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ScienceDirect
Telecommunications Policy 32 (2008) 246–261
TELECOMMUNICATIONS POLICY
www.elsevierbusinessandmanagement.com/locate/telpol

Early mover advantages: An empirical analysis of European mobile phone markets ☆

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Abstract

This paper analyzes empirically whether and if so to what extent later entrants in the European mobile telephony industry have a disadvantage vis-à-vis incumbents and early mover entrants. To analyze this question a dynamic model of market share development and a series of static models are considered. There is clear evidence of early mover advantage, mainly caused by the influence of the penetration rate: it pays to enter when still few people have acquired a mobile telephone. Another important determining factor is the Herfindahl–Hirschman Index at the moment of entry: it is significantly easier to enter a highly concentrated industry. Finally, there are important differences between countries, possibly indicating the relative strength of the national regulators.

Keywords: Early mover advantages; Mobile telecommunication

1. Introduction

There is a long tradition in economics of studying the question whether incumbent firms have a first-mover advantage vis-à-vis later entrants. Von Stackelberg (1934), for example, early demonstrated in the context of quantity-setting firms that a leader (first mover) is able to secure a larger market share and higher profits than a follower (second mover). There are several reasons why first-mover advantages may arise.[1] In the economics (see, e.g., Mueller, 1997) and strategic management (see, e.g., Lieberman and Montgomery, 1988) literature

☆The data used for this research are based on the Global Mobile Subscriber Database (GMSD) of the Informa Group. The data are provided to the authors by Proximus (Belgacom Mobile) for whom they carried out a research assignment. The results reported here are a revised version of the research for Proximus. They are very grateful to Proximus for letting them use these data and report these results to a wider audience. The authors are also grateful to three anonymous referees for their very thoughtful comments on earlier versions of the paper. Bijwaard's research is partly supported by the Netherlands Organization for Scientific Research (NWO) nr 451-04-011.
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[1]Of course, there are also factors pointing at advantages for late entrants in markets. In particular, later entrants may learn from mistakes of others or may free ride on investments (and advertisement expenditure making the product known by a large group of consumers) made by early entrants. Also, they typically may enter when technological or demand uncertainties are considerably smaller.

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doi:10.1016/j.telpol.2007.08.006

the following factors are mentioned. On the demand side, there is the predominant importance of switching costs (Klemperer, 1987a, 1987b). These can arise (i) from the fact that consumers have to make some initial investment in adapting to a seller's product or services, (ii) from firm-specific learning on how to use the product (habit formation), or (iii) because of contractual costs imposed by the firm. With switching costs, firms that already exist in the market when consumers have to make their first adoption choice benefit as later firms have to convince consumers to switch. Other sources for first-mover advantage on the demand side include network externalities and uncertainty about the quality new firms offer (Schmalensee, 1981). On the supply side, there are similar factors working to the advantage of early entrants in the market, most notably sunk costs and economies of scale (Schmalensee, 1982) and cost efficiencies through learning by doing. There are also possible strategic effects, implying that firms find it more difficult to gain market share in markets where many firms are already active.

There is also a large empirical literature on first-mover advantages, mostly in management and marketing journals (see, e.g., Kalyanaram and Urban, 1992; Robinson, Kalyanaram, & Urban, 1994; Urban, Carter, Gaskin, & Mucha, 1986, for an overview). An important part of this literature studies how market shares at a particular moment in time depend on the firm's position in entering the market: what is the typical (long-run) market share of the pioneer firm, the second entrant, etc.? These studies are based on cross-sectional data from many different markets. Kalyanaram and Urban (1992) were the first to study a combination of cross-section data and time series. They also considered the impact of factors such as price differences, relative advertising expenditures, relative quality perception, etc. on the development of market shares. Their model allows a comparison in the rate of convergence to an asymptotic market share level by later entrants. Pioneering advantage is also related to the time a firm (or brand) is in the market. Longer lead time, which is the time between entries, should increase this advantage. Two papers by Huff and Robinson (1994) and Brown and Lattin (1994) confirm this for frequently purchased consumer goods and show that the pioneering advantage declines over time with competition. An overview of different studies can be found in Lieberman and Montgomery (1988, 1998) and in Robinson et al. (1994).

The vast majority of empirical studies find that market pioneers have substantially higher market shares than later entrants. This strong association between order of entry and market share is questioned by some authors (e.g., Golder and Tellis, 1993). They argue that most of the empirical studies have potential limitations. One such limitation is the fact that entry is usually treated as an exogenous parameter, whereas timing of entry of a firm might be a choice variable that depends on the perceived market expectations after entry. Moore, Boulding, and Goodstein (1991) extended the Robinson and Fornell (1985) model to allow for the possibility that market entry is endogenous.

This paper studies whether early entrants in the European mobile telephony sector have benefited through a long-term larger market share from their pioneering activities. The paper makes three types of contributions. To the best of the authors' knowledge, this is the first paper studying the consequences of the order of entry using data from one particular sector where consumers buy infrequently. A disadvantage of traditional cross-section analysis is the potentially large differences between sectors in the data set. Ideally, one would like to have a (large) number of entrants in one or similar market(s). There are not many cases where such conditions apply. European telecommunication in the 1990s is an exception. In the 1990s telephone services were liberalized in many European countries and with the advent of mobile telephony more and more operators entered the different markets over time. The critique of endogenous entry decisions pointed to above does not arise in this context as the timing of entry can (to a large extent) be considered an exogenous variable due to the fact that firms can only enter the market at times the government is willing to sell additional licenses. The data set used contains monthly data about market shares in all Western European countries. The next section describes the data used for this study in more detail, and there it will become clear that there are 45 market introductions in this period and that the development of the mobile telecom sectors is quite similar in the different countries. The sector is therefore an ideal case for considering empirically the impact of the timing of entry into a market.

A second contribution is that this is the first study of its kind on the mobile telephony sector. Mobile telephony has attracted considerable attention, especially in policy circles. Competition authorities and regulators have tried to ensure that the interests of entrants are well taken care of. A consistent empirical investigation of the success or failure of this policy has, however, been lacking up to this point.

This study shows how the order of entry has co-determined the evolution of market shares of firms in different countries. Thirdly, because of the nature of the data set, this research is able to estimate whether there are systematic differences between the way market shares of entrants develop in different European countries.

The data set also has its limitations, however. For each country, only data concerning mobile telephony market penetration and the number and names of the active operators and their market shares are available. Given this restriction, there are many potentially interesting questions that cannot be addressed. In particular, there can be no empirical discrimination between the different explanations for first-mover advantages if they do exist. Nevertheless, this research addresses some questions that are of interest, such as the following. What are the main success factors determining the growth in market shares of entrants? In particular, what is the impact of (the growth in) market penetration, measured as the percentage of the population that already has a mobile telephone; and what is the impact of factors such as the market concentration at the moment of entry? If market penetration is an important factor, then demand considerations in general, and switching costs in particular, are likely to be the main source for early mover advantages.

The main empirical studies of the European telecommunications industry are the two papers by Gruber and Verboven (2001a, 2001b). These papers examine a related, but very different question, namely whether the diffusion rate of mobile telephones in a country depends on the degree of competition. They find that such a positive relationship exists, but that it is relatively weak compared to the national differences in diffusion speed. There is, of course, a vast literature on entry in the telecommunications literature (see, e.g., De Bijl and Peitz, 2002; Laffont and Tirole, 2001, for overviews). This literature deals, however, with an entirely different issue, namely that of access regulation on an essential facility.

The rest of the paper is organized as follows. The next section provides a global description of the development of the main features of European telephony markets and it describes the data set used. Section 3 discusses the structure of the models used to analyze the data. Section 4 gives an overview of the different results and provides an interpretation. Finally, Section 5 concludes.

2. The European mobile telephony markets

At the beginning of the 1990s, most European countries had one incumbent firm offering telephone services to the population.[2] Mobile telephony was at its infancy. This incumbent company usually was a state monopolist. At that time European telephony markets were being liberalized and the former state monopolists gradually became privately owned companies with a monopoly position. During the 1990s these companies started offering mobile telephony services and governments started issuing licenses to new companies, sometimes using auctions to allocate the licenses among the interested firms.[3] Each of these licenses entitled the owner to use a certain spectrum band to offer mobile telephony services to its clients. The fact that a license is needed to operate in the market implies that the timing of entry is not a choice variable in the same sense as it is in other markets. Here, the only choice firms have is to enter at a time the government issues new licenses or not to enter at all.

National regulators were given the task of forcing incumbent companies to allow other firms access to their fixed network (using the essential facilities doctrine) and also to look after the fact that in the mobile telephony sector two-way access was granted so that subscribers to one network could easily call subscribers to other networks at fair prices (see, e.g., Cave, Majumdar, & Vogelsang, 2002). One of the goals the national governments had set for the mobile telephony sector was to create a situation of competition between infrastructures where firms owning their own network could compete with one another so that the regulatory problem of creating access to the fixed telephony network of the incumbent firm would not arise. Apart from mobile network operators, most countries nowadays also host mobile virtual operators that roam on the network of others to offer their services to clients.

[2]France, Sweden, and the UK already had two mobile operators in 1990; Greece had none.

[3]This paper does not make a distinction between countries where new licenses were auctioned and those where they were not, nor does it distinguish between countries where licenses were given away free of charge and those where firms had to pay. Implicitly, it takes the view that license fees are to a large extent sunk costs that do not affect the behavior of firms in the marketplace (and therefore do not seriously impact on the development of market shares).

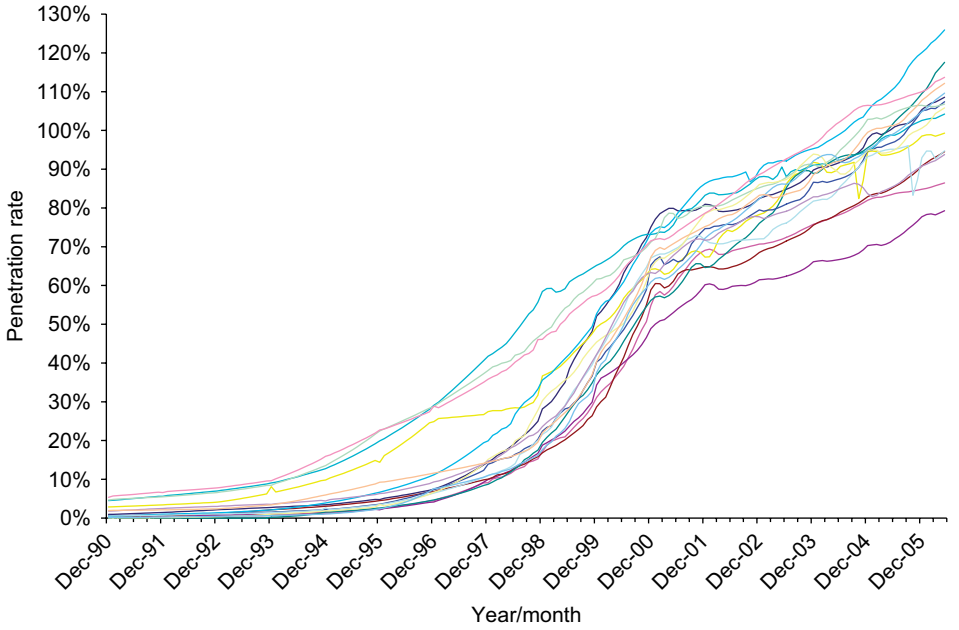

Fig. 1. Development of penetration rate in different countries.

When the market for mobile telephony services gradually took off (see also Fig. 1), almost all demand was generated by firms. In most countries, consumers entered the market in large numbers only towards the end of the 1990s. The startup of consumer markets led to a dramatic increase in the penetration rate around the turn of the millennium.[4] The agents on the demand side that create, however, the largest telephone traffic (firms in other sectors) usually choose to buy their mobile telephony services from the incumbent parties or the very early entrants. Moreover, later entrants[5] need time to build a reliable network with country-wide coverage, creating temporary quality differences at the time the later entrants entered the market.

Switching costs and network effects may explain early entrants' dominance in the mobile telephony markets in the following way. Switching costs arise in several ways. First, for quite some time and in quite a few countries, consumers could not continue to use their "own" telephone number when switching firms, i.e., number portability was not possible. The time and effort it takes to inform friends or business relations of a change in number is a considerable switching cost, certainly for the larger users. In most countries, national regulators were able to enforce number portability in recent years, so that this type of switching costs does not exist anymore. However, other forms of switching costs continue to prevail, most notably the terms of the subscription contracts (1–2 years) and the time it takes to adapt to a firm's services. Because of the switching costs, one may expect that there is a premium for entering the market when the penetration rate is still low.

Network effects prevail for two reasons. First, on the supply side the sector's technology is one with large fixed costs (the cost of creating and maintaining a network) and very small marginal costs. Hence, if all firms are equally efficient, the firm with the largest market share has the lowest average cost. If there are no significant differences in the average revenue per user (ARPU), then this firm may price below its competitors, thereby further increasing its market share.[6] A larger firm also has more possibilities of investing in its network, thereby offering a more reliable service. A second source of network effects arises in some countries where firms are allowed to charge different prices for call terminating on their own network and call

[4]On the basis of the data set, it is impossible to determine whether or not there is a clear relationship between the European liberalization process and the rise in subscribers. The S-shape in the adoption pattern (see Fig. 1) is what one typically observes in the technology adoption literature.

[5]Entrants are certainly not necessarily weak parties. The European market is populated with relatively many firms that compete in several countries. Therefore, a later entrant in one country typically is an incumbent firm in another country.

[6]Larger firms typically will also be the first firms in the market and therefore will serve most of the business community (the larger users).

terminating on the network of others. This pricing strategy may induce consumers to subscribe to the firm where most friends are also subscribed to.

2.1. Description of the data

Out of the data set, the following 16 European countries are analyzed: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and the United Kingdom. These are the larger countries in which there are at least two mobile operators active in the market. These larger markets are of most interest for mobile operators and for the debate on European telecommunications policy. For each country, the data set contains information on: market penetration (the percentage of the population that has a mobile telephone), the number and names of the active operators, and their market shares. No information is available on other potentially relevant factors such as the prices that the companies charge for their services.[7]

For the years 1998–May 2006 the data set reports monthly data. For the years 1990–1997 only annual data (as at December each year) are available. The data set contains market shares of those companies that have their own network, leaving the mobile virtual operators that subcontract the use of a network out of the data set. The data has been revised with respect to measurement errors or other improbable data. Since December 1990, 45 market introductions (new operators that enter the market) have taken place in these countries of which 2 are incumbents and 43 entrants. The tables presented in the Appendix provide the names of early incumbents and entrants in different countries. An early incumbent[8] is defined as an operator who either was already active in the market offering mobile telephony services at the moment the data set starts (in 1990) or was the first operator active in the market (and entered after 1990).[9] All other firms are considered entrants. From Table A2 in the Appendix it becomes transparent that most entrants in a country have a telecommunications company as a parent, often a formerly state-owned company of another European country.

Over the years, different technologies have been used in mobile telephony, from 1G in the early and mid 1990s to 2G from the late 1990s until the introduction of 3G in recent years. Even though the data set does discriminate between the numbers of users of different technologies, this distinction has not been made for the reason that most operators have been able to transfer their customers from an old technology to a new one. Certainly in the transition from 1G to 2G (GSM900/1800) the number of subscribers to the old technology with an operator vanishes quickly and these customers switch to the new technology. Also, the introduction of new technology is typically the moment new players come into the market and the analysis below does take these market introductions into account. The introduction of 3G (UMTS) is relatively so recent that it is difficult to discern any pattern so far. For these reasons the number of subscribers with an operator has simply been added over all available technologies. This variable has been taken as the basic unit of analysis.

2.1.1. Penetration rate

The penetration rate in the different countries is depicted in Fig. 1 as a function of time. Each country is described by a different curve. The three countries where mobile telephony took off at a distinguished earlier moment are the three Scandinavian countries, Finland, Norway, and Sweden. The picture suggests that the development of the penetration rate over time follows the familiar S-curve (see also Gruber and Verboven (2001a, 2001b) for the European Mobile Telephony Markets). It also shows that the development in each country follows a very similar pattern. It is interesting to observe that in some countries penetration rates have reached 100% and higher, which is due to the fact that some people have more than one mobile phone (e.g., for business and private use).

2.1.2. Market shares

For each entrant (with entry in 1998 or later) the analysis shows how its market share develops over time, from *the moment of introduction onwards*.[10] The developments in market shares measured in this way are

[7] If price data were available, these were very difficult to use, as most companies offer an extensive menu of price choices to their clients.

[8] "Early incumbents" is used to be able to use the term incumbent for all those companies that are active in the market at the moment a new player enters.

[9] This definition is used as it is not possible to econometrically distinguish between companies that were already active at the moment the data set starts.

[10] The moment of introduction starts when the number of subscribers to the network becomes positive.

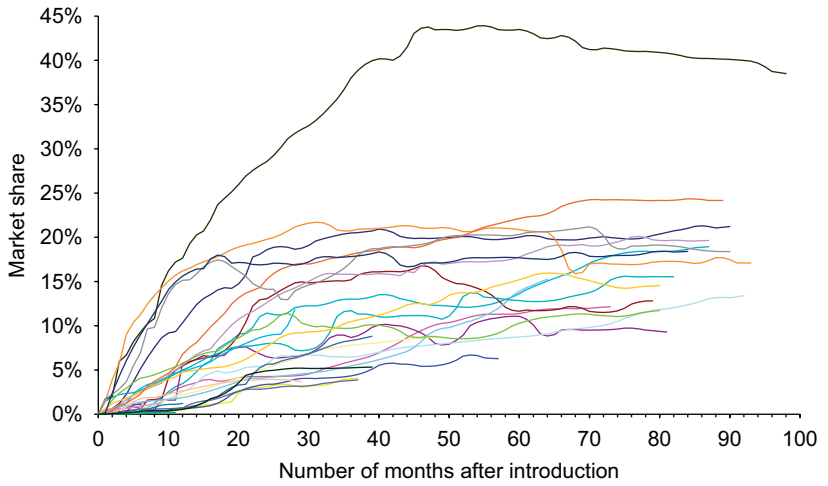

Fig. 2. Development of market shares (introduction from 1998 onwards).

depicted in Fig. 2. One can easily see that an average firm's market share increases most steeply immediately after entering the market. Moreover, a rough first impression suggests that the increase in market shares flattens off to become more or less stable after approximately 40 months after entry. The figure also shows that one entrant has been particularly successful. This is the Greek firm Cosmote. Cosmote is the only mobile telephone company in Europe that is (i) a subsidiary of the former state monopolist and national incumbent in the fixed telephony market and (ii) not the first entrant in the mobile market. Apart from the possibility that Cosmote had a particularly successful marketing strategy,[11] these facts may explain its unusual development.

In 2003–2005, there were some acquisitions of one operator by another. Mention is made of the acquisition of Telia Finland by Finnet in Finland, of Orange Denmark by TeliaSonera in Denmark, and of Telfort by KPN Mobile in the Netherlands. In case this had a relatively large impact on market shares—in for example the Netherlands the market share of KPN Mobile went up from 34% to almost 50%—it was decided not to use data in such a specific country after the takeover. Thus, the data on the Netherlands is used up to September 2005. In Fig. 2 this has led to some curves being cut off after a certain moment in time.

3. The models

In order to investigate the impact of market concentration and the penetration rate on the development of market shares of entrants, two types of models are investigated: (i) a dynamic model and (ii) a series of static models.

The *dynamic* analysis attempts to explain the course of development of the market share over the time a firm is present in the market place. To understand the model used, it is useful to reconsider the data presented in the previous section (Fig. 2). Fig. 2 shows that market shares do not increase linearly over time. Instead, market shares first increase more rapidly (in the first months after market introduction). Subsequently, the increase in market share slows down and after some time a more or less stable market share emerges. To capture this aspect of the development in the empirical analysis a non-linear model is proposed in the spirit of Kalyanaram and Urban (1992). In such a model two parameters are crucial: the "long-run" market share and the speed with which the market share converges to this level. The model below is one of the simplest mathematical expressions that captures these two aspects:

$$m_{it} = \gamma_i(1 - e^{-\beta_i t}),$$

where m_{it} is the market share of firm i t months after introduction and t the time measured in months after introduction, β and γ are firm- (or country-specific) parameters.

[11]This is what is argued for in Knyphausen-Aufseß, Krys, and Schweizer (2002).

The parameter γ_i has a clear interpretation: it is the "long-run" market share of firm i. The parameter β determines the speed of convergence. In the dynamic analysis these parameters are determined by a number of exogenous factors. The specification of γ in the base model (model A in the analysis section below) is as follows:

$$\gamma_i = e^{\alpha_1 p_i + \alpha_2 p_i^2 + \alpha_3 \mathrm{HHI}_i + c_i},$$

where p is the penetration rate at the moment of introduction (the variable takes on values between 0 and 1), HHI the Herfindahl–Hirschman Index at the moment of market introduction, taking values between 0 and 1, c a dummy variable for each country, and α's are parameters.

An exponential functional form for γ was chosen to ensure it is always positive. The penetration rate itself is introduced as well as the penetration rate squared. One would expect a negative relationship between market penetration rate at the moment of entry and "long-run" market share. The relationship may, however, be non-linear, as the strength of this negative relationship may become much stronger when the market penetration rate is relatively large at the moment of entry. Moreover, it may be that there is an optimal moment (read: optimal penetration rate) to enter the market. This is the case when α_2 is negative and α_1 is positive. When both α_2 and α_1 are negative, firms want to enter as early as possible and this effect increases with a delay of entry. When α_1 is negative and α_2 is positive but with an absolute value smaller than α_1, firms want to enter as early as possible, but the effect of early entry vanishes.

There are two different measures of market concentration one may use, the HHI and the number of active firms at the moment of introduction. Typically, it would be expected that entry would be more difficult the more concentrated the market. The HHI is a more sophisticated index of market concentration as it takes both the number of competitors and their market shares into account. Moreover, it does so in a non-linear way, implying for example that the effect of an increase in the number of operators becomes smaller the larger the number of already active operators. The analysis therefore uses the HHI as a measure of market concentration.[12] The HHI *at the moment of market introduction* is included to measure whether it is more or less difficult to enter a more concentrated market. Note that this index is exogenous as it is taken at the moment just before entry and that it does not depend on the evolution of market share. Estimates were made of a variation of the model (model B in the analysis section below) with both the number of active operators at the moment of entry and the HHI to investigate which of the two possible effects of the HHI dominates the analysis. The country dummy measures the fact that the institutional environment and regulatory framework may make market entry much easier in one country than in another.

The specification for β is as follows:

$$\beta_i = \beta_1 + \beta_2 \mathrm{HHI}_{it} + \beta_3 \Delta p_{it},$$

where HHI_{it} is the Herfindahl–Hirschman Index at time period t measured after entry of firm i, taking values between 0 and 1, ΔP_{it} the change in penetration rate measured from the moment of introduction, and β's are parameters.

This specification allows the convergence speed to the "long-run" market share to depend on the development of the HHI and on the change in penetration rate. It would be expected that the number of firms would have a negative impact on the speed of convergence: it is easier to enter a more concentrated industry. The change in penetration rate should also have a positive impact on the speed of convergence: the larger the change in penetration rate, the more new consumers in the market and the easier it is to gain market share.

The full data set is used to estimate this dynamic model. To this end, for the period before 1998 the annual data was interpolated to monthly data. Imputing the missing data on the penetration rate in each country is based on a simple logistic curve that equates the penetration rate for two consecutive years. The missing

[12]On the other hand, for a given number of active operators one would expect that it is easier to enter a market where operators are of more or less equal size than in a market with one large player and some very small players. The reason is that smaller operators have more incentives to compete severely in order to gain more customers so that it is more difficult for entrants to enter. The impact of the HHI on the explanatory variable may therefore be ambiguous. With more firms (and thus, ceteris paribus, a market that is more difficult to enter), the HHI is typically lower. However, if the number of active operators is the same in two different countries, but one country has a market where operators are of very unequal size compared to the other country (and thus again, ceteris paribus, is more difficult to enter), the HHI of this first country is higher.

market shares are imputed in an indirect way, by first imputing the number of subscribers of an operator (again using a logistic curve) and then dividing by the total number of active users at a particular point in time. From these imputed market shares the imputed the HHI was calculated. Note that for the "long-run" market share, the γ_i, only the imputed values of the penetration rate and the HHI at the moment of introduction were needed. Although the convergence rate, the β_i, is based on more imputed values than the long-run market share, it is also based on more observed monthly data as the dynamic analysis uses all monthly data from January 1998 to May 2006.

Given the data constraint, the specification above is quite flexible. It takes the smoothing of the growth of the market shares over time into account. Furthermore, the HHI is allowed to determine the speed of growth in market share of firms as well as the level of the "long-run" market share. The penetration rate at the moment of introduction co-determines to what level the market share of a firm can grow, and the change of the penetration rate in a certain month co-determines how fast the market share of a firm in that month grows. Finally, country dummies are introduced to measure country-specific differences, most notably the impact national regulators have on protecting the interests of entrants. The next section reports the estimated size of these effects on the basis of the data. Due to data limitations it is, however, not possible to test directly whether the possible endogeneity of the penetration rate leads to biased inference in the dynamic model. On the other hand, this endogeneity is tested in the context of the static model (see below). If that test does not indicate any endogeneity problem it is safe to assume that the penetration rate is exogenous in the dynamic model.

The static models analyze how the number of customers of the entrants expressed as percentage of the total population depends on the number of entrants and the change in the penetration rate, i.e., the developments in market shares are not directly investigated. This specification is chosen for the following reason. Because of the presence of switching costs, the main interest is in knowing which percentage of the new adopters (those who first buy a subscription to mobile telephony) will buy from the entrant. By choosing the variable that is to be explained in this way, the estimated coefficient for the change in penetration rate measures exactly how large this percentage is.

In the series of static models, the impact of a change in the market penetration rate and the HHI on the number of customers of entrant i expressed as a percentage of the total population was analyzed. These static analyses are estimated at different moments in time to get an idea of the development over time: 1, 2, and 3 months after introduction, and then 6, 12, 18, 24, 30, and 36 months after introduction.

The linear basic model is thus as follows:

$$n_{it} = \xi_{1t} + \xi_{2t}\,\Delta p_{it} + \xi_{3t}\,\mathrm{HHI}_i + \varepsilon_{it}, \tag{1}$$

where n_{it} is the number of customers of entrant i expressed as a percentage of the total population at time t months after entry, Δp_{it} the change in penetration rate measured from the moment of introduction of firm i to t months after introduction (the variable takes on values between 0 and 1), HHI_i, the Herfindahl–Hirschman Index at the moment of market introduction of firm i, taking values between 0 and 1, ε_{it} the error term, and ξ's are parameters.

The parameters in this linear model are easily interpretable. The parameter ξ_{2t} measures the percentage of new adopters since the moment firm i entered the market that have chosen to buy mobile telephony services from firm i. The parameter ξ_{3t} measures the impact of a hypothetical change from perfect competition to full monopoly, i.e., a change in the HHI from 0 to 1, on the percentage of the population that has chosen to buy mobile telephony services from firm i since the moment firm i entered the market.

As it is difficult to combine annual and monthly data in estimating the static model, only the monthly data available since 1998, and thus the corresponding 27 market entries was used (see Table A2 in the Appendix for details). As the model measures the number of customers of entrant i at t months after entry, only entrants after 1998 are considered. The annual data over the period 1991–1998 could be interpolated to construct monthly data as was done in the dynamic model (and then accommodate 16 more market entries), but this would imply that for each estimation results approximately 30% of the relevant data is artificially constructed. As described above, this problem is much less acute in the dynamic analysis, because the dynamic analysis uses all monthly data from January 1998 to May 2006. The impact of the interpolation method (and the possible

difference between the imputed values and the true, unobserved, values of the penetration rates and market shares) is much larger in the static model.

Clearly, it may be the case that there is an endogeneity problem in the sense that changes in the penetration rate may depend on the market share of entrants.[13] Penetration rates are likely to depend on price and quality of the services delivered and these clearly depend on the sector's competitiveness. In this case, the error term in (1) is not independent of the value of the penetration rate and the OLS estimated parameters, especially the one measuring the effect of the change in penetration rate, may be biased. One method for dealing with this problem is to build a system of equations, one for market share and one for penetration rate, and estimate its parameters simultaneously. Unfortunately, due to a lack of data about other potentially relevant variables, it is impossible to build such a system of equations and estimate its parameters. Given the data set, this inevitably would lead to identification problems of parameters.

Another method to correct for possible endogeneity is to use an Instrumental Variable (IV) method.[14] If the change in penetration rate is truly exogenous the OLS-estimator is unbiased and efficient. Although the IV-estimator is then also unbiased it is less efficient. If, however, endogeneity is a problem the OLS-estimator is no longer unbiased, while the IV-estimator remains unbiased. Based on two such estimators, where one estimator is unbiased and asymptotically efficient under the null hypothesis of no endogeneity, but biased and inconsistent under the alternative hypothesis of endogeneity, and the other estimator is consistent both under the null and the alternative hypotheses, Hausman (1978) suggests a simple test on endogeneity. The test exploits the fact that if the regression equation is extended to include one additional variable that represents the projection of the potential endogenous change in penetration rate on its instruments, an (OLS) estimator of the coefficient of this extra variable will be equal to zero if the penetration rate is exogenous. A test on endogeneity is, therefore, a student's t-test on the significance of this extra variable. As an instrument/proxy for the (possible) endogenous change in the penetration rate in country X where a new introduction has taken place, the average change in penetration rates in other countries was used from the moment the penetration rate is equal to the penetration rate in country X. As there is no clear pattern of introductions across countries, this constructed variable (on the basis of all other countries apart from the country where firm i is active) can safely be considered independent of the market share of the entrant.

4. Analysis

This section discusses the empirical results obtained from estimating the two alternative models.

4.1. Analysis of the dynamic model

The estimation results of investigating the development of market shares in the context of the dynamic model are reported in Table 1 below. Consider first the variables that explain the "long-run" level of market shares. A first striking factor is that the impact of the penetration rate is quite strong, significant, and highly non-linear and that it is best to enter as early as possible, i.e., it is not optimal to wait with an entry decision. This follows from the relatively large negative estimated impact (−0.43) of the penetration rate itself and the large negative estimated impact (−1.48) of the squared penetration rate. A second striking factor is that the HHI also has a strong impact, implying that it is more difficult to enter a concentrated market. When the penetration rate is already large and some operators are already present in the industry, the "long-run" market share to be reached is very small. To get some idea of the joint impact of the penetration rate and the HHI on the "long-run" market share compare (ceteris paribus) two situations, the first being a situation where a firm enters when the penetration rate is 10% and there is only one active operator in the market, and the other when the penetration rate is 70% and there are three equally large operators active in the market.[15] In the first situation the entrant will get an estimated "long-run" market share of roughly 38%, whereas it will only reach a market share of 6% in the second situation.

[13]Note that this is a different type of endogeneity than the one discussed in the Introduction.

[14]Loosely speaking: a good instrument is (highly) correlated with the variable it instruments but not with the error of the equation.

[15]Assume an average country with a dummy constant of −2.2.

Table 1
Estimation results for the dynamic model

	Model A		Model B	
	Parameter	Std. error	Parameter	Std. error
Gamma				
Country dummies				
Austria	−2.1407	0.0659	−2.0169	0.1237
Belgium	−2.3458	0.0635	−2.2171	0.1186
Denmark	−2.4893	0.0629	−2.2956	0.1249
Finland	−2.5067	0.0737	−2.2672	0.1298
France	−2.3443	0.0479	−2.2597	0.1047
Germany	−2.5519	0.0500	−2.4104	0.1123
Greece	−1.5259	0.0536	−1.4958	0.1095
Ireland	−1.9639	0.0721	−1.8365	0.1268
Italy	−2.0784	0.0700	−1.9464	0.1231
Netherlands	−2.3901	0.0617	−2.1478	0.1349
Norway	−2.4728	0.0743	−2.2918	0.1304
Portugal	−2.0214	0.0597	−1.9364	0.1126
Spain	−2.2678	0.0618	−2.1617	0.1169
Sweden	−2.8840	0.0680	−2.6946	0.1309
Switzerland	−2.4952	0.0841	−2.2265	0.1416
UK	−2.1034	0.0400	−1.9435	0.1074
Other characteristics				
Penetration-rate at entry	−0.4319	0.1595	−0.5711	0.2023
Penetration-rate at entry (squared)	−1.4838	0.1459	−1.4638	0.1838
Number of other active firms at entry			−0.0618	0.0191
Herfindahl–Hirschman Index at entry	1.3290	0.0580	1.2842	0.0912
Beta				
Time t (# months) since entry	0.0308	0.0014	0.1367	0.0039
Number of other active firms at t			−0.0107	0.0005
Herfindahl–Hirschman Index t months after entry	−0.0059	0.0024	−0.1432	0.0037
Change in penetration rate at t	0.1351	0.0166	0.1574	0.0163

Finally, the difference between countries is not very striking. The average parameter value of the country dummies is approximately −2.2. Some countries (most notably Northern European countries) have somewhat lower estimates, implying that entrants have a harder time gaining market share than in some other countries (most notably Southern European countries).[16] To the extent that there are significant differences they are probably due to different types of policies the regulators have to protect the interest of entrants.

Concerning the speed of convergence, it is interesting to observe that changes in penetration rate are an important factor determining the speed with which firms may gain market share: when many new consumers enter the market, it is easier to attract these consumers and gain market share than in a case where penetration rates are almost constant. The sign of the HHI in determining the speed of convergence is different from what may be expected, but the coefficient is not as strongly significant as the other coefficients. If there is a plausible explanation for this sign it has to do with what was outlined in footnote 12, namely that the HHI captures two different effects. These opposite effects are at work while comparing the results with the estimation results of model B: when the number of active operators is used as an additional explanatory variable, the coefficient for the HHI becomes much more strongly negative (or less positive as in the long-term effect) indicating that for a given number of operators, it is more difficult to gain market share when the market shares of other firms are highly unequal. However, note that the number of providers and the HHI are very highly correlated with a correlation coefficient of −0.76. Thus the two measures of concentration are close to being collinear and the

[16]Note, however, that the estimated coefficient for Greece is probably due to the unusual case of Cosmote (see the discussion in Section 2).

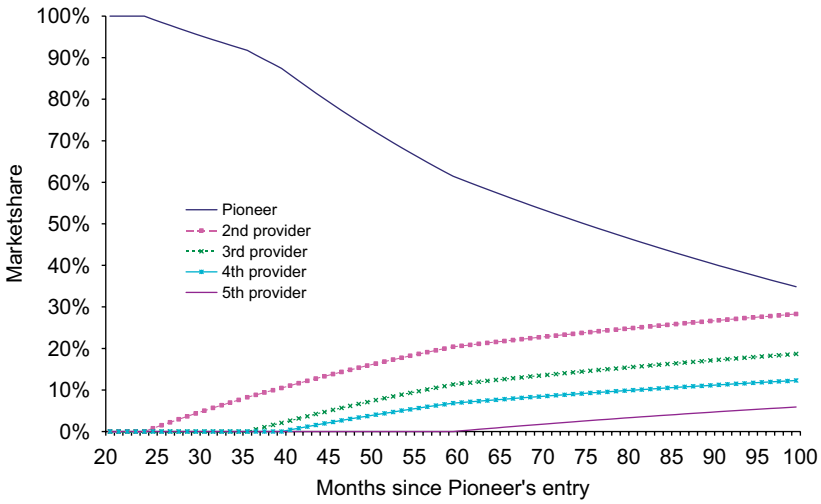

Fig. 3. Market shares by order of entry.

estimated coefficients of the regression with both factors are not very precise. All other estimated parameters have the expected sign and are significantly different from zero.

Another way to interpret the results is by simulating the development of market shares over time in a controlled situation. Fig. 3 below considers model A and a country where a first entrant enters the market when the penetration rate is 5%, a second entrant enters when the penetration rate is 22% and the HHI is 0.58, a third entrant enters when the penetration rate is 40% and the HHI is 0.38, and a fourth entrant enters when the penetration rate is 53% and the HHI is 0.29. The moment of entry of the respective parties can be read from the figure. It can easily be seen from the figure that the first entrant is still able to gain quite a large market share and in the long-run approach the market share of the pioneer. Later entrants, however, stay at much lower market shares.

4.2. *Analysis of the static models*

The results of estimating the parameters at different durations after entry in the analysis of the static models are given in the "OLS column" of Table 2. Table 2 also reports in the "IV column" the results of the IV approach described in the previous section. It appears that the IV-estimates are somewhat different from the OLS-estimates. The last column of the table gives the Hausman t-values of the coefficient of the additional variable. As all the Hausman t-values are below 2, the null hypothesis cannot be rejected, implying that although the IV-estimates for the effect of a change in penetration rate seem to differ somewhat, the Hausman test does not reject the exogeneity of the change in penetration rate. Thus, endogeneity is not an issue. As the OLS-estimates are unbiased and efficient in this case, these estimated values seem to be the most reliable. As endogeneity in the sense of this section does not seem to be a problem, adjustments of the dynamic analysis are not necessary either.

There are some important results that attract attention. First, all the estimated parameters have the expected signs: changes in the penetration rate have a positive impact, and an increase in market concentration, as measured by the HHI, has a positive impact on the relative number of consumers an entrant is able to attract. A more concentrated market usually implies fewer competitors and therefore a larger share of consumers choosing for the entrant. On the other hand, it is much easier to attract consumers who are choosing their first mobile phone operator than inducing consumers to switch operators, i.e., churn does play an important role. Therefore, when many new consumers are entering the market it is easier to gain market share than when the change in penetration rate is low. Many parameter estimates, especially in the first 18–24 months after entry, are significantly different from zero and, although the model is relatively simple and it was not possible to include an important factor such as price (due to non-availability of data), the model is able to explain an

Table 2
Estimation results of static analyses

Month	OLS				IV				Hausman t-test
	Intercept	Delpen	HHI	R^2	Intercept	Delpen	HHI	R^2	
1	−0.001	0.021	0.003	0.205	−0.001	−0.029	0.004	0.110	−0.552
	(−0.928)	(0.707)	(2.021)		(−0.846)	(−0.311)	(1.831)		
2	−0.002	0.054	0.007	0.352	−0.002	−0.007	0.009	0.217	−0.803
	(−1.514)	(1.981)	(2.486)		(−1.088)	(−0.082)	(2.448)		
3	−0.004	0.079	0.011	0.398	−0.003	−0.005	0.014	0.222	−1.241
	(−1.677)	(2.504)	(2.394)		(−1.092)	(−0.056)	(2.510)		
6	−0.010	0.114	0.025	0.455	−0.008	0.005	0.035	0.289	−0.988
	(−1.809)	(2.841)	(2.337)		(−1.260)	(0.042)	(2.227)		
12	−0.027	0.126	0.068	0.573	−0.026	0.087	0.077	0.562	−0.421
	(−2.682)	(2.376)	(3.003)		(−2.632)	(0.850)	(2.624)		
18	−0.023	0.087	0.096	0.536	−0.022	0.036	0.115	0.515	−0.687
	(−1.643)	(1.718)	(2.934)		(−1.573)	(0.427)	(2.829)		
24	−0.002	0.113	0.063	0.391	−0.002	0.113	0.063	0.391	0.011
	(−0.078)	(2.145)	(1.449)		(−0.084)	(1.687)	(1.377)		
30	0.006	0.132	0.057	0.291	0.010	0.089	0.077	0.278	−1.113
	(0.205)	(1.929)	(0.908)		(0.372)	(1.201)	(1.252)		
36	0.003	0.149	0.064	0.267	0.007	0.132	0.071	0.266	−0.369
	(0.090)	(1.800)	(0.938)		(0.191)	(1.496)	(1.074)		

Delpen: change in penetration rate.
t−value in brackets.

important fraction (between 40–60% in the intermediate period) of the fluctuations in the data. It also seems to be the case that after around 18–24 months, the model starts performing worse, indicating that other factors—such as marketing strategy—may start becoming important.

Most striking is the fact that the parameter values increase with the time span considered after entry. Immediately upon entry an entrant is on average able to get 2% of the new consumers, while 1 year after entry an average entrant is able to get some 11–14% of the new consumers who have started to adopt mobile telephones since the date of entry. This increase in the ability of attracting new users can be explained by referring to two factors. First, entrants usually need some time to build up a complete network with a nation-wide coverage. In the beginning of their existence, they therefore do not offer the same quality and during this period consumers will prefer one of the incumbent operators that already have an optimal coverage. A second reason may be that for entrants also, it is important to build up a "local" reputation in a country even if they have a parent in another country. Building a "local" reputation simply takes some time. There is no evidence of a "shock therapy," according to which entrants have to attract their customers in the first months after entry.

The impact of the HHI grows significantly from a negligible number in the first months to the effect of a 6–9% reduction for a hypothetical change from full monopoly to perfect competition. This means that other things being equal and with equal market shares of incumbent operators the difference in ability to attract new clients between a first entrant (second player in the market) and a third entrant (fourth player in the market) is just 6%. Of course, another important difference between the first and third entrant is the fact that the penetration rate at the moment of market entry is higher for the third entrant. Given the estimations on the impact of changes in penetration rate, the impact of the change in the penetration rate is more important than the impact of the HHI.

5. Discussion and conclusion

This paper has empirically analyzed to what extent later entrants in the European mobile telephony industry have a disadvantage vis-à-vis incumbents and early mover entrants. To analyze this question a dynamic model of market share development and a series of static models have been considered. In the dynamic model, the development in market share is explained by factors such as changes in the penetration rate, the HHI at the moment of entry and a country dummy. The penetration rate and the HHI are the most important factors

determining early mover advantages. Some, but not very strong, differences between individual countries were found. If there are differences, they indicate the relative strength of the national regulators. It is, for example, relatively difficult to enter the mobile telephony sector and gain market share in Northern European countries. Each of the static models regresses the percentage of new users an entrant is able to acquire on the HHI and the change in penetration rate from the moment of entry onwards. There is strong evidence for early mover advantages. These advantages are mainly caused by the influence of the penetration rate: it pays to enter when only a small number of subscribers have acquired a mobile telephone. These static results corroborate the idea that it is mainly switching costs on the part of the consumer that causes early-mover advantages to exist.

From a policy perspective, probably the most striking aspect of the analysis is that the relatively simple models used due to data limitations are still able to explain a large proportion of the fluctuations in entrants' market shares. Penetration rates and market concentration at the moment of entry appear to be able to predict market shares of entrants quite well. This would imply that if governments want to create a level-playing field between operators, the decision when to allocate (new) licenses is indeed a very important one. Care should be taken, however, not to put too much confidence in the results as the models used remain very simple and cannot discriminate between alternative interpretations (see also below). The results should be interpreted as a first, interesting step towards a more thorough inquiry into the nature of first-mover advantages.

The paper admittedly leaves quite a few issues unexplained and it would be interesting to see what insights further research on these issues may yield. As already mentioned earlier, number portability has been enforced by national regulators in different years around the turn of the millennium and it would be interesting to see whether this has facilitated customers switching from one operator to another: is having an installed base less important when number portability is allowed? Also, pre-paid customers now make up a significant share of the total population of mobile users. As it could be argued that it is easier for pre-paid users to switch, it would be useful to make a distinction between pre-paid customers and other subscribers. Another issue is the importance of large multi-country brands. Many operators have recently adopted their parent company's name in all member states. Does this marketing strategy pay off in terms of more clients?

An important reason why these issues have not been addressed is the constraint imposed by the availability of data. One crucial point here is, of course, the lack of data on profits, cost, and especially pricing. The notion of market concentration used, the HHI, may not be a very appropriate measure of the degree of competition in a rapidly expanding market, such as the mobile telecommunications markets. Severe competition, especially if low prices emerge as a result, may partly explain the evolution of market penetration. If in future research a sufficiently rich data set could be used, it would be possible to estimate a system of equations where in one equation market shares are explained, *inter alia*, by price differences, and in another equation prices or their differences are explained, *inter alia,* by market shares. To make such a systems approach workable, data on identifying variables would be needed such as marketing expenditures, customer acquisition costs, other cost factors, and profits. In such an enriched model, some of the issues mentioned in the previous paragraph could also be addressed.

Finally, it was decided not to analyze dynamic models with dummies for firm-specific effects for the following two reasons. First, it is not entirely clear what is needed to capture firm-specific effects and there are potentially many ways to introduce these effects, of which just three are mentioned here: (i) is it necessary to know whether a firm's brand name is of importance (e.g., is it easier for a firm with a well-known brand name to enter a market than for an unknown company), or (ii) is it required to know whether a firm's size (possibility for heavily investing in marketing) is important, or (iii) is it necessary to know how easy it is for a firm with a well-known brand name to enter in country X, Y, or Z? Each of these three questions requires a different modeling of firm dummies. In the first case, an introduction has to be made of one and the same dummy for each case where the firm with the known brand name has entered a market under its own name; in the second case, it is necessary to introduce one and the same dummy for each case where the firm with the known brand name entered a market even if it uses a different name in that country; the third case requires the introduction of different dummy variables for each entry of a company in a different country.[17]

The second, probably more important, reason for abstaining from introducing firm dummies (in whatever way) is that certainly when using the third option discussed above, firm dummies would interact heavily with

[17]The question is also what to do with firms that have entered under a different name, but later changed the name to the name of the original mother company.

the effects that require to be measured (the effect of penetration rates and the HHI). The point is that every firm enters the market at a particular value of the penetration rate and the HHI. When introducing firm dummies, the firm dummy itself will measure part or most of the influence of entering at that point in time. Thus, the individual effect can then not be distinguished from the general effect so that the coefficients of the analysis become much more difficult to interpret.

The disadvantage of not introducing firm dummies and of the data limitations mentioned above is that it is difficult to exclude the possibility that the results are (partly) driven by a ''survival of the fittest'' story (where firms with the best price/quality ratio win). It is left to future research to establish whether it is possible to build a dynamic model with firm dummies that is able to discriminate between the switching cost interpretation and the survival of the fittest interpretation of the available data.

Appendix A. Information about market players and their date of entry, organized by country

The appendix first presents a table with ''early incumbents'' (Table A1) and then a table with entrants with their date of entry (Table A2).

Table A1
Early incumbents organized by country

Country	Operator	Date of introduction[a]
Austria	Mobilkom (PTV Austria)	(November) 1984
Belgium	Belgacom Mobile (Proximus)	(July) 1987
Denmark	TDC Mobil (Tele Danmark Mobile)	(January) 1982
Finland	TeliaSonera Finland	(March) 1982
France	Orange France (France Telecom Mobiles)	(November) 1985
	SFR	(March) 1989
Germany	T-Mobile	(September) 1985
Greece	*No incumbent firm before 1990*	
	Vodafone (Panafon)	(July) 1993
	TIM (STET Hellas)	(July) 1993
Ireland	Vodafone Ireland (Eircell)	(December) 1985
Italy	TIM	(September) 1985
Netherlands	KPN Mobile	(January) 1985
Norway	Telenor Mobil	(November) 1981
Portugal	TMN	(January) 1989
Spain	Telefónica Móviles	(November) 1982
Sweden	TeliaSonera Sweden (Telia Mobitel)	(October) 1981
	Tele2 AB (Comviq)	1981
Switzerland	Swisscom Mobile	(September) 1987
United Kingdom	O2 (BT Cellnet)	(January) 1985
	Vodafone	(January) 1985

Source: File WEurope-2006-06.xls and West Europe countries.xls (monthly data 1998).

[a]The date of introduction is defined as the moment there is at least one subscriber. This date is not always equal to the official month of introduction. For date of introductions before 1998 the month (if mentioned in the data set) is put in brackets because for this period monthly data is lacking.

Table A2
Entrants organized by country

Country	Operator	Date of introduction[a]
Austria	T-Mobile Austria (Max.Mobil)	(December) 1996
	Connect Austria (ONE)	December 1998
	tele.ring	May 2000
	Hutchison 3G (3 Austria)	May 2003

Table A2 (*continued*)

Country	Operator	Date of introduction[a]
Belgium	Mobistar	(August) 1996
	BASE (KPN Orange)	March 1999
Denmark	Sonofon	(March) 1992
	TeliaSonera Denmark	January 1998
	Orange Denmark (Mobilix)	March 1998
	Hi3G Denmark (3 Denmark)	October 2003
Finland	Elisa Mobile (Radiolinja)	(January) 1992
	Telia Finland Mobile	September 1998
	Finnet (Finnish 2G Suomen)	February 2001
France	Bouygues Telecom	(May) 1996
Germany	Vodafone D2 (Mannesmann)	(July) 1992
	E-Plus	(May) 1994
	O2 (Viag Interkom)	October 1998
Greece	Cosmote	April 1998
	Infoquest (Q-Telecom)	June 2002
Ireland	O2 (Esat Digifone)	(March) 1997
	Meteor Communications	February 2001
	Hutchison 3G	September 2005
Italy	Vodafone (Omnitel)	(December) 1995
	Wind	March 1999
	Blutel	May 2000
	H3G (3 Italy)	March 2003
Netherlands	Vodafone (Libertel)	(September) 1995
	Telfort (O2)	December 1998
	Orange (Dutchtone)	February 1999
	T-Mobile Netherlands (Ben)	February 1999
Norway	Netcom	(September) 1993
Portugal	Vodafone (Telecel)	(October) 1992
	Optimus	September 1998
Spain	Vodafone España (Airtel)	(October) 1995
	Amena	January 1999
Sweden	Telenor Sverige AB (Vodafone/NordicTel/ Europolitan)	(September) 1992
	Hi3G (3 Sweden)	May 2003
Switzerland	TDC Switzerland (DiAx/Sunrise)	December 1998
	Orange Communications (OCSA)	June 1999
	Tele2	June 2005
United Kingdom	T-Mobile (One2One)	(September) 1993
	Orange	(April) 1994
	Hutchison 3G (3 UK)	March 2003

Source: File WEurope-2006-06.xls and West Europe countries.xls (monthly data 1998).

[a]The date of introduction is defined as the moment there is at least one subscriber. This date is not always equal to the official month of introduction. For date of introductions before 1998 the month is put in brackets because for this period monthly data is lacking.

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