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A PROPOSAL FORECASTING MODEL FOR THE GROWTH OF THE MOBILE TELEPHONE MARKET IN BRAZIL

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ABSTRACT

The element that characterizes the information era is the key role of communication and connectivity, broadly speaking, in social life. Among the ways in which users can enter voice or data networks, one of the most prominent is mobile telephony. Therefore, determining the number of mobile phones in operation in Brazil over the next few years is a relevant issue for the strategic planning of firms in this sector. Thus, this article aims to define a mathematical model suitable for calculating the number of mobile phones in operation in Brazil in forthcoming years, as a function of the behavior of the following variables during the course of time: GDP per capita, population and percentage GDP growth. To this end, a quantitative study was conducted, based on secondary data taken from preceding survey; then a linear and polynomial regression was employed to correlate GDP per capita with mobile phone density. The results showed high correlation (97.5%) between phone density and Brazil's GDP growth from 2004 to 2007. This correlation is also high in Russia, India and China. Moreover, we found that the limiting value of good correlation between GDP per capita and mobile phone density is roughly US$20,000.00 and that the limit of mobile telephony penetration is approximately 120%. Thus, taking into account several economic growth rates, we estimate that the penetration of mobile telephony will take 5 to 11 years to reach its upper limit in Brazil.

Key words: Mobile telephony. Prediction model. Telecommunications.

UMA PROPOSTA DE MODELO PREDITIVO PARA O CRESCIMENTO DA TELEFONIA CELULAR NO BRASIL

RESUMO

A Era da Informação caracteriza-se pelo papel central que a comunicação e a conectividade, em sentido amplo, desempenham na vida social. Dentre as formas pelas quais os usuários podem se conectar a redes de voz ou dados, uma das que mais têm se destacado é a telefonia celular. Isso torna a determinação da quantidade de telefones celulares que estarão em operação no Brasil nos próximos anos uma discussão relevante para o planejamento estratégico das empresas do setor. Neste artigo, objetiva-se definir um modelo matemático adequado ao cálculo da quantidade de terminais celulares em operação no Brasil para os próximos anos, como função do comportamento das seguintes variáveis ao longo do tempo: PIB per capita, população, e crescimento percentual do PIB. Para tanto, desenvolveu-se uma pesquisa quantitativa, com base em dados secundários obtidos em levantamentos anteriores, e empregou-se a regressão linear e polinomial para correlacionar o PIB per capita com a densidade da telefonia celular. Observou-se uma alta correlação (97,5%) entre a densidade telefônica e o crescimento do PIB do Brasil entre 2004 e 2007. Essa correlação também é alta na Rússia, Índia e China. Além disso, constatou-se que o valor limitante da boa correlação entre o PIB per capita e a densidade de telefonia celular gira em torno de U$ 20.000,00, e o limite da penetração da telefonia celular é de aproximadamente 120%. Assim, levando em conta as várias taxas de crescimento econômico, estima-se que a penetração telefônica celular levará entre 5 e 11 anos para atingir seu teto no Brasil.

Palavras-chave: Telefonia celular. Modelo de predição. Telecomunicações.

1 INTRODUCTION

The element that characterizes the information era is the key role of communication and connectivity, broadly speaking, in social life. In today's world, it is inconceivable for people and firms to be unable to be totally connected. The exception concerns countries with specific political conditions or lacking the requisite infrastructure, typically those that are still in the early stages of development.

In the first quarter of 2009, the International Telecommunication Union, an entity linked to the United Nations, estimated that there were roughly 4.2 billion mobile phones in the world; more specifically, there were some 55 mobile phones in operation for every 100 inhabitants of our planet (International Telecommunication Union -ITU, 2009).

Brazil has actively joined the information society, as indicated by fact that in May 2009, it had more than 157 million active mobile phones, 42 million wireline phones (Agência Nacional de Telecomunicações – ANATEL, 2009), and approximately 54 million Internet users (Teleco, 2009).

Mobile telephony is one of the most important ways – among others - for users to connect to voice or data networks. In the last few years, the layout, functionalities and technology of mobile phones have undergone several transformations. In addition to simplifying access to voice networks, mobile phones now include such features as digital music players, videos, photo cameras, digital film cameras, text processors, interfaces to access e-mail accounts, Internet access platforms and other functions that enable users from all over the world to connect.

The large-scale use of mobile telephony has had a major social impact, because as users incorporate the functionalities of this means of communication into their daily lives (Machado, 2006), their absence – even if only momentarily – gives rise to major frustration. According to Ling (2004), mobile communication is changing how people interact, especially in the case of younger generations in big cities.

Just like individuals, who have adopted mobile phones to a great extent, firms have also used them widely to strengthen communication ties with their employees and interest groups, such as clients, suppliers and partners (Krotov & Junglas, 2006). These mobile devices are increasingly important tools for professionals in transit, as they allow remote, virtual and instant access to any corporate applications connected to the Internet.

In addition, productivity is furthered by other mobile device applications, such as GPS, which provides directions in the city or for tracking vehicles; appointment agendas synchronized with workstations; Internet telephony; text reading and processing; spreadsheet editing; and data storage, among other handset features. On-line access to applications, at any moment or from anywhere in the area of coverage, defines the "anything, at any time, anywhere" paradigm (Sadler et al, 2006), which has resulted in several benefits for society and which challenges mobile phone operators to maintain a complex and consistently available infrastructure.

1.1 TOPIC AND OBJECTIVE

The problem this study focuses on is establishing the number of active mobile phones in Brazil in upcoming years, an important issue for mobile phone operators' strategic planning. The analysis is based on the extrapolation of socioeconomic data and on the penetration of mobile telephony in Brazil and in counterpart countries, taking into account existing growth indicators and the limits of mobile phone density growth.

Within the scope of this topic, this paper aims to define a suitable mathematical model for calculating the number of mobile telephony terminals in operation in Brazil in upcoming years, as a function of the behavior of the following variables during the course of time: GDP per capita, population and percentage GDP growth.

This paper comprises the following sections: introduction, research methods and techniques, bibliographical review, predictive analysis of the growth of the mobile phone base, final comments and bibliographical references.

2 RESEARCH METHODS AND TECHNIQUES

Exploratory research can be formally understood as a rational, systematic and mostly procedural activity, whose aim is to produce robust answers for the problem under analysis, by combining available knowledge and the careful use of methods, techniques and other scientific procedures (Gil, 2002). Research can be expected to stand out when its subject matter has not been sufficiently documented yet or, due to its nature, has not been conceptually grasped in an efficient manner. Gil (1999) emphasizes that exploratory research is appropriate when the available information on a phenomenon of common interest is dispersed – with over-generalized, inefficient inferences – in view of the degree of uncertainty that involves it.

This paper resorts to exploratory research methodology, as its objective is to generate insights, thereby offering the reader a conceptually based tool able to predict, with some accuracy, the number of active mobile phones in Brazil in forthcoming years. The development of the research work stems from quantitative research, based on an analysis of secondary data from previous surveys, an approach that, according to Creswell (2003), is suitable when the objective is to understand factors that influence or predict a result.

The data analysis was conducted by applying linear, or polynomial, regression, correlating GDP per capita (Purchasing Power Parity - PPP) and mobile telephony density. According to Montgomery, Pech and Vining (2001), regression analysis is a statistical method that resorts to the relation between two or more quantitative or qualitative variables, so that one variable can be predicted from the other variable or variables. Linear regression, whose relationship with variables is modeled by a straight line, is one of the methods used in statistical studies, as it is relatively simple, yet robust.

3 LEADING PLAYERS IN THE TELECOMMUNICATIONS INDUSTRY

The Information Technology (IT) industry encompasses a wide variety of technological segments, ranging from the production of equipment parts and components to the development of service platforms to meet consumers' growing connectivity and service availability needs.

According to Neves (2002, p. 16), the telecom sector consists of four major segments: Switched Wireline Phone Services, Mobile Phone Services, Mass Communication Services (radio broadcasting and cable TV) and Multimedia Services (data communication, dedicated line, etc.)

One should emphasize that wireline and mobile telephony operators, application developers and infrastructure providers play a critical role in the dissemination of technological solutions for a wide range of consumers (Fransman, 2002), from low-income clients (typical users of pre-paid mobile phones) to multinational corporations that demand specific solutions for their needs.

Until the mid-1990s, state-owned monopolies were among the most important enterprises in Brazil's telecom industry. Following their privatization in the mid-1990s, they were totally restructured. Privatization caused new operators to form and to enter the market, thus fostering a competitive arena that substantially increased the supply, availability and volume of services for the population. The wireline and mobile telephony operators play a leading role as the drivers of the chain that develops and offers the sector's technological innovations.

The layers model proposed by Fransman (2002) represents the contemporary telecom industry; it comprises six interdependent layers, where the upper layer uses the services and infrastructure provided by the lower layers. Figure 1 illustrates this model.

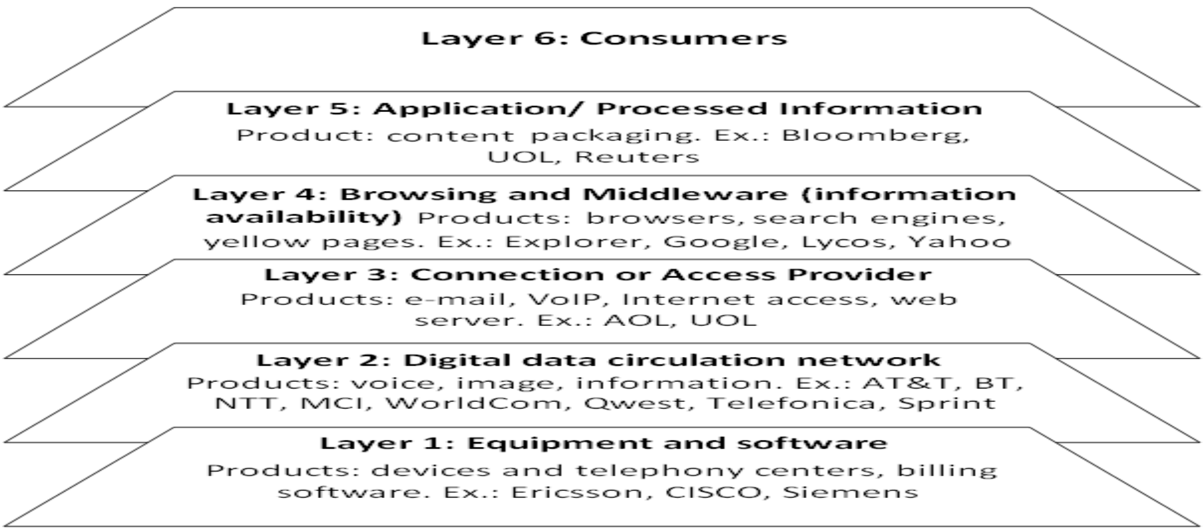

Figure 1: Telecom sector structure

Source: SBRAGIA *et al*, 2006, p. 14

Although the telecom industry has grown significantly in the last ten years, one must keep in mind that technologies that make Internet access easy via broad band and mobile phone systems are still in their first stage of evolution, whereas wireline telephony is at higher stage of technological maturity. Marchetti and Prado (2006) refer to a study conducted in Brazil by Pyramid Research, a consulting firm, which identified the evolution of telecom technologies (Figure 2).

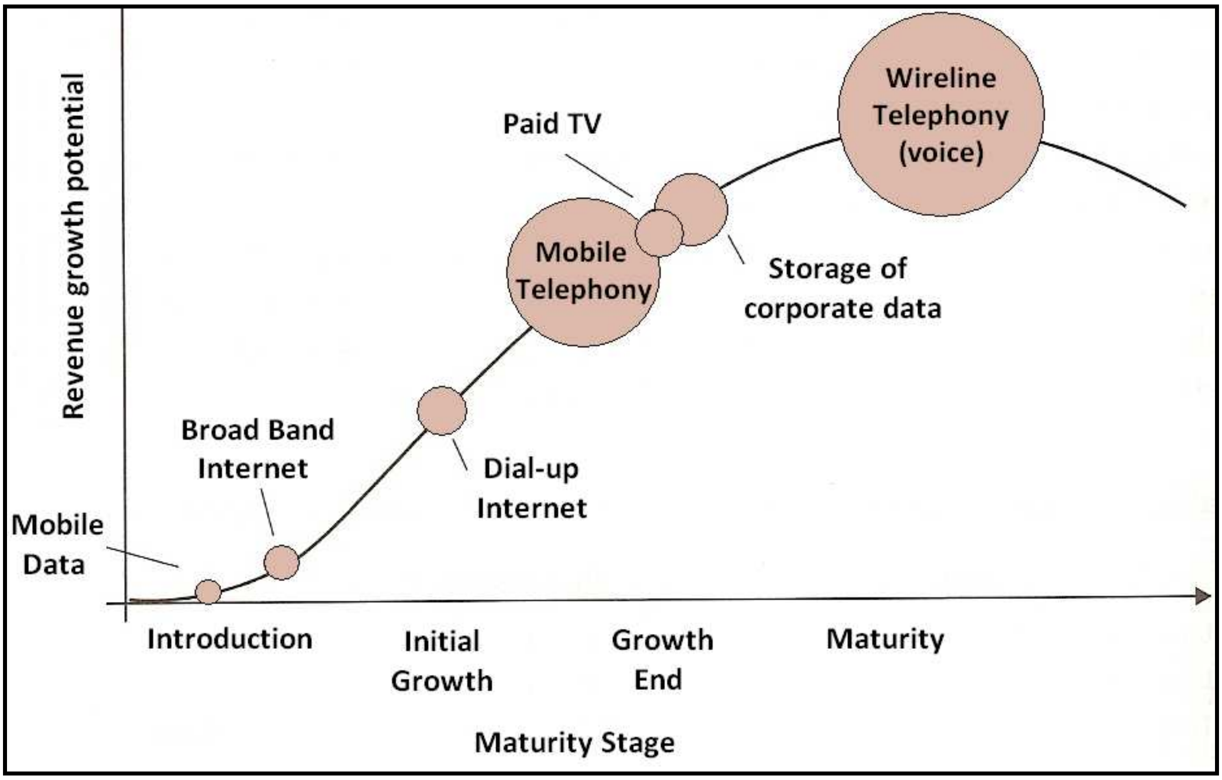

Figure 2: Evolution of connectivity technologies

Comment: The size of the circumference indicates the volume of resources involved in each stage.

Source: Marchetti and Prado (2006, p. 232)

The definition of technology that is most in keeping with this study is the one Dosi (1984, pp.13-4) put forth and discussed:

> Technology is a set of knowledge fragments, not only directly practical – related to real problems and theoretical devices - knowhow, methods, procedures, successful and unsuccessful experiences, but also, of course, practical devices and equipment. The existing physical devices incorporate the results of the development of technology into a defined problem-solving activity. At the same time, the ‛de-incorporated´part of technology consists of specific skills and of the experience gained from past efforts and past technological solutions, in combination with knowledge and state-of-the-art achievements.

3.1 THE TECHNOLOGICAL JOURNEY OF MOBILE TELEPHONY

One can define mobile communication as that which allows the relative movement of the communicating parties or systemic parties involved in the communication. Examples of this include communication between airplanes, between an airplane and a land base and between vehicles, as well as mobile telephony, mobile computing and some classes of telemetry systems.

The first technological experiments involving wireless voice transmission occurred in the United States and Japan in the early 1950s. However, commercial mobile phone services first appeared in the market only in the mid-1970s. The first mobile terminals were portable, weighed about one kilogram and ran on batteries that went flat after some 20 minutes of conversation.

The desired feature of any communication system is to transmit the highest amount of information in the shortest time. Given the expected quality at reception, each kind of information (voice, data, and video) requires specific bandwidth and transmission power. However, the prerequisites for transmission and reception systems are different, depending on whether the information is transmitted in analog form or digitally.

In analog mobile communication, improved transmission quality is achieved by increasing transmission power; this, however, involves significant limitations of a practical nature. The main drawbacks of analog transmission include limited immunity from noise, few services that can be offered and limited communication security. Digital communication is superior to analog communication; that fact that today there are virtually no analog systems in commercial operation around the world evidences this superiority.

Concerning the evolution of mobile telephony terminals, the growing demand for sophisticated services has pressured manufacturers to develop innovations in their materials and electronic components continuously, making the devices more durable and lighter, while also providing them with computer power to support increasingly complex applications.

Innovation in the materials used to manufacture mobile devices include replacing plastic, previously used in the devices' body, by a magnesium alloy (lighter and more resistant to mechanical wear-and-tear), and using chemically strengthened glass for the displays, again instead of plastic, which is less durable and less resistant.

3.1.1 Evolution of mobile telephony generations

The first generation analog systems were developed to provide voice transmission services only. Among these, one must highlight the Advanced Mobile Phone System (AMPS), adopted by the United States and by most South American countries. In this system, a voice channel is allocated during the entire call, each channel uses a radio frequency pair to transmit and another pair to receive information, the size of the cells ranges from 0.5 km to 10 km, and the mobile terminal must have high transmission power.

The structural features of the analog system significantly limit its geographic coverage. Moreover, even if high transmission power is used, this system cannot achieve reasonable data transmission capacity. Although it was a major technological breakthrough in its time, analog systems are not attuned to market demands.

The generation that succeeded the analog network provided users with significant benefits in terms of the quality of the calls, value-added services and handset quality. The second generation, named 2G, was implemented under a set of standards, three of which should be highlighted: Time Division Multiple Access (TDMA), Global System for Mobile Communication (GSM) and Code Division Multiple Access (CDMA). The GSM standard predominated by far, having been adopted in most of Europe, Asia, the Middle East and Africa. In objective terms, from the user’s point of view, the system is not very important, as all of them deliver similar functionalities.

One possible difference is the quality and price of the handsets; GSM devices, for example, benefit from economies of scale, which makes them less expensive for consumers. They also have a wider range of models. From the operators’ point of view, GSM, because it is an open architecture, enables the combination of components from various manufacturers, making implementation more flexible and cheaper.

One of its drawbacks, however, is the difficulty of implementing a roaming system within the frequency bands under which Brazilian and international networks operate. Only the so-called tri-band (900MHz, 1.800MHz and 1.900 MHz) devices automatically go into roaming mode in networks in Europe, for example. However, most mobile devices are already equipped with tri-band frequencies, the standard in Brazil, the United States and Europe.

The second generation was improved and enhanced during its life cycle, consolidating an intermediate generation, known as 2.5G. Its main attributes are increased data transmission speed (ten times faster) and value-adding services that demand greater speed, such as the transmission of multimedia messages (low-resolution photos and videos) and web access. The main standards of the 2,5G generation were CDMA 1xRTT (an evolution of the CDMA standard) and EDGE (based on the GSM standard).

The next step in the technological evolution of the telecom network was the advent of the Third Generation (3G); among other features, this system provides broad band web access in a mobile environment. Handsets and modems can be used as mobile access points to high speed Internet (in many cases ten or twenty times faster than the speed provided by the 2.5G system); this has led to a broad range of service and application possibilities that operators and their business partners are eager to exploit.

They include applications based on locations, in which information, marketing or weather forecast services can be offered based on the client's location. The leading 3G network standards are CDMA 1xEV-DO, while the GSM evolution standards are W-CDMA (or Wideband CDMA) and HSPDA (High-Speed Downlink Packet Access).

The main commercial objective of mobile telephony operators in adopting the 3G is to increase revenue by providing value-added services that are overlaid on the voice service and but that are not confused with it. This issue is crucial for operators in saturated or near-saturated markets, or when they have experienced a drop in voice service revenues, the result of fierce competition and frequent price wars. For some operators, however, the increase in capacity provided by the 3G technologies solved the problems of voice congestion.

Figure 3 illustrates the relation between the generations, whereas Chart 1 details some of the technical characteristics of the mobile telephony generations.

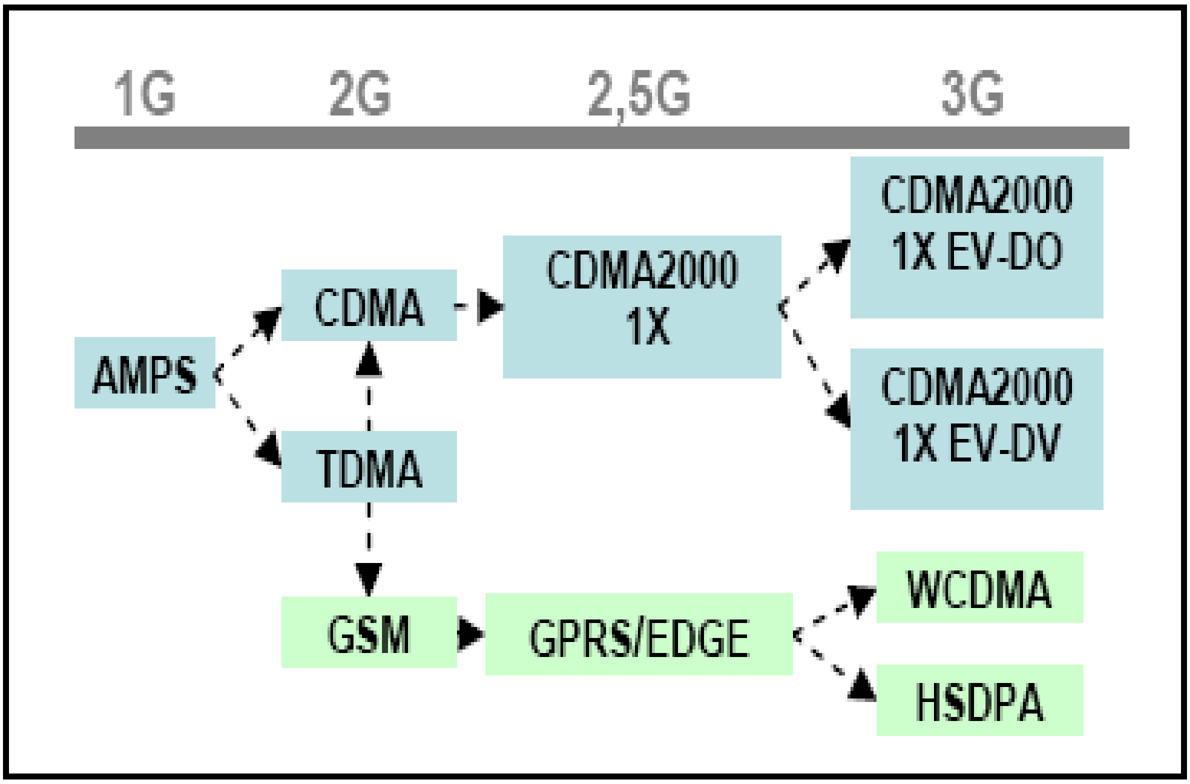

Figure 3: 3G evolutionary roadmap

Source: the authors

GENERATION	TECHNOLOGY	BANDWIDTH (Hz)	TRANSMISSION RATE
1G	AMPS	30 kHz	Lower than or equal to 16.2kb/s
2G	TDMA	30 kHz	Lower than or equal to 28.8kb/s
	CDMA	1.25 MHz	
	GSM	200 kHz	
2,5G	GPRS	200 kHz	Lower than or equal to 144kb/s
	CDMA20001X	1.25 MHz	Lower than or equal to 144kb/s
	EDGE	200 kHz	Lower than or equal to 2mb/s
3G	WCDMA	5 MHz	Lower than or equal to 2mb/s
	CDMA20001XEVDV	1.25 MHz	Lower than or equal to 2mb/s
	CDMA20001XEVDO	1.25 MHz	Lower than or equal to 2mb/s
	HSDPA	5 MHz	Lower than or equal to 10mb/s

Chart 1: Mobile telephony generation details

Source: the authors

3.2 THE MOBILE PHONE MARKET IN BRAZIL

Chart 1 illustrates the growth of the number of mobile phones in operation in Brazil and the ratio of the number of phones per 100 inhabitants as of July 2000.

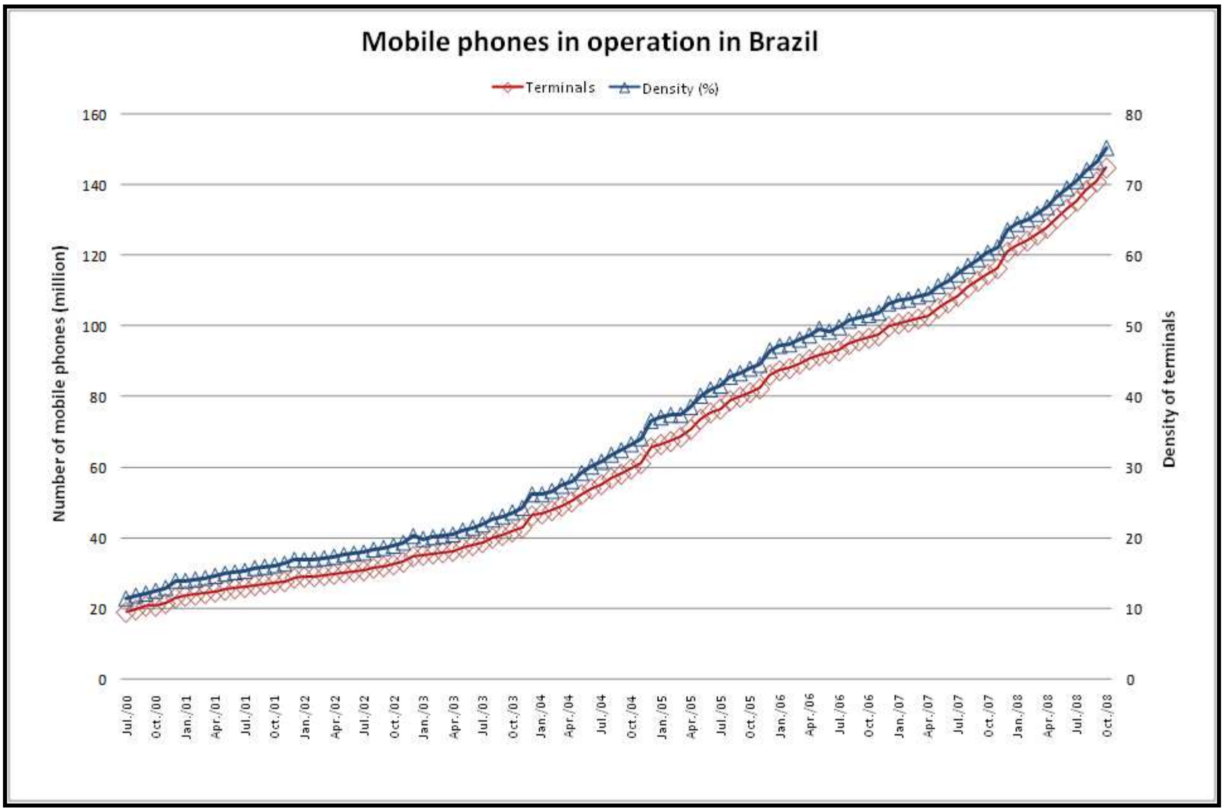

Chart 1: Mobile phones in operation in Brazil from July 2000 to October 2008

Source: ANATEL (2009)

Though the population increased from July 2000 to October 2008 (Chart 1), the correlation between the number of terminals and mobile telephony density (measured in number of mobile phones per 100 inhabitants) is extremely high, suggesting that the population's vegetative growth is an indirectly important measure of the number of active mobile phones in Brazil during this period.

Chart 2 illustrates the aggregated quantity of net additions to the base of active mobile phones in Brazil (Net Add/Total Base) from 2000 to 2008. This amount refers to the difference between the mobile phones activated in the period and those that were no longer in operation, taking into account all the active operators in the country. Chart 2 shows the density or phone penetration (mobile phones per 100 inhabitants) which, as shown in Chart 1, grew significantly in the period. An analysis of Chart 2 shows that the net additions behave erratically, varying by an average 22% a year, with relatively high standard deviation in the period (6.9%).

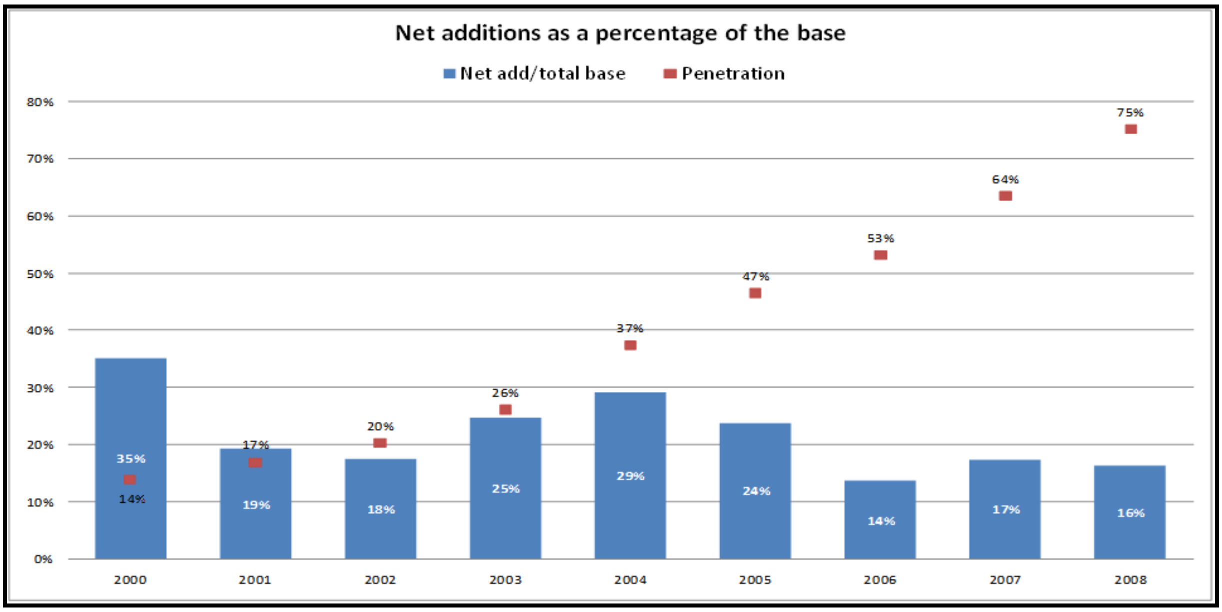

Chart 2: Net additions to the base and penetration of mobile phones in Brazil

Source: ANATEL (2009)

4 PREDICTIVE ANALYSIS OF THE GROWTH OF THE MOBILE PHONE BASE

Despite the evolution of mobile telephony in Brazil, Chart 3 is the most interesting one in this paper. It correlates the country’s phone density with GDP growth from 2004 to 2007, as shown below.

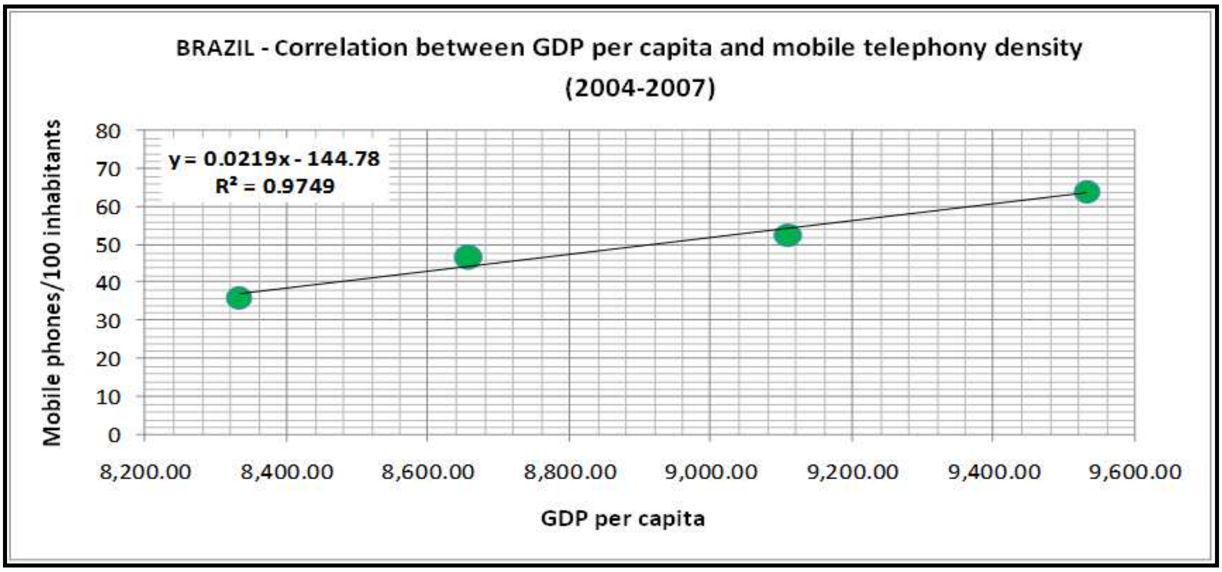

Chart 3: Correlation between GDP per capita and mobile telephony density in Brazil

Sources: IMF, World Economic Outlook Database, ITU World Telecommunication/ICT Indicators Database

The high correlation (97.5%) between the two variables in the period in question is surprising. To support the assumption that such a phenomenon also occurred in economies similar to that of Brazil, the study was extended to the other BRIC emerging economies (Brazil, Russia, India and China). Charts 4, 5 and 6 show these results.

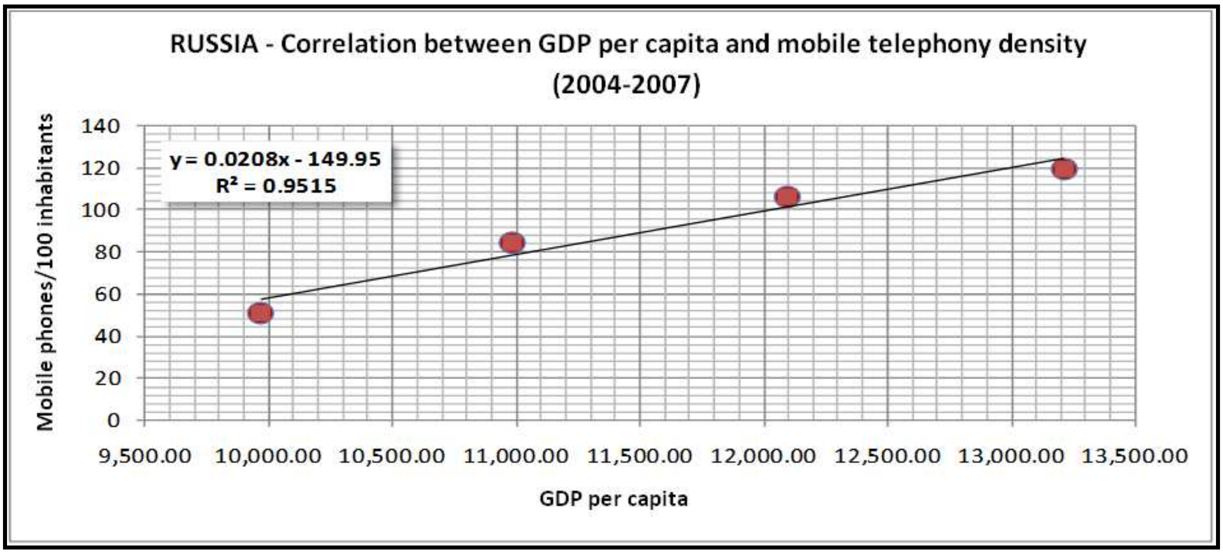

Chart 4: Correlation between GDP per capita and mobile phone density in Russia

Sources: IMF, World Economic Outlook Database, ITU World Telecommunication/ICT Indicators Database.

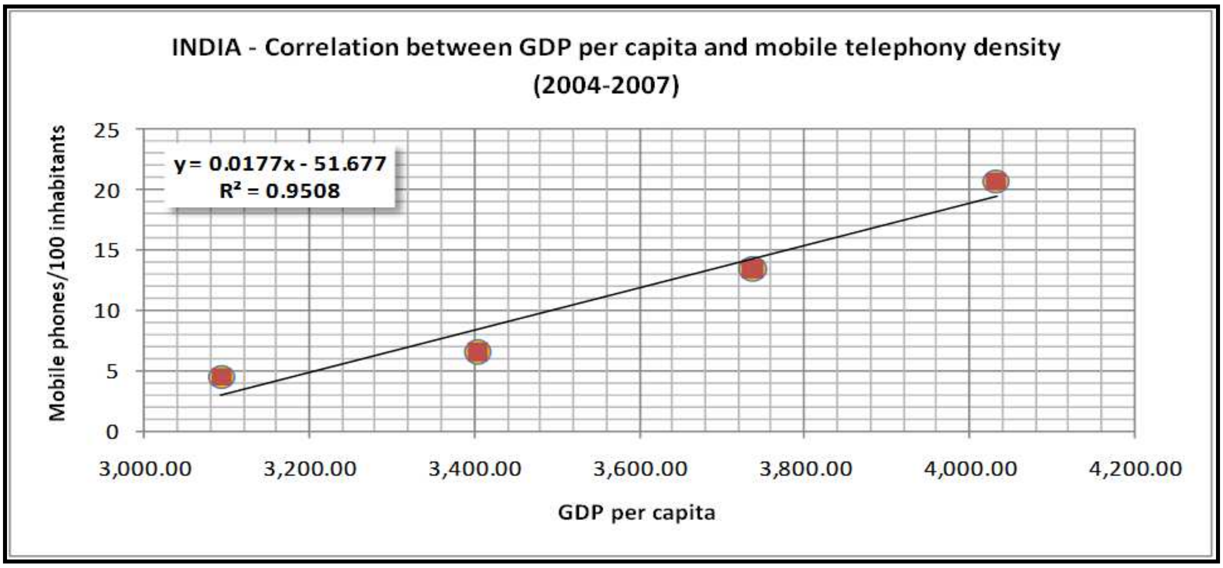

Chart 5: Correlation between GDP per capita and mobile phone density in India

Sources: IMF, World Economic Outlook Database, ITU World Telecommunication/ICT Indicators Database.

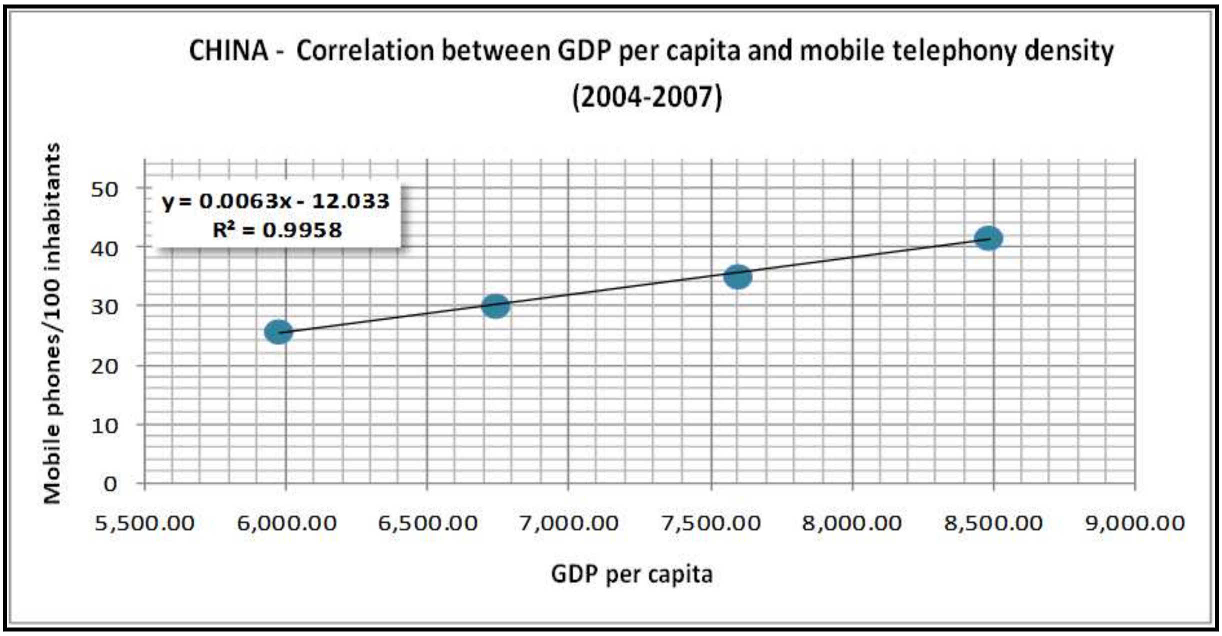

Chart 6: Correlation between GDP per capita and mobile phone density in China

Sources: IMF, World Economic Outlook Database, ITU World Telecommunication/ICT Indicators Database.

Table 1 correlates the data on density of mobile phones with the evolution of GDP per capita in Brazil, Russia, India and China.

Table 1: Evolution of GDP per capita and mobile phone density

COUNTRY	BRAZIL		RUSSIA		INDIA		CHINA	
	GDP PER CAPITA	DENSITY	GDP PER CAPITA	DENSITY	GDP PER CAPITA	DENSITY	GDP PER CAPITA	DENSITY
2004	8,333.28	36.13	9,971.72	51.2	3,093.07	4.45	5,974.67	25.76
2005	8,656.99	46.79	10,984.15	84.6	3,402.86	6.53	6,743.39	30.09
2006	9,108.41	52.59	12,096.28	106.4	3,736.69	13.43	7,597.66	35.09
2007	9,531.21	63.90	13,210.28	119.3	4,031.33	20.70	8,485.71	41.60
GDP X DENSITY	97.5%		95.15%		95.08%		99.58%	

Sources: IMF, World Economic Outlook Database, ITU World Telecommunication/ICT Indicators Database

In all the cases, we adjusted the polynomial trend line that seemed to be most appropriate to the conformation of the data. In countries with a high correlation between the density and GDP per capita variables, the R^2 of the trend lines was significantly high, indicating that a prediction based on the equation determined for each country can be considered reasonable (Table 2).

Table 2: GDP per capita x Mobile telephone density correlation

COUNTRY	R^2
Brazil	0.975
Russia	0.951
India	0.951
China	0.996

Though the data for the period under analysis behaved well, there is a factor that limits good correlation between GDP per capita and density of cellular telephony, a figure corresponding to roughly US$ 20,000.00. Likewise, there seems to be a limit of approximately 120% in relation to the penetration of cellular telephony, although this is not the case in Italy, where this percentage is 141%.

Table 3 and Chart 7 illustrate a broader sample of countries and specify the significant correlation limit between GDP per capita and mobile telephony density.

Table 3: GDP per capita and mobile telephone density per country

COUNTRY	GDP PER CAPITA	CELLULAR DENSITY
India	$ 2,700	20.7
China	$ 5,300	41.6
Colombia	$ 6,700	68.0
Costa Rica	$ 10,300	42.1
Uruguay	$ 11,600	93.9
Venezuela	$ 12,200	86.8
Mexico	$ 12,800	64.87
Argentina	$ 13,300	102.7
Chile	$ 13,900	76.7
Russia	$ 14,900	119.3
Brazil	$ 9,700	63.9
South Korea	$ 24,783	89.8
Italy	$ 30,400	141.5
Japan	$ 33,600	82.4
Germany	$ 34,200	121.5
United Kingdom	$ 35,100	121.8
Australia	$ 36,300	21.26
Canada	$ 38,400	60.4
United States	$ 45,800	84.4

Source: IMF, World Economic Outlook Database, April 2008. Gross domestic product based on per capita purchasing power parity for the year 2007.

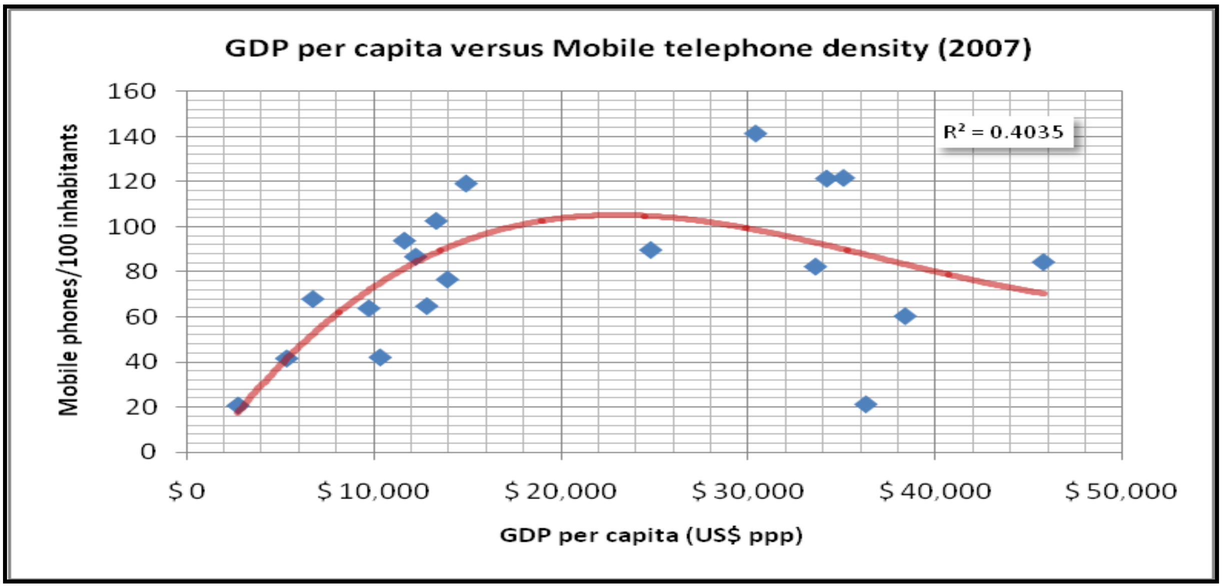

Chart 7: Correlation between GDP per capita and mobile phone density

Sources: IMF, World Economic Outlook Database, ITU World Telecommunication/ICT Indicators Database

Thus, a reasonable estimate for mobile phone density can be made based on the regression above, up to the limit of US$20,000 of GDP per capita and 120% of aggregated telephone penetration in the country (the sum of all the active mobile phones over the population). The simulation shown in Chart 8 defines the 120% ceiling for telephone penetration and specifies the corresponding GDP per capita.

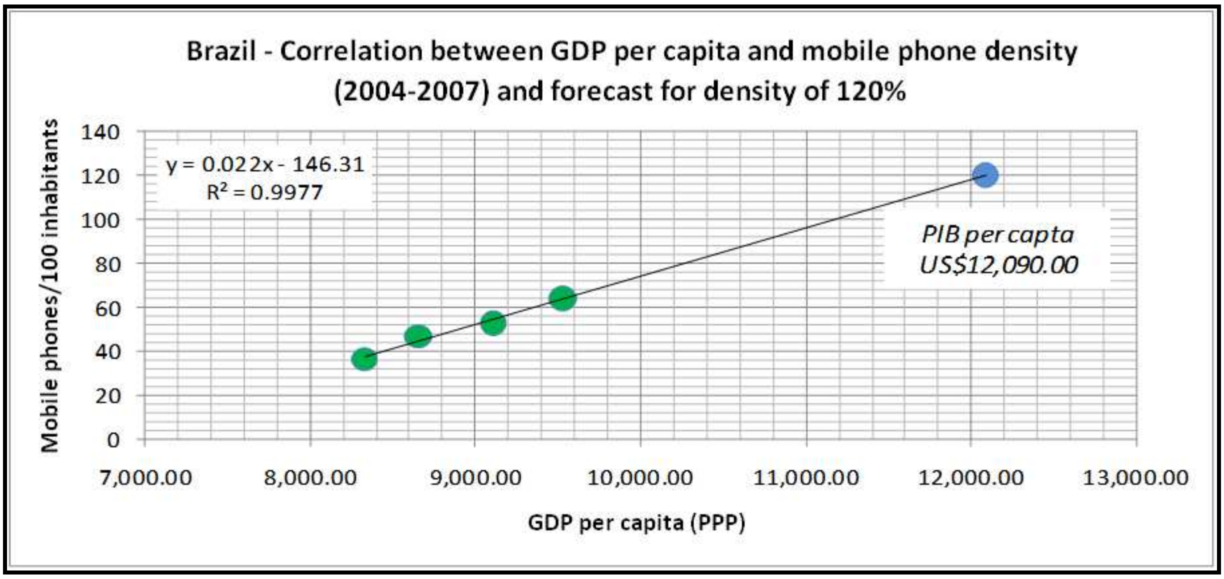

Chart 8: Simulation for phone density of 120%

Sources: IMF, World Economic Outlook Database, ITU World Telecommunication/ICT Indicators Database.

Given the assumptions about average annual growth of GDP per capita, the target figure is some US$12,090, which can be achieved in 5.6 to 11.1 years, depending in the GDP growth estimate used (Table 4).

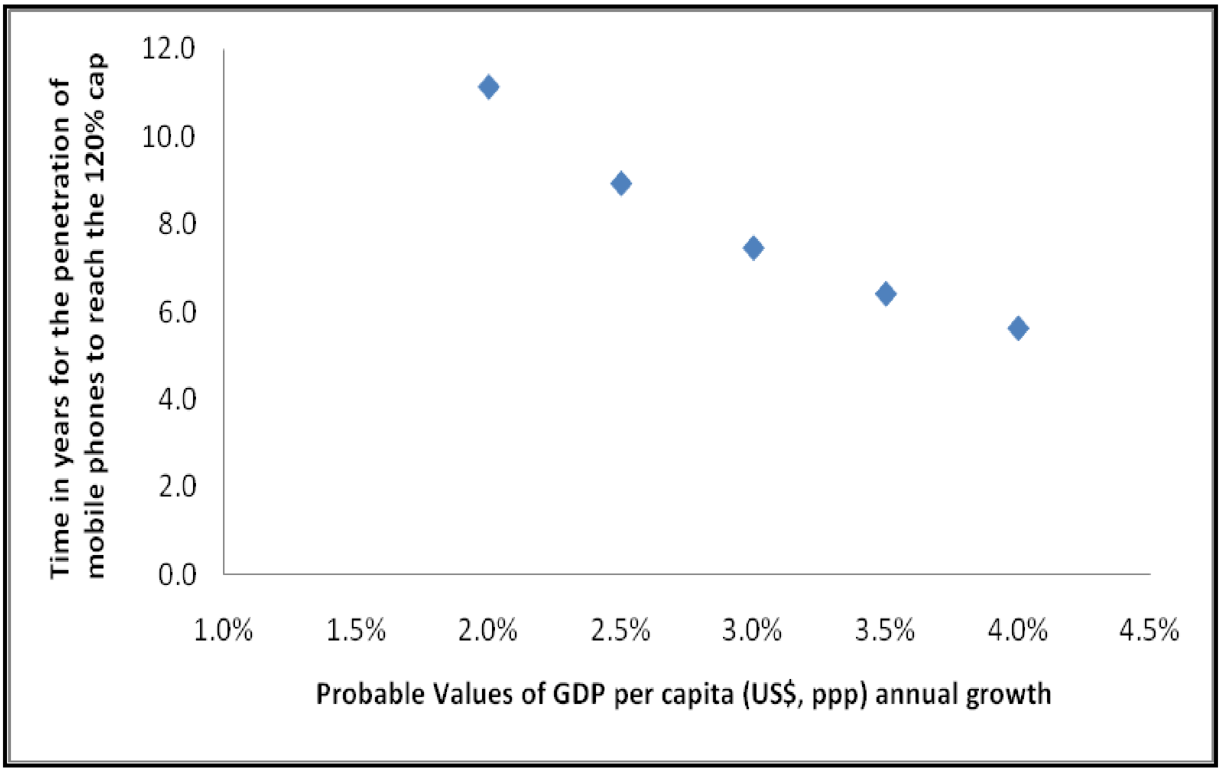

Chart 9: Time for mobile phone penetration to reach 120% based on GDP growth estimate

Table 4: GDP growth estimate and time to reach US$ 12,090

ESTIMATE OF ANNUAL GDP GROWTH	TIME UNTIL GDP OF US$12,090 IS REACHED(YEARS)
4.0%	5.6
3.5%	6.4
3.0%	7.5
2.5%	8.9
2.0%	11.1

5 FINAL COMMENTS

Mobile telephony has become increasingly important for the lives of citizens of developed and developing countries. Despite the improvement of the network and services that resulted from successive breakthroughs (2G, 2,5G and, recently, 3G), there is a strong correlation between the average improvement of the population's economic conditions (measured in terms of GDP per capita) and the systematic use of mobile phone lines. In the case of the major emerging countries, such as Brazil, Russia, India and China, this feature stood out in the data related to the 2004 to 2007 period (data from the International Telecommunications Union - ITU).

A broader sample of countries shows that the mobile phone density cap seems to be 1.2 mobile phones per inhabitant, no matter how wealthy the country. In Table 5, using Brazil's regression of data and considering alternative possible economic growth rates, we estimate scenarios that indicate the time needed for mobile phone density to reach 120% and the corresponding number of active mobile phones that would then exist in the country (Table 5).

Table 5: Calculation of the time for mobile telephony to achieve 120% density and estimated number of active mobile phones in Brazil

ESTIMATED ANNUAL GDP GROWTH	TIME UNTIL GDP OF US$12,090 IS REACHED (YEARS)	ESTIMATED POPULATION	ESTIMATED NUMBER OF MOBILE PHONES
4.0%	5.6	197,217,942	236,661,530
3.5%	6.4	198,747,941	238,497,529
3.0%	7.5	200,210,470	240,252,564
2.5%	8.9	202,945,021	243,534,025
2.0%	11.1	205,445,403	246,534,483

Source: IBGE

Based on the data analysis, we forecast that the maximum penetration of mobile telephony in Brazil will be reached in 5 to 11 years, the forecast varying according to the country's average growth in this time. We hope that this study will contribute to the strategic planning of mobile telephony operators, so that new income sources – such as on-line games, Internet access, music downloading and other content – can offset the expected market saturation that will result from the growth of the client base.

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