A Model of Wireless Broadband Diffusion in Latin America

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Abstract

Countries in Latin America have lagged behind much of the world in telephone lines, but they have made up this gap through cellular networks. The limited wired infrastructure means that broadband access will more likely be achieved through wireless technology. In this paper, we argue that Latin America will experience a patchwork pattern of adoption where segments of society will have state of the art broadband access while many segments will be left behind without connectivity. We test this hypothesis through a simulation developed using iThink® and show how 3G cellular and WiFi access could evolve in Latin America. Data cellular networks will have a slower take-up rate because of the high costs of the handset (as well as access fees); while WiFi, although imperfect, will experience faster growth. The patchwork adoption framework argues that socioeconomic indicators affect the way technologies are diffused. We present data on these indicators for four countries: Brazil, Chile, Mexico and Peru.

1 Introduction

Voice connectivity in Latin America is predominantly achieved through wireless technologies. While in government hands, the wired infrastructure was under resourced, poorly maintained, and rarely upgraded (Wellenius 1994). Because of this, after liberalization, the fastest and least expensive way of providing connectivity to the region was through cellular phones. While cellular telephony facilitated access to voice communication, it is now facing an important challenge as the region moves toward connecting to the Internet through fast broadband networks. The problem, nonetheless, is that the current wireless network will require significant upgrades in order to support data. If this is not done, many segments of the Latin America population will likely be on the wrong side of the digital divide.

In this paper, we present the potential adoption alternatives and patterns in Latin America for wireless broadband. We review both WiFi as a potentially inexpensive but still deficient technology and third generation cellular services, which are considerably more expensive.

In order to help understand the adoption patterns for Latin America, this paper uses and further refines a theoretical framework used before by García-Murillo on patchwork adoption (2003). The framework's main idea is that Latin America, as a region, cannot be categorized as being entirely on the wrong side of the digital divide. Instead, the great income, educational, and technological disparities have led to a patchwork adoption of technology, where the wealthy can adopt state of the art technology before most people in developed nations. There are also many other poorer segments of the population for which adoption patterns are much slower or even non-existent.

Taking into consideration those disparities, as well as the technological differences between cellular based data networks and WiFi, we present a model that helps determine how these two technologies will diffuse in Latin America. We predict that both third generation technologies and WiFi based technologies will coexist, but given the income disparities, we will see the more expensive one diffusing at a lower rate among the wealthier sectors of the population, the less expensive alternatives prevailing among the middle class and a large number of individuals still working with obsolete technologies.

2 Patchwork adoption framework

This framework was originally suggested by García-Murillo (2003). In this paper, we use it to help us determine the adoption trends for wireless broadband technologies.

Publications on adoption have generally assumed a certain amount of uniformity in the population. They take into consideration the fact that there are some individuals that are more amenable to technology and will tend to adopt technology much sooner than those who are more averse to innovations (Rogers 2003). Other diffusion theories (Adams et al. 1992; Davis 1989; Hendrickson et al. 1993) concentrate on the features of the technology, instead of on the attributes of the individuals, which determine adoption. Thus, problems of adoption are identified as being problems with technology and people rather than resources.

There is a major difference between traditional diffusion of innovation theories and the present contribution. First, the existing theory on the diffusion of innovation focuses on people's attitudes and preferences towards technology or the inherent characteristics of these innovations. The patchwork adoption framework instead focuses on the resources that people have. Independent of their desire to adopt new technologies, individuals in less developed countries are limited by their income and their educational and social circumstances.

The main tenet of the patchwork adoption framework is that adoption does not evolve in a smooth S curve, but it manifest in a persistent patchwork state where some segments have state of the art technology while others maintain obsolete tools.

This paper thus argue that technology adoption will diffuse in a patchwork manner because of socioeconomic, cultural (i.e. education and social rituals), and technological factors that can lead to pockets of adoption and non-adoption in any given country.

While not necessarily focusing on issues of adoption, a recent book published by the International Development Research Center entitled *Digital Poverty: Latin American and Caribbean Perspectives* (Petrazzini 2007) recognizes the fact that the digital divide is an issue of poverty and inequality in society which can leave some segments behind in the information society.

Figure 1 shows that factors have dual causality effects. While income affects educational opportunities, these in turn affect income. Similarly, while education affects digital literacy, lack of digital literacy can undermine educational opportunities.

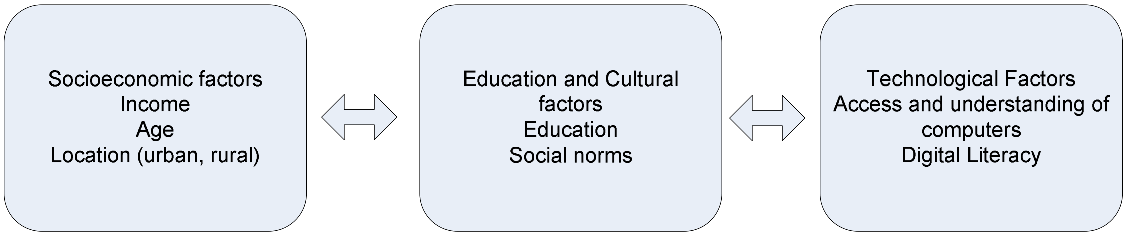

Fig. 1. Factors that lead to patchwork adoption

In Latin America, there are such great inequalities in each of these three areas that technology adoption for different segments would occur, we expect, at different rates for different segments. This means that different technologies can have different adoption patterns depending on the resources of the population.

The urban and rural wealthy are likely to have access and the material assets necessary to adopt state of the art technology. The young population in this segment is thus in tune with the developments that are taking place around the world. These are digitally literate individuals who are active global participants through the use of international information networks. In addition, many in this segment, given their privileged status, are likely to also be fluent in English, the predominant language of the Internet.

Because of the close interrelation between income, education, and technology, we use “wealthy” to refer to those who have high income, are highly educated, and have a high level of digital literacy. Those who do not have these characteristics are defined as “poor”.

3 Context

Before providing evidence of the economic, educational, and technological disparities that exist in developing countries, and Latin America in particular, this section presents some general differences in the patterns of adoption between developed and developing countries based on the above-mentioned factors.

First, the distribution of the population in Latin America is different. Instead of having several large and medium cities with relatively developed rural communities, there are usually a few mega cities in the developing world with many isolated and severely underdeveloped rural areas. In developed nations, there tends to be a large middle class with small segments of very wealthy or poor. In developing nations, there are few wealthy individuals, a small middle class, and a large percentage of poor people. Income distribution also leads to differing access to education. Here, again, there is a segment of the population that can afford technologically sophisticated private education. The rich tend to have connectivity and computer access at home while many segments of the population have limited access to technology and public schools rarely have access. Cities are densely populated, with all of the basic services, while rural areas lack these services.

In general, income and education have an impact on the way the population uses telecommunications services (Dwivedi and Lal 2007). While in developed countries people have access to computers and broadband connectivity, in Latin America the prevailing communication device is the mobile phone. Given the size and speed limitations, communications happens through prepaid voice or text messaging. In order for adoption to occur, technology introduction needs to take into consideration the economic, technological, and cultural traits of the population.

Because of the quantitative nature of the analysis used in the modeling section of this paper, and the lack of adequate means to quantify the cultural and social factors that affect adoption, we focus primarily on the macro factors that lead to patchwork adoption—including income and technology characteristics of wireless broadband. In addition, cultural factors are not included in the quantitative model because the model is based on a single country for which education and culture do not vary over time.

To understand the patchwork adoption pattern that is likely to occur in Latin America for wireless broadband technologies, the following section presents basic statistics that show the great differences that exist between the poor and the wealthy in the region. These differences are present in urban settings, but are more pronounced when the comparison is made with rural communities.

Socioeconomic factors, including access to basic services, and educational and technological differences need to be addressed because all these factors have been found to be related to adoption patterns (Sundqvist et al. 2005).

3.1 Socioeconomic differences

Income and age are socioeconomic factors that can have a role in the process of adoption. One of the great differentiators between developed and underdeveloped nations is the age composition. In developed nations, the population has been declining and older adults make up the largest percentage of the population. In Latin America, the population is considerably younger. Figure 2 presents the age composition of the four Latin American countries.

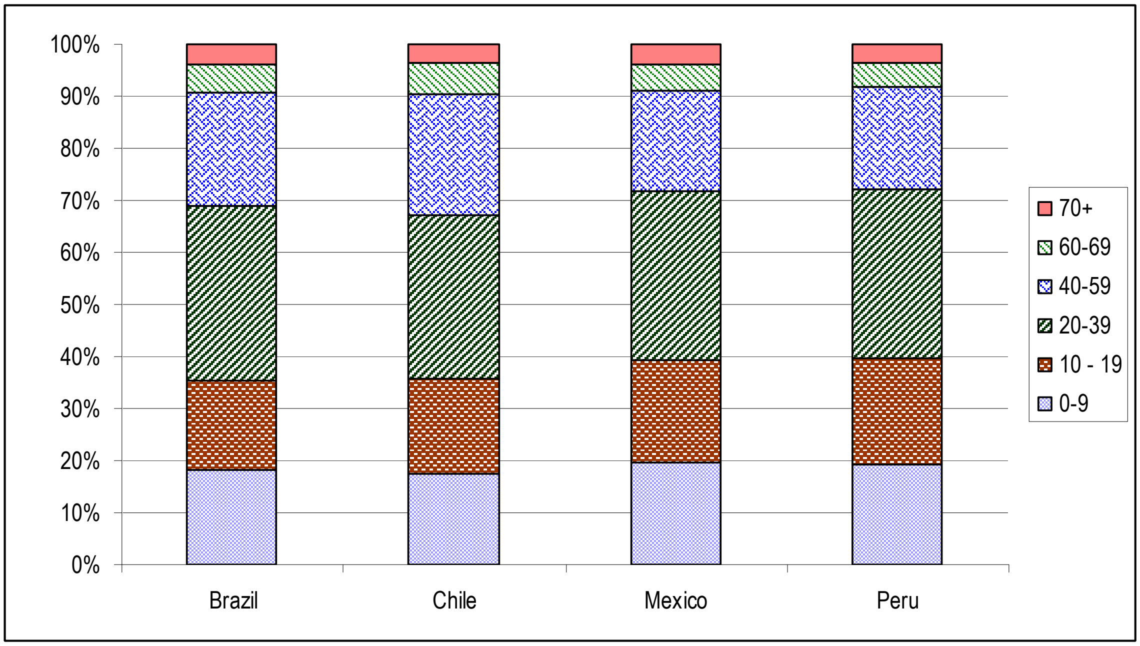

Fig. 2. Age distribution in Latin America *Source:* (World Bank 2007)

Children are a large percentage of the population, while seniors are a small minority. An adoption strategy or business model that emphasizes work or professional applications will have less appeal among this young population.

On technology adoption issues, a young population should be considered an advantage, given that young people are perhaps more willing to tinker with devices and experiment with technology. Young people also tend to be more socially inclined than older adults, whose professional and family obligations may limit the amount of communications that they may want to do via voice or data (Dwivedi and Lal 2007; Ha et al. 2007).

However, even though young people can more easily learn about technology, income can be an important limitation, and this is one of the great disparities that leads to different patterns of adoption within a country.

There is substantial unemployment in this very young population. The lack of employment opportunities contributes to the great income disparities. The percentage of unemployment among youth between the ages of 15 and 24 is 18%, 7%, 7%, and 21% for Chile, Brazil, Mexico, and Peru, respectively.

Unemployment is one of the factors that contributes to income disparities (Porto 2007; Sotomayor 2004). Figure 3 shows that the bottom 30% of the population receives about 5% of the total income, while 10% of the population receives more than 40% of the total income. This wealthy section of the population is likely to have an adoption rate that is similar to the adoption rate in developed countries. It would not be surprising if this segment of the population in Latin America is among the earliest adopters in the world, as they have the means to afford the latest technologies.

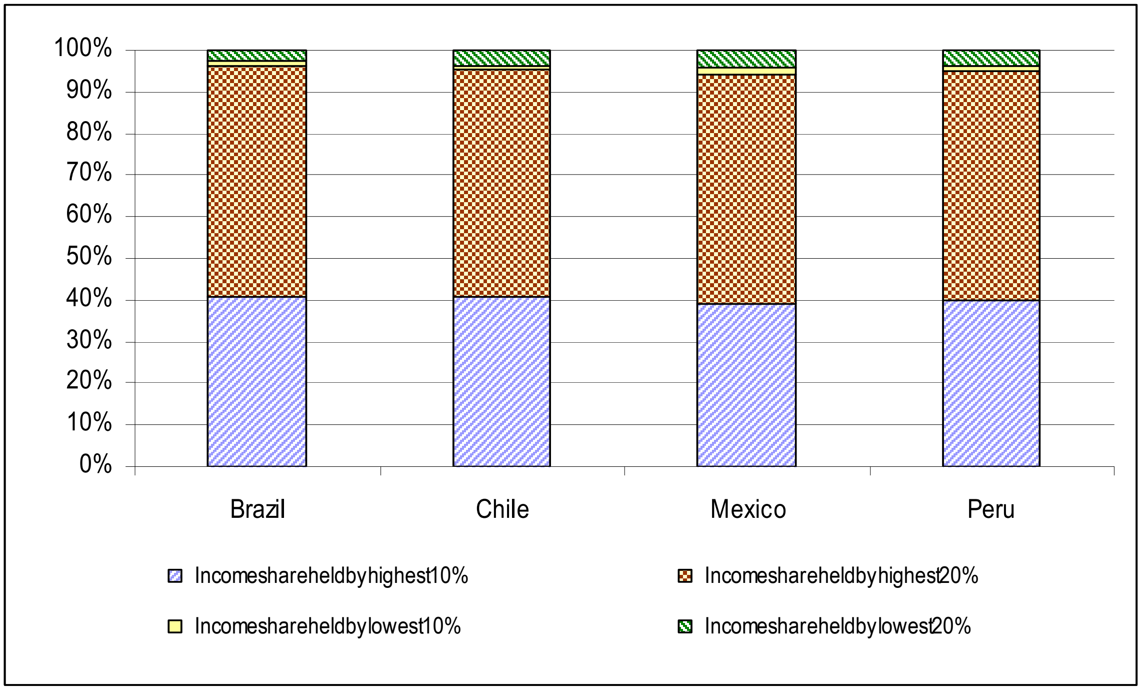

Fig. 3. Income disparities *Source*: Own development data from the World Bank

Contrary to popular belief, much of the Latin American population resides in urban, rather than rural, areas. Adoption patterns between the poor and the wealthy differ in the cities. While many efforts to increase connectivity in the region have focused on rural communities (Ramirez 2007; Saha 2006), there is a similarly challenging problem when one looks at the huge concentrations of populations in urban centers that have large pockets of abandonment for many services, including connectivity.

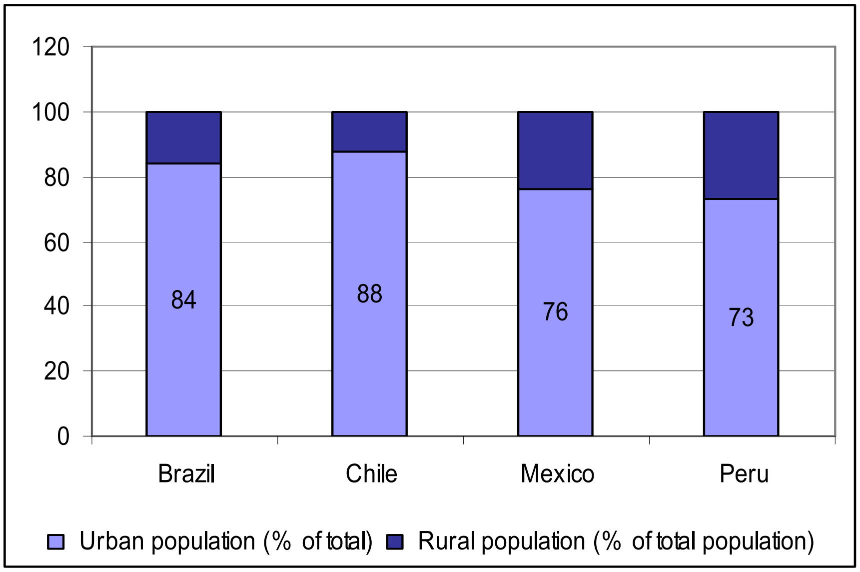

Fig. 4. Population distribution. *Source:* Own development data from the World Bank

3.2 Education and Cultural Factors

The literacy rate in Latin America is close to 100%. This means that the adult population—15 years of age or older—can read and write. Almost all students finish primary education; about 80% of them continue to secondary education, and about a third go on to pursue a college degree. In high-income countries, the percentage of enrollment in tertiary education varies between 60% and 80%, which is about twice the enrollment in Latin America.

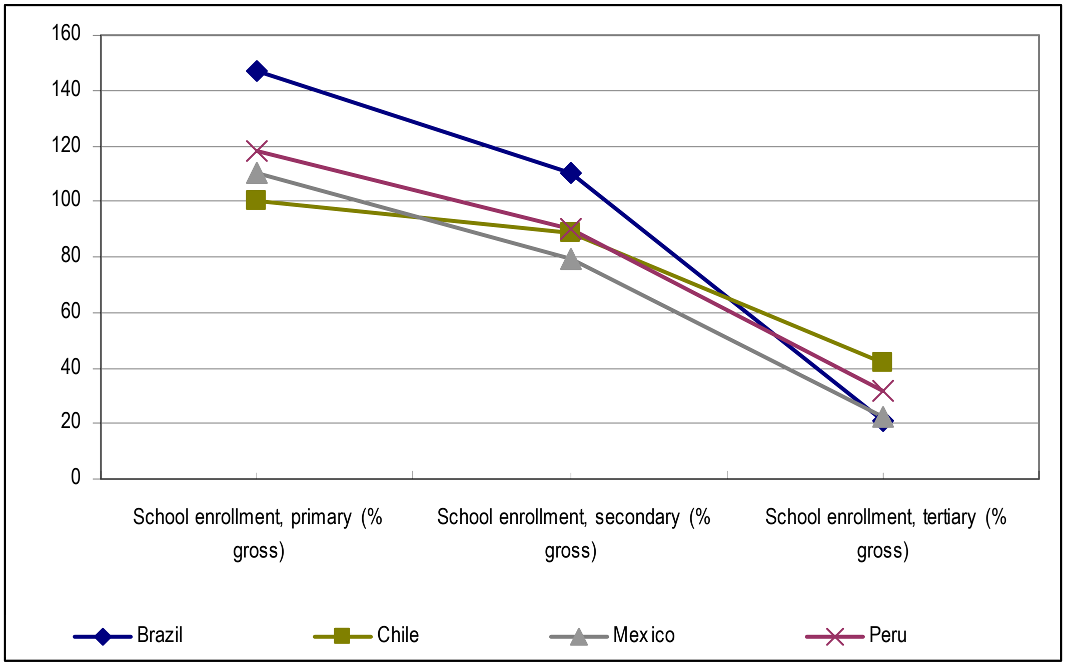

Fig. 5. Progression of enrollment *Source:* Own development data from the World Bank
Note. the numbers are higher than 100% because of repeat grade by some students

While there is still much progress to be made in education, governments recognize that access to the Internet is important for education, and they have been involved in providing connectivity. These efforts are just beginning, but much progress has been made. The most recent data from the World Bank (2007) indicates that penetration of computers at primary and secondary schools is around 50% in these four countries. In general, it is more common to have computers in secondary schools than at the elementary level. Young people are thus able to have access to the Internet at school.

With respect to the cultural traits of Latin American Internet users, a recent study by the Venezuelan consulting company Tendencias Digitales indicates that Internet users who read blogs are interested in entertainment, technology, news, and personal experiences (Tendencias 2007). This is clearly in tune with the youthful demographics that are prevalent in the region. At the same time, many Internet users in the region access videos through YouTube and Google. In Chile, for example, the study reported that Internet users connect to the web to read and write blogs, to watch videos, to play online games, and to post photos (Tendencias 2007).

Given that a large percentage of the population is young, they are likely to be familiar with Internet technologies and available applications. With the desire to access videos and games, the demand for broadband will increase as more people connect to the network.

3.3 Technological factors

In Latin America, wireless connections exceed wired lines. Figure 6 shows that in the four countries studied, the wireless infrastructure is more widespread. In the case of Chile, wire lines are almost tripled by wireless. In Mexico and Peru, wireless nearly doubles the wire line infrastructure. Only in Brazil are the two types of infrastructure almost at par. This means that even when the copper lines are upgraded to be able to provide ADSL, only a small percentage of the population will have access to it.

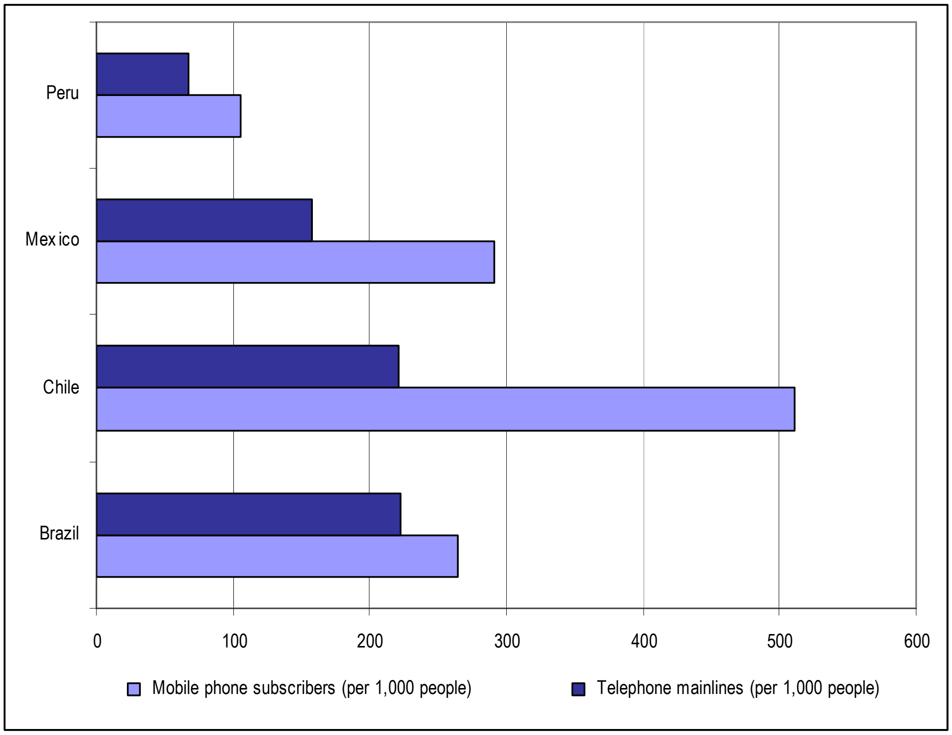

Fig. 6. Wireless and wireline infrastructure 2003 *Source:* Data from the World Bank

Cable, an alternative broadband infrastructure, has also developed slowly in Latin America. None of the four countries that we focus on exceeds 20% penetration, according to the most recent information (Lanic 1999). It is thus not surprising to see ADSL as the dominant wired access to broadband networks in the region. In Mexico in 2004, only 13.7% of the population had a cable subscription (Mares 2007).

Broadband through the wired infrastructure will reach a limit, and once again the region will find itself in a situation where the demand for broadband access is greater than what is available. This is why the wireless infrastructure grew so quickly, and there is thus an opportunity for wireless providers to upgrade these wireless networks to provide high speed data access.

In addition to the wired infrastructure limitations, there are also equipment limitations. The mobile phone is the most prevalent communication equipment in the region. Internet access through third generation networks would take time to adopt, given that 3G technologies require 3G phones and these devices are quite expensive, from $300 in the used market to close to $1,000 for new handsets (Mercado Libre 2008). Given the average income level of the population, Internet access over mobile phones will be slow. It is thus not surprising that companies offering higher data speeds through these more advanced networks are targeting business. Some companies in the region have upgraded their networks to offer higher bandwidths through network cards that can be connected to computers. These cards are more affordable, and access through a computer will offer greater flexibility to the users.

The lack of computers, nonetheless, will continue to be an obstacle for access. Less than 15% of the population in the four countries had a computer in 2005 (World Bank 2007). This means that, independent of the wireless technology used, connectivity is likely to happen first through school, work, or public computer centers such as telecenters or cyber cafés (Tendencias 2007).

4 Wireless broadband technologies

In this section we briefly describe the different technology alternatives for broadband wireless access. The cellular technologies deployed can be divided into the following branches: GSM/GPRS/EDGE/UMTS/HSDPA and IS-136 (TDMA), IS-95 (cdmaOne), and IS-2000 (CDMA2000). The non-cellular options are WiFi and WiMAX. WiFi is a technology that has gained acceptance, especially in the residential market, but WiFi hotspots in commercial establishments are beginning to expand—particularly in the tourist sector of Latin America. WiMAX is a promising technology that could be used to offer data and voice services in areas with no telephony or data access. The next subsections describe the technical aspects of these four technologies.

4.1 GSM/GPRS/EDGE/UMTS/HSDPA

The 2G Global System for Mobile Communications (GSM) wireless system was designed as a pan-European digital cellular system that improves the different 1G cellular systems that were deployed in Europe in the 1980s. GSM has enhanced voice quality and much more secure voice transmission. GSM is now the most widely deployed cellular system in the world. GSM is a mature technology that operates in Europe, the Middle East, Africa, Asia, and the Americas. General Packet Radio Service (GPRS) is a 2.5G wireless system that works on top of GSM and can be considered an upgrade of GSM. Whereas GSM is a circuit-switched technology, in which a user receives a time slot with a maximum data transmission rate of 9.6 kbits/s, GPRS is a packet-switched system that enables a transmission at a data rate of up to 171.2 kbits/s. Enhanced Data Rates for GSM Evolution (EDGE) and Enhanced GPRS (EGPRS) can be considered 2.75G systems that work on top of GSM and GPRS networks.

Universal Mobile Telecommunications Systems (UMTS) is a 3G wireless cellular system that works with the Wideband Code Division Multiple Access (W-CDMA) air interface. In order to deploy UMTS, a new W-CDMA air interface needs to be installed from scratch because the GSM/GPRS air interface cannot be reused. UMTS permits a data transmission rate of 2 Mbits/s. Together with High Speed Downlink Packet Access

(HSDPA), UMTS can offer a maximum theoretical transmission rate of 14.4 Mbits/s. HSDPA is considered a 3.5G system.

4.2 IS-136 (TDMA), IS-95 (CDMA One) and IS-2000 (CDMA2000)

IS-136 is a 2G wireless cellular system that is based on the Time Division Multiple Access (TDMA) technique. Several carriers in the world adopted IS-136, but in the last years they started migrating to GSM/GPRS and to CDMA2000 in order to implement a 2.5G cellular system. IS-136 is an upgrade of the IS-54 system, which is based on the 1G wireless system Advanced Mobile Phone System (AMPS). IS-136 is also known as Digital AMPS (D-AMPS) and has a transmission data rate of 9.6 kbits/s.

Interim-Standard 95 (IS-95) is a 2G CDMA system with the brand name of CDMA One. CDMA2000 is a 2.5G/3G system that was standardized by 3GPP2 and it improves the IS-95 system. CDMA has the following standards: CDMA2000 1xRTT, CDMA2000 EV-DO (Evolution-Data Only) and CDMA2000 EV-DV (Evolution-Data/Voice). CDMA2000 1xRTT basically made modifications to the IS-95 radio interface and its deployments have a limited peak rate of 144 kbits/s. Depending on the modality used, CDMA2000 EVDO has data rates of 2.4Mbits/s and 3.1 Mbits/s in the downlink. Finally, CDMA2000 EV-DV offers a downlink transmission of up to 3.1 Mbits/s.

4.3 WiFi

WiFi is a wireless technology based on the IEEE Ethernet 802.3 Local Area Network (LAN) technology that was modified to take into account a wireless interface. The Wireless LAN (WLAN) standard was created, and it was named IEEE 802.11. WiFi defines a new physical and data link layer. WiFi works in the 2.4GHz and 5GHz bands.

There are several WiFi standards, but the most widely known standards are 802.11b and 802.11g. The 802.11b standard offers a theoretical maximum rate of 11 Mbits/s, whereas the 802.11g standard offers 54 Mbits/s. In both cases, the range can be around 80-100 meters. WiFi has had success because the equipment (a router) is simple to install and the price is affordable in residential environments. Moreover, many laptops now include a WiFi antenna.

5 Simulation

In academic research, it is common to do after the fact analysis because data exists to conduct any type of evaluation. This type of research is important and useful because it helps to identify both failures and successes of the program/process. There is nonetheless a need for work that can provide some guidance for the future; although, understandably, this approach is riskier and more prone to errors. Data is extrapolated from existing sources into an uncertain future. This is the approach used in this paper.

The model is for Mexico only.[‡] It was constructed with the iThink® software to help determine the diffusion patterns of cellular based technologies, as well as WiFi. As a simplified version of the real world, it is imperfect; but we hope it captures some of the most important elements of the manner in which adoption of these two types of technologies can happen. In particular, we want to determine if there is evidence of patchwork adoption patterns.

[‡] Because of space limitations we cannot present the results for all countries selected for this paper.

This preliminary model includes two of the three components described in the previous section: technological and economic factors. The model also combines the cellular based technologies into one and contrasts them with WiFi. The reason why we combined the two cellular technologies is because of the great similarities between them and the little difference that the user perceives in terms of costs and quality. Figure 7 shows the schematic of the model.

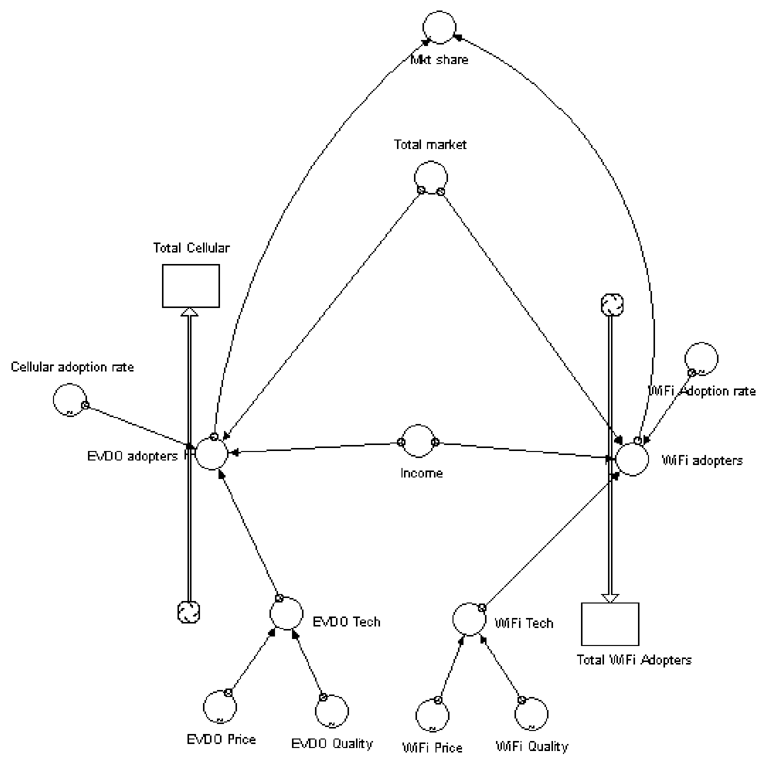

Fig. 7. Model for cellular vs. WiFi adoption for broadband access

The model consists of three parts. Two of them are the technologies that are explored for this paper, and the third corresponds to the different components that influence adoption factors. The model assumes that 3G cellular based technologies are substitutes for WiFi broadband access. It is expected that great income inequalities will result in

WiFi being more widely adopted by some mobile companies for the wealthier population.

The factors modeled to affect adoption are the total market, the expected adoption rate for each technology, characteristics such as quality and price, and economic factors (primarily income).

The market data used for the model include the entire Mexican population from 15 to 64 years old. We assumed that people within those age ranges are potential adopters of this technology.

Because we do not have adoption statistics about these two technologies, we utilized adoption rates that are similar to earlier technologies. Given the prevailing price differences between 3G cellular and WiFi, we expect that the adoption rate of 3G cellular voice/data will be closer to that of the Internet in these countries, while the adoption rate for WiFi, we assume, will be similar to second generation cellular. We expect 3G broadband access to be similar to the Internet because the monthly cost is higher than what we expect WiFi access to be. We thus use second-generation cellular adoptions as the proxy for the WiFi adoption rate because of price reasons and also because we assume that individuals are more likely to have a computer than a new 3G phone.

The technology factor is a combined variable that includes quality and price. Table 2 shows the formula that combines price and quality with their respective weights. We assume that, for the most part, individuals will put greater weight on price than quality. The former receives a weight of 7 on a ten-point scale, while the latter is weighted at 3.

The price variable is represented through a graph for both technologies. We assume that, over time as adoption increases, the costs for the provision of these services will decrease, as will the price. For both technologies, the initial price is the current price for the two services. The price for 3G access is simulated to decline from the current price in Mexico of approximately $70 to $60, while the price of WiFi decreases from $21 to $18 over the course of the simulation, which is 36 months.

The quality variable is represented on a scale from 1 to 7. In general, to determine the quality rate for these two technologies, we considered four factors: reliability, speed, security, and convenience based on access/penetration. Reliability is determined by the amount of time that the system is up and available to the user. The speed is the throughput in kilobytes that data is sent through the two networks. Security is measured by the probability that the network could be hacked and pose a threat to the user, and convenience is determine by the geographic availability of the network. In general, we believe that cellular based technologies are more reliable, safer, and potentially more convenient than WiFi access, given that these networks are more pervasive and users can connect from almost any urban location. WiFi, although inferior in those areas, does offer higher bandwidth than 3G services. Table 1 shows the differences between these two technologies on these four measures, as well as the weight we gave them in the model based on their features.

Table 1

Quality descriptors for both 3G cellular technologies and WiFi

Factors	Description	Cellular (EV/DO - EDGE)	Score 0-7	WiFi	Score 0-7
Reliability	Amount of time the system is up (%)	98%	6	100%	6
Speed	Mbits/s	1.8 Mbits/s (HSPA)	2	11 Mbits/S	5
Security	Probability that the network could be hacked (%)	5%	5	25%	3
Penetration	Geographic availability	45% (2005)	3	743 hotspots	1
Price	Monthly charge for unlimited use	68.00	1	29	4
Total quality score	Average of the individual score		3		4

Sources: GSM World; Digiworld América Latina 2007 (Telefónica 2007); JiWire 2008.

As a dynamic model, it assumes that quality for both will improve; and, while initially we have 3G cellular services rated at 3, we expect it to increase to at least 5, while quality for WiFi is expected to increase from 4 to 6 over a 36 month period.

Finally, the income variable was constructed representing the current distribution of incomes in Mexico. This is data that we actually have, so we were able to put an income variable in the model that mimics the actual income distribution. We consider that the average income of the population is approximately $100 and the percentage amount that the population spends on communications services is approximately 15% of income. We determined that individuals with an annual income of $1200 or less will be unlikely to select the 3G cellular option and will opt for a less expensive alternative—which, in this case, we assume will be WiFi. It is for this reason that we determine that anyone with income higher than $1200 will opt for 3G cellular, while anyone below will opt for WiFi. Table 2 shows the formulas and explanations for the different variables of the model.

Table 2

Definition of model components

Model Component	Formula	Explanation
3 G cellular adopters	IF(Income >1200) and (WiFi_Tech >=41) THEN (WiFi_Adoption_rate* Total_market) ELSE 0	Rate of adoption based on economic and technological conditions
WiFi adopters	IF(Income <1200) and (WiFi_Tech <20) THEN (WiFi_Adoption_rate* Total_market) ELSE 0	WiFi rate of adoption based on economic and technological conditions
3G Technology	3G_Price*.7+ 3G_Quality*.3	Composite variable that combines the price and quality variables
WiFi Technology	WiFi_Price*.7+ WiFi_Quality*.3	Composite variable that combines the price and quality variables
3G Price	This was represented through a graph that begins with the current price of $70 a month and declines over a 36 month period to $60	Current price for the 3G cellular services
WiFi Price	This was represented through a graph that begins with the current price of $25 a month a declines over a 36 month period to $18	Current price of the technology
3G adoption rate	The adoption rate is a graph that simulates the adoption rate for the Internet	Adoption rate trend based on Internet adoption of the last 10 years
WiFi adoption rate	The adoption rate is a graph that simulates the adoption rate for cellular	Adoption trend based on 2nd generation cellular adoption
3G quality	This is represented also through a graph that begins at a rate of 3 and increases to 5 over a 36 month period	The quality variable is assessed on a 1 to 7 scale
WiFi quality	This is represented also through a graph that begins at a rate of 4 and increases to 6 over a 36 month period	The quality variable is assessed on a 1 to 7 scale
Income*	Income is represented as a constant and it is varied throughout the simulation	Income is the average annual income

* Income has been annualized for the model

Figure 8 shows the results of the simulation over the 36-month period in millions of users. It shows that both technologies will coexist, as people with high income levels will be able to afford 3G access while the more affordable WiFi will have greater appeal among poorer segments—even with the quality problems that this technology still exhibits.

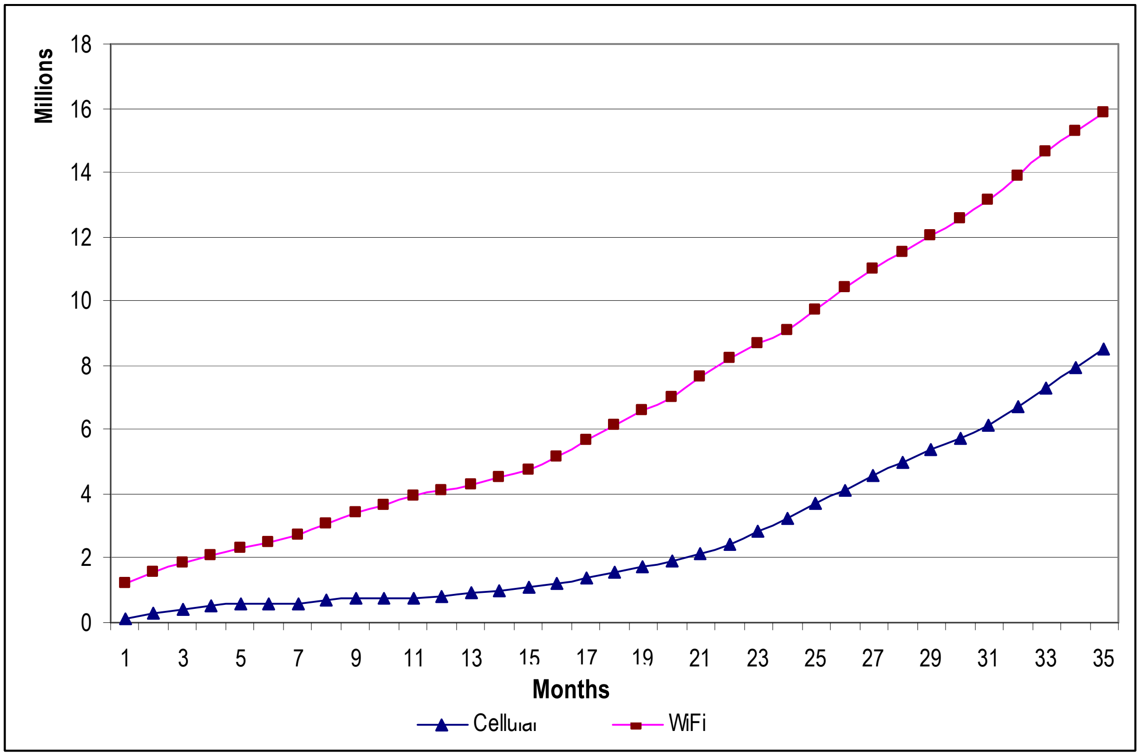

Fig. 8. 3G Cellular vs WiFi adoption (Data from Mexico, 2008)

The results of the simulation for Mexico support the patchwork adoption model, where different segments of the population will adopt different technologies based on their income level. In addition, we also suspect that at lower income levels individuals would be more tolerant to the potential inconveniences related to the lack of WiFi access or potential security weaknesses that this technology may have. 3G technologies show, as we expected, a lower rate of adoption. Given that we assume a total of potential users of approximately 42 million, we expect the adoption to grow relatively quickly, particularly for WiFi access, as this type of technology requires a multipurpose computer as opposed to a 3G mobile phone.

The results also show a similar path of adoption but at different rates. This can be explained by the smaller market size of individuals that can afford this more expensive alternative. Carriers aware of these income differences are marketing 3G services for corporate users, as they expect this market to be the first one to contract these services.

Because of price differences between these two technologies, the adoption pattern that is represented in the graph is likely to remain that way: with lower income individuals choosing only one of the two, and the higher income ones contracting services for both. There is also likely to be a segment that will be unable to afford either of the technologies, thus for them access will have to be through a school or workplace.

5.1 Additional Evidence of adoption patterns

In addition to the model, we wanted to determine if the patterns of adoption shown by the model had support in the initial deployment of 3G and WiFi networks in Mexico. In 2007, the cellular telephony penetration rate in Mexico was 52.9%, and the broadband cellular penetration was 0.5% (based on a study done by Amipci, 2007). There are four main cellular operators: Telcel, Movistar, Iusacell and Unefon, with 79%, 15%, 4% and 2% of the market share, respectively. Telcel and Movistar use GSM, GPRS, and EDGE technologies, whereas Iusacell and Unefon work with CDMA. Telcel is deploying 3G UMTS-HSDPA technology, and Iusacell has been deploying the 3G system CDMA2000 1xEV-DO Revision A.

There are some shops that offer access to WiFi services. They are typically located in airports, restaurants, cafes, and hotels. In Mexico City, there are a few public initiatives to deploy WiFi services in several sections of the city. The WiFi penetration in Mexico in 2007 was 4.6% (based on a study done by Amipci, 2007).

In Latin America, there is no reason to believe that GSM or CDMA technologies are being favored by public authorities. Initially, there were a few GSM operators in the region, but the number of GSM operators has increased over time. WiFi network deployment depends on the willingness of people to pay for the corresponding services. The public initiatives are, of course, welcomed, but so far public wireless hotspots have been deployed in few locations.

5.2 Policy implications

Technological development in the telecommunications and information sector is accelerating. Advances in computing are making possible the introduction of new services from unlikely parties that are seriously challenging traditional business models. While technology is advancing rapidly, regulation and policy in Latin American tends to be reactive. This is not necessarily bad, as most technological developments come to the region at a slower pace than in developed nations. Major corporations, however, are now mounting pressure on regulators to delay or impede the implementation of technologies that cannibalize more profitable markets.

In addition to the pressures from the private sector, there is also the desire to connect rural communities, and many efforts have been made through universal service programs to offer connectivity to these isolated areas. As this paper shows, however, there are many segments of the population that live in urban areas that could potentially have access to the Internet. They have had limited opportunities to take advantage of these networks, though, due to their income level, lack of computers, and limited digital literacy.

The simulation reflects this pattern of adoption. The more expensive cellular technology will evolve, but the market will be limited, given the cost of connection. In fact, many of the companies that are offering the service now target the business segment alone for broadband connectivity.

The simulation predicts that WiFi will have a greater uptake, mostly because of its lower price. People can connect to the Internet through WiFi in restaurants and cafés—either for free or at a lower rate than the cellular option.

The patterns of adoption mimic the income differences and regulators, and policy makers should recognize these differences and implement programs that target urban populations. A "one size fits all" approach to connectivity will not be enough to alleviate these deficiencies. There is a need for policy that takes into account demographics and income differences, in order to facilitate not only access at reduced rates, but also opportunities to learn about the Internet and the types of services and opportunities available. Clearly young people can learn quickly, and they will explore the network to satisfy their personal interests; but they should also be made aware of the educational opportunities, government services, and career sites that can help their academic or professional lives.

Potentially governments and companies can partner to offer training and access at lower rates. Regulators should provide opportunities for less expensive technologies to flourish. Telecom operators in the region have developed creative solutions, such as selling computers at reduced prices and in installments.

Because of the way technology is adopted in less developed countries, regulation for the sector needs to take into consideration demographic differences to make sure that some segments of the population are not left behind. For example, there should be policies to ensure that the urban poor can obtain access. This can be done through school and community centers. One of these policies could be twinning, the granting of spectrum licenses that require provision to rural areas in addition to cities.

6 Conclusions

Latin America desperately needs a broadband wireless solution, given its limited wired infrastructure. In this paper, we looked at two technologies and provide some hints about how we expect these two types of broadband access to evolve. We explored wireless broadband adoption in Latin America. This is an important issue that both regulators and operators are facing, because connectivity through high bandwidth methods is becoming increasingly necessary. Both the government and the private sector need to realize and utilize the strengths and weaknesses of the population to foster use. Unlike the rural areas, which lack any type of connection, the main problem in urban areas is lack of technology literacy skills, income, and access to computers.

Wide income disparities allow the adoption of state of the art technologies such as 3G wireless—for some. Poorer segments of the population can access the Internet through WiFi in commercial establishments. More importantly, there is another sector that will not be able to take advantage of these networks at all. In the absence of policies that target these isolated urban pockets, there will continue to be a patchwork adoption of technology, with many holes in the map comprised of the population with the lowest income.

References

Adams DA, Nelson, R.R., and Todd, P.A., 1992. Perceived Usefulness, Ease of Use and Usage of Information Technology: A Replication. MIS Quarterly 16(2):227-250.

Amipci. 2007. Usuarios de Internet en México 2007. Asociación Mexicana de Internet (AMIPCI).

Davis FD. 1989. Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. MIS Quarterly (September):319-340.

Dwivedi YK, Lal B. 2007. Socio-economic determinants of broadband adoption. Industrial Management & Data Systems 107(5-6):654-671.

Garcia-Murillo M. 2003. Patchwork Adoption of ICTs in Latin America. Electronic Journal of Information Systems in Developing Countries 15(1).

GSM World. 2007. Available at http://hspa.gsmworld.com/networks/

Ha I., Yoon Y., Choi M. 2007. Determinants of adoption of mobile games under mobile broadband wireless access environment. Information & Management 44(3):276-286.

JiWire. 2008. Available at http://www.jiwire.com

Hendrickson AR, Massey, P.D., and Cronan, T.P. 1993. On the Test-Retest Reliability of Perceived Usefulness and Perceived Ease of Use Scales. MIS Quarterly 17(2):227-230.

Lanic. 1999. Percentage of Homes with Cable TV Subscriptions. Trends in Latin American Networking. Austin, TX: LANIC.

Mares MA. 2007. Ricos y Poderosos. Cronica: Medios Mexico.

Mercado Libre. 2008. Telefonos Celulares. Mexico: Mercado Libre.

Petrazzini BA, editor. 2007. Digital Poverty: Latin American and Caribbean Perspectives. Ottawa, ON: International Development Research Center.

Porto GG. 2007. Globalisation and poverty in latin america: Some channels and some evidence. World Economy 30(9):1430-1456.

Ramirez R. 2007. Appreciating the contribution of broadband ICT with rural and remote communities: Stepping stones toward an alternative paradigm. Information Society 23(2):85-94.

Rogers EM. 2003. Diffusion of Innovations. New York, NY: Free Press.

Saha H. 2006. Special issue on Information Communication Technology Initiative for Rural Developments (ICTIRD). Iete Technical Review 23(5):274-275.

Sotomayor O. 2004. Development and income distribution: The case of Puerto Rico. World Development 32(8):1395-1406.

Sundqvist S, Frank L, Puumalainen K. 2005. The effects of country characteristics, cultural similarity and adoption timing on the diffusion of wireless communications. Journal of Business Research 58(1):107-110.

Telefónica. 2007. Digiworld América Latina 2007. Fundación Telefónica.

Tendencias. 2007. Usos de Internet en Latinoamérica. Tendencias Digitales.

Wellenius B. 1994. Telecommunications Restructuring in Latin America. In: Wellenius B, Stern PA, editors. Implementing Reforms in the Telecommunications Sector: Lessons from Experience. The World Bank, Washington DC

World Bank. 2007. World Development Indicators.