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Abstract

This study discusses some empirical findings on telephone and cell phone adoptions in Latin American and Caribbean nations. Exhaustive pooled regressions are undertaken for this set of nations, using data from the World Bank for the period of 1989-1999. The results show that telephone and cell phone adoptions are different in nature, and cell phone adoption complements telephone adoption. Country effects and year effects are also discernible.

Keywords: Telecommunications, Latin America, Caribbean, adoption, pooled regression

Introduction

The Latin American and Caribbean [LAC] set of nations is recognized as a world region with a distinct culture of its own (www.eclac.cl). The region contains approximately 6% of the world's population and 3% of world IT investment (Callaos 1999). The region has seen impressive growths in the IT field in recent times. For example, the software market has grown 300% from 1998 to 2002. In the telecommunications sector, cell phones have seen rapid growth, whereas telephone mainlines registered a weaker growth. It is important to know which factors are responsible for the growth of telecommunication technologies in these nations. In this paper, we attempt to identify some factors, including economic and diffusion-related, as well as alternative types of telecommunication services, that may play a role in the adoption of a given telecommunication technology.

After the privatization of state-owned telecommunication firms in many LAC countries in the late 1980s and into the 1990s, the telecommunication infrastructures of many LAC nations have been and continue to be overhauled. Telecommunications liberalization (the lowering of barriers to entry of new operators) has taken place in many LAC nations (Primo Braga and Ziegler 1998). Many foreign and local investors bought state-owned telecommunications firms and launched new ventures in both cellular and fixed-line service throughout LAC nations (Grosse 2000; Gutierrez and Berg 2000). Governments, though, still hold a monopoly on telephone service in about a third of Latin American nations. Brazil, Peru, Argentina, Colombia, and Mexico enjoy healthy competition in telecom markets (Bremer 2000). By the year 2010, fixed-line telephone penetration will have more than doubled to 49% reach, mobile penetration will have tripled to 60% reach, and access to the Internet will have quadrupled to about 50% reach by the population. This optimism is shared throughout the region (Latincom 2002). The liberalization of the telecommunications sector has progressed enough to allow the LAC nations to now make the most of cheaper technologies.

The major factors driving the growth in telecommunication technologies are the Internet, computing technologies, and wireless communication. The growth of cellular telephony in LAC nations is remarkable. O'Connor (2003) reports that the number of wireless subscribers in Latin America increased from 100,000 to 39 million in the 1990s. He further points out that, due partly to inadequate infrastructure for traditional telephony, the number of wireless subscribers has surpassed the number of land lines throughout the region. It has been argued that wireless communication is used as a substitute for traditional telephony growth in developing nations, whereas in developed nations it is used as a complementary gadget to mainline telephones (Menezes 2000).

Some experts claim that the growth of wireless telephones in this region has been due to the fact that there is more competition in wireless than in fixed telephony (BridgeNews Report 2000). Others think that cell phones are rapidly growing because telephone services are not uniformly available in this region. It is reported that Chile, El Salvador, Mexico, Paraguay, and Venezuela currently have more cell phone than land line subscribers, as does the whole of Latin America (O'Connor 2003).

Literature Review

Barro and Sala-i-Martin (1998) and other researchers discuss the problems of cross-country regressions. Often, data availability is limited, data sets are incomplete, and data contain error. This, however, has not deterred researchers from using available data in their research.

Nadeau et al. (2000) made an exhaustive study on telephone service in French speaking nations for the period 1988-1998. They found that deregulation drives down the price of the service and the impact of price on telephone services is not clear. Estache et al. (2002) did an involved study on LAC Internet use and found that a) diffusion effects were not present in the LAC sample, and b) regulation, privatization and income inequality all play a role. Gutierrez and Berg (2000) conducted a study on 19 LAC nations on telephone adoption factors for the period 1985-1995. They found that GDP and a host of other institutional variables could explain 95% of the variance in the dependent variable, the telephone mainlines. From the above studies, one can find that detailed empirical studies are needed to determine the major factors behind telecommunication adoption in LAC nations.

The literature, in particular, is lacking in identifying what impacts, if any, one type of service may have on another. The present study departs from others in that it studies all LAC nations for a longer period of time and, in doing so, it investigates the roles of telephone and cell phones on the adoption of each other.

Hypothesis Development

Needless to say, all the hypotheses developed and tested in the current study are related to the LAC nations, which are listed below:

> Argentina, Antigua and Barbuda, Bahamas, Barbados, Belize, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Dominica, Dominican Republic, Haiti, Honduras, Ecuador, El Salvador, Grenada, Guatemala, Guyana, Jamaica, Mexico, Nicaragua Panama, Paraguay, Peru, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Suriname, Trinidad.

We use GDP per capita as a measure of economic conditions and development. Most of these nations are in the middle-income category per World Bank definition (GDP per capita > U.S. $760 but ≤ U.S. $9360 in 1998), with the exception of Haiti, Honduras, and Nicaragua, which belong to the low-income group (GDP per capita ≤ U.S. $760 in 1998), and the Bahamas which is the lone LAC nation listed in the high-income category (GDP per capita > U.S. $9360 in 1998).

Sample data for telephone and cell phone adoptions are shown for a few selected LAC nations in Tables 1-2. Data show that for both telephone mainlines as well as cell phones, the growths of LAC nations are closer to those of middle-income nations worldwide. There is a large disparity between low-income and high-income nations worldwide on this score.

For LAC and middle-income nations, the increases in cell phone numbers were from 0 to 45 and from 0.01 to 31 per 1000, respectively, during 1986-1998. LAC nations are showing growths consistent with middle-income nations of the world, suggesting the importance of economic conditions on both telephone and cell phone adoptions. As mentioned earlier, most LAC nations are in the middle-income category. Of note is the fact that LAC average cell phone growth started a little slower, but eventually surpassed the average growth of middle-income nations.

Telephones have usually grown faster in high-GDP nations (de Sola Pool, 1981). We need to test whether this trend is valid also for LAC nations. Cell phones may not follow this trend in LAC nations. As a matter of fact, it appears that many of the poorer LAC nations are bypassing the telephone infrastructure to adopt cell phones (mentioned earlier). The President of BellSouth Latin America has noted that the total cellular penetration in Latin America as of early 2002 presents significant opportunities for growth for companies like BellSouth and its major competitors in the region, Spain's Telefonica, Telefonos de Mexico, and Telecom Italia (Brown 2002).

Table 1. Telephone Mainline Penetration Data for Selected LAC Nations (per 1,000 people)

Nations	1975	1980	1985	1990	1995	1998
Argentina	63.38	66.83	89.85	94.9	159.09	202.73
Bahamas	120	148	179.43	273.91	300.02	352.34
Barbados	109.94	138.71	191.65	280.61	345.33	424
Brazil	20.38	40.81	53.33	65.02	85.12	120.51
Chile	28.74	32.58	44.48	65.65	132.48	205.49
Haiti	..	..	5.29	6.94	8.36	..
Honduras	5.64	8.11	10.97	17.23	27.03	38.15
Mexico	27.93	40.27	49.55	64.83	93.86	103.59
Nicaragua	9.05	11	13.43	12.6	22.17	31.34
Peru	15.76	17.48	21.15	26.15	47.14	66.73
Latin America & the Caribbean (average)	28.62	40.68	51.33	64.12	91.72	122.77
Low income nations – worldwide	5.45	7.27	8.1	10.5	15.67	21.55
Middle income nations – worldwide	14.47	22.08	30	41.31	70.46	103.01
High income nations – worldwide	252.99	320.76	388.3	457.43	522.15	566.26

Source: World Bank 2003; .. denotes missing data.

Table 2. Mobile Phone Penetration Data for Selected LAC Nations (per 1,000 people)

Nations	1992	1995	1998
Argentina	1.39	9.8	78.12
Bahamas	9.86	14.7	26.68
Barbados	3.07	17.68	44.78
Brazil	0.21	8.25	46.79
Chile	4.76	13.82	65.05
Honduras	0	0	5.33
Mexico	3.49	7.34	34.95
Nicaragua	0	1.01	4.48
Peru	0.96	3.13	29.96
Latin America & the Caribbean (average)	1.38	7.91	44.7
Low income nations – worldwide	0.026	0.2	1.52
Middle income nations – worldwide	0.62	4.87	25.6
High income nations – worldwide	24.17	85.27	266.23

Source: World Bank 2003.

Hypothesis H1: Economic development of a nation will be positively significant in telephone adoption but not in cell phone adoption

LAC nations have gone through rapid privatization and liberalization reforms in the 1990s. These reforms usually introduce competition and are expected to eventually drive down the prices of telecommunication services. With the introduction of cell phone services, telephone services are expected to become cheaper and, accordingly, more accessible. Thus, cell phones may have contributed to more adoption of telephones. However, it is also true that cell phones may serve as substitutes to, and in cases bypass the adoption of, telephones in some nations. An existing telephone infrastructure may help in cell phone adoption, as adopters of the old technology are more conversant with the pros and cons of the technology in general.

Hypothesis H2: Cell phone adoption will complement telephone adoption; likewise, telephone adoption will complement cell phone adoption.

Finally, we want to test whether or not telephone and cell phone adoptions are identical in nature for LAC nations. Many researchers observe that adoption decisions can be influenced by a variety of factors: independent use, management encouragement, level of use, network externality, to name a few (Fichman, 1992). For a given set of nations, this may indeed make each IT type diffuse differently. Cell phones are believed to be diffusing much faster than telephones, especially in LAC nations. The data sets of Tables 1-2 also tend to support that view.

Hypothesis H3: Telephone and cell phone adoptions are different.

Model

The model we test for hypotheses H1 and H2 is specified as follows:

$$\ln\left(\text{Telecomm1}_{n,t}\right) = c_0 + c_1 \ln\left(\text{GDP}_{n,t}\right) + c_2 \ln\left(\text{Telecomm2}_{n,t}\right) + \varepsilon \quad (1)$$

where, for a nation n in year t:

$\ln\left(\text{Telecomm1}_{n,t}\right) =$ natural logarithm of telecommunication product of type 1 (say, telephone lines);
$\ln\left(\text{Telecomm2}_{n,t}\right) =$ natural logarithm of telecommunication product of type 2 (say, cell phone 'lines');
$\ln\left(\text{GDP}_{n,t}\right) =$ natural logarithm of GDP per capita; and
$\varepsilon =$ error term.

This is a standard log-log model and the coefficients in regression measure elasticities.

Data and Method

The data used in this study are those reported for all LAC nations in the World Bank database, covering the period 1989-1998. For each nation, GDP per capita is expressed in constant 1995 US$. The absolute numbers of telephone lines and cell phone 'lines' (or simply "cell phones") were calculated from the database and used in the regression analyses. To keep errors in data under control, natural logarithms of GDP per capita and the dependent variables are used.

Incomplete data series are deleted from the final regression to get a more accurate picture. Pooled regression, which has been adopted in the present study, has often been cited as a powerful tool to do regression analyses (Stimson 1989; Wooldridge 2000). In the final weighted regression, the weight variable used is population, obtained from the World Bank database. In the pooled regression, year dummies and country dummies are used for all years and all LAC countries available. The dummy variables for the year 1989 and the nation Haiti were dropped from the final pooled regression to obtain fixed effects associated with years and nations. Thus the coefficients of years measure changes relative to 1989 and the coefficients of nations measure telecommunication changes of a nation relative to Haiti.

Results

Our results are shown in Tables 3-4, which present the results of WLS regression with population as the weight variable. In Table 3, the results of WLS regression of equation (1), with telephone mainlines as dependent variable, are shown. The coefficient of GDP per capita captures the income elasticity of demand for telephone mainlines, while the coefficient of cellphones captures the positive impact of cell phones on telephone mainlines. Coefficients associated with GDP per capita and cellphones are both positive. Moreover, both regression coefficients are statistically significant, particularly for cell phones. White's test for heteroscedasticity with GDP per capita and cell phones (candidates for possible heteroscedasticity) as independent variables failed to produce $n \times R^2 > \chi^2(263)$ at the 5% level of significance, thus implying that the test could not find a problem. Hence,

support for relevant parts of hypotheses H1 and H2 can be seen. Fixed effects by nations and years are mostly positive and significant. Finally the adjusted R^2 value is very high (0.997).

Table 3. WLS Regression for Telephone Mainlines, 1989-1999

Dependent variable: Logarithm of telephone mainlines
Weight variable: Population

Variable/Statistic	Coefficient/ Value	T [p-value]
ln (GDP per capita)	0.081	1.7 [.092]
ln (cellphones)	0.071	4.56 [.000]
Constant	---	11.41 [.000]
Adjusted R^2	0.997	
F-statistic	2275.83	[.000]
No. of observations	263	
Significant year variates	8 / 10	
Significant country variates	32 / 35	

Thus it appears that cell phone adoptions positively influence telephone line adoptions.

In Table 4, the cell phone regression of equation (1) is shown. Both telephones and GDP per capita coefficients are significant. The GDP per capita coefficient captures the income elasticity of telephone mainlines demand and it is negative in this regression. This may be because many poor LAC nations are rapidly adopting the cell phones. This could also be due to the possible presence of heteroscedasticity in data (Greene 2000). However, White's test for heteroscedasticity with GDP and telephone mainlines (candidates for possible heteroscedasticity) as independent variables failed to produce $n \times R^2 > \chi^2(263)$ at the 5% level of significance, thus implying that the test could not find a problem. The telephone coefficient captures the positive impact of telephones on cell phone adoption, which is positive and significant. Thus support for hypotheses H1-H2 can be seen. Fixed effects by nations and years are fairly significant. Finally the adjusted R^2 value is quite high (0.962).

In order to test whether or not telephone and cell phone adoptions in LAC nations are the same, we tested whether significant differences in variability in adoption data in cell phones and telephones exist. Since F(0.05) = 1.95 and since this is larger than the critical value of 1.00 (with numerator = 272 and denominator = 373), there is enough evidence to claim a difference in variability of adoption data of cell phones and telephones. This provides support for hypothesis H3.

In order to test hypothesis H3 using another perspective, the diffusion rates were calculated for cell phones and telephones in LAC nations. The logistic model was used to calculate the rates. The models fitted the data closely ($R^2 = 0.98$ for telephones during the year 1975-1998 as also for cell phone data during the year 1988-1998) and the fits are shown in figures 1-2. The growth rates for telephone came out as 0.062 ($p < .000$) and for cell phones it was 0.755 ($p < .000$). These values are widely different, suggesting that cell phones are diffusing much faster than telephones in LAC nations.

Table 4. WLS Regression for Cellphones, 1989-1999

Dependent variable: Logarithm of cellphones
Weight variable: Population

Variable/Statistic	Coefficient/ Value	T [p-value]
ln (GDP per capita)	-0.353	-1.78 [.077]
ln (telephone mainlines)	1.239	4.56 [.000]
Constant	---	-1.11 [.271]
Adjusted R^2	0.962	
F-statistic	126.07	[.000]
No. of observations	263	
Significant year variates	10 / 10	
Significant country variates	8 / 32	

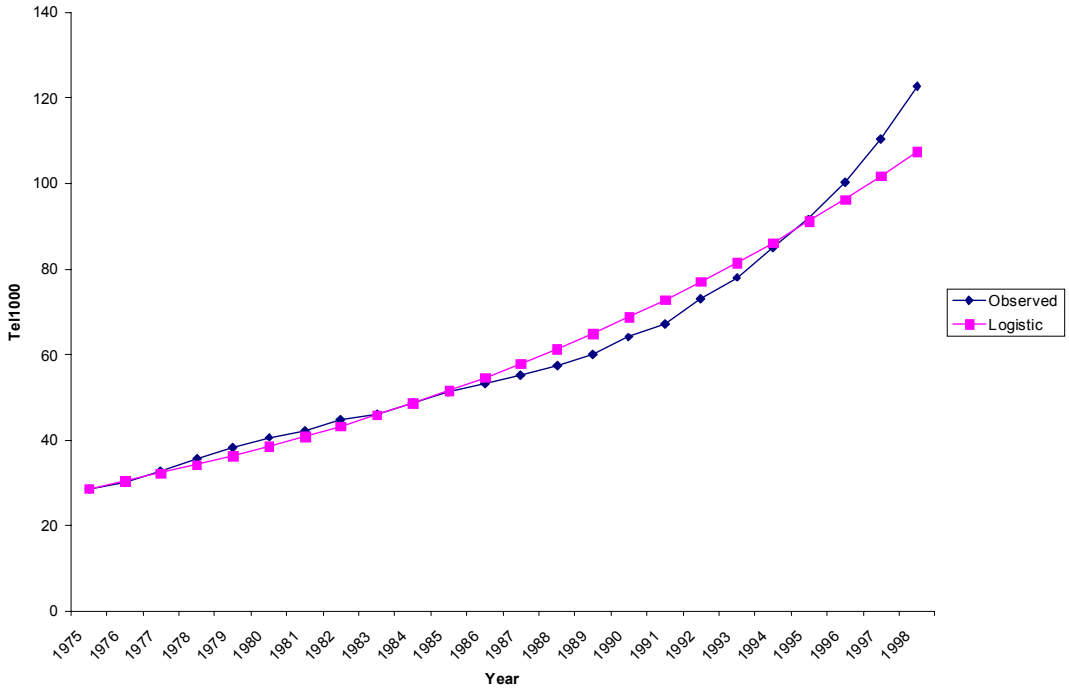

Figure 1. Telephone Diffusion Rate and Logistic Fit in LAC Nations

Our results are summarized in Table 5. Overall, H3 is strongly supported. Hypothesis H1 is supported when regression is performed based on equation (1). Hypothesis H2 is supported with respect to cell phone adoption complementing telephone adoption and telephone adoption complementing cell phone adoption.

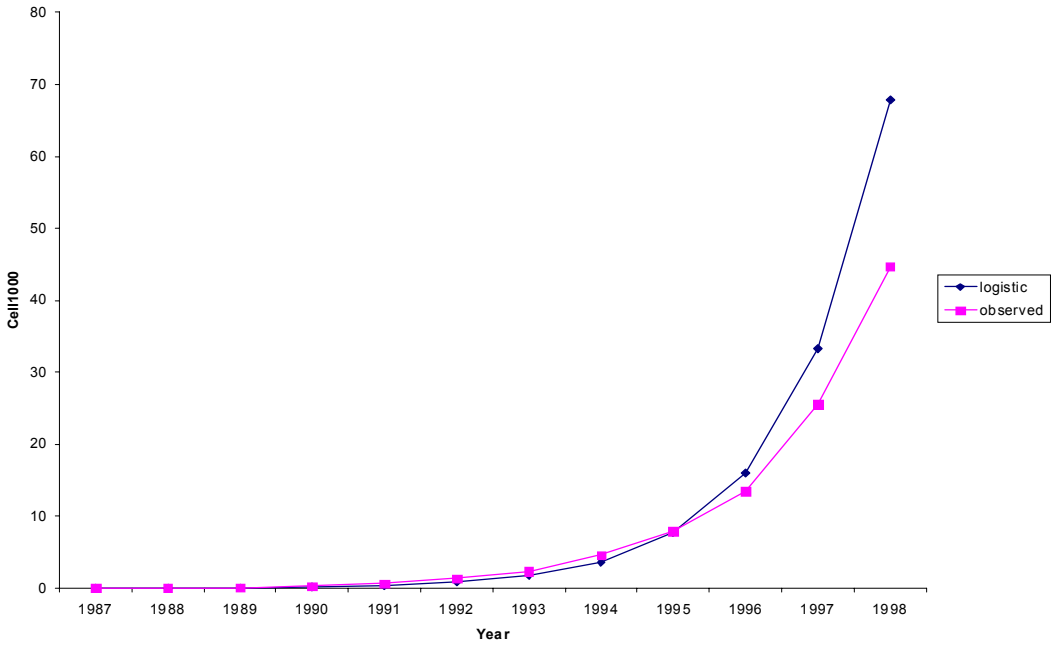

Figure 2. Cell phone Diffusion Rate and Logistic Fit in LAC Nations

Table 5. Summary of Findings

Technology	Factors responsible for adoption	Hypothesis	Result
Telephone	Economic development	H1	Supported
Telephone	Positive impact of cell phone	H2	Supported
Cell phone	Economic development	H1	Supported
Cell phone	Positive impact of telephone	H2	Supported
Telephone and Cell phone	Difference in adoption	H3	Supported

Conclusions

This preliminary study sheds new light on telecommunications adoption in LAC nations. Cell phone adoption complements telephone adoption and vice-versa. The results have implications for policy makers. In comparison to a slower growth of telephone main lines, the rapid emergence of cell phones suggest the importance of this new gadget in LAC nations.

We did not take diffusion effects into consideration in our simplified model (Rogers, 1983). It is important to consider the stage of diffusion (early, middle, late) of a technology diffusion in a nation (or a set of nations), because it can have an impact on the diffusion. Factors impacting the diffusion of a technology may not be same at different stages of diffusion. We also need to find out whether LAC nations are different from the rest of the world in this respect. The work on this is ongoing. We also intend to conduct further studies that would also look into the impact of privatization and liberalization reforms alongside diffusion and telephone-cell phone complementation effects.

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