December 2002

INFORMATION TECHNOLOGY DIFFUSION IN LATIN AMERICA: SOME EMPIRICAL RESULTS

Kallol Bagchi
Louisiana Tech/UTEP

Paul Hart
Florida Atlantic University

Robert Cerveny
Florida Atlantic University

INFORMATION TECHNOLOGY DIFFUSION IN LATIN AMERICA: SOME EMPIRICAL RESULTS

Kallol Bagchi
Louisiana Tech/UTEP
kbagchius@yahoo.com

Paul Hart
Florida Atlantic University
hart@fau.edu

Robert Cerveny
Florida Atlantic University
cerveny@fau.edu

Abstract

This paper presents some empirical results related to information technology (IT) diffusion in Latin American nations. The paper finds that diffusion speeds of five IT products are quite high and comparable to other nations. The results also show that for these products, IT diffusion is accelerating. Factors such as base IT infrastructure and institutional indicators such as regulatory burden are expected to be related to such diffusion acceleration in Latin America.

Keywords: Information technology, diffusion, Latin America, empirical results, logistic model

Introduction

Some scholars think that modern information technology (IT) is converting the world into a global village (Negroponte, 1995), and some others think that the world consists of separate nations with distinct cultures. This difference will continue to exist for sometime to come (Inglehart and Baker, 2001). However, few will disagree that a study is needed to find out how these differences or lack of differences are playing out in the IT diffusion arena. IT diffusion pattern may vary from one nation to another. Information technology diffusion is important to planners and policy makers all around the world. As de Sola Pool had observed, IT infrastructure planning is important for a nation as it is connected to her social planning (de Sola Pool, 1981). Therefore, it is important to know how ITs are diffused throughout the world in general and in Latin America in particular.

A study of IT growth in Latin America is important for several reasons. The East Asian and the Latin American regions experienced rapid economic growths in the early 1990s. The 1994 Mexican Peso crisis, the 1997-1998 financial and economic problems in Brazil, and the recent Argentine economic crisis may not have deterred this potential of growth (The FEALAC Report, 2002). Further, the nations in the Latin American group are bound by a regional culture. Many scholars think the concept of Latin America as a regional entity is often ignored and although nations in this region have occasionally faced difficult times, the people maintained their existences and derived their strengths from a regional perspective.

Therefore, it is important to study Latin American IT growth both as a group as well as individual nations. In the present study, the Latin American Group of nations (21 in total) is included in a larger set of 34 nations called Latin America & Caribbean Nations for doing a general study . This larger set of nations includes the following: Antigua and Barbuda , Argentina, Bahamas, Barbados, Belize, Bolivia, Brazil, Chile, Colombia, Costa Rica , Cuba , Dominica, Dominican Republic , Ecuador, El Salvador, Grenada, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, Puerto Rico, Saint Kitts and Nevis, Saint Lucia, Saint Vicent and the Granadines, Suriname, Trinidad and Tobago, Uruguay and Venezuela

This larger set of nations as a group may not be culturally as cohesive as the group of only Latin American nations, although geographically, this set of nations is considered as a separate region by the World Bank/United Nations. There may be some

additional justifications for considering this larger set of nations as a separate region. For example, the Economic Commission for Latin America and the Caribbean (ECLAC) thinks the region's institutional legacy and inherited production structure influence the economic dynamics of these developing countries and generate behaviors that differ from those of developed nations. The Latin American set of nations is also exclusively used in the study when appropriate.

In studying the IT growths of a nation or a set of nations, several important issues need to be addressed. The first is determining the speed of IT diffusion of that nation and finding out how that compares with the speed of other nations. The second issue is determining whether the speed of diffusion accelerates with the progress of time. Many scholars think the speed of diffusion of most innovations increases with the progress of time. As a consequence, these innovations may impact the existing social order. This is particularly true for IT products. Some studies provide evidence that rate of adoption is increasing (Olshavski, 1980 ;Van den Bulte 2000). Other studies dispute this conjecture (Bayus, 1992, Kohli et al., 1999). A third important issue is what factors contribute to or retard acceleration of IT diffusion. These issues are discussed in this article primarily with Latin American nations as examples.

Some of the questions that flow from the above issues are:

- What is the speed of IT product diffusion in Latin American nations?
- What will be the nature of future IT growth in Latin American nations?
- How do the IT diffusion speeds in Latin America compare with the U.S or the rest of the World?
- Do these IT diffusion speeds increase with time?

This study attempts to answer to these questions and posits how the IT products are gaining acceptance in Latin America.

IT Diffusion Speed

We measure the diffusion speed by estimating the logistic diffusion model(Mansfield 1961, Olshavski, 1980) and using the parameter estimate of β as an indicator of diffusion speed (Van Der Bulte, 2001). The parameter β is determined from the equation:

$$dy/dt= \beta y(y^*-y)$$

where y is the number of existing adoption and y* is the saturation level. The formulation leads to a logistic curve, which can be expressed as

$$P=K/(1+e^{-(l+\beta^*T)})$$

where K is the upper limit of diffusion, P is the percentage adopting the innovation, T is the time variable, and l is the constant of integration. The logistic is an increasing S-curve which tends to the limit 1/K as T (the time) tends to infinity. The diffusion rate is symmetric in nature and the maximum diffusion rate (inflection point) is achieved at the point 0.5K after which it starts to decline.

A two-step analysis approach is followed. First, an estimate of the parameter β of the logistic diffusion model is done and the speed of diffusion is calculated. For the next step, the estimate of speed is used as a dependent variable to drive various multiple regressions.

Data

Data for various IT products of different nations are gathered from the World Bank (2001) database. Since data on IT product adoption on Latin American nations is sparse, the available penetration data series for each set of nations is used. The IT innovations considered consist of five IT products: The telephone, the cell phone, the personal computer (PC), the Internet (measured in terms of Internet hosts), and FAX machines. The nations examined are the Latin American and Caribbean, the World, the U.S., and the high-income group nations (as defined by the World Bank). The high-income group consisted of those nations whose per capita GNP was greater than U.S. $9360 in 1998. Along with the Latin American and Caribbean nations, other groups of nations were included to make a comparison framework. The nature of data is summarized in Table 1. The diffusion

data of various ITs consists of the annual observations for a number of years. Data for all ITs are not available for the time shown in Table 1; however, for most of the ITs, nations under study had enough data to arrive at an estimate of the parameter of the logistic regression model. The time was operationalized as the year in which the data became available. This was done for two reasons: to increase the size of the sample and to avoid ambiguity in finding out which year the innovation was started in a particular nation or a group of nations (the ambiguity is due to the absence of reliable data).

Table 1. Parameter Estimates and Goodness- of- Fit Measures From Logistic Model for Five Products and Four Sets of Nations

*-- per 1,000 people **--per 10,000 people

Nations	IT studied and the measure	Years in the data series	R^2	Logistic β
High income Group	Mobile phones*	1981-1998	0.9975	0.42312
Latin America & Caribbean Nations	Mobile phones*	1981-1998	0.9783	0.748237
The United States	Mobile phones*	1981-1998	0.9931	0.38126
The World	Mobile phones*	1981-1998	0.9982	0.422052
High income Group	Telephone mainlines*	1960-98	0.9957	0.054773
Latin America & Caribbean Nations	Telephone mainlines *	1960-98	0.9824	0.061131
The United States	Telephone mainlines *	1960-98	0.9879	0.049295
The World	Telephone mainlines*	1960-98	0.9767	0.036664
High income Group	Personal computers*	1981-1998	0.9951	0.148372
Latin America & Caribbean Nations	Personal computers *	1981-1998	0.9921	0.246156
The United States	Personal computers*	1981-1998	0.9809	0.127379
The World	Personal computers*	1981-1998	0.9783	0.120136
High income Group	Internet hosts **	1995-1999	0.9711	0.509493
Latin America & Caribbean Nations	Internet hosts **	1995-1999	0.9164	0.502857
The United States	Internet hosts **	1995-1999	0.9518	0.4360
The World	Internet hosts **	1995-1999	0.969	0.390675
High income Group	Fax machines *	1986-97	0.9938	0.186932
Latin America & Caribbean Nations	Fax machines *	1986-97	0.6154	0.186209
The United States	Fax machines *	1986-97	0.9717	0.200038
The World	Fax machines *	1986-97	0.9923	0.170314

Results and Discussions

Table 1 shows the results of parameter estimation calculations as well as the measures of goodness of fit. The logistic model provides a good fit to each set of data. The diffusion speed (denoted by the logistic β in Table 1) for the Latin America & Caribbean group of nations is quite fast (highest for three ITs) during the period of study and compares quite favorably with the speed of the high-income group, the U.S and the World. The diffusion process of some of these ITs for the U.S. and the high income group (including many western nations) started earlier stabilized during the study period. The IT diffusion speeds of Latin America & the group of Caribbean nations started later, are on the rise, and perhaps will continue in this fashion for some time. The projected penetration levels based on actual data up to the year 1999 for various ITs (as obtained

from the logistic model) are shown in Table 2. Except for Fax machines (which had a low fit), all other models of ITs provided quite reasonable fits to data (see Table 1 for R^2 values). This provides answers to questions 1 -3.

Table 2. The Projected Penetration Levels and Corresponding Years for Five ITs

Latin America & Caribbean Nations	IT type	Start year	% of population to be penetrated	Estimated year of such penetration
	Personal computers	1988	50%	2011
	Cell phones	1987	50%	2002
	Internet hosts	1995	50%	2013
	Telephone mainlines	1975	20%	2010
	Fax machines	1990	10%	2016

In order to answer question 4, the diffusion speeds (β's from Table 1) for each product and for each nation set were regressed on the time variable at which the data series started for each IT. The tested null hypothesis was that diffusion speed is not increasing over time. The regression equation obtained was:

$$\beta_j = -0.01 + 0.0113 * \text{time}$$

The coefficient of time variable was positive and significantly different from zero ($F=9.48$, $p<.007$, $R^2=0.35$), so the null hypothesis could be rejected . This implied that the value of the diffusion parameter increased with time and this was indicative of acceleration of the speed of overall diffusion. This phenomenon was also tested for individual Latin American nations. Table 3 shows support for diffusion speed acceleration for individual ITs, when only Latin American nations are used. The coefficient of time in each regression is positive (Table 3) , which indicates that the acceleration is again positive. The available Internet diffusion data starts from the same year for most nations. So, to increase the variability in start time in the time calculation method for the Internet, a penetration level of .005% was used for time calculation. The R^2 values in Table 3 are low but the regressions are statistically significant. This finding provided a general answer to question four for all groups of nations and particularly for Latin American nations.

Table 3. Diffusion Speed Acceleration for Three IT Products, Using Only Latin American Nations

IT Type	Coefficient of time	R^2	F	N (no. of nations)	Time calculation Method
PC	.006 (+)	.21	4.23 ($p<.07$)	18	Start of data series
Internet hosts	.068 (+)	.28	7.12 ($p<.02$)	20	.005% penetration level
Cell Phone	.069 (+)	.34	10.66 ($p<.005$)	23	Start of data series

The observed IT diffusion speeds are in general higher than many other innovations studied (Olshavsky, 1980), with the exception of the telephone, which has been around for more than 100 years. This shows that IT diffusion in particular could be much faster than other innovations. In fact, most ITs have been shown to capture the first 25% of the U.S. consumer market at a much faster rate than other innovations. This could be due to the fact that ITs are a special group of products that diffuse faster or because ITs are of recent origin, compared to other products or a combination of both of these or other factors. This investigation could be done in a separate study.

What are the factors responsible for IT diffusion acceleration in Latin American nations? It is conjectured that some of the economic indicators such as GDP per capita, inflation, income inequality, investment/GDP, unemployment ratio (Barro et al., 1995; Barro, 1997) and institutional indicators such as accountability, government efficiency, regulatory burden, graft etc., (Kaufmann et al., 1999) could be influential factors together with IT base infrastructure of a nation. The base value of the technology is expected to be negatively related to the IT diffusion rate: the higher the starting level of diffusion (in terms of number of installations), the lower is the rate. This is so because late starters try to catch up at a faster speed , when everything else is equal (Barro, 1997). Institutional variables such as regulatory burden (which measures the unfriendly market policies and excessive foreign trade regulation for business development used by the government of a nation) is expected to emerge as significant and positive in the IT regressions as higher values of these measured institutional variables indicate better governance outcomes. A better government helps the growth of businesses in general. Preliminary regression results using three ITs (the cell phone, the PC and the Internet) confirm that regulatory burden and IT infrastructures emerge as significant factors of such IT diffusion acceleration (not shown) . Finally, for cell phone adoption factor regression, the telephone infrastructure was tried as

an additional indicator (not shown), but did not emerge as significant in the overall regression. This may indicate that many Latin American nations are bypassing their telephone infrastructures in an attempt to adopt cell phones and cell phone diffusion may not be dependent on the telephone infrastructure of a nation.

Limitations

There are several limitations to this study. The data used in this study are secondary in nature. However, in cross-country research, use of secondary data is common and perhaps inevitable. The two-stage analysis method used in the present study has some weaknesses. This can be improved with a unified single step method as outlined in recent research. Using a longer time-series data, when available may increase the estimation accuracies. However, as Mahajan and Peterson (1995) noted, using even a time-series consisting of a limited number of data points may yield a reasonable estimate in the early phases of an innovation's diffusion.

Conclusion

This preliminary study contributed to the present knowledge of IT diffusion in several ways. First, there is no empirical study considering IT growths in Latin American nations. These nations are showing some rapid economic growths in recent times, and are culturally rich and cohesive as a group. Second, the study found that for several ITs, the diffusion speeds for Latin American nations during the period of study are quite high and can be compared favorably with many other nations. Third, the study found that IT diffusion speed is accelerating in general and for Latin American nations in particular, as time progresses. This is also an important observation since in the past some studies using other products have contradicted this observation. Preliminary results also show that several factors contributed to the explanation of the variance in IT diffusion speed for Latin American nations. These were base IT infrastructure and institutional indicators such as regulatory policies of nations. The amount of variability of the dependent variable explained by these indicators ranged from 24%-30%. Future studies on IT diffusion in Latin American nations may focus on these aspects.

References

Barro, R. Determinants of Economic Growth, Cambridge, Massachusetts: The MIT Press, 1997.

Barro, R. and Sala-I-Martin, X. Economic Growth, McGrew-Hill, 1995.

Bayus, B. "Have Diffusion Rates Been Accelerating Over Time?" Marketing Letter (3), July 1992, pp. 215-226.

de Sola Pool, Ithiel. The Social Impact of the Telephone, Cambridge, Massachussets: MIT Press, 1981.

The FEALAC Economy and Society Working Group Report, "Sustainable Development in East Asia and Latin America: Comparative Study," 2002.

Inglehart, R. and Baker, W. "Modernization, Cultural Change and the Persistence of Traditional Values," Amercan Sociological Review (2: 65), February 2000, pp. 19-51.

Kaufmann, D., Kraay, A., and Zoido-Lobaton, P. " Aggregating Governance Indicators," World Bank Policy Research Working Paper 2195, October, 1999.

Kohli, R., Lehmann, D., and J. Pae, "Extent and Impact of Incubation Time in New Product Diffusion," Journal of Product Innovation Management (16), March 1999, pp. 134-144.

Mahajan, V. and Peterson, R. Models for Innovation Diffusion, Sage University Paper series on Quantitative Applications in the Social Sciences, (2nd ed.), Beverly Hills and London: SAGE Publications, 1987.

Mansfield, E. "Technical Change and the Rate of Imitation," Econometrica (10:29), 1961, pp.741-766.

Negroponte, N. Being Digital, Random House Trade, 1995.

Olshavski, R. "Time and Rate of Adoption of Innovations," The Journal of Consumer Research (2: 6), March 1980, pp. 425-428.

Van den Bulte, C. "New Product Diffusion Acceleration: Measurement and Analysis, " Marketing Science (4:19), Fall 2000, pp. 366-380.

The World Bank Report, 2001. www.worldbank.org.