

# Early Mover Advantages: An Empirical Analysis of European Mobile Phone Markets<sup>1</sup>

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**Abstract.** In this paper we analyze 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 we consider a dynamic model of market share development and a series of static models. We find a clear 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.

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<sup>1</sup> The data used for this research are based on the Global Mobile Subscriber Database (GMSD) of the Informa Group. The data are provided to us by Proximus (Belgacom Mobile) for whom we carried out a research assignment. The results reported here are a revised version of the research for Proximus. We are very grateful to Proximus for letting us use these data and report these results to a wider audience. We also are 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 Organisation for Scientific Research (NWO) nr 451-04-011.

# 1. Introduction

There is a long tradition in economics to study the question whether incumbent firms have a first-mover advantage vis-à-vis later entrants. Von Stackelberg (1934), for example, showed already in the context of quantity-setting firms that a leader (first-mover) is able to get a larger market share and higher profits than a follower (second-mover). There are several reasons why first-mover advantages may arise.<sup>2</sup> In the economics (see, e.g., Mueller, 1997) and strategic management (see, e.g., Lieberman and Montgomery, 1988) literature the following factors are mentioned. On the demand side, there is the pre-dominant importance of switching costs (Klemperer, 1987a,b). Switching costs 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 already many firms are active.

There is also a large empirical literature on first-mover advantages, mostly in management and marketing journals (see, e.g., Urban et al., 1986, Kalyanaram and Urban, 1992, and Robinson et al., 1994, 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) are the first to study

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<sup>2</sup> 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.

a combination of cross-section data and time series. They also consider 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 a 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 et al. (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 our 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 at 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

was willing to sell additional licenses. The data set we use contains monthly data about market shares in all Western European countries. In the next section, where we describe the data we used for this study in more detail, it will become clear that there are forty-five 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 to consider 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 quite some 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. We will study how the order of entry has co-determined the evolution of market shares of firms in different countries. Third, because of the nature of our data set, we are 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, we only have data concerning mobile telephony market penetration, the number and names of the active operators and their market shares. Given this restriction, there are many potentially interesting questions we cannot address. In particular, we cannot empirically discriminate between the different explanations for first-mover advantages if they do exist. Nevertheless, we can address 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 we know of the European Telecommunications industry are the two papers by Gruber and Verboven (2001a,b). These papers study 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., Laffont and Tirole, 2001, and de Bijl and Peitz, 2002, 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 we have. Section 3 discusses the structure of the models we use to analyze the data. In Section 4 we give an overview of the different results and provide an interpretation. Finally, Section 5 concludes.

## **2. The European Mobile Telephony Markets**

In the beginning of the 1990s, most European countries had one incumbent firm offering telephone services to the population.<sup>3</sup> 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.<sup>4</sup> 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.

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<sup>3</sup> France, Sweden, and the U.K. had already two mobile operators in 1990; Greece had none.

<sup>4</sup> In this paper we do not make a distinction between countries where new licenses were auctioned and those where they were not, nor do we distinguish between countries where licenses were given away free of charge and those where firms had to pay. Implicitly, we take 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).

National regulators were given the task to force 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 et al., 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 regulation 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.

When the market for mobile telephony services gradually took off (see also Figure 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 start-up of consumer markets has led to a dramatic increase in the penetration rate around the turn of the millennium.<sup>5</sup> The agents on the demand side that create, however, the largest telephone traffic (firms in other sectors) usually chose to buy their mobile telephony services from the incumbent parties or the very early entrants. Moreover, later entrants<sup>6</sup> needed 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 cost 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 the 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,

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<sup>5</sup> On the basis of our 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 Figure 1) is what one typically observes in the technology adoption literature.

<sup>6</sup> 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.

other forms of switching costs continue to prevail, most notably the terms of the subscription contracts (one to two 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 to 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 Average Revenue Per User (ARPU), then this firm may price below its competitors thereby further increasing its market share.<sup>7</sup> A larger firm also has more possibilities to invest 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 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 our data set, we have analyzed the following sixteen European countries: 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 potential relevant factors such as the prices that the companies charge for their services.<sup>8</sup>

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<sup>7</sup> Larger firms typically will also be the first firms in the market and therefore will serve most of the business community (the larger users).

<sup>8</sup> If price data were available, these were very difficult to use, as most companies offer an extensive menu of price choices to their clients.

For the years 1998 – May 2006 we have monthly data at our disposal. For the years 1990 - 1997 only yearly data (of 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. We have revised the data with respect to measurement errors or other improbable data. Since December 1990, forty-five market introductions (new operators that enter the market) have taken place in these countries of which two are incumbents and forty-three entrants. The tables presented in the appendix provide the names of early incumbents and entrants in different countries. We define an early incumbent<sup>9</sup> as an operator who either was already active in the market offering mobile telephony services at the moment our data set starts (in 1990) or was the first operator active in the market (and entered after 1990).<sup>10</sup> All other firms are considered entrants. From Table A.2 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 number of users of different technologies, we have not used this distinction for the fact 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) we see that the number of subscribers to the old technology with an operator quickly vanishes and that these customers switch to the new technology. Also, the introduction of new technology is typically the moment new players come into the market and our analysis 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 we have simply added the number of subscribers with an operator over all available technologies and take this variable as our basic unit of analysis.

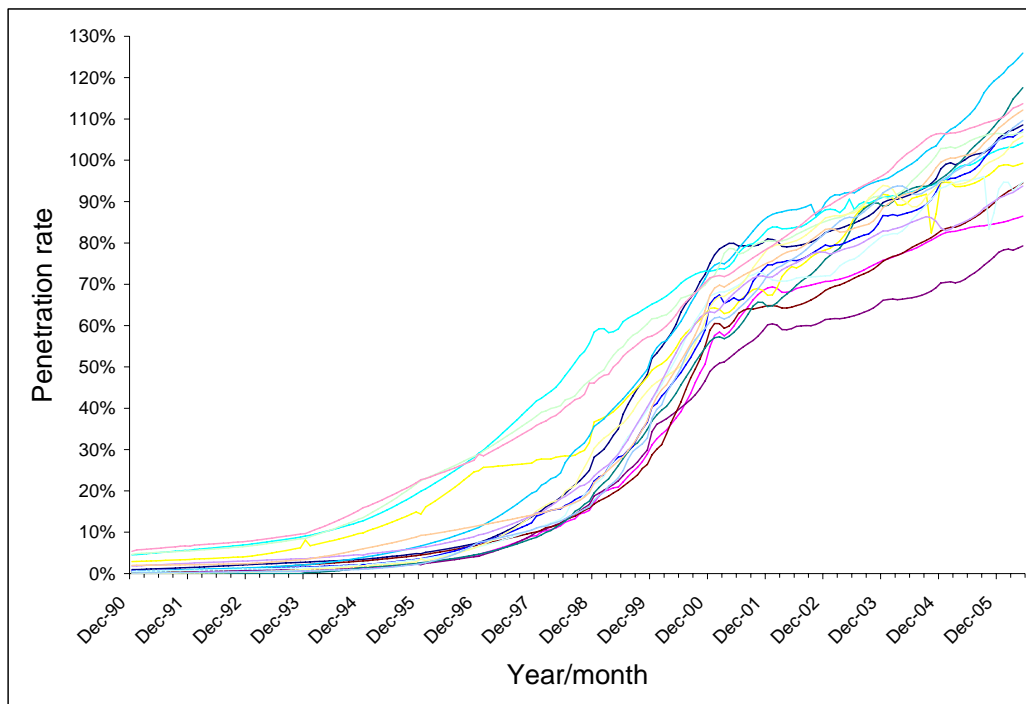
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<sup>9</sup> We use “early incumbents” to be able to use the term incumbent for all those companies that are active in the market at the moment a new player enters.

<sup>10</sup> This definition is used as we cannot econometrically distinguish between companies that were already active at the moment our data set starts.

### *Penetration rate*

The penetration rate in the different countries is depicted in Figure 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,b) 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).



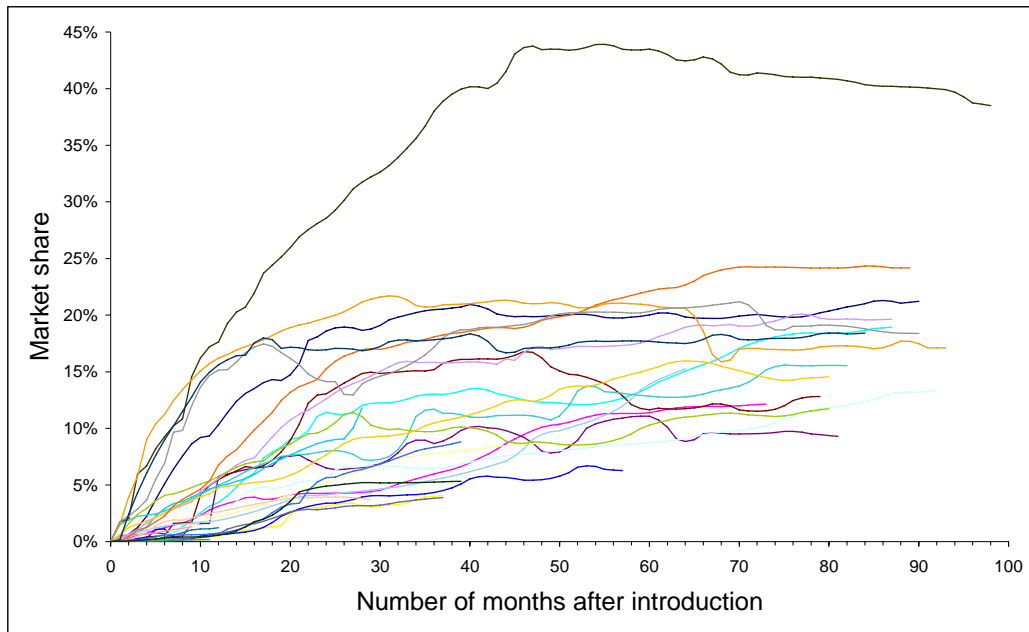
*Figure 1. Development of penetration rate in different countries*

### *Market shares*

For each entrant (with entry in 1998 or later) we have analyzed how its market share develops over time, from *the moment of introduction onwards*.<sup>11</sup> The developments in market shares measured in this way are depicted in Figure 2. One can easily see that an average firm's market share increases most steeply immediately after entering the

<sup>11</sup> The moment of introduction starts when the number of subscribers to the network becomes positive.

market. Moreover, a rough first impression suggests that the increase in market shares flattens off to become more or less stable after approximately forty 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,<sup>12</sup> these facts may explain its unusual development.



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

In 2003-2005, there have been some acquisitions of one operator by another. We mention 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% - we have decided not to use data in such a specific country after the take-over. Thus, we use the data on the Netherlands up to September 2005. In Figure 2 this has lead to some curves being cut off after a certain moment in time.

<sup>12</sup> This is what is argued for in Knyphausen-Aufseß et al. (2002).

### 3. The Models

In order to investigate the impact of market concentration and the penetration rate on the development of market shares of entrants, we have investigated two types of models: (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 (Figure 2). Figure 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 we propose a non-linear model 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:

- $m_{it}$  : the market share of firm  $i$   $t$  months after introduction;
- $t$  : time measured in months after introduction;
- $\beta, \gamma$  : firm (or country specific) parameters.

The parameter  $\gamma_i$  has a clear interpretation: it is the “long-run” market share of firm  $i$ . The parameter  $\beta$  determines the speed of convergence. In the dynamic analysis these parameters are determined by a number of exogenous factors. For  $\gamma$  we have chosen the following specification in the base model (model A in the analysis section below):

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

where:

- $p$  : 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;
- $\alpha$  : parameters.

We have chosen an exponential functional form for  $\gamma$  to assure it is always positive. We introduced the penetration rate itself 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 market penetration rate is already quite 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  $\alpha_2$  is negative and  $\alpha_1$  is positive. When both  $\alpha_2$  and  $\alpha_1$  are negative, firms want to enter as early as possible and this effect increases with a delay of entry. When  $\alpha_1$  is negative and  $\alpha_2$  is positive but with an absolute value smaller than  $\alpha_1$ , firms want to enter as early as possible, but the effect of early entry vanishes.

There are two different measures of market concentration we may use, the HHI and the number of active firms at the moment of introduction. Typically, one would expect entry to 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. We therefore use the HHI as a measure of market concentration.<sup>13</sup> We have included the Herfindahl-Hirschman Index *at the moment of market introduction* 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

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<sup>13</sup> 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 our 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.

evolution of market share. We have also estimated 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.

For  $\beta$  we have chosen the following specification:

$$\beta_i = \beta_1 + \beta_2 HHI_{it} + \beta_3 \Delta p_{it},$$

where:

$HHI_{it}$  : the Herfindahl-Hirschman Index at time period  $t$  measured after entry of firm  $i$ , taking values between 0 and 1;

$\Delta p_{it}$  : the change in penetration rate measured from the moment of introduction;

$\beta$ 's : 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. One would expect the number of firms to 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.

We estimate this dynamic model using the full data set. To this end, we interpolate for the period before 1998 the yearly data 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 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 we calculate the imputed HHI. Note that for the “long-run” market share, the  $\gamma_i$ , we only need the imputed values of the penetration rate and HHI at the moment of introduction. Although the

convergence rate, the  $\beta_i$ , 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, we introduce country dummies to measure country specific differences, most notably the impact national regulators have on protecting the interests of entrants. In the next section we will estimate the 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. We do test, on the other hand, for this endogeneity in the context of the static model (see below). We are confident that if that test does not indicate any endogeneity problem it is safe to assume that the penetration rate is exogenous in the dynamic model.

In the static models, we 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., we do not directly investigate the developments in market shares. We have chosen to do this for the following reason. Because of the presence of switching costs, we are mainly interested in 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, we analyze 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. We have carried out these static analyses 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 we use is thus as follows:

$$n_{it} = \xi_{1t} + \xi_{2t}\Delta p_{it} + \xi_{3t}HHI_i + \varepsilon_{it}, \quad (1)$$

where:

- $n_{it}$  : the number of customers of entrant  $i$  expressed as a percentage of the total population at time  $t$  months after entry;
- $\Delta p_{it}$  : 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;
- $\varepsilon_{it}$  : error term;
- $\xi's$  : parameters.

The parameters in this linear model are easily interpretable. The parameter  $\xi_{2t}$  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  $\xi_{3t}$  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 yearly and monthly data in estimating the static model, we only use the monthly data available since 1998, and thus the corresponding twenty-seven market entries (see Table A.2 in the appendix for details). As we measure the number of customers of entrant  $i$  at  $t$  months after entry, we only consider entrants after 1998. We could interpolate the yearly data over the period 1991-1998 to construct monthly data ourselves as we did in the dynamic model (and then accommodate sixteen more market entries), but this would imply that for each estimation results approximately 30% of the relevant data is artificially constructed. As we 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.<sup>14</sup> 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 to deal 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 our 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.<sup>15</sup> 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

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<sup>14</sup> Note that this is a different type of endogeneity than the one discussed in the Introduction.

<sup>15</sup> Loosely speaking: A good instrument is (highly) correlated with the variable it instruments but not with the error of the equation.

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 we used the average change in penetration rates in other countries 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

In this section we discuss the empirical results we obtained from estimating the two alternative models.

### 4.1. Analysis of the dynamic model

We start the analysis by investigating the development of market shares in the context of the dynamic model. The estimation results are reported in Table 1 below. We first look at 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.<sup>16</sup> In the first situation the entrant will get an estimated

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<sup>16</sup> Assume an average country with a dummy constant of -2.2.

“long-run” market share of roughly 38%, whereas it will only reach a market share of 6% in the second situation.

<i>Gamma</i>		Model A		Model B	
		parameter	std error	parameter	std error
	<i>Country dummies</i>				
	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
	<i>Other characteristics</i>				
	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
<i>Beta</i>					
	Time (# months) since entry (t)	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

*Table 1. Estimation results for the dynamic model*

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).<sup>17</sup> To the extent that there are significant differences

<sup>17</sup> Note, however, that the estimated coefficient for Greece is probably due to the unusual case of Cosmote (see the discussion in Section 2).

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 case 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 said in footnote 13, namely that the HHI captures two different effects. We see these opposite effects 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 stronger 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 correlation coefficient -0.76. Thus the two measures of concentration are close to being collinear and the 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. Figure 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. One can easily see 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.

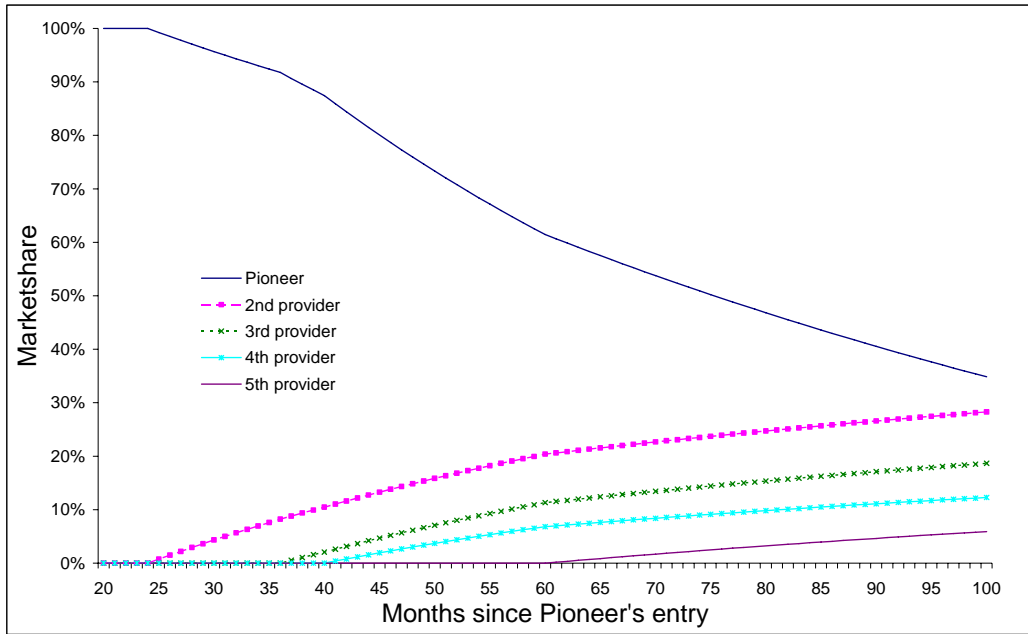


Figure 3. Market shares by order of entry

#### 4.2. Analysis of the static models

We start the analysis of the static models by estimating the parameters at different durations after entry. The results are given in the “OLS column” of Table 2 below. Table 2 also reports in the “IV column” the results of the Instrumental Variable 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. We conclude that 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, we do not have to adjust our dynamic analysis either.

## Estimation results of static analyses

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

Delpen: change in penetration rate  
t-value between brackets

Table 2. Estimation results of static analyses

There are some important results that attract the attention. First, all the estimated parameters have the expected signs: changes in the penetration rate have a positive impact, while an increase in market concentration, as measured by the HHI, has a negative impact on the relative number of consumers an entrant is able to attract. A more concentrated market usually implies more competitors and therefore a smaller 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 important fraction (between 40 to 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 to become important.

Most striking is 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 one 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 to attract 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 also for entrants 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. We do not find 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 an 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 attracting new clients between a first entrant (2<sup>nd</sup> player in the market) and a third entrant (4<sup>th</sup> 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, we conclude that impact of the change in the penetration rate is more important than the impact of the HHI.

## 5. Discussion and Conclusion

In this paper we have analyzed empirically 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 we have considered a dynamic model of market share development and a series of static models. In the dynamic model, we explain the development in market share by factors such as changes in the penetration rate, the Herfindahl-Hirschman Index at the moment of entry and a country dummy. The penetration rate and the Herfindahl-Hirschman Index are the most important factors determining early mover advantages. We also find some, but not very strong, differences between individual countries. 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. In each of the static models, we have regressed 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. We find strong evidence for early mover advantages. These advantages are mainly caused by the influence of the penetration rate: it pays to enter when still few people 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 our analysis is that the relatively simple models we had to use 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 seem 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. One should be careful, however, not to put too much confidence in our results as the models we were using remain very simple and cannot discriminate between alternative interpretations (see also below). We interpret our results as a first, interesting step into a more thorough inquiry into the nature of first-mover advantages.

The paper 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 one may argue that it is easier for pre-paid users to switch, one would like 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 we have not addressed these issues is that we are quite constrained 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 we have used, the Herfindahl-Hirschman Index, may not be a very appropriate measure of the degree of competition in a rapidly expanding market, like 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, one can think of estimating a system of equations where in one equation market shares are explained by price differences, among other things, and in another equation prices or their differences are explained by market shares, among other things. To make such a systems approach workable, one need data on identifying variables, such as marketing expenditures, customer acquisition costs, other cost factors and profits. In such a richer model, one also could take up some of the issues mentioned in the previous paragraph.

Finally, we have decided not to analyze dynamic models with dummies for firm-specific effects for the following two reasons. First, it is not entirely clear what one wants to capture with firm-specific effects and there are potentially many ways to introduce these effects, of which we mention just three here: *(i)* does one want 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)* does

one want to know whether a firm's size (possibility for heavily investing in marketing) is important, or *(iii)* does one want 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 ways require a different modelling of firm dummies. In the first case, we have to introduce 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, we have 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 to introduce different dummy variables for each entry of a company in a different country.<sup>18</sup>

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 heavily interact with the effects we really want to measure (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). We leave it 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.

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<sup>18</sup> 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.

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## Appendix: Information about Market Players and Their Date of Entry, Organized by Country

We first present a table with “early incumbents” and then a table with entrants with their date of entry.

Country	Operator	Date of introduction <sup>19</sup>
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) SFR	(November) 1985 (March) 1989
Germany	T-Mobile	(September) 1985
Greece	<i>No incumbent firm before 1990</i> Vodafone (Panafon) TIM (STET Hellas)	 (July) 1993 (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) Tele2 AB (Comviq)	(October) 1981 1981
Switzerland	Swisscom Mobile	(September) 1987
United Kingdom	O2 (BT Cellnet) Vodafone	(January) 1985 (January) 1985

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

Table A.1. “Early incumbents” organized by country

<sup>19</sup> 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 we have put the month (if mentioned in the data set) between brackets because for this period we lack monthly data.

<b>Country</b>	<b>Operator</b>	<b>Date of introduction<sup>20</sup></b>
Austria	T-Mobile Austria (Max.Mobil) Connect Austria (ONE) tele.ring Hutchison 3G (3 Austria)	(December) 1996 December 1998 May 2000 May 2003
Belgium	Mobistar BASE (KPN Orange)	(August) 1996 March 1999
Denmark	Sonofon TeliaSonera Denmark Orange Denmark (Mobilix) Hi3G Denmark (3 Denmark)	(March) 1992 January 1998 March 1998 October 2003
Finland	Elisa Mobile (Radiolinja) Telia Finland Mobile Finnnet (Finnish 2G Suomen)	(January) 1992 September 1998 February 2001
France	Bouygues Telecom	(May) 1996
Germany	Vodafone D2 (Mannesmann) E-Plus O2 (Viag Interkom)	(July) 1992 (May) 1994 October 1998
Greece	Cosmote Infoquest (Q-Telecom)	April 1998 June 2002
Ireland	O2 (Esat Digifone) Meteor Communications Hutchison 3G	(March) 1997 February 2001 September 2005
Italy	Vodafone (Omnitel) Wind Blutel H3G (3 Italy)	(December) 1995 March 1999 May 2000 March 2003
Netherlands	Vodafone (Libertel) Telfort (O2) Orange (Dutchtone) T-Mobile Netherlands (Ben)	(September) 1995 December 1998 February 1999 February 1999
Norway	Netcom	(September) 1993
Portugal	Vodafone (Telecel) Optimus	(October) 1992 September 1998
Spain	Vodafone España (Airtel)	(October) 1995

<sup>20</sup> 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 we have put the month between brackets because for this period we lack monthly data.

	Amena	January 1999
Sweden	Telenor Sverige AB (Vodafone/NordicTel/Europolitan) Hi3G (3 Sweden)	(September) 1992 May 2003
Switzerland	TDC Switzerland (DiAx/Sunrise) Orange Communications (OCSA) Tele2	December 1998 June 1999 June 2005
United Kingdom	T-Mobile (One2One) Orange Hutchison 3G (3 UK)	(September) 1993 (April) 1994 March 2003

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

Table A.2. Entrants organized by country