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SUBSTITUABILITY BETWEEN MOBILE AND FIXED TELEPHONES: EVIDENCE AND IMPLICATIONS FOR INDIA

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Abstract

This paper estimates the determinants of household subscription to mobile and fixed phones in India based on a binary logit model and using the household sample survey data from the Karnataka State in South India. The determinants include access and usage price of mobile and fixed phone services, income, age, social caste, education, and occupation of head of household and family size. Using the econometric estimates, marginal effects and elasticities of probability of subscription to mobile services are computed. Elasticities are distinguished by own price elasticity, cross-price elasticity, and income elasticity. Estimated cross price elasticity offers empirical evidence for substitutability rather than complementarity between fixed and mobile phone services. This evidence is symmetric in mobile and fixed phone models. The implications of empirical results are shown to have relevance for on-going policy discussion on subsidization under Universal Service Obligation and Access Deficit Charge.

Keywords: Access price, Usage price, Substitutability, Complementarity, Universal Service Obligation, Fixed phones, Mobile phones, India

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1. Introduction

As part of the national economic reforms since July 1991, privatization of manufacturing and service provisioning, globalization of international trade and capital, deregulation of public sector monopoly, and international competition have been introduced into the Indian telecom sector. An important consequence of these reforms is evident in the remarkable increase in subscriber base of mobile telephone since 2000. This has explicitly contributed to increase in teledensity (or penetration rate) and access to telecom services. At the same time, mobile phones have posed intense competition to retaining existing subscribers and attracting new subscribers by fixed phones. Whether or not competition from mobile phones result in higher or slower growth of subscriber base for fixed phone is an empirical question, and depends on complementarity or substitutability between mobile and fixed phones. This evidence is relevant for many policy purposes including current and future discussions on subsidization policies. Nevertheless, to our knowledge, no empirical evidence is available on substitutability and complementarity between fixed and mobile phones for India.

International literature on substitutability and complementarity between fixed and mobiles phone are many with focus on developed economies, transitional, and developing economies.[1] These studies include Sung and Lee (2002), Rodini et al (2003), Vagliasindi et al (2006), and Garbacz and Thompson Jr (2007). These studies show diversities in empirical modeling, measurement of price and non-price variables, estimation techniques and testing for whether or not mobile phones are a substitute or complement to fixed phones.

Sung and Lee (2002) estimated the impact of stock of mobile phones on demand for new fixed connections and fixed phone disconnections in Korea by using panel data at provincial level from 1991-1998. A positive (or negative) and significant coefficient of stock of mobile

[1] An excellent general discussion on substitutability and complementary in telecom subscription and services is presented in Albon (2006).

phones offers evidence for substitutability of mobile phones for fixed phones in the context of new fixed connections (or disconnections).

Rodini et al (2003) estimates the Logit model to test for substitution of mobile for fixed phones in USA, using a large scale household level in 2000 and 2001. A novel contribution of this study lies in estimation of access and usage price for fixed and mobile phones, using the consumers' billing data and applying random coefficient model technique. Estimated logit cross price elasticity of fixed price on mobile demand is negative and significant. This indicates that consumers are more probable to subscribe to mobile phones in places where fixed access price is higher and, hence, mobile phone is a substitute for fixed phone access.

Vagliasindi et al (2006) estimated the Probit model to test for substitution of fixed phones for mobiles in 26 transitional economies, using the enterprise level data from Business Environment and Enterprise Performance Survey by the EBRD and the World Bank in 2002. The estimation showed a negative effect of an increase in fixed phone penetration rate on mobile use. This result offers evidence for substitution of fixed phones for mobile phones at country level. However, this result is contingent upon the specification of the binary dependent variable in which enterprises use only mobile phones for their business purposes. For instance, an alternative specification of the binary dependent variable in which the enterprises use both mobile and fixed phones for their business purposes resulted in positive coefficient of fixed phone penetration rate and supported for complementarity between fixed and mobile phones.

Garbacz and Thompson Jr (2007) estimated the effect of fixed residential price on mobile telephone demand, and the effect of mobile price on fixed residential telephone demand, to test for substitutability as well as complementarity between mobiles and fixed phones, by using panel data on 53 developing countries (including India) from 1996-2003. Both residential and mobile demand models are formulated in the context of privatization, competition, and regulation of telecom sector, and provide with a basis for estimating telephone prices as endogenous variables in a recursive equation framework. Telephone prices are distinguished by monthly charges and connection charges. These prices enter the demand equations in two different ways. First, both monthly and connection charges enter directly as exogenous variables. Second, monthly charges

are treated as endogenous variables and estimated by separate price equations. The estimated monthly charges enter demand equations as instrument variables. The estimation results offer interesting evidence. Negative coefficient of mobile price variable in residential demand model indicates for complementarity between fixed and mobile phones; and positive coefficient of residential price variable in mobile demand model indicates that fixed phones are a substitute for mobile phones. This contrasting evidence is attributed for divergence in range of services and characteristics between fixed and mobile phones.

This paper learns from the above international experiences and attempts to estimate the substitutability and complementarity between fixed and mobile phones in India in two different contexts. First, mobile phone demand is estimated among the fixed phone subscribers. Second, fixed phone demand is separately estimated by using subscribers and non-subscribers data. Both the estimations employ a binary Logit model, and use a sample survey data on household subscribers and non-subscribers of fixed and mobile phones in Karnataka State in south India. Access and usage prices for subscribers of fixed and mobile phone services are specified at household level. Two separate specifications are developed for the two different estimations above. The estimations are useful to determine the common and unique factors that influence the demand for mobile and fixed phones; test for substitutability and complementarity between fixed and mobile phones; and test for symmetry of substitutability and complementarity in mobile and fixed phone markets. In addition, the implications of the empirical evidence are related to current policies for subsidization as per the National Telecom Policy 1999.

Rest of the paper is organized as follows. Section 2 presents some basic numbers on the growth of mobile phones, using data at national level of aggregation. In addition, survey results on current subscribers' and non-subscribers' perceptions of relative uses of mobile and fixed phones are described. Section 3 models demand for mobile phones for estimation of determinants and test for substitutability and complementarity between fixed and mobile phones. Data and variables for estimations are described in section 4. In section 5, estimation results of mobile demand are analyzed with computed probabilities and price and income elasticities. Section 6 presents the determinants of fixed phone demand and results for the symmetry.

Implications of empirical results are highlighted for current policy debates on telecom subsidization in section 7. Major conclusions and implications are summarized in section. 8

2. Some basic numbers

Since 2000, mobile telephones have exhibited a phenomenal growth in India. For instance, subscriber base of mobile phones reached 165.09 million in 2006-07. From April-December 2007, new mobile subscribers increased by about 67.54 million, about 11 times more number of total mobile subscribers that India had in 2001-02 (6.54 million). Teledensity (i.e. number of telephones per 100 persons in total population) is a simple summary indicator to capture the impact of mobile telephony on access to telecom services. **Figure 1** shows this impact from 2000-01 in comparison with teledensity without mobile telephones. India's teledensity reached 18.35 in 2006-07 with mobile teledensity of 14.71. India's National Telecom Policy 1999 had set the target of achieving a teledensity of 7 by 2007 and 15 by 2010. These targets have been achieved well before the time due to introduction and expansion of mobile phones.

Teledensity by fixed phones remained around 4 and marginally declined since 2003-04. Consequently, fixed phones per mobile phone declined from 5.87 in 2001-02 to 1.15 in 2003-04 and to 0.25 in 2006-07 (**Figure 2**). Does this decline mean preference of mobile phones to fixed phones and vice-versa? [2] To find an answer to this question, a random sample survey of fixed phone subscribers and non-subscribers was conducted by this author in January-March 2003 in Karnataka State of south India. The sample subscribers (or non-subscribes) were identified with his/her subscription (or non-subscription) to fixed telephone on the day of the survey, as provided by the public telephone company, viz., Bharath Sanchar Nigam Limited (BSNL). The BSNL continues to be the largest provider of fixed telecom services in India as well as in Karnataka State. Administratively, the State has been divided into 27 districts. Bangalore (globally known as *Silicon Valley of India, IT Hub of Asia, and IT Capital of India)* is the capital of the State. In each district, the telecom services have been organized and provided through a

[2] Newspapers report that surrendering of fixed telephones since 2000 as a case for substitution of fixed to mobile phones. The Hindu-Business Line (04 February 2003) reported 0.25 million fixed phones surrendered in 2002-03 and the Economic Times (21 February 2008) reported 1.56 million fixed phones surrendered for reasons including preference for cell phones and non-payment of bills.

wide network of rural and urban telephone exchanges. At first stage, 1 urban exchange and 2 rural exchanges from each of the 27 districts within the State were randomly selected as sample exchanges.[3] In the second stage, about 20 (or 10) subscribers were randomly selected in each of the sample urban (or rural) exchanges. In total, the sample comprised 1100 (520 rural and 580 urban) subscribers from 81 (52 rural and 29 urban) exchanges. About 8 percent of total sample subscribers of fixed phones had subscribed to mobile phones. In the same way, 1100 non-subscribers of fixed phones were separately sampled and interviewed from the same exchanges in rural and urban areas.[4] Throughout the state, mobile connectivity was available in both rural and urban areas and, hence, the choice between fixed and mobile phones was not constrained by unavailability of either or both.

The survey responses of mobile subscribers are summarized in **Table 1**. Mobile phones are mainly used for making local and domestic long distance calls. Easy to get connection, personal necessity, can be contacted anywhere and at any time, easy to handle, and social status are the main reasons for have a mobile phone with fixed phone. On the other hand, reasons to have a fixed phone as well as a mobile phone included usefulness for family members and contacts, gives identity proof, availability of directory facility, flexibility to chose call rates, and useful alternative if fixed phone is faulty. Possession of both fixed and mobile phones had increased the incoming calls to fixed as well as outgoing calls from fixed phone. These responses implied usefulness of fixed phones and mobiles phones in meeting unique needs of telecom services of the subscribers.

Table 2 highlights the responses of non-subscribers on the future subscription to fixed and mobile phones. As in the case of current subscribers, current non-subscribers would also use the phones for local call and domestic long distance purposes. Preference of fixed phones over mobiles is dominated by reasons such as usefulness for family members and contacts,

[3] Urban exchanges were chosen if their direct exchange lines (DELs) were approximately equal or closer to the average number of urban DELs in their respective districts. For selection of two sample rural exchanges, two alternative criteria are adopted: An exchange with the highest number of DELs among the rural exchanges in the district. Or, an exchange if it's number of DELs was approximately equal or closer to the average number of DELs of rural exchanges in their respective districts.

[4] Among the non-subscribers of fixed phone, about 0.5 percent of households had subscription to mobile phones. These subscribers are not included in the following descriptions and later estimations of mobile demand.

availability of directory facilities, and low call rates. However, no strong preference to have a mobile phone with a fixed phone was expressed, because 68.12 percent of non-subscribers did not have the necessary of a mobile phone.

The perceptions above indicate for relative advantages of fixed and mobile phone services, but do not imply for substitutability or complementary between fixed and mobile phone. This calls for a rigorous analysis that can test for substitutability and complementarity between fixed and mobiles phones on empirical grounds.

3. Empirical framework for estimation of mobile demand

A general framework for estimation of price and non-price determinants mobile demand, and for testing for substitutability and complementarity between mobile and fixed phones, within a telecom circle is presented below. To start with, specification of price variables is discussed.

3.1. Specification of price variables

Price of fixed phone services varies, among others, by location (e.g. rural and urban) and capacity of exchanges. These variations account for differential in the telecom prices faced by subscribers in a cross-section data. In contrast, for a given service, price of mobile phone services does not vary across subscribers within a state/telecom circle. These differences add complications to formulate separate price variables for fixed and mobile phone services for cross-section estimation purposes. For instance, uniform price of mobile phone services cannot be used as a separate explanatory variable. This precludes the estimation of effect of mobile prices on demand for telecom services in a cross-section data. To overcome this problem, this paper specifies price variables as a linear combination of price of fixed and mobile phone services, but separates the price variables by access and usage prices. That is, we specify the access price (P_i^{AP}) and usage price (P_i^{CP}) for i-th subscriber as follows.

$$P_i^{AP} = M^{AP} - F_i^{AP} \quad (1)$$

$$P_i^{CP} = M^{CP} - F_i^{CP} \quad (2)$$

Where $\{M^{AP}, M^{CP}\}$ are the uniform access and usage/call price of mobile phone services, and $\{F_i^{AP}, F_i^{CP}\}$ are the variable access and usage/call price of fixed phone services. Price variability of fixed phone services include differential prices changed to subscribers by their location in rural and urban areas, and in areas covered by telephone exchange of different capacities. In this formulation, prices enter into estimation as $\{P_i^{AP}, P_i^{CP}\}$ but not separately as mobile and fixed phone access and usage prices. In the absence of this specification, however, only fixed access and usage prices can be incorporated into the estimations. Such a formulation may not be plausible if (a) sample households comprise mobile subscribers among the fixed line subscribers and (b) the objectives of estimation are to determine the probability of mobile phone subscriptions among the fixed line subscribers and test for substitutability and complementarity between mobile and fixed phones.

3.2. Framework for estimation

The framework for estimation is the standard binary Logit model. Probability of subscription to mobile phone services by the i-th household (ρ_i^M) is specified as follows.

$$\text{In}\,[\rho_i^M / (1- \rho_i^M)] = \alpha.P_i^{AP} + \beta.P_i^{CP} + \Sigma(\gamma_j.X_{ij}) , \quad (3)$$

where X_{ij} are non-price variables, or socio-economic and demographic background variables of households, which influence the probability of subscription to mobile phone services, such as, income, age, literacy, social caste, and occupation of the head of household and the family size.

Following Garbacz and Thompson Jr (2007), substitutability and complementarity between mobile and fixed phones are tested by the following predicted sign on the coefficients of the

price variables. First, other things being the same, mobile phone is a substitute for fixed phones if a rise in price of fixed phones increases demand for mobile phones. This can be tested by predicting $\alpha<0$, and $\beta<0$, because $d(P_i^{AP})/(dF_i^{AP})<0$, and $d(P_i^{CP})/(dF_i^{CP})<0$. Hence, $\delta(\rho_i^M)/\delta(P_i^{AP}) >0$, and $\delta(\rho_i^M)/\delta(P_i^{CP}) >0$. Second, mobile phone is a complement to fixed phone, if $\alpha > 0$, and $\beta >0$, because a rise in price of fixed phones reduces the demand for mobile phones. Hence, $\delta(\rho_i^M)/\delta(P_i^{AP}) <0$, and $\delta(\rho_i^M)/\delta(P_i^{CP}) <0$. In addition, the own price elasticity of mobile phone services is predicted to be negative. That is, a rise in price of mobile phone services will reduce the probability of subscription to mobile services. This is testable by predicting negative sign for α and β, because $d(P_i^{AP})/(dM^{AP})>0$, and $d(P_i^{CP})/(dM^{CP})>0$. Hence, $\delta(\rho_i^M)/\delta(M^{AP}) <0$, and $\delta(\rho_i^M)/\delta(M^{CP}) <0$.

For later computational purposes, let the estimated model in (3) be equal to: $\text{In} [\rho_i^M */ (1- \rho_i^M *)] = \alpha*.P_i^{AP} + \beta* + \Sigma(\gamma_j*.X_{ij}) = Z_i*$, where asterisk (*) indicates the estimated value of the probability and parameters. Then, probability of subscribing to mobile phones services, given the configuration of variables, is computable by: $\rho_i^M * = 1 / \{1 + \text{In} (-Z_i*)\}$. For continuous explanatory variable, such as, P_i^{CP} , the marginal effect can be determined by the following approximation formula. $\delta(\rho_i^M *)/\delta(P_i^{CP})= \rho_i^M * (1- \rho_i^M *). \beta*$. In case of dummy-explanatory variables, the marginal effect is computable by the *change-in probability method,* i.e., difference between two predicted probabilities for an event is calculated and the difference is interpreted as marginal effect.[5] The elasticity of $\rho_i^M *$ with respect to P_i^{CP} is computable at its sample mean value $[A(P_i^{CP})]$ by: $A(P_i^{CP}). (1- \rho_i^M *). \beta*$.[6] Other elasticities can also be computed at their mean values and by using this equation.[7]

4. Data and variable descriptions

The database for estimation is the sample survey of household subscribers and non-subscribers of mobile services, as described in section 2 above. The definition and specification

[5] This method is suggested by Liao. (1994).

[6] This approach to computation of elasticity is adopted from Train (1986).

[7] Alternatively, as in Rodini et al (2003), price elasticities can be calculated as average of household elasticities.

and sources of data for all price and non-price variables are given in **Table 3**. Descriptive statistics of all non-dummy variables are presented in **Table 4**. Construction of data for measuring the price variables in equation (1) and (2) for sample survey period (January-March 2003) is elaborated below.

Access price for fixed phone services (F_i^{AP}) comprised one time installation charges and monthly rentals. These access prices differed for subscribers located within the area served by telephone exchanges on two criteria: (a) exchange system capacity, and (b) location of exchanges in rural or urban areas.[8] These criteria were also the bases for determining the number of free calls for fixed phone subscribers. These differentials were ways of cross-subsidization of subscribers in small and rural areas by subscribers in large and urban areas. Using the survey information on the location of subscribers, access price is constructed for each of the subscribers of fixed phone service [i.e. sum of installation charges and rentals minus the value of free calls (i.e. number of free call multiplied by unit local call rate)]. On the other hand, usage/call price for fixes phones (F_i^{CP}) differed between rural and urban subscribers. The call rate used in this study refers to unit call charge for rural subscribers up to 250 calls and for urban subscribers up to 500 calls.

Karnataka Telecom Circle comprised four licensed providers of mobile telephone services: three private providers (Bharti Mobile, Spice Communication, and Hutch Essar South) and one public sector provider (BSNL). Access price included activation/installation charges and monthly rentals. These charges and rentals varied between the providers. In the same way, unit (per minute) call charges differed between incoming and outgoing calls at peak and off-peak hours. In the absence of information on the household subscription to mobile phones by name of providers, the access price (M^{AP}) is constructed by a sum of simple average of activation charges

[8] Exchange system capacity is measured by direct exchange lines. The lowest capacity was below 1000 lines and highest is 0.3 million and above. In addition, monthly rentals were differentiated in urban areas by low (up to 200 calls monthly) calling subscribers and high callers. This criterion is not adopted in this paper for lack of data on number of calls made by the sample subscribers.

and monthly rentals of all four providers. The usage price (M^{CP}) is constructed by a simple average of all unit call charges of all providers.[9]

5. Estimation results

Table 5 presents the estimation results of the Logit models. In total, 6 models are estimated by step-wise inclusion of different explanatory variables. Overall goodness of fit of the models is judged by the Likelihood Ratio test. The test statistic shows that all the estimated models are significant at 1 percent level or more by the Chi-square test. Pseudo R^2 is sensitive to number of explanatory variables and is highest for model 6. In terms of other qualitative indicators (e.g. sign and statistical significance of individual coefficients), all other variables in all models have predicted signs and significant, except the coefficient of access price variable. Thus, the following interpretation of estimation results is based on model 6.

The coefficients of price variables have predicted signs. This may be interpreted in two alternative ways. First, other things being the same, an increase in the access price of fixed phone services increases the demand for mobile phone services. This implies that mobile phones are a substitute for fixed phones. As compared to the coefficient of access price variable, the coefficient of usage price variable is significant and larger in magnitude. Thus, substitutability of fixed phones for mobile phones is largely influenced by the usage price rather than the access price of fixed phone services.

Monthly income from all sources is included as a measure of capacity of households to subscribe to mobile phone services. On the assumption that telecom is a normal service, the sign of the estimated coefficient is predicted to be positive. The estimation results show that in all the models the income variable has predicted sign and is significant. Thus, other things being

[9] In principle, access price should also include interest foregone on the refundable security deposit. This is excluded for the sake of simplicity of analysis and by presuming that the deposits are refunded with a market rate of interest. In addition, subscription to mobile requires succeeds the purchase of a handset. In case of fixed phones, the the telephone receiver was supplied by the provider and its charges were included in the monthly rentals. This implies that the price of handset may be a component of mobile access price. This is not included in this paper for lack of data on expenditure on handsets by sample mobile subscribers.

constant, a one percent increase in the monthly income of households will lead to unity increase in the logarithm of the odds that the household will chose to subscribe to mobile phone services.

Family size is included as an explanatory variable to estimate the impact of the number of persons in a household on probability of subscription to mobile phone services. It is presumed that demand for telecom services is higher, if the family size is bigger. The estimation results show that the estimated coefficient of family size variable is positive and significant. Thus, other things being constant, an increase in family size by addition of a new person will lead to an increase of about 1.34 times in the logarithm of the odds that households will choose to subscribe.

The impact of age of head of household is positive and the odds ratio is about 1.03. This implies that an increase in the age of head of households by one year results in increase of 0.031 in the logarithm of the odds that the household will chose to subscribe to mobile phone services.

Education variable is included to capture whether a literate or schooled household (i.e. head of household) has higher odds in favour of subscribing to mobile phone services than illiterate or unschooled households. The coefficient of dummy education variable is positive and significant. Thus, educated households have 1.34 times higher odds in favour of subscribing to mobile phone services than households in which the head of household is illiterate.

Caste variable is included to estimate whether household belonging to Scheduled Castes and Tribes have a different perception to subscribe to mobile phone services than households belonging to social categories. The estimation results show that coefficient of dummy caste variable is positive and significant. Thus, other things being constant, the odds for households belonging to Scheduled Castes and Tribes to subscribe to mobile phone services is about 1.92 times higher than for households belonging to other social casters and tribes.

Occupation variable is aimed to capture whether a household (i.e. head of household) working in rural sector occupations has higher odds in favour of subscribing to mobile phone services than households working in secondary and tertiary sector occupations. The estimated coefficient of dummy occupation variable is positive and significant. Thus, households who work in rural occupations have 1.23 times higher odds in favour of subscribing to mobile phone services. This

result provides with a strong empirical basis for expansion of rural subscription of mobile phone services in India.

Estimated probability

Table 6 presents the estimated probability of subscription to mobile phone services among the fixed phone subscribers. Probabilities are computed using the estimated equation (6) in Table 5 and for the average value of all non-dummy variables. For instance, given the average access price, usage price, income, family size and age of households, and if the head of household is literate, belongs to Scheduled Caste or Tribe category, and work in rural sector jobs, the computed probability of subscription to mobile services is equal to 0.47. Other things being equal, if the head of household is illiterate, belongs to non-Scheduled Caste or Tribe category, and work in non-rural sector jobs, the probability of subscription is reduced to 0.41. Hence, the marginal effect on probability is equal to 0.06. These results indicate the relative importance of different socio-economic background characteristics of households that influence the subscription to mobile phone services, especially among the socially backward castes and tribes and in rural areas.

Estimated price and income elasticity

Estimated price and income elasticity of probability of subscription to mobile phone services are presented in **Table 7**. These elasticities are computed for the average values of access price, usage price, and monthly income of households, and using the estimated results of model 6 in Table 5. Given the average access price, usage price, and monthly income, the computed elastcities are respectively equal to -0.284 percent, -10.390 percent, and 0.608 percent. Other things being the same, a rise in the average access price as well as the usage price of fixed phone services by 5 percent each results in substitution of fixed phone services for mobile phone services to the extent of 0.303 percent and 10.610 percent respectively. Or, a rise in monthly income of households by 5 percent increases mobile phone services to the extent of 0.638 percent. In essence, these elastcities single out the largest impact of changes in usage prices on subscription to mobile phone services, either through own negative price elasticity or positive

cross price elasticity of usage price of fixed phone services or through substitutability of fixed phone services for mobile phone services.

6. Estimation of demand for fixed phones

Demand for fixed phones is modeled below in the same framework of a binary logit model as in equation (3), except for the specification of access and usage prices. In particular, we specify price variables by the ratio of fixed phone prices to mobile phone prices. That is,

$$P_i^{AP*} = (F_i^{AP} / M^{AP}) \quad (4)$$

$$P_i^{CP*} = (F_i^{CP} / M^{CP}) \quad (5)$$

This implies that subscribers demand for fixed phones depends, among others, on the relative prices of access and usage of fixed and mobile phone services. Accordingly, the estimable equation for probability of subscription to fixed telephone services is as follows.

$$\text{In}\,[\rho_i^F / (1- \rho_i^F)] = \eta.\, P_i^{AP*} + \lambda.P_i^{CP*} + \Sigma(\theta_j.X_{ij}) , \quad (6)$$

Given the result that fixed phones are substitutable in mobile phone markets in mobile markets, a test for symmetry requires that mobile phones are substitutable for fixed phones in fixed phone markets. This is tested below by predicting the following signs on the coefficients of price variables: $\eta<0$, and $\lambda<0$, because $d(P_i^{AP*})/(dM^{AP})<0$, and $d(P_i^{AP})/(dM^{CP})<0$. Hence, $\delta(\rho_i^F)/\delta(P_i^{AP}) >0$, and $\delta(\rho_i^F)/\delta(P_i^{CP}) >0$.

Equation (6) is estimated by using the household subscribers and non-subscribers of fixed telephone services in Karnataka State, as described in section 2. Total number of observations is equal to 2200, in contrast to 1100 observations for the mobile demand estimation. To start with, model in (6) is estimated by using the same set of non-price explanatory variables in the mobile demand estimation. The estimation results are presented in **Table 8** under model 1. The coefficients of access price and usage price variables have predicted signs, and offer evidence for

substitutability of mobile phones for fixed phones. This evidence supports for the symmetry of substitutability in mobile and fixed phone markets. This symmetry may be attributable for use of both fixed and mobile phones by household subscribers for basic services. This was evident in section 2 from the usage of telecom services by current and future subscribers. This result is in contrast with asymmetry in fixed and mobile phone markets for developing countries in Garbacz and Thompson Jr (2007). In particular, these authors offered evidence for complementarity in residential demand model and for substitutability in mobile demand model.

Unlike the estimated mobile demand model 6 in Table 5, the estimated coefficients in model 1 in Table 8 are insignificant for age, family size, literacy variables, and opposite sign for caste and occupation variables. This may suggest that demand for the fixed phones may be influenced by other variables relating to subscribers and non-subscribers. To test for the same, model 1 in Table 8 is re-estimated with five new dummy explanatory variables: CASTE-NEW (=1, if household head belongs to Scheduled Caste/Tribe/Other Backward Castes/Tribes; =0 otherwise): EDUCATION-NEW (=1, if household head completed higher education; =0 otherwise): OCCUPATION-2 (=1, if household head is working in tertiary sectors; =0 otherwise): INCOME TAX PAYEE (=1, if household head paid income tax in 2000-01; =0 otherwise): and LOCATION (=1, if majority of friends and relatives of the household head live in local call area; =0 otherwise). The results with these new explanatory variables are summarized from model 2 through model 5 in **Table 8**. These results offer three contrasting evidence as compared to results in mobile demand model. First, both Caste and Caste-2 variables have negative coefficients. This implies that, other things being equal, probability of subscription to fixed phone services is less for households belonging to socially backward castes and tribes. Second, households with higher education rather than mere literacy have higher probability of subscription to fixed phone services. Third, households working in tertiary sector occupations rather than in rural sector occupations have higher probability of subscription. In addition, households who pay income tax have higher probability of subscription than those who earn less than income tax limits. Location of large number of friends and relatives in the local areas has a negative impact on subscription to fixed phones, because telephone may be less useful for social contact purposes. These results add to the unique factors that influence the probability of subscription to fixed phones in India.

It may noted here that the estimated coefficients of access price variable is bigger in fixed phone model than in mobile demand model, but in both the models the coefficient is insignificant.[10] In contrast, the coefficient of usage price variable is bigger in mobile demand model than in fixed phone model, and highly significant in both the models. Surprisingly, coefficient of income variable has the same magnitude in both the models. These comparisons signify the role of usage price variable in influencing the demand for mobile and fixed phones, including for policy purposes.

7. Implications for subsidization issues

India's National Telecom Policy 1999 emphasized on the Government's commitment to provisioning of basic telecom services to all people at affordable and reasonable prices. This commitment is called Universal Service Obligation (USO). Under the USO, the service providers are subsidized for their network expansion costs in rural and remote areas. The resources to meeting with implementation of USO are raised through a Universal Service Levy on all licensed providers of telecom services. The basis for the levy is a measure of providers' gross revenue. In addition, Telecom Regulatory Authority of India (TRAI) introduced the Access Deficit Charge (ADC) in 2003, financed by Interconnection Usage Charge, to subsidize the providers for continuing with their below the cost rentals and tariff in providing with universal access and services at affordable cost. A recent consultation paper by the TRAI (2008) present details of evolution and implementation status of these subsidies, and indicates for possibilities for merging ADC into USO.

The results of this paper have implications for above on-going policy discussions on subsidies. First, as fixed phones are substitutable for mobile phones, USO need not be liked with fixed phone services. Rather, it may be redefined by inclusion of substitutable mobile phone services. Second, if the ADC is abolished and the benefits are passed on to subscribers by way

[10] The simple correlation coefficient between access price and usage price is equal to 0.537. This does not imply for the presence of multicolinearity between these two prices. Nevertheless, model 6 in Table 5 and model 5 in Table 8 were re-estimated with access price or usage price variable. In all these re-estimations, coefficients of access price variable and usage price variables were negative and significant, and the sign and statistical significance of other explanatory variables remained the same.

of reduced access and usage prices, it would be contributory for expansion of both access and usage of telecom services in the rural areas because, other things being the same, persons in rural sector occupations have higher probability of subscribing to mobile telephone services. Third, given that usage price is highly significant and has the biggest impact on demand for mobile phones, the present design of subsidization may need a thorough reexamination of its basis from fixed to mobile phones, and from access price to usage price.

8. Conclusions and implications

Since 2000, mobile phone services have greatly expanded in India and contributed to increase in access to telecom services in terms of teledensity. At the same time, mobile phones have been offering stiff competition to expansion and retention of subscribers' base of the fixed phone services. Substitutability and complementarity between fixed and mobile phones is essential to determine the winners and losers of this competition.

This paper has proposed and implemented a simple methodology for estimation of price and non-price effects on the subscription of mobile and fixed phone services in India. Price effects are distinguished by access and usage prices of fixed and mobile phone services. The simple specification of access and usage prices accommodates uniform mobile prices and varying fixed phone prices. This formulation is useful for cross-section estimation of own and cross price effects, and to test for substitutability and complementarity between fixed and mobile phone services and its symmetry in fixed and mobile phone markets.

The descriptions and empirical results of this paper lead to the following major conclusions and implications. First, fixed phone services are substitutable for mobile phone services in India and vice versa. This symmetry is largely attributable for use of both mobile and fixed phones for basic services. Nevertheless, fixed phones are perceived to have many non-price advantages by current and future subscribers of fixed phone services in regard to their owning either or both fixed and mobile phones. If the fixed phone providers do not attempt to strengthen these advantages of fixed phone services, mobile phones may become the ultimate

winners in expanding and retaining subscribers' base in India. Second, probability of subscription to mobile phone services is significantly influenced by telecom prices, and socio-economic and demographic characteristics of subscribers, such as, income, age, social caste, occupation, and literacy of head of household and family size. The nature and magnitude of non-price determinants of subscription to fixed phones are different from subscription to mobile phones. These price and distinct non-price variables are useful to design for mobile and fixed phone promotion policies in India. This also suggests the complementary efforts required to increase literacy and education levels, because literates (or higher educated) have a higher probability to subscription to mobile (or fixed) phone services. Third, of all the price and non-price variables, the largest effect on probability of subscription to mobile and fixed phone services is evident for usage price of telecom services. This provides with an empirical basis for stronger price-based interventions for provisioning of universal access and services in India.

Given the evidence of this paper that fixed phones are substitutable for fixed phones, and subscription to mobile phone services is higher for household who belong to socially backward caste and tribes and who work in rural areas and occupations, the subsidization issue needs to be reexamined with emphasis on mobile phones. Whether mobile phone services would meet with the objectives of Universal Service Obligation without subsidization of fixed phone services may depend upon further affordability of mobile phone services in rural and remote areas. This will depend on the extent to which the withdrawal of subsidies is replaceable by lower access and usage price of telecom services. However, given that usage price is highly significant and has the biggest impact on demand for mobile phones, the present design of subsidization may need a thorough reexamination of its basis from fixed to mobile phones, and from access price to usage price. These topics are important extensions of this paper with potential implications for on-going policy debates for India in particular, and for other developing countries in general.

The empirical evidence in this paper is based on a small sample survey from within a state in India. A nationally representative survey in future may be useful to offer supporting evidence for the hypotheses tested and generalize conclusions and implications of this paper.

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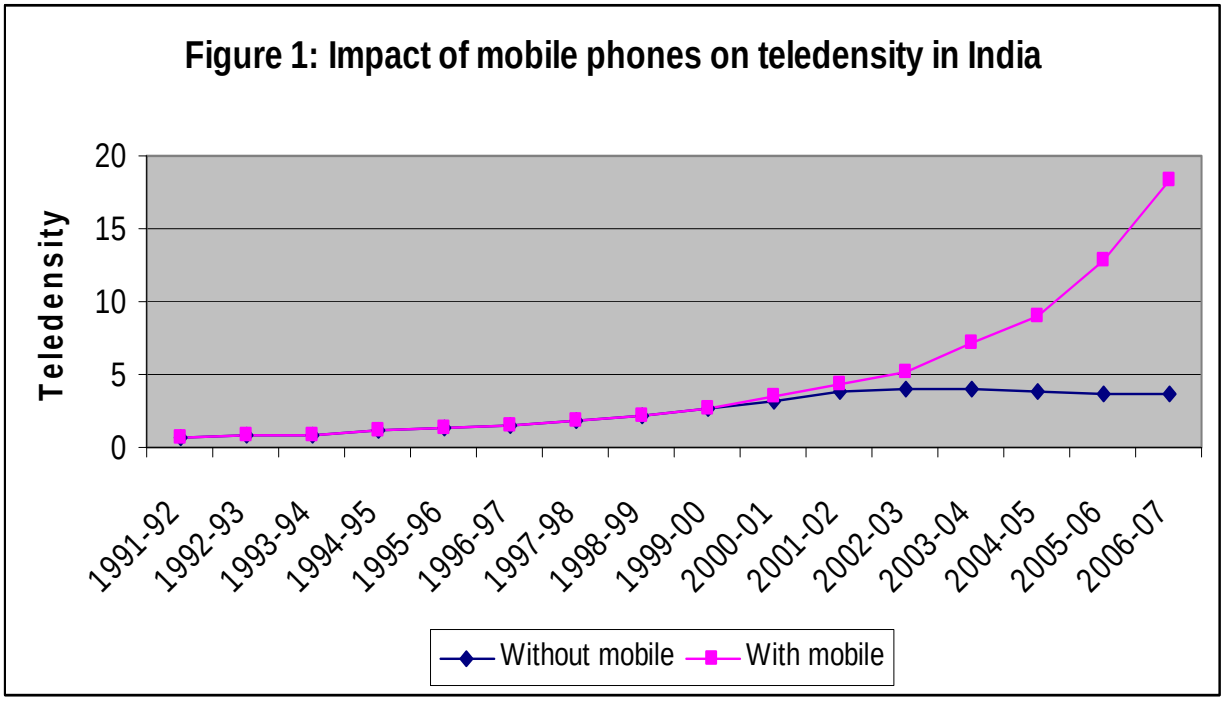
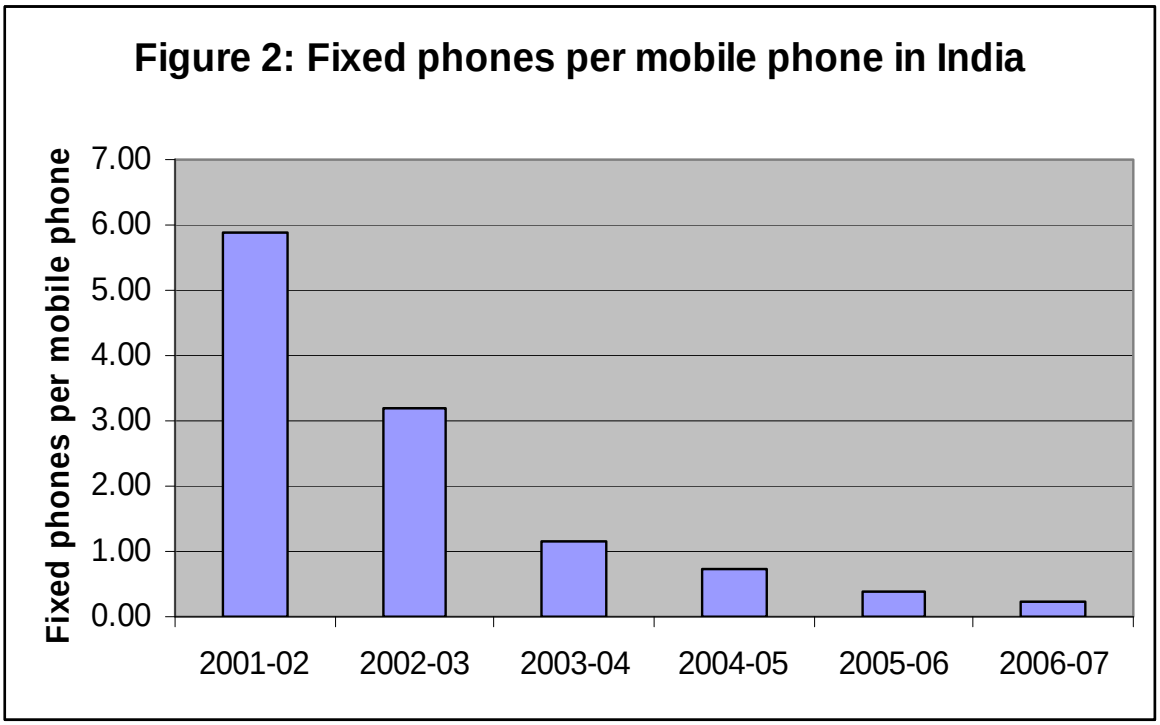


Source: Economic Survey of Government of India – Various issues.



Source: Economic Survey of Government of India – Various issues

Table 1: Utilization of mobile phone services by fixed phone subscribers in India

Indicators of mobile telephone services	Percent of mobile subscribers
1. Type of services used	
• Basic services: Local calls	41.38
• Basic services: STD	37.93
• Basic services: ISD	3.45
• Value added services	5.75
2. Reasons for having a mobile telephone along with a fixed telephone	
• Necessary for job which involves frequent movements	27.59
• Can be contacted anywhere and at any time	25.29
• Easy to handle	20.69
• Low call rates	8.05
• Less rental rates	14.94
• Easy to get connection	28.74
• No waiting period	12.64
• Reasonable registration charges	9.20
• No problems in billing	8.05
• Better quality of service	4.60
• No fault repair problems	4.60
• Indicator of social status	18.39
• Flexibility in choosing call rates and number of calls	12.64
3. Reasons for having a fixed telephone along with a mobile telephone	
• Useful to family members and contacts	31.03
• Give identify/proof of residence	17.24
• Have many supplementary basic services	12.64
• Has many supplementary value added services	2.30
• Directory facility exists	24.14
• Costly if only mobile telephone is used	2.30
• Useful to operate cordless telephone	2.30
• Useful if mobile telephone is out of order or *vice versa*	14.94
• Flexibility in choosing call rates between fixed and mobile phones	19.54

Source: Author's survey.

Table 2: Probable utilization of mobile phone services by current non-subscribers in India

Indicators of mobile telephone services	Percent of non-subscribers
1. If subscribed to a telephone, type of services to be used	
• Local calls	67.94
• STD	65.07
• ISD	4.31
• Value added services	6.70
2. Reasons to have a fixed telephone without a mobile telephone in future	
➢ Useful to family members and contacts	72.82
➢ Give identify/proof of residence	15.09
➢ Have many supplementary basic services	2.00
➢ Directory facility exists	30.55
➢ Low call rates	26.45
➢ Useful to operate cordless telephone and/or extension lines within the house	1.18
➢ Easy to handle	12.27
➢ Less registration and rental charges	1.73
3. Reasons to have a mobile telephone along with a fixed telephone in future	
➢ Necessary for job which involves frequent movements	8.27
➢ Can be contacted anywhere in the world	14.73
➢ Easy to handle	2.00
➢ Low rental rates	1.18
➢ Easy to get connection	6.55
➢ No waiting period	3.64
➢ Reasonable registration charges	1.00
➢ No problems in billing	2.82
➢ No fault repair problems	2.73
➢ Indicator of social status	9.64
➢ No problem of transfer along with residence transfer	1.45
➢ Flexibility in choosing call rates and number of calls	1.73
4. Reasons for not wishing to have a mobile telephone in future	
➢ Not necessary	62.18
➢ Not aware of providers	1.55
➢ Not aware of uses/services	7.18
➢ Not aware of cost	2.18
➢ Have a fixed telephone	7.36
➢ No directory facility	0.64
➢ Costly	37.91

Source: Author's survey

Table 3: Definition, specification, and data sources of variables

List of variables	Definition and specification	Data source
Dependent variable		
Subscription to telecom services	=1, if subscribed to a mobile phone =0, otherwise	Author's sample survey
Independent variables		
1. Access price	Access price of mobile phone services minus access price of fixed phone services in Indian rupee at current prices	TRAI (2002a and 2002b)
2. Usage price	Unit call price of mobile phone minus call price of fixed phone in Indian rupee at current prices	TRAI (2002a and 2002b)
3. Income	Monthly income in Indian Rupee at current prices	Author's sample survey
4. Age	Actual completed age	Author's sample survey
5. Family Size	Total number of household members	Author's sample survey
6. Education	=1, if literate/educated =0, otherwise	Author's sample survey
7. Occupation	=1, if working in agricultural sectors =0, otherwise	Author's sample survey
8. Caste	=1, if belong to Scheduled Caste and Tribute =0, otherwise	Author's sample survey

Notes: All variables in the table are defined with respect to the head of household except the family size variable.
Source: Author.

Table 4: Descriptive statistics

Variable	Mean	Standard deviation	Maximum	Minimum
1. Access price	534.86	239.96	946.00	336.00
2. Usage price	2.15	0.10	2.26	2.06
3. Income	5729.74	4158.15	55000.00	600.00
4. Family size	5.21	2.25	20.00	2.00
5. Age	37.91	11.25	75.00	16.00

Source: Author

Table 5: Determinants of subscription to mobile phone services: Estimates of Binary Logit Model

Independent variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
INTERCEPT	18.426* [5.823]	-12.406** [6.24]	13.923** [6.459]	-15.521* [2.922]	12.388*** [6.620]	12.942*** [6.700]
ACCESS PRICE	-0.001 [0.001]	-0.001 [0.001]	-0.001 [0.002]	-0.001 [0.002]	-0.001 [0.002]	-0.001 [0.002]
USAGE PRICE	-9.914* [2.913]	-7.844* [3.096]	-8.880* [3.263]	-8.938* [3.327]	-8.877* [3.340]	-9.112* [3.381]
INCOME		0.0002* [0.00003]	0.0002* [0.00003]	0.0002* [0.00003]	0.0002* [0.00003]	0.0002* [0.00003]
FAMILY SIZE			0.146** [0.057]	0.133** [0.578]	0.141* [0.058]	0.126** [0.060]
AGE				0.028** [0.013]	0.031** [0.014]	0.031** [0.014]
EDUCATION					0.292** [0.144]	0.294** [0.144]
CASTE					0.637 [0.399]	0.652*** [0.399]
OCCUPATION						0.208*** [0.127]
-2 Log likelihood	171.060	147.204	87.150	142.224	139.639	138.404
Chi-square	33.69*	81.40*	144.328*	91.360*	96.53*	99.000*
Pseudo-R^2	0.090	0.217	0.232	0.243	0.257	0.263
N	1100	1100	1100	1100	1100	1100

Notes: (1) Figures in the parentheses are standard errors. (2) * significant at 1 percent level; ** at 5 percent level; and *** at 10 percent level.
Source: Author

Table 6: Estimated probability of subscription to mobile phone services in India

Socio-economic and demographic characteristics	Estimated probability	Marginal effect on probability	
1. Given the average access price, usage price, income, family size and age of households: and if the head of household is: literate, belongs to Scheduled Caste or Tribe category, and work in rural sector jobs	0.470		
2. Same as in (1), except that the head of household works in non-rural sector jobs		0.456	
3. Same as in (1), except that the head of household: illiterate, belongs to non-Scheduled Caste and Tribe category, and work in non-rural sector jobs			0.409

Source: Author.

Table 7: Estimated price and income elasticity of subscription to mobile phones services among fixed phone subscribers in India

Assumptions	Price elasticity		Income elasticity
	Access price	Usage price	
(1) Given the average access price, usage price, income, family size and age of households and the head of household is literate, belongs to Scheduled Caste or Tribe category, and work in rural sector jobs	-0.284	-10.390	0.608
(2) Same as in (1) except that average price of access price and usage price of fixed phone services is increased by 5 percent each	0.303	10.610	
(3) Same as in (1) except that average price of access price and usage price of mobile phone services is increased by 5 percent	-0.317	-11.129	
(4) Same as in (1) except that average income is increased by 5 percent			0.638

Source: Author

Table 8: Determinants of subscription to fixed phone services: Estimates of Binary Logit Model

Independent variables	Model 1	Model 2	Model 3	Model 4	Model 5
INTERCEPT	0.446 [0.487]	0.926 [0.484]	0.693 [0.454]	0.477 [0.440]	0.837 [0.455]
ACCESS PRICE	-.201 [0.277]	-.208 [0.279]	-.204 [0.279]	-.189 [0.280]	-.224 [0.279]
USAGE PRICE	-3.751** [1.656]	-3.404** [1.671]	-3.473** [1.670]	-2.976*** [1.673]	-3.187*** [1.676]
INCOME	0.0002* [0.00002]	0.0002* [0.00002]	0.0002* [0.00002]	0.0002* [0.00002]	0.0001* [0.00002]
FAMILY SIZE	0.009 [0.025]				
AGE	-0.005 [0.004]	-0.006 [0.004]			
EDUCATION	0.189 [0.131]				
CASTE	-0.291* [0.399]	-0.182 [0.116]	-0.189*** [0.115]	-0.307*** [0.111]	
OCCUPATION	-0.273* [0.092]	-.189** [0.093]	-.199** [0.093]	-.218** [0.091]	-.206** [0.091]
CASTE-2		-0.399* [0.115]	-0.377* [0.114]		-0.432* [0.110]
EDUCATION-2		0.259** [0.118]	0.284 [0.117]	0.212** [0.116]	0.249** [0.117]
OCCUPATON-2		-0.347*** [0.198]	-0.343*** [0.201]		
INCOME TAX PAYEE		0.894* [0.207]	0.892* [0.207]	0.910* [0.206]	0.997* [0.206]
LOCATION				-0.318* [0.098]	-0.325* [0.098]
-2 Log likelihood	1409.493	1389.456	1390.444	1392.050	1388.171
Chi-square	230.85*	270.93*	268.96*	265.75*	273.49*
Pseudo-R^2	0.076	0.088	0.088	0.087	0.090
N	2200	2200	2200	2200	2200

Notes: (1) Figures in the parentheses are standard errors. (2) * significant at 1 percent level; ** at 5 percent level; and *** at 10 percent level.
Source: Author.