance in their mobile markets. Their views were subsequently endorsed by the European Commission and remedies were imposed, i.e., entry of Mobile Virtual Network Operators (MVNOs) was allowed in both countries.[1]

In December 2005, after a four-year investigation, the French competition authority (CdC) found that three network operators, Orange, SFR and Bouygues, illegally shared sales data and conspired to undermine competition.[2] According to CdC the operators shared "precise and confidential" commercial information every month for six years and even agreed to freeze their market shares in 2000-2002.[3] The regulator said that "the existence of this collusion has been established through the recovery of serious, precise and consistent evidence, including handwritten documents explicitly mentioning an agreement between the three operators." "The market-share deal was concluded at a time when sales were slowing on the maturing French mobile market", the regulator said, "leading to increased prices for consumers as operators sought to squeeze profits from existing clients instead of competing for new subscribers." During the investigation, the three mobile networks admitted sharing confidential sales data, but argued unsuccessfully that it had not distorted competition and that they had not sought to freeze market shares.[4]

[1] A Mobile Virtual Network Operator provides mobile services to its customers, but does not have an allocation of spectrum. In general, an MVNO can set its own pricing structures, subject to the pricing structure agreed with the network operators. The first commercially successful MVNO was Virgin Mobile UK, which was launched in the United Kingdom in 1999 and now has over 4 million customers.

[2] See Conseil de la Concurrence (2005): "Décision n 05-D-65 du 30 novembre 2005 relative á des pratiques constatées dans le secteur de la téléphonie mobile."

[3] The three operators began exchanging sales data in 1997 and stopped the practice in late 2003, in response to the antitrust probe.

[4] The total fines imposed on the operators were the second-largest in European antitrust history and amounted to 534 million Euros. Orange vowed to appeal its 256 million Euros fine describing the penalty as "unfounded and excessive." SFR and Bouygues also said that they planned to challenge their respective penalties of 220 million Euros and 58 million Euros in the appeal courts. On the other hand, The French consumer group, UFC-Que Choisir, said that it may pursue the three operators on behalf of customers for civil damages, saying that "30 million subscribers had suffered a detriment totalling 1.2 billion Euros."

This paper provides an insight into this matter by comparing mobile markets in France and Germany. The empirical analysis is based on aggregate industry-level data on subscriptions and prices and consists of separate estimations of: (i) demand for mobile subscriptions using binomial logit model and (ii) reduced-form pricing equations.

An initial inspection of data on subscriptions and prices shows an interesting picture of mobile markets in France and Germany. The penetration of mobiles in France was initially higher than in Germany, but this situation was reversed in the middle of 2000 (see Figure 1). By the end of 2002, penetration in Germany was higher by about 10 percentage points than in France. This change could potentially indicate the presence of anticompetitive practices as suggested by the CdC, but it does not seem to be supported by a comparison of prices in both countries. In the same period, minimum prices of mobile services in France, computed for a defined low-usage basket, were by about 58% lower than corresponding prices in Germany. It is a surprising difference, because the number of competitors, market concentration, market size and the hypothesis of collusion in France, all suggest that we should potentially observe lower prices in Germany.[5] A few explanations are possible for this situation. First, the French network operators may be drastically more efficient, or marginal cost factors are significantly cheaper in France. However, due to bigger market size and potential economies of scale, network operators in Germany may be expected to have lower costs than in France. The differences in potential marginal cost factors, such as cost of labor and capital, are also relatively small between these two countries. Secondly, there is collusion in Germany and competition in France (or collusion in both countries). Thirdly, there are significant differences in price elasticities between these two countries.[6].

Demand estimation tries to shed light onto the last aspect. The empirical framework is based on aggregate data binomial logit model. Consumers are assumed to decide whether to subscribe to fixed telephony services only or to both mobile and fixed services. Mean utility levels of subscribing to mobile telephony services may be then imputed via a simple transformation of observed penetration of mobiles.

[5]For instance, in this period, the average Herfindahl index in France was 0.39, compared to 0.36 for Germany. In both countries, there was a small decrease in the index value throughout 1998, but afterwards it remained almost unchanged. The initial values in January 1998 were 0.43 for France and 0.40 for Germany and by December 2002, they were 0.39 and 0.34 respectively.

[6]Also, handsets are more heavily subsidized in Germany than in France. However, this comparison is based on low-usage pre-paid tariffs, for which consumers have to pay full price for the handset

Demand for mobile phones is found to be more elastic in France than in Germany. Moreover, demand estimates suggest that there may be also another explanation for observed differences in subscriptions and prices. Consumers seem to perceive mobile telephony as a substitute to fixed-line services in France and as a complement in Germany. Thus, network operators in France may have to compete with fixed-line providers, which results in lower market prices. On the other hand, decreases in fixed-line prices in Germany stimulate demand for mobiles, without imposing a competitive pressure on mobile providers.

In a separate supply side estimation, industry-level prices are regressed on marginal cost and demand factors. Mobile prices in both countries are found to be independent on the prices of fixed-line communications. Furthermore, we fail to find that the share-fixing agreement had an adverse effect on prices.

[*Figure* 1]

The empirical results of this analysis are useful for antitrust investigations of mobile markets. The European Commission and the national competition authorities, in a number of decisions on mobile communications services, used product market definitions which excluded fixed-line communications services. The Commission claimed that mobile communications services cannot be seen as being substitutable for fixed communications services, because of the mobility inherent in all mobile services, i.e., mobile numbers are associated with individuals on the move, rather than with a fixed location.[7] This analysis suggests that fixed-line services can be a substitute to mobile telephony and that product market definition may be, in fact, country specific.

The next section provides a short overview of the empirical literature on the telecommunications industry. Section 3 presents a brief history and outlines current state of the mobile markets in France and Germany. The empirical model is presented in Section 4. Data description and estimation results follow in Sections 5 and 6, respectively. Section 7 provides some concluding remarks.

[7]See, for example, Commission Decision of 10 July 2002, Case No. COMP/M.2803 TeliaSonera, Commission Decision of 20 September 2001, Case No. COMP/M.2574 Pirelli/Edizone/Olivetti/Telecom Italia, Commission Decision of 20 September 2001, Case No. COMP/M.1439 Telia/Telenor and Commission Decision of 12 April 2000, Case No. COMP/M.1795 Vodafone Airtouch/Mannesmann.

2 Literature

There is a large body of literature on the estimation of demand for telecommunications services using industry and consumer-level data. For instance, Tishler et al. (2001) use data on consumers in Israel to estimate a multinomial logit model for the decision to purchase mobile telephones of different providers, a linear demand function for minutes of usage and a logistic diffusion model for aggregate subscriptions. Rodini et al. (2003) estimate the substitutability of fixed and mobile services for telecommunications access using data on US households. Barros and Cadima (2000) simultaneously estimate diffusion curves for mobile and fixed telephony in Portugal and find a negative impact of mobile penetration on fixed-line density. Okada and Hatta (1999) analyze the demand for mobile and fixed telephony services using Japanese data. They find that own-price elasticities and substitution effect are relatively high. Doganoglu and Grzybowski (2007) use a nested logit model to estimate the demand for subscription for mobile telephony in Germany. Their results suggest that network effects played a significant role in the diffusion of mobile telephony. Grzybowski and Pereira (2006) apply the same framework to merger simulation in mobile telephony in Portugal.

Another range of studies analyzes the diffusion of mobile technology worldwide using cross-country panel data. For instance, Gruber and Verboven (2001) estimate a logistic diffusion model for mobile subscriptions in the EU. They find, among other results, that the penetration rate of fixed telephony has a negative influence on the diffusion of mobiles. However, the results of similar studies for other countries suggest that mobile and fixed-line services may be complements, for instance, Gruber (1999) for Central and Eastern European countries, Gebreab (2002) for African countries, and Ahn and Lee (1999) for 64 countries worldwide. Hamilton (2003), using data on African countries, finds that mobile and fixed-line subscriptions may be both complements and substitutes at different stages of market development. In the early stage of diffusion, mobile services may be complementary to fixed-line telephones, but the substitution effect takes over once mobile usage becomes more widespread.

In summary, the results of empirical studies are ambiguous with respect to whether mobile and fixed-line services are substitutes or complements. However, in recent antitrust investigations, as mentioned before, product market definition for mobile communications excludes fixed-line services. This study suggests that mobile and fixed-line services may be substitutes or complements, even for countries which are very similar in socioeconomic terms.

3 Mobile Telephony in France and Germany

The era of mass mobile telecommunications in the European Union started in the early 1980s with the first generation analog systems, such as Nordic Mobile Telephone (NMT), British Extended Total Access Communication System (ETACS) and the German standard (C-450). The licenses for providing analog mobile services were granted to state-owned, fixed-line monopolies, with the exception of France, the United Kingdom and Sweden, where duopolies were created. Because of capacity constraints, incompatibility, low quality and security, the analog systems have been phased out. Meanwhile, the European countries decided to introduce common technology platforms, GSM-900 and later DCS-1800, to allow for pan-European roaming. This time the licenses were not exclusively granted to the incumbent operators. Licensing policies varied by countries, which allowed for a different number of operators and simultaneous or sequential market entries. After 2000, European governments began auctioning licenses for UMTS standard, commonly referred to as 3G technology. The main advantage of 3G is much faster data transmission speeds than GSM, which allows for high bandwidth data services, including multimedia services, such as real time video and broadband Internet access.

In 2006, there were 83.1 million subscribers to mobile telephony in Germany and 49.8 million in France, which amounts to about 27.8% of the mobile market in the European Union of approximately 478.4 million subscribers. The penetration rate was about 103% in the EU as a whole. Mobile telephony, with revenue of 133 billion Euros, accounted for 46% of total revenues in the telecommunications industry in the European Union.

3.1 Germany

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

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 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 ensure fair competition between retailers. Typically, the tariffs offered by ISPs reflect the tariffs of the network carriers.[8]

In August 2000, six companies received licenses to develop UMTS networks: Group 3G (Quam), T-Mobil, Mannesmann-Vodafone, Auditorium, Mobilcom Multimedia and O2. This technology allows data to be transferred at much higher rates in order to satisfy the demands of multimedia applications. One of the license winners, Quam, entered the market in November 2001 by signing roaming agreements with incumbent network operators. It attracted about 200,000 consumers but subsequently went bankrupt a year later.

In 2003, in Germany there were four network operators – T-Mobile, D2 Vodafone, E-Plus and O2 – and about twelve ISPs. Only O2 has not reached an agreement with any ISPs. 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]

3.2 France

In March 1992 two licenses for digital mobile services GSM 900 were granted to the fixed-line incumbent operator France Telecom Mobiles, and Societe Francaise de Radiotelephonie (SFR).[10] This duopoly structure existed until June 1996, when a third network operator, Bouygues Telecom, entered the market after being granted a license to operate digital technology GSM 1800.

After entry in 1996, Bouygues gained market share quite rapidly, which led to a significant decrease in industry concentration. This entry fostered competition, which resulted in lower prices and a proliferation of new tariff plans. The penetration rate in France grew from 4.2% for the year 1996 to 63.5% for the year 2002. However, in spite of a growing penetration rate, from 1998 the distribution of market shares among the mobile providers remained quite stable. The most recent entrant, Bouygues, did not manage to extend its market share considerably, with

[8] As discussed in the section on the data, the industry-level prices are computed using minimum tariffs of network operators only.

[9] Source: www.RegTP.de

[10] France Telecom marketed mobile services under the brand Itineris until May 2001 and afterwards changed its brand name to Orange. The main shareholders of SFR are Vivendi Universal and Vodafone.

about 15.9% of subscribers by the end of 2003. France Telecom remained the market leader with an almost stable share of 48.8%, followed by SFR with the share of 35.3%.[11]

In June 2001, the French government awarded two out of four UMTS licenses to France Telecom and SFR using a "beauty contest". Bouygues and several other players pulled out of the bidding due to the high license price. In 2002, the French authorities altered license conditions and published a new call for applications for the allocation of the two UMTS licenses not issued in the first round. Only Bouygues applied this time and received the license in October 2002.

4 Empirical Analysis

4.1 Demand Side

All consumers are assumed to have access to fixed-line services.[12] They decide between continuing to use fixed telephony only, or subscribing also to mobile services. The utility derived by consumer i from using fixed-line telecommunications services in period t is given by:

$$U_{ift} = r_f - \alpha_f p_{ft} + \gamma_f V_t + \xi_{jt} + \epsilon_{ift} = \delta_{ft} + \epsilon_{it}, \tag{1}$$

where r_f is the stand alone value of fixed-line services, p_{ft} is the price of fixed-line in period t, V_t is the expected network benefit in period t, which results from an increase in communications possibilities due to a larger number of mobile users, ξ_{ft} is the unobserved utility of fixed-line services, and ϵ_{ift} is an idiosyncratic taste variable.[13] The mean utility level of using fixed-line in period t is therefore denoted by δ_{ft}.

When consumers decide to use mobile services together with fixed-line, the utility of fixed-line may change, which is represented by $\lambda\delta_{ift}$, where $\lambda \geq 0$. Thus, the utility of using mobile

[11] Along with the three network operators, mobile services in France are also provided by MVNOs. However, by June 2005 they had only about 40 thousands consumers in total.

[12] In December 2005, 87% of households in Germany had fixed-line access, compared to 85% in France, see Eurobarometer (2006). These values should have been higher in the time period of this analysis.

[13] A number of empirical studies suggest that network effects are present in mobile telephony (see, for instance, Doganoglu and Grzybowski (2007)). The utility of fixed-line and mobile access may depend on the number of current users of telecommunications services. The number of fixed-line users is basically constant and may be represented by the whole population. In addition to voice telephony, mobile firms can offer several other services, such as SMS, MMS, WAP and email, which may themselves be subject to network effects. Thus, lagged penetration of mobile telephony is used in the regressions as a proxy for industry-wide network effects.

services together with fixed-line in period t is given by:

$$\begin{aligned} U_{imt} &= \lambda\delta_{ft} + r_m - \alpha_m p_{mt} + \gamma_m V_t + \xi_{mt} + \epsilon_{imt} \\ &= (\lambda r_f + r_m) - \lambda\alpha_f p_{ft} - \alpha_m p_{mt} + (\lambda\gamma_f + \gamma_m)V_t + (\lambda\xi_{ft} + \xi_{mt}) + \epsilon_{imt} \\ &= \delta_{mt} + \epsilon_{imt}, \end{aligned} \tag{2}$$

where δ_{mt} is the mean utility level of using fixed-line together with mobile services. After normalizing with respect to the mean utility of using fixed-line services only, i.e., δ_{ft}, equation (2) may be rewritten as:

$$\begin{aligned} \widetilde{U}_{imt} &= [(\lambda-1)r_f + r_m] - (\lambda-1)\alpha_f p_{ft} - \alpha_m p_{mt} + [(\lambda-1)\gamma_f + \gamma_m)V_t + \widetilde{\xi}_{mt} + \epsilon_{imt} \\ &= \widetilde{r}_m - \widetilde{\alpha}_f p_{ft} - \alpha_m p_{mt} + \widetilde{\gamma} V_t + \widetilde{\xi}_{mt} + \epsilon_{imt} \\ &= \widetilde{\delta}_{mt} + \epsilon_{imt}. \end{aligned} \tag{3}$$

When $\widetilde{\alpha}_f < 0$, which implies that $\lambda < 1$, the utility of fixed-line connection decreases when a consumer acquires a mobile telephone. Thus, mobile and fixed-line services are perceived as substitutes. On the other hand, for $\widetilde{\alpha}_f > 0$, the utility of fixed-line services increases, i.e., mobile and fixed-line services are complements.[14] The probability that consumer i subscribes to mobile services in addition to fixed-line in period t may be written as:

$$P_{imt} = Pr\big(\widetilde{\delta}_{mt} + \epsilon_{imt} > \epsilon_{ift}\big). \tag{4}$$

When ϵ_{ijt} has an extreme value distribution, this probability has a closed form given by:

$$P_{imt} = \frac{\exp(\widetilde{\delta}_{mt})}{1 + \exp(\widetilde{\delta}_{mt})}, \tag{5}$$

which is the same for all consumers and equals the share s_{mt} of consumers choosing in period t mobile services together with fixed-line. The share of consumers who choose not to subscribe to mobile telephony in period t is given by $s_{ft} = 1 - s_{mt}$. Following Berry (1994), the observed share of mobile subscribers can be inverted to compute the mean utility of using mobile services together with fixed-line, which for the specification in (3) may be written as:

$$\log(s_{mt}) - \log(1 - s_{mt}) = \widetilde{r}_m - \widetilde{\alpha}_f p_{ft} - \alpha_m p_{mt} + \widetilde{\gamma} V_t + \widetilde{\xi}_{mt}. \tag{6}$$

[14]Note that nobody gives up fixed-line connection. Substitution/complementarity with fixed-line influences the speed of diffusion of mobiles. In reality, some consumers resign from fixed-line. Unfortunately, there is no data available in the form of time series on the percentage of consumers who have: mobile phone only, fixed-line only and mobile plus fixed-line together.

The price elasticity of demand for mobiles in this framework is specified as:

$$\eta = -\alpha_j p_{jt}(1 - s_{mt}).$$

The elasticities of demand with respect to the price of fixed-line services and lagged penetration have analogous formulations.

Along with price and network effects represented by lagged penetration, dummies for the entry of O2 and Quam are used in the estimation for Germany, because demand could increase if consumers have preference for variety. For France, a dummy for the share-fixing period 2000-2002 is used in order to test whether there was any detrimental effect on subscriptions. Moreover, in both countries a dummy for November and December is included to account for higher demand in the months preceding Christmas, and a time trend to control for improvements in the quality of handsets and other technological innovations. The total number of consumers who can make subscription decisions, i.e., market size, is assumed to be equivalent to total population in each country.

The demand for mobile subscriptions is regressed on the market prices, which are endogenous and require an instrumental variables estimation method. The explanatory variables from the model are used as instruments. In particular, price indices for fixed-line services are assumed to be exogenous. Fixed-line markets in France and Germany were liberalized on January 1st, 1998. There has been an increasing entry and competition, especially in the national and international markets. Also, entries of O2 and Quam were regulated and may be considered as exogenous. Moreover, potential marginal cost factors are used as instruments, which is a common approach in the empirical literature. In addition, market prices in Germany are used as instruments for prices in France and vice versa. Prices may be correlated through common shocks to marginal costs, while demand shocks in France and Germany should be independent. Thus, the following set of instruments is used for Germany: $Z_t = [time_t,\ o2_t,\ quam_t,\ christmas_t,\ price - fixed_t,\ capital_t,\ labor_t,\ electronic_t,\ price - france_t]$, and analogously for France but without entry dummies. The identifying assumption is the mean independence of the demand shocks, given by $\widetilde{\xi}_{mt}$, with the set of instruments, i.e., $E(\widetilde{\xi}_{mt} \mid Z_t) = 0$.

4.2 Supply Side

In addition to demand estimation, the supply side is estimated separately for each country by a simple reduced-form regression of average market prices on demand and cost factors. The

purpose of this estimation is to test whether there was a price increase due to the share-fixing agreement and whether there is a dependence between mobile and fixed-line prices. The following pricing equation is estimated:

$$p_{jt} = X_{jt}\beta + MC_{jt}\gamma + \epsilon_{jt}, \tag{7}$$

where $j = 1, 2$ is the country subscript, $t = 1, ..., T$ is the time subscript and p_{jt} is the monthly basket price for mobile services, which construction is discussed in the data section. On the right-hand side X_{jt} are demand factors, i.e., the price of fixed-line, time trend, network effects approximated by lagged penetration, dummy for Christmas sales, dummies for entry of Viag and Quam in the case of Germany and a dummy for the period of share-fixing in the case of France. Marginal cost determinants MC_{jt} are represented by the country-level cost of labor, capital and electronic equipment. The term ϵ_{jt} represents unobservable demand and supply shocks which are assumed to be normally distributed and mean independent with the explanatory variables. Under this assumption, the ordinary least squares (OLS) method is a consistent estimation strategy.[15]

4.3 The Data

For the estimation of the aggregate demand function for mobile subscriptions, market price and information on demand factors are needed. In addition, for the estimation of the pricing regression, one needs information on marginal costs, which are also used as instruments for prices in the estimation of demand function. For each country there are 60 monthly observations from January 1998 to December 2002.

Firm-level subscriptions statistics for France were collected from the website of the French Telecommunications and Posts Regulator (ARCEP) and for Germany from the website of the Regulatory Authority for Telecommunications and Posts (RegTP).[16] Unfortunately, precise information on gross sales is not available. In fact, according to the CdC, exactly confidential information on gross sales was regularly exchanged among network operators in France. For

[15]Because of data limitations, i.e., lack of firm specific cost factors, and difficulties with estimation of firm specific demands, we do not attempt to estimate a structural model of demand and supply. A simple linear pricing regression seems to be a viable approach. Figure 3 shows changes in network operator prices in France, and Figure 2 in Germany. It may be difficult to explain observed price movements by changes in marginal cost and demand factors. In particular, in France, Bouygues seems to set almost constant prices between 1998-2002. There is also no visible dependence on competitors' prices.

[16]When monthly observations for France were not available, they were extrapolated using quarterly data.

this reason, instead of estimating firm-level demands, this paper focuses on aggregate demands for mobile subscriptions in France and Germany.

The market prices are computed using information on tariffs available each month on the market in France and Germany as described below. The computation is based on user profile methodology, which is similar to the one used by the Federal Statistical Office in Germany.[17] A similar approach was also used by the Irish Commission for Communications Regulation in its analysis of wholesale mobile access and call origination.[18]

Data on France have been collected from telecommunications magazines: "Phone House", "Journal de téléphone", "Mobiles magazine" in the time period January 1998 – December 2002. Tariff information for Germany has been collected for the same period of time from the price listings published in telecommunications magazine "Connect" and on the Internet [19]

First, firm-level price indices are computed for a consumer who uses mobile services infrequently, so that he is interested in purchasing a pre-paid tariff rather than contract. This is the consumer with the lowest valuation of mobile services and his decision to subscribe potentially determines market demand. The following algorithm is used for the calculation of firm-specific price indices. An infrequent mobile user is assumed to make on average 15 calls per month (uniform distribution from the interval [10,20]). The 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,

[17]The FSO provides separate CPI indices for fixed-line and mobile telecommunications. Four different price indices are computed for mobile services – three different user profiles: infrequent, average and frequent users, and an aggregate index. Network operators bundle different services together and frequently change mobile phone packages and tariffs. Thus, the construction of mobile price indices requires more effort than ordinary price tracking. Tariffs consist of many components, such as on-net, off-net, fixed-line, time zones, billing intervals and so on. The statistical office uses only the most important ones in the calculation of price indices. Consumers are assumed to be perfectly informed about the range of tariffs available each month on the market. For all tariffs within each usage profile, an expected monthly bill is calculated. Then consumers choose the cheapest one from each service provider. User profile indices and aggregate index for mobile services are computed using selected bills with appropriate weighting factors. The aggregating function used is the Laspeyers formula as a weighted arithmetic mean of price relatives (see Beuerlein (2000)).

[18]This analysis was the basis for the assessment of collective dominance in mobile telephony in Ireland. See Commission for Communications Regulation (2004).

[19]There are 2926 tariff-month observations for France and, 1457 for Germany in the time period January 1998 – December 2002. In the case of Germany, there are also tariffs offered by ISPs, which are not considered in this analysis.

between 8 am and 8 pm on weekdays. The distributions over days and hours of the day are uniform. Then, for the first draw, the expected bill value is computed for all tariffs available on the market in a given month. The simulation of monthly calls is repeated 1000 times and an average expected bill value is calculated. The cheapest tariffs offered by each firm constitute firm-specific price indices (see Figures 2 and 3).[20]

[*Figure* 2]

[*Figure* 3]

The market prices in France and Germany are computed as the share-weighted average of the cost of usage of mobile services for the cheapest tariff on the market offered by each network operator (see Figure 4). It may be interpreted as an expected market price.

[*Figure* 4]

As described in the Section 3, two entries took place in Germany in the period of this analysis. The first one, Viag (now O2), entered in November 1998 and the second one, Quam, in November 2001. Only prices of Viag are used in the computation of market prices because the number of Quam users was marginal.[21]

[20]There are some differences in the types of tariffs available in France and Germany. Mobile phone services in France are charged for in the following ways : (i) "Abonnement" - is a contract which often lasts for up to a year and requires a one-off payment for both handset and contract. Calls are charged per second/minute according to the time of day, etc. (ii) "Forfait" - is a contract for 12-24 months which provides a varying number of free minutes per month. The use of these free minutes may be restricted to certain times of day - e.g. off-peak, or to certain types of users - e.g. calls to subscribers on the same network. Calls in addition to free minutes, or calls during peak periods, for instance, are charged per second/minute. This tariff was first offered by Bouygues in August 1996. (iii) "Carte" - handset is bought separately and call vouchers are purchased. Vouchers may provide airtime access for a limited or unlimited period. In the first case vouchers expire within certain period of time if unused. Vouchers are sold in various denominations, with calls per minute typically being cheaper for the larger denomination vouchers. This tariff was first offered by France Telecom in March 1997. In Germany, mainly tariffs of type (i) and (iii) in unlimited version are offered. However, E-plus also offers tariffs of type (ii), which includes a non-transferable monthly volume of minutes.

[21]As can be seen in Figure 2, prices of T-Mobile and Vodafone did not react to these entries, while E-plus reacted with price cuts.

Price indices for fixed-line telecommunications are used in the form provided by statistical offices in France and Germany, as presented in Figure 5. Unfortunately, these indices are computed using different definitions and are not directly comparable.[22]

[*Figure* 5]

Demand and reduced-form pricing regressions should include non-price demand factors. Demand for mobile services may depend on the network quality, i.e., reception quality and coverage. By January 1998 the main network operators in Germany, T-Mobile, Vodafone and E-plus, as well as in France, Orange, SFR and Bouygues were sufficiently established in the market to provide coverage for the whole country. Thus, it may be expected that there were no significant changes in the quality of networks between January 1998 and December 2002.[23] Other important issues are handset subsidies and advertising. Unfortunately, due to a lack of data on these factors, they cannot be controlled 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 handset subsidies over time, which may have a negative impact on demand.

The statistical offices in France and Germany and Eurostat provide country-level information on potential marginal cost factors, such as the cost of labor, capital and electronic equipment (see Table 1). These variables are used as exogenous explanatory variables in the reduced-form pricing regressions and as instruments for prices in demand estimation. Moreover, the time trend may be a component of the cost function and can be interpreted as technological innovation.

5 Estimation Results

The results of OLS and GMM estimations for France and Germany separately are presented in Table 2. According to the Hansen test the null hypothesis that the over-identifying restrictions are valid, i.e., the instrumental variables are not correlated with the error term, cannot be rejected. Thus, GMM estimates are used for interpretation. The coefficients on mobile prices are significant in both countries. The equality of price coefficients countries can be rejected statistically. Mean price elasticities for the period analyzed and their standard deviations are

[22] There were drastic decreases in the prices of fixed-line services in France and Germany. The drop in prices in France could have been caused by the introduction of carrier pre-selection and fixed number portability which took place in January 2000. In Germany, these regulations were introduced in January 1998.

[23] This is confirmed by the statistics on coverage which are available for the network operators in France.

presented in Table 3. According to the estimation results, price elasticity for mobile subscriptions in France equals on average -0.75 and for Germany -0.27. Therefore, difference in price elasticities is a possible explanation at least for part of the observed price differences.

[*Table* 2]

Interestingly, the coefficient on the price of fixed-line services is positive for Germany and negative for France. Thus, fixed-line services are found to be complements in Germany and substitutes in France. This finding could also be a possible explanation for observed differences in prices and diverging diffusion rates of mobiles between France and Germany. It implies that network operators in France may have to compete with fixed-line providers, which results in lower market prices. On the other hand, decreasing prices of fixed-line in Germany stimulate demand for mobiles without imposing a competitive pressure on mobile providers.[24]

This hypothesis seems also to find support in the results of the household survey conducted by the European Commission across the EU member states (see Eurobarometer (2006)). According to this survey the substitution of mobile and fixed-line subscriptions seems to vary significantly across the EU countries. In particular, countries which are similar in socioeconomic terms, such as Finland and Sweden, may differ in the degree to which fixed-line subscriptions are substituted by mobiles. In 2005 in Sweden, 93% of households reported having access to both fixed-line and mobile services, while in Finland the figure was only 46%. At the same time, penetration of mobiles in both countries was close to 100%. The difference in numbers for France and Germany is not as great. However, in another question, consumers were asked whether they would give up fixed-line connection, if the prices of mobile and fixed-line services were equal. The percentage of consumers who answered this question positively was twice as high in France (29%) as in Germany (14%).

[*Table* 3]

The remaining results of demand estimation are as follow. There are significant network

[24]In fact, before 1998, the low-end prices of network operators in France were roughly at the same level as in Germany in January 1998, or even slightly higher. Unfortunately, comparable data on prices of mobile services in Germany before January 1998 are not available. There was a drastic decrease in prices in France before January 1998 when fixed-line telecommunications markets were liberalized. This was mainly due to the introduction of pre-paid tariffs but may potentially suggest that there was fierce price competition before 1998 leading to drastic price decreases and prices subsequently stabilized at a relatively competitive level.

effects in both countries, which appear to be much stronger in France (see Table 3). If the previous period installed base in France increased by 1%, current period penetration would surge on average by 1.36%. The respective increase in penetration in Germany would be 0.58%. There is also a significant Christmas sales effect in both countries. In Germany, the entry of Viag in November 1998 increased penetration, which may be due to consumer preference for variety. However, there is no positive impact on demand due to the entry of Quam in November 2001.[25] Importantly, there is seems to be a slowdown in demand for mobile subscriptions in France between 2000-2002, i.e., in the period of the share-fixing agreement. The agreement, could have eased competition, for instance, firms may have reduced marketing activities.

The estimation of market pricing equations does not provide clear support for the findings on substitution/complementarity of mobile and fixed-line subscriptions which is suggested by the demand analysis (see Table 4). The coefficients on fixed-line indices are insignificant. Thus, both in France and Germany, mobile prices seem not to be set in dependence on the prices of fixed-line communications.

[*Table* 4]

Apart from that, a dummy for the period of share-fixing has a significant coefficient, but with a negative sign, which suggests that market prices in France decreased in 2000-2002. Thus, there is no detectable negative effect due to the share-fixing agreement on prices of mobile communications in France.

The other results of the pricing regressions are as follows. The coefficient on the time trend is significant for both France and Germany. This suggests that there is a continuous decrease in prices of mobile services, which is potentially due to decreasing marginal costs resulting from innovation. The coefficient on lagged penetration is significant and positive for France, but negative for Germany. Thus, increasing penetration leads to price increases in Germany, but decreases in France. This positive sign may imply that, when the market approaches saturation level, in the presence of switching costs, firms have more incentives to charge higher prices and exploit locked-in consumers. On the other hand, lagged penetration of mobile telephony is used in the estimation of demand as a proxy for industry-wide network effects. Since network effects are supposed to stimulate demand, they should show up with a negative sign in the reduced-form

[25] Lack of significant product differentiation, own installed base and the inability to charge lower prices could be the reasons for the failure of Quam.

pricing regressions. The sign on lagged penetration may, therefore, be ambiguous.

Finally, the Christmas dummy for France is not significant, suggesting that there are no decreases in prices in the period preceding Christmas. However, its coefficient has a significant negative sign for Germany. The estimates of marginal cost factors show the same pattern in both countries. The cost of electronic equipment is insignificant, the cost of labor has a significant positive sign and the cost of capital has a significant, but unexpectedly negative sign. Turning to the entry dummies, in Germany, the entry of Viag did not have any impact on market prices, while the entry of Quam seems to have caused the prices to increase.

6 Conclusion

This paper is motivated by the antitrust investigation initiated by the French competition authority and compares mobile markets in France and Germany. The empirical analysis tries to test whether the share-fixing agreement among French network operators in years 2000-2002 had any adverse effect on subscriptions and prices.

The empirical analysis is based on aggregate industry data on subscriptions and prices and consists of separate estimation of: (i) demand for mobile subscriptions using binomial logit model and (ii) reduced-form industry-level pricing equations. According to the demand estimation, price elasticities of demand for mobile subscriptions are significantly higher in France than in Germany. Moreover, consumers of mobile services seem to perceive fixed-line access as a substitute in France and as a complement in Germany. Thus, network operators in France may have to compete with fixed-line providers, which results in lower market prices. On the other hand, decreasing prices of fixed-line in Germany stimulate demand for mobiles without imposing a competitive pressure on mobile providers. The hypothesis that dependencies between mobile and fixed-line communications services vary across countries seems also to find some support in the results of the household survey conducted by the European Commission across the EU member states.

On the supply side, reduced-form industry pricing equations are estimated separately for France and Germany. The price regressions do not provide clear support for the findings on substitution/complementarity in demand estimation. Mobile prices in both countries do not seem to depend on the prices of fixed-line communications.

Finally, we find an adverse effect of the share-fixing agreement in France on subscriptions, but

we fail to find price increases. The dummy for share-fixing agreement has a significant negative coefficient in the pricing regression. This suggests that market prices in France decreased in 2000-2002.

In conclusion, the results of this empirical analysis suggest that the French mobile industry may be relatively competitive if indeed consumers perceive mobile and fixed-line services as substitutes and demand for mobile subscription is more elastic than in Germany. As illustrated and discussed in this paper, the issue of dependencies between mobile and fixed-line services may have important consequences for antitrust investigations in telecommunications markets. Therefore, there is need for further analyzes of these dependencies based on consumer, firm and industry-level data.

Bibliography

Ahn, H. and M.H. Lee, 1999. "An Econometric Analysis of the Demand for Access to Mobile Telephone Networks," *Information Economics and Policy*, 11, pp.297-305.

Barros, P. and N. Cadima, 2000. "The impact of mobile phone diffusion on the fixed-link network," *CEPR Discussion Paper*, No.2598.

Beuerlein, I., 2000. "New computation of the consumer price index for telecommunications services on base 1995," Federal Statistical Office, Wiesbaden, Germany.

Berry, S.T., 1994. "Estimating Discrete-Choice Models of Product Differentiation," *RAND Journal of Economics*, 25(2), pp.242-262.

Commission for Communications Regulation, 2004. "Market Analysis - Wholesale Mobile Access and Call Origination."

Doganoglu, T. and L. Grzybowski, 2007. "Estimating Network Effects in Mobile Telephony in Germany," *Information Economics and Policy*, 19(1), pp.65-79.

Eurobarometer, 2006. "E-Communications Household Survey Fieldwork December 2005 - January 2006," available at http://ec.europa.eu/public_opinion/inde_en.htm.

Gebreab, F.A., 2002. "Getting Connected: Competition and Diffusion in African Mobile Telecommunications Markets," World Bank Policy Research Working Paper 2863.

Gruber H. and F. Verboven, 2001. "The Diffusion of Mobile Telecommunication Services in the European Union," *European Economic Review*, 45, pp.577-588.

Gruber, H., 2001. "Competition and Innovation: The Diffusion of Mobile Telecommunications in Central and Eastern Europe," *Information Economics and Policy*, 13(1), pp.19-34.

Grzybowski, L. and P. Pereira. 2006. "Simulation of Merger in Mobile Telephony in Portugal," *Review of Industrial Organization*, forthcoming.

Hamilton J., 2003. "Are main lines and cell phones substitutes or complements? Evidence. from Africa," *Telecommunications Policy*, 27, pp.109-133.

Okada, Y. and K. Hatta, 1999. "The Interdependent Telecommunications Demand and Efficient Price Structure," *Journal of the Japanese and International Economies*, 13(4), pp.311-335.

Rodini, M., Ward M. and G. Woroch, 2003. "Going Mobile: Substitution Between Fixed and Mobile Access," *Telecommunications Policy*, 27, pp.457-476.

Statistisches Bundesamt Wiesbaden, 1999. "Neuberechnung des Verbraucherpreisindex für Telekommunikationsdienstleistungen auf Basis 1995", Sonderdruck aus Wirtschaft und Statistik.

Tishler, A., Ventura, R. and J. Watters, 2001. "Cellular Telephones in the Israeli Market: The Demand, the Choice of Provider and Potential Revenues," *Applied Economics*, 33, pp.1479-1492.

7 Appendix

Table 1: Summary Statistics

Germany	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 O2 (Euro/100)	60	0.1565	0.035	0.106	0.209
avg.price Germany (Euro/100)	60	0.1647	0.034	0.128	0.215
price fixed (index)	60	1.0741	0.129	0.958	1.297
electronic	60	0.9223	0.035	0.866	0.983
bonds (%)	60	0.0478	0.004	0.037	0.055
labor (index)	60	1.1808	0.044	1.097	1.263
lagged penetration	60	0.4215	0.229	0.104	0.707
France	Obs	Mean	Std	Min	Max
price Orange (Euro/100)	60	0.0773	0.021	0.046	0.108
price SFR (Euro/100)	60	0.0616	0.019	0.039	0.104
price Bouygues (Euro/100)	60	0.0500	0.006	0.041	0.056
avg.price France (Euro/100)	60	0.0679	0.017	0.043	0.102
price fixed (index)	60	0.9519	0.046	0.893	1.010
electronic	60	0.9485	0.048	0.887	1.008
labor (index)	60	1.0987	0.057	1.012	1.198
bonds (%)	60	0.0488	0.004	0.037	0.056
lagged penetration	60	0.3898	0.182	0.102	0.626

Table 2: Estimation of Aggregate Demand for Mobile Services in France and Germany

	OLS				GMM			
	Estimate	STD	t	Pr>t	Estimate	STD	t	Pr>t
France								
Price mobile	-1.403	0.124	-11.29	0.001	-1.737	0.144	-12.03	0.001
Network effect	6.888	0.409	16.82	0.001	6.779	0.315	21.46	0.001
Price fixed	2.851	0.453	6.29	0.001	2.320	0.332	6.98	0.001
Cartel dummy	-0.147	0.040	-3.64	0.001	-0.182	0.033	-5.38	0.001
Christmas	0.063	0.022	2.83	0.005	0.068	0.018	3.74	0.001
Time trend	-2.540	0.366	-6.93	0.001	-2.785	0.303	-9.17	0.001
Intercept	-4.063	0.515	-7.88	0.001	-3.207	0.345	-9.29	0.001
Hansen J test					2.02	0.57		
Centered R2	0.99							
Germany								
Price mobile	-0.372	0.099	-3.74	0.001	-0.584	0.099	-5.90	0.001
Network effect	3.180	0.099	31.84	0.001	3.091	0.074	41.76	0.001
Price fixed	-1.342	0.153	-8.75	0.001	-1.172	0.132	-8.87	0.001
Viag	0.074	0.020	3.58	0.001	0.093	0.022	4.16	0.001
Quam	-0.106	0.023	-4.54	0.001	-0.113	0.019	-5.81	0.001
Christmas	0.059	0.015	3.87	0.001	0.042	0.007	5.36	0.001
Time trend	1.009	0.180	5.59	0.001	1.036	0.145	7.12	0.001
Intercept	-0.676	0.150	-4.50	0.001	-0.636	0.115	-5.53	0.001
Hansen J test					4.89	0.18		
Centered R2	0.99							

Table 3: Estimation Results Mean Elasticities and Standard Deviation for 1998-2002

	France		Germany	
	mean	STD	mean	STD
mobile	-0.75	0.41	-0.27	0.15
fixed	1.35	0.46	-0.58	0.29
network	1.36	0.34	0.58	0.13
Viag			0.04	0.02

Table 4: Estimation of Reduced-Form Pricing Equations (OLS)

France	Estimate	STD	t	Pr>t
Price fixed	12.878	11.608	1.11	0.273
Cartel dummy	-0.170	0.030	-5.50	0.000
Christmas	0.013	0.018	0.73	0.470
Time trend	-5.563	0.736	-7.55	0.000
Network effect	1.808	0.415	4.35	0.000
bonds	-6.189	1.739	-3.56	0.001
electronic	-12.602	11.974	-1.05	0.298
labor	9.402	1.430	6.57	0.000
Intercept	-8.316	1.739	-4.78	0.000
Adj R2		0.95		
Germany	Estimate	STD	t	Pr>t
Price fixed	-0.012	0.208	-0.06	0.953
Viag dummy	0.024	0.024	1.03	0.310
Quam dummy	0.070	0.023	3.03	0.004
Christmas	-0.037	0.014	-2.51	0.015
Time trend	-0.877	0.307	-2.85	0.006
Network effect	-0.264	0.122	-2.16	0.035
bonds	-5.611	1.214	-4.62	0.000
electronic	1.351	0.781	1.73	0.090
labor	2.273	0.639	3.55	0.001
Intercept	-2.306	1.030	-2.24	0.030
Adj R2		0.96		

Figure 1:

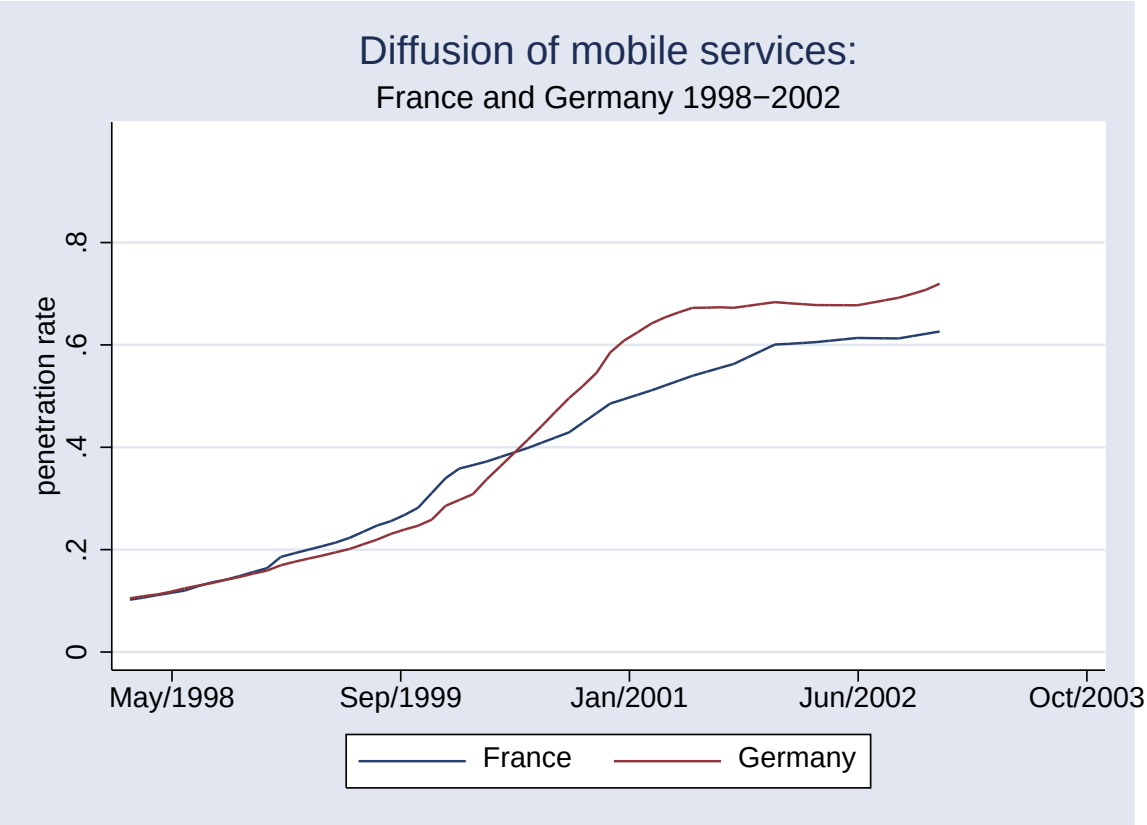

Diffusion of mobile services:
France and Germany 1998−2002
penetration rate
0
.2
.4
.6
.8
May/1998
Sep/1999
Jan/2001
Jun/2002
Oct/2003
France
Germany

Figure 2:

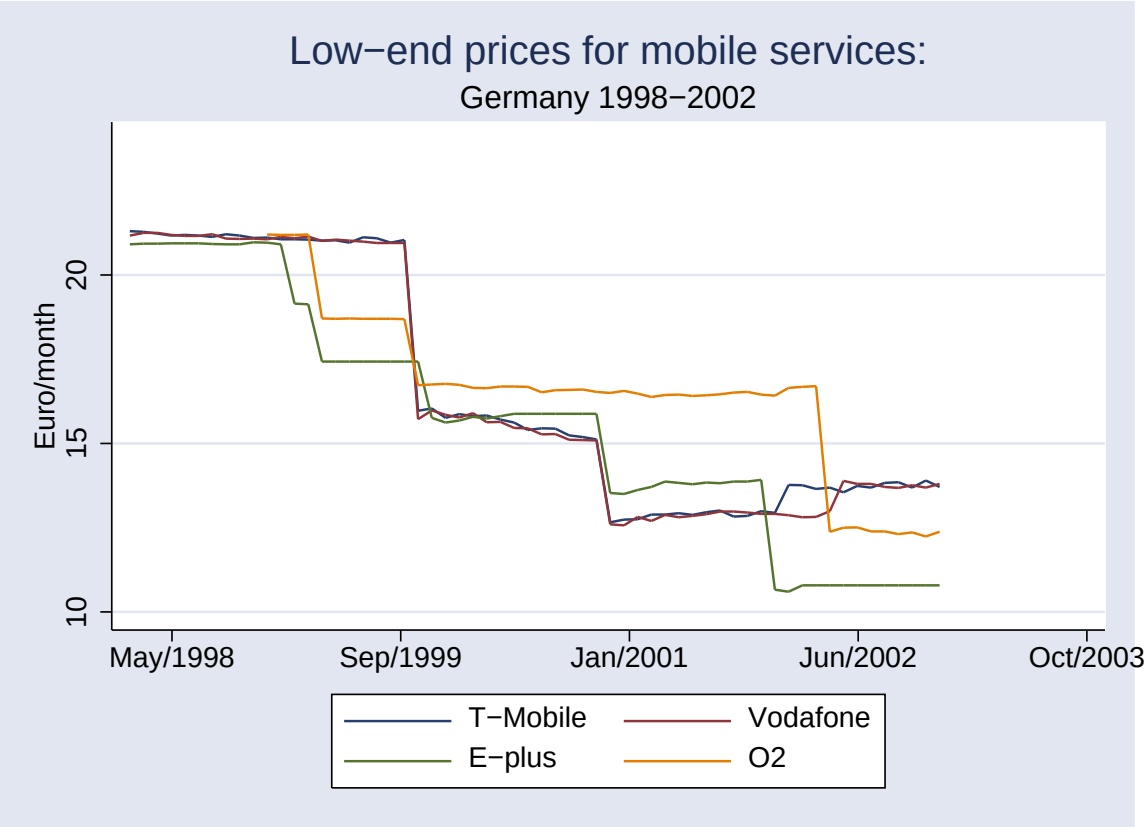

Low−end prices for mobile services:
Germany 1998−2002
Euro/month
10
15
20
May/1998
Sep/1999
Jan/2001
Jun/2002
Oct/2003
T−Mobile
Vodafone
E−plus
O2

Figure 3:

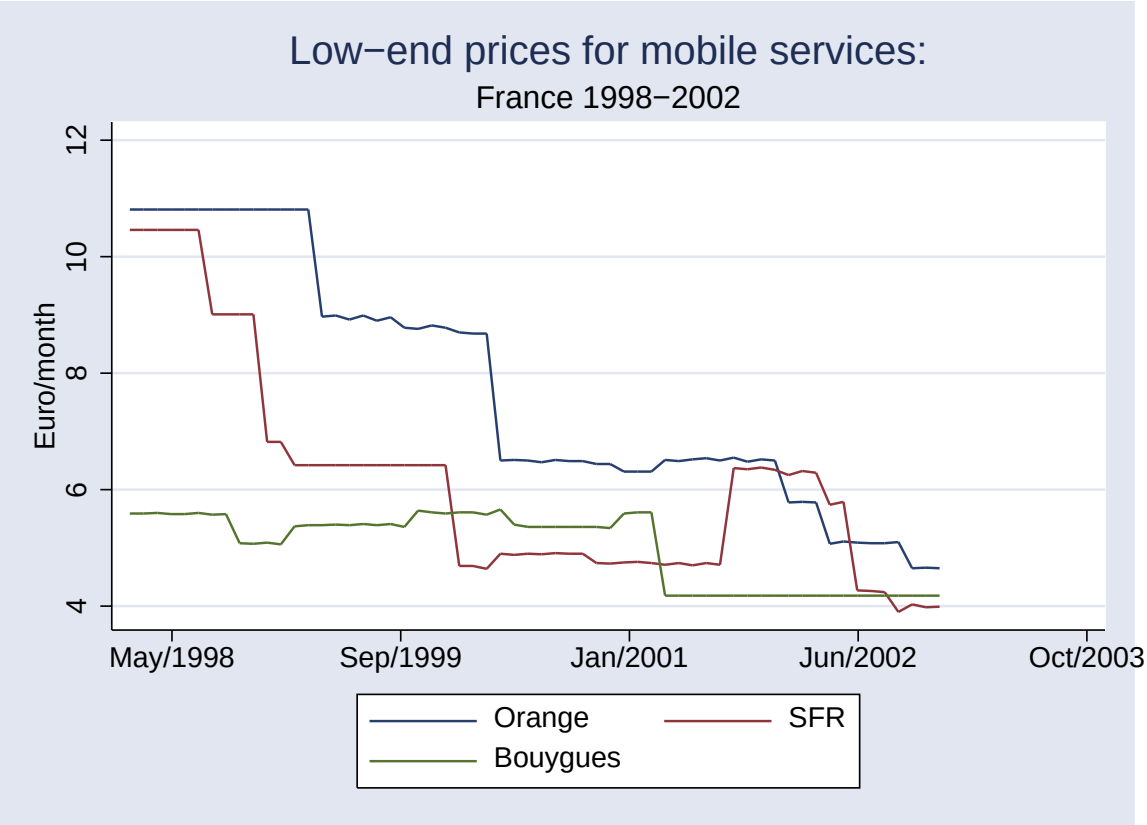

Low−end prices for mobile services:
France 1998−2002
Euro/month
4
6
8
10
12
May/1998
Sep/1999
Jan/2001
Jun/2002
Oct/2003
Orange
SFR
Bouygues

Figure 4:

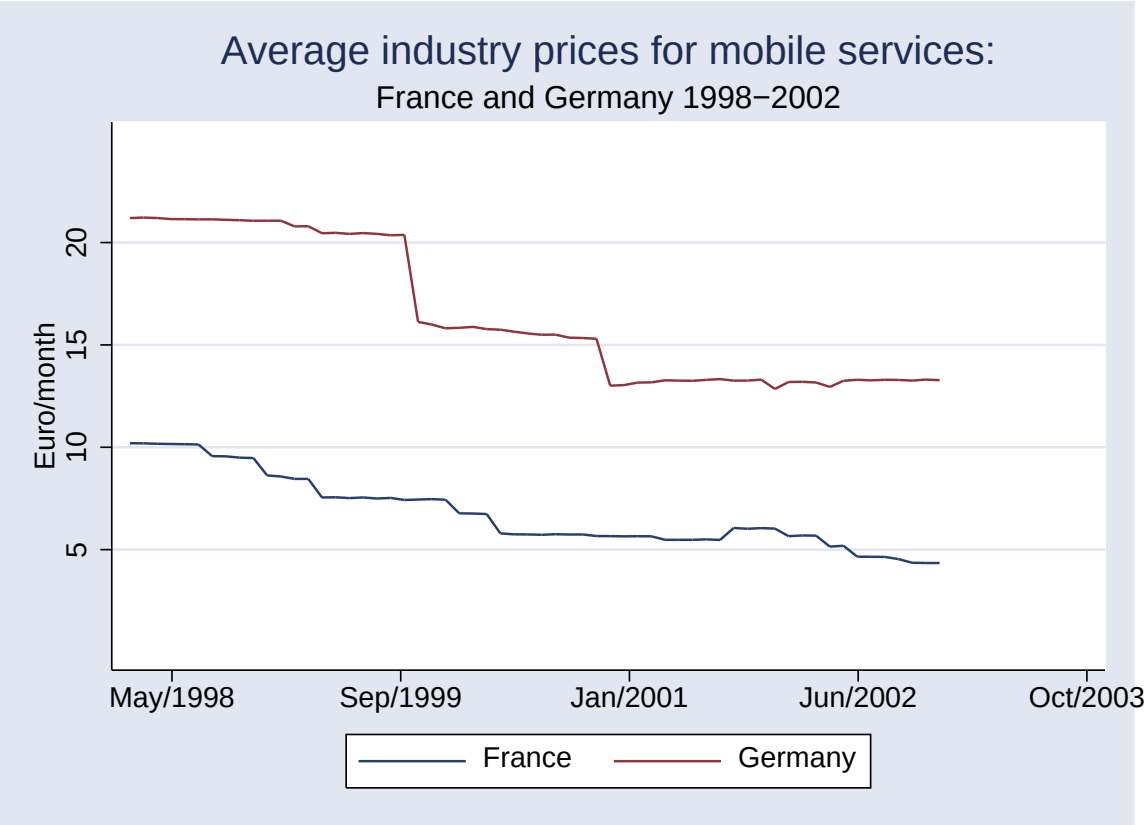
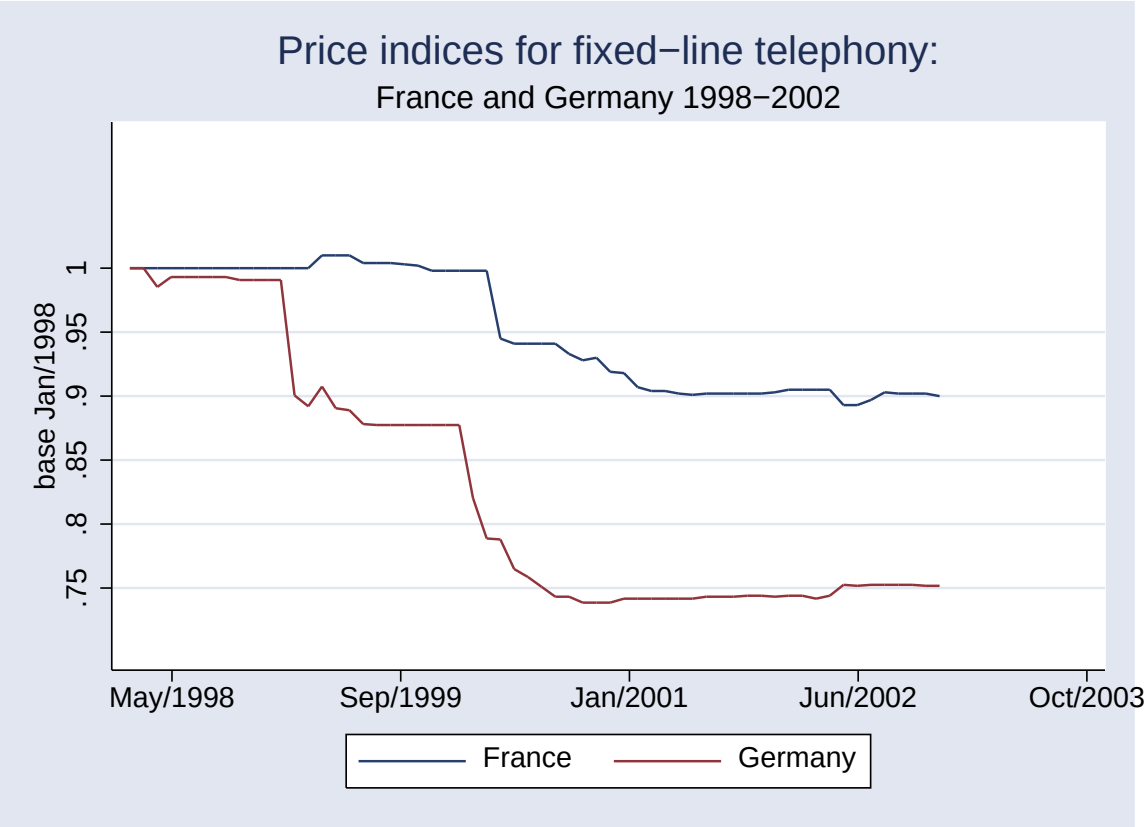

Average industry prices for mobile services:
France and Germany 1998−2002
Euro/month
5
10
15
20
May/1998
Sep/1999
Jan/2001
Jun/2002
Oct/2003
France
Germany

Figure 5:


Price indices for fixed−line telephony:
France and Germany 1998−2002
base Jan/1998
.75
.8
.85
.9
.95
1
May/1998
Sep/1999
Jan/2001
Jun/2002
Oct/2003
France
Germany