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## Calling Party Pays or Receiving Party Pays?

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**43**

# **Calling Party Pays or Receiving Party Pays?**

Ralf Dewenter & Jörn Kruse

# Calling Party Pays or Receiving Party Pays?

## The Diffusion of Mobile Telephony with Endogenous Regulation\*

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November 18, 2005

### Abstract

This paper analyzes the impact of different payment regimes for mobile-to-mobile off-net calls on the diffusion of mobile telephony, using data on 84 countries from all over the world. Since the decision whether or not countries are likely to switch from RPP to CPP is not independent from penetration rates, a problem of endogenous regulation arises. In order to account for this problem we refer to data on political and democratic stability to instrument endogenous policy decisions. However, positive effects from regime switching seem to vanish when accounting for endogenous regulation. The effects of introducing competition instead seems to be underestimated ignoring endogeneity.

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# 1 Introduction

With the exception of licensing and spectrum allocation, mobile telephony markets have mostly not been regulated until the end of the 1990ies. However, in recent years most European countries (exceptions are e.g. Germany and Switzerland) have introduced price regulation of wholesale mobile termination markets. The reasoning for regulating mobile-to-mobile terminations fees is closely connected with the applied type of payment regime for off-net calls or, more exactly, with the underlying market structure.

While under the so called receiving party pays regime (RPP) mobile operators charge their own subscribers for termination services, under the calling party pays regime (CPP) terminating operators charge originating operators which gives rise for market power in termination markets. Thus, depending on the existing number of substitutes for off-net calls terminating mobile operators are likely to exploit subscribers from originating networks. Defining own relevant termination markets regulatory authorities therefore regard mobile termination markets to be monopolistic bottlenecks when CPP is applied.

A possible alternative to avoid monopolistic termination fees is to apply the receiving party pays rule (see e.g. Doyle & Smith, 1998; Laffont et al., 1998; Littlechild, 2005). In case that a RPP regime is applied subscribers are able to compare not only prices for on-net calls, subscription fees, handset subsidies etc. but also retail prices for incoming calls when deciding to join a network. Hence, market power in termination markets would be no longer existent and termination rates would drop. A changeover from CPP to RPP seems therefore to be an adequate solution.

However, there are also some reservations with RPP (see Littlechild, 2005). Beside concerns about the costs of implementation and about consumer resistance, users are particularly supposed simply to switch off their handsets. Since subscribers are not able to identify whether or not they would benefit from being called and therefore have only limited cost control when being charged for incoming calls they might precautionary turn off their mobile phones. As a consequence both on- and off-net traffic as well as penetration of mobile telephony might be reduced.

So far there is only little empirical evidence on both the effects of RPP on mobile traffic and the diffusion of mobile telephony (see OECD, 2000; Littlechild, 2005). For this reason the purpose of this paper is to analyze the impact of payment regimes for off-net calls on penetration rates in mobile markets. In the following we use data in 84 countries from all over the world and apply panel data techniques in order to shed some light on the influence of CPP and RPP on the diffusion of mobile telephony. By using information on original CPP and RPP countries as well as on switching countries, we are able to identify (i) whether CPP in general leads to higher penetration rates and (ii) whether or not changing the payment regime has a significant effect on penetration.

Since (de-)regulatory interventions are frequently not exogenous but frequently endogenously determined by other factors such as market outcome, lobbying, and political as well as institutional factors (see Persson & Tabellini, 2000) we account for a possible endogeneity of the regulation of payment regimes. Using data on political stability and polity factors we are able to instrument market interventions by regulatory bodies. Moreover, we use average penetration rates from neighbor countries as instrument variables in order to account for spatial correlation.

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

## 2 Mobile termination

When a customer  $A$  of a mobile network, say network  $O_A$ , wants to call a subscriber  $B$  from a different mobile network, say network  $M_B$ , both networks have to be interconnected. In that case network  $A$  is providing an origination service and network  $B$  terminates the call. Both operators usually charge fees for their services, namely the call charge ( $Z_a$ ) and the termination rate ( $Z_{MT}$ ) to cover costs. Under the calling party pays regime mobile operator  $M_B$  charges network  $O_A$  a termination fee which  $O_A$  completely charges to its subscriber in addition to or as part of the call charge. Under RPP, in contrast, subscribers of network  $O_A$  have to pay for origination services exclusively while the recipient in network  $M_B$  will be charged for the termination service (see Figure 1).

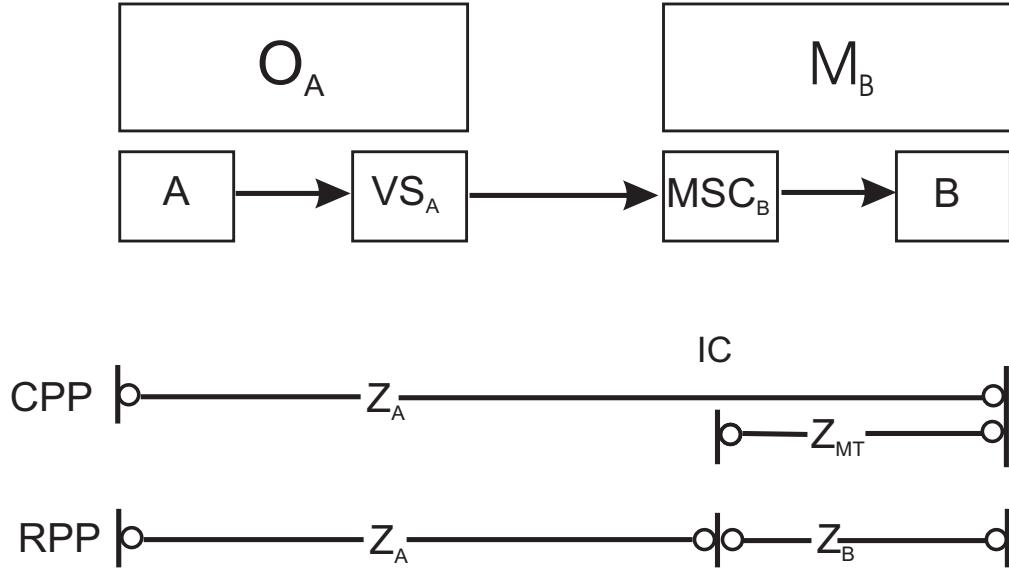


Figure 1: CPP and RPP

While under CPP the terminating network is able and has the incentive to exploit subscribers from originating networks or, more exactly, to exploit originating *networks* directly — due to its monopolistic market power — there is no such an incentive under RPP.<sup>1</sup> Potential customers are then in a position to compare the whole price basket (for on-net and off-net calls as well as for other services) and mobile operators are likely to compete over a complete bundle of prices.

However, monopolistic exploitation is only feasible when there is a lack of possible substitutes. And despite of possible alternatives to off-net calls, such as emails or fixed line telephony, the European Commission and other regulatory authorities define own relevant mobile-to-mobile termination markets. As a consequence mobile termination services can be seen as monopolistic bottlenecks when CPP is applied (Armstrong, 1998).

## 2.1 RPP as an alternative to regulation

One possible way to deal with this “monopolistic” situation is to regulate termination fees. Beside the usual problems of price regulation (costs of price control, predictable regulatory framework, asymmetric information), there are however some peculiarities which are closely connected with price control in mobile telephony markets. That is inter alia (i) high common and fixed costs (ii) the so called waterbed effect, (iii) Ramsey pricing, and (iv) consumer ignorance (see Crandall & Sidak, 2004; Haucap, 2004; Littlechild, 2005).

Typically, mobile network operators have to face a huge amount of fixed costs, e.g. licensing costs, network’s set-up costs, marketing expenditures, and handset subsidies. When prices for a specific service are regulated equal to short-run marginal costs — which are more or less negligible in mobile markets — fixed costs cannot be recovered with this service. Due to the waterbed effect other prices such as on-net calls or subscription rates have to increase in order to cover fixed costs. However, increasing charges for on-net calls or subscriptions are more likely to decrease mobile markets penetration (see also Kruse, 2004).

More importantly, mobile operators are no longer free to compete over the whole price basket with regulated penetration rates. To recover fixed and common costs at least some of the prices have to exceed marginal costs. Following the quasi efficient Ramsey pricing rule (Ramsey, 1927) prices of goods whose demand is relatively inelastic have to be set relatively high while prices for goods whose

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<sup>1</sup>Even though originating networks are able to neglect to pass high termination rates along to the callers, terminating networks will exploit the originating mobile network operators under CPP. Therefore, originating networks have the incentive to bill the termination rate to its customers. As Armstrong (1998) and Laffont et. al (1998) have pointed out bargaining of network operators over termination fees is likely to result in collusive behavior and therefore in high termination fees. However, this outcome strongly depends on the firms’ symmetry, and on the pricing structure (for further discussion see Crandall & Sidak (2003), Haucap (2004), Littlechild (2005)).

demand is elastic have to be set lower. Since demand for off-net calls is typically less elastic than for other services (Hausman, 2000) one would expect relatively high termination rates under the Ramsey rule. Regulating termination fees with inelastic demands leads therefore to avoidable welfare losses.

However, there are also few reasons that termination rates can be “too high” in sense of total welfare. One aspect is consumer ignorance about exact prices for off-net calls. Gans & King (2000) (see also Buehler & Haucap, 2003; Dewenter & Haucap 2005) argue that subscribers do not base their calling decisions on actual prices but only on average rates. Given consumer ignorance increasing prices (from a specific operator) have only limited impact on average prices and therefore on the demand for off-net calls. As a consequence prices tend to be inefficiently high.

Introducing receiving party pays instead of calling party pays is an appropriate way to prevent most of the problems mentioned above. With RPP consumers are able to compare each prices and mobile operators are likely to compete over the whole price basket. Since termination markets can no longer be regarded as monopolistic markets regulation becomes unnecessary and prices are likely to fall.<sup>2</sup> Furthermore, mobile operators are able to set prices according to Ramsey pricing and are able to recover high common fixed costs.

Moreover, also consumer ignorance would no longer play any role under RPP. As mobile networks operators do not need to negotiate termination fees under RPP, marginal costs for off-net calls would be equal, independently from the networks involved in interconnection. Accordingly, common prices for off-net calls as well as common termination rates can be installed.

Additionally, since under CPP the caller is billed exclusively for a call but both parties probably do benefit, CPP could be an inefficient regime. Given that both parties benefit also the costs should be distributed in accordance with the benefits of callers and receivers (DeGraba, 2003). Even though it is not clear whether or not both parties benefit from each call, CPP can only be efficient when the receiver does not benefit at all.

Summing up, the consideration of RPP in favor of CPP would help to solve a number of problems of mobile-to-mobile termination. Regulatory interventions would become needless, prices are likely to decrease, and also problems with consumer ignorance would vanish.

## 2.2 Possible drawbacks of RPP

There are however also some concerns about RPP. A changeover from CPP to RPP would, for example, cause costs for implementing the new system and for

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<sup>2</sup>Empirical Evidence suggests that termination rates under RPP are in fact much lower than under CPP (see Littlechild 2005).

reorganizing the price structure.<sup>3</sup> Furthermore, mobile customers could also suffer from junk and marketing calls to a higher degree, when being charged for incoming calls.

Most importantly, there are also some concerns about calling behavior and mobile penetration with receiving party pays. Since consumers are not aware whether or not they would benefit from a call (and have therefore limited cost control) they might switch their mobile phone off to reduce costs. This in turn leads to reduced on- and off-net traffic as long as subscribers are not available. Even though there is some empirical evidence that consumers shut down their handsets — especially in the early days of mobile telephony — broad statistical evidence is still missing.<sup>4</sup> On the other hand, there are also technical features such as caller identification or pager to identify callers. Moreover, regarding junk and marketing calls, it might even be efficient not to answer a call. In case that termination rates will considerably decrease with RPP — as can be observed in some countries — this problem might be negligible.

Nevertheless, in case that subscribers turn off their mobile handsets this could also have negative impacts on growth rates in mobile telephony markets: (i) when consumers anticipate that they are not able to identify whether or not they would benefit from incoming calls and would therefore switch off their phones, they might refuse to sign mobile contracts in advance. This is most likely for consumers who are willing to be achievable but do not frequently place own calls. In this case especially prepaid cards — which have contributed to mobile penetration to a considerable amount in some countries — would be of less interest. (ii) Given that competitive pressure on termination markets lowers termination rates but, due to the waterbed effect, increases prices for on-net calls and subscription rates, again, penetration rates would be lower under RPP.

There is also little evidence on the impact of RPP and CPP on the diffusion of mobile telephony. Apart from some case studies (Zehle 1998, 2003; OECD, 2000) we are not aware of a comprehensive statistical analysis on this issue. While some of the RPP countries have reached nearly a 100% penetration rate (e.g. Hong Kong and Singapore) some others, such as United States and Canada, are fairly behind this numbers. However, a simple comparison of penetration rates without taking care for other factors, such as income, penetration of fixed line telephony, and the availability of prepaid cards, does not allow to evaluate the impact of different payment regimes.

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<sup>3</sup>Littlechild (2005) argues that installing the RPP system instead of a CPP regime would neither cause significant costs nor would the technical work be problematic. Moreover, RPP would be also cheaper to some extend, since mobile operators are no longer engaged to record and bill incoming calls to originating operators.

<sup>4</sup>Littlechild (2005) discusses some case studies as well as anecdotal evidence, however, an extensive study comparing different countries is not existent to our knowledge.

### 3 Empirical Evidence

#### 3.1 Modelling diffusion processes and specification

To analyze the impact of CPP/RPP regimes on the growth rates of mobile telephony adoptions it is essential to find an adequate diffusion model. Economic literature on both technology and product penetration provides a wide range 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 & Bass, 1990; Maede & Islam, 1998; Geroski, 2000). Since the S-shaped logistic curve has proved to fit well for several mobile telephony markets across the world (see e.g. Gruber & 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

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

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 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 or simply the period with highest growth.

In order to keep the model as simple as possible we use a linear version of equation (1).<sup>5</sup> 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:

$$(2) \quad \hat{y}_i = \hat{\lambda}POP_{it},$$

where  $\hat{\lambda}$  is the saturation rate of this process.<sup>6</sup> In case that the saturation rate has been determined the three-parametric logistic model can be linearized as

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

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<sup>5</sup>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.

<sup>6</sup>To estimate the saturation rate, we have assumed different functional forms and specifications: (i) the original non-linear version of a three parametric using 2SLS techniques and a linearized version using a first difference approach. Furthermore, we have calculated different types of the 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 lambda's.

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

$$(4) \quad y_{it}^* = a_i + b_i t + \varepsilon_{it}$$

can be derived.

Because of the heterogeneity of the countries in our sample we do not restrict our analysis assuming that parameters  $A_i$  and  $B_i$  are constant over cross-sections. However, following Gruber & 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

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

where  $\alpha_i$  and  $\beta_i$  are country specific fixed effects,  $\delta$  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

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

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 The data

The data used in this study are annual and cover 84 countries. Our earliest observations are from 1980 and the most recent one from 2003, hence, 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 for details). Interestingly, none of the countries has switched from CPP to RPP yet. 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 (see Table 2 for an overview).

Overall, we use four different dummy variables indicating the payment regime: *CPP* is a dummy equal to one if a country applies calling party pays at time  $t$ , independently whether it is a switching country or whether this country has always applied CPP. The variable *CPP<sub>country</sub>* is equal to one in case that a country

is an “original” CPP country. In this case  $CPP_{country}$  equals one over the whole period for each CPP country. In the same manner  $RPP_{country}$  and  $RPP2CPP$  indicate original RPP countries and switching countries. None of the latter three variables therefore vary over time but only 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 population density (population divided by  $\text{km}^2$ ). Given that richer countries are both more likely to adopt mobile telephony and that firms in richer countries are also more able to built mobile networks, we expect that  $GDPC$  has 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 even more population density is a measure of costs. In case that, for 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.<sup>7</sup>

To account for telecommunication specific effects we have used 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.  $COMP$  is therefore equal to one if there are at least two competitors in a specific market at time  $t$ .<sup>8</sup> We expect that both  $PREPAID$  and  $COMP$  have a positive influence on penetration rates. The effect of the number of subscribers to fixed line telephony instead is ex-ante not clear.<sup>9</sup> In case that fixed lines are seen as a substitute to mobile telephony, the influence should be negative, however, in case that fixed and mobile telephony are complementary products a positive influence should be detectable.

Figures 2–4 depict the diffusion processes for three countries exemplarily: while the USA have always applied RPP, Germany is a typical CPP country. Moreover, the Czech Republic switched from RPP to CPP regime in 1996. Obvious differences between the three countries are the maximum number of adopters

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<sup>7</sup>Not only absolute 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 for these variables our sample has been reduced by a remarkable amount.

<sup>8</sup>Of course, this is only a crude measure for competition since independently of the number of players competition can be either harsh or soft.

<sup>9</sup>The introduction of digital technology in mobile telephony markets, e.g. GSM, could be also an interesting determinant for the diffusion process (see e.g. Gruber & Verboven, 2001). However, a dummy indicating availability of digital networks has been found to be highly correlated with  $COMP$ . We therefore have skipped the dummy indicating digital technology.

and the distinctiveness of the S-shaped functions. While diffusion of mobile technology in Germany follows a distinctive S-shaped curve, the process in the USA is relatively flat. On the other hand, nearly 100% of customers in the Czech republic have already adopted mobile telephony, whereas in Germany (about 80%) and the United States (about 55%) this number is considerably lower. Of course, this simple comparison does not allow any judgement on the impact of different payment regimes.

Due to linearizing the logistic function, 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). Since both  $\hat{y}_{it}$  and the saturation rate are unknown, we have first estimated a three-parametric logistic curve (using the penetration rate of country  $i$  in time  $t$ ) in order to determine the average turning point, the average growth rate and the average saturation rate, using non-linear least squares and neglecting all exogenous variables except population (POP) and a trend. For this purpose we have used data on all 192 countries reported in the ITU database. Using non-linear least squares we have found an average saturation rate of about 65% and an average growth rate of about 36% per year (see Table 3 in the appendix). The fourteenth period in our sample (i.e. 1994) has been proved to be the period with highest growth rates.

Since the estimated saturation rate of 65% of the whole population seems to be rather low, it is not likely that it represents most of the countries in our sample. We have therefore repeated the non-linear least squares regression with the 84 countries of our original sample. However, again, a very low average saturation rate has been determined. Because of strongly varying numbers of observations across the different countries we have not been able to calculate own saturation rates for each country using NLS. Therefore, we have applied a first-difference approach, in order to calculate individual  $\hat{\lambda}_i$ 's. Taking the first difference of a three-parametric logistic function and simple algebra lead to a linear function in parameters as:

$$(7) \quad \Delta y_{it} = \gamma y_{it} - \mu y_{it}^2,$$

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

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

All of the following results have been derived using country specific saturation rates. Of course, we have also tested whether the results are robust against varying  $\lambda$ 's and have used various  $\lambda$ 's [0.65,0.8,1,1.2,1.35] to calculate the left hand side variable in our diffusion model. Overall, the results did not change qualitatively and only gradually quantitatively.

### 3.3 Empirical results

#### 3.3.1 Exogenous regulation

As a first pretest we have simply regressed  $y_{it}^*$  on three dummy variables indicating the payment regime within a country ( $CPP_{countries}$ ,  $RPP_{countries}$  and  $RPP2CPP$ ) in order to analyze possible differences in average growth rates using the whole sample of 84 countries. As can be seen from regression I in Table 4, we have also added the control variables described above, fixed affects and fixed effects multiplied with a linear trend.

The results from regression I provide only little evidence for an positive influence of CPP on the diffusion of mobile telephony. On the one hand, there is a difference between CPP, RPP and switching countries, on the other hand, coefficients for CPP and RPP are only significant on a 10% level (note that coefficients have to be multiplied by minus one to achieve the correct sign). Both the availability of prepaid cards as well as the introduction of competition is found to have a positive influence on average growth rates, while other controls except population are statistically insignificant. While the introduction of prepaid contracts has led to an increase in growth rates by about 1.2 percent points, competition increases average growth by about 2.7 basic points.

In order to analyze the influence of the application of CPP for both switching countries and original CPP countries simultaneously, we have used the  $CPP$  dummy exclusively in regression II. In comparison with periods where RPP payment regimes have been applied, a higher growth by about 2.15 basic points is now detectable. Hence, while there seem to be only slight differences between countries using different payment regimes, a comparison of periods under different regimes provides some evidence for a positive impact of CPP.

Interestingly, some of the results have changed using sub-samples for switching countries and non-switching countries. Using data on switching countries exclusively a comparison of periods under RPP and CPP is possible. As can be seen from regression III 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 2.33 basic points under CPP. When analyzing original CPP countries and comparing them with original RPP countries (regression IV) the CPP dummy is statistically insignificant. Hence, there seem to be no differences in diffusion processes comparing original CPP and RPP countries, only when countries have changed their payment regime a positive effect is detectable.

Given the previous analysis a specification bias could arise due to neglecting a possible influence of the explanatory variables on  $a_i$  or i.e. the turning point of the diffusion process. Assuming that  $\mathbf{x}_{it}$  also affects the turning point and therefore inserting these variables in  $a_i$  leads unfortunately to a large number of insignificant coefficients. Because of this multicollinearity (each explanatory variable is now included in levels and multiplied with a trend) we have dropped

the explanatory variables from  $a_i$ . In order to test the robustness of the results we have run a further regression, in first differences:

$$(9) \quad \Delta y_{it}^* = \tilde{b}' \Delta(\mathbf{x}_{it} t) + u_i.$$

Unfortunately, this is not a valid test for the exclusive use of data on original CPP countries, since taking the first difference of the CPP dummy result in a constant. As our sample includes only few original RPP countries we observed collinearity when dropping the switching countries from the sample. Nevertheless, as can bee seen from Table 5 the results of this regression are very similar to the results from regression III in Table 4. Hence, the results are robust against a possibly miss-specified model.

### 3.3.2 Endogenous regulation

The preceding analysis has neglected to consider a possible endogeneity in policy decisions. However, as, e.g., Duso (2001, 2002) and Duso & Röller (2003) have pointed out in their work on telecommunication deregulation both political and institutional factors systematically influence the decisions to deregulate. Neglecting the endogeneity of policy factors would therefore lead to biased results<sup>10</sup>. Thus, since policy decisions and regulatory interventions are typically not independent of (i) the market outcome and (ii) of external factors (such as, e.g. lobbying and elections) we have tested both the CPP dummy as well as the competition dummy (COMP) against a possible endogeneity, using Hausman-Wu tests. As can be seen from Table 4, as expected, most of the tests support the hypothesis of endogenous policy decisions. These results give reason for a closer inspection of this endogeneity problem.

#### *Instruments*

As mentioned above a major problem of the previous analysis is that both the decision to switch from RPP to CPP as well as the decision to open the market for competitors have been found to be endogenous. Thus the coefficients of both variables are very likely to be biased as it is not possible to identify the effects of regime switching. A solution to this problem is to find adequate instruments which are able to explain regulatory interventions but are not strongly correlated with the diffusion process. Rather than telecommunication specific variables which are probably 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.

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<sup>10</sup>See also Kaserman et al., 1993; Donald and Sappington, 1995, 1997; Ros, 2003 for further work on telecommunications markets; see also Persson & Tabellini, 1999, 2000; Boylaud & Nicoletti, 2000

For this purpose Duso (2001, 2002) and Duso & Röller (2003) use political and institutional variables such as information on the electoral system, the political system and information on regulatory authorities (e.g., whether there is a report duty or whether regulatory authorities are independent) 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 a considerably biased results when neglecting this endogeneity.

However, as our panel consists of a time span of at most 23 years and 84 countries it is hard to find adequate instruments for policy decisions. Most of the existing studies by Duso (2001, 2002), Duso & 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 & 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 are available on-line at no costs (see <http://www.cidcm.umd.edu/inscr/polity/index.htm>).

Interestingly, the database does not only include indicators of democracy, e.g., a democracy score or the durability of political regimes, but also some authority characteristics, e.g., 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 6). Altogether these variables are supposed to be good proxies for the stability of 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 instruments for our purposes.<sup>11</sup>

Conspicuously, 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 therefore be a dependency on the performance in countries located in the same region. To account for possible dependencies we have built a new variable *YREG* which is the difference of the average penetration rate over the region the country is located and a country's own penetration rate. Regions definitions have been adopted by the ITU database as follows: East Asia & Pacific, Europe & Central Asia, Latin America & Caribbean, Middle East & North Africa, North America, South Asia, Sub-Saharan Africa.

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<sup>11</sup>Of course, especially information on regulatory agencies would be adequate measures for instrumenting regulatory decisions. However, this information is only limitedly available in terms of countries and especially over time. Therefore we must rely on polity variables and other determinants.

### *Instrumenting procedure*

Using the variables from the *Polity IV* database, *YREG*, and the explanatory variables from the first set of regressions, we are now able to instrument both *CPP* and *COMP*. Since both variables to be instrumented are dummy variables, it would not be adequate to simply use instrumental variable techniques. However, an adequate method to deal with this problem is to regress both dummies on the instruments using logit (or probit) analyses as (see e.g. Heckman, 1978; Guterrez, 2003):

$$(10) \quad CPP_{it} = \rho' \mathbf{z}_{it} + u_{it}$$

where  $\mathbf{z}_{it}$  is a vector of instrumental variables and  $\rho$  is a vector of coefficients. Using logit analysis we can now calculate the probability of *CPP* (and *COMP*) to be equal to one:

$$(11) \quad Prob(CPP_{it} = 1) = 1 - F(-\rho' \mathbf{z}_{it}).$$

The predicted values from the logit model

$$(12) \quad \hat{p}_{CPP} = 1 - F(-\rho' \mathbf{z}_{it}) = \frac{e^{\hat{\rho}' \mathbf{z}_{it}}}{1 + e^{\hat{\rho}' \mathbf{z}_{it}}}$$

can now be used as an instrumental variable in our fixed effects model:

$$(13) \quad y_{it}^* = \alpha_i + \beta_i t + \delta_1 CPP_{it} (\hat{p}_{CPPt}) + \tilde{\delta}' (\tilde{\mathbf{x}}_{it}) + \nu_{it},$$

where  $\tilde{\mathbf{x}}_{it}$  is a vector of the remaining explanatory variables and  $\nu_{it}$  is an error term. A similar procedure has to be applied for the competition dummy.

### *Results – Logit regressions*

The results from logit regressions can be found in Table 7. Regression CPP I reports first results for logit estimates on calling party pays regime transitions. Interestingly, while the democracy index is found to be statistically significant *AUTO* is not. This is possibly due to multicollinearity. Moreover, *YREG* has a positive and significant influence on CPP. A relative high penetration in other countries within the same region, as expected, increases the probability to switch to CPP. Also *DURABLE*, indicating the durability of polity regimes, has a highly significant influence on CPP. To put it differently, the more durable a polity regime the lower the probability that regulatory authorities introduce CPP. A transition in polity therefore increases also the probability of a transition in regulatory issues. Population seems to have a negative impact on the likelihood of CPP to be introduced.

Furthermore, also some of the other variables seem to have an impact on regime switching, even though not all polity variables are found to be statistically significant. However, since most of the variables from the *Polity IV* database are highly correlated one has to be careful interpreting the results. Moreover, using different specifications leads to slightly different results. In order to test for robustness of the results, we have therefore restricted the number of explanatory variables (see CPP II) using only penetration numbers and democracy/autocracy measures as well as DURABLE. Again, all variables proof to have the expected sign. Moreover AUTOC is now significantly negative.

The results from the COMP model are as much impressive as the results from the previous model. In this case, especially *YREG* and *DURABLE* are driving the probability that a country switches from RPP to CPP. More exactly, the more durable a political and democratic regime the more likely is the introduction of competitive mobile telephony markets. Higher relative penetration rates in neighbor states have, as expected, a positive impact on COMP. In contrast to the CPP model POP has now a positive impact on CPP. Surprisingly, DEMOC is statistically significant and negative. Again, reducing the number of explanatory variables and relying on regulatory issues provides support for the robustness of the results, except DEMOC which is now (as expected) positive and AUTOC which is now found to be significant.<sup>12</sup>

Summing up, 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 are not isolated but compare to the results from neighbor markets.

#### *Results – IVFE regressions*

Table 8 reports the results from fixed effects analyses using instrumental variable regressions. In all of the regressions CPP is now found to be statistically insignificant. Taking into account the endogeneity of CPP leads therefore to a complete reverse result. Thus the assumed positive impact of a regulatory transition to CPP has not been approved. In contrast, neither a changeover to CPP nor a primary choice of CPP influences the average growth rate. Independently from a possible influence of the calling party pays regime on the traffic in mobile networks, there is *no* evidence for higher penetration under CPP.

Moreover, competition has a considerably stronger influence on penetration rates using IV methods. The decision to introduce competition in mobile markets is, as expected, also an endogenous political decision and ignoring this endogeneity leads to conspicuously biased results. Most probably, this endogeneity is

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<sup>12</sup>Even if the results from the reduced models are somewhat more intuitive we have however used the results from models CPP I and COMP I to calculate instrumental variables, since these models provide a much better fit in explaining CPP and COMP.

responsible for the fact that many studies have measured only a slight influence of competition on the diffusion process (see e.g., Gruber & Verboven, 2000). Controlling for endogenous regulatory interventions leads therefore to more credible results.

While the introduction of prepaid cards has either a positive or an insignificant influence on the diffusion of mobile telephony, the coefficients from other controls are ambiguous and vary over the sub-samples. Possible explanations are, again, the existence of multicollinearity, the heterogeneity of the countries and different sizes of the sub-samples.

## 4 Conclusion

Many regulatory bodies consider mobile-to-mobile termination markets under calling party pays as monopolistic bottlenecks requiring regulatory interventions. However, turning away from CPP to a receiving party pays system would not only supersede regulation of termination fees but also solve many of the problems connected with CPP. Unfortunately, also receiving party pays bears some possible drawbacks and the concerns about RPP aim especially at a possible negative impact on mobile traffic and penetration rates. So far empirical evidence on the impacts of the RPP regime is however poor.

For this purpose, this paper analyzes the impact of different payment regimes for off-net calls on the diffusion of mobile telephony. While most of the existing studies on diffusion processes in mobile markets so far have ignored a possible endogeneity of (de-)regulation, this analysis sheds some new light not only on the impact of payment regimes but also on the effects of competition. Both the introduction of competition in mobile markets and the switching from receiving party pays to calling party pays regimes are found to be endogenous.

Taking into account the possible endogeneity of regulatory interventions we find in contrast to other studies that CPP has no statistically significant impact on subscriber penetration. Neither switching countries nor original CPP countries have been found to show a significantly higher number of subscribers. We therefore expect that a switch from CPP to RPP would not reduce penetration rates, independently whether a country's penetration process has just started or has nearly reached saturation levels. Thus, applying RPP instead of CPP seems to be a feasible tool to reduce market power and mobile termination rates and additionally to make the regulation of termination fees redundant.

Moreover, introducing competition has a statistically and economically significant impact on penetration rates. In contrast to other studies we found a strong influence of a competitive environment when accounting for endogenous deregulation. Countries are likely to introduce competition when subscriber numbers are relatively low which in turn increases penetration rates.

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## A Tables

Table 1: CPP, RPP and switching countries

CPP countries	CPP2RPP 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 2: Descriptive statistics and data sources

Variable	Mean	Std. Dev.	Nobs	Description	Source
CPP	0.6703	0.4702	1165	dummy	various sources
CPP <sub>countries</sub>	0.5424	0.4984	1165	dummy	various sources
RPP <sub>countries</sub>	0.1648	0.3711	1165	dummy	various sources
RPP2CPP	0.2909	0.4544	1165	dummy	various sources
PREPAID	0.3894	0.4879	1165	dummy	various sources
COMP	0.5493	0.4977	1165	dummy	GSM World, ITU, Worldbank
POP	5.26e+07	1.72e+08	1165	population	ITU
POPAREA	827.19	4143.04	1165	population per km <sup>2</sup>	ITU
FIXEDSUBS	0.3217	0.2094	1133	fixed lines per capita	ITU
GDPC	12450.57	48528.29	1075	GDP per capita	Worldbank
y <sub>it</sub> *	3.6723	2.773074	1175	penetration	ITU

Table 3: NLS regression

$y_{it} = b_1/(1 + \exp(-b_2(t - b_3)))$	
Saturation rate (b1)	0.6492 (24.71)
Growth rate (b2)	0.3636 (19.77)
Turning point (b3)	13.98 (46.63)
adj. R <sup>2</sup>	0.61
Nobs	2258

Note: Robust t-statistics are given in parenthesis.

Table 4: Diffusion processes

$y_{it}^*$	I all obs	II all obs	III RPP2CPP=1	IV RPP2CPP=0
$CPP$	-	-0.0215 (-3.93)	-0.0233 (-4.10)	0.0137 (0.32)
$CPP_{countries}$	-0.6092 (-1.85)	-	-	-
$RPP_{countries}$	-0.5950 (-1.83)	-	-	-
$RPP2CPP$	-0.4801 (-3.86)	-	-	-
$PREPAID$	-0.0120 (-2.98)	-0.0155 (-3.89)	-0.0099 (-1.29)	-0.0505 (-7.18)
$COMP$	-0.0266 (-5.36)	-0.0246 (-4.95)	-0.0148 (-1.91)	-0.0747 (-8.95)
$FIXEDSUBS$	-0.0056 (-0.26)	-0.0037 (-0.17)	-0.0313 (-1.23)	-0.1310 (-3.14)
$POP$	5.11e-09 (6.80)	5.33e-09 (7.27)	8.46e-09 (3.72)	2.92e-09 (3.29)
$POPAREA$	0.00001 (0.46)	-2.26e-06 (-0.05)	-0.0003 (-0.34)	0.00001 (0.62)
$GDPC$	7.18e-10 (0.08)	-2.56e-09 (-0.27)	-1.55e-09 (-0.16)	2.38e-06 (1.57)
$\beta_i$	-	-1.590 (-4.23)	-0.6296 (-1.76)	-0.1755 (-6.84)
$\alpha_i$	10.48 (2.40)	11.18 (4.96)	16.81 (7.90)	9.22 (24.54)
$FE, FE \cdot t$	YES	YES	YES	YES
adj. $R^2$	0.96	0.96	0.97	0.86
Nobs	925	925	269	656
No. of groups	77	77	26	51
Hausman (endog. CPP)	-	YES	YES	NO
Hausman (endog. COMP)	-	YES	NO	YES

Note: Robust t-statistics are given in parenthesis.

Table 5: First difference regression

$\Delta y_{it}^*$	all obs	RPP2CPP=1
$\Delta CPP$	<b>-0.0217</b> (-4.46)	<b>-0.0231</b> (-4.46)
$\Delta PREPAID$	-0.0076 (-2.06)	-0.0215 (-2.21)
$\Delta COMP$	-0.0136 (-2.84)	-0.0137 (-1.62)
$\Delta GDPC$	-1.03e-08 (-1.21)	-1.10e-08 (-1.09)
$\Delta POP$	7.52e-11 (0.77)	-8.93e-11 (-0.74)
$\Delta POPAREA$	0.0001 (1.81)	0.0002 (1.47)
$\Delta FIXEDSUBS$	-0.0043 (-0.31)	-0.0317 (-1.65)
$\Delta t$	-0.6111 (-27.23)	-0.5662 (-11.63)

Note: Robust t-statistics are given in parenthesis.

Table 6: Instruments from Polity IV database

Variable	Description
DEMOC	<p>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 guaranteed 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.</p> <p>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).</p>
AUTOC	<p>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.</p> <p>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)</p>
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.
XRCOMP	Competitiveness of Executive Recruitment: extent to which executives are chosen through competitive elections.
XROOPEN	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 XROOPEN.
POLCOMP	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).

Table 7: Logit analysis

CPP, COMP	CPP I	COMP I	CPP II	COMP II
<i>POP</i>	-4.58e-09 (-5.69)	2.87e-09 (3.41)	-5.62e-09 (-3.14)	3.12e-09 (3.74)
<i>GDPC</i>	1.07e-08 (0.01)	-1.92e-06 (-2.28)	-	-
<i>FIXEDSUBS</i>	-0.2615 (-0.58)	-0.4322 (-1.05)	-	-
<i>ln YREG</i>	0.3451 (5.28)	0.9310 (11.22)	0.3494 (7.32)	1.0102 (16.18)
<i>PREPAID</i>	0.1727 (0.64)	1.0561 (3.38)	-	-
<i>DEMOC</i>	0.6809 (3.31)	-1.4911 (-2.82)	0.2074 (10.99)	0.1117 (5.48)
<i>AUTOC</i>	0.1195 (0.50)	-0.1399 (-0.55)	-0.2056 (-8.10)	-0.1158 (-4.76)
<i>DURABLE</i>	-0.0117 (-4.50)	0.01591 (5.09)	-0.0040 (-1.90)	0.0117 (4.26)
<i>XRREG</i>	-0.9372 (-3.18)	0.5186 (1.67)	-	-
<i>XROPE</i>	-0.5703 (-2.49)	-1.9815 (-1.92)	-	-
<i>XCONST</i>	0.1337 (0.64)	1.2857 (2.36)	-	-
<i>PARCOMP</i>	1.1916 (2.37)	0.5585 (1.01)	-	-
<i>EXREG</i>	-0.0561 (-0.43)	0.6835 (2.42)	-	-
<i>PLOCOMP</i>	-0.5520 (-2.76)	0.5252 (2.73)	-	-
<i>Constant</i>	1.4113 (4.54)	1.4282 (4.16)	0.9666 (5.29)	2.2105 (11.44)
Pseudo <i>R</i> <sup>2</sup>	0.28	0.38	0.19	0.32
Nobs	1045	1054	1165	1165

Note: Robust t-statistics are given in parenthesis.

Table 8: Instrument variable (2SLS) regression of diffusion processes

	all obs	RPP2CPP=1	RPP2CPP=0
<i>CPP</i>	0.0102 (0.33)	0.0615 (1.46)	0.5477 (1.62)
<i>COMP</i>	-0.0613 (-2.46)	-0.1132 (-2.28)	-0.0938 (-3.11)
<i>PREPAID</i>	-0.0103 (-2.01)	-0.0211 (-1.75)	-0.0038 (-0.60)
<i>POP</i>	-1.75e-09 (-5.53)	-5.78e-10 (-1.23)	2.15e-09 (1.95)
<i>POPAREA</i>	0.0001 (1.26)	0.0008 (1.21)	0.0001 (2.21)
<i>FIXEDSUBS</i>	-0.0020 (-0.08)	0.0005 (0.01)	0.0192 (0.58)
<i>GDPC</i>	-5.47e-09 (-0.62)	3.45e-08 (0.94)	3.75e-06 (2.99)
$\beta_i$	-6.8760 (-6.07)	0.0200 (0.05)	-1.138 (-3.55)
$\alpha_i$	10.57 (4.69)	14.31 (16.71)	11.33 (4.98)
<i>FE, FE · t</i>	YES	YES	YES
adj. $R^2$	0.96	0.96	0.96
Nobs	925	269	656
No. of groups	77	26	51
Instrumented	CPP	CPP	-
	COMP	COMP	COMP
Instruments	$\hat{p}_{CPP}$	$\hat{p}_{CPP}$	-
	$\hat{p}_{COMP}$	$\hat{p}_{COMP}$	$\hat{p}_{COMP}$

Note: Robust t-statistics are given in parenthesis.

## B Figures

Figure 2: Diffusion of mobile telephony in the United States

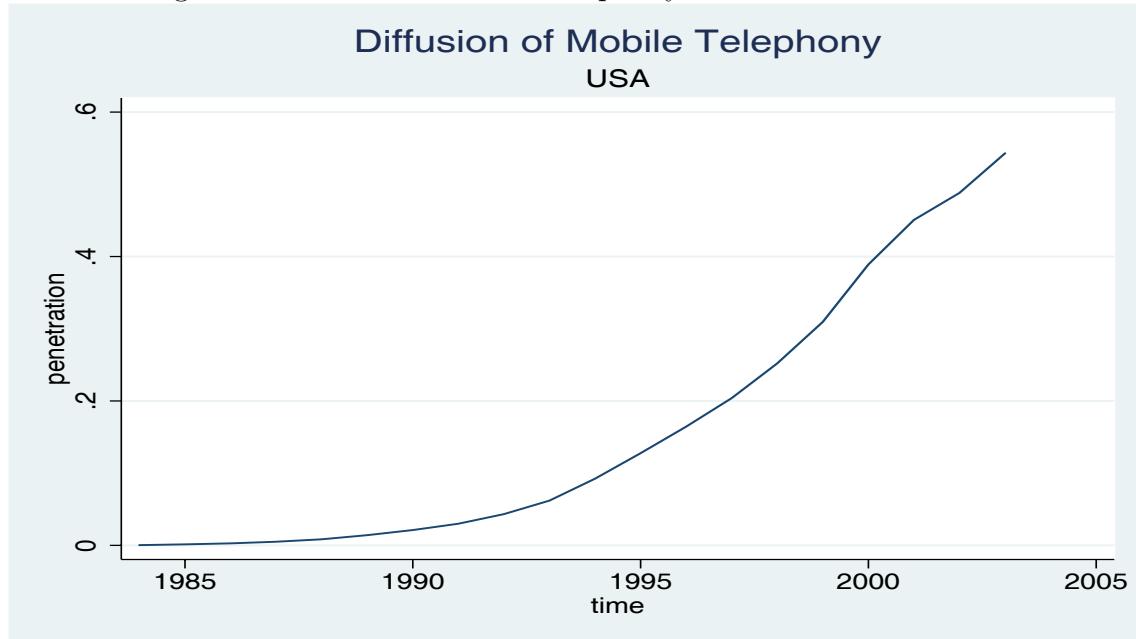


Figure 3: Diffusion of mobile telephony in Germany

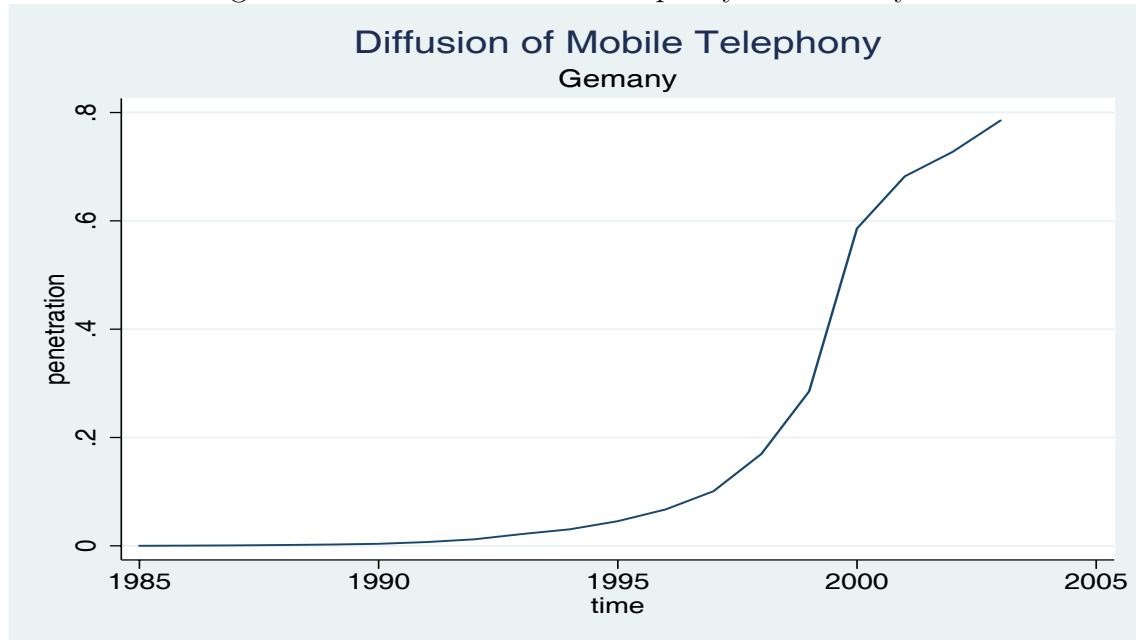
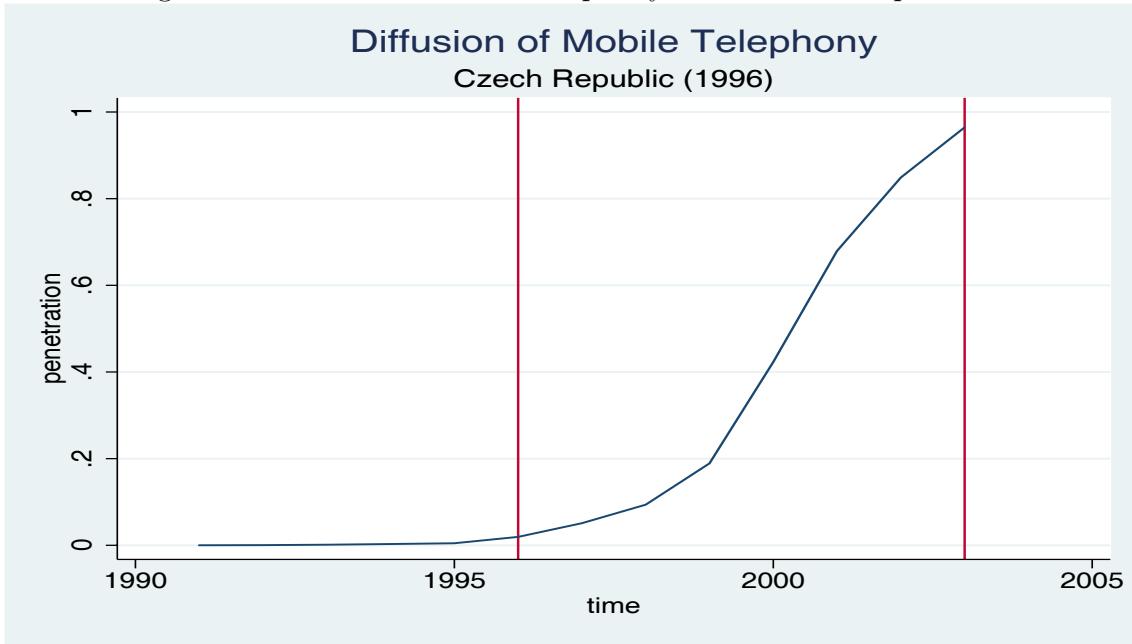


Figure 4: Diffusion of mobile telephony in the Czech Republic



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