Fixed-to-Mobile Substitution in the European Union *

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February 2011

Abstract

This paper analyzes substitution between access to fixed-line and mobile telephony in the European Union. We derive a structural model of household's demand for: (i) fixed-line only, (ii) mobile only, (iii) and both fixed-line and mobile access. We estimate demand for mobiles conditional on having fixed-line access and demand for fixed-line conditional on having mobile access. These regressions suggest that mobile and fixed-line access are perceived as substitutes in the Western European countries and as complements in Central and Eastern European countries. We also estimate unconditional household's demand for fixed-line only and mobiles only access, which confirm that mobile and fixed-line access are substitutes. In addition, we find that use of cable broadband decreases fixed-line connections. A decline in fixed-line is on the way in Central and Eastern European countries both due to substitution with mobiles and growing use of alternative to fixed-line means of internet access. Once, households start using cable broadband to access Internet and mobiles to make calls, fixed-line becomes obsolete. The complementarity between mobile and fixed-line access in Western European countries postpones a decline in fixed-line connections but this can change in the nearest future with increasing competition for the provision internet access from both mobiles and cable.

JEL Classification: L13, L43, L93

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1 Introduction

The relationship between fixed-line and mobile telephony is one of the main research questions in the economics of telecommunications industry. Over the past few years, the incumbent operators in most EU countries have seen a decline in its fixed-line business as consumers have increasingly used mobile phones to communicate. The extent of fixed-to-mobile substitution (FMS) has been also affected by rapid growth in Internet usage and broadband access.

Deteriorating voice revenues from fixed-line telephony require telecommunications regulators to monitor and analyze fixed-to-mobile substitution.[1] Also, the competition authorities must take into account the extent of substitutability between mobile and fixed-line when carrying out antitrust investigations in telecommunications markets.[2] The importance of FMS resulted in a growing body of empirical literature. In general, empirical findings on FMS are mixed. Fixed-line and mobile telephony is found to be complementary in developed countries in the early years of mobile telephony. At this stage, when the prices for the usage of mobiles were relatively high as compared to fixed-line usage, consumers perceived mobile and fixed-line access as complements. They wanted to enjoy the benefits of having a mobile access but used fixed-line for making calls whenever possible. Hence, after getting a mobile phone they were not giving

[1] In the UK, for instance, the telecommunications incumbent, British Telecom (BT), is obliged to assess the level of its non-domestic rates liability every five years. For this purpose BT engages in discussion with the Valuations Office Agency (VOA), an executive agency of HM Revenue & Customs (HMRC) that, amongst other functions, is responsible for setting the rate that small network operators must pay to BT for light fibre cables. As suggested by VOA, the rates are set using the methodology of profit based value (PBV), for which one of the critical inputs are the forecasts of the future development and usage volumes of telecommunications services. The substitutability between different technologies, including FMS, plays a critical role in producing these forecasts. If the FMS is underestimated, the business rate may be set too low negatively affecting profitability of the incumbent. On the other hand, if it is overestimated, the business rate may be set too high with negative consequences for competition and consumers.

[2] In a number of cases, the European Commission did not consider that mobile communications services can substitute fixed communications services because of the mobility inherent in all mobile services, i.e. mobile numbers are associated with individuals on the move, rather than with a fixed location.

up on fixed-line access. On the other hand, there is evidence on substitutability in developing countries where fixed-line infrastructure is poor, and in developed countries in the mature years of mobile telephony. In the later stage of development of mobile telephony, with decreasing prices for mobile usage, consumers started to substitute mobile and fixed-line usage to a greater extent. At certain point of time, low prices for mobile calls and higher utility for having a mobile phone, made fixed-line obsolete and consumers started to perceive mobile and fixed-line access as substitutes.[3] However, the majority of Internet connections still relies copper lines which could have slowed down fixed-to-mobile substitution.[4]

Within the European Union there is a large variation in the extent to which households use fixed-line only, mobiles only or both telecommunications services. Overall, both fixed and mobile telephone access are more widespread in the old Member States than in the new ones but the proportions of mobile-only households are significantly higher in the new Member States. There may be many reasons for this, such as regulatory measures, maturity of the markets, extension of fixed networks and time of development of mobile ones as well as the rate and type of adopted broadband technology. Also, an increasing number of operators offer bundles of fixed telephone and mobile access, IPTV and broadband internet connection. According to Eurobarometer, in December 2009, already 38% of Europeans said that their household buys two or more communication services as part of a bundle.[5]

In a recent literature review on FMS, Vogelsang (2009) discusses gaps in research on FMS. More research is needed into behavior of mobiles-only households. Also, the effects of broadband adoption on FMS need to be analyzed. In particular, one would like to know if high Internet access is limiting FMS and if mobile broadband is increasing FMS. Even though, FMS is an

[3]In Slovenia, a survey conducted on behalf of APEK, the Slovenian regulatory authority, found that 34,6% of those interviewed had considered cancelling their fixed telephone connection because of the wide-spread use of mobile telephony. The majority of these were male, middle age, having a high school education, students and those with the highest income.

[4]According to Eurobarometer (2010), in December 2009, on average 79% of broadband access in the EU was by means of DSL with significant differences between countries, especially new and old Member States.

[5]Source: "Special Eurobarometer 335, E-communications Household Survey", 2010

issue of critical importance for regulators, there is no empirical analysis of FMS in the EU Member States. This paper analyzes substitutability between fixed-line and mobile telephony in 27 EU countries in years 2005-2009 using cross-country panel data on households' choices of telecommunications technologies.

We estimate household's demand for mobiles only, fixed-line only, and mobiles plus fixed-line access using structural model derived from discrete choice framework. We estimate demand for mobiles conditional on having fixed-line access and demand for fixed-line conditional on having mobile access. These regressions suggest that mobile and fixed-line access are perceived as substitutes in the Western European countries and as complements in Central and Eastern European countries. We also estimate unconditional household's demand for fixed-line only and mobiles only access, which confirm that mobile and fixed-line access are substitutes. We provide estimates of prices elasticities for fixed-line and mobile access, including cross-price elasticities between both technologies. In addition, we find that use of cable broadband decreases fixed-line connections. A decline in fixed-line is on the way in Central and eastern European countries both due to substitution with mobiles and growing use of alternative means of internet access. The complementarity between mobile and fixed-line access in Western European countries postpones a decline in fixed-line connections but this can change in the nearest future with increasing competition for the provision internet access from both mobiles and cable.

The next section discusses related literature. Section 3 introduces the empirical framework. Section 4 discusses data. Section 5 discusses estimation results and finally, Section 6 concludes.

2 Literature Review

There is a large body of literature on the estimation of demand for telecommunications services using industry and consumer-level data, which as mentioned in the introduction, has been recently reviewed in Vogelsang (2009). For instance, Barros and Cadima (2000) simultaneously estimate diffusion curves for mobile and fixed telephony in Portugal and find a negative impact of mobile penetration on fixed-line density. Okada and Hatta (1999) analyze the demand for

mobile and fixed telephony services using Japanese data. They find that own-price elasticities and substitution effect are relatively high. Rodini et al. (2003) estimate the substitutability of fixed and mobile services for telecommunications access using data on US households. Their estimates of cross-price elasticities confirm that second fixed line and mobile services are substitutes for one another. Doganoglu and Grzybowski (2007) use a nested logit model, in which consumers choose between mobile and fixed-line services to estimate the demand for subscription for mobile telephony in Germany. Grzybowski and Karamti (2010) analyze the development of mobile telephony in France and Germany in 1998-2002 using probit model for aggregate data and conclude that there is a significant difference between price elasticities of demand in these two countries. Moreover, they find that consumers perceive mobile telephony as a substitute for fixed-line connection in France and as a complement in Germany.

Another range of studies analyzes the diffusion of mobile technology worldwide using cross-country panel data. For instance, Gruber and Verboven (2001) estimate a logistic diffusion model for mobile subscriptions in the EU. They find, among other results, that the penetration rate of fixed telephony has a negative influence on the diffusion of mobiles. However, the results of similar studies for other countries suggest that mobile and fixed-line services may be complements, for instance, Gruber (1999) for Central and Eastern European countries, Gebreab (2002) for African countries, and Ahn and Lee (1999) for 64 countries worldwide. Hamilton (2003), using data on African countries, finds that mobile and fixed-line subscriptions may be both complements and substitutes at different stages of market development. In the early stage of diffusion, mobile services may be complementary to fixed-line telephones, but the substitution effect takes over once mobile usage becomes more widespread.

In summary, the results of empirical studies are ambiguous with respect to whether mobile and fixed-line services are substitutes or complements. The contribution of this paper is to derive and estimate structural model of household's demand for fixed-line only, mobiles only and both fixed-line and mobile access in the European Union. Such choice set has not been considered so far in the previous literature due to lack of information usage of different technologies by

households.

3 The Telecommunications Industry in the EU

4 Econometric Model

4.1 Utility Functions

We derive demand equations using discrete choice model for aggregate data, in which we model decisions of households to use mobile and fixed-line telecommunications technologies. There are four types of households with respect to the usage of telecommunications services: (i) fixed-line only; (ii) mobile only; (iii) both fixed-line and mobile; and (iv) without access to any telecommunications services. Figure (1) shows distribution of household types across countries in December 2009. Since the last type of households has positive share mainly in some of the new Member States we ignore it in the further modeling.[6]

[*Figure* 1]

Source: Eurobarometer (2010)

The utility derived by household i from using fixed-line telecommunications services in period t is given by:

$$U_{ift} = r_{ft} - \alpha_f p_{ft} + \gamma_f V_t + \xi_{ft} + \epsilon_{ift} = \delta_{ft} + \epsilon_{ift}, \tag{1}$$

where r_{ft} is time-varying stand alone value of fixed-line telephony, p_{ft} is the price paid for using fixed-line services in period t, V_t is the expected network benefit in period t, which results from an increase in communications possibilities due to a larger number of mobile users, ξ_{ft} is the unobserved utility of fixed-line telephony in period t, and ϵ_{ift} is an idiosyncratic taste

[6] In general, some households may not be interested in using neither mobile nor fixed-line even for a very low price level. Such households are infinitely inelastic and are not part of the market for access to telecommunications.

variable.[7] The mean utility level of using a fixed-line in period t is therefore denoted by δ_{ft}. The stand alone value of fixed-line telephony may vary over time and across countries depending on country-specific factors, such as level of income, country area and population density, usage of Internet, cable broadband penetration, etc.

The utility derived by household i from using exclusively mobile telecommunications services in period t can be written analogously:

$$U_{imt} = r_{mt} - \alpha_m p_{mt} + \gamma_m V_t + \xi_{mt} + \epsilon_{imt} = \delta_{mt} + \epsilon_{imt}, \tag{2}$$

where r_{mt} is time-varying stand alone value of mobile telephony, p_{mt} is the price paid for using mobile services in period t, V_t is the expected network benefit in period t, ξ_{mt} is the unobserved utility of mobile telephony in period t, and ϵ_{imt} is an idiosyncratic taste variable. The mean utility level of using a mobile services in period t is denoted by δ_{mt}.

When consumers decide to use mobile services together with fixed-line, the utility of both technologies may change, which is denoted by $\lambda_f \delta_{ft}$ and $\lambda_m \delta_{mt}$, where $\lambda_f \geq 0$ and $\lambda_m \geq 0$. Thus, the utility of using mobile services together with fixed-line in period t is given by:

$$\begin{aligned} U_{ibt} &= \lambda_f \delta_{ft} + \lambda_m \delta_{mt} + \epsilon_{ibt} \\ &= (\lambda_f r_f + \lambda_m r_m) - \lambda_f \alpha_f p_{ft} - \lambda_m \alpha_m p_{mt} + (\lambda_f \gamma_f + \lambda_m \gamma_m) V_t + (\lambda_f \xi_{ft} + \lambda_m \xi_{mt}) + \epsilon_{ibt} \\ &= \delta_{bt} + \epsilon_{ibt} \end{aligned} \tag{3}$$

where δ_{bt} is the mean utility level of using fixed-line together with mobile services.

4.2 Conditional Demand

First, we consider only households which use fixed-line telephony and model their decision whether to use mobile services in addition, i.e., equations (1) and (3) represent utilities of their

[7] A number of empirical studies suggest that network effects are present in mobile telephony (see, for instance, Doganoglu and Grzybowski, 2007). In addition to voice telephony, mobile firms can offer several other services, such as SMS, MMS, WAP and email, which may themselves be subject to network effects. Hence, the utility of mobile and fixed-line access may depend on the number of current users of mobile telecommunications services.

choice set. Since only relative utilities matter, we normalize these utilities with respect to the utility of using fixed-line services only (1). After subtracting δ_{ft} , equation (3) can be rewritten as:

$$\begin{aligned}\widetilde{U}_{ibt} &= [(\lambda_f - 1)r_f + \lambda_m r_m] - (\lambda_f - 1)\alpha_f p_{ft} - \lambda_m \alpha_m p_{mt} \\ &+[(\lambda_f - 1)\gamma_f + \lambda_m \gamma_m]V_t + [(\lambda_f - 1)\xi_{ft} + \lambda_m \xi_{mt}] + \epsilon_{ibt} \\ &= \widetilde{r}_b - \widetilde{\alpha}_f p_{ft} - \widetilde{\alpha}_m p_{mt} + \widetilde{\gamma} V_t + \widetilde{\xi}_{bt} + \epsilon_{ibt} \\ &= \widetilde{\delta}_{bt} + \epsilon_{ibt}. \end{aligned} \tag{4}$$

When $\widetilde{\alpha}_f < 0$, which implies that $\lambda_f < 1$, the utility of fixed-line connection decreases when a consumer acquires a mobile telephone. Thus, mobile and fixed-line services are perceived as substitutes. On the other hand, when $\widetilde{\alpha}_f > 0$, the utility of fixed-line services increases, i.e., mobile and fixed-line services are complements. When there is no change in utility of fixed-line, $\lambda_f = 1$ and the coefficient on fixed-line price is insignificant.

The probability that consumer i subscribes to mobile services in addition to fixed line in period t may be written as:

$$\widetilde{P}_{ibt} = Pr(\widetilde{\delta}_{bt} + \epsilon_{ibt} > \epsilon_{ift}),$$

When ϵ_{ijt} has an extreme value distribution, this probability has a closed form given by:

$$\widetilde{P}_{ibt} = \frac{\exp(\widetilde{\delta}_{bt})}{1 + \exp(\widetilde{\delta}_{bt})},$$

Since we model household's decision to adopt mobile phone conditionally on their continued usage of fixed-line, the market size is represented by all fixed-line households. The probability to adopt mobile phone is the same for all households and equals to the share among all fixed-line users of consumers choosing in period t mobile services together with fixed line, $\widetilde{s}_{bt}$. The share of households with fixed-line connection who choose not to subscribe to mobile telephony in period t is given by $\widetilde{s}_{ft} = 1 - \widetilde{s}_{bt}$. Following Berry (1994), the observed share of mobile subscribers can be inverted to compute the mean utility of using mobile services together with fixed line, which for the utility specification (4) may be written as:

$$\log(\widetilde{s}_{bt}) - \log(\widetilde{s}_{ft}) = \widetilde{r}_b - \widetilde{\alpha}_f p_{ft} - \widetilde{\alpha_m} p_{mt} + \widetilde{\gamma} V_t + \widetilde{\xi}_{bt}. \tag{5}$$

The price elasticity of demand for mobiles conditional on having fixed-line is given by:

$$\eta = -\widetilde{\alpha}_j p_{jt}(1 - s_{bt})$$

The decision of households with mobile access to use fixed-line can be modeled in the same way, with equations (2) and (3) representing utilities of the choice set. The utility of using mobile services together with fixed line in period t, after normalizing with respect to the mean utility of using mobile services only, δ_{mt}, may be rewritten as:

$$\begin{aligned}
\widehat{U}_{ibt} \quad &= [\lambda_f r_f + (\lambda_m - 1) r_m] - \lambda_f \alpha_f p_{ft} - (\lambda_m - 1)\alpha_m p_{mt} \\
&+ [\lambda_f \gamma_f + (\lambda_m - 1)\gamma_m] V_t + [\lambda_f \xi_{ft} + (\lambda_m - 1)\xi_{mt}] + \epsilon_{ibt} \\
&= \widehat{r}_b - \widehat{\alpha}_f p_{ft} - \widehat{\alpha}_m p_{mt} + \widehat{\gamma} V_t + \widehat{\xi}_{bt} + \epsilon_{ibt} \\
&= \widehat{\delta}_{bt} + \epsilon_{ibt}. \qquad (6)
\end{aligned}$$

As before, when $\widehat{\alpha}_m < 0$, the utility of mobile connection decreases when a household acquires fixed-line connection. Thus, mobile and fixed-line services are perceived as substitutes. On the other hand, $\widehat{\alpha}_m > 0$, the utility of mobile services increases, i.e. mobile and fixed-line services are complements. When $\widehat{\alpha}_m$ is insignificant, there is no change in utility of mobile connection after adopting fixed-line. In this case, the market size consists of all mobile users and the estimable equation can be written as:

$$\log(\widehat{s}_{bt}) - \log(\widehat{s}_{mt}) = \widehat{r}_b - \widehat{\alpha}_m p_{mt} - \widehat{\alpha}_f p_{ft} + \widehat{\gamma} V_t + \widehat{\xi}_{bt}. \qquad (7)$$

where $\widehat{s}_{bt}$ is the share of consumers choosing in period t mobile services together with fixed line among all mobile users. The share of households with mobile connection who choose not to subscribe to fixed-line telephony in period t is given by $\widehat{s}_{mt} = 1 - \widehat{s}_{bt}$. The price elasticity of demand for fixed-line connections conditional on having mobile is given by:

$$\eta = -\widehat{\alpha}_j p_{jt}(1 - \widehat{s}_{bt})$$

4.3 Unconditional Demand

In this model specification we consider household's choice set consisting of using: (i) fixed-line only; (ii) mobile phones only; (iii) both fixed-line and mobile phones. The utility functions are specifies by equations: (1), (2) and (3). In this case we normalize all utilities with the utility of using both fixed-line and mobile services. After subtracting δ_{bt}, equation (1) can be rewritten as:

$$\begin{aligned}\bar{U}_{ift} &= [(1-\lambda_f)r_f - \lambda_m r_m] - (1-\lambda_f)\alpha_f p_{ft} + \lambda_m \alpha_m p_{mt} \\ &+[(1-\lambda_f)\gamma_f - \lambda_m\gamma_m]V_t + [(1-\lambda_f)\xi_{ft} - \lambda_m\xi_{mt}] + \epsilon_{ift} \\ &= \bar{\delta}_{ft} + \epsilon_{ift}, \end{aligned} \tag{8}$$

The coefficient for the price for mobile services should positive since $\lambda_m > 0$. The sign of the coefficient for the price for fixed-line services is ambiguous. The sign is negative when $\lambda_f < 1$, i.e., the utility of fixed-line connection decreases when a consumer acquires a mobile telephone. Thus, mobile and fixed-line services are perceived as substitutes. The sign is positive when $\lambda_f > 1$, i.e., the utility of fixed-line services increases. Finally, the coefficient is insignificant when $\lambda_f = 1$, i.e., there is no change in the utility of fixed-line services when used together with mobile phones.

Equation (2) after subtracting δ_{bt} can be written as:

$$\begin{aligned}\bar{U}_{imt} &= [\lambda_f r_f - (1-\lambda_m)r_m] + \lambda_f\alpha_f p_{ft} - (1-\lambda_m)\alpha_m p_{mt} \\ &+[\lambda_f\gamma_f - (1-\lambda_m)\gamma_m]V_t + [\lambda_f\xi_{ft} - (1-\lambda_m)\xi_{mt}] + \epsilon_{ift} \\ &= \bar{\delta}_{mt} + \epsilon_{imt}, \end{aligned} \tag{9}$$

Again, the coefficient for the price for fixed-line services should positive since $\lambda_f > 1$. The sign of the coefficient for the price for mobile services is ambiguous: (i) negative when $\lambda_m < 1$, i.e., mobile and fixed-line services are perceived as substitutes; (ii) positive when $\lambda_f < 0$, i.e., mobile and fixed-line services are complements and (iii) insignificant when $\lambda_f = 1$, i.e., there is no change in utility of mobile services when used together with fixed-line.

The probability that consumer i subscribes to mobile services only in period t may be written as:

$$\bar{P}_{imt} = \frac{\exp(\bar{\delta}_{mt})}{1 + \exp(\bar{\delta}_{ft}) + \exp(\bar{\delta}_{bt})}, \tag{10}$$

and analogously for subscription to fixed-line only services. The demand equations can be derived in a similar way to the conditional demand case, using the transformation suggested in Berry (1994). In this case, the market size is represented by all households having access to fixed-line or mobile services. Denote by: $\bar{s}_{mt}$ the share of mobiles only households in period t; $\bar{s}_{ft}$ the share of fixed-line only households; and by $\bar{s}_{bt} = 1 - \bar{s}_{mt} - \bar{s}_{ft}$ the share of households with both mobiles and fixed-line. Demand for mobiles only can be written as:

$$\log(\bar{s}_{mt}) - \log(\bar{s}_{bt}) = \bar{r}_m - \bar{\alpha}_{mf} p_{ft} + \bar{\alpha}_{mm} p_{mt} + \bar{\gamma}_m V_t + \bar{\xi}_{mt}. \tag{11}$$

and demand for fixed-line only can be written as:

$$\log(\bar{s}_{ft}) - \log(\bar{s}_{bt}) = \bar{r}_f + \bar{\alpha}_{ff} p_{ft} - \bar{\alpha}_{fm} p_{mt} + \bar{\gamma}_f V_t + \bar{\xi}_{ft}. \tag{12}$$

Since prices for fixed-line and mobile show up in both utilities (8) and (9), the own price elasticity for mobiles only is given by:[8]

$$\eta = -\bar{\alpha}_{mm} p_{mt}(1 - s_{mt}) - \bar{\alpha}_{fm} p_{ft} s_{ft}$$

and the own price elasticity for fixed-line only is given by:

$$\eta = -\bar{\alpha}_{ff} p_{ft}(1 - s_{ft}) - \bar{\alpha}_{mf} p_{mt} s_{mt}$$

4.4 Estimation Strategy

The conditional demands for mobile and fixed-line access (5) and (7) are regressed on prices for mobile services, which are endogenous and require the instrumental variables estimation method. Similarly, prices for mobile services are endogenous in unconditional demand regressions (11) and (12). The other explanatory variables used in the model are exogenous and may

[8]The elasticities are derived by differentiating respective probability (10) by price.

be used as instruments. In particular, price indices for fixed-line services are assumed to be exogenous because fixed-line markets in most EU countries were liberalized on 1 January 1998. There have been many market entries and increasing competition, especially in the national and international markets.

To fulfil the order condition for identification, we have to find at least one variable that has a causal effect on price but does not have a direct causal effect on demand. Marginal cost factors are commonly used as instruments for prices in the empirical literature but we lack reliable data on cost factors. However, since mobile network across Europe use similar technologies, there may be many common cost factors. Prices in different countries may have therefore common determinants and be correlated through common shocks. We can use mobile telecommunications prices in other markets as instruments for prices in given market, as in Hausman (1996) and Nevo (2001).

5 The Data

The data used in this paper comes from the following sources. The data on different types of telephone and Internet access within home in the 27 Member States of the European Union comes from the "Eurobarometer: E-Communications Household Surveys" carried out by TNS Opinion & Social Network on behalf of the Directorate-General Information Society and Media. The purpose of these surveys is to follow the trends in electronic communications markets and to assess how EU households and citizens derive benefits from the increasingly competitive and innovative digital environment. There were four Eurobarometer surveys so far which were conducted in: November - December 2009; November 2007 - January 2008; November - December 2006 and December 2005 - January 2006. In the most recent survey, the interviews were conducted among 26,761 EU citizens in the 27 Member States of the European Union. The data have been weighted on individuals over 15 years of age or EU households depending on the nature of the question. Indicators are presented at household level whereas opinion questions

have been made representative of the individuals over 15 years of age.[9]

Data on prices of mobile and fixed-line telecommunications services comes from the reports on "Telecoms Price Developments" produced on regular basis by consultancy firm Teligen on behalf of the European Commission Directorate General for Information Society. The objective of these reports has been to analyze the price developments in the Member States of the European Union in years 1998-2008. The reports show the prices as of 1st August each year from 1998 to 2004 and as of 1st September from 2005 to 2007, and as of 15th September 2008. Teligen has collected tariff data directly from the telecoms operators, their websites and price-lists. Data were validated by the NRAs so as to reinforce the reliability of the information.

Prices used in this study are so called 'Composite baskets', which are constructed calculating the cost of a number of different types of calls per annum, and including the appropriate annual rental charge, and the installation charge depreciated over 5 years. The number and distribution of calls are kept fixed throughout the whole period. The definitions of the fixed-line and mobile 'Composite baskets' are explained in detail in the reports. For the fixed-line services, data used by the Teligen is for the incumbent operator in each country. Standard tariffs are used, excluding any discount packages. This means that lower costs can be achieved if the user selects another operator or another tariff package. For mobile services the operators covered follow the selection made for the OECD Price Benchmarking Baskets, based on the two network operators with highest subscriber numbers. In the regression we use an average of these tariffs.

The remaining data has been collected from the Eurobarometer studies and Eurostat, as shown in Table (1).

[*Table* 1]

The key inputs into demand models specified by equations: (5), (7), (11) and (12) are the shares of households using different telecommunications technologies and prices for using fixed-line and mobile services. Figures (2) and (3) show dependencies between the ratio of mobile to

[9] A technical note on the way in which the interviews were conducted by the Institutes within the TNS Opinion & Social Network is included as an annex to the reports.

fixed-line prices and percentages of mobiles only and fixed-line only households, respectively.

[*Figure* 2]

Source: Eurobarometer and Teligen, 2005-2009

[*Figure* 3]

Source: Eurobarometer and Teligen, 2005-2009

Figures (4) and (5) show respectively dependencies between percentage of households using Internet and cable broadband and share of households with both fixed-line and mobile access. These figures indicate that percentage of households with mobiles and fixed-line access is positively correlated with share of households using Internet. On the other hand, share of households accessing Internet through cable broadband is negatively correlated with percentage of households with both fixed-line and mobile access. Thus, the usage and means of accessing Internet may be among the factors impacting the fixed-to-mobile substitution.

[*Figure* 4]

Source: Eurobarometer and Teligen, 2005-2009

[*Figure* 5]

Source: Eurobarometer and Teligen, 2005-2009

6 Estimation Results

6.1 Conditional Demand Estimation

First, we estimate equations (5) and (7) using OLS, followed by random effects estimation. It takes into account presence of country-specific effects, which are assumed to be uncorrelated

with the independent variables. If the random effects assumption holds, the random effects model is more efficient than the fixed effects model. However, if this assumption does not hold, the random effects model is not consistent. Fixed-effects regression is not possible due to short time dimension of four years only.

The main explanatory variables are prices for fixed-line and mobiles services represented by 'composite baskets', as discussed in data section. A dummy variables interacted with price is used for ten Central and Eastern European (CEE) countries: Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia, Slovenia and Romania.[10] It should take into account potential differences in the perception of mobile and fixed-line services due to historical reasons. The CEE countries in general inherited poor fixed-line infrastructure. The roll-out of mobile network coincided with transition of these countries into market economies. Mobile subscriptions quickly surpassed fixed-line subscriptions, which began to fall without reaching Western European levels. Thus, access to mobile and fixed-line is more a substitute in CEE than a complement, as it may be the case in the Western European (WE) Member States.

We also use lagged penetration of mobile telephony to proxy for industry-wide network effects, GDP per capita in Purchasing Power Parities (PPP) to account for income effect and density of population as an exogenous demand determinant.

Estimation results of equation (5) are presented in Table (2). Models I and Ia are OLS regressions, where in the first one price for mobile services is approximated by low-usage basket and in the second one by medium-usage basket. Models II and IIa are random effects regressions with low and medium usage baskets, respectively. In the random effects regressions, the coefficients on mobile prices are significant and negative as expected. The coefficient on the price for fixed-line services is insignificant for WE countries but has a significant and negative sign for CEE countries, which according to equation (5) indicates that, conditional on having fixed-line, fixed-line and mobile access are perceived as complements. Lagged penetration of mobile phones is significant with a positive sign indicating presence of network effects, i.e., a higher mobiles

[10]Malta and Cyprus are among new Member States but were not part of socialist block and are considered to belong to Western Europe.

penetration increases utility and demand for mobile access. Income level and density positively influence demand for mobiles in OLS regression but are insignificant in random effects regressions. We dropped these variables from random effects regressions. They control for differences in demand for mobile access across countries which may be also captured by random effects.

Estimation results of equation (7) are presented in Table (3). Again, Models I and Ia are OLS regressions with low and medium-usage baskets used for prices of mobile services, respectively. Models II and IIa are random effects regressions with low and medium usage baskets, respectively. In the random effects regressions, the coefficient on mobile prices is significant and positive, which according to equation (7) indicates that, conditional on having mobile access, fixed-line and mobile access are perceived by households as complements. The coefficient on the price dummy for CEE countries is insignificant in the random effects regression, but significant and negative in OLS regressions with a greater magnitude than for the WE countries. This indicates that fixed-line and mobile services are perceived as substitutes in CEE countries. Lagged penetration of mobile phones is significant with a negative sign indicating presence of network effects, which make households prefer mobile over fixed-line access. Income level and density positively influence demand for fixed-line. In countries with greater population density there are more fixed-line plus mobile households.

6.2 Unconditional Demand Estimation

Table (5) presents estimation results of equation (11), with Models I and Ia being OLS regressions for low and medium-usage baskets, respectively. Models II and IIa are random effects regressions for low and medium-usage baskets. In the random effects regressions, the price of mobile services is found to be significant with a positive as expected from equation (11). The price for fixed-line services is insignificant for both WE and CEE countries, which according to equation (11) indicates that there is no change in valuation of fixed-line access when used together with mobiles. On this basis we cannot conclude whether mobiles and fixed-line are substitutes or complements. The other explanatory variables used in these regressions are the same as for the

conditional demand estimation, except that cable broadband penetration is used in addition. Cable broadband penetration should account for the availability of an alternative mean to use Internet than fixed-line access. It is expected to decrease the share of fixed-line connections, as suggested by Figure (5). It is found to be insignificant in random effects regression but significant with a negative sign in the OLS regression. Thus, it indicates that in countries with a higher cable broadband penetration, there is a greater demand for fixed-line only access, relative to both fixed-line and mobile.

Table (6) presents estimation results of equation (12), with Models I and Ia being OLS regressions for low and medium-usage baskets, respectively. Models II and IIa are random effects regressions for low and medium-usage baskets. In the random effects regressions, the price of fixed-line services is found to be significant and positive, as expected from equation (12). The price for mobile services is insignificant for medium-usage basket but significant and negative for low-usage basket. Negative sign indicates that mobiles and fixed-line access are perceived as substitutes. Mobile price dummy for CEE countries is insignificant. There are significant network effects which increase demand for mobiles only households. Also, higher penetration of cable broadband increases demand for mobiles only households, as indicated by significant and positive coefficient on cable broadband in the OLS regressions. This result suggests that fixed-line access may be maintained for access to Internet. Once, households start using cable broadband to access Internet and mobiles to make calls, fixed-line becomes obsolete. A greater GDP per capita and density of population decrease demand for mobiles only households.

7 Conclusion

In this paper we derive a structural model of households demand for fixed-line only, mobile only and both fixed-line and mobile access. We estimate demand for mobiles conditional on having fixed and demand for fixed-line conditional on having mobiles. These regressions suggest that mobile and fixed-line access are perceived as substitutes in Western European countries and as complements in Central and Eastern European countries. We also estimate unconditional

household's demand for fixed-line only and mobiles only access, which confirm that mobile and fixed-line access are substitutes. In addition, we find that use of cable broadband decreases fixed-line connections. A decline in fixed-line is on the way in Central and Eastern European countries both due to substitution with mobiles and growing use of alternative means of Internet access. Once, households start using cable broadband to access Internet and mobiles to make calls, fixed-line becomes obsolete. The complementarity between mobile and fixed-line access in Western European countries postpones a decline in fixed-line connections but this can change in the nearest future with increasing competition for the provision internet access from both mobiles and cable.

This is the first paper which derives a structural model of demand to analyze mobiles only households. The results of this study are important for competition and regulatory proceedings with respect to market definition of access to telecommunications services.

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Appendix

Figure 1:

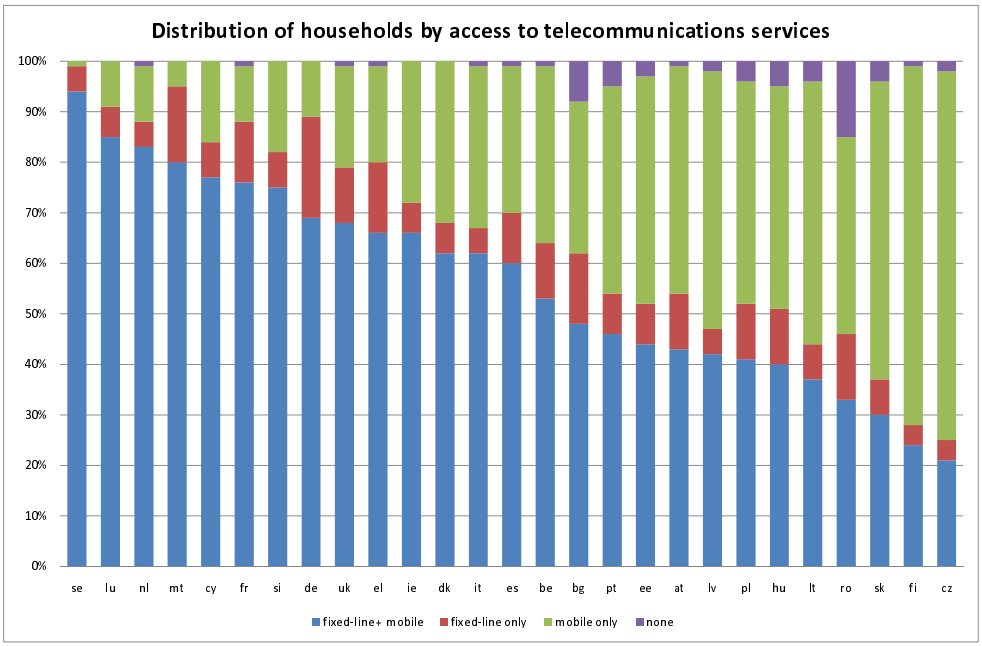

Figure 2:

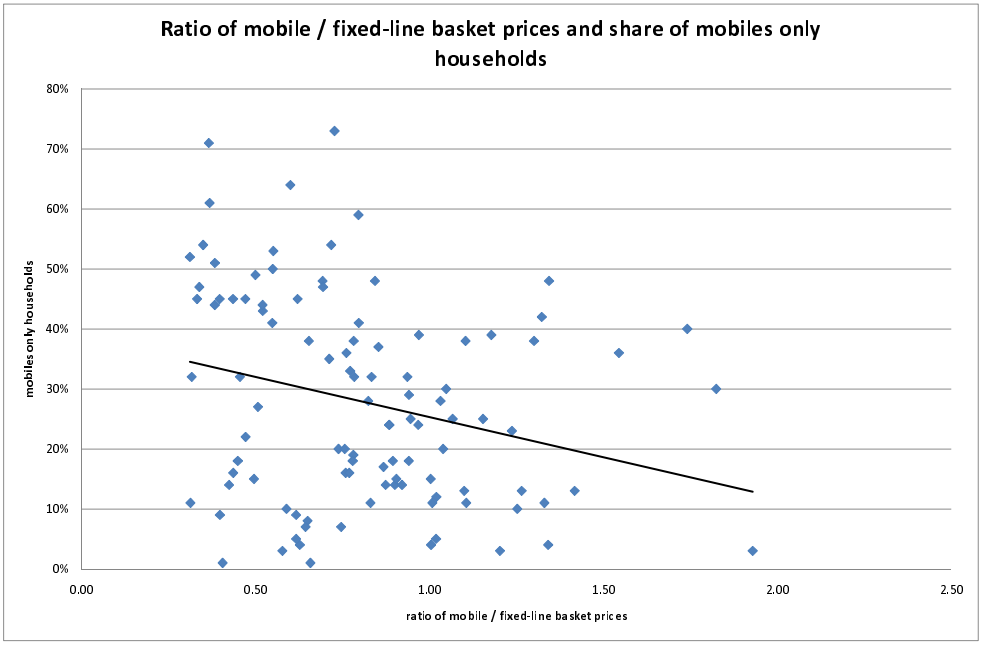

Table 1: Summary statistics

variable	mean	std	min	max
Fixed only (%)				
Mobile only (%)				
Fixed+Mobile (%)				
Price mobile low	14.18	6.43	5.085	31.945
Price mobile medium	29.41	12.30	9.3	65.295
Price fixed	36.49	7.05	18.02	52.35
GDP per capita	23.11	10.56	7.9	68.6
Density	0.17	0.24	0.0155	1.306867
Lagged mobile penetration	1.03	0.21	0.4716	1.680047
Cable penetration	0.21	0.15	0	0.55

Figure 3:

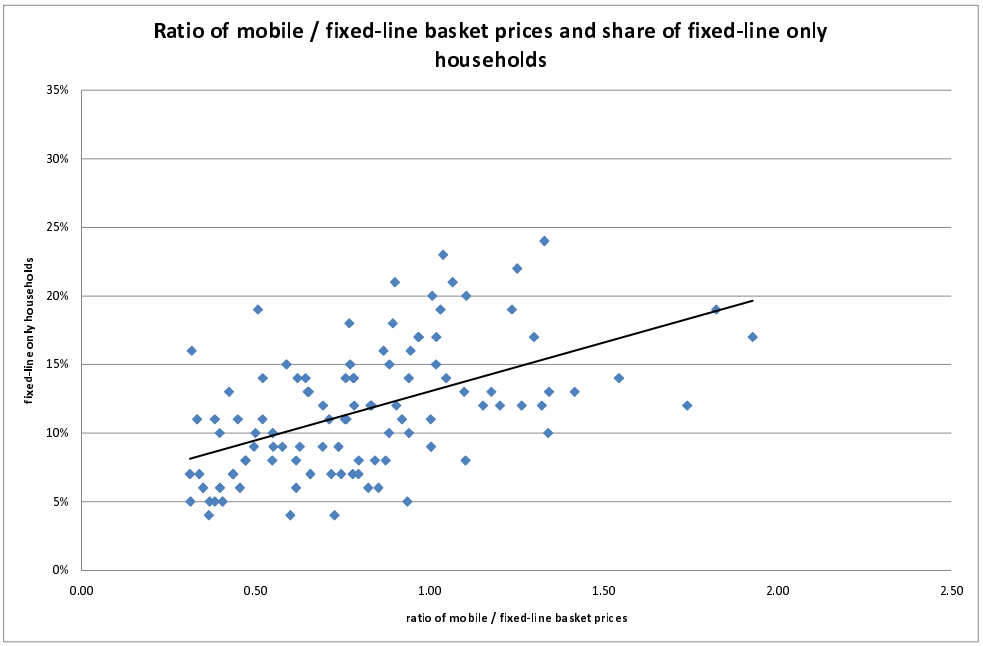
Ratio of mobile / fixed-line basket prices and share of fixed-line only households
35%
30%
25%
20%
15%
10%
5%
0%
fixed-line only households
0.00
0.50
1.00
1.50
2.00
2.50
ratio of mobile / fixed-line basket prices

Figure 4:

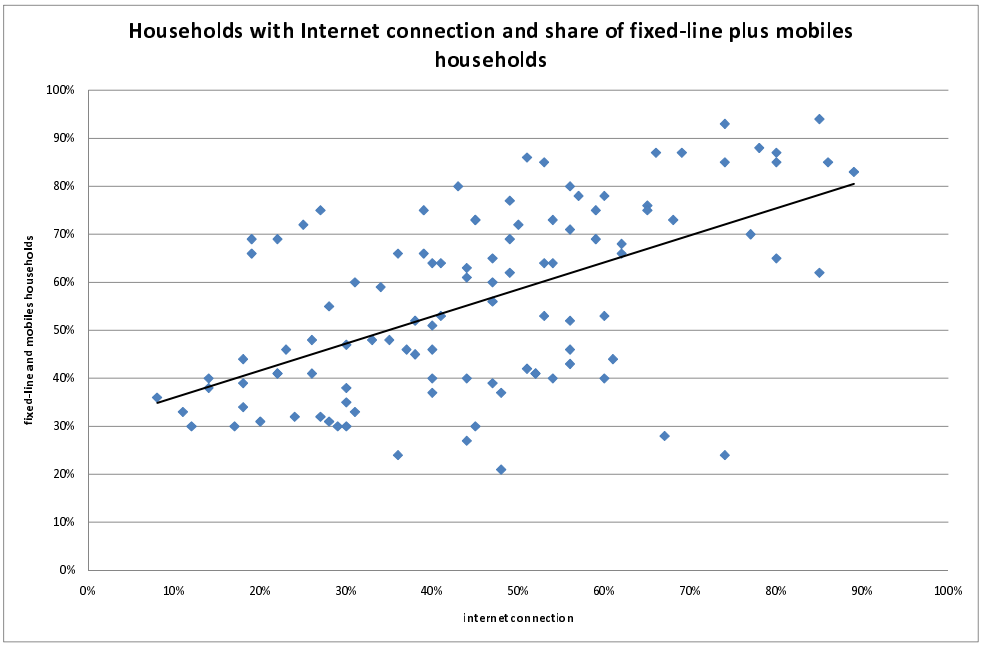
Households with Internet connection and share of fixed-line plus mobiles households
fixed-line and mobiles households
internet connection
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%

Figure 5:

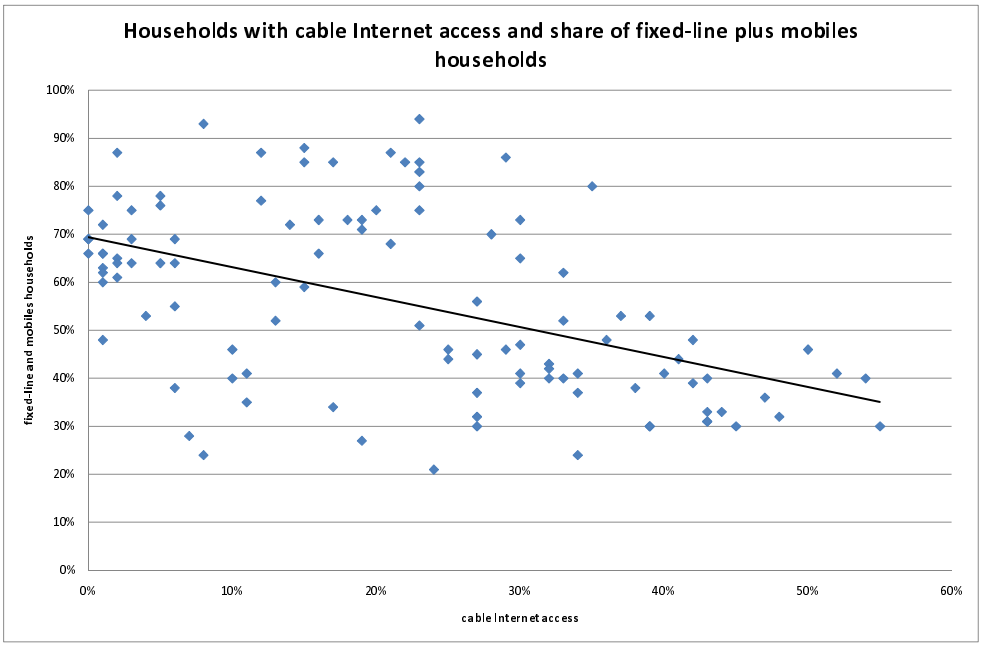
Households with cable Internet access and share of fixed-line plus mobiles households
fixed-line and mobiles households
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0%
10%
20%
30%
40%
50%
60%
cable Internet access

Table 2: Demand for mobile conditional on having fixed-line access

	Model I		Model Ia		Model II		Model IIa	
variable	Coef.	t	Coef.	t	Coef.	t	Coef.	t
Price mobile	-0.0174	-2.87	-0.0135	-3.54	-0.0141	-2.24	-0.0076	-2.69
Price fixed	0.0003	0.06	0.0034	0.60	0.0092	1.08	0.0093	1.11
Price fixed (EE)	-0.0062	-2.07	-0.0052	-1.78	-0.0124	-2.57	-0.0118	-2.52
GDP per capita	0.0130	2.08	0.0129	2.17				
Density	0.4432	3.26	0.5334	3.58				
Network effects	0.5512	2.44	0.4851	2.07	0.9215	5.16	0.8841	5.02
Intercept	0.9474	2.43	1.0301	2.65	0.6289	1.50	0.6797	1.68
sigma u								
sigma e								
rho								
R sq								

Table 3: Demand for fixed-line conditional on having mobile access

	Model I		Model Ia		Model II		Model IIa	
variable	Coef.	t	Coef.	t	Coef.	t	Coef.	t
Price mobile	0.0276	2.69	0.0101	1.54	0.0309	2.65	0.0135	2.14
Price mobile (EE)	-0.0334	-2.98	-0.0162	-3.52	-0.0157	-1.17	-0.0078	-1.17
Price fixed	-0.0590	-5.28	-0.0593	-5.38	-0.0346	-2.59	-0.0363	-2.70
GDP per capita	0.0512	8.63	0.0511	7.95	0.0293	2.18	0.0305	2.25
Density	1.5532	7.10	1.5853	7.79	1.7334	2.50	1.7490	2.46
Network effects	-1.0795	-2.52	-1.1650	-2.71	-0.4629	-1.85	-0.5279	-2.10
Intercept	2.4720	3.32	2.6801	3.79	1.2989	1.86	1.4515	2.10
sigma u								
sigma e								
rho								
R sq								

Table 4: Elasticities

Elasticity	mean	std	min	max
Fixed own	-0.43	0.29	-1.23	0
Fixed cross (WE)	0.13	0.08	0	0.46
Fixed cross (EE)				
Mobile own	-0.04	0.02	-0.11	-0.01
Mobile cross (WE)				
Mobile cross (EE)	-0.10	0.04	-0.18	-0.03

Table 5: Demand for fixed-line only households

	Model I		Model Ia		Model II		Model IIa	
variable	Coef.	t	Coef.	t	Coef.	t	Coef.	t
Price mobile	0.0208	3.10	0.0165	3.72	0.0123	1.88	0.0071	2.36
Price fixed	0.0005	0.10	-0.0028	-0.51	-0.0064	-0.76	-0.0067	-0.82
Price fixed (EE)	0.0052	1.72	0.0035	1.21	0.0078	1.34	0.0069	1.28
GDP per capita	-0.0100	-1.57	-0.0090	-1.46	-0.0135	-1.52	-0.0122	-1.43
Density	-0.5172	-3.64	-0.6480	-3.96	-0.4159	-1.17	-0.4481	-1.35
Network effects	-0.5385	-2.37	-0.4604	-1.98	-0.8701	-4.79	-0.8343	-4.62
Cable broadband	0.6074	2.05	0.8121	2.67	-0.3768	-0.93	-0.2217	-0.55
Intercept	-1.2142	-3.08	-1.3891	-3.54	-0.2351	-0.50	-0.3430	-0.76
sigma u								
sigma e								
rho								
R sq								

Table 6: Demand for mobiles only households

	Model I		Model Ia		Model II		Model IIa	
variable	Coef.	t	Coef.	t	Coef.	t	Coef.	t
Price mobile	-0.0165	-1.68	-0.0007	-0.11	-0.0249	-2.13	-0.0094	-1.44
Price mobile (EE)	0.0239	2.10	0.0104	2.27	0.0114	0.85	0.0043	0.64
Price fixed	0.0595	5.60	0.0578	5.35	0.0301	2.27	0.0315	2.35
GDP per capita	-0.0380	-7.18	-0.0363	-6.50	-0.0255	-1.87	-0.0274	-2.01
Density	-1.8077	-8.16	-1.9369	-9.51	-1.7899	-2.63	-1.8445	-2.69
Network effects	0.8926	2.34	0.9817	2.59	0.5606	2.00	0.6399	2.28
Cable broadband	1.9603	4.30	2.2120	4.66	0.8810	1.44	0.8827	1.40
Intercept	-3.1518	-4.86	-3.4722	-5.51	-1.6163	-2.32	-1.7737	-2.57
sigma u								
sigma e								
rho								
R sq								