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Calling Party Pays or Receiving Party Pays?

The Diffusion of Mobile Telephony with Endogenous Regulation

Ralf Dewenter* Jörn Kruse†

Abstract

This paper analyzes the impact on mobile telephony diffusion patterns of the two predominant payment regimes, calling party pays (CPP) and receiving party pays (RPP), for mobile termination services. By applying instrumental variable techniques to panel data we account for a possible interdependency of penetration rates and regulatory interventions. For this purpose we use data on political and institutional factors to instrument endogenous regulatory decisions. We conclude from our empirical analysis that there is no significant impact of either RPP or CPP on penetration rates. Therefore an application of RPP in order to obviate regulation of termination fees would be feasible.

Keywords: Mobile telephony markets, calling-party-pays, mobile termination fees, endogenous regulation.

JEL-Classification: L1, L5, L96.

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1 Introduction

European mobile telephony markets have, with few exceptions, largely dispensed without much regulation until the end of the 1990s. However, in recent years most European and many other countries have introduced additional regulatory interventions. Particularly price regulation of wholesale mobile termination markets has become a relevant regulatory issue. Nowadays, regulation of mobile (M2M) termination rates is a widespread practice in many countries worldwide. The reasoning for regulating M2M terminations fees is closely connected with the underlying payment regime for termination services. While under the so-called "receiving party pays" (RPP) regime terminating mobile networks charge their own customers for termination services, under the "calling party pays" (CPP) regime terminating operators charge the originating network instead. The CPP regime, however, gives rise to market power in termination markets and is widely accepted as justification for regulatory interventions (see Armstrong, 1998, Laffont, Rey and Tirole, 1998a).

A potential alternative to price regulation is to apply the receiving party pays payment regime for M2M termination services (see e.g. Doyle and Smith, 1998, Laffont, Rey and Tirole, 1998a, Littlechild, 2006). In case that a RPP system is applied, subscribers are able to compare the entire price ranges. That is, customers are able to compare prices for on-net calls, subscription fees, handset subsidies as well as for termination services, before joining a network. Hence, mobile networks are able to compete over the whole price basket and termination rates are expected to fall. For this reason, a changeover of the payment system from CPP to RPP seems to be an adequate solution to obviate regulation.

However, since under receiving party pays the termination networks charge their own consumer for incoming calls there are also some reservations about RPP. The most important apprehension is that customers are likely to switch off their mobile phones since they have only limited cost control under RPP. Since under RPP the caller is charged less, he might place calls for which his willingness to pay is less than marginal costs. The number of calls initiated by callers could therefore be inefficiently high (including nuisance calls). Depending on the recipients's marginal willingness to pay, these calls can be solicited or unsolicited. However, in order to avoid unwanted calls, recipients are likely to switch off their mobiles phones. As a consequence, mobile telephony usage could probably be much lower in comparison to CPP countries. This could induce an inefficient amount of minutes-of-use and also an inefficient number of calls under RPP (for a discussion see, e.g., OFTEL, 2002). However, one could also counter that recipients are either able to identify callers (i.e. by calling numbers) or simply stop unwanted calls. Overall, since there is only limited empirical evidence (see e.g. Littlechild, 2006, for an exception) there is still room for empirical research.

In case of consumers anticipating that they have only limited cost control and are likely to switch off their phones under RPP, they might refuse to join a mobile

network. Penetration rates might therefore be much lower than in markets where CPP is applied. Indeed, anecdotal evidence for such behavior could be observed and especially in the early days of mobile telephony in some RPP countries such as the United States. For this reason, reduced penetration has always been an important argument against RPP. Since there is only little statistical evidence on the impact of the underlying payment regime on penetration rates (exceptions are Littlechild, 2006, and Cunningham et al., 2010), the aim of this paper is to fill this gap to some degree.

For this purpose, we use data on 77 countries over a time span of 23 years. Our sample consists of three types of countries: original CPP (RPP) countries using CPP (RPP) over the whole sample and switching countries. By this means, we are able to identify the impact of CPP and RPP over time as well as between different countries using panel data techniques. A major difficulty resides in the fact that the decision for a changeover of the payment regime and also other regulatory interventions are possibly endogenous - which is commonly referred to as "endogenous regulation" (see e.g. Persson and Tabellini, 2000, Duso and Röller, 2003). That is, decisions of regulatory authorities are possibly not independent of market outcomes and political or institutional factors. Ignoring this endogeneity could, however, lead to seriously biased results. We take this into account by using instrumental variables such as relative market performance, democracy scores and measures of political stability in order to identify the impacts of regulatory actions.

The remainder of the paper is now organized as follows. Section 2 discusses possible needs for regulatory intervention in mobile termination markets and the two predominant payment regimes. In Section 3 we offer a detailed empirical analysis on the impact of CPP and RPP on mobile telephony penetration rates. Finally, Section 4 concludes.

2 Mobile termination and penetration rates

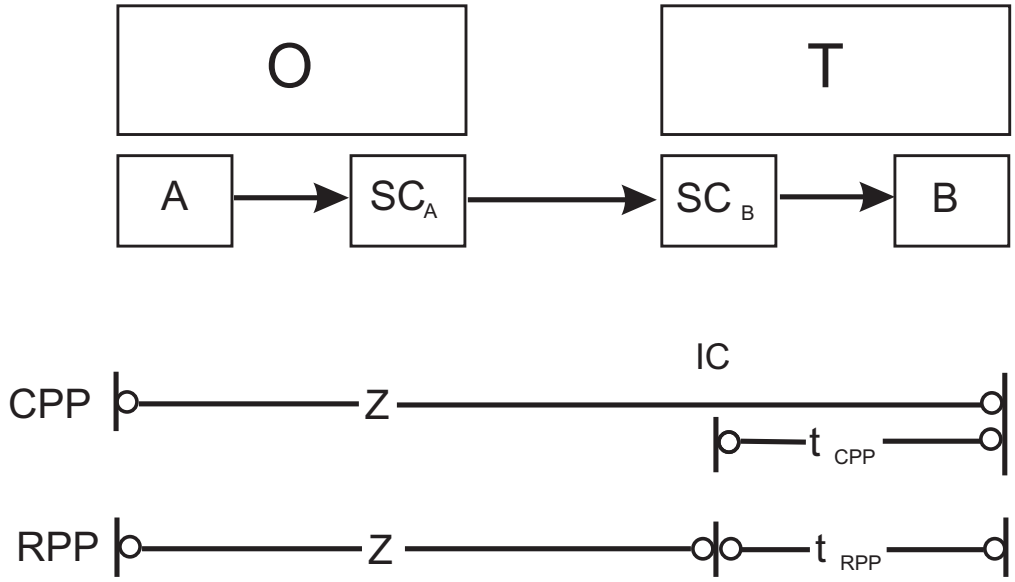
This section provides a brief discussion of mobile termination and the role of the underlying payment regime (CPP or RPP) with respect to regulation. Moreover, we discuss possible impacts of the payment regimes on adoption patterns.

2.1 Mobile termination under CPP and RPP

Suppose that a customer A of a mobile network, say network O, intends to reach a subscriber B from a different mobile network, T. For this purpose both networks have to be interconnected. While in the case assumed, network O has to provide an origination service, network T terminates the call. Both operators usually charge fees for their services, namely the call charge (Z) and the termination rate (t) in order to cover costs. Under the calling party pays regime, mobile operator

T charges network O a termination fee which O completely passes on to his own subscriber in addition to the call charge. Under RPP, in contrast, subscribers of network O have to pay for origination services only while the recipient in network T is charged (by T) for the termination service (see Figure 1).[1]

Figure 1: CPP and RPP



Note: SC = Switching Center

Given that there is no substitute for a termination service, the terminating network (T) enjoys a monopoly position for this service under the CPP regime. T is thus able to exploit the originating network O by setting monopolistic termination rates. Of course, this holds for each termination of mobile calls under CPP as long as termination can be realized by only one single network. Thus, there is always an incentive for terminating networks to set monopolistic termination rates, independently of which network (here T or O) serves as the originating or terminating network. Moreover, since termination fees can be considered as part of the marginal costs of calls, originating networks have the incentive to pass high termination rates along to their own customers. As Armstrong (1998) and Laffont, Rey and Tirole (1998a) put it, bargaining of network operators over termination

[1]It is worthwhile to note that there is a difference between the end-user payment regimes on the one hand and the network payment regimes on the other. The end-user regimes (CPP and RPP) are typically initialized by a corresponding network payment regime. While under calling party network pays (CPNP) regime the originating network pays a per-minute charge to the terminating network, under a receiving party network pays (RPNP) regime the receiving network pays a charge to the originating network. In the case of networks passing their costs on to their customers, a CPP or RPP regime, respectively, results. In case that a bill and keep regime is applied, calls from other networks are terminated at no extra charges.

fees results in some kind of tacit collusion and therefore in high termination fees (see also Carter and Wright, 1999).[2] For these reasons, the European Commission (and also other regulatory authorities) define own relevant M2M termination markets in order to analyze possible anticompetitive outcomes. As a consequence of the terminating networks' monopolistic positions and also because of a lack of substitutes for mobile telephony, mobile termination services can be seen as non-contestable monopolistic bottlenecks (when CPP is applied) and regulation of mobile termination fees is assumed to be inevitable. Consequently, today most European regulatory authorities regulate the mobile networks' termination fees (see European Commission, 2009).

The application of the receiving party pays regime, however, leads to different outcomes. Following, e.g., DeGraba (2000), Quigley and Vogelsang (2003), Valletti and Houpis (2005), Berger (2005) and Littlechild (2006), under the RPP regime mobile network operators have no incentives for charging monopolistic termination rates (for opposite assessments see Gans and King, 2001 and Wright, 2002).[3] Since terminating networks charge their own customers for the termination services, customers are able to compare the networks' price baskets (including, for example, prices for on-net and off-net calls, data services as well as for termination services) before signing up to a network. Mobile network operators then compete over a complete bundle of prices and have no incentive to charge their own customers high termination rates. Competitive pressure should lead to much lower termination fees under RPP. With competitive termination fees, there is, however, no need for regulation. Receiving party pays can therefore be (among other solutions, such as mobile termination carrier selection; see Kruse, 2009) regarded as a possible way to obviate regulation of mobile termination fees.[4]

Despite of the seemingly superior characteristics of RPP there is no serious initiative of CPP countries to change the payment regime in favor of RPP. The initial choice of the payment system is likely to be caused for historical reasons. Most countries have presumably adopted the system from fixed-line telephony. However, to our knowledge, only the UK Competition Commission considered RPP as an alternative to the calling party pays regime when deciding on the regulation of termination fees in 2002 (see Littlechild, 2006). Quite a number of countries switched from RPP to CPP instead (see Section 3.2). One reason for this could be consumer resistance against RPP. Oftel (2002), for example, argued that a strong reaction of consumers against being charged for incoming calls can

[2]However, this outcome strongly depends on factors such as the firms' symmetry and the pricing structure (see, e.g., Laffont, Rey and Tirole, 1998b and Dessein, 2003). For further discussion see, e.g., Crandall and Sidak (2004) and Haucap (2004). See also Gabrielsen and Vagstad, 2008, for a review of the literature.

[3]See Harbord and Pagnozzi (2010) for a survey of the related literature.

[4]There is also strong empirical evidence for this outcome. In countries where RPP is applied, networks' termination rates are much lower (see, Littlechild, 2006).

be expected and that "*Oftel would have a hard job explaining that overall it was in their [the consumers] interests to pay for such calls when previously they received them for free.*"

A major concern against RPP is, however, that a changeover from CPP to RPP would involve a completely different calling behavior and therefore lead to lower penetration rates (see, e.g., OECD, 2000, Oftel, 2002).[5] As termination rates–and therefore also prices for off-net calls – presumably fall under RPP, such lower prices could lead to a higher number of undesired calls, such as junk or marketing calls. Moreover, as consumers are not aware whether or not they would benefit from an incoming call and have therefore only limited cost control, they might switch off their mobile phones in order to reduce costs. This in turn leads to an overall reduced number of call minutes (in terms of on-net as well as off-net traffic). Furthermore, when consumers anticipate that they are not aware whether they would benefit from incoming calls or not (and would therefore turn off their handsets), they might refuse to sign mobile contracts in advance. This effect should be especially relevant for prepaid contracts. Because of higher call charges, prepaid cards are especially interesting for customers who prefer to be reachable by their mobile phone. Prepaid cards are, however, important drivers for mobile telephony diffusion in many countries (see OECD, 2000). Countries with a high share of prepaid contracts would probably suffer from the introduction of RPP in terms of lower penetration rates.

Another argument in favor of CPP and against RPP is connected with fixed to mobile termination. Typically under a calling party pays regimes fixed to mobile termination rates have always been about as high as mobile to mobile fees. High profits from fixed to mobile calls have therefore potentially been used to subsidize mobile networks. Due to the waterbed effect (see Cunningham et al., 2010, and Genakos and Valletti, 2010, for empirical evidence on the waterbed effect) networks have been able to set lower subscription rates and similar prices for mobile telephony. Lower prices for mobile telephony have probably led to higher mobile penetration rates under CPP (see, e.g., Littlechild, 2006, Genakos and Valletti, 2010). Thus, in a way this paper also studies the effects of fixed to mobile pricing on mobile telephony penetration.[6]

2.2 Empirical studies on diffusion of mobile telephony

Even though there is some empirical evidence that CPP generates a more intense calling behavior, therefore leading to higher penetration rates, broad statistical evidence is still lacking. Most empirical studies are, in contrast, based on anec-

[5]There are also some minor advantages and disadvantages of RPP compared to CPP. However, a detailed consideration is beyond the scope of this paper. For some discussions of the pros and cons of both payment regimes see, e.g., DeGraba, 2003, Crandall and Sidak, 2004, Haucap, 2004 or Littlechild, 2006).

[6]We are grateful to an anonymous associate editor who raised this important point.

dotal evidence or case studies (see Littlechild, 2006, for an overview): The US, for example, have long been regarded as a typical RPP country with low penetration rates (see Crandal and Sidak, 2004).[7] Apparently, some countries could considerably improve their diffusion rates after re-regulating the payment regime from RPP to CPP. This is commonly referred to as an argument against receiving party pays. Samajariva and Melody (2000) find a positive impact induced by a change from RPP to CPP in their case study for Mexico. Zehle (1998, 2003) provides case studies on countries from Central and South America and the Caribbean, finding also that countries switching to CPP enjoy positive impact. To our knowledge, Littlechild (2006) is the only study explicitly providing statistical evidence on CPP and RPP on (inter alia) penetration rates. Using cross-section data he finds no evidence that RPP lowers mobile telephony penetration. Moreover, receiving party pays regimes are found to be correlated with lower average revenues (per minute) as well as higher average usage (measured by call minutes).

More general empirical studies on mobile telephony diffusion (see, e.g., Gruber, 2001, Gruber and Verboven, 2001, Koski and Kretschmer, 2004, Massini, 2004, Michalakelis et al., 2008, Chu et al., 2009, Cunningham et al., 2010) identify a number of factors to be crucial for the diffusion process. According to these studies, the introduction of the digital GSM standard is responsible for an early acceleration of mobile telephony diffusion. Increased competition is also a factor for penetration rates, however, the impact seems to be relatively small. There is also a convergence between late and early adopters (at least considering EU countries). The effects of prices on penetration rates are ambiguous. While most price variables have no significant impact, monthly charges are statistically significant in most of these studies. Massini (2004) found also an impact of decreasing handset prices. Income, measured by GDP per capita, also seems to have an impact on diffusion rates.

As payment systems for termination services are expected to affect competition, prices as well as the customers' calling behavior and also penetration rates are possibly affected by the choice between RPP and CPP. Therefore, the next section aims at exploring the impact of CPP and RPP on diffusion patterns.

3 Empirical Evidence

3.1 Modelling diffusion processes and specification

An analysis of the impact of the two payment regimes on the growth rates of mobile telephony diffusion requires an adequate econometric strategy. Economic literature on both technology and product penetration provides a wide range

[7] Meanwhile, the US have caught up with many European countries showing high mobile penetration.

of models to analyze the diffusion patterns. The most prominent deterministic models used are the Gompertz function, the Bass model (see Bass, 1969) and the logistic model (for a discussion of various models see e.g. Mahajan, Muller and Bass, 1990, Maede and Islam, 1998, Geroski, 2000). Since the S-shaped logistic curve has proved to be well-suited for the analysis of several mobile telephony markets across the world (see e.g. Gruber and Verboven 2000, 2001, Gruber 2001), we have also adopted this model to analyze the impact of the payment regimes on diffusion processes.

Starting from a three-parametric logistic function

$$y_{it} = \frac{\hat{y}_{it}}{1 + \exp(-A_i(t - B_i))}, \tag{1}$$

where y_{it} is the number of subscribers to mobile telephony in country i at time t, $\hat{y}_i$ is the ceiling of the diffusion process or, i.e., the number of potential adopters, the parameter A_i measures the average growth rate, t is a linear trend and B_i is the turning point of the S-shaped function (period with highest growth).

In order to keep the model as simple as possible, we use a linear version of equation (1).[8] For this purpose we first have to estimate the maximum number of potential adopters, assuming that the ceiling of the diffusion process can be described by a function of total population (POP_{it}) in country i at time t as:

$$\hat{y}_{it} = \hat{\lambda} POP_{it}, \tag{2}$$

where $\hat{\lambda}$ is the saturation rate of this process.[9] In case that the saturation rate has been determined, the three-parametric logistic model can be linearized as

$$\ln\left(\frac{\hat{\lambda} POP_{it}}{y_{it}} - 1\right) = A_i B_i - A_i t. \tag{3}$$

Adding an error term and assuming that $a_i = A_i B_i$, $b_i = -A_i$ and $y^*_{it} = \ln\left(\frac{\hat{\lambda} POP_{it}}{y_{it}} - 1\right)$, a linear estimation equation

$$y^*_{it} = a_i + b_i t + \varepsilon_{it} \tag{4}$$

results.

[8] At a first step we have used non-linear least squares to estimate equation (1) directly, however, because of a high number of observations and a high number of explanatory variables (described below), global maxima have hardly been reached.

[9] To estimate the saturation rate, we have assumed different functional forms and specifications: (i) the original non-linear version of a three-parametric function using 2SLS techniques and a linearized version using a first difference approach. Furthermore, we have calculated different types of saturation rate, namely identical saturation rates for all countries and country-specific parameters. Interestingly, the results from analyzing the underlying diffusion process have been proved to be relatively robust against using different types of estimated λ's.

Because of the heterogeneity of the countries in our sample, we do not restrict our analysis to constant parameters A_i and B_i over cross-sections. Rather, following Gruber and Verboven (2000), we assume that both parameters are affected by country-specific fixed effects. Furthermore, we assume that the average growth rate is also influenced by a number of exogenous variables. Therefore, a_i and b_i can be specified as

$$a_i = \alpha_i \quad \text{and} \quad b_i = \beta_i + \delta' \mathbf{x}_{it}, \tag{5}$$

whereas α_i and β_i are country-specific fixed effects, δ is a vector of coefficients to be estimated and $\mathbf{x}_{it}$ is a vector of explanatory variables. Combining equations (4) and (5) yields then

$$y^*_{it} = \alpha_i + (\beta_i + \delta' \mathbf{x}_{it})\, t + \varepsilon_{it}, \tag{6}$$

which can simply be estimated using fixed effects panel techniques. In our analysis the vector $\mathbf{x}_{it}$ consists of different country-specific variables, such as income or population density, variables identifying sector-specific peculiarities, such as the introduction of prepaid cards, and of course variables indicating the payment regime.

3.2 Data

The data used in this study is annual and initially covered 84 countries. Our earliest observations are from 1980 and the most recent ones from 2003. Our panel is unbalanced. The data set includes information on countries under both regimes, where 39 countries have applied CPP from the beginning of mobile telephony, 31 have switched from RPP to CPP, and 14 countries have applied RPP from the introduction of mobile telephony up to 2003 (see Table 1 in the appendix for details). As mentioned above, none of the countries has switched from CPP to RPP. The variables have been extracted from various databases: the *ITU World Telecommunication Indicators 2004*, the *World Development Indicators*, published by the *Worldbank*, and from various publications of regulatory authorities. The most important right- hand-side variable is, of course, CPP, which is a dummy equal to one if a country applies calling party pays at time t and, conversely, zero, either when it is a switching country or when this country has always applied CPP. Hence, this variable varies over time as well as over cross-sections.

The country-specific variables used in this study are $GDPC$, which is the real GDP per capita, POP, which is the population of each country over time, and $POPAREA$, which is the average population density (population divided by km^2). Given that (a) richer countries are more likely to adopt mobile telephony and (b) that firms in richer countries are in a better position to build

mobile networks, we expect $GDPC$ to have a positive influence on penetration. Population is also expected to have a positive impact, since the potential market size increases with population. On the other hand, population might to some degree be correlated with the size of a country, in this case POP is also a measure for costs. However, not only the absolute number of inhabitants but, more significantly, population density is a measure of costs. If, to take an example, a small population is distributed over a huge country (in terms of the area of that country), per capita costs to built an area-wide network are extremely high in comparison to small and dense countries.[10]

In order to account for telecommunication-specific effects we have used a number of variables: the number of fixed telephony lines per capita ($FIXEDSUBS$), $PREPAID$, a dummy which is equal to one if prepaid cards are available in country i at time t, and $COMP$, which is also a dummy variable indicating competition.[11] $COMP$ is equal to one if there are at least two competitors in a specific market at time t. Of course, this is only a crude measure for competition since independently of the number of players, competition can be either harsh or soft. However, $COMP$ can at least be seen as a measure for liberalization of the markets. Moreover, there is also some evidence that market entry of a second firm (i.e. a first competitor) has the strongest effect on competition (see e.g., Crandall and Hausman, 2000). We expect both $PREPAID$ and $COMP$ to have a positive influence on penetration rates. The effect of the number of subscribers to fixed line telephony instead is apriori not clear. In case of mobile telephony being regarded as a substitute to fixed lines, the influence should be negative, however, in case that fixed and mobile telephony are complementary products, a positive influence should be detectable.

Of course, prices too (e.g., for on-net and off-net calls or price baskets) are possible drivers towards the adoption of mobile telephony. However, we have neglected to use price variables in our estimations for two reasons. First, data limitations would lead to significantly smaller samples. Prices are available only for some of the countries over a relatively short time span. Second, prices should be affected by quantities and by network size. Prices are therefore likely to be endogenous which would result in biased estimates. Since prices being only available on a highly aggregated level for small samples, we omitted to use such variables.[12]

[10]Not only average population density but also other variables could be further proxies for networks' set-up costs. These are for example the percentage of people that live in (larger) cities or territorial coverage. For this reason, we have also included both variables as explanatory variables, however, because of a lower number of observations of our disposition regarding these variables, our sample has been noticeably reduced. This specification has therefore not been used in the following.

[11]We have also introduced a dummy variable GSM indicating the application of the GSM standard. However, GSM and $PREPAID$ were so highly correlated such that we were not able to identify both effects. We therefore skipped GSM from our sample.

[12]We expect variation in prices as well as in price levels between countries to be reflected in

Figures 2–4 (in the appendix) depict the diffusion processes for three countries in exemplarily fashion: while the US have always applied RPP and Germany is a typical CPP country, the Czech Republic switched from RPP to CPP in 1996. The curves show some varieties in maximum numbers of adopters and the shape of the functions. While diffusion of mobile technology in Germany follows a distinctive S-shaped curve, the process in the US is relatively flat. On the other hand, nearly 100% of customers in the Czech Republic have already adopted mobile telephony at the end of 2003, whereas in Germany (about 80%) and the United States (about 55%) this number was considerably lower. Of course, this simple comparison does not warrant any judgement on the impact of different payment regimes.

3.3 Results

3.3.1 Estimation of the saturation rate

Recall that the left-hand-side variable in our study is not simply the penetration rate but an artificial variable given as the endogenous variable in equation (2). To calculate the left-hand- side variable for each country, country-specific $\hat{\lambda}_i$'s have to be determined as well.[13] For this purpose, we have applied a first-difference approach. Taking the first difference of a three-parametric logistic function and simple algebra leads to a linear function in parameters as:

$$\Delta y_{it} = \gamma y_{it} - \mu y_{it}^2, \tag{7}$$

where the saturation rate is $\hat{\lambda} = \frac{\hat{\gamma}}{\hat{\mu}}$. Using country- specific dummy variables leads to individual estimates for each $\hat{\lambda}_i = \frac{\hat{\gamma}_i}{\hat{\mu}_i}$:

$$\Delta y_{it} = \gamma_i \sum_{i=1}^{N} D_i y_{it} - \mu_i \sum_{i=1}^{N} D_i y_{it}^2. \tag{8}$$

Overall, this method has led to more conclusive results for individual saturation points, ranging from about 65% to about 120%, than assuming an average rate for all countries. Therefore, all of the following results have been derived using these country-specific saturation rates.[14]

fixed effects as well as in country-specific trends.

[13] We also estimated average saturation points for all 192 countries in our sample. However, these estimates hade to be dropped because of inconclusive results.

[14] We have also tested whether the results are robust against varying λ's and have used various magnitudes to calculate the left-hand-side variable. Overall, the results did not change qualitatively and only gradually quantitatively.

3.3.2 Diffusion processes with exogenous regulation

At first stage, we have ignored a possible dependency of regulatory interventions from market outcomes. To analyze the impact of CPP on diffusion processes (proceeding from the assumption of exogenous regulation) we have therefore started with equation (6) using the whole sample (see regression I in Table 2).[15] In comparison to periods where RPP payment regimes have been applied, a higher growth by about 2.01 basic points can be found with CPP regimes. Hence, pooling switching countries with countries using CPP over the whole time span as well as countries which relied on RPP provides some evidence in favor of a positive impact of calling party pays on diffusion rates.

By restricting our analysis to switching countries (regression II) a comparison of the penetration rates before and after the introduction of CPP is possible. Analyzing only non-switching countries instead, a comparison between different countries can be addressed. By these means both variations over time as well as variations between countries can be analyzed separately. As can be seen from regression II (switching countries), there is a slightly higher influence of CPP on average growth rates in contrast to periods under the RPP payment regime. Growth rates increase by 2.17 basic points under CPP.

When analyzing CPP countries and comparing them with RPP countries instead (regression III), the CPP dummy is statistically insignificant. Hence, there seem to be no differences in diffusion processes comparing CPP and RPP countries. Merely, when countries have changed their payment regime, a positive effect is detectable.

Table 2: Diffusion processes

[15] Note that the coefficients in the tables carry the reverse sign. The estimation results have been multiplied by -1 for a more comfortable interpretation. Because of missing observations the number of countries has been reduced to 77.

y^*_{it}	I all obs	II switching countries	III non-switching countries
CPP	0.0201	0.0217	0.2531
	(3.75)	(3.92)	(0.70)
$COMP$	0.0256	0.0179	0.0286
	(5.23)	(2.39)	(4.79)
$PREPAID$	0.0157	0.0113	0.0171
	(3.98)	(1.49)	(3.75)
$FIXEDSUBS$	0.0038	0.0305	-0.0074
	(0.18)	(1.20)	(-0.25)
POP	-4.90e-09	-7.12e-09	-4.08e-09
	(-7.73)	(-3.88)	(-5.19)
$POPAREA$	1.84e-06	3.35e-06	-7.13e-06
	(0.04)	(0.00)	(-0.16)
$GDPC$	-6.82e-07	-5.41e-07	-6.64e-06
	(-4.91)	(-4.41)	(-14.29)
β_i	0.499	0.7333	0.5169
	(1.48)	(2.41)	(1.48)
FE, $FE \cdot t$	YES	YES	YES
adj. R^2	0.97	0.97	0.97
Nobs	925	269	656
No. of groups	77	26	51

Note: Robust t-statistics are given in parentheses. Coefficients have been multiplied by -1 for a more comfortable interpretation.

Moreover, competition as well as the availability of prepaid cards is found to have a positive impact on diffusion processes. While $FIXEDSUBS$ and $POPAREA$ are statistically insignificant, population and real GDP per capita seem to have a negative impact.[16,17]

3.3.3 Diffusion processes with endogenous regulation

The preceding analysis has neglected so far to consider a possible endogeneity in regulatory decisions. However as, e.g., Duso (2001, 2002) and Duso and Röller (2003) have pointed out in their work on telecommunication deregulation, both

[16]Given the previous analysis, a specification bias could arise due to neglecting a possible influence of the explanatory variables on a_i. However, the assumption that $\mathbf{x}_{it}$ also affects a_i has led to an extremely high degree of multicollinearity.

[17]To test the robustness of our results we have also run a regression in first differences: $\Delta y^*_{it} = \tilde{b}'\Delta(\mathbf{x}_{it}t) + u_{it}$, which support our initial outcomes.

political and institutional factors systematically influence the decisions to deregulate. Neglecting the endogeneity of policy factors would therefore lead to biased results when analyzing the effects of regime switching.[18] We therefore account for a possible dependency of regulatory interventions on market outcomes and political institutions in the following.

There are good reasons for regulatory regimes, to depend on (i) the market outcome and (ii) external factors such as political stability and democratization. In the case of market outcome affecting the probability of changing regulatory regimes a negative bias should be discernible. Since regulatory bodies tend to change regulation rather with low than with high penetration rates, one would expect the results to be biased towards too low a coefficient. That is, in the case that the impact of CPP on penetration rates being inseparable from the impact of market penetration on regulation (of the payment system), both effects interfere.[19]

In case that political factors affect the probability of changing regulatory regimes (such as switching the payment regime and introducing competition), positive as well as negative effects possibly come into play. As Duso (2003) shows, especially politically stable and democratic countries should be less dependent upon lobbying and exertion of the influence of firms. On the other hand, one might argue that autocratic systems are less dependent on the voters' favor. Since political agents in democratic systems other than their counterparts from autocratic systems, naturally strive for re-election, they may also be more vulnerable to lobbying and the pressure to come to popular decisions. However, it can hardly be predicted what kind of regime prefers re-regulation of a specific kind.

Moreover, there is a number of reasons why and how firms and interest groups tend to influence regulation (see Kroszner and Strahan, 1999, Potters and Sloof, 1996, for the influence of interest groups on regulatory interventions). Monopolistic mobile telephony providers, for example, should have an incentive to prevent liberalization and deregulation in order to safeguard their profits. It is arguable whether democratic or autocratic systems are more vulnerable to lobbying of monopolists or networks with significant market power.

One might also argue that competitors have an incentive to advocate CPP regimes. Since under calling party pays tacit collusion (and therefore higher profits) is very likely, firms are able to maximize profits when they achieve a regime switching. Mobile network operators therefore might have an incentive to exert influence on political decisions on regulatory issues.

Last but not least, regulatory authorities are also likely to aim at self-preservation.

[18] See also Kaserman et al., 1993, Donald and Sappington, 1995, 1997, Ros, 2003 for further work on telecommunications markets, see also Persson and Tabellini, 1999, 2000, Boylaud and Nicoletti, 2000

[19] To put it differently: while the effect of CPP on penetration is unclear, a reverse effect is (if existent), of course, negative. Therefore a possible bias should be negative.

Regulation and re-regulation can, of course, be used to ensure future regulatory actions. Regulatory bodies might therefore have incentives to overregulate markets in order to ensure future regulatory interventions. A more or less independent regulatory authority might be more powerful in doing so.

Instrumental Variables
A solution to the problem of endogeneity is to find adequate instrumental variables which are capable of explaining regulatory interventions but must not be correlated with the error term. Rather than telecommunication-specific variables which are presumably closely connected with the diffusion process and therefore not the first choice for instrumenting policy decisions, it would be worthwhile to find different kinds of variables.

For this purpose Duso (2001, 2002) and Duso and Röller (2003) use political and institutional variables such as information on the electoral system, the political system and information on regulatory authorities to instrument policy decisions. Using different models for either the interdependency or independency of market outcome and policy decisions, the authors are able to evaluate a possible simultaneity bias. Overall, strong evidence is provided for both the endogeneity of political decisions as well as for considerably biased results when neglecting this endogeneity.

However, as our panel consists of a maximum time span of 23 years and 77 countries, it is hard to find adequate instrumental variables for policy decisions. Most of the existing studies by Duso (2001, 2002), Duso and Röller (2003), and others rely on OECD countries or carry out cross-section analyses. An exception to these relatively restrictive databases is provided by the Center for International Development and Conflict Management at the University of Maryland. The so-called *Polity IV Project* consists of information on political regime characteristics and transitions and covers data on the period from 1800 to 2003 for all independent states with more than 500,000 inhabitants. The data is available online at no costs.[20]

Interestingly, the database does not only include indicators of democracy, e.g., a democracy score or the durability of political regimes, but also some features concerning the exercise of authority, such as a measure on the regulation of recruitment requirements, executive constraints or political competition (for a short description of the data used in this study see Table 5 in the appendix). Altogether these variables are acknowledged to be good proxies for the stability of a democratic environment and the independency of regulatory authorities. In case that political and institutional variables are well-suited to explain (de-)regulation decisions, the *Polity IV* variables should also be good instrumental variables for our purposes.[21]

[20]See http://www.cidcm.umd.edu/inscr/polity/index.htm.

[21]Of course, information on regulatory agencies would specifically constitute a perfect yardstick for instrumenting regulatory decisions. However, this information is limited in terms of

Moreover, the huge diversity in diffusion patterns could also have imposed pressure on some (less successful) countries to adopt a different regulatory system. This might be evident especially when neighboring countries which underlie similar political and economic conditions show a much better performance (i.e., higher penetration rates). Many of the countries which have switched from RPP to CPP are located on the American continent and especially in South America. A possible explanation for regime switching could be a dependency on the performance in countries located in the same region. To account for possible dependencies we have introduced two new variables $\ln YREG$ and $\ln YREG2$. $\ln YREG$ is the natural logarithm of the difference of the average penetration rate over the region where the country is located and the country's own penetration rate. The second variable, $\ln YREG2 = [\ln YREG]^2$, is built to account for possible non-linear effects.[22]

Results – Logit regressions
To analyze the performance of the instrumental variables we first regressed both possibly endogenous variables (CPP and COMP dummies) on a number of political variables (see Table 5 for a description of the variables), on $\ln YREG1$ as well as on $\ln YREG2$.[23]

Table 3 summarizes the results derived from logit analyses. A positive and statistically significant coefficient of $\ln YREG$ in both regressions indicates that countries with (relative to their neighbors) low penetration rates are more likely to change the payment system as well as liberalizing markets. Put differently, countries with a low relative market outcome seem to be more likely to change regulation. Estimates of $\ln YREG$ indicate non-linear effects, at least in the CPP regression.

While the autocracy index ($AUTOC$) is found to be statistically significant in both regressions, $DEMOC$ has a significant impact exclusively on $COMP$. This result is possibly caused by high correlation between $DEMOC$ and $AUTOC$.[24] Regarding the CPP regression, $AUTOC$ has a negative impact on the probability for a switch to CPP. More democratically structures countries seem to switch the payment system with higher probability. At the same time, a more stable system ($DURABLE$) is less likely to switch the payments systems. Especially former transition countries such as the Czech Republic and Romania and also politically less stable countries such as Guatemala, Mexico and Mongolia are more likely

countries and especially over time.

[22]Regional definitions have been adopted by the ITU database as follows: East Asia and Pacific, South Asia, Europe and Central Asia, Latin America and Caribbean, North America, Middle East and North Africa, Sub-Saharan Africa.

[23]We also included other explanatory variables from regression I–III as further instrumental variables (not reported here).

[24]Unfortunately, both logit regressions suffer from high degrees of multicollinearity, since most of the political variables are found to be highly correlated with each other. However, F-tests indicate that the instrumental variables are appropriate.

to change their payment systems than other countries. Regarding the $COMP$ regression opposite results can be observed. Surprisingly, a positive coefficient of ($AUTOC$) as well as a negative value of $DEMOC$ suggest a negative impact of the level of democracy on the introduction of competition. However, closer inspection of this outcome has revealed that a slightly non-linear influence does exist (not reported). Introducing $DEMOC^2$ as a second democracy score leads to a definitely positive (but non-linear) impact of $DEMOC$ on liberalization. Over and above this aspect, more stable political systems ($DURABLE$) are positively related to $COMP$. That is, democratic and stable countries are more inclined to introduce competition in mobile telephony markets.

The other instrumental variables such as regulation of executive recruitment ($XRREG$) and openness of executive recruitment ($XROPEN$) are somewhat ambiguous with respect to statistical significance. However, overall the remaining instrumental variables support the outcomes of democracy scores, autocracy scores and polity durability. Both regressions show a good performance. χ^2-tests as well as F-statistics support the validity of the instrumental variables.

Altogether, both regressions provide evidence for the hypothesis that regulation of mobile markets is endogenous. Moreover, variables indicating the democratic and political situation within a country are well suited to explain transitions in regulatory behavior. A key aspect, at least for introducing competition to mobile markets, is that countries do not act in isolation but with an eye to developments in neighboring countries.

Table 3: Logit analysis

	CPP	COMP
$\ln YREG$	0.7060	0.4321
	(7.31)	(7.02)
$\ln YREG2$	0.0931	0.0826
	(5.25)	(0.44)
$DEMOC$	-0.1105	-0.3211
	(-1.43)	(-3.18)
$AUTOC$	-0.8718	0.3176
	(-2.95)	(2.31)
$DURABLE$	-0.0243	0.0120
	(-8.44)	(4.35)
$XRREG$	1.6177	1.0281
	(3.27)	(2.24)
$XROPEN$	-0.8682	-0.8433
	(-2.04)	(-4.02)
$XCONST$	0.5045	0.4362
	(3.13)	(2.71)
$PARCOMP$	4.6630	-1.1682
	(7.05)	(-2.34)
$EXREG$	-0.1661	0.1410
	(-0.83)	(0.95)
$PLOCOMP$	-2.4036	0.4637
	(-6.37)	(1.78)
$Constant$	2.5618	0.4313
	(5.37)	(1.49)
Pseudo R^2	0.37	0.25
χ^2	259.73	199.19
(Prob.)	(0.00)	(0.00)
F	17.31	13.27
(Prob.)	(0.00)	(0.00)
Nobs	993	993

Note: Robust t-statistics are given in parentheses.

Note that logit regressions in Table 3 are only used exemplarily as a measure of performance of the instrumental variables. Of course, first stage regressions have been conducted using panel instrumental variable techniques for each (sub-)sample (for switching and non-switching countries as well as for all countries). Overall, there is only little variation when analyzing the performance of the instrumental variables with sub-samples. Results for switching countries (i.e., for the effects of a regime change) do not differ qualitatively from those in Table 3. However, $DEMOC$ as well as $DURABLE$ show reverse signs in the CPP regression when focussing on non-switching countries alone. The initial decision between CPP and RPP seems to affected by political factors in a manner different

from the decision to change the payment system.[25]

Results – IVFE regressions
Having controlled the validity of our instrumental variables, we then have run instrumental variable fixed effects regressions to account for possible endogeneity of CPP and $COMP$ (see Wooldridge, 2007). By this means CPP has now been found to be statistically insignificant in all of the regressions (see Table 4). Taking into account the endogeneity of CPP therefore leads to a complete reverse result. The assumed positive impact of calling party pays on diffusion patterns of mobile telephony cannot be supported. Quite the contrary: neither a changeover to CPP nor a primary choice of CPP influences the average growth rate. Independent from a possible influence of the calling party pays regime on the traffic in mobile networks, there is *no* evidence at all for higher penetration under CPP. Therefore, a change of the payment regime to RPP would in all probability not lead to reduced or lower penetration rates. Durbin–Wu–Hausman tests suggest that standard OLS estimates are not consistent and suffer from endogeneity bias. Instrumental variable methods seem to provide consistent results.

Table 4: Instrumental variable (2SLS) regression of diffusion processes

[25]Because of the relatively large size of our sample with respect to both time and the heterogeneity of countries, the results should interpreted very carefully. It would be nevertheless worthwhile to take a closer look at this issue using more detailed information on variables such as, e.g., independency of regulatory authorities. However, this would be beyond the scope of this paper.

	all obs	switching countries	non-switching countries
CPP	-0.0148	-0.0265	-0.3511
	(-0.54)	(-1.41)	(-0.54)
$COMP$	-0.0691	0.0280	0.0640
	(-1.29)	(2.43)	(1.90)
$PREPAID$	0.0227	0.0131	0.0103
	(2.01)	(1.62)	(1.59)
POP	-4.96e-09	-5.80e-09	-3.71e-09
	(-6.37)	(-3.29)	(-4.32)
$POPAREA$	0.0002	0.0007	-0.0001
	(1.44)	(0.62)	(-1.13)
$FIXEDSUBS$	0.0416	0.0690	-0.0099
	(1.55)	(1.32)	(-0.32)
$GDPC$	5.47e-09	-6.64e-07	-7.66e-06
	(0.62)	(-3.64)	(-6.95)
β_i	6.8760	7.87	1.1341
	(6.07)	(3.68)	(1.86)
FE, $FE \cdot t$	YES	YES	YES
adj. R^2	0.96	0.96	0.96
Nobs	883	240	643
No. of groups	77	26	51
Durbin-Wu-Hausman χ^2	12.44	14.10	9.91
(Prob.)	(0.00)	(0.01)	(0.01)

Note: Robust t-statistics are given in parentheses. Coefficients have been multiplied by -1 for a more comfortable interpretation.

The results concerning the impact of competition are ambiguous. Using the whole sample $COMP$ is now no longer statistically significant. With switching countries only, however, IV estimates suggest a stronger impact in comparison to usual fixed effects regression. Finally, the third sample, too, shows a higher impact of $COMP$, though the significance level is rather low. We carefully interpret this result as some slight evidence for a tendency of underestimating the impact of competition when not controlling for endogeneity. Nevertheless, we are of course aware that using a dummy variable to identify the impact of competition on diffusion can only be a crude measure. The results should therefore be interpreted with circumspection.

While the introduction of prepaid cards has either a positive or an insignificant influence on the diffusion of mobile telephony, the coefficients of POP and $GDPC$ (in all but one regression) show negative coefficients. The reasoning for

a seemingly negative impact of $GDPC$ is that population numbers are also included in $POPAREA$ and POP. The variables $POPAREA$ and $PREPAID$ are insignificant in the majority of the regressions. Possible explanations for this insignificance must be sought in the existence of multicollinearity, in the heterogeneity of the countries and different sizes of the sub-samples.

To sum up, accounting for endogenous regulation yields completely different results regarding a possible impact of the payment regime on diffusion patterns. While using instrumental variables measuring the influence of market outcomes and political factors on regulatory interventions helps to identify the mere effect of CPP on penetration rates a statistically significant impact of CPP, however, cannot be ascertained. In contrary to concerns expressed by regulatory authorities and the OECD, there is no empirical evidence for a negative impact of RPP on penetration rates.

4 Conclusion

Most regulatory bodies regard mobile termination markets under calling party pays payment system as monopolistic bottlenecks requiring regulatory interventions. However, turning away from the calling party pays payment system to a receiving party pays regime could possibly be an adequate way to obviate regulation of termination fees. Unfortunately, receiving party pays also exhibits some possible drawbacks, whereas the major apprehension concerning RPP aims at a possible negative impact on mobile telephony penetration rates. Since statistical evidence on the impact of CPP and RPP is poor, this paper analyzes the impact of the two predominant payment regimes for M2M termination on the diffusion of mobile telephony.

While in a first step a positive impact of CPP on penetration rates is found using simple panel data techniques, a second set of regressions leads to different results by accounting for possible endogeneity of regulatory interventions. Endogenous regulation in this context is assumed to arise from a dependency of regulatory interventions from relative market outcomes as well as from political and institutional factors and is also proved by the data. To address this endogeneity issue, we use a set of instrumental variables such as a measure for relative performance (in comparison to neighboring countries), democracy scores and measures for stability of political systems.

By the use of instrumental variable methods we then find that CPP has no statistically significant impact on subscriber penetration. Countries that switched the payment system or countries that used CPP over the whole sample do not exhibit significantly higher penetration rates. We therefore assume that RPP instead of CPP would not reduce penetration rates, irrespective of whether a country's penetration process has just begun or has nearly reached saturation levels. Moreover, we expect that adopting RPP instead of CPP seems to be a

possible way to reduce market power of terminating networks as well as of mobile termination rates and, additionally, to obviate regulation of M2M termination fees.

Furthermore, competition (liberalization of mobile telephony markets) is also found to have a stronger impact on penetration rates when accounting for endogenous regulation. Since regulatory bodies tend to change regulations with poor market outcomes, effects of competition on diffusion patterns tend to be underestimated. Again, using instrumental variables techniques eliminates this bias.

Finally, this study (consistent with others) has ascertained that it is important to understand to which extent regulatory interventions cannot be treated as independent decisions by regulatory authorities but must rather be interpreted as endogenous. Regulatory bodies are potentially influenced by political and institutional factors as well as by economic concerns. Measuring the impact of such interventions will by all probability lead to biased results when ignoring a possible endogeneity.

Overall, the instrumental variables used in this study show a good performance with respect to endogeneity. Stability of political systems as well as a country's relative performance, in particular, are found to have impact on regulatory interventions. However, open questions remain, concerning, e.g., the exact kinds of biases induced by endogenous regulation. A detailed analysis of these kinds of questions is beyond the scope of this paper and should be objective of future studies.

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A Tables

Table 1: CPP, RPP and switching countries

CPP countries	Switching countries	RPP countries
Australia	Venezuela (1991)	Albania
Austria	Brazil (1994)	Barbados
Belgium	Colombia (1994)	Cameroon
Belize	Israel (1994)	Canada
Botswana	Dominican Republic (1995)	China
Cyprus	Uruguay (1995)	Croatia
Denmark	Costa Rica (1996)	Hongkong
Estonia	Czech Republic (1996)	Mauritius
Finland	Mongolia (1996)	Russia
France	Peru (1996)	Singapore
Germany	Cambodia (1997)	St. Kitts and Nevis
Gibraltar	Panama (1997)	Ukraine
Greece	Ecuador (1998)	USA
Hungary	Romania (1998)	Sri Lanka
Iceland	Argentina (1999)	
Ireland	Bolivia (1999)	
Italy	Chile (1999)	
Japan	El Salvador (1999)	
Korea (Rep.)	Guatemala (1999)	
Lithuania	Mexico (1999)	
Luxembourg	Antigua and Barbuda (2000)	
Madagascar	Honduras (2000)	
Malaysia	Jamaica (2000)	
Malta	Cayman Islands (2001)	
Moldova	Pakistan (2001)	
Netherlands	Trinidad and Tobago (2001)	
New Zealand	Dominica (2002)	
Norway	Grenada (2002)	
Philippines	Saint Lucia (2002)	
Poland	St. Vincent (Grenad.) (2002)	
Portugal	India (2003)	
Slovak Republic		
Slovenia		
Spain		
Sweden		
Switzerland		
Turkey		
UK		
Zimbabwe		

Table 5: Instrumental variables from Polity IV database

Variable	Description
DEMOC	Democracy Score: general openness of political institutions. Institutionalized Democracy: Democracy is conceived as three essential, interdependent elements. One is the presence of institutions and procedures through which citizens can express effective preferences about alternative policies and leaders. Second is the existence of institutionalized constraints on the exercise of power by the executive. Third is the guarantee of civil liberties to all citizens in their daily lives and in acts of political participation. Other aspects of plural democracy, such as the rule of law, systems of checks and balances, freedom of the press, and so on are means to, or specific manifestations of, these general principles. We do not include coded data on civil liberties. The 11-point Democracy scale is constructed additively. The operational indicator is derived from codings of authority characteristics, Range = 0-10 (0 = low, 10 = high).
AUTOC	Autocracy Score: general closeness of political institutions. Institutionalized Autocracy: "Authoritarian regime" in Western political discourse is a pejorative term for some very diverse kinds of political systems whose common properties are a lack of regularized political competition and concern for political freedoms. We use the more neutral term Autocracy and define it operationally in terms of the presence of a distinctive set of political characteristics. In mature form, autocracies sharply restrict or suppress competitive political participation. Their chief executives are chosen in a regularized process of selection within the political elite, and once in office they exercise power with few institutional constraints. The 11-point Autocracy scale is constructed additively. The operational indicator is derived from codings of authority characteristics, Range = 0-10 (0 = low, 10 = high)
DURABLE	Indicator of polity durability based on the number of years since the last (3-point or greater change in DEMOC-AUTOC) regime transition. The DURABLE variable is coded from the year of the first regime transition or the first year of independence.
XRREG	Regulation of Executive Recruitment: institutionalized procedures regarding the transfer of executive power.
XROPEN	Openness of Executive Recruitment: opportunity for non-elites to attain executive office.
XCONST	Executive Constraints: operational (de facto) independence of chief executive.
PARCOMP	Competitiveness of Participation: extent to which non-elites are able to access institutional structures for political expression.
EXREC	Executive Recruitment: Concept variable combines information presented in three component variables: XRREG, XRCOMP, and XROPEN.
PLOCOMP	Political Competition: Concept variable combines information presented in two component variables: PARREG (not included here) and PARCOMP.

Source: Marshall, M.G. and K. Jaggers (2002).

Figure 2: Diffusion of mobile telephony in the United States

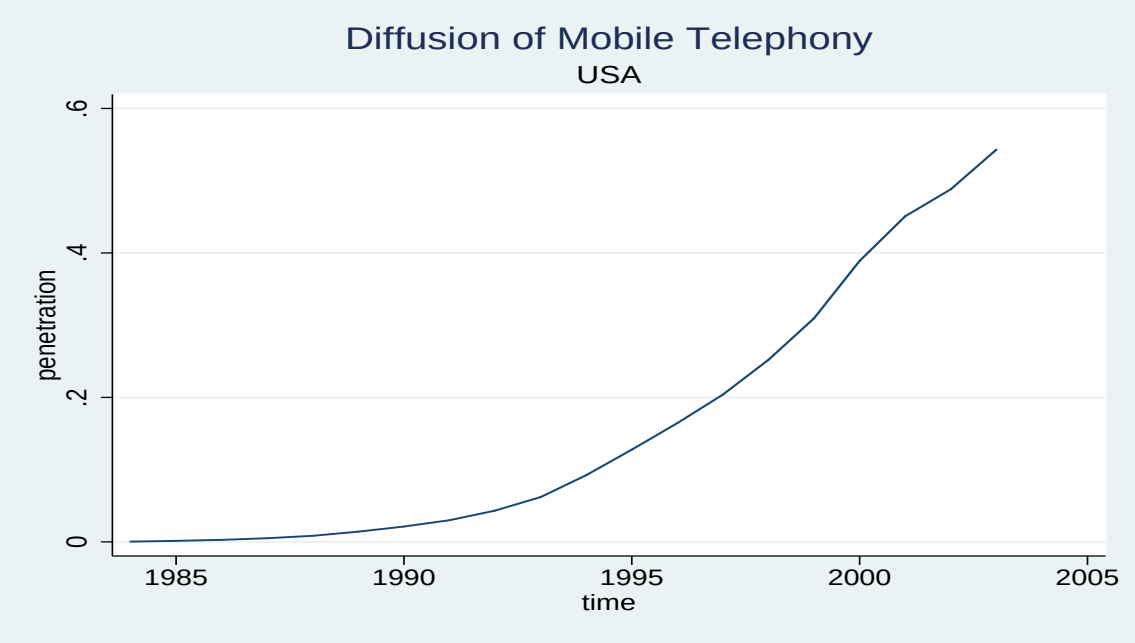


Figure 3: Diffusion of mobile telephony in Germany

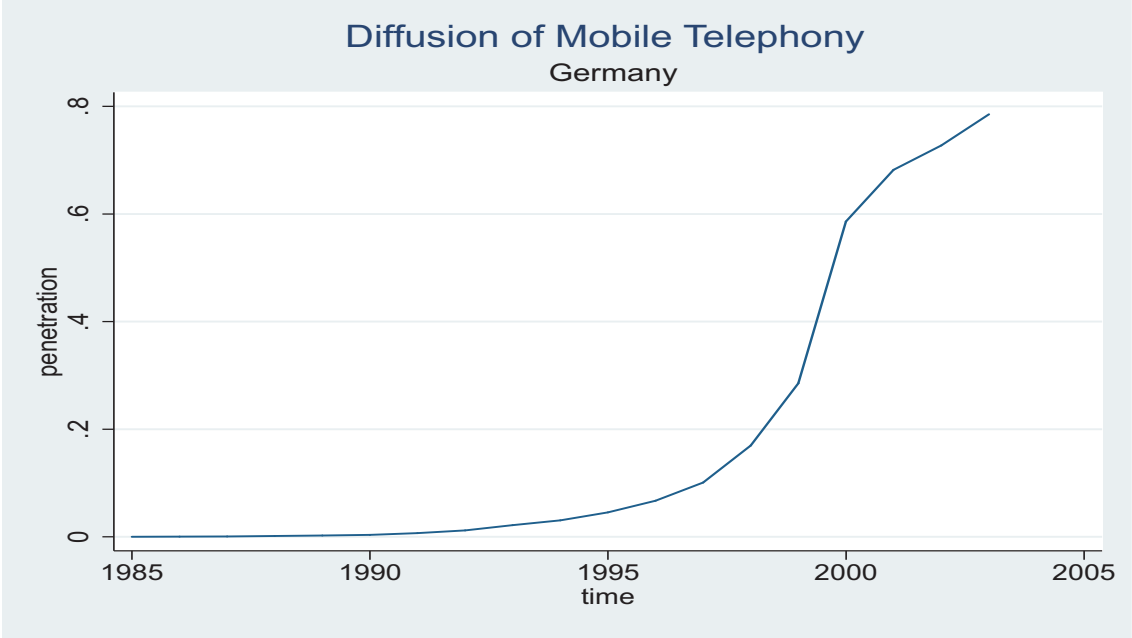
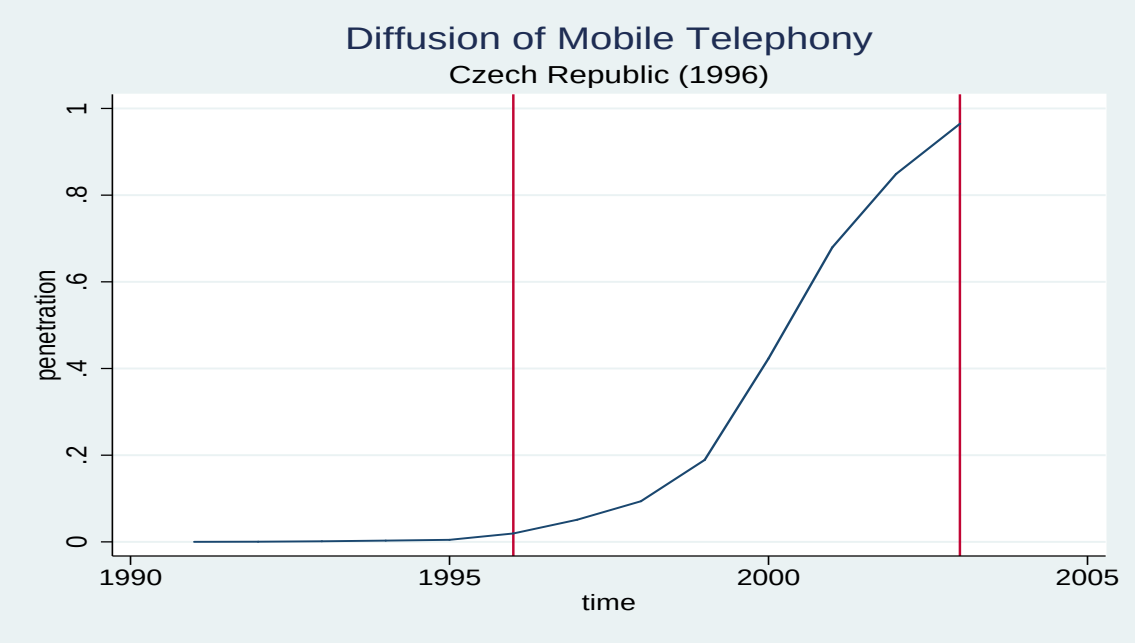


Figure 4: Diffusion of mobile telephony in the Czech Republic



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