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# The Determinants of the Global Mobile Telephone Deployment: An Empirical Analysis

Sheikh Taher ABU[1], Masatsugu TSUJI[2]
[1, 2] GSAI, University of Hyogo, 1-3-3, Higashi-Kawasaki-Cho, Kobe 650-0044, Japan
knipuljp@yahoo.co.jp, tsuji@ai.u-hyogo.ac.jp

*This study aims to analyze the global mobile phones by examining the instruments stimulating the diffusion pattern. A rigorous demand model is estimated using global mobile telecommunications panel dataset comprised with 51 countries classified in order to World Bank income categories from 1990-2007. In particular, the paper examines what factors contribute the most to the deployment of global mobile telephones. To construct an econometric model, the number of subscribers to mobile phone per 100 inhabitants is taken as dependent variable, while the following groups of variables (1) GDP per capita income and charges, (2) competition policies (3) telecom infrastructure (4) technological innovations (5) others are selected as independent variables. Estimation results report the presence of substantial disparity among groups. Additionally GDP per capita income and own-price elasticity comprised with call rate, subscription charges, are reported. The analysis of impulse responses for price, competition policies, and technological innovations such as digitalization of mobile network, mobile network coverage indicates that substantial mobile telephone growth is yet to be realized especially in developing countries. A new and important empirical finding is that there are still many opportunities available for mobile phone development in the world pro-poor nations by providing better telecom infrastructure.*
***Keywords:*** *Mobile Phone Adoption, 3G, Technological Innovations, Competition Policy, Panel Data Analysis, Digital Divide*

## 1 Introduction

The total number of worldwide mobile phone use surpassed the number of fixed telephone network in 2002. It took a century for the world to accumulate the first billion fixed telephones, but only a decade or so to do the same with mobile phones. Projections from [1] suggested that the world would continue to add mobile lines faster than fixed lines; indeed, the next billion new phone users would use primarily mobile phones. The projections have impacted both the developed and the developing world, but may be doing so in different ways such as voice and data communications.

Mobile phone usage has doubled worldwide since 2000 especially after the digitalization of mobile network, with developing countries leading the surge. Living standards and economic growth in developing countries are invariably linked to the availability and use of telecom services [2]. There are now approximately 3.19 billion mobile phone subscribers worldwide, more than half of the human population. That is a significantly faster rate of growth for the technology than landline service, which now totals 1.85 billion users a century after it was invented, as well as Internet service, which grew from 400 million users in 2000 to approximately 1.27 billion users by 2007.

The bulk of the growth in mobile phone usage came from large developing countries, in particular China, India, and Russia. Such countries now account for 56% of all mobile phone users and 79% of the growth since 2000. China alone is now reporting 547 million users, more than one quarter of its population yet larger than the population of the United States. India claims 223 million mobile phone subscribers, more than 25% increase in 2007 alone. Russia, meanwhile, jumped from 73 million subscribers in 2004 to 163 million as of September 2007.

**Table 1.** Mobile penetration by World Bank income categories

| World Bank 2007 categorization (GNI per capita '06) | Five largest countries | Population 2006 (millions) | Fixed phones 2006 (millions) | Median Fixed phones per 100 (y) | Mobile Phones 2006 | Mobile Fixed Ratio per 100 (x/y) | Median Mobile phones per 100 (x) |
|---|---|---|---|---|---|---|---|
| Low income<$905 | India+<br>Pakistan<br>Bangladesh<br>Nigeria<br>Vietnam | 2,409 | 75 | 0.9 | 329 | 8.3 | 7.5 |
| Lower middle income $906-$3,595 | China<br>Indonesia<br>Philippines<br>Egypt<br>Iran | 2,289 | 479 | 10.9 | 850 | 2.8 | 30.4 |
| Upper middle income $3,596-$11,115 | Brazil<br>Russia<br>Mexico<br>Turkey<br>South Africa* | 834 | 181 | 20.2 | 571 | 3.3 | 65.8 |
| High income > $11,116 | United States<br>Japan<br>Germany<br>France<br>United Kingdom | 1,030 | 535 | 44.3 | 935 | 2.3 | 100.8 |
| World totals** | | 6,563 | 1,270 | 13.2 | 2,685 | 3.8 | 50.8 |

*Note:* + India is categorized as Lower middle income country according to ITU, 2008 Statistics
* South Africa studies are included in the review despite upper-middle income classification
** World totals *N* = 2008, excludes some small geographic not appearing in the World Bank Classification or in the ITU statistics
Sources: Telecom and Population: ITU Free Statistics (2007), Country Income Categorizations: the World Bank (2007)

Table 1 illustrates the nature and magnitude of mobile phone use across four income categories as defined by the World Bank. As with the case of other communication technologies, GDP per capita and mobile use is highly correlated [3], thus it is not surprising that the highest concentration of mobile phones is in the high-income nations; the 1,030 million people living in these 54 nations owned 935 million mobiles; a median per-country penetration of 100.8 lines per 100 people.
The structure of the paper is as follows. Section 2.examines the previous literature related to deployment of mobile phones. Section 3.discusses digitalization of global mobile phone services and market trend followed by 2G and 3G services. Section 4 explains the empirical analysis followed by methodology, data sources, and empirical results. Section 5 elaborates estimation results. Section 6 concludes with a summary of the results, their implications, and discussion.

## 2 Literature review

Mobile phone services have experienced drastic growth in recent years, especially in the developing countries. In the last decade, following the establishment of the global system for mobile communication (GSM) and code division multiple access (CDMA) technologies, the market has seen a remarkable growth in the digital mobile phone services. Generally, economists believe that the diffusion of mobile phone services is affected by further technological innovations, such as the transition from analogue to digital technology, the regulation of spectrum licensing, competition [4], 3G mobile phones adoptions [5], and other factors such as fixed telephone services [6]. However, the main determinants for global mobile phones that brought high penetration are still in doubt among policy makers and researchers apart from 3G adoptions.

Studies have suggested that economic wealth of a nation stimulates demand for mobile phones. Ahn and Lee [7] were first to undertake a cross-country modelling of mobile services using ITU data for one year. They find a complementary relationship between mobile phones and per capita GDP. Substitution effect between mobile and fixed-telephone is estimated by [8] with ITU 1994-2000 in a lagged dependent variable model. They find mobile phone can be a substitution for fixed-telephone of many countries. Madden and Coble-Neal [9] find that technological substitution in some countries and economic substitution in others may explain differential patterns of development in global fixed and mobile telephony. Telecommunications demand model is estimated for residential mainline and mobile telephone service for developing countries for the period 1996-2003 by [2]. Their findings show that mobile phones are not substitutes in the wire line market, and in fact may be considered complements.

Only a few studies empirically address standardization policy as the key measure for mobile phone deployment. Gruber and Verboven [4] conclude the early diffusion of digital technologies in mobile markets was faster in Europe because of single standard. Koski and Krestchmer [10] focus on the effects of standardization through two approaches and conclude that standardization has a positive but insignificant effect on the timing of initial entry of 2G services. Market-mediated standardization policy contribution to international diffusion of digital mobile phone has investigated by [11].

Instead, many of the diffusion studies seem to be econometric, relying on aggregate measures of mobile phone penetration, compared across nations. Some researches explain penetration rates using geography and income level [12], income alone Rouvinen (2006), Socio-cultural attributes and Internet and telecom use [13] or national industry structure, pricing schemes and feature availability [14] [15].

Based on the literature, this paper is aimed at finding the best-suited diffusion factors for mobile phone services of 51 countries in the world in order to understand the main determinants of diffusion at a provision of economy, market size, mobile cost, fixed network, telecom infrastructure, technology and technological innovation. The empirical results aim to produce useful insights for regulators, policy makers, and operators contributing to the further development of the mobile telecommunication market at a national level, especially with respect to the future of 3G services.

## 3 Digitalization of global mobile network and market trend

Digitalization of mobile network was first introduced worldwide during the early 1990s [16]. Denmark, France, Germany launched its first digital mobile phones in 1992 while some countries launched after 2000 such as Bhutan and Colombia with the adoption of GSM or CDMA technology. Since then, mobile phones have shown a remarkable growth through its 2G network until 2000. During 2001-2005, most of the developed countries have demonstrated to upgrade 2G network to 3G and asked for government and private initiative via its existing network. In addition to a competitive licensing policy that opened the market for 3G, public-private initiative helped guide market to develop 3G network. Consequently, the diffusion process accelerated rapidly because of fierce competition, especially encouraging to the new entrant using the same network and technology. In terms of ITU 2008 report, (60.80%) countries have perfect competition while (10.23%) monopoly and (28.98%) become partial competition, respectively.

**Table 2.** Countries used in the study in order to GDP per capita income*

| **Developing countries** | | | **Developed countries** | |
|---|---|---|---|---|
| **Lower Income countries** | **Lower-middle income countries** | **Upper-middle income countries** | **High-income OECD countries** | **High-income non-OECD countries** |
| Bangladesh ($428) | Bhutan ($1,982) | Argentina ($6,636) | Australia ($45,590) | Bahrain ($26,127) |
| Cambodia ($598) | China ($2,604) | Brazil ($6,852) | Canada ($43,368) | Estonia ($15,932) |
| Ghana ($647) | Colombia ($3,648) | Chile ($9,854) | Denmark ($57,257) | Hong Kong ($28,685) |
| Kenya ($786) | Egypt ($1,770) | Costa Rica ($5,801) | France ($40,090) | Israel ($23,383) |
| Myanmar ($379) | India ($976) | Malaysia ($7,027) | Germany ($40,162) | Singapore ($36,370) |
| Nepal ($419) | Indonesia ($1,869) | Mexico ($8,386) | Italy ($35,585) | Saudi Arabia ($15,255) |
| Pakistan ($996) | Jordan ($2,654) | Poland ($11,008) | Japan ($34,225) | Quarter ($75,978) |
| Vietnam ($815) | Maldives ($3,454) | Russia ($9,050) | South Korea ($19,841) | |
| | Peru ($3,880) | South Africa ($5,826) | Netherlands ($46,669) | |
| | Philippines ($1,639) | Venezuela ($8,559) | New Zealand ($31,219) | |
| | Sri Lanka ($1,676) | | Sweden ($49,873) | |
| | Thailand ($3,841) | | Switzerland ($56,579) | |
| | | | United Kingdom ($45,549) | |
| | | | United States ($45,047) | |

*The countries are classified according to ITU statistics (2008) and GDP per capita shows in the parentheses according to UN data (2009)
Source: ITU statistics (2008); UN (June, 2009)

### 3.1 2G and 3G network

2G networks are sufficient for voice, but there is a growing interest in shifting from 2G to 3G, based on a number of important drivers. First, the higher speed of 3G technologies interprets into added convenience, capacity and functionality for the subscriber. Second, there is much excitement over adding IP capability, and hence Internet access, to the mobile phone. 3G networks use the spectrum more efficiently, and support a family of global standards to facilitate roaming. In developing 3G standards, ITU worked with regional bodies and industry associates to reduce a large number of initial proposals to a smaller number of global standards such as IMT-2000 family to ensure interoperability.

The mainstream of the IMT-2000 was to harmonize different radio interfaces and produce a single family of 3G standards that would be able to cover future value-added services and applications. Three different access technologies such as time division multiple access (TDMA), CDMA and frequency division multiple access (FDMA) for five radio interfaces were included in the IMT-2000 family. Most deployments to date have implemented one of two interfaces, CDMA 2000 and wide-band code division multiple access (W-CDMA) same as universal mobile telecommunication system (UMTS) in Europe. China has chosen a third interface, time division synchronous code division multiple accesses (TD-SCDMA), for its national deployment of 3G.

**Table 3.** Category of variables, definitions and sources

| Category | Variable | Definitions and source |
|---|---|---|
| **Dependant** | MOBILE100 | number of mobile phones per 100 population, ITU |
| **Wealth** | Income* | GDP per capita income, ITU & World Bank |
| **Cost of mobile** | Rate3M*<br>chargeM* | price per 3 minutes peak time (in US$), ITU<br>monthly mobile phone charges (in US$), ITU |
| **Market size** | Pdensity<br>Urb | population density (per km$^2$), World Bank<br>percentage of urban population, World Bank |
| **Infrastructure** | Network<br>Switch | percentage of mobile network coverage, ITU<br>telecommunication switching capacity, ITU |
| **Fixed network** | FPEN100<br>chargeF<br>Rate3F<br>waitingF1000 | fixed telephones per 100 inhabitants, ITU<br>fixed phones connection charge (in US$), ITU<br>3 minutes peak-time rate for fixed phones (in US$), ITU<br>waiting lists for fixed phones per 1000 inhabitants, ITU |
| **Technology** | PCPEN100<br>INPEN100<br>Bandwidth | PC penetration per 100 inhabitants, ITU<br>Internet penetration per 100 inhabitants, ITU<br>Internet bandwidth bits per inhabitants, ITU |
| **Competition** | COMP | competition dummy, 1 if competition exist, 0 otherwise |
| **Technological innovation** | DIGITAL | mobile phone digitalization dummy, 1 after digitalization. 0 before digitalization, Euromonitor, ITU |

*Income and price variables are adjusted to constant 1995 US dollars using World Bank Consumer Price Index

## 4 Empirical Analysis

In order to fully examine the underlying variables selected in the analysis, the study utilizes a secondary dataset and conducts methodologies such as panel data analysis to investigate the role of the aforementioned factors in affecting mobile phone diffusion at the national level. Models are estimated via ordinary least squares with fixed effects using data for up to 51 countries depending on information available for countries included in the study according to World Bank country classifications for the period 1990-2007. All data are entered in log form so that coefficient estimates may be interpreted as elasticity. Countries are defined in order to ITU's income classifications. Table 2 represents the countries by GDP per capita income from which individual model data are drawn.

### 4.1 Empirical model and methodology

The most widespread method of estimating models of diffusion on pooled cross-section or aggregate time-series data is to use two-stage procedure that was first introduced by [17] in his seminal study on hybrid corn. In this first stage, a logistic, or some other S-shaped curve, is imposed on the data on a proportion of the adopters. The second stage consists of using a linear regression to explain the slope coefficient of the fitted curves representing diffusion in terms of various factors.

In this estimation, a fixed effect model is used as a special case of random effects model of panel data analysis. It assumes that the dataset being analyzed consists of a hierarchy of different countries used in the study whose differences relate to that hierarchy. Simply, the model can be written as follows:

$Y_{it} = \alpha_i + \beta X_{it} + u_{it}$, with $v_{it} = \alpha_{it} + u_{it}$

where *Y* and *X* represent dependent and independent variables, respectively. Or more specifically the model can be written in log form as:

$$\ln(\text{MOBILE}/_{100}) = \beta_0 + \sum \ln \beta_{it} X_{it} + \sum \beta_{it} dummy_{it} + u_{it}$$

Where, ln (MOBILE/$_{100}$) is the number of mobile phones per 100 population of the *i*th country at time *t*, $X_{it}$ is the vector of repressors, $\beta_{it}$ is the vector of coefficients, $\alpha_i = \alpha$ are the fixed effects, and $u_{it}$ is the error term, then $\alpha_i$ assumes a normal distribution with mean zero and a constant variance that allows to estimate the model representing $v_{it}$ for the standard error. $dummy_{it}$ explains the variables consider in the analysis which take binary variables 0 and 1 for each factor. Table 3 contains the variable definitions and source.

**Table 4**. Result of estimation (world)

| Dependent variable: No. of mobile phones per 100 population (MOBILE100) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Extended Model** | | | | | | **Reduced Model** | | | | | |
| | **Coef.** | **Std. Err.** | **t** | **P>\|t\|** | | **MPEN100** | **Coef.** | **Std. Err.** | **t** | **P>\|t\|** | |
| Rate3M | -0.2104 | 0.1014 | -2.08 | 0.041 | ** | Rate3M | -0.2344 | 0.0725 | -3.23 | 0.001 | *** |
| chargeM | -0.2169 | 0.0961 | -2.26 | 0.027 | *** | chargeM | -1.0732 | 0.0754 | -14.23 | 0.000 | *** |
| INCOME | 0.5661 | 0.2857 | 1.98 | 0.051 | ** | INCOME | 1.1121 | 0.2515 | 4.42 | 0.000 | *** |
| pdensity | 0.0007 | 0.0005 | 1.40 | 0.165 | | pdensity | 0.0008 | 0.0003 | 3.07 | 0.002 | *** |
| Network | 1.7117 | 0.4461 | 3.84 | 0.000 | *** | Network | 3.4979 | 0.5318 | 6.58 | 0.000 | *** |
| FPEN100 | 1.1057 | 0.3328 | 3.32 | 0.001 | *** | FPEN100 | (deleted) | | | | |
| chargeF | -0.0482 | 0.1068 | -0.45 | 0.653 | | chargeF | -0.6253 | 0.1105 | -5.66 | 0.000 | *** |
| INPEN100 | 0.1912 | 0.0907 | 2.11 | 0.038 | ** | INPEN100 | (deleted) | | | | |
| rateF | -0.5671 | 0.2204 | -2.57 | 0.012 | *** | rateF | 0.7733 | 0.2187 | 3.54 | 0.001 | *** |
| PCPEN100 | 0.3433 | 0.2874 | 1.19 | 0.236 | | PCPEN100 | (deleted) | | | | |
| Bandwidth | 0.0999 | 0.0362 | 2.76 | 0.007 | *** | Bandwidth | (deleted) | | | | |
| DIGITAL | 0.2539 | 0.1392 | 1.82 | 0.072 | * | DIGITAL | 0.7677 | 0.1411 | 5.44 | 0.000 | *** |
| _cons | -13.3135 | 3.0705 | -4.34 | 0.000 | *** | _cons | -20.5476 | 3.2347 | -6.35 | 0.000 | *** |
| | R-sq | within | 0.9339 | | | | R-sq | within | 0.8524 | | |
| | | between | 0.7547 | | | | | between | 0.5357 | | |
| | | overall | 0.6547 | | | | | overall | 0.4652 | | |
| | Observations | | 234 | | | | Observations | | 243 | | |
| | Countries | | 51 | | | | Countries | | 51 | | |

***, **, and * represent 1%, 5%, and 10% significance levels, respectively

### 4.2 Extended model

A total of 51 countries were analyzed employing regression analysis. Results were identified in order to extract the importance of each groups classified in the analysis. To meet the assumptions of variables classified in Table 3, two models were estimated. We first measure the extended model for world, developed and developing countries and then for reduced model. Each group was identified according to the variables selected in the analysis. Also, after testing Pearson's correlation method (r>.8) in independent variables, some variables are removed to overcome biasness in reduced model.

With regard to variables selected in the empirical analysis, we next discuss the results of identifying factors promoting mobile phones in both models. Variables are classified as wealth, mobile phone user cost, market size, infrastructure, fixed network, technology, technological innovation. Table 4, 5, and 6 represents the estimation results of extended and reduced model.

**Table 5.** Result of estimation (developed countries)

| **Dependent variable: No. of mobile phones per 100 population (MOBILE100)** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Extended Model** | | | | | | **Reduced Model** | | | | | |
| | **Coef.** | **Std. Err.** | **t** | **P>\|t\|** | | | **Coef.** | **Std. Err.** | **t** | **P>\|t\|** | |
| chargeM | -0.3634 | 0.0648 | -5.61 | 0.000 | *** | chargeM | -0.4554 | 0.0602 | -7.57 | 0.000 | *** |
| Rate3M | 0.0286 | 0.0664 | 0.43 | 0.667 | | Rate3M | -0.0742 | 0.0596 | -1.24 | 0.216 | |
| INCOME | 0.0076 | 0.2555 | 0.03 | 0.976 | | INCOME | 0.5798 | 0.1959 | 2.96 | 0.004 | *** |
| Pdensity | -0.4178 | 0.5960 | -0.70 | 0.485 | | Pdensity | -0.3177 | 0.5671 | -0.56 | 0.576 | |
| Network | 6.3787 | 1.8219 | 3.50 | 0.001 | *** | Network | 6.6777 | 1.8532 | 3.60 | 0.000 | *** |
| FPEN100 | 0.8713 | 0.5296 | 1.65 | 0.102 | * | FPEN100 | 1.5346 | 0.4785 | 3.21 | 0.002 | *** |
| rateF | 0.2123 | 0.2084 | 1.02 | 0.310 | | rateF | 0.2940 | 0.2062 | 1.43 | 0.156 | |
| chargeF | -0.3209 | 0.0876 | -3.66 | 0.000 | *** | chargeF | -0.3715 | 0.0833 | -4.46 | 0.000 | *** |
| PCPEN100 | 0.5278 | 0.2117 | 2.49 | 0.014 | ** | PCPEN100 | (deleted) | | | | |
| INPEN100 | 0.3204 | 0.0607 | 5.28 | 0.000 | *** | INPEN100 | 0.3808 | 0.0437 | 8.71 | 0.000 | *** |
| DIGITAL | 0.1217 | 0.1061 | 1.15 | 0.253 | | DIGITAL | 0.1375 | 0.1071 | 1.28 | 0.201 | |
| _cons | -28.0354 | 10.2307 | -2.74 | 0.007 | *** | _cons | -36.3233 | 10.1861 | -3.57 | 0.001 | |
| | R-sq | within | 0.9477 | | | | R-sq | within | 0.9486 | | |
| | | between | 0.2902 | | | | | between | 0.4115 | | |
| | | overall | 0.5585 | | | | | overall | 0.638 | | |
| | Observations | | 170 | | | | Observations | | 167 | | |
| | Countries | | 21 | | | | Countries | | 21 | | |

***, **, and * represent 1%, 5%, and 10% significance levels, respectively

**Table 6.** Result of estimation (developed countries)

| **Dependent variable: No. of mobile phones per 100 population (MOBILE100)** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Extended Model** | | | | | | **Reduced Model** | | | | | |
| | **Coef.** | **Std. Err.** | **t** | **P>\|t\|** | | | **Coef.** | **Std. Err.** | **t** | **P>\|t\|** | |
| chargeM | -0.3634 | 0.0648 | -5.61 | 0.000 | *** | chargeM | -0.4554 | 0.0602 | -7.57 | 0.000 | *** |
| Rate3M | 0.0286 | 0.0664 | 0.43 | 0.667 | | Rate3M | -0.0742 | 0.0596 | -1.24 | 0.216 | |
| INCOME | 0.0076 | 0.2555 | 0.03 | 0.976 | | INCOME | 0.5798 | 0.1959 | 2.96 | 0.004 | *** |
| Pdensity | -0.4178 | 0.5960 | -0.70 | 0.485 | | Pdensity | -0.3177 | 0.5671 | -0.56 | 0.576 | |
| Network | 6.3787 | 1.8219 | 3.50 | 0.001 | *** | Network | 6.6777 | 1.8532 | 3.60 | 0.000 | *** |
| FPEN100 | 0.8713 | 0.5296 | 1.65 | 0.102 | * | FPEN100 | 1.5346 | 0.4785 | 3.21 | 0.002 | *** |
| rateF | 0.2123 | 0.2084 | 1.02 | 0.310 | | rateF | 0.2940 | 0.2062 | 1.43 | 0.156 | |
| chargeF | -0.3209 | 0.0876 | -3.66 | 0.000 | *** | chargeF | -0.3715 | 0.0833 | -4.46 | 0.000 | *** |
| PCPEN100 | 0.5278 | 0.2117 | 2.49 | 0.014 | ** | PCPEN100 | (deleted) | | | | |
| INPEN100 | 0.3204 | 0.0607 | 5.28 | 0.000 | *** | INPEN100 | 0.3808 | 0.0437 | 8.71 | 0.000 | *** |
| DIGITAL | 0.1217 | 0.1061 | 1.15 | 0.253 | | DIGITAL | 0.1375 | 0.1071 | 1.28 | 0.201 | |
| _cons | -28.0354 | 10.2307 | -2.74 | 0.007 | *** | _cons | -36.3233 | 10.1861 | -3.57 | 0.001 | |
| | R-sq | within | 0.9477 | | | | R-sq | within | 0.9486 | | |
| | | between | 0.2902 | | | | | between | 0.4115 | | |
| | | overall | 0.5585 | | | | | overall | 0.638 | | |
| | Observations | | 170 | | | | Observations | | 167 | | |
| | Countries | | 21 | | | | Countries | | 21 | | |

***, **, and * represent 1%, 5%, and 10% significance levels, respectively

### 4.3 Reduced model

To assess the biasness of results identified in the extended model, non-significant variables are removed using Pearson correlation matrix (r>0.8) method. The purpose of the reduced model is to extract only the factors affect the deployment of mobile phone in the world, developed and developing countries. In terms of estimation results and significant variables obtained, discussion is elaborated in the following section.

Table 7 reports the factors identifying significant at the 1%, 5%, and 10% levels, respectively. In what follows, we discuss variables that are significant in the following section.

## 5 Discussion

In accordance with the importance of factors promoting mobile phone (table 3), explanation is based on the findings from empirical analysis and its implications to world, developed and developing countries focusing on opportunities and challenges for 3G deployment at national level. Besides, the section is dedicated to analyzing the implications of mobile phone adoption comprised with total number of subscribers (1G, 2G and 3G) assuming that these factors will propose a diffusion pattern similar to 3G. Also, the study takes account of the possible implications to developing countries where 3G deployment is underrepresented.

**Table 7.** Factors identifying significant for world, developed and developing countries (extended model)

| World | Developed | Developing |
|---|---|---|
| 1% significant level<br>Network (infrastructure)<br>FPEN100 (fixed network)<br>Rate3F (fixed network cost)<br>Bandwidth (technology)<br>5% significant level<br>INCOME (wealth)<br>Rate3M (mobile user cost)<br>chargeM (mobile user cost)<br>10% significant level<br>DIGITAL (technological innovation) | 1% significant level<br>chargeM (mobile user cost)<br>Network (infrastructure)<br>chargeF (fixed network cost)<br>INPEN100 (technology)<br>5% significant level<br>PCPEN100 (technology)<br>10% significant level<br>FPEN100 (fixed network) | 1% significant level<br>Rate3M (mobile user cost)<br>Urb (market size)<br>Switch (infrastructure)<br>PCPEN100 (technology)<br>5% significant level<br>Pdensity (market size)<br>10% significant level<br>INCOME (wealth)<br>DIGITAL (technological innovation) |

**Table 8.** Factors identifying significant for world, developed and developing countries (reduced model)

| World | Developed | Developing |
|---|---|---|
| 1% significant level<br>INCOME (wealth)<br>Rate3M (mobile user cost)<br>chargeM (mobile user cost)<br>Pdensity (market size)<br>NETWORK (infrastructure)<br>chargeF (fixed network cost)<br>Rate3F (fixed network cost)<br>DIGITAL (technological innovation) | 1% significant level<br>INCOME (wealth)<br>chargeM (mobile user cost)<br>NETWORK (infrastructure)<br>FPEN100 (fixed network)<br>chargeF (fixed network cost)<br>INPEN100 (technology) | 1% significant level<br>chargeM (mobile user cost)<br>Pdensity (market size)<br>Urb (market size)*<br>Switch (infrastructure)<br>PCPEN100 (technology)<br>10% significant level<br>DIGITAL (technological innovation |

### 5.1 Wealth

While the positive correlation between income and mobile phone deployment is observed in the world and developed countries, this trend is counter intuitive to developing countries in terms of empirical findings. World estimation shows INCOME as key drivers for the early adoption of mobile phone and ends up with different generations. But for developing countries mobile phone is only phone corresponding to scarcity of fixed network infrastructure. In addition, low fixed and operating costs of mobile networks, ability to operate in areas with no electricity, low social barriers on adoption, less possibility of phone theft and vandalism, geographical flexibility, and innovative pricing (such as prepaid services) are main reasons to adopt mobile phone, especially in lower-income countries [18]. In terms of estimation, INCOME find significant at the 1% levels with coefficient of (1.11) at reduced model which is similar to developed countries. Meanwhile, insignificant impact of INCOME has observed on developing countries comprised with lower, lower middle and upper middle income countries. Therefore, new policy implications emerge from this finding while other deployment factors such as technological innovations, policy or open market initiative rather than INCOME may promote 3G mobile phone.

### 5.2 Cost of mobile phone use

Aggregate costs of mobile phone use are

available in basically two forms as generally specified in the literature. In this study, the cost of mobile phone use is also classified as two-fold tariff with a monthly subscription charge that may be related to the monthly cost (chargeM) of accessing the network and a usage charge usually applied as 3 minutes peak rate call (Rate3M). Both prices have expected a negative sign on demand function in order to economic theory. In all estimations, cost of mobile use is satisfied with negative sign corresponds to the general theory of demand function. In this respect, reductions of chargeM and Rate3M have impacted mobile phone adoption. For example, most of countries monthly charge was ten to twenty times high compare to now while Rate3M does not have such differences. Besides, prepaid services are growing especially in the developing countries that reduce total cost of mobile phone use.

**5.3 Market size**

Population density (Pdensity) and percentage of urban population (Urb) are included as a proxy for total market size of a country and as a proxy for the network effect. The more the population is concentrated the greater the impact this has on mobile phone adoptions. Likewise, at the early stage, urban citizens are connected to mobile phone because of income affordability. These should be true in all equations of telecommunication demand estimation and positive impact across models is expected. The estimation results find at the 1% for world and 5% significant levels for developing countries, respectively. In contrast, developed countries demand for mobile phones is not related to Pdensity. The underlying assumption is thus, most of developed countries in the world, especially in Europe or in America, Pdensity is low but their penetration rate is high. Meanwhile, Urb is indicated that urban populations connect to the device very fast and the market for urban population is high.

**5.4 Infrastructure**

A strong effect is generally expected for variables reflecting telecom infrastructure comprised with switching capacity of fixed network (Switch) and mobile network coverage (Network). There may be a substitution effect between Switch and Network for this subset of countries though this is not certain, as the final result is an empirical question. Our sample has countries with 10% to 100% Network. While most developed countries have already reached to 100% coverage, Myanmar, lower income sample shows only 10% coverage with less than 1% penetration as of 2007. Besides, Switch and Network is positively correlated that defines country's telecom infrastructure is relatively plausible to adopt mobile phone. Also, the countries that have higher switching capacity have also more network coverage. Switch in developing countries promote mobile phones adoption. Surprisingly, no impact has found for Switch for this specific group. This result coincides with [8], estimated a substitution effect between mobile and fixed-line services. Lower income countries have relatively lower network coverage that demonstrates significant roles for mobile phone adoption. While the countries have 100% network coverage to support every base station, they are also able to support diversified services for 3G such as mobile payment or Internet access. It is evident in the case of leading 3G economies such as South Korea and Japan, which has advanced infrastructure of information and communication environment [19, 20].

**5.5 Fixed network**

Mobile phone is a substitute or a complement for fixed phone in many countries. If fixed phone penetration (FPEN100) has a positive impact on mobile phone demand model, then a fixed phone is a substitute for mobile phone. Meanwhile, as for fixed network cost comprised with monthly connection charge (chargeF) and 3 minutes peak time call rate (Rate3F) have positive impact, thus it is a substitute for mobile phones [2]. If the effect is negative then the two services are complements in the market. Estimation results show, fixed phone is substitute for developed countries but complements for developing countries. In particular, developed countries FPEN100 are higher than developing countries. Besides, chargeF and Rate3F are indicators for subscribers to switch to mobile phone in developing countries. Another indicator, i.e., waiting for fixed network (waitingF1000) in developing countries is positively significant at the 10% levels. This is obvious that relative advantage of mobile phone compare to fixed network potentially saves time, ability to connect same network using Subscribers Identification Module (SIM) or port the same number under Mobile Number Portability (MNP).

**5.6 Technology**

Personal Computer (PCPEN100), Internet (INPEN100) and bandwidth per 100 inhabitants are selected as the country is advanced of using Information and Communication Technology (ICT). For selected countries these variables are included as a proxy for technology. In network industries, substitutes in the product market may carry degree of complementarities via the network effect; especially regarding usage intensity [21]. According to the estimation results, INPEN100 is significant at the 10% levels for developed countries while PCPEN100 is found significant at the 1% levels for developing countries, respectively. The findings coincide with the reality since INPEN100 is important indicators for developed countries that encompass technologically advancement of using ICT which belongs to mobile phone. For instance, PCPEN100 assumes the primary indicator for countries with the consciousness toward ICT use and positively relates to mobile phone adoption.

**5.7 Competition**

Competition dummy for mobile phone (COMP) may take account of how rapidly new technologies are rolled out, the level and quality of services and possibly the level of price competition [22]. Obviously, COMP should have positive impact on mobile phones adoption. But for developed countries this variable is removed because of unexpected sign (negative) which is similar to the finding of [2]. Meanwhile, COMP for specific groups of developing countries as noted before, find significant at the 5% levels for all. Thus, market competition reduces cost of mobile phone use and affordable for user in terms of income. Another scenario is prepaid contracts or simply pay as you go, perhaps the most successful strategy for mobile operators to capture mass market of developing countries. For example, in India, Bangladesh or even in Ghana, more than 90% subscribers use prepaid contracts. This is because of fine market competition exist among operators. In contrast, Japan and South Korea, focus on post-paid rather than prepaid contracts. There may be some underlying reasons that developed countries lead to follow post-paid strategy to promote market competition.

**5.8 Technological innovation**

After the invention of digital technologies in mobile phones in early 1990s, analog technologies have captured by digital ones. Among the developed countries the average penetration of analog mobile phone was low before digitalization took place. Digitalization of mobile network was killer steps to enter mobile phone into the new communication era. Among the developed countries, the penetration of analog mobile phones reached at less than 5% in the 1990s, whereas the digital mobile phone is currently more than 90%. The corresponding changed was also observed in developing countries while the subscribers switch to digital technology somewhat slower than developed countries. The diffusion pattern of mobile phones is significantly affected by this technological innovation which leads to operators and regulators among the world to upgrade new generations of mobile phones such as 2G and 3G. In addition, success of this innovation also provide improved voice quality, advanced data services, lower power consumption to battery, etc.[23]. The variable finds significant at the 1% to 10% levels, respectively. This is clear indication that while digitalization took place some new functionality emerged such as short message service

(SMS), games or ringing tones.

## 6 Conclusion

The paper examined mobile phone adoption and diffusion growth, analyzed subscriber and national disparity of diffusion among 51 countries in major regions of the world to understand the extent of the global mobile phone adoption in the provision of analog and digital subscribers. The empirical methods included analysis of subscriber penetration and growth, econometric analysis of panel data models to explore country-specific drivers of diffusion growth and approaches to find influence of the selected variables. We study usage patterns and followed extended and reduced models to find significant results. Besides, developing countries are estimated in terms of income categorization as lower, lower middle and upper middle income as World Bank stated. As expected, the result shows that mobile phones adoption is positively correlated to income, revenue from mobile phones, mobile network coverage and digitalization of mobile phones. In contrast, it was examined that mobile user cost comprised with monthly charges and 3 minutes peak time call rates, negatively correlated with the mobile phone adoption.

Therefore, the analysis suggests that certain subgroups of the population, while unrepresented in terms of income, have adopted mobile devices at rates equal or faster than the base population. As such, digitalization of mobile phones or simply a migration path from 2G to 3G services may be the most plausible avenue to be connected to the unconnected world. Accordingly, policy formulation should be aware of the opportunity to advance digital inclusion through mobile computing devices.

Given the extremely powerful positive effect of mobile competition in developing countries sub-classification, policy makers and regulators should re-consider to open the market for launching new generations such as 3G. Since penetration rate in developing countries have achieved 30% to 40% around the world which is almost reaching toward saturation in terms of income, now the questions is how they shift from existing technology to new technology. Win-win relationship between mobile operators and content providers should exist to offer heterogeneity in services since 3G means functionality development of mobile phones comprised with high speed Internet, entertainment services, banking, and health and so on. The real ubiquitous world (Ubi-WORLD) is therefore possible if all those services possibly to launch, especially for developing countries.

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**Sheikh Taher ABU** is a PhD candidate at Graduate School of Applied Informatics, University of Hyogo, Japan. He has many contributions in telecommunications research, especially in the field of cellular technology adoptions, services and service architectures from the user point of view. He has published papers in peer review journals, discussion papers, and conference proceedings.

**Masatsugu TSUJI** is a professor of Graduate School of Applied Informatics, University of Hyogo, Japan and former professor emeritus of Osaka University, Japan. He received his PhD in Economics from Stanford University, USA. His research focuses on telecommunication economics, telemedicine and has numerous publications in peer review journals, books and conference proceedings, etc.