Determinants of Mobile Phone Penetration Rates in Latin America and the Caribbean

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Using panel data analysis for Latin American and the Caribbean for 2001-2015, this paper studies the factors influencing the mobile phone subscription rates and its growth. The results suggest that GDP per capita, urbanization rate, total population, population growth rate and population density are significant drivers of mobile phone penetration rates. For the growth of mobile phone subscriptions, significant factors include GDP per capita and its growth rate, population and population density, and overall penetration level. The results confirm the S-shaped trajectory and place Latin America and the Caribbean countries farther along the diffusion curve where mobile phone subscriptions are increasing at a diminishing rate.

INTRODUCTION

The stellar growth and rapid diffusion of mobile telephony has far reaching implications for the economic development of countries. The cellular technology is providing empowering access, financial inclusion, and connectivity to citizens and transforming their lives and livelihoods especially in developing regions. (Lechman, 2015; Aker and Mbiti, 2010; Gruber and Koutrompis, 2011; Zambrano and Seward, 2012; Vodafone, 2005).

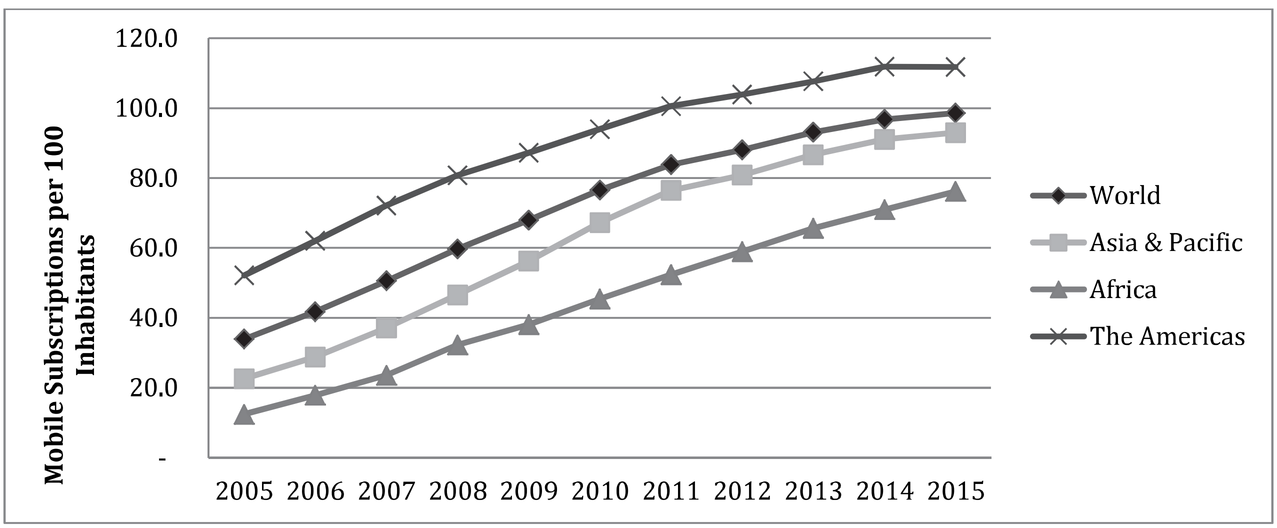
According to the GSMA 2016 report, there were 7.6 billion mobile connections representing 4.7 billion unique subscribers in 2015. Latin America and the Caribbean have 687 million mobile connections and 414.4 million unique subscribers, representing 65% of the mobile penetration rate. Latin America is the most heterogeneous region in terms of mobile subscription growth ranging from over 90% in Argentina, Chile, and Uruguay to 57% in Brazil and 23% in Cuba. Strong growth in mobile subscriptions is expected to come from large countries such as Brazil and Mexico.

The research objective of the paper is to empirically investigate the role of economic and demographic factors affecting mobile phone penetration rates in Latin America and the Caribbean for the period of 2001-2015. Using panel data analysis, the study analyzes both the number of mobile phone subscribers and the rate of growth of mobile phones per 100 inhabitants. Some of the research questions addressed are: How does GDP per capita affect the level and growth of mobile phone subscribers? Are landlines substitutes for mobile phones? What roles do demographic variables such as population and its growth rate, population density and urbanization play in explaining mobile phone penetration rates?

AN OVERVIEW OF MOBILE PHONE DIFFUSION

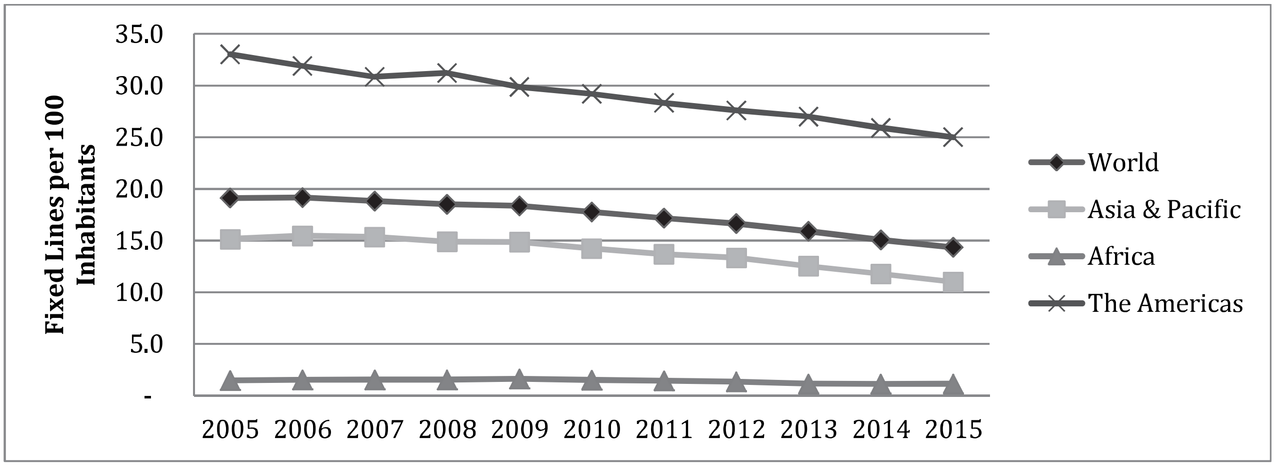
Mobile telephony has diffused at an unprecedented rate in last two decades. “Mobile growth is increasingly focused on the developing world: more than 90% of the incremental 1 billion new mobile subscribers forecast by 2020 will come from developing markets.” (GSMA, 2016). International Telecommunications Union (ITU) collects statistics on mobile and fixed phones penetration rates worldwide, among other ICT related variables. ITU bases its mobile phone data on mobile connections as opposed to unique subscribers[1]. Figure 1 and Figure 2 show mobile subscriptions and fixed lines per 100 inhabitants respectively for 2005-2015. Globally, mobile penetration rates have increased from 33.9 in 2005 to 98.6 in 2015. In the Americas, mobile penetration rates increased from 52.1 in 2005 to 111.8. On the other hand, fixed lines per 100 inhabitants declined from 33.0 in 2005 to 25 in 2015. This is consistent with an overall declining trend worldwide. In 2002, mobile subscriptions surpassed the number of fixed lines per 100 inhabitants. It shows that increasingly cellular technology is leapfrogging the traditional inadequate landline infrastructure in many developing countries. Africa has the lowest tele density of fixed lines- 1.1 per 100 inhabitants.

FIGURE 1
MOBILE SUBSCRIPTIONS PER 100 INHABITANTS, 2005 – 2015



http://www.itu.int/en/ITU-D/Statistics/Pages/stat/default.aspx

FIGURE 2
FIXED LINES PER 100 INHABITANTS, 2005 – 2015



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Figures 3A-3C trace the mobile phone penetration rates by the level of income for 2001-2015 for Latin America and the Caribbean countries. The World Bank country classification is used to group countries in different income categories. Haiti being the only country classified as a low-income country, it is included in the lower-middle income group. Similar figures for the Caribbean countries are provided in the appendix.

FIGURE 3A
LOWER MIDDLE INCOME LATIN AMERICAN COUNTRIES

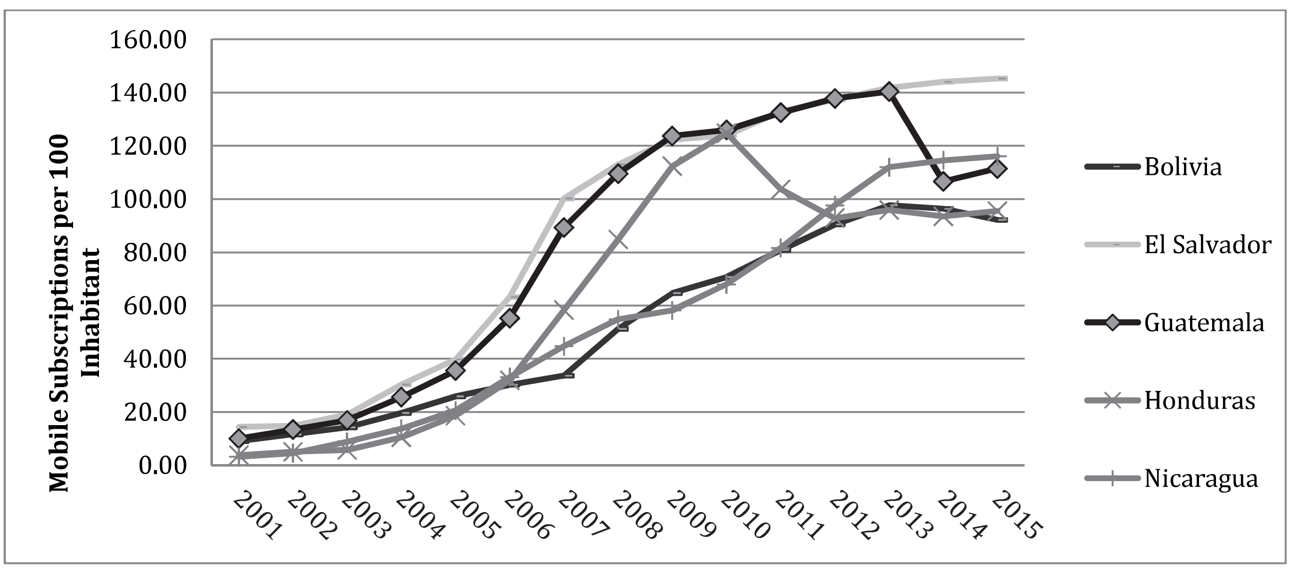

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FIGURE 3B
UPPER MIDDLE INCOME LATIN AMERICAN COUNTRIES

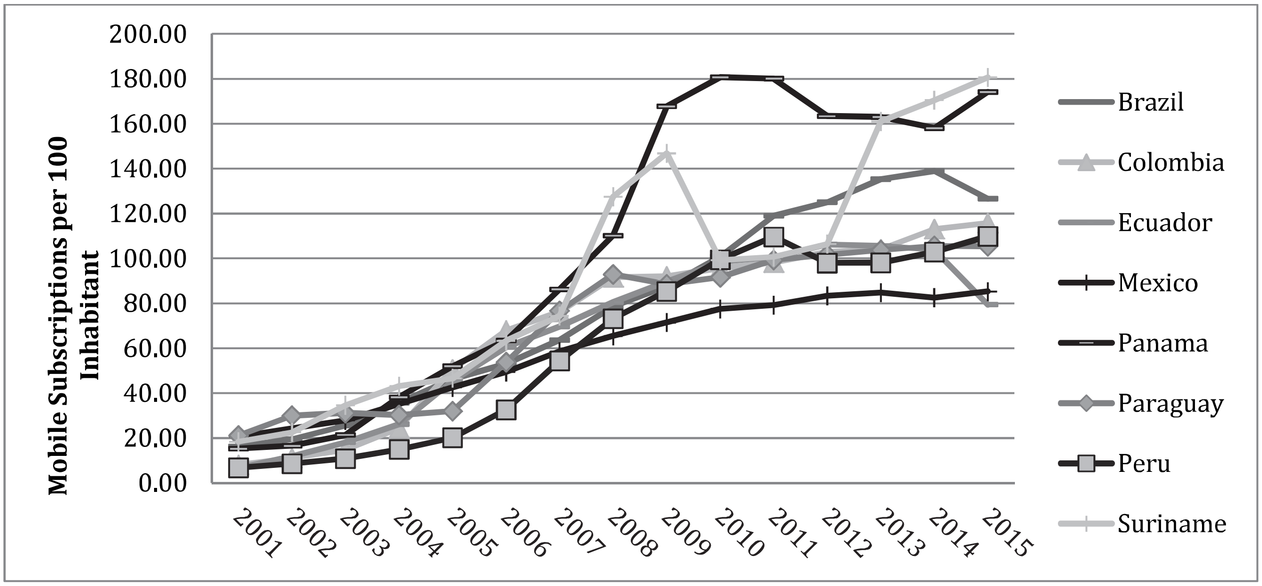

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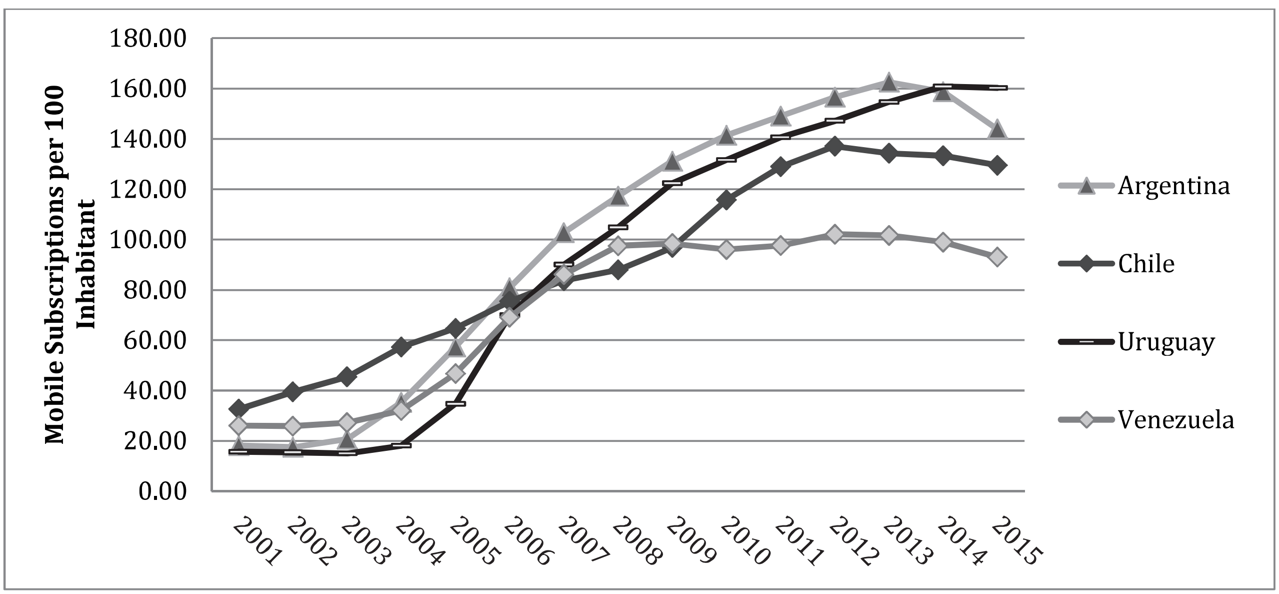
FIGURE 3C
HIGH INCOME LATIN AMERICAN COUNTRIES



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REVIEW OF LITERATURE

One strand of research on mobile phone adoption relates to the literature on the diffusion of innovations. According to Rogers (2003), the spread of a new innovation over time typically follows an S-curve, as the early adopters select the technology first, followed by the majority until an innovation is common. Many researchers have estimated the S-curve for mobile phone diffusion using various functional forms such as Bass Model (Bass, 1969), or Logistic or Gompertz functions (Singh, 2008; Doshi, 2012; Michalakelis et al, 2008; Kumar and Shankar, 2007).

Existing research also includes the studies focusing on the determinants of mobile phone penetration on a broader scale. Donner (2008) provides an extensive survey of such studies. Ahn and Lee (1999) found a positive relation of mobile diffusion to GDP Per capita and fixed line penetration. Many cross-country studies (Grueber, 2001; Grueber and Verboven, 2001; Koski and Kretschemer, 2005) focused on industry factors such as competition, standardization, regulation and fixed line penetration. Rouvinen (2006) studied the mobile phone diffusion across developed and developing countries. Most studies conclude that single standard for mobile platform and market competition (number of operators) have positive effects on mobile phone adoption. Income and urban population were not found to be statistically significant factors. In a study of 29 countries over a period of 1993-2004, Chakravarty (2007) examined the mobile phone penetration rates in Asia, using panel data analysis. His findings indicate that GDP per capita, fixed lines per capita, number of mobile providers and regulatory policy have a positive and statistically significant influence on mobile phone penetration rates. Gebreab (2002) using the fixed effect model analyzed mobile phone diffusion determinants in 41 African countries for 1987-2007. In his study, competition was found to be the main driving force behind mobile phone diffusion. Urbanization and fixed lines had positive and significant effects, while income and population were not significant factors. Addressing the issue of digital divide, Stump et al. (2008), study the role of socio-economic factors in determining country level mobile phone adoption. In a global study of 170 countries, they found mean age of population, GDP per capita and population density to be positively related and fixed lines to be negatively related to mobile phone adoption. Lechman (2015), uses panel data and up to 17 explanatory variables for low-income and lower-middle income countries to estimate adoption rates of mobile phone and internet.

A vast majority of research studies have explored the relation between fixed telephone line and mobile phone penetration in different contexts. Some studies have looked at the relation as 'technology substitution' and network effects while others have focused on economic substitution involving cross-price elasticities. In terms of the regions studied, the majority of them have focused on Europe and Africa. Hamilton (2003) explicitly addresses the issue of complementarity or substitution between fixed lines and mobile phones in Africa using a sample of 23 developing countries of Africa. Using panel data estimation for 1985-1997, his results suggest that mobile phones are complementary to fixed telephone lines. However, this may be the result of strategic competition within the industry. According to him, "At different stages of cellular development, mobile can play the role of both a substitute for and a complement of main line demand" (pp. 130). Aker and Mbiti (2010), provide a qualitative overview of mobile phone coverage in Africa. In the studies on Africa, population density, per capita income and poor quality of landlines seem to have positive correlation with mobile phone coverage. Comer and Wilke (2008) study the worldwide diffusion of mobile phones during 1995-2005 and found that GNP per capita explained more than 75 percent of variations in mobile phone penetration rates globally and 90 percent in Asia. The study also finds that "mobile phones are clearly a substitute for mainline phones in most African countries" (pp. 266). The evidence is mixed for the rest of the world. Another study (Bagchi, Solis, and Gemoets 2003), explores the relation between fixed telephone lines and cell phones in 32 Latin American countries for 1989-1999. The findings suggest that cell phone adoption complements the adoption of fixed telephone lines. Kalba (2008) finds a strong but declining correlation between income and mobile phone penetration. His research also shows that the fixed lines are substitutes for mobile phones, especially in emerging African markets. He concludes that underlying income levels may be responsible for such a relation between fixed lines and mobile phones. Using the logistic model, Lee and Lee (2011), empirically analyze the factors affecting the diffusion of mobile broadband in OECD countries. Focusing on 3G subscribers, the study concludes that larger and less densely populated countries are at a disadvantage in mobile broadband adoption. Mobile service is found to complement fixed broadband services. Banerjee and Ros (2004), explore the drivers of mobile services demand growth in 64 developing and developed countries for 1996-2000, using panel data analysis. Their findings suggest that the fastest growth in the cellular density occurs in the countries with the lowest per capita

GDP. Regarding the substitution between fixed lines and mobile services, their results indicate that long waiting list for fixed phones boost the cellular density growth rate. In a study of 27 European countries, Barth and Heimeshoff (2014) show a strong substitution between fixed lines and mobile penetration. They also estimate cross-price elasticities and find that mobile demand is more elastic than fixed lines demand. In another recent study of 25 European countries, a similar conclusion was drawn by Lange and Saric (2016).

Thus, the review of existing literature shows that a growing body of research has explored a variety of determinants of mobile phone penetration covering various regions and time periods. Most consistently, the factors such as income, fixed lines, industry competition and regulatory policy emerge as the most important predictors of mobile phone penetration. However, the evidence is mixed whether fixed telephone lines are substitutes or complements for mobile phones.

The present study contributes to the literature in many ways. Most existing research studies have focused on supply-side and industry variables such as competition, regulation and the telecommunications policy environment. This paper systematically studies the role of demand-side factors such as income, urbanization rate, population density and other demographic variables using panel data methodology. As can be seen from the review of existing research, very few studies are available for Latin America and the Caribbean. Bagchi et al (2003) have expressed this concern and emphasized the need for such studies to fill the research gap. Given the wide variations in mobile phone penetration in different regions, a study of Latin America and the Caribbean will provide important insights into the region-specific factors. Expanding the existing research, this study provides the most recent evidence using a large sample of Latin American and the Caribbean countries for 2001-2015.

Our most important contribution is to systematically model the growth of mobile subscriptions in addition to the level of mobile subscriptions. Such estimation corresponds to the familiar S-curve and offers an alternative to study mobile phone diffusion over time. This is likely the first study that examines the change in mobile phone penetration rates in a panel data framework and highlights the importance of the stage of mobile phone adoption. The findings of the study will have significant policy implications for the government and industry players in devising development and regulatory policies.

METHODOLOGY AND MODEL

Model I: Dependent Variable- Mobile Phone Subscriptions Pooled Regression Model

Equation (1) below specifies the Pooled Regression model, which does not differentiate country or time effects, while equation (2) specifies the fixed effects model.

$$Y_{it} = b_0 + b_1 X_{1it} + \ldots + b_k X_{kit} + e_I \quad (1)$$

where Y_{it} is the number of mobile phone subscriptions per 100 inhabitants in a country i at time t

$$Y_{it} = b_0 + b_1 X_{1it} + \ldots + b_k X_{kit} + a_i + g_t + e_{it} \quad (2)$$

where a_I represents country specific fixed effects and g_t represents time period specific fixed effects. By capturing such fixed effects, the fixed effect model improves upon the specification issues found in the pooled regression model.

The same general set of variables is used to explain variation in the mobile phone subscription rate in both Latin America and the Caribbean. The exact specification varies slightly and the results reported are for the best fit. The explanatory variables used for the estimation of Model I include: GDP per capita, GDP per capita growth rate, Total Population, Population Growth Rate, Population Density (number of people per square kilometer), Percent Urban (% of total population living in urban areas), and Fixed Lines (Subscriptions per 100 inhabitants)[2]. Most studies use urbanization or rural rate as a proxy for population density. Here, population density is explicitly included to capture network effect and cost conditions. The hypothesized signs on these variables are discussed in section V on Results.

The data on mobile phone and fixed line subscriptions is collected from ITU (2016). The World Development Indicators (World Bank, 2016) data is used for the remaining explanatory variables. Table 1 and Table 2 provide descriptive statistics for Latin America and the Caribbean respectively.

Due to missing data, the following countries were omitted from the Caribbean: Aruba, Cayman Islands, Curaçao, Sint Maarten (Dutch Part), St. Martin (French Part), Turks and Caicos Islands, Virgin Islands (U.S.) were omitted. The list of included countries is provided in the Appendix.

TABLE 1
DESCRIPTIVE STATISTICS – 19 LATIN AMERICAN COUNTRIES (n=266)

Variable	Mean	Std. Dev.	Minimum	Maximum
Mobile Subscriptions	78.524	81.296	4.520	180.699
Mobile Growth	8.13	10.8	-47.6	57.6
GDP per capita	5783	4470	914	16879
GDP Growth Rate	2.582	2.569	-11.877	16.233
Total Population	28,770,619	9,679,358	262,202	208,000,000
Population Growth Rate	1.341	1.333	-0.064	2.789
Population Density	52.879	32.127	3.117	295.685
Percent Urban	69.792	66.592	43.973	95.311
Fixed Lines	15.208	14.982	3.270	32.590

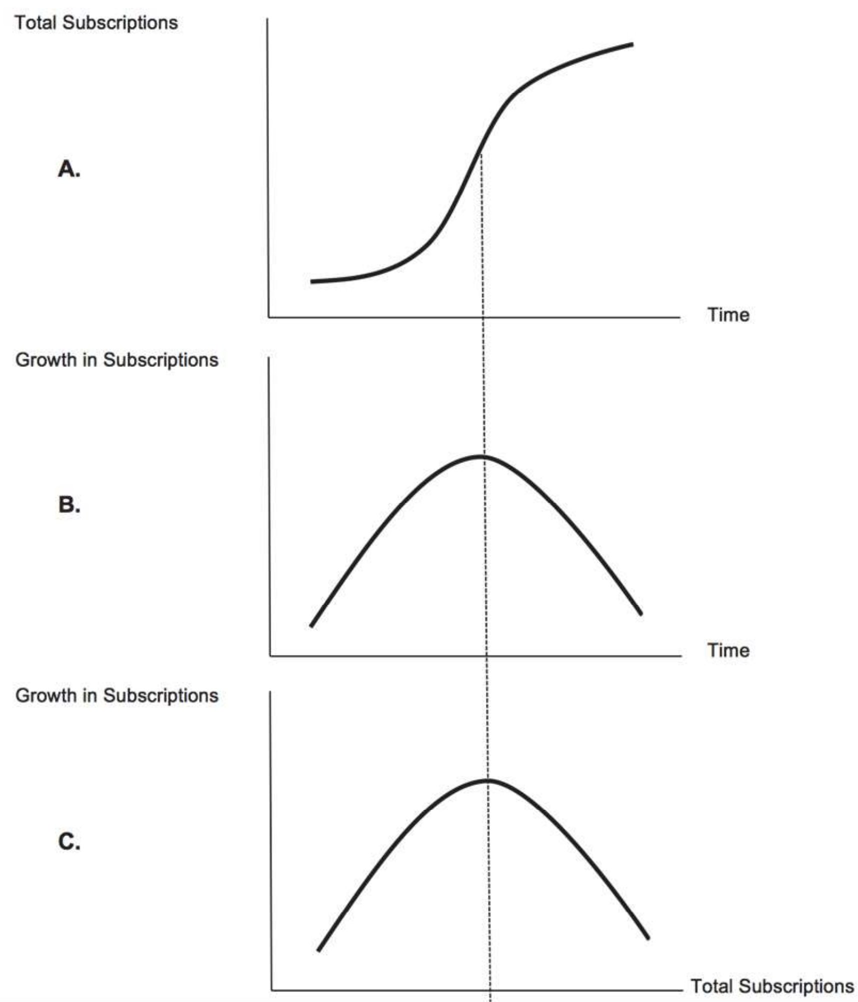
TABLE 2
DESCRIPTIVE STATISTICS – 15 CARIBBEAN COUNTRES (n=209)

Variable	Mean	Std. Deviation	Minimum	Maximum
Mobile Subscriptions	81.034	43.698	0.159	199.664
Mobile Growth	6.90	14.3	-56.6	95.0
GDP per capita	9860	7220	330	29329
GDP Growth Rate	1.399	4.067	-15.539	13.880
Total Population	2613360	3869349	46935	11362505
Population Growth Rate	0.654	0.672	-1.732	2.125
Population Density	243.118	155.869	3.770	660.965
Percent Urban	48.335	24.311	8.445	94.278
Fixed Lines	24.280	13.589	0.387	54.562

Model II: **Dependent Variable- Growth of Mobile Phone Subscriptions**

In addition to modeling the number of mobile phone subscriptions, this paper also examines the growth in mobile phone subscriptions. As noted previously, many researchers have modeled mobile phone diffusion using the familiar "S-curve" and estimating techniques such as Bass Diffusion Model. A graphical depiction of the model is represented in Figure 4.

FIGURE 4
MOBILE SUBSCRIPTIONS AND MOBILE SUBSCRIPTIONS GROWTH



By examining the rate of change in mobile subscriptions, the relationship depicted in Figure 5 (panel A) can be estimated using Equation (3). For the following analysis, the dependent variable ΔMS_{it} is defined as follows:

$$\Delta MS_{it} = (MS_{it} - MS_{it-1}) = b_0 + b_1X_{1it} + \ldots + b_kX_{kit} + e \quad (3)$$

The explanatory variables in Equation 3 will then include both the level of mobile phone subscribers and this term squared. This allows for the estimation of the relationship between the growth rate and the underlying market size. Following the "S-curve" hypothesis, Figure 5 (panel 3) represents the relationship between the change in mobile phone subscriptions and the level of subscriptions.

RESULTS AND DISCUSSION

The 34 countries included in this analysis are a mix of countries from both Latin America as well as the Caribbean. There is a wide range in the characteristics of the countries ranging from St. Kitts and Nevis with a population of little more than 50,000 people, to Brazil with a population of over 200 million people. Treating the 34 countries as one sample in determining the factors that affect both the total level of mobile phone subscriptions as well as the growth rate in mobile phone subscriptions seems unreasonable. Not surprisingly, a Chow test for the equality of coefficients across the two major groups results in the conclusion that the two groups need to be treated as separate samples. The following analysis utilizes this separation. In addition, the model was estimated both with and without country specific fixed effects. In all cases, the fixed effect models provide better explanatory power than those without fixed effects. The F-test for model specification rejects a simple pooled model in favor of the fixed effects model at the 1% level.

As is common with panel data, both the random effects and fixed effects models are estimated for both the level of mobile phone subscribers as well as the change in the number of mobile phone subscribers. As a critical assumption in the random effects model is that the random effects are uncorrelated with the explanatory variables, we employ the Hausman specification test for the random effects model. The random effects model is rejected at the 1% level of significance; therefore, the fixed effects model is identified as the appropriate specification.

TABLE 3
TOTAL NUMBER OF MOBILE SUBSCRIPTIONS PER 100 INHABITANTS

	Latin America (n=264)		Caribbean (n=210)	
Variable	Coefficient	t-Statistic	Coefficient	t-Statistic
Constant	-2174.8***	-3.073	-1487*	-1.727
Ln GDP per capita	66.7***	13.43	77.92***	12.541
GDPPC Growth Rate	-0.221	-0.701	-1.282***	-3.7885
Ln Total Population	78*	1.725	65.47	0.9398
Population Growth	27.02***	2.983	13.77**	2.4069
Population Density	2.102***	3.93	0.732***	2.785
Percent Urban	4.087***	3.982	-1.256**	-2.0455
Number of Fixed Lines	-0.173	-0.358	-4.8402***	-9.2234
R-Squared	0.886		0.855	

* - Significant at the 10% level, ** - 5% level, *** - 1% level

Table 3 presents the results for the total number of mobile subscribers for countries both in Latin America and in the Caribbean. Overall, the results show a much better fit for Latin American countries than Caribbean countries.

Focusing on the fixed effects model, Ln GDP per capita, Ln Total Population, Population Growth, Percent Urban and Population Density are statistically significant variables explaining the variations in mobile phone penetration rates in Latin America with an R-Squared of 88.6%. As explained below, the results conform to the hypothesized signs.

Income is a strong predictor of mobile phone penetration rate. The Ln GDP per capita variable representing income, affordability, and level of development was expected to have a positive sign. The estimated coefficient is positive and significant at the 1% level of significance. While the level of per capita income is significant, GDPPC Growth Rate is not significant.

The model included four demographic variables – Ln Total Population, Population Growth, Population Density, and Percent Urban. A positive sign was expected on Ln Total Population as the variable represents market size and total demand. It can also capture "emerging network effects" as explained in Rouvinen (2006). The variable has an expected positive sign and the variable is significant at the 10% level. Population Growth is also expected to have a positive sign. The findings show that the variable has the anticipated positive sign and is significant at the 1% level. In Latin America, countries with larger population and higher population growth are expected to experience higher mobile phone penetration rates.

Population Density, as a proxy for market size and network effect, is expected to have positive signs. As discussed in Lechman (2015), Rouvinen (2006) and Stump et al (2008), mobile technology spread is favored in densely populated and highly urbanized areas due to network effects. The propensity to adopt a new technology is higher in urban areas. Backbone infrastructure is better developed in urban areas, which can facilitate the access to mobile phone technology. Population Density may represent additional supply-side conditions representing the cost of deployment of new technology and falling prices due to economies of scale. Percent Urban has a positive sign and is significant at the 1% level. Population Density also has a positive and significant effect on mobile penetration rates.

In mainstream literature, there is an ongoing empirical debate on the impact of fixed lines on mobile phone diffusion. Are the two technologies substitutes or complements? No a-priori sign can be assigned as existing research has demonstrated both the possibilities. "Whether fixed line and mobile service are substitutes or (complements) has proved to be difficult to determine as the occurrence of technology improvement and network effects are, more or less, concurrent" (Madden et al 2004). In our Latin American sample, Number of Fixed Lines per 100 inhabitants, while significant at 1% in the pooled model, does not exert any statistically significant influence on mobile phone penetration rates when country and time specific effects are taken into account. There is no recent evidence available for Latin America as a region. But, in their 2003 study of Latin American countries, Bagchi et al found a similar result when they controlled for the stage of diffusion. According to them, the result indicates that cell phone adoption is independent of fixed lines in Latin American countries as people, especially in rural areas, adopt cell phones, bypassing telephone lines.

Thus, the findings suggest that economic and demographic variables are significant drivers of mobile subscriptions in Latin America. Countries with higher per capita income and higher population are likely to witness higher mobile phone penetration rates. Densely populated and highly urbanized areas are likely to have higher mobile subscriptions.

Table 3 also presents the results for the total number of mobile subscribers for Caribbean countries. The fixed effects model has an R-squared of 85.5%. The results show all of the variables except Ln Total Population as statistically significant. Ln GDP per capita variable has an anticipated positive sign and is significant at the 1% level. GDPPC Growth Rate- the variable that was not significant for Latin American sample- is significant at the 1% level for Caribbean countries. Its negative sign shows that faster growing countries are likely to have lower mobile penetration rates. Population Density is statistically significant at the 1% level of significance although the coefficient is smaller compared to Latin America. Percent Urban has a negative sign and is significant at the 5% level. Average urbanization rate in Caribbean sample is 48.33 percent as compared to 69.79 percent in Latin America. Mobile phone penetration rates in the Caribbean sample are lower in more urbanized areas.

In contrast to Latin American sample, for the Caribbean countries, Number of Fixed Lines per 100 inhabitants has a negative and statistically significant impact on mobile penetration rate. As described earlier, the negative sign of the coefficient implies technological substitution between fixed phone lines and cellular technology.

TABLE 4
GROWTH OF MOBILE SUBSCRIPTIONS PER 100 INHABITANTS

	Latin America		Caribbean	
Variable	Coefficient	t-Statistic	Coefficient	t-Statistic
Constant	1562.4***	3.167	1867.3***	2.99
Ln GDP per capita	-17.68***	-4.112	-25.06***	-3.904
GDPPC Growth Rate	0.451**	2.205	0.647***	2.656
Ln Total Population	-82.37***	-2.666	-129.7***	-2.57
Population Growth	-5.962	-1.036	-4.55	-1.137
Population Density	-1.072***	-2.905	-0.113	-0.585
Percent Urban	-0.638	-0.843	0.513	1.095
Number of Fixed Lines	-0.105	-0.326	1.89***	4.156
Mobile Subscriptions	0.69***	7.783	0.534***	3.99
Mobile Subscriptions Squarec	-0.0023***	-5.696	-0.0015***	-2.49
R-Squared	0.327		0.315	

* - Significant at the 10% level, ** - 5% level, *** - 1% level

Table 4 reports the results from the fixed effects models for both Latin America and the Caribbean using Growth of Mobile Subscriptions per 100 inhabitants as the dependent variable. As was the case with modeling the total number of mobile phone subscribers, the results for modeling the growth of mobile phone subscribers are stronger for Latin America than for the Caribbean. An R-Squared of 32.7% for Latin America shows that the growth in mobile subscribers is more difficult to explain than the total number of subscribers. The coefficients on Ln GDP per capita and GDPPC Growth Rate are significant. The negative and significant coefficient on Ln GDP per capita suggests that countries with higher income may be farther along the adoption curve, leading to lower growth rates of mobile subscriptions. A similar finding is reported by Banerjee and Ross (2002). According to them, the negative sign on Ln GDP per capita signifies that "fastest (slowest) growth in cellular density has occurred in countries with the lowest (highest) per capita GDP" (pg. 33). The result has important policy implications for bridging the digital divide with the spread of mobile technology. An increase in the growth rate of income causes an increase in the growth of mobile phone adoptions. Increases in either the overall size of the population or the population density leads to lower growth in mobile phone adoptions. The coefficient of Population Density is negative and significant at the 1% level. While the level of mobile subscriptions tends to be higher in high-density areas as in Table (3), its growth rate is likely to be lower in densely populated areas. Population Growth and Percent Urban do not have statistically significant effect on the growth of mobile phone subscriptions, although both the variables were important predictors of the level of mobile phone subscriptions. In the Latin American sample, Number of Fixed Lines is not a significant variable.

As discussed earlier, previous research has confirmed an S-shaped adoption curve. Mobile Subscriptions and Mobile Subscriptions Squared were entered to capture the S-curve, showing the trajectory of diffusion of a new technology over time, as shown in Figure 5 above. The results presented in Table (4) support the hypothesis of an S-shaped diffusion of mobile phones in Latin America over this time period. The signs on these variables imply that the rate of growth of mobile phone subscriptions is increasing at a diminishing rate.

Table (4) also presents the results from the fixed effects model explaining the growth of Mobile Subscriptions per 100 inhabitants for the Caribbean countries. As with Latin America, higher income countries tend to have lower growth rates, as they may be further along on the adoption curve. An increase in GDPPC Growth Rate leads to an increase in the growth of mobile phone subscriptions. Among the demographic variables, only the overall size of the population seems to matter. The negative sign on the coefficient of Ln Total Population suggests that the growth of mobile phone subscriptions is lower in countries with larger population. Number of Fixed lines is significant at the 1% level. However, the coefficient has a positive sign.

The adoption pattern of mobile phones in the Caribbean countries does display the expected S-curve over this time period, as the coefficients of Mobile Subscriptions and Mobile Subscriptions Squared are statistically significant. As with Latin America, the rate of growth of mobile phone subscriptions is increasing at a diminishing rate, implying that the Caribbean countries are also in the later stage of mobile phone adoption.

CONCLUSION

The paper examines the role of economic and demographic factors affecting mobile phone penetration rates in Latin America and the Caribbean. The paper fills in the gap in literature by providing additional and most recent evidence on the Latin America and the Caribbean. This study models both the level and the growth of mobile subscriptions and the findings have useful policy implications. Confirming an S-shaped adoption trajectory for mobile phone subscriptions, our results place both Latin America and the Caribbean farther along the curve where mobile phone subscriptions are increasing at a diminishing rate. Ln GDP per capita is a significant predictor of mobile subscriptions and its growth rate both in the Latin American and the Caribbean regions. While higher per capita GDP tends to increase the level of mobile subscriptions, it results in lower rate of growth of mobile subscriptions. Low income (high income) countries have high (low) rates of growth of mobile subscriptions, implying that less developed countries are 'catching up' and bridging the digital divide with the spread of mobile telephony. In the same way, highly populated areas witness higher levels of mobile subscriptions but are likely to have lower growth rates of mobile subscriptions. Population density and urbanization rate are important drivers of the level of mobile subscriptions in both Latin America and the Caribbean countries. Policies focused on economic growth and urbanization are likely to help the governments in increasing the mobile phone penetration rates. Consistent with the predictions of GSMA report, in Latin America, countries with large population and high income are likely to drive the mobile phone subscriptions. Fixed lines do not seem to have any significant influence, in Latin America, on the level or the growth of mobile subscriptions. It seems that the telecommunication technology infrastructure is not an important factor in mobile phone adoption. Or, the substitution effect - mobile phone access overcoming the limitations of often non-existent or inadequate landlines - is perhaps offset by the complementarity due to the network effect of enhanced subscriber base. For the Caribbean region however, fixed lines emerge as a substitute for mobile phone subscriptions. Such technological substitution will have important implications for the policy makers and industry players in terms of telecom regulatory policies. Usually, fixed lines network is subject to a high degree of regulation. However, if mobile phones compete with fixed phone lines, such a competition will soften the market power of fixed line operators, reducing the need for their heavy regulation. Fixed lines network, in the Caribbean countries, however has a positive effect on the growth of mobile phone subscription rates. As discussed earlier, the relation between fixed lines and mobile phones is very complex involving demand and supply side factors, leapfrogging and the level of development.

For future research, we can include mobile phone price and regulatory variables such as competition and privatization and analyze the complex relationship between fixed lines and mobile phones. A comparative study of Latin America, Asia and Africa will also provide useful insights in the process of diffusion of mobile telephony.

ENDNOTES

1. Mobile penetration rate is measured as the number of mobile subscriptions per 100 inhabitants. ITU statistics reflect the number of mobile connections (SIM cards), not the number of mobile users. Due to the multiple SIM cards, inactive accounts, and sharing of mobile phones, these statistics may not accurately estimate mobile phone adoption. According to GSMA, there are an estimated 1.6 SIM cards per every mobile subscriber.
2. Latin American countries are characterized by high levels of income inequalities. We estimated the models with Gini coefficient to capture the inequalities. However, the variable was not found to be statistically significant either for the level or the growth rates of mobile subscription rates. For the Caribbean sample, we did not have sufficient data on Gini coefficient.

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APPENDIX
List of Countries Included in the Sample:

Latin America	**Caribbean**
Argentina	Antigua and Barbuda
Belize	Bahamas, The
Bolivia	Barbados
Brazil	Cuba
Chile	Curacao
Colombia	Dominica
Costa Rica	Dominican Republic
Ecuador	Grenada
El Salvador	Guyana
Guatemala	Haiti
Honduras	Jamaica
Mexico	Puerto Rico
Nicaragua	St. Kitts and Nevis
Panama	St. Lucia
Paraguay	St. Vincent and the Grenadines
Peru	Trinidad and Tobago
Suriname	
Uruguay	
Venezuela, RB	

FIGURE A1
LOWER MIDDLE INCOME CARIBBEAN COUNTRIES

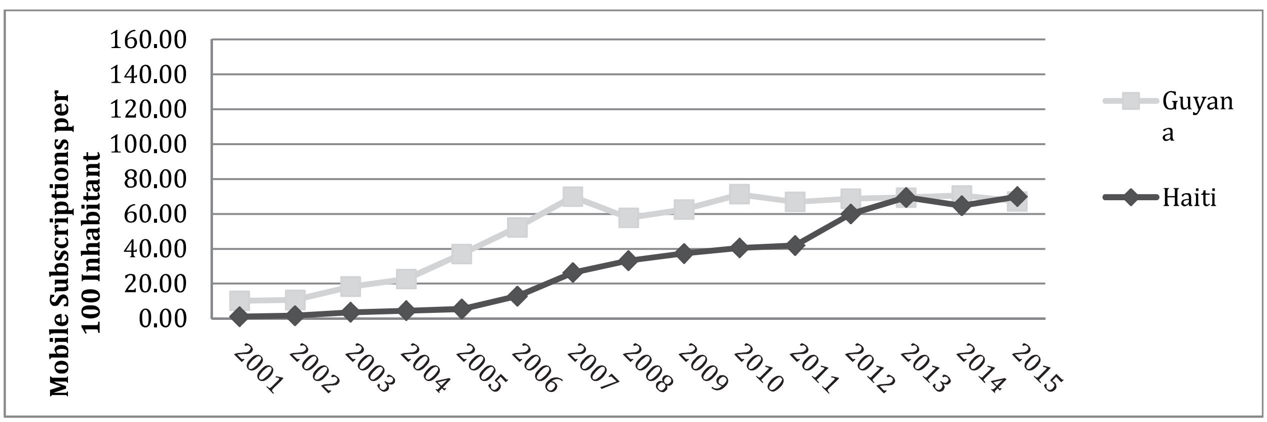

FIGURE A2
UPPER MIDDLE INCOME CARIBBEAN COUNTRIES

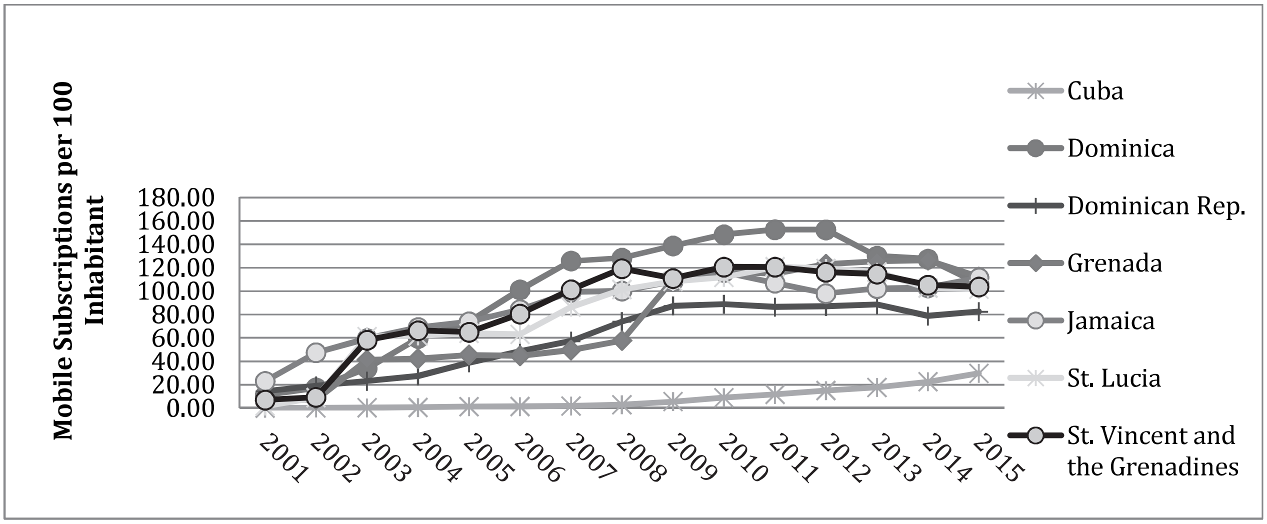

FIGURE A3
HIGH INCOME CARIBBEAN COUNTRIES