Fixed-to-Mobile Substitution in the European Union

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Abstract

This paper analyzes substitution between access to fixed-line and mobile telephony in the European Union. We estimate a structural model of household's demand for: (i) fixed-line only; (ii) mobile only; (iii) and both fixed-line and mobile access. We find that decreasing prices for mobile services increase the share of 'mobile only' households and decrease shares of 'fixed only' and 'fixed + mobile' households which suggests substitution between fixed-line and mobile connections. Moreover, growing Internet and DSL usage increase the share of 'fixed + mobile' households, which suggests that households keep their fixed line connection to access Internet. However, spread of 3G and cable modem broadband access decreases the share of 'fixed + mobile' households and increases the share of 'mobile only' households. Hence, in the future, fixed-line connection used for Internet access may be substituted by mobile broadband, as was in the case of voice telephony. On the other hand, bundling increases the share of 'fixed + mobile' households and decreases the shares of 'mobile only' and 'fixed only' households, which suggests that firms which provide both fixed-line and mobile services may slow down the substitution by bundling products.

Keywords: Fixed-To-Mobile Substitution; Fixed Broadband; Mobile Broadband

JEL Classification: L13, L43, L96

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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 their 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 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 into 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 was 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

[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 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 to all mobile services, i.e., mobile numbers are associated with individuals on the move rather than with a fixed location.

mobile phone they were not giving up 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 on 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, mobile only or both telecommunications services. Overall, both fixed and mobile telephone access are more widespread in the old EU countries than in the new ones, which joined EU in 2004 or later, but the proportions of 'mobile only' households are significantly higher in the new EU countries. There may be many reasons for this, such as regulatory measures in place, maturity of the markets, coverage of fixed networks and timing of development of mobile networks as well as the type of adopted broadband technology and speed of adoption. Also, an increasing number of operators offer bundles of fixed and mobile telephone access, IPTV and broadband internet connection. According to Eurobarometer, in December 2009, already 38% of Europeans declared that their household buys two or more communication services as part of a bundle.[5]

In a recent literature review, Vogelsang (2009) discusses gaps in research on FMS. More research is needed into behavior of 'mobiles only' households. Also, the effects of broadband

[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." Source: The European Regulators Group, (2009), "Report on fixed-mobile convergence: implications on competition and regulatory aspects", ERG (09)06

[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 across countries, especially new and old Member States.

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

adoption on FMS need to be analyzed. In particular, one would like to know if Internet adoption is limiting FMS and if adoption of mobile and other broadband technologies is increasing FMS. Even though, FMS is an issue of critical importance for regulators, there is no recent empirical analysis of FMS in the EU countries. 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: (i) fixed-line only; (ii) mobile only; (iii) and both fixed-line and mobile access using structural model derived from discrete choice framework. We find that decreasing prices for mobile services increase the share of 'mobile only' households and decrease shares of 'fixed only' and 'fixed + mobile' households which suggests substitution between fixed-line and mobile connections. Moreover, growing Internet usage increased the share of 'fixed + mobile' households, which suggests that households kept their fixed line connection to access Internet. However, spread of 3G and cable modem broadband access decreases the share of 'fixed + mobile' households and increases the share of 'mobile only' households. Mobile broadband and cable modem are complements to mobile telephony, while DSL is complement to fixed-line telephony. Hence, in the future, development of alternative to DSL broadband access, will further reduce fixed-line penetration. On the other hand, bundling increases the share of 'fixed + mobile' households and decreases the shares of 'mobile only' and 'fixed only' households, which suggests that firms which provide both fixed-line and mobile services may slow down the substitution by bundling products.

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 growing body of literature on substitution between fixed-line and mobile services, which was recently reviewed in Vogelsang (2009). Among country-level studies, Barros and Cadima (2000) estimate simultaneously diffusion curves for mobile and fixed telephony in Por-

tugal and find a negative impact of mobile penetration on fixed-line density. Okada and Hatta (1999) use Almost Ideal Demand System (AIDS) and data on Japan to analyze demand for mobile and fixed-line telecommunications services. They find that own-price elasticities and substitution effect are relatively high. Rodini et al. (2003) estimate the substitutability of fixed-line and mobile access using data on U.S. households and binary logit model. They find that second fixed line and mobile services are substitutes for one another. In another paper, Ward and Woroch (2004) use the AIDS model for US household survey data and find significant positive cross-price elasticities between mobile and fixed-line usage. Grzybowski and Karamti (2010) analyze the development of mobile telephony in France and Germany in 1998-2002 using binary logit 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. Briglauer et al. (2011) use monthly data on call minutes and price approximated by average revenues per minute in Austria between 2002 and 2007 to estimate short- and long-run cross-price elasticities for domestic calls on fixed-line with respect to mobile prices. They find that access is inelastic while calls are elastic and conclude that the retail market for national calls of private users can be deregulated due to sufficient competitive pressure from mobile. Access-substitution on the other hand does not seem to be strong enough to justify de-regulation.

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, mobile only and both fixed-line and mobile access in the European Union. Such consumer decision framework has not been considered so far in the previous literature due to lack of information on parallel usage of different technologies by households.

3 Econometric Model

3.1 Utility Functions

Demand equations are derived using discrete choice framework for aggregate data, in which we model decisions of households whether to use mobile and/or 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 EU countries in March 2011. Since the last type of households has a positive share only in some of the new Member States we ignore it in the further modeling.[6]

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

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

where r_f is time-invariant stand alone value of fixed-line telephony; p_{ft} is the price paid for using fixed-line services in period t; X_t are country-specific factors affecting utility from fixed-line in period t, such as Internet penetration or usage of mobile broadband; ξ_{ft} is the unobserved utility

[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 inelastic and are not part of the market for access to telecommunications services.

of fixed-line telephony in period t; and ϵ_{ift} is an idiosyncratic taste variable. The mean utility level of using a fixed-line in period t is therefore denoted by δ_{ft}.

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

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

where r_m is time-invariant stand alone value of mobile telephony; p_{mt} is the price paid for using mobile services in period t; X_t are country-specific factors which affect utility from mobiles in period t and are assumed to be the same as in the case of fixed-line; 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:

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

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

We normalize all utilities with respect to the utility of using both fixed-line and mobile services. After subtracting δ_{bt}, equation (1) can be rewritten as:

$$\begin{aligned} \bar{U}_{ift} &= [(1-\lambda_f) r_f - \lambda_m r_m] - (1-\lambda_f) \alpha_f p_{ft} + \lambda_m \alpha_m p_{mt} \\ &+ [(1-\lambda_f)\gamma_f - \lambda_m \gamma_m] X_t + [(1-\lambda_f)\xi_{ft} - \lambda_m \xi_{mt}] + \epsilon_{ift} \\ &= \bar{\delta}_{ft} + \epsilon_{ift}, \end{aligned} \tag{4}$$

The coefficient for the price for mobile services should be non-negative since $\lambda_m \geq 0$ and $\alpha_m \geq 0$. 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 the consumer acquires

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. In this case, mobile and fixed-line services are complements. 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. Hence, mobile and fixed-line are neither complements nor substitutes.

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

$$\begin{aligned}\bar{U}_{imt} &= [(1-\lambda_m)r_m - \lambda_f r_f] + \lambda_f \alpha_f p_{ft} - (1-\lambda_m)\alpha_m p_{mt} \\ &+[(1-\lambda_m)\gamma_m - \lambda_f \gamma_f]X_t + [(1-\lambda_m)\xi_{mt} - \lambda_f \xi_{ft}] + \epsilon_{ift} \\ &= \bar{\delta}_{mt} + \epsilon_{imt}, \end{aligned} \tag{5}$$

In this equation, the coefficient for the price for fixed-line services should be non-negative because $\lambda_f \geq 0$ and $\alpha_f \geq 0$. 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 $\lambda_m > 1$, i.e., mobile and fixed-line services are complements and (iii) insignificant when $\lambda_m = 1$, i.e., there is no change in utility of mobile services when used together with fixed-line.

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

$$\bar{P}_{ift} = \frac{\exp(\bar{\delta}_{ft})}{1 + \exp(\bar{\delta}_{ft}) + \exp(\bar{\delta}_{mt})}, \tag{6}$$

and analogously for subscription to mobile services only. The demand equations can be derived using the transformation suggested in Berry (1994). The market size is represented by all households having access to fixed-line or mobile services. Denote by: $\bar{s}_{ft}$ the share of 'fixed only' households in period t; $\bar{s}_{mt}$ the share of 'mobile only' households; and by $\bar{s}_{bt} = 1 - \bar{s}_{mt} - \bar{s}_{ft}$ the share of 'fixed + mobile' households. Demand for fixed-line only can be written as:

$$\log(\bar{s}_{ft}/\bar{s}_{bt}) = \bar{r}_f - \bar{\alpha}_{ff} p_{ft} + \bar{\alpha}_{fm} p_{mt} + \bar{\gamma}_f X_t + \bar{\xi}_{ft}. \tag{7}$$

and demand for mobile only can be written as:

$$\log(\bar{s}_{mt}/\bar{s}_{bt}) = \bar{r}_m + \bar{\alpha}_{mf} p_{ft} - \bar{\alpha}_{mm} p_{mt} + \bar{\gamma}_m X_t + \bar{\xi}_{mt}. \tag{8}$$

Estimating these equations we do not intent to identify all the parameters in equations (4) and (5).

3.2 Estimation Strategy

The demands for fixed-line and mobile access (7) and (8) are regressed on prices for mobile services, which are endogenous and require the instrumental variables estimation method. The non-price explanatory variables used in the model are considered to be exogenous and may be used as instruments. In particular, price indices for fixed-line services are assumed to be exogenous because fixed-line markets in the EU countries were liberalized between 1993 and 2001. There have been many market entries and increasing competition, especially in the markets for national and international calls. Retail prices for fixed-line are also regulated in some of the EU countries (see Grzybowski (2008)).

To fulfil the condition for identification we have to find at least one variable which has direct causal effect on price but does not have a direct causal effect on demand. Cost factors are commonly used in the empirical literature as instruments for prices but we lack reliable data on costs. However, since mobile networks across Europe use similar technologies to provide services, part of the costs can be considered to be similar. In result, prices in different countries should be correlated due to common cost determinants. We can use mobile telecommunications prices in other markets as instruments for prices in a given market, as suggested in Hausman (1996) and Nevo (2001). We instrument mobile prices in each country with mobile prices in selected neighboring countries. For instance, mobile prices in Belgium are instrumented with mobile prices in Netherlands, France and Luxembourg. Mobiles prices in Czech Republic are instrumented with mobile prices in Slovakia, Hungary and Poland. For some countries instruments are chosen on the basis of socioeconomic proximity. For instance, mobile prices in Greece are instrumented with mobile prices in Italy, Spain and Portugal. These instruments are valid under the condition that unobserved shocks to demand are not correlated across these countries.

4 The Data

The data used in this paper was collected from the following sources. The data on different types of telephone and Internet access at home in 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 European Commission. The purpose of these surveys is to follow trends in electronic communications markets and to assess how EU households and citizens derive benefits from increasingly competitive and innovative digital environment. So far there were five Eurobarometer surveys, which were conducted in: December 2005 - January 2006; November - December 2006; November 2007 - January 2008; November - December 2009 and February - March 2011. In the most recent survey, the interviews were conducted among 26,836 EU citizens in 27 Member States of the European Union. The data was collected for households' representatives and statistics is presented at the household level.[7] In this paper we use aggregate annual response data which is publicly available on the websites of the European Commission.

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 is to analyze price developments in the Member States of the European Union in years 1998-2010. The reports show 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 from 2008 to 2010. Teligen collected tariff data directly from the telecoms operators, from their websites and price-lists. Data were validated by the NRAs to reinforce the reliability of the information.

Prices used in this study are so called 'composite baskets', which are constructed by calculating the cost of a fixed number of different calls per annum, including annual rental charge as well as installation charge depreciated over five years. The number and distribution of calls are kept

[7] 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.

constant throughout the whole period. The definitions of the fixed-line and mobile 'composite baskets' are explained in detail in Teligen's reports, which are publicly available on the website of the European Commission. For fixed-line services, Teligen uses tariff data for the incumbent operator in each country. Standard tariffs are used excluding any special prices. Hence, the cost of the tariff is not necessarily the lowest on the market. Mobile prices are constructed using mobile tariffs selected by Teligen for the "OECD Price Benchmarking Baskets". Prices are calculated using representative tariffs from two network operators with the highest numbers of subscribers. In the regression we use an average of these tariffs for each country.

In the regression analysis, a dummy variable is interacted with price for mobile services for ten Central and Eastern European (CEE) countries: Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia, Slovenia and Romania.[8] It should take into account potential differences in the perception of mobile and fixed-line services in these countries due to historical reasons. The CEE countries in general inherited poor fixed-line infrastructure and 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 decrease without reaching Western European levels. Thus, access to mobile and fixed-line in the CEE countries may be more a substitute rather than a complement, as it may be the case in other EU countries.

The remaining data was collected from the Eurobarometer studies and Eurostat, as shown in Table (1). The key inputs into demand models specified by equations (7) and (8) are 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 fixed-line prices and the percentage of 'fixed only' and 'mobile only' households, respectively. Figures (4) and (5) show dependencies between share of households with both fixed-line and mobile access and percentage of households using Internet and cable broadband, respectively. These figures indicate that percentage of 'fixed + mobile' households is positively correlated with the share of households using Internet. On the other hand, share of households using Internet through

[8]Malta and Cyprus are among new Member States but were not part of the socialist block and are considered to belong to the group Western European countries.

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 which impact the degree of fixed-to-mobile substitution.

5 Estimation Results

Tables (2) and (4) present estimation results for equation (7) and (8), respectively. First, we estimate these equations using OLS, followed by random effects and fixed effects regressions. The fixed-effects model controls for all time-invariant differences between countries. The fixed effects can absorb the impact of some of the variables used in the model which do not vary significantly over time. Hence, such variables become insignificant when fixed effects are used. Fixed effects regression allows for the fixed effects to be correlated with the independent variables. Random effects regression, on the other hand, takes into account presence of country-specific fixed 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. Finally, we estimate random and fixed effects instrumental variables regressions to take into account endogeneity of prices for mobile services, which we discussed in the previous section. To decide between fixed and random effects we use Hausman test, in which the null hypothesis is that the unique errors are not correlated with the regressors, i.e., the preferred model is random effects.

In the case of model given by equation (7), the Hausman test does not allow to reject the null hypothesis that random effects are not correlated with the regressors. Hence, random effects instrumental variables model is preferred. Model IV in Table (2) shows that prices for fixed-line and mobiles are insignificant. This is likely due to difficulties to construct prices which are relevant for subscription decisions. As discussed in data section we use 'composite baskets' defined by Teligen for incumbents' fixed-line services and average of 'composite baskets' for two main mobile operators in each country. These prices may not be considered by marginal consumers in their decisions whether to use fixed-line services only or to use fixed-line and

mobile services together. On the other hand, given our specification of demand for fixed-line only services, insignificant prices can be interpreted as $\lambda_f = 1$ and $\lambda_m = 0$. The first equality implies that there is no change in the utility of fixed-line services when used together with mobile phones. The second equality means that the utility of mobile service is zero when used together with fixed-line. Since market conditions in the CEE countries differ from the WE countries we estimate separate coefficient on fixed-line price for these countries, which is nevertheless insignificant.

The only variables which are significant in the random effects and IV random effects regression are the share of households using bundled offers and Internet penetration. Bundled offers may reduce demand for having only fixed-line connection, i.e., there is more demand for having fixed-line and mobile connections together. Also, spread of Internet usage decreases demand for having only fixed-line connection. Since, spread of Internet has no effect on the share of 'mobile only' households in the regression of equation (8), this implies that demand for Internet access stops households which use mobiles to give up on fixed-line connection. Usage of mobile broadband and cable modem has no effect on the likelihood of using fixed-line only.

In addition to estimating structural demand for fixed-line only given by equation (7) we also estimate a linear regression, in which the share of 'fixed only' households is regressed on the same set of explanatory variables by means of simple linear regression. Estimation results are presented in Table (3). In the linear regression based on IV random effects, price for mobile services has a positive impact on the share of 'fixed only' households. This price effect suggests substitution between fixed-line and mobile connections. There is a negative impact of Internet penetration on the share of 'fixed only' households which is analogous to the case of multinomial logit. However, the share of households using bundled offers is not significant. Also, the share of 'fixed only' households is not correlated with penetration of mobile broadband and cable modem, as in the logit regression.

In the case of model given by equation (8), the Hausman test rejects the null hypothesis that random effects are not correlated with the regressors, hence fixed effects instrumental variables

model is preferred. Again, prices for mobile and fixed-line services are insignificant in Model V in Table (4) but in Models I-IV there is a significant negative impact of the price for mobile services on the likelihood of using mobile only relative to having fixed-line and mobile connections together. Insignificance of fixed-line prices may be again due to measurement problems. Alternatively, given our specification of demand for mobile only services, insignificant prices can be interpreted as $\lambda_f = 0$, which implies that the utility of fixed-line service is zero when used together with mobiles. There is also a negative effect of the share of households using bundles on the likelihood to have mobile only. This result is analogous to the regression of demand for fixed-line only shown in Table (2), i.e., bundle offers encourage households to use both technologies at the same time. Moreover, the share of households using mobile broadband has a positive impact on the likelihood of having mobile connection only. This suggests that the share of 'mobile only' households will increase with increasing usage of mobile broadband to access Internet. Also, cable modem penetration increases the likelihood of households decision to be 'mobile only'. Mobile broadband and cable modem penetration account for the availability of an alternative means of Internet access to DSL which relies on copper lines. As suggested by Figure (5), cable modem is negatively correlated with the share of fixed-line connections. Hence, usage of mobile broadband and cable modem for data services is complementary to usage of mobile services for voice.

The results from a linear regression of share of 'mobile only' households on the same set of explanatory variables are broadly analogous, as shown in Model IV in Table (5). There is a negative impact of price for mobile services on the share of 'mobile only' households, and a positive impact of price for fixed-line services in the case of the CEE countries. The price effect suggest that there is substitution between fixed-line and mobile connections. Moreover, the share of households using bundles is negatively correlated with the share of 'mobile only' households and spread of mobile broadband and cable modem are positively correlated with the share of 'mobile only' households.

We also estimate a linear regression of the share of 'fixed + mobile' households on the same set

of explanatory variables, as shown in Table (6). According to Hausman test the null hypothesis that random effects are not correlated with the regressors cannot be rejected. Hence, random effects instrumental variables model is preferred. Model IV in Table (6) shows that there is a positive impact of price for mobile services on the share of 'fixed + mobile' households and a negative impact of price for fixed-line services in the case of the CEE countries. This suggests that households may be less likely to give up on fixed-line connection when mobile prices are high (complementarity). On the other hand, in the CEE countries, households are more likely to give up fixed-line connection when prices for fixed-line services are high (substitution). Share of households using bundled offers is positively correlated with the share of households using both fixed-line and mobile connections. Spread of Internet positively influences share of 'fixed + mobile' households. On the other hand, mobile broadband and cable modem penetrations are negatively correlated with the share of households having both fixed-line and mobile. These results support the results of regressions based on discrete choice framework discussed above.

We conclude that the spread of Internet is a factor which postpones fixed-to-mobile substitution. However, the usage of mobile broadband and cable modem reinforce the transition towards 'mobile only' or 'mobile + cable modem' households. These results suggest that future penetration of fixed-line will depends on the development of alternative means of Internet access. When quality and speed of mobile broadband increases the number of fixed-line connections may be expected to decline. Firms may postpone this decline by offering bundled offers of mobile and fixed-line services.

6 Conclusion

The future of fixed-line telecommunications depends on the extent of fixed-to-mobile substitution. 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. Within the European Union there is a large variation in the extent to which households use fixed-line only, mobile only or both technologies. Overall, both fixed and mobile telephone ac-

cess 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.

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 derive a structural model of household's demand for fixed-line only, mobile only and both fixed-line and mobile access. We find that decreasing prices for mobile services increase the share of 'mobile only' households and decrease shares of 'fixed only' and 'fixed + mobile' households, which suggests substitution between fixed-line and mobile connections. Moreover, growing Internet and DSL usage increase the share of 'fixed + mobile' households, which suggests that households increasingly keep their fixed-line connection to access Internet. However, spread of cable modem and 3G broadband access decreases the share of 'fixed + mobile' households and increases the share of 'mobile only' households. Usage of mobile broadband and cable modem to access Internet complement usage of mobiles for voice. Hence, in the future, when mobile broadband will be more widespread, fixed Internet may share the destiny of fixed voice telephony. On the other hand, bundling increases the share of 'fixed + mobile' households and decreases the shares of 'mobile only' and 'fixed only' households. This suggests that firms which provide both fixed and mobile services may slow down the substitution process by bundling telecommunications products.

Due to lack of detailed data on the share of households using mobile and fixed-line connections together, all former studies analyzing fixed-to-mobile substitution use data on the absolute numbers of mobile and fixed-line connections. This paper improves upon this by using results from Eurobarometer surveys, which collects data on usage and substitution between different technologies. The contribution of this paper is to derive and estimate structural model of household's demand for fixed-line only, mobile only and both fixed-line and mobile access in the European Union. The results of this study should be useful for policy makers suggesting that fixed-to-mobile substitution is likely to continue with the deployment of alternative to DSL broadband technologies such as mobile broadband and cable modem.

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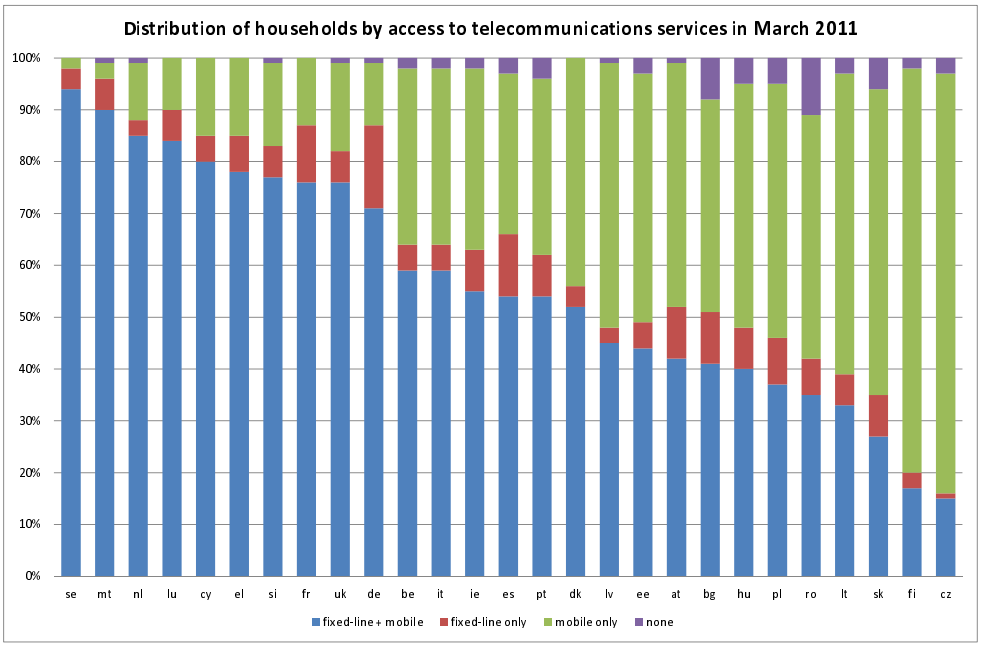
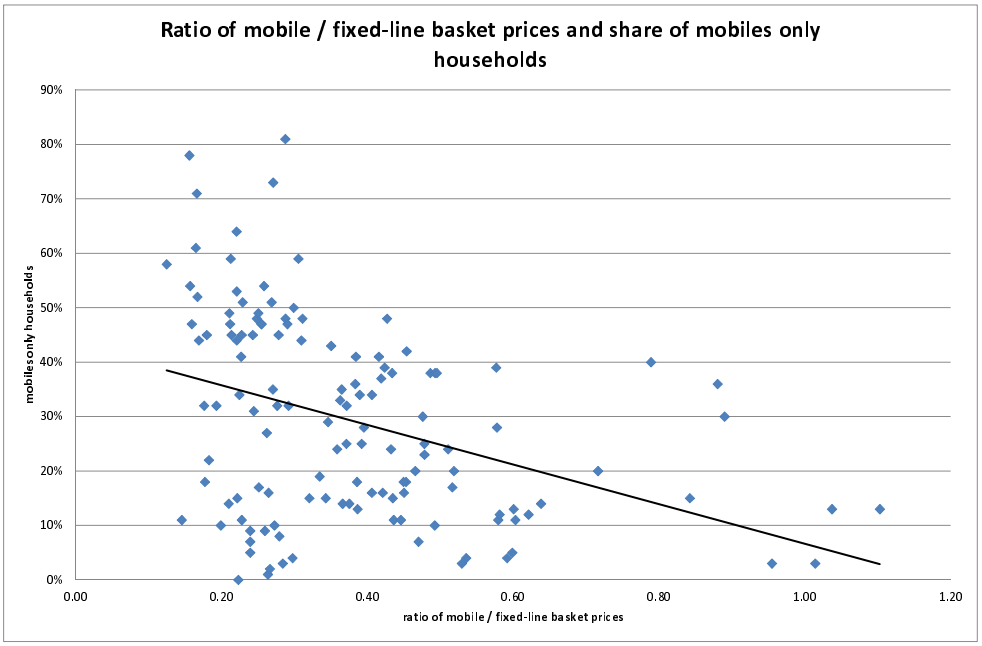
Appendix

Figure 1:



Source: Eurobarometer (2010)

Figure 2:

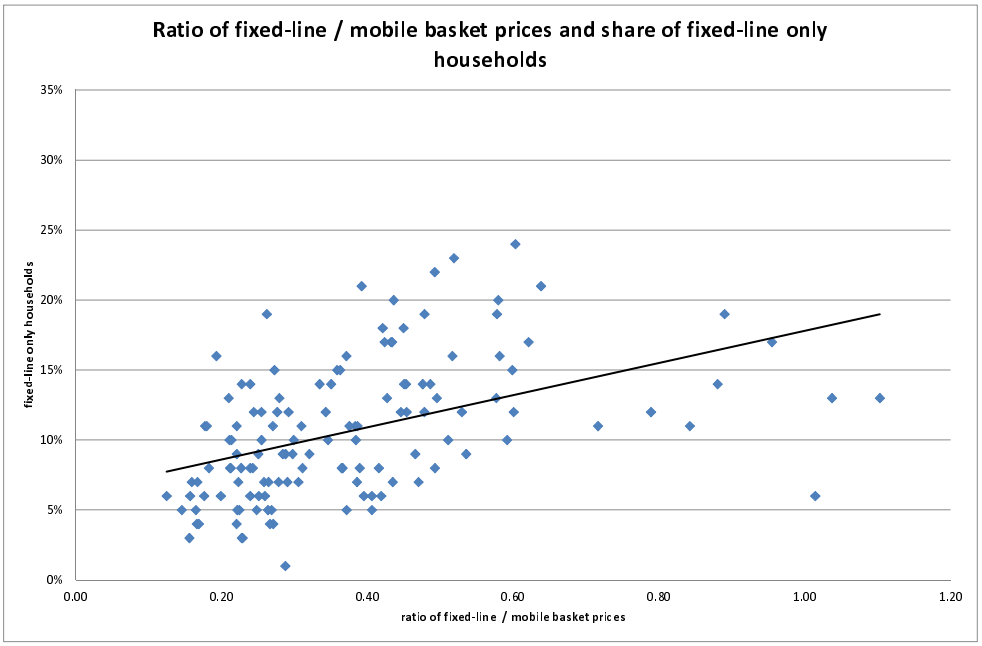


Source: Eurobarometer and Teligen, 2005-2011

Table 1: Summary statistics

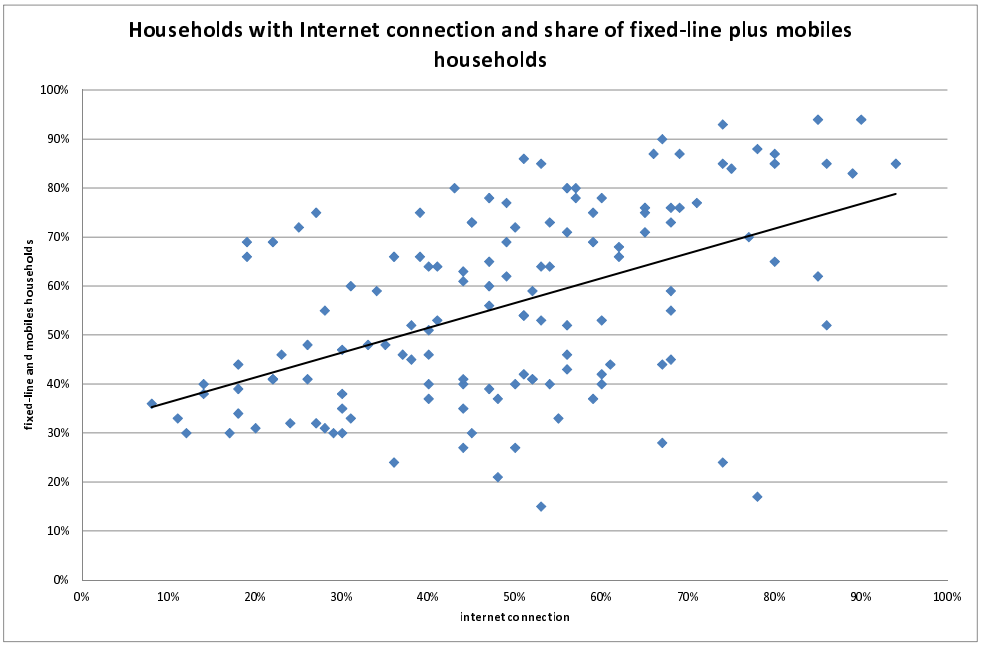
variable	N	mean	std	min	max	Source
Fixed only (%)	135	0.110	0.054	0.010	0.310	Eurobarometer
Mobile only (%)	135	0.290	0.182	0.000	0.810	Eurobarometer
Fixed+Mobile (%)	135	0.560	0.197	0.150	0.940	Eurobarometer
Price mobile	131	13.493	6.262	4.170	31.945	Teligen
Price fixed	135	36.324	7.695	16.270	57.420	Teligen
GDP PPP per capita	135	23.336	10.658	7.900	69.100	Eurostat
Bundles (%)	135	0.280	0.140	0.000	0.670	Eurobarometer
3G penetration	135	0.035	0.047	0.000	0.290	Eurobarometer
Cable penetration	135	0.227	0.153	0.000	0.620	Eurobarometer
Internet penetration	135	0.489	0.195	0.080	0.940	Eurostat

Figure 3:



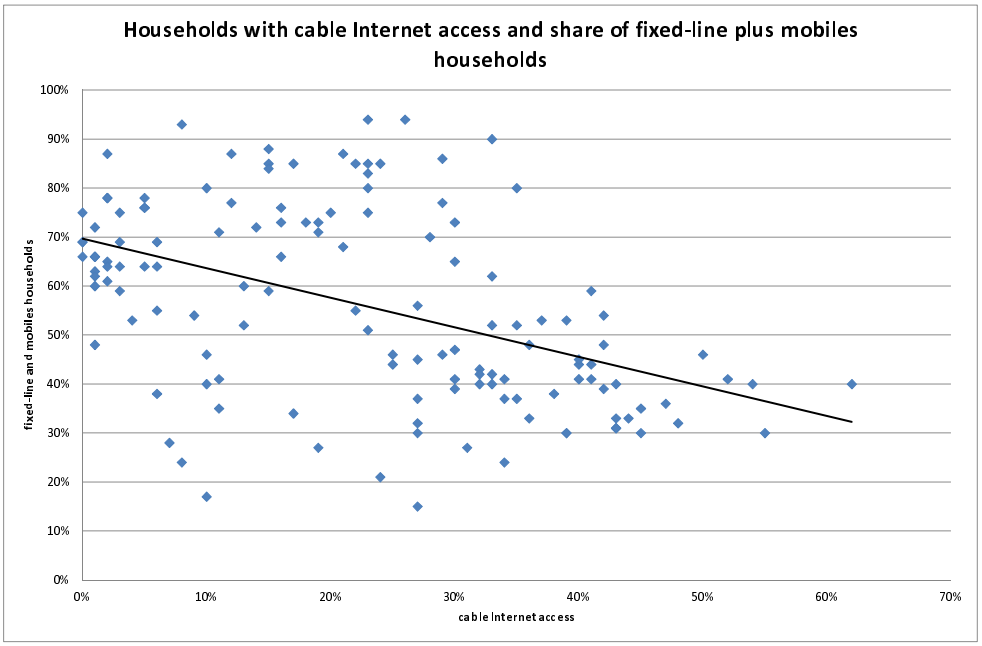
Source: Eurobarometer and Teligen, 2005-2011

Figure 4:



Source: Eurobarometer, 2005-2011

Figure 5:



Source: Eurobarometer, 2005-2011

Table 2: Logit demand for 'fixed only' connection

	Est. I	t-stat	Est. II	t-stat	Est. III	t-stat	Est. IV	t-stat	Est. V	t-stat
Price mobile	0.004	0.72	0.003	0.61	0.001	0.21	0.006	0.58	0.001	0.10
Price fixed	0.004	0.99	-0.001	-0.14	-0.003	-0.53	-0.001	-0.15	-0.003	-0.48
Price fix EE	0.000	-0.10	-0.001	-0.23	0.003	0.24	-0.001	-0.13	0.002	0.23
GDP	0.003	0.66	0.000	-0.01	-0.010	-0.73	0.000	-0.05	-0.010	-0.68
Bundles	-0.349	-0.97	-0.524	-2.14	-0.494	-1.87	-0.508	-2.07	-0.494	-1.85
3G	-0.150	-0.15	0.461	0.85	0.696	1.20	0.457	0.83	0.695	1.14
Cable modem	0.845	2.80	0.446	1.27	0.264	0.59	0.422	1.18	0.263	0.59
Internet	-2.215	-8.63	-2.517	-7.95	-2.601	-7.05	-2.466	-6.59	-2.600	-5.82
Intercept	-0.947	-3.60	-0.426	-1.48	-0.031	-0.07	-0.485	-1.22	-0.034	-0.05
R2	0.578									
sigma u			0.369		0.385		0.372		0.384	
sigma e			0.201		0.202		0.201		0.202	
rho			0.771		0.785		0.774		0.784	

Model I: OLS; Model II: random effects panel data; Model III: fixed effects panel data; Model IV: random effects instrumental variables; Model V: fixed effects instrumental variables

Table 3: Share of 'fixed only' regression

	Est. I	t-stat	Est. II	t-stat	Est. III	t-stat	Est. IV	t-stat	Est. V	t-stat
Price mobile	0.002	4.31	0.002	3.65	0.002	3.65	0.003	3.10	0.002	1.68
Price fixed	-0.001	-1.39	0.000	0.56	0.000	0.56	0.000	0.63	0.000	-0.15
Price fix EE	0.000	-1.73	-0.001	-1.91	-0.001	-1.91	-0.001	-1.40	0.000	-0.20
GDP	0.000	1.05	0.000	-0.64	0.000	-0.64	0.000	-0.53	-0.003	-2.36
Bundles	0.030	1.14	0.003	0.13	0.003	0.13	0.008	0.35	0.007	0.33
3G	-0.191	-3.06	-0.036	-0.78	-0.036	-0.78	-0.050	-1.04	-0.008	-0.16
Cable modem	-0.007	-0.25	-0.021	-0.70	-0.021	-0.70	-0.020	-0.62	-0.019	-0.53
Internet	-0.135	-6.61	-0.221	-8.08	-0.221	-8.08	-0.193	-5.79	-0.225	-6.36
Intercept	0.160	7.66	0.213	8.30	0.213	8.30	0.175	4.90	0.271	5.14
R 2	0.494									
sigma u			0.033		0.034		0.033		0.056	
sigma e			0.015		0.016		0.015		0.016	
rho			0.819		0.819		0.819		0.925	

Model I: OLS; Model II: random effects panel data; Model III: fixed effects panel data; Model IV: random effects instrumental variables; Model V: fixed effects instrumental variables

Table 4: Logit demand for 'mobile only' connection

	Est. I	t-stat	Est. II	t-stat	Est. III	t-stat	Est. IV	t-stat	Est. V	t-stat
Price mobile	-0.061	-4.30	-0.028	-3.33	-0.018	-2.18	-0.045	-2.67	-0.030	-1.59
Price fixed	0.049	5.20	-0.001	-0.16	0.009	1.00	-0.003	-0.41	0.006	0.64
Price fix EE	0.014	2.95	0.015	1.64	-0.012	-0.82	0.010	0.97	-0.010	-0.63
GDP	-0.013	-1.94	-0.005	-0.36	0.038	1.86	0.000	0.00	0.033	1.45
Bundles	-0.936	-1.07	-0.799	-2.02	-0.756	-2.00	-0.884	-2.30	-0.804	-2.07
3G	5.135	2.17	3.063	3.46	2.488	2.96	3.096	3.58	2.653	3.00
Cable modem	1.749	3.97	1.513	2.47	1.381	2.17	1.483	2.42	1.402	2.18
Internet	-2.603	-3.59	-0.217	-0.40	0.000	0.00	-0.497	-0.81	-0.232	-0.37
Intercept	-0.691	-1.53	-0.614	-1.17	-1.887	-2.87	-0.205	-0.27	-1.404	-1.45
R 2	0.589									
sigma u			0.772		1.443		0.776		1.336	
sigma e			0.288		0.287		0.292		0.289	
rho			0.877		0.962		0.875		0.955	

Model I: OLS; Model II: random effects panel data; Model III: fixed effects panel data; Model IV: random effects instrumental variables; Model V: fixed effects instrumental variables

Table 5: Share of 'mobile only' regression

	Est. I	t-stat	Est. II	t-stat	Est. III	t-stat	Est. IV	t-stat	Est. V	t-stat
Price mobile	-0.009	-4.87	-0.005	-3.63	-0.005	-1.60	-0.008	-2.85	-0.008	-2.85
Price fixed	0.007	4.70	-0.001	-0.83	0.000	-0.31	-0.001	-1.06	-0.001	-1.06
Price fix EE	0.003	3.11	0.003	2.29	0.000	0.07	0.003	1.82	0.003	1.82
GDP	-0.002	-2.29	-0.002	-0.85	0.003	0.86	-0.002	-0.82	-0.002	-0.82
Bundles	-0.311	-2.52	-0.256	-4.11	-0.258	-4.26	-0.268	-4.26	-0.268	-4.26
3G	1.148	3.80	0.629	4.56	0.531	3.83	0.652	4.63	0.652	4.63
Cable modem	0.289	4.31	0.253	2.67	0.246	2.44	0.251	2.61	0.251	2.61
Internet	-0.193	-1.90	0.213	2.57	0.241	2.38	0.155	1.56	0.155	1.56
Intercept	0.262	3.67	0.286	3.58	0.181	1.20	0.374	3.41	0.374	3.41
R 2	0.582									
sigma u			0.114		0.182		0.116		0.120	
sigma e			0.046		0.046		0.046		0.046	
rho			0.859		0.941		0.86		0.874	

Model I: OLS; Model II: random effects panel data; Model III: fixed effects panel data; Model IV: random effects instrumental variables; Model V: fixed effects instrumental variables

Table 6: Share of 'fixed + mobile' regression

	Est. I	t-stat	Est. II	t-stat	Est. III	t-stat	Est. IV	t-stat	Est. V	t-stat
Price mobile	0.008	4.10	0.004	2.87	0.003	1.83	0.006	2.30	0.003	1.09
Price fixed	-0.007	-4.55	0.001	0.72	0.000	-0.04	0.001	0.93	0.000	0.08
Price fix EE	-0.003	-3.27	-0.003	-2.21	0.000	-0.01	-0.003	-1.80	0.000	-0.07
GDP	0.002	1.84	0.001	0.32	-0.005	-1.58	0.001	0.24	-0.005	-1.36
Bundles	0.281	2.09	0.237	3.75	0.230	3.67	0.246	3.88	0.233	3.66
3G	-0.955	-2.89	-0.602	-4.30	-0.510	-3.70	-0.621	-4.38	-0.524	-3.60
Cable modem	-0.389	-5.18	-0.316	-3.30	-0.282	-2.68	-0.311	-3.20	-0.285	-2.69
Internet	0.444	4.27	0.163	1.94	0.126	1.43	0.212	2.11	0.143	1.35
Intercept	0.501	6.57	0.444	5.52	0.613	5.64	0.372	3.35	0.579	3.65
R 2	0.624									
sigma u			0.123		0.187		0.123		0.179	
sigma e			0.049		0.048		0.049		0.048	
rho			0.863		0.938		0.863		0.934	

Model I: OLS; Model II: random effects panel data; Model III: fixed effects panel data; Model IV: random effects instrumental variables; Model V: fixed effects instrumental variables