

THE IMPACT OF MOBILE NUMBER PORTABILITY ON THE DIFFUSION OF MOBILE TELECOMMUNICATIONS ACROSS EUROPE.

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ABSTRACT. This paper investigates the determinants of diffusion of mobile telecommunications in European Union. In addition to several technological and competitive related factors that are typically considered in other diffusion studies of mobile telephony present paper focuses on the impact of mobile number portability (MNP) as a potential driver of diffusion process. Within the frames of logistic diffusion model the study confirms the significant positive impact of MNP introduction on the speed of diffusion, however the strength of this relation differs both with respect to type of subscriber contract and between EU-15 and EU-12 countries.

1. INTRODUCTION

There is a consensus in the literature that the development of mobile telecommunications has been influenced by several events that have occurred throughout in the industry.

Main body of research on this issue was done when mobile penetration rate in most European markets did not exceed 40-50%. In this early phase of industry development technological developments were found to be the most important determinants of diffusion as shown by Gruber and Verboven [5], Gruber [3] and [4]. Their main conclusion is that the transformation from analog to digital transmission and utilization of higher frequency spectrum was the main driver of diffusion in the 90ties as it removed strong capacity constraints. These papers also conclude that regulatory policy aimed at entry promotion influenced the development of mobile telephony to a lesser extent. These conclusions are not surprising since in that time action undertaken by national regulatory authorities to promote effective competition between operators were limited mainly to licensing policy and did not utilized other measures.

Like in the case of many other innovations, the development of cellular telephony is a nonlinear process. In almost all European countries diffusion path of mobile services resembles the sigmoid curve. At present this process entered in a maturity phase. The penetration of digital mobile telephony exceeds 100%. In many countries there are already 3G networks under full coverage operation, offering next generation services based on high speed data transfer. Competition between network operators in each country continuously increases, putting a strong pressure on price levels. Beside ongoing regulation within common regulatory framework, in last few years we have observed several competition enchaning

Key words and phrases. diffusion models, mobile number portability.

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initiatives undertaken at national level and by European Commission. The most notable are promotion of market entry by virtual operators (MVNO), mandated introduction of mobile number portability (MNP) and recent fixing of price ceiling on roaming inside EU.

There is a strong supposition that some of these relatively recent events might influence the development of mobile telecommunications in a very much similar way as technological transformation did in the beginning of previous decade. These factors, which obviously could not have been considered in earlier research, are potential drivers in the mature stage of diffusion process. The present study focuses on one of those potential drivers, namely number portability. Our main research question is whether the diffusion process of mobile telephony in the recent years has been speeded up by the introduction of MNP.

The main motivation to post this research question is the ongoing debate about the effectiveness of mobile number portability. In official documents by EC, OECD and national regulatory authorities as well as consultation agencies, introduction of MNP was seen *ex ante* as the key action supporting the development of competition. See for instance consultation document by Ovum [14] for Oftel and assessment report by OECD [13].¹ This view has been supported by the results of academic research.²

Despite the common belief that the MNP is an effective tool to promote competition, post implementation opinions are somehow ambiguous. While some research from US market and on EU level show moderately positive impact of mobile number portability, it seems that on country level this regulatory measure did not contributed in many cases to the growth of competitiveness, due to unfavorable conditions for customers porting their numbers between network operators.³ Author believes that examination of the relationship between MNP and the diffusion process of mobile telephony would be a valuable contribution to this discussion.

The rest of the paper is organized in the following way. In the second section we briefly discuss literature related to diffusion concept and mobile number portability. In the third section we turn to model description. The fourth section is devoted to estimation details. Section fifth concludes. All estimation results and figures are gathered up in the Annex.

2. RELATED LITERATURE

2.1. Diffusion. According to the classical definition by Rogers [15] diffusion of innovation is a process by which new ideas, products and technologies spread in the social system. The key questions in diffusion

¹In 2002 OECD assessed that one of the most important shortcomings of regulatory environment of polish telecommunications market is lack of mobile number portability and its introduction was the basic recommendation for promoting price competition, which was insufficient in light of OECD basket benchmarks.

²For theoretic research the reader is refereed to papers by Klemperer [7], [8], [9]. For positive empirical results on the relationship between number portability and price competition see Viard [16], Lee et al. [10] and Grzybowski [6].

³This includes not only porting fee, but also a long transition period when sim module is disabled from operation. Porting conditions differ to great extent among EU member states.

analysis are in what manner and in what pace customers adopt new services and ideas. The process of diffusion has four main elements: innovation, transmission channels, time and adoption dynamics and social system.

Out of these four elements the one that is common for almost all innovations is the dynamics of diffusion. Cumulated number of adoptions set against passing time graphically resembles sigmoid curve. In the beginning phase, only few members of social system adopt the innovation, but the speed of adoptions is constantly increasing over time. In a certain point of time - called the inflection point - the pace of adoption slows down and the diffusion path flattens approaching the horizontal asymptote. In this maturity phase the social system becomes satiated with the innovation. This kind of diffusion was confirmed for thousands of products and services in hundreds of empirical research papers.

There are many modelling alternatives in diffusion analysis. The review of most commonly used is provided by Mahajan and Peterson in [11]. As for mobile telecommunications the most popular models are logistic curve, Gompertz curve, Bass model and non-uniform influence (NUI) model which is a generalization of the former. These models, which may also include covariates, have different number of parameters and different properties concerning symmetry of diffusion curve and the range in which inflection point may occur. The choice between alternative approaches in specific case/market depends usually on the characteristics of empirical diffusion path such as its shape and maturity.

2.2. Switching costs. Without number portability a subscriber who wants to change his network operator has to give up his phone number. This is a classical example of switching cost in telecommunications. According to Padila et al. [12] switching costs can be defined as real or perceived costs that are incurred when changing supplier but which are not incurred by remaining with the current supplier. Switching costs is a widely spread phenomenon which fundamentally changes the way in which firms behave and markets operate. The existence of such costs leads to economies of scale in repeat purchasing, because a customer who has previously bought from one firm incurs extra cost in purchasing an otherwise identical product from a new firm, even if that product is sold at the same unit price. As a consequence, in markets with consumer switching costs demand is less elastic and consumers have limited incentives to migrate to cheaper offers which dampens competition.

In telecommunications lack of number portability is not the only instance of consumer switching costs. Other forms of switching costs include simlocking handsets, fines for breaking contract and loyalty discounts.

The impact of switching costs on market competition has been analyzed by many researchers. Surely one of the most important contributions have been made by Klemperer in [8] and [7] and [9]. He discusses the impact of switching costs on prices, market shares, profits and entry deterrence. The fundamental way in which switching costs change firms behavior is that each supplier with an installed base of customers will have interest in exploiting his customers, because they are locked-in by previous purchase. This

motivation, especially in case of no price discrimination, will cause a weak interest in competing for rivals' or new customers.

Another consequence of switching costs and lock-in mechanism is that for each supplier market share is a fundamental goal of business strategy. Firms will invest in future market shares, since installed customer base is valuable for them. In the dynamic market perspective, when firms first compete for new customers who later on face switching costs of changing supplier, prices are lower in the beginning and higher in later periods of competition as compared to identical market with no switching costs. This is known as bargain then rip-off pricing. Although in this pricing pattern low prices for new customers are followed by high prices for locked-in customers, but average market prices and profits are still higher than in the absence of switching costs.

2.3. Mobile number portability. Although MNP was not mandated by the EU regulatory framework before the year 2003, it was already offered in ten member states. Among UE countries, MNP was first introduced in United Kingdom in January 1999. The next were: Spain (10/2000), Holland (01/2001), Denmark and Portugal (07/2001), Sweden (09/2001), Italy (04/2002), Belgium (10/2002), Ireland and Germany (11/2002). The change in legal framework making mobile number portability compulsory was set in the European Parliament and Commission Directive 2002/22/EC on Universal Service and Users' Rights. The new framework took effect on 25 July 2003 and this date was the final deadline for mobile network operators in all member states to have completed a full commercial launch of mobile number portability.⁴

The effect of MNP introduction should be consistent with lowering switching costs. The main expectation is that average market prices should fall down. A price decrease will affect not only old mobile subscribers but also new customers and this should positively affect adoption rate. This is however only true if new consumers have rational expectations. Naive customers do not see the relation between lower prices today and higher prices tomorrow, so that reduction of switching costs would actually discourage them from buying today because of less attractive promotional offers (weaker 'bargain' part of pricing strategy).

There are several types of benefits from MNP introduction. In a report [14] made by Ovum for Oftel prior to MNP launch in United Kingdom, the benefits were estimated on average at £1.5 for individuals and £99 for business subscribers. In case of business subscribers keeping their number allows to avoid cost of informing clients (£27); cost of updating advertisements, business cards, cars repainting (£174); cost of losing and substituting part of business contacts. On average 10 percent of clients are lost and cost of substituting one client was estimated at £39 for small and medium enterprisers. Although the results of cost benefit analysis for UK market were estimated positive, MNP has not to be always welfare enhancing, as Buehler et al. argue in [2]. They identify different types of beneficiaries

⁴This deadline was actually met in all EU-15 states, see Table 4.

of MNP introduction and point out on the negative consequences of this functionality on fixed-to-mobile termination charges resulting from network identification problem.

The last part of literature includes few empirical studies of the impact of MNP on price competition. In this respect there are at least two notable papers. The first one concerns the market for 800 toll-free info lines in US (Viard [16]) and the second concerns mobile market in European Union (Grzybowski [6]). There are also many empirical studies concerning the impact of lowering switching costs on market price indices in other industries, such as airline, banking, and gasoline.⁵

3. MODEL

The present paper utilizes logistic model of diffusion in a much similar way as Gruber in [4]. Therefore we follow his notation in large parts. The logistic model can be specified as:

$$(1) \quad \frac{Y_t}{M} = \frac{1}{1 + \exp(-a - bt)} \quad \text{where } b \in R^+$$

where a is location parameter and b is related to growth rate of diffusion process. Parameter M is market potential. Greater values of location parameter shift diffusion curve backwards, so that the adoption process can be described as more advanced as is depicted in Figure 1. For a complete description of diffusion path within a framework of diffusion model all three parameters need to be estimated. However the market potential parameter M is difficult to estimate unbiased together with the remaining two, especially in cases when diffusion curve has not reached its inflection point.⁶ In the present paper market potential has been estimated simultaneously with location and speed parameters in a logistic model and it turned to be underestimated for many countries. For this reason market potential has been also estimated with three different models and the most reliable one out four estimates was selected.⁷

For estimation purposes the logistic model given in (1) is often presented in the following linearized form:

$$(2) \quad z_t = LN\left[\frac{Y_t}{M - Y_t}\right] = a + bt$$

⁵Refer to Borenstein [1] as a illustrative example.

⁶See Gruber [4] for further discussion and solutions.

⁷They are put in column with header 'combined' in tables 2a and 2b. For further details refer to section 3.1.

Both location and speed parameters are assumed to be the following functions of explanatory variables (covariates):

$$(3) \quad a = \alpha^0 + \sum_{j=1}^J \alpha^j D^j + \sum_{k=1}^K \alpha^k x_k$$

$$b = \beta^0 + \sum_{j=1}^J \beta^j D^j + \sum_{k=1}^K \beta^k x_k$$

where D^j is dummy variable for introducing certain events in the regulatory environment and \mathbf{x} is a vector of other non-binary covariates affecting one or both parameters of diffusion.

3.1. Market potential. The three additional diffusion models used for market potential estimation were: Gompertz model:

$$(4) \quad \frac{Y_t}{M} = \exp[-\exp(-p(t - q))]$$

Bass model:

$$(5) \quad \frac{Y_t}{M} = \frac{1 - \exp[-t(p + q)]}{1 + \frac{q}{p} \exp[-t(p + q)]}$$

and Non-Uniform Influence (NUI) model:

$$(6) \quad y_t = \frac{dY_t}{dt} = [p + q(\frac{Y_t}{M})^c][M - Y_t]$$

First two models have three parameters just like logistic model. The last model is a generalization of Bass model. It has one more parameter and does not have a closed-form solution. The rationale for utilization of these models is that they poses different mathematical properties allowing for flexible estimation of market potential. The results of modelling market potential M for postpaid services and for all types of contract are presented in Tables 2a and 2b.⁸

Figure 3 and first two columns of Table 4 present the results of logistic model estimation for all EU-27 member states. Figure 3 reveals strong negative relationship between location and speed effects in the sample. The least advanced countries with respect to mobile services diffusion (low value of a) have at the same time greater values of speed parameter. This is well known symptom of international convergence in mobile telecommunications between leaders and catching up countries.

⁸All estimations were done using nonlinear least squares procedure.

4. ESTIMATION

4.1. Description of Data and Hypotheses. The annual data covers the period from 1985 to 2006 for all 27 EU member states. The data comes mainly from ITU World Telecommunication ICT Indicators 2007 database. We have also utilized two other sources of public data: www.gsmworld.com and Implementation Reports by the European Commission. List of variables taken into consideration included:⁹

sim_postpaid - number of postpaid subscribers.

sim_prepaid - number of prepaid subscribers.

gdp_usd_pc - gross domestic product per capita in USD. This variable is expected to have positive impact on diffusion.

fixed_per_100inh - number of main lines per 100 inhabitants. This variable might have positive or negative impact on diffusion depending whether fixed lines are used in a complement (ADSL) or substitute (voice calls) manner to mobile services.

mnp_intro - year of MNP introduction. This variable is expected to have positive impact on diffusion as was justified in the literature section.

3G_intro - year of 3G technology introduction.

2G_operators - number of 2G operators.

2G_intro - year of 2G technology introduction.

prepaid_intro - year of prepaid introduction.

The last four variables are also expected to positively influence diffusion. While introduction of 2G technology removed tight capacity constraints, the 3G technology offers new services which extend the functionality of mobile subscription and therefore should attract new customers. The number of 2G operators is a proxy for competition intensity. The prepaid mobile offer attracted very many customers, who have either low income or specific usage profile or preferred not to bind with the network operator for a long period of time. Due to its huge popularity prepaid offer boosted mobile penetration rate in almost every country. As an illustration see Figure 5 for UK case. In some countries in reaction to prepaid introduction a temporal decline in penetration of postpaid offer was observed.

4.2. Econometric specification and estimation results. The estimated model is based on equations (2) and (3) and has the following form:

⁹Selected country characteristics are presented in Table 4.

$$(7) \quad z_{it} = LN\left[\frac{Y_{it}}{M_i - Y_{it}}\right] = a_{it} + b_{it} \cdot t + \epsilon_{it} \quad \text{where}$$

$$a_{it} = f\{\text{intercept} ; \text{fixed_per_100inh}_{it} ; \text{mnp_intro}_{it} ; 2G_intro_{it} ; 3G_intro_{it} ; 2G_operators_{it} ;$$

$$\text{gdp_usd_pc}_{it} ; \text{prepaid_intro}_{it}\} \quad \text{and}$$

$$b_{it} = f\{\text{fixed_per_100inh}_{it} ; \text{mnp_intro}_{it} ; 2G_intro_{it} ; 3G_intro_{it} ; 2G_operators_{it} ;$$

$$\text{gdp_usd_pc}_{it} ; \text{prepaid_intro}_{it}\}$$

From the above equation it follows that all dependent variables entered formulas for both diffusion parameters. This equation was estimated using panel regression procedure with fixed effects for six different data sets. The panel has been limited to period 1993-2006 in order to obtain balanced data for all 27 cross sections.¹⁰

First two estimations were done for all EU-27 countries on two different dependent variables: postpaid subscribers and all subscribers regardless of type of contract.¹¹ The reason for this separation was the expectation that the MNP maybe attractive much more for the postpaid subscribers then for prepaid group. The former group includes business subscribers, who are usually targeted by network operators with different tariff schemes offered on the contract basis and are likely to have the greatest incentive to change service provider. Therefore MNP might occur to be important for diffusion of mobile services only in the postpaid subscribers population.

Another four estimations were performed on the same two dependent variables but separately for EU-15 and EU-12 new member states. The reason for this separation is similar as before. In majority of new member states the introduction of MNP was done only very recently, so that it might be difficult to detect its impact on diffusion of mobile subscriptions.

The results of all panel regressions are presented in Tables 6 and 7. Table 6 indicates that in the EU-27 the diffusion of all types of mobile subscriptions has been positively influenced by introduction of mobile number portability, prepaid offer, 2G technology, and also to the lesser extent by the number of 2G operators. Negative estimates for speed effects indicate that the positive shocks on location parameter are diminishing over time. Mobile number portability seems to be very important driver of diffusion in EU-12 countries while in EU-15 introduction of 2G technology and prepaid offer played a major role. Competition effect although significant play a minor role in both groups of countries.

While MNP has been insignificant for diffusion of all mobile subscriptions in EU-15 countries it is important for diffusion of postpaid contracts in this group, however again introduction of 2G technology

¹⁰The alternative estimation method used in Gruber [4] and Gruber and Verboven [5] - nonlinear least squares on pooled data did not provide interesting and significant results. Also contrary to both papers, no restrictions on parameters values for variables entering both location and speed equations occurred to be significant.

¹¹The variable prepaid_intro has been ruled out from all estimations on postpaid data.

is the most influential factor (see Table 7). For both dependent variables, 3G introduction has no impact on the diffusion in EU-12.

5. CONCLUSIONS

The study yields interesting results concerning the impact of mobile number portability on the diffusion of mobile telecommunications. Number portability influenced the diffusion of all mobile subscriptions in EU-27 and in new member states (EU-12). It has also been important factor of postpaid subscriptions diffusion in EU-15. The latter result is the most significant, because in EU-15 number portability and prepaid services were introduced almost in the same time and analyzing only the postpaid segment enabled to separate the impact of both.

For both types of mobile subscriptions 2G remains the most important diffusion driver in EU-15 countries, while in EU-12 this factor has not been important. This not surprising since new member states have launched mobile services when analog technology was passing away. It seems that in case of EU-12 number portability and prepaid plays similar role as main drivers of diffusion as 2G technology introduction in EU-15 in the 90ties.

Introduction of 3G technology occurred to be insignificant for diffusion in any configuration and competition intensity measured by number of 2G operators occurred to have positive, although very little impact on diffusion of mobile telecommunications. With respect to the last result and also to the huge role of 2G introduction in EU-15 the present study is consistent with results of previous research.

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The impact of mobile number portability on the diffusion of mobile telecommunications across Europe.

Annex.

Figure 1. Stylized diffusion paths in logistic model.

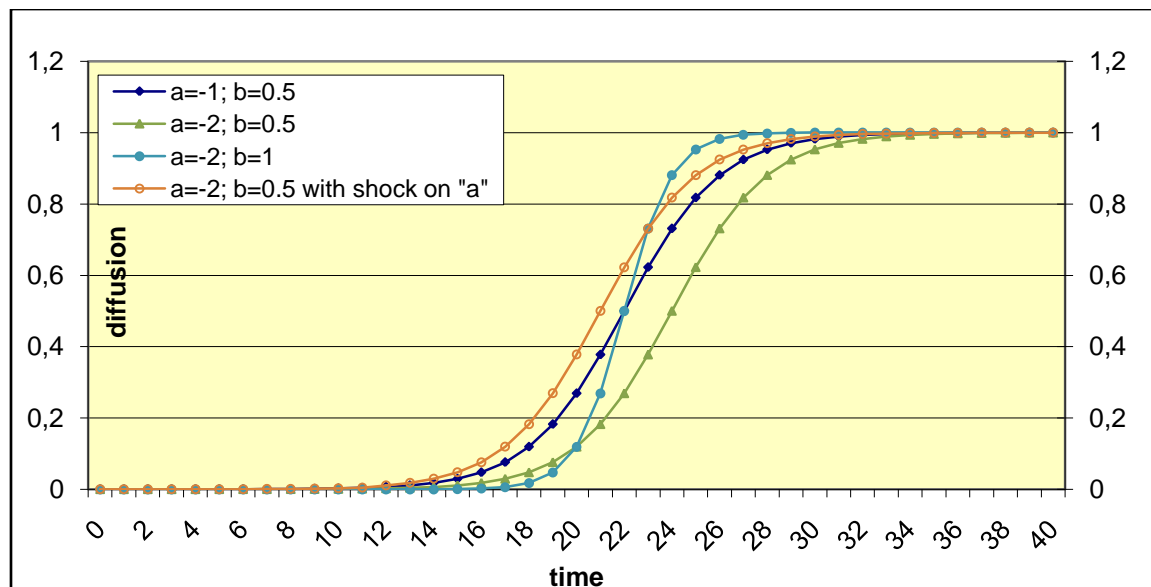


Table 2a. Market Potential. Prepaid and postpaid mobile.

STATE	COUNTRY	SIM_ALL	POPULATION	sim_pop_ratio	combined	nui_m	bass_m	gompertz_m	logistic_m
1	UK	69 656 619	59 847 100	1,164	1,270	1,140	1,140	1,270	1,140
2	Poland	36 745 453	38 498 600	0,954	1,498	5,036	1,498	3,964	1,498
3	Austria	9 256 000	8 204 600	1,128	1,185	1,058	1,042	1,111	1,042
4	Belgium	9 659 819	10 437 000	0,926	0,940	0,891	0,902	0,940	0,902
5	Bulgaria	8 253 416	7 671 200	1,076	1,664	4,865	1,664	4,068	1,664
6	Cyprus	867 785	844 600	1,027	1,389	1,148	1,389	3,093	1,389
7	Czech Rep.	11 882 202	10 209 200	1,164	1,237	1,167	1,160	1,237	1,160
8	Danmark	5 828 157	5 446 300	1,070	1,386	1,157	1,130	1,386	1,130
9	Estonia	1 658 700	1 324 900	1,252	1,522	2,641	1,522	2,385	1,522
10	Finland	5 670 000	5 261 800	1,078	1,220	1,127	1,072	1,220	1,072
11	France	51 662 000	60 722 900	0,851	0,855	0,826	0,799	0,855	0,799
12	Germany	85 652 000	82 715 600	1,035	1,085	0,999	0,989	1,085	0,989
13	Greece	10 979 826	11 140 400	0,986	1,035	0,928	0,920	0,968	0,920
14	Hungary	9 965 720	10 071 200	0,990	1,102	0,980	0,997	1,102	0,997
15	Ireland	4 740 000	4 209 900	1,126	1,188	1,188	1,100	1,254	1,100
16	Italy	78 571 000	58 139 600	1,351	1,491	1,474	1,303	1,491	1,303
17	Latvia	2 183 696	2 295 400	0,951	1,210	1,523	1,210	2,109	1,210
18	Lithuania	4 718 215	3 417 400	1,381	1,518	1,518	1,863	3,559	1,863
19	Luxembourg	713 800	470 800	1,516	1,647	1,654	1,647	1,950	1,647
20	Malta	346 771	403 400	0,860	0,903	0,800	0,797	0,818	0,797
21	Holland	17 500 000	16 366 600	1,069	1,123	1,000	0,976	1,049	0,976
22	Portugal	12 226 439	10 545 000	1,159	1,237	1,195	1,125	1,237	1,125
23	Romania	17 400 000	21 629 300	0,804	1,516	4,321	1,516	7,611	1,516
24	Slovakia	4 893 232	5 400 700	0,906	1,060	0,947	0,930	1,060	0,930
25	Slovenia	1 819 572	1 965 900	0,926	0,972	0,894	0,908	0,923	0,908
26	Spain	46 152 024	43 378 800	1,064	1,117	1,055	1,012	-	1,012
27	Sweden	9 607 000	9 069 900	1,059	1,314	1,083	1,115	1,314	1,115

For Spain the Gompertz curve estimation did not converge. In case of underestimation by all four models, market potential was calculated as 1,05 of current sim-to-population ratio. Currently in EU-27 sim-to-population ratio equals on average 1,059.

Table 2b. Market Potential. Postpaid mobile.

STATE	COUNTRY	SIM_ALL	POPULATION	sim_pop_ratio	combined	nui_m	bass_m	gompertz_m	logistic2_m
1	UK	22917965	59 847 100	0,383	0,418	0,442	0,418	0,522	0,408
2	Poland	12426937	38 498 600	0,323	0,375	0,677	0,375	0,493	0,362
3	Austria	5376000	8 204 600	0,655	0,739	0,654	0,643	0,739	0,642
4	Belgium	3905213	10 437 000	0,374	0,393	0,297	0,305	0,328	0,305
5	Bulgaria	2949586	7 671 200	0,385	0,583	-	0,902	0,879	0,583
6	Cyprus	357227	844 600	0,423	0,453	0,456	0,453	0,548	0,450
7	Czech Rep.	4862538	10 209 200	0,476	0,500	0,353	0,341	0,340	0,341
8	Denmark	4804923	5 446 300	0,882	0,926	1,395	1,261	2,471	1,228
9	Estonia	939700	1 324 900	0,709	0,807	0,980	0,807	0,988	0,783
10	Finland	5290000	5 261 800	1,005	1,081	0,999	0,986	1,081	0,986
11	France	33572000	60 722 900	0,553	0,580	0,738	0,580	0,695	0,578
12	Germany	45705000	82 715 600	0,553	0,628	0,979	0,628	0,879	0,623
13	Greece	4292725	11 140 400	0,385	0,393	0,392	0,393	0,432	0,386
14	Hungary	3527865	10 071 200	0,350	0,360	0,360	-	-	1,248
15	Ireland	1345480	4 209 900	0,320	0,336	0,265	0,258	0,262	0,258
16	Italy	11782661	58 139 600	0,203	0,213	0,113	0,106	0,113	0,106
17	Latvia	580863	2 295 400	0,253	0,299	0,304	0,299	0,299	0,299
18	Lithuania	1558097	3 417 400	0,456	0,479	0,440	0,451	0,507	0,450
19	Luxembourg	341800	470 800	0,726	0,820	0,849	0,696	0,820	0,693
20	Malta	34003	403 400	0,084	0,123	0,123	-	0,074	0,066
21	Holland	8145379	16 366 600	0,498	0,523	2,433	-	-	2,093
22	Portugal	2455608	10 545 000	0,233	0,244	0,244	0,224	0,223	0,224
23	Romania	5900000	21 629 300	0,273	0,528	2,124	0,622	2,576	0,528
24	Slovakia	2511444	5 400 700	0,465	0,851	1,713	0,851	2,895	0,784
25	Slovenia	1084797	1 965 900	0,552	0,607	0,567	0,549	0,607	0,549
26	Spain	25271064	43 378 800	0,583	0,874	1,979	0,874	-	0,853
27	Sweden	4914000	9 069 900	0,542	0,555	0,583	0,495	0,555	0,493

(-) indicates no convergence. In case of underestimation by all four models, market potential was calculated as 1,05 of current sim-to-population. Currently in EU-27 sim-to-population ratio in postpaid equals on average 0,44.

Figure 3. Location and speed effects. Logistic diffusion model on postpaid and prepaid mobile.

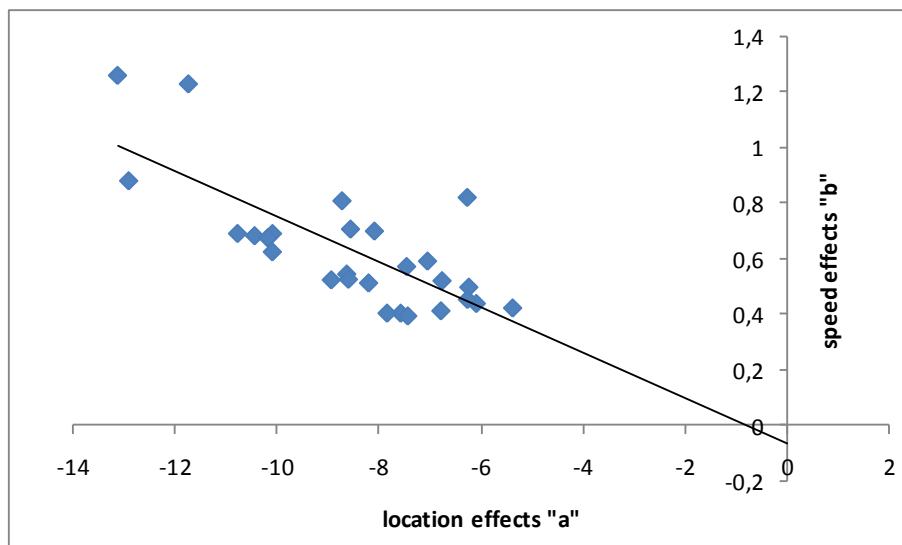


Table 4. Location 'a' and speed effects 'b' from logistic model of diffusion and selected characteristics of mobile industries.

COUNTRY	a	b	beginning of mob. services	2G introduction	3G introduction	MNP introduction	prepaid introduction	number of 2G MNO in 2006
UK	-8,63	0,55	1985	1991	2003	1999	1998	5
Poland	-6,09	0,44	1992	1996	2004	2006	1998	4
Austria	-10,43	0,68	1985	1993	2003	2003	1997	4
Belgium	-12,90	0,88	1986	1994	2004	2002	2000	3
Bulgaria	-6,76	0,52	1993	1995	2006	-	2001	4
Cyprus	-6,78	0,41	1988	1995	2005	2004	1999	2
Czech Rep.	-8,72	0,81	1991	1996	2005	2006	2001	3
Danmark	-7,57	0,40	1982	1992	2003	2001	1999	3
Estonia	-5,37	0,42	1991	1995	2005	2005	2000	3
Finland	-7,84	0,41	1980	1991	2004	2003	2003	4
France	-10,08	0,69	1986	1992	2004	2003	1999	6
Germany	-10,09	0,63	1985	1992	2004	2002	1998	4
Greece	-6,26	0,82	1993	1993	2004	2002	1997	4
Hungary	-8,55	0,71	1990	1994	2005	2004	1997	3
Ireland	-8,59	0,53	1985	1993	2004	2002	1998	3
Italy	-8,20	0,51	1985	1995	2003	2002	1997	3
Latvia	-6,23	0,50	1992	1995	2004	-	1998	3
Lithuania	-7,45	0,57	1992	1995	2006	2005	2002	3
Luxembourg	-8,93	0,53	1985	1993	2003	2003	1998	3
Malta	-13,12	1,26	1991	1997	-	2006	2000	2
Holland	-10,77	0,69	1985	1994	2004	2001	1998	3
Portugal	-7,04	0,59	1989	1992	2004	2001	2000	3
Romania	-6,26	0,45	1993	1997	2005	-	1997	3
Slovakia	-8,08	0,70	1991	1997	2006	2006	1999	2
Slovenia	-11,73	1,23	1991	1996	2004	2006	1998	2
Spain	-10,18	0,68	1986	1995	2004	2000	1998	3
Sweden	-7,43	0,40	1980	1992	2000	2001	1997	4

Figure 5. MNP and prepaid introduction. UK case.

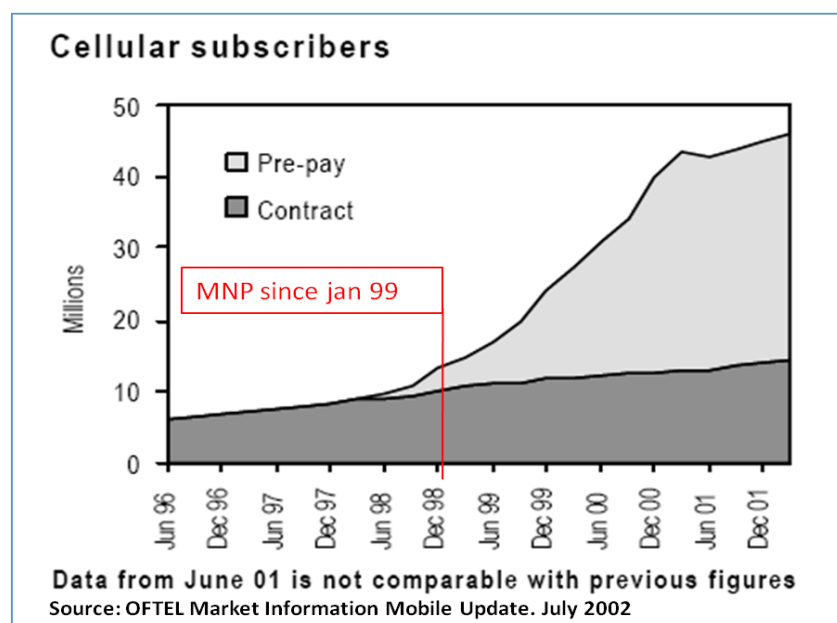


Table 6. Diffusion of postpaid and prepaid mobile. Panel estimation.

Variable	EU-27			EU-15*			EU-12 (new member states)		
	Estimate	St. Error	Pr > t	Estimate	St. Error	Pr > t	Estimate	St. Error	Pr > t
Location effects									
FIXED_PER_100INH	0.073024	0.0131	<.0001	0.121662	0.0250	<.0001	0.074476	0.0175	<.0001
MNP_INTRO	1.455606	0.6689	0.0303	0.838975	0.7366	0.2563	11.19149	2.9567	0.0002
_2G_INTRO	0.651572	0.3366	0.0538	4.813074	2.5812	0.0640	0.952448	0.6293	0.1326
_3G_INTRO	0.165831	0.6374	0.7949	1.118492	0.8727	0.2018	-0.48144	1.9239	0.8028
_2G_OPERATORS	0.415969	0.1338	0.0020	0.39844	0.1866	0.0342	0.603855	0.2513	0.0177
GDP_USD_PC	-0.00007	0.000031	0.0178	-0.00008	0.000038	0.0260	-0.00036	0.000099	0.0004
PREPAID_INTRO	0.84536	0.3118	0.0071	1.636682	0.4976	0.0012	2.093542	0.6595	0.0019
Speed effects									
FIXED_PER_100INH	-0.00388	0.000770	<.0001	-0.00505	0.00138	0.0003	-0.01024	0.00150	<.0001
MNP_INTRO	-0.09043	0.0417	0.0310	-0.04488	0.0443	0.3126	-0.74516	0.1945	0.0002
_2G_INTRO	-0.10104	0.0435	0.0209	-0.5349	0.2892	0.0662	-0.20112	0.0977	0.0416
_3G_INTRO	-0.02118	0.0387	0.5843	-0.06303	0.0484	0.1946	0.030367	0.1348	0.8221
_2G_OPERATORS	-0.01021	0.00950	0.2834	-0.00933	0.0118	0.4306	-0.03655	0.0251	0.1484
GDP_USD_PC	3.556E-6	1.288E-6	0.0061	4.045E-6	1.623E-6	0.0136	0.000027	5.534E-6	<.0001
PREPAID_INTRO	-0.06307	0.0256	0.0142	-0.11116	0.0349	0.0017	-0.25359	0.0755	0.0010
(*) h0 in F test saying 'no fixed effects' is always rejected.	DF= 320	MSE= 0,237	R-Sq.= 0,970	DF= 166	MSE= 0,198	R-Sq.= 0,967	DF= 127	MSE= 0,190	R-Sq.= 0,982

Table 7. Diffusion of postpaid mobile. Panel estimation for period 1993-2006.

Variable	EU-27			EU-15			EU-12 (new member states)		
	Estimate	St. Error	Pr > t	Estimate	St. Error	Pr > t	Estimate	St. Error	Pr > t
Location effects									
FIXED_PER_100INH	0.054379	0.0159	0.0007	-0.01331	0.0245	0.5870	0.045564	0.0243	0.0636
MNP_INTRO	0.195732	0.8171	0.8108	1.390151	0.7274	0.0577	3.257542	4.1183	0.4304
_2G_INTRO	0.912258	0.4099	0.0268	7.497437	2.5274	0.0035	-0.67294	0.8772	0.4444
_3G_INTRO	1.293135	0.7781	0.0975	0.617212	0.8548	0.4713	0.700301	2.6776	0.7941
_2G_OPERATORS	0.23244	0.1629	0.1545	0.401162	0.1837	0.0304	0.6342	0.3501	0.0725
GDP_USD_PC	-0.00008	0.000038	0.0347	-0.00008	0.000037	0.0324	-0.00022	0.000138	0.1114
Speed effects									
FIXED_PER_100INH	-0.00466	0.000934	<.0001	0.001257	0.00135	0.3533	-0.01165	0.00209	<.0001
MNP_INTRO	-0.0114	0.0509	0.8231	-0.08901	0.0438	0.0435	-0.176	0.2710	0.5172
_2G_INTRO	-0.19238	0.0528	0.0003	-0.89529	0.2832	0.0019	0.034212	0.1363	0.8022
_3G_INTRO	-0.07059	0.0472	0.1356	-0.05658	0.0474	0.2344	0.022149	0.1875	0.9062
_2G_OPERATORS	-0.00564	0.0115	0.6250	-0.01931	0.0116	0.0975	-0.0608	0.0353	0.0877
GDP_USD_PC	3.713E-6	1.571E-6	0.0187	3.283E-6	1.597E-6	0.0413	9.87E-6	7.792E-6	0.2077
(*) h0 in F test saying 'no fixed effects' is always rejected.	DF= 315	MSE= 0,349	R-Sq.= 0,940	DF= 163	MSE= 0,186	R-Sq.= 0,951	DF= 125	MSE= 0,367	R-Sq.= 0,958