Alternative Mobile Broadband Deployment in Countries with Low Spectrum Allocation and Low Fixed Line Penetration

The Case of Ecuador

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Master of Science Thesis
Stockholm, Sweden
2013
Abstract

The research work presented in this document deals with the problem of implementing high capacity mobile networks that are able to accommodate the ever increasing amounts of data traffic produced by mobile broadband users, given the dramatic expansion this service has experienced in the recent past due to the popularity of smartphones and tablets. Moreover, the analysis focuses in the feasibility of considering alternative deployment strategies that may render cost-efficient solutions while overcoming the challenges posed by the low amount of spectrum allocated to operators and the limited number of fixed telephone and internet lines available, which are characteristic of developing countries.

In this context, an assessment in the scenario of the Telecommunications market in Ecuador is provided, for three specific strategies: network sharing, the use of secondary spectrum in TV white spaces, and offloading of traffic to local networks. The main factors considered are the economic situation, the penetration of fixed and mobile services, the regulatory environment, and the set up of the mobile operators in the market. Descriptions and comparisons with Chile and Sweden are included, as they present scenarios with higher levels of development, giving the opportunity to look at the way they have managed to improve the conditions in their markets and provide suggestions to allow Ecuador to follow their steps.

The results show that network sharing could be feasible mostly in the way of passive sharing, given regulatory restrictions. Also, the introduction of at least one new operator could provide better conditions for this strategy. On the other hand, the use of secondary spectrum would be a great solution, but it may be hard to implement it due to regulatory delays and economic issues related to the potentially high costs mobile phones supporting cognitive radio technologies may have. Finally, offloading of traffic to local networks is possible, but limited to urban areas where the density of fixed internet and telephone lines may support the deployment of femtocells or Wi-Fi networks.
Acknowledgements

I want to thank all my family for always being there for me, in spite of being far away for so long. Their support and encouragement has been invaluable during these two years, and I feel really lucky to know that they always back me up. Special thanks go to my parents, without their lessons and their love, I could have never gotten to where I am today. They have provided amazing opportunities to me, and for that I will always be grateful. Another word to my grandparents, all four of them, for setting an extraordinary example to all our family. If we can achieve half of the things they did, we can consider ourselves lucky. I dedicate this work to them.

I would also like to dedicate some words to all the amazing people I have met along the way during my stay in Europe. It has been an incredible experience, mostly for the stories I have seen and heard, for all the great moments I could share with such remarkable individuals. I can say I was able to be at the right moment, at the right time, in many occasions. I take all the things I learned from you as the most valuable asset as I go back home. Thank you for everything.

Finally, I would like to thank all the professors I had during my Master studies. Especially, I want to express my gratitude to Jan Markendahl, for giving me the opportunity to work within his research group. It has been an honour to learn from him both in person and from the knowledge spread in his own work. Also, to Ashraf Awadelakrim Widaa Ahmed, for the constant guidance provided, his useful advice, and his relevant contributions.
**Acronyms**

APT - Asia Pacific Telecommunity

ARPU - Average Revenue Per User

AWS - Advanced Wireless Services

CDMA - Code Division Multiple Access

CDMA-EVDO - Code Division Multiple Access - Evolution-Data Optimized

CONATEL - Consejo Nacional de Telecomunicaciones (Ecuador)

CNT - Corporación Nacional de Telecomunicaciones (Ecuador)

DSL - Digital Subscriber Line

EDGE - Enhanced Data for GSM Evolution

FDD - Frequency Division Duplexing

FODETEL - Fondo Nacional para el Desarrollo de las Telecomunicaciones (Ecuador)

GDP - Gross Domestic Product

GPRS - General Packet Radio Service

GSM - Global System for Mobile Communications

HSDPA - High Speer Download Packet Access

HSPA - High Speed Packet Access

HSPA+ - Evolved High Speed Packet Access

ICT - Information and Communication Technologies

IP - Internet Protocol

ISDB-Tb - Integrated Services Digital Broadcasting - Terrestrial Brazil

ISM - Industrial, Scientific and Medical

ISP - Internet Service Provider

ITU - International Telecommunications Union

LTE - Long Term Evolution
MinTel - Ministerio de Telecomunicaciones (Ecuador)

MMDS - Microwave Multipoint Distribution Service

MNO - Mobile Network Operator

MVNO - Mobile Virtual Network Operator

PTS - Svenska Post- och Telestyrelsen (Sweden)

SENATEL - Secretaría Nacional de Telecomunicaciones (Ecuador)

SUBTEL - Subsecretaría de Telecomunicaciones (Chile)

SUPERTEL - Superintendencia de Telecomunicaciones (Ecuador)

SIM - Subscriber Identity Module

SUNAB - Svenska UMTS-Nät AB

TDD - Time Division Duplexing

TDLC - Tribunal de Defensa de la Libre Competencia (Chile)

UHF - Ultra High Frequency

UMTS - Universal Mobile Telecommunications System

Wi-Fi - Wireless Fidelity

3GIS - 3G Infrastructure Services AB
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1. Introduction

The first chapter of this document provides an introduction to the topics that are to be dealt with throughout the present research work. First, the background of the project is discussed, leading to the formulation of the problem that will be addressed, along with the proposed of the research questions that must be responded by the end of the study. Additionally, a summary of the most relevant related work conducted by other authors is presented, as it will be used as a support for the research methodology and some of the argumentations made in this project.

In a subsequent section, a description of the research methodology to be utilized in order to answer the proposed research questions is included, followed by the scope that will be covered and the contributions the author wants to make by the end of the project. Finally, a perspective of how the results of this research will be shown to the reader is done.

1.1. Background

In past years, a lot of efforts have been made in order to develop new mobile broadband technologies and implement cellular wireless networks that would accommodate them accordingly, in order to provide internet access anytime, anywhere to all types of end users. However, the research and industry tendency has been to focus on efficient solutions for markets with somewhat "ideal" conditions. The spectrum allocation for network operators is high and the number of fixed lines available reaches high levels, allowing for high capacity networks that yield high peak data rates. Moreover, these conditions are set in developed countries like the United States and those located in Western Europe.

The present research project wants to focus on the study of different markets, where the conditions mentioned above are not met. In this scenario, mobile operators are allocated low amounts of spectrum and the number of operational fixed telephone and internet lines is low, forcing to a different approach in network deployment strategies and choice of alternative mobile broadband technologies.

More specifically, research work will be conducted to analyze the telecom market in Ecuador, compare it to the status of the markets in Chile and Sweden, and then make recommendations for the deployment of alternative strategies for mobile broadband deployment in the country. The motivation for this line of work is that Ecuador has been proven to be one of the countries with the least development in telecommunications in South America, as far as fixed line penetration, the allocation of spectrum, and the introduction of 4G technologies is concerned.

The interest in this comparative analysis is found in that there is a big contrast between the Swedish telecom market, the Chilean, and the Ecuadorian one. Chile is nowadays the country in South America with one of the highest levels of fixed line penetration and spectrum allocation (although these levels are still
low, compared to Europe). Given the differences presented, it is interesting to present reasons to these differences, and also suggest solutions for the Ecuadorian market that will help its improvement, which will for sure go along with improvements in the economic growth of the country, since these two factors have been proven to be highly correlated for other countries in the world.

1.2. Problem Formulation and Research Questions

The proliferation of smartphones and tablets has caused the demand of mobile broadband services and data traffic in mobile networks to increase all over the world. In order to deploy mobile networks to satisfy these needs, several factors that are subject to the reality of each country must be taken into account. The two main variables considered when proposing implementation strategies in different scenarios are: the amount of existing fixed lines for telephone and internet services in the country, and the amount of spectrum national regulators allocate to network operators.

Moreover, this project proposes to focus specifically in the Ecuadorian Telecom Market, which is pertained to a small economy, characteristic of a developing country. In this type of market, network operators are allocated small amounts of spectrum and the number of fixed lines available is limited. Nevertheless, the demand for mobile broadband subscriptions is forecasted to increase, as shown in Figure 1.1. In this sense, the main research question to answer is:

- What are the requirements in a strategy for the design and deployment of mobile communications networks that will accommodate the demands of mobile broadband users?

![Figure 1.1. Forecast for 4G Subscriptions in Ecuador](http://maps.yankeegroup.com/ygapp/content/ab3f3b692e0d4fc7b1d7d385ade4b55a/68/DAILYINSIGHT/0)

1 Source: http://maps.yankeegroup.com/ygapp/content/ab3f3b692e0d4fc7b1d7d385ade4b55a/68/DAILYINSIGHT/0
Due to the research methodology that is being proposed, several facts about the situation of the three markets analyzed will be documented. This will allow to answer to the complementary research questions listed below:

- What are the main differences that can be found in the telecom market scenarios described for Ecuador, Chile, and Sweden? Are there any similarities?
- What are the consequences of the differences found in each market?
- How can the Ecuadorian operators and regulator follow the steps of Chile and Sweden to improve development and competitiveness in their own market?. Are there any actions that should not be imitated?

1.3. Related Work

A previous research work deals with the importance of Telecommunications markets in the economic growth of developing countries. Results show that the impact is positive, as these countries have historically had a tendency to present economic improvements as the penetration of mobile phones became larger. Another important conclusion drawn from this article is that mobile telephony acted as a substitute of fixed lines, as their penetration has been low through the years and the rollout of mobile networks was faster and cheaper.\(^2\)

The problem of spectrum as a scarce resource is addressed in another paper. It is stated that allocation of spectrum to operators is becoming harder and harder, as useful spectrum bands are becoming saturated. It is proposed to use alternative, secondary spectrum for mobile broadband deployment, taking advantage of unused frequencies in the TV bands, which are denominated "TV White Space". The paper concludes that good business opportunities may arise for incumbent operators using TV White space, while Greenfield operators may have trouble using this strategy, since they must also spend money on site installation, marketing and other expenses related to launching their business. Of course, the technical and business challenges related to this type of deployment are also studied.\(^3\)

The information displayed in other two documents that were found by the author is a set of responses made by several technology companies to the inquiries of the British regulator, Ofcom, with respect to the use of cognitive radio for the operation of TV White Space technology.\(^4\)^\(^5\)

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4 DELL, GOOGLE, MICROSOFT, PHILIPS. "Joint Response to Ofcom's Consultation on Cognitive Access to the Interleaved Spectrum". May 1, 2009.
Another Conference paper cited, addresses the need to make a clear differentiation of market scenarios where to deploy mobile broadband technologies. It is clearly stated that in past years the focus of research in the area has been to propose solutions for markets with developed economies where spectrum allocation is high, the penetration of fixed lines is significant and high peak data rates can be achieved. An effort is made to come up with network deployment strategies suitable for different regions of the world, where the Telecom scenario is different according to each circumstance, which is affected by diverse business and technical challenges. The statistics considered to assess each country are fixed and mobile phone penetration, number of mobile operators, average amount of spectrum allocated per operator, and as an economic indicator, GDP per capita\(^6\).

The work presented in another research study takes a more specific approach and makes a comparison between the situation in Sweden and the one in India, suggesting the most suitable network deployment strategies for both countries and the reasons for these suggestions, according to the challenges presented in each case\(^7\).

The ideas depicted in the next document analyzed are a strong support to consider spectrum scarcity as a threat to the development of high quality, competitive mobile broadband services. The authors focus on the fact that it will be hard for regulators to provide big amounts of spectrum in the future, which leads them to propose alternatives for operators that involve sharing physical infrastructure, network equipment or even spectrum itself in order to keep their businesses efficiently running. The deployment of smaller cell sizes is also encouraged, mainly due to frequency reuse benefits and the possibility to operate with lower transmission power\(^8\).

A different study presents insights on how spectrum is assigned in several countries in Latin America, including views and the regulatory guidelines used and the impact of spectrum scarcity for operators in the region. An analysis of the status of TV White Spaces and the denominated "Digital Dividend" is also made\(^9\). Some complementary research to this topic was also found, since it is shown in it that in most Latin American countries the regulatory measures taken have inefficiently constrained spectrum access given the non-liberal nature of their telecommunication authorities. The authors encourage to liberalized regulations, where more spectrum is allocated to operators, or at least their current license contracts involve bigger concessions to operate. It is


\(^7\) Markendahl, J. & Mölleryd, B. "On Network Deployment Strategies for Mobile Broadband Services Taking into Account Amount of Spectrum and Fixed Line Penetration - Comparison of Network Deployment in Europe and India". February, 2011.

\(^8\) Chapin, J. & Lehr, W. "Mobile Broadband Growth, Spectrum Scarcity, and Sustainable Competition". September 23, 2011.

concluded that this may lead to economic development and to reduced retail prices for mobile services\textsuperscript{10}.

An important organization, 4G Americas, conducts an extensive analysis of the evolution of mobile broadband in the world in of their papers. Among other things, it studies the ever increasing consumption of data services from mobile devices, market trends in the deployment of 3G and 4G networks, and predictions of network traffic for the following decade, along with interesting insights on how to cope with the upcoming demands from mobile users, both for operators and regulators\textsuperscript{11}.

Another research developed by 4G Americas deals with the same topics, but with a focus on the Telecom markets in Latin America. Ultimately, it analyzes several barriers for mobile broadband deployment in these developing economies and proposes best practices to overcome them and accelerate the process of penetration of this technology in the region. The main goal, according to the paper, is to contribute in reducing the gap between telecommunications markets in developing and developed countries, or at least keep it from becoming larger than what it already is. The fact that ICT development highly contributes to economic growth in developing countries is again confirmed\textsuperscript{12}.

An overview of the Telecommunications market and the status of broadband services and internet access in Ecuador by the end of 2010 is provided in another document. A description of network infrastructure available, the market situation for both fixed and mobile ICT services, and a general explanation of several public policies adopted by the Government are included. The conclusion the authors reached is that internet services penetration to that date had failed to become extensive in the country, due to several factors, like the high cost of services, small deployment investments in rural areas, and "monopoly-like" actors in the market and administrative issues related to a lack of stability in the structure of the regulator in recent years\textsuperscript{13}.

1.4. Scope and Contribution

After going through some related research material, it is clear that in the past, a lot of research efforts have been carried into finding solutions that would yield high peak data rates in mobile data networks that adjust to "ideal" conditions found in developed countries, where the legislations allow operators to hold fairly high amounts of spectrum and they can rely on the fact that there are a lot of fixed telephone lines available to provide alternative mobile broadband services, which have historically proven to increase demand around the world.

Also, interesting insights about the situation of the Telecom Market in Latin America have been presented, including several market trends, the main barriers they have to face due to political and economical issues, and several approaches to cope with those challenges.

However, it has been noticed that Ecuador possesses one of the least developed Telecom Markets in the region, since the amount of fixed telephone lines available is low and there are severe regulations regarding spectrum allocation, including spectrum caps for each operator. In this sense, a research gap has been found, rising the need to investigate in more detail the current situation of mobile operators and the regulator authority in the country, looking for similarities and differences with other, more developed markets, like the case of Chile, which holds one of the top markets in South America, and Sweden, that has even implemented one of the first 4G networks in the world.

This comparative analysis will allow to find reasons for the current limitations in the mobile telecommunications business in Ecuador and propose recommendations to cope with them and overcome them. Ultimately, the main contribution will be to weigh different mobile network deployment strategies for operators to offer mobile broadband services and determine which solution is the most suitable according to the current market environment.

1.5. Research Methodology

The research approach taken will first make an effort to analyze the current situation of the telecommunications environment in the three countries involved. In order to perform this analysis, relevant information will be gathered from different sources. This information must include the following parameters:

- Statistics describing the evolution of the telecom market in each country showing the following:
  - Mobile telephony penetration.
  - Mobile broadband penetration.
  - Fixed line penetration, both for telephony and internet services.
- Description of the market regarding the economic situation and financial facts, including:
  - Total annual revenues perceived by operators
  - Evolution of Average Revenue Per User (ARPU) along the years.
  - GDP per capita, as a reflection of the economic power of each country.
- Number of mobile operators and market shares.
- Amount of spectrum allocated to mobile operators.

To complement the above mentioned parameters, a description of the regulatory environment of each country will be carried on, as it has direct influence in the evolution and level of development reached. The aspects included in this part of the research are as follows:
- The structure of the national telecom regulatory authorities.
- The approach taken by regulators in order to award concession licenses to operators.
- The rules operators are subject to in their concession licenses.
- The general framework for the policies issued by the authorities of each country regarding the use of spectrum and the operations of mobile communications services.

After the first stage of the project, a clear picture of the characteristics of each market can be deducted. This will allow to conduct a comparison between them, in order to understand what are the main differences and similarities observed from the information gathered from each country, along with their impact on the current situations. In this manner, the first two complementary research questions proposed will be answered.

Furthermore, looking at the way that the operators and the regulators have handled to develop the markets in Chile and Sweden, some of their best practices can be identified as valid for Ecuador, as well as some of their mistakes can be rejected as lines of action for Ecuadorian actors in their attempt to improve the development and competitiveness of the market. Thus, an answer to the third complementary research question will be obtained.

Finally, once the stage of analysis and comparison of the markets is completed, an assessment of the advantages, disadvantages and challenges of deploying alternative mobile broadband technologies in Ecuador will be carried out. The evaluation will include three strategies: network sharing, the secondary use of spectrum in TV white spaces, and the offloading of traffic to local networks. As theoretical background, the concepts behind these three network deployment approaches will be explained. In the end, this process will allow to answer the main research question of the present Master Thesis.
2. Telecom Market in Ecuador

The objective of this chapter is to present a thorough description of the current situation of the telecommunications market in Ecuador. The actors in the mobile services business are identified, including operators and regulators. Statistical figures are provided in order to understand the current trends and to help predict future demands mobile operators will have to address in order to maintain their customer base satisfied.

An analysis of the structure of the regulatory body is also included, along with an overview of the laws that pertain the mobile operator environment, focusing especially in the way the Government has handled spectrum allocation in the past, as well as their plans to handle this issue in the near future. This is done with the purpose of presenting the different challenges and advantages operators will have to face when they design strategies and deploy network infrastructure to provide mobile broadband services.

2.1. Relevant Statistics

The past decade has marked a great evolution in the Ecuadorian telecom market, especially in the development of the mobile sector. Figure 2.1 presents how the number of mobile subscriptions has constantly increased, reaching over 17 million connections by the end of 2012. This number represents a penetration of 113% of the population. However, it must be noted that although the number of SIM cards in service has surpassed the number of inhabitants in the country, not all the population is able to afford mobile telephony services. This statistical figure is the reflection of the fact that there are people who own more than one mobile phone, or others who access the internet through mobile dongles.\textsuperscript{14}

\textbf{Figure 2.1. Number of Mobile Subscriptions in Ecuador}\textsuperscript{15}

\textsuperscript{14} http://www.extensia-ltd.com/documents/ecuador-telecoms-mobile-broadband-and-forecasts/9080/

\textsuperscript{15} Source: Consejo Nacional de Telecomunicaciones de Ecuador - www.conatel.gob.ec
It is important to mention that although there are now a big amount of mobile connections in the country, most of them belong to prepaid subscriptions. This can be related to the fact that a fair percentage of the population earn relatively low salaries, which translates in an average GDP per capita of 8,800 US dollars (approx. € 6,700) as of 2012\(^\text{16}\). Thus, many people cannot afford to pay for a monthly postpaid contract, so they choose to pay for their mobile telephone services according to the amount of money they can destine to it. Figure 2.2 illustrates the evolution of prepaid and postpaid subscriptions in the past few years.

![Prepaid vs. Postpaid Mobile Subscriptions in Ecuador](image)

**Figure 2.2.** Comparison of prepaid and postpaid mobile subscriptions in Ecuador\(^\text{17}\)

It can be observed that the dominance of prepaid connections is significant, with the gap having increased along the years. At the end of 2012, an 82.5% of mobile subscriptions were prepaid, while only 17.5% of them were postpaid.

Another relevant fact is that mobile broadband has not yet reached high levels of penetration in the market, like the number of voice subscriptions has. However, ever since operators started offering these services with 3G technologies, the number of customers has followed an increasing trend, as it is shown in Figure 2.3. This presents a great opportunity for operators, since this is obviously a service that customers will be demanding in the near future, while there is still a lot to be done in terms of coverage and quality of service.

\(^{16}\) Source: CIA World Fact Book - www.cia.gov

\(^{17}\) Source: Consejo Nacional de Telecomunicaciones de Ecuador - www.conatel.gob.ec
The constant increase of mobile subscribers in the country has been complemented by the decrease in prices per minute of voice call. This had an impact in the revenues mobile operators obtain for each subscription, which has shown a tendency to decrease in the last 10 years. Figure 2.4 presents the evolution of the Average Revenue Per User (ARPU) for mobile operators since 2003 until 2012.

It is clearly noted that, by the end of 2012, mobile operators were obtaining a little over a half of the income they reported for each subscriber back in 2003. The key to this phenomenon was the entry in the market of a third mobile

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18 Source: Wireless Intelligence - www.wirelessintelligence.com
19 Sources: Financial Reports for América Móvil and Telefónica 2009-2012
20 Source: Consejo Nacional de Telecomunicaciones Ecuador - www.conatel.gob.ec
operator precisely in 2003, which offered very low prices per minute. Additionally, the regulator authority established caps in the tariffs of voice call minutes.

However, operators mentioned in their latest financial reports that they have benefited from net additions in their postpaid subscriber base, as well as the fact that data usage on smartphones and tablets has exploded in the past couple of years\textsuperscript{21}. These two factors have represented an increase in ARPU during 2012, with respect to 2011. Additionally, Figure 2.5 shows that the operators have increased their revenues every year up until now.

\begin{figure}[h!]
\centering
\includegraphics[width=\textwidth]{mobile_operators_revenues.png}
\caption{Revenues for Mobile Operators in Ecuador\textsuperscript{22}}
\end{figure}

The mobile market in Ecuador proves to have been in constant expansion, especially for private operators in the recent past. Although the growth rate of revenues was smaller during 2009 and 2010, it picked up in 2012. However, it never reached the levels it had prior to 2008, when the prices per minute were still very high.

The tendency of expansion for the amount of mobile subscriptions can be attributed, in part, to the fact that historically the number of fixed lines in the country is low. As a matter of fact, it suffered a deficit of fixed telephone line supply of around one million, in comparison to the amount of demands for new lines made by end users in 2009\textsuperscript{23}. This tendency has not changed, as it is shown in Figure 2.6. In 10 years, the amount of operational fixed telephone lines increased from 1.5 to 2.3 millions. This represents an increment of

\begin{itemize}
  \item \textsuperscript{21} Sources: Financial Reports for América Móvil and Telefónica 2009-2012
  \item \textsuperscript{22} Sources: Financial Reports for América Móvil and Telefónica 2009-2012; www.conatel.gob.ec
  \item \textsuperscript{23} Hidalgo, M. "Ecuador: Wireless Networks as an Opportunity for Access to Broadband and Development". June 2009.
\end{itemize}
roughly over 3% in the penetration rate of this service, reaching only a 15.3% of the population by the end of 2012.

Given the lack of growth and improvement in fixed telephone services, finally much of the population decided that it was not worth waiting for a fixed line operator to install a telephone in their home, and decided to just use a mobile phone as a solution to communicate with others instead.

![Fixed Telephone Line Penetration in Ecuador](image)

**Figure 2.6. Number of Fixed Telephone Lines in Ecuador**

The number of end users that have access to fixed broadband services through technologies like ADSL or Cable Modem has also been expanding. In Figure 2.7, there is a reflection of the amount of subscriptions to internet services in the past decade. It should be mentioned that in Ecuador, there is still a small amount of dial-up subscribers, called "narrowband subscribers" by the regulator, which are also accounted for in these statistics. Also, a broadband line is referred to as "a connection with a speed of 256 kbps or more".

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24 Source: Consejo Nacional de Telecomunicaciones de Ecuador - www.conatel.gob.ec
The number of subscriptions is presented, instead of the total number of users, in order to yield an estimation of the number of fixed broadband lines that may be available as infrastructure for alternative mobile broadband deployment. It is clear that there was an explosion of internet connections after 2008, when both private users and companies started to switch from slow dial-up connections to broadband services.

The actual number of users that access the internet through fixed broadband services is estimated in almost 6 million as of March 2013, which represents almost 39% of the population\(^\text{26}\). The regulator has considered several users per subscription in order to make their calculations, adding also an average number of cybercafé customers every month, as well as end users in rural areas and low-income neighborhoods that go to public facilities that have been implemented by the Government for them to access the internet.

A factor that has encouraged the access to broadband internet services through fixed lines is that in recent years the national fiber optics network has been extended from approximately 1000 kilometers in 2006, to over 10000 kilometers in 2012\(^\text{27}\). Additionally, the capacity towards backbone connections like the Pan American fiber optic cable has been increased. This has translated in the cancellation of other links Ecuador was leasing through Colombia and Peru, that represented 40% of the cost for internet services in the country\(^\text{28}\). All

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25 Source: Consejo Nacional de Telecomunicaciones Ecuador - www.conatel.gob.ec
27 www.ecuadorinmediato.com - "Ecuador registra crecimiento en telecomunicaciones y fortalecimiento del sector"
these factors meant better broadband connections at lower prices for end-users.

2.2. Mobile Operators and Market Shares

The mobile market in Ecuador began with the first concession licenses awarded to private operators Conecel (owner of the brand name Porta) and Otecel (with the brand name Cellular Power) in 1993. Back then, they were granted the permission to operate for 15 years. In 2003, a third operator named Telecsa (with the brand name Alegro) entered the market, with the idea of breaking the duopoly that had been reigning in the country, which derived in certain abuses from the existing operators towards the end users. However, the new operator always failed to make a significant impact, although it did encourage a reduction in prices for voice services. Even today, they remain as a minor force, providing services to a very small segment of mobile subscribers.

Later in the 1990s, Otecel changed its administration and became Bell South. During the year 2004, it was sold to Telefónica, which now commercializes the brand name "Movistar". Operator Conecel started as a company owned by a group of investors, but later became a part of the América Móvil empire. In 2011 they changed the name of their brand to "Claro", which they use in most countries in the region. Additionally, Telecsa became part of state owned Telecom company Corporación Nacional de Telecomunicaciones (CNT) in 2010, after it was declared bankrupt. It now operates under the brand name of CNT Móvil. The market shares of each of these operators are depicted in Figure 2.8. They refer to the total number of end user subscriptions to the services of each mobile operator. The data corresponds to January 2013.

<table>
<thead>
<tr>
<th>Operators in Ecuador - Market Shares</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conecel (Claro) 68.77%</td>
</tr>
<tr>
<td>Otecel (Movistar) 29.20%</td>
</tr>
<tr>
<td>CNT Móvil 2.02%</td>
</tr>
</tbody>
</table>

Figure 2.8. Market Shares for Mobile Operators in Ecuador

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30 Carrión, H. "Regulación e Inversión en Telecomunicaciones - Estudio de Caso para Ecuador". October 2007
31 Source: Consejo Nacional de Telecomunicaciones Ecuador - www.conatel.gob.ec
It is clear that Conecel is the dominant operator in the market, while Otecel holds a fair amount of subscribers, leaving CNT Móvil in a very challenging position to survive its competitors. The Herfindahl-Hirschman Index measures the level of competitiveness in a market, with a scale of 0 for a status of completely even competition, and 10,000 for no competition at all. The Ecuadorian market has scored an average 5,600 in the recent past\textsuperscript{32}, which reflects that the market competition is rather unbalanced, like it can be deducted from the figure. Some relevant facts about each operator are presented in Appendix A.

2.3. Regulatory Body Structure

Historically, the regulatory body in Ecuador has been marked by a lack of a clear structure and the redundancy of competences between the different national entities that compose it. The current Government decided to revise this structure and set some changes in order to better define the role of each entity and adopt new public policies. However, the structure still remains quite complex. This is a brief description of the public offices in charge of enforcing the law for the telecommunications sector in the country:

- **Ministerio de Telecomunicaciones - MinTel (Ministry of Telecommunications):** It was created in August 2009. It has the power to create and issue regulatory policies. It mainly manages public plans and projects for the development of the telecom sector\textsuperscript{33}. It is important to mention that the Minister is also the President of the regulator authority, CONATEL.

- **Consejo Nacional de Telecomunicaciones - CONATEL (National Telecommunications Council):** It is recognized by the International Telecommunications Union (ITU) as the official regulator authority of the country. Regulations are managed by this entity, including spectrum allocation and policies related to it. This office was merged with the former Consejo Nacional de Radio y Televisión (National Council for Radio and Television), which also gives it competences to regulate frequency allocations for the media broadcasting sector that it did not have before\textsuperscript{34}.

- **Secretaría Nacional de Telecomunicaciones - SENATEL (National Secretary of Telecommunications):** It is the entity that actually executes and implements policies and regulations for the sector. It may be said that CONATEL and SENATEL work as one entity.

- **Superintendencia de Telecomunicaciones - SUPERTEL (Superintendence of Telecommunications):** It is in charge to

\textsuperscript{32} Source: Wireless Intelligence

\textsuperscript{33} Navas, M. "Espectro abierto para el desarrollo - Estudio de caso: Ecuador”. September 2011

\textsuperscript{34} Navas, M. "Espectro abierto para el desarrollo - Estudio de caso: Ecuador”. September 2011
monitor and control the proper use of radio spectrum, as well as the performance of telecommunications service providers. It ensures that the rights of the end-users are protected and it presents reports when sanctions have to be imposed\textsuperscript{35}.

In addition to these three entities, there exists an additional one, called Fondo Nacional para el Desarrollo de las Telecomunicaciones - FODETEL (National Fund for the Development of Telecommunications). This organism is in charge of generating and implementing projects that expand the access to telecommunications services in rural and marginal areas, especially benefitting underprivileged communities and families.

It is clear that given the power of the Ministry of Telecommunications, the actual regulatory authority is not completely free to operate. It will always be subject to the supervision of the Ecuadorian Government, which may or may not look after political interests for some regulations and decisions. This is clearly not an ideal situation for the market and its actors.

2.4. Concession Licenses and Spectrum Allocations

The first concession licenses for mobile telephony services in Ecuador were awarded in the year 1993. Operator CONECEL signed their contract on 25 August, while OTECEL did the same on 29 November. They both paid US $ 2 million and agreed to pay a percentage of their gross revenues in the following 15 years, starting at 0% on year 1 and escalating to 70% on year 15, when the licenses expired. However, in 1996 Ecuador accepted the payment of 51 million dollars per operator instead\textsuperscript{36}. The licenses included 25 MHz (2x12.5 MHz) of spectrum for each operator in the 850 MHz band and the authorization to provide mobile telephony services.

It is important to note that the Ecuadorian law establishes one license for the use of spectrum and another one to provide telecommunications services\textsuperscript{37}. Due to this licensing procedure, operators had to request a new license to offer mobile data services in 2006. They were granted their petition, along with an allocation of 10 MHz in the 1 900 MHz band. In exchange, they paid an amount of 4.4 million dollars.

When the current Government took office in 2007, it considered that the former operator licenses had been an unfair negotiation, arguing that the mobile telephony business had generated 7500 million between 1993 and 2008. According to their calculations, the State had lost an estimate of 4477 millions in their concession license negotiations. That is why, for the renewal of licenses, operators were expected to pay 1.200 million dollars\textsuperscript{38}.

\begin{flushright}
\textsuperscript{35} Navas, M. "Espectro abierto para el desarrollo - Estudio de caso: Ecuador". September 2011
\textsuperscript{36} Carrión, H. "Regulación e Inversión en Telecomunicaciones - Estudio de Caso para Ecuador". October 2007.
\textsuperscript{37} Afonso, C. "Uso del Espectro en América Latina". June, 2011.
\textsuperscript{38} www.conatel.gob.ec - "internet Móvil, otra concesión".
\end{flushright}
In the end the renewal of licenses in 2008 represented a first payment of US $ 289 million for CONECEL and US $ 90 million for OTECEL. Additionally, they agreed to pay 3.93% (1% for FODETEL) of their annual revenues until 2023. The total amount of money the Ecuadorian State will receive for these concession licenses is estimated to be between 1200 and 1500 million dollars in the 15 years\(^{39}\).

The situation for the third operator, CNT Móvil (named TELECSA at the time) has been different. They entered the market in 2003, being awarded a spectrum license to use 30 MHz in the 1900 MHz band, for which they paid 31 million dollars. They also requested and were awarded an additional 10 MHz in the same band in 2006\(^{40}\).

After being absorbed by CNT and becoming a State-owned operator, CNT Móvil was granted 70 MHz of 4G spectrum in 2012, which CONATEL directly allocated to them. Ecuadorian regulations exonerate public companies from auctions and payments from spectrum in general. The operator was given 30 MHz in the 700 MHz band and 40 MHz in the 1.7/2.1 GHz band\(^{41}\).

The spectrum allocation given to this operator might be an effort of the Ecuadorian Government to increase their competitive power against the two private operators. Another reason is that it would help the market become more competitive if the third actor became a stronger force in the struggle for market shares. A spectrum auction for 4G spectrum is expected in the near future, although a precise date has not been established. There are small possibilities that new actors might bid for this spectrum. Table 2.1 presents a summary of the spectrum allocated to each operator. It is relevant to mention that the regulator established a spectrum cap of 65 MHz per operator, which still applies at least to Conecel and Otecel\(^{42}\).

<table>
<thead>
<tr>
<th>Operator</th>
<th>700 MHz</th>
<th>850 MHz</th>
<th>1700/2100 MHz</th>
<th>1900 MHz</th>
<th>Total (MHz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conecel</td>
<td>0</td>
<td>25</td>
<td>0</td>
<td>10</td>
<td>35</td>
</tr>
<tr>
<td>Otecel</td>
<td>0</td>
<td>25</td>
<td>0</td>
<td>10</td>
<td>35</td>
</tr>
<tr>
<td>CNT Movil</td>
<td>30</td>
<td>0</td>
<td>40</td>
<td>40</td>
<td>110</td>
</tr>
<tr>
<td>Total</td>
<td>30</td>
<td>50</td>
<td>40</td>
<td>60</td>
<td>180</td>
</tr>
</tbody>
</table>

Table 2.1. Spectrum Allocations per Band and per Operator in Ecuador

Some additional information regarding the policies established for the use of spectrum and for the operation of mobile services in Ecuador is provided in Appendix B.

\(^{39}\) [eltelegrafo.com.ec](http://www.eltelegrafo.com.ec) - "Solines quería cobrar solo $60 millones por la concesión telefónica”.

\(^{40}\) Carrión, H. "Regulación e Inversión en Telecomunicaciones - Estudio de Caso para Ecuador". October 2007

\(^{41}\) SENATEL Annual Report 2012 (Informe Senatel 2012).

\(^{42}\) [elcomercio.com](http://www.elcomercio.com) - "Erasmo Rojas: Ecuador avanza hacia una nueva red para móviles".
3. Telecom Market in Chile

The present chapter aims to provide the most important facts about the Chilean telecom market, especially regarding its mobile segment. It portrays the regulatory environment, the actors, and some of their performance statistics.

In the scope of this research project, the goal is to obtain a clear picture of the current situation of the sector in this country, in order to later compare it with that of the Ecuadorian telecom market and make different assessments on the levels of development achieved in each case. This will help further suggest actions that may be taken by actors in the Ecuadorian market in order to enhance its conditions.

Moreover, the findings made in this chapter will provide important information about the state of mobile broadband technologies in a rather developed country of Latin America. In this manner, conclusions can be made on whether alternative network deployment strategies are considered as an option for mobile operators in the region.

3.1. Relevant Statistics

Chile is considered to be one of the most developed countries in Latin America. Their telecommunications sector is coherent with that reality, being often classified as the most mature market in the region. Their mobile sector is one of the oldest around, with services available since the end of the 1980s and beginning of the 1990s. Figure 3.1. presents the evolution of mobile subscriptions in the past decade, where it is clear that their level of penetration has constantly increased, reaching 139% by the end of 2012. The total number of subscriptions reaches little over 24 million, for a total population of only 17.4 million.

![Penetration of Mobile Services in Chile](image_url)

*Figure 3.1. Number of Mobile Subscriptions in Chile*

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43 Source: Subsecretaría de Telecomunicaciones Chile - www.subtel.gob.cl

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Even though the levels of penetration of mobile services is very high, not everyone in Chile uses mobile telephony services nowadays. This occurs in part because there are some remote areas where mobile networks have not been deployed, given the difficult conditions and long distances needed to reach them. In this manner, the expansion of mobile services is being strongly encouraged by the Government. In the past few years, they have launched projects to provide coverage in the mentioned remote areas of the country, with the collaboration of actors in the private sector\textsuperscript{44}.

Another reason for this phenomenon is the fact that the unequal distribution of wealth is still an issue in the country. The GDP per capita was estimated to be US $ 18400 by the end of 2012\textsuperscript{45}, the highest in the region, but still low in a worldwide scale. This translates in a portion of the population not being able to afford mobile telephony, while another segment owns more than one cell phone since they usually possess one for personal use and their employer provides them with another one. There are other customers who own two SIM cards, one for a mobile phone and another one to make use of a mobile dongle.

Given the level of the salaries of some types of jobs, some people are not able to afford contract subscriptions that usually demand what is perceived as a significant amount of money every month. In this sense, Figure 3.2 shows that the number of prepaid subscriptions surpasses the amount of postpaid subscriptions significantly.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{Figure3_2.png}
\caption{Comparison of prepaid and postpaid subscriptions in Chile\textsuperscript{46}}
\end{figure}

\textsuperscript{44} www.subtel.gob.cl. “Gobierno inaugura segunda etapa del proyecto de conectividad Todo Chile Conectado”
\textsuperscript{45} Source: CIA Fact Book - www.cia.gov
\textsuperscript{46} Source: Subsecretaría de Telecomunicaciones Chile - www.subtel.gob.cl
However, 10 years ago the proportion was of 80% to 20%, while now contract subscriptions have gained a bigger portion of the market, reaching a 28% of total subscriptions. Operators have reported that part of the reason for this is the fact that some customers have switched from prepaid services to newly available low-cost contracts.

Mobile broadband services have experienced a considerable expansion, as it can be noted in Figure 3.3. The number of subscriptions went from under 1 million to almost 5 million in only four years, to reach a penetration level of 28%. The key to this development has been the strong focus of operators to offer smartphones to their customers. There has been a proliferation of these devices, especially among the upper-middle class population\(^47\). This type of service is expected to gain a lot more demand in the upcoming years, according to reports from the operators and the Chilean regulator authority.

![Figure 3.3. Penetration of Mobile Broadband Subscriptions in Chile\(^ {48} \)](image)

About the average revenue per user (ARPU) perceived by operators, it can be observed in Figure 3.4 that it climbed in 2009 and then declined in the following years. Part of the reason for this variation is that the country experienced a devastating earthquake in February 2010. This affected the economic situation of many families, given the destruction of many houses and buildings, forcing operators to offer more convenient prices for end users.

Later on, in 2011, the financial crisis that had started a few years ago in other countries in the world hit the Chilean market, keeping ARPU at the same level

\(^{47}\) www.pwc.com . "Market profile: Chile"

\(^{48}\) Source: Subsecretaría de Telecomunicaciones Chile - www.subtel.gob.cl
from the previous year. Finally, the economy picked up and there was an increase of around US $ 0.90 in 2012. This has lead the regulator to take action with several new rules that attempt to reduce the prices of telephony services, which will be explained in a later section.

![Average Revenue Per User for Mobile Services in Chile](image.png)

**Figure 3.4.** Evolution of ARPU for Mobile Services in Chile

Mobile operators have seen very favorable business, with their revenues increasing every year, as it can be deducted from Figure 3.5. The year 2012 was especially positive, with a growth rate of 25.7% and over US $ 5 billion of total revenues. This is a reflection of the constant increase in the penetration rates for mobile subscribers, as well as the higher level of ARPU seen during that year, compared to 2011, which was affected by a financial crisis in the country. Again, the constant expansion of the market has been attributed to the intensification of mobile data traffic, which operators have reported to contribute more and more to total revenues every year.

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49 Source: Annual Reports 2009-2012 from ENTEL, América Móvil, and Telefónica
The evolution of the number of fixed telephone lines in Chile is depicted in Figure 3.6. It is clear that it has always remained at the same levels in the past 10 years, with penetration rates around 20%. Moreover, the total amount of connections started to decrease since 2010, with an estimation of around 3.2 million at the end of 2012. That number is equivalent to a penetration rate of 18.8%.

This circumstance can be justified by the fact that it was historically complicated to deploy the pertinent infrastructure to offer fixed telephony services in many remote areas of the country, making the number of lines available remain at low levels in comparison to more developed countries.

Eventually, the explosion of mobile telephony also contributed for this sector to remain underdeveloped, along with the appearance of new technologies like IP telephony that are now offered by the operators. In this manner the amount of fixed telephone lines in Chile is expected to continue its decreasing tendency.

Figure 3.5. Revenues for Mobile Operators in Chile

Source: Annual Reports 2009-2012 from ENTEL, América Móvil, and Telefónica

NOTE: The calculations for ARPU and Revenues were made using data from annual reports from Entel, Claro and Movistar, since the new operators have not presented any financial statements yet. Also, the financial data presented was transformed from Chilean Pesos in the case of the first two operators mentioned, and from Euros in the case of the latter, using the website www.oanda.com.
The market segment of fixed internet has experienced a steady tendency to grow, reaching almost 2.2 million connections and a penetration rate of 12.6% by the end of 2012, as it can be observed in Figure 3.7. However, the expansion of mobile broadband has been more significant, having outnumbered the amount of fixed internet subscriptions since 2011. It must be said that these services are delivered through broadband technologies like DSL and Cable Modem, with dial-up connections being basically extinct now. This business promises to keep expanding, as several providers now offer triple play packs (fixed telephony + pay TV + fixed broadband).

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52 Source: Subsecretaría de Telecomunicaciones Chile - www.subtel.gob.cl
3.2. Mobile Operators and Market Shares

The Chilean mobile market is one of the first to start operations in Latin America, dating back to 1989. The operators present in the market from the start have evolved along the way, leading to several changes in the share holdings of some of them, including mergers and acquisitions. In this manner, there currently exist three private actors that may be classified as incumbent. They are Empresa Nacional de Telecomunicaciones de Chile S.A. (usually referred to as ENTEL Chile), Telefónica Chile (with the brand name Movistar), and Claro (currently owned by América Móvil).

It can be observed in Figure 3.8. that the three incumbent operators are currently dominating the market, with Movistar and ENTEL in a leading position with similar market shares, while Claro holds almost one quarter of mobile subscriptions, leaving them in a fairly good place as well. Nevertheless, in an interesting turn of events, the regulator decided it would be positive to encourage competition in the market by introducing new actors. Thus, concession licenses were awarded to two new operators, Nextel and VTR Móvil during 2009. Additionally, licenses for Mobile Virtual Network Operators (MVNOs) have been granted in 2011. As a reminder, "market shares" refer to the total number of end user subscriptions to the services of each mobile operator.

![Operators in Chile - Market Shares](image)

**Figure 3.8. Market Shares for Mobile Operators in Chile**

While the figure clearly shows that the incumbent operators are still dominating, it will be interesting to see how the new ones evolve, as they have

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53 Source: Subsecretaría Nacional de Telecomunicaciones Chile - www.subtel.gob.cl
54 Source: Subsecretaría de Telecomunicaciones Chile - www.subtel.gob.cl
not yet been around long enough. Up until now, this market has been qualified as a fairly competitive one, having scored an average of little under 3,400 in their Herfindahl-Hirschman rating\textsuperscript{55} recently. Some more detailed facts about each operator are provided in Appendix C.

3.3. Regulatory Body Structure

The official regulator authority in Chile is called Subsecretaría de Telecomunicaciones (Telecommunications Sub-Secretary), often referred to as SUBTEL. It is their duty to create and issue different policies in order to maintain a regime of free competition in the telecom market of the country, while encouraging the constant development of it. They are also in charge of awarding concession licenses for the delivery of telecommunications services and for the use of spectrum. Finally, they are in charge of monitoring the operations of telecom operators, to make sure they comply with national regulations and laws, as well as with the conditions of their licenses.

Even though SUBTEL works as the regulator authority, they are still under the jurisdiction of Ministerio de Transportes y Telecomunicaciones (Ministry of Transport and Telecommunications), because all of the so-called Sub-secretaries in Chile are considered branches of the Ministries in charge of their sector. In this manner, it could be said that SUBTEL does not operate as a completely free entity, and that it may still be subject to political influences coming from the Executive power in the country for some of its decisions.

Additionally, there is another organism in charge of controlling monopoly-like situations in all business sectors. It is called Tribunal de Defensa de la Libre Competencia, or TDLC (Tribunal for the Defense of Free Competition). In the telecom segment, it has mainly influenced decisions over some of the regulations regarding the prices for different services.

Finally, it is important to mention that SUBTEL has proposed to create a new Superintendence of Telecommunications, which is supposed to assume the duties of monitoring the performance of service providers and controlling their operations. They argue that the market has expanded to levels that make it difficult for only one entity to handle all the responsibilities they are currently taking. However, the creation of this new organism has not been approved yet\textsuperscript{56}.

\textsuperscript{55} Source: Wireless Intelligence - www.wirelessintelligence.com
\textsuperscript{56} www.mediatelecom.com.mx - “Chile creará Superintendencia de Telecomunicaciones”
3.4. Concession Licenses and Spectrum Allocations

As one of the first countries in Latin America to adopt mobile telephony, Chile granted their first concession licenses to offer these services in 1989, for operations in the 800 MHz band and for an unlimited period of time. There were two licenses awarded for operations in the entire country, and a state of duopoly dominated for some years. Those licenses currently belong to operators Movistar (Telefónica Chile) and Claro (América Móvil).

Towards 1997, the regulator saw the need to encourage competition in the market. A total of three licenses to operate in the 1900 MHz band were granted in a public auction, with two of them being taken by ENTEL and the third one by a company called Telex Chile (currently, Claro). Later on, in 1999, ENTEL sold one of their licenses to former Bell South (now a part of Telefónica Chile).

The regulator saw the need to give new actors the opportunity to enter the mobile broadband market in 2009, given the increasing demand of end users. They were also aiming to encourage more competition in the sector. Thus, they launched a public auction to assign a concession license to provide 3G services. The proposals to be picked as the new licensees would be the ones that provided the largest coverage area, both rural and urban, in the shortest time possible. Also, the economic offer of each operator was considered.

Since this auction attempted to bring new actors into the market, incumbent operators Claro, Movistar, and ENTEL were banned to participate by the establishment of spectrum caps of 60 MHz each. In this sense, Nextel and VTR Móvil bid for three portions of 30 MHz (2x15 MHz) spectrum in the 1700/2100 MHz (AWS) band.

The result was that Nextel won the bid for two of the three bands in question, being allocated a total of 60 MHz with a total investment of US $ 14.7 million. On the other hand VTR Móvil was awarded one 30 MHz band, having invested US $ 3.02 million. Both operators committed to deploy their...

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57 Moguillansky, G. "Telecomunicaciones en Chile y el Comportamiento de la Inversión". August 1998.
59 www.subtel.gob.cl, "MTT abre concurso para incrementar competencia en telefonía móvil 3G”
60 Note: SUBTEL publishes financial units in terms of “Unidad de Fomento (U.F.)”, used by the Chilean Gov't for their transactions. The sums paid in spectrum auctions have been converted to U.S. dollars by the author of the present document, using the conversion rates stated by the Central Bank of Chile for the days they took place.
networks within one year after the spectrum auction, which took place in September 8th, 2009\textsuperscript{61}.

A new spectrum auction was carried out in July 2012. It involved three spectrum portions of 40 MHz (2x20MHz) in the 2.6 GHz band, defined as Bands "A", "B", and "C", and destined for the provision of 4G services. Like in the previous auction, operators were given a period of 12 months to deploy their networks in the country. Additionally, in this case they were required to provide coverage for a list of 543 small rural communities located in very remote areas of Chile that had no internet connectivity, being given 2 years to complete that implementation. They also made the compromise to offer roaming agreements for the entry of MVNOs in the market\textsuperscript{62}.

The process saw only the three incumbent operators participate in the bid. There was a bidding process for each band, with the highest offer being declared the winner in each case. Claro invested US $ 2.9 million for their Band A license, while ENTEL invested US $ 8.8 million for Band B, and Movistar invested US $ 503.2 thousand for Band C\textsuperscript{63}.

Regarding this last auction, it may be said that the 40 MHz allocated to each of the three incumbent actors could be a bit excessive. Although the process was open to all the operators, it was known that the new operators, VTR Móvil and Nextel were probably not going to participate given their recent investments to launch their 3G networks, as they had just started their services in 2012. Perhaps it would have been better to allocate 2.6 GHz spectrum in smaller portions, making room for future participation of the new actors in this band.

Additionally, the policies adopted to guarantee roaming agreements with MVNOs and to provide network coverage in remote communities have established a turning point in spectrum allocation processes in the country. The first one has been positive for the market. As it was noted in section 3.2, the entry of MVNOs in the market has provoked high expectations, and has been successful so far, especially for the case of Virgin Mobile. For the second one, it is still hard to tell whether it will have a good impact or not, as the operators were given two years to implement infrastructure in the remote areas in question; less than one year has passed since the auction, and so far 4G coverage is only available in certain urban areas, under test conditions.

\textsuperscript{61} www.subtel.gob.cl. "Finaliza con éxito concurso que permite entrada de Nextel y VTR a mercado móvil"

\textsuperscript{62} www.subtel.gob.ec "Subtel lanza concurso para servicios 4G impulsando mayor cobertura y competencia en banda ancha móvil"

\textsuperscript{63} www.subtel.gob.cl. "Licitación 4G: se definen frecuencias para Entel, Movistar y Claro"
It can be observed that, even though concession licenses have been awarded mainly through spectrum auctions, the regulator always considered important for the coverage areas offered by the bidders in their technical proposals to be large enough. Moreover, big efforts are taking place in order to enable a bigger part of the population to access broadband services, resulting in the encouragement made to operators to deploy base stations in remote areas that historically have not enjoyed connectivity. This is why in the latest auctions the focus has been to reach compromises from operators, rather than to raise high amounts of money from their bids.

The amount of spectrum allocated to operators in Chile in the past few years places them in a privileged position in the Latin American region, even reaching the levels of some more developed countries. A summary of the current spectrum allocations per operator is shown in Table 3.1. It is important to mention that the regulator has announced an auction in the near future for the 700 MHz digital dividend band. It will be interesting to see how spectrum is distributed once the regulator makes it available for mobile services.

<table>
<thead>
<tr>
<th>Operator</th>
<th>800 MHz</th>
<th>1900 MHz</th>
<th>1700/2100 MHz</th>
<th>2.6 GHz</th>
<th>Total (MHz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Movistar (Telefónica)</td>
<td>25</td>
<td>30</td>
<td>0</td>
<td>40</td>
<td>95</td>
</tr>
<tr>
<td>ENTEL</td>
<td>60</td>
<td>0</td>
<td>40</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Claro (Amér. Móvil)</td>
<td>25</td>
<td>30</td>
<td>0</td>
<td>40</td>
<td>95</td>
</tr>
<tr>
<td>Nextel</td>
<td>0</td>
<td>60</td>
<td>0</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>VTR Móvil</td>
<td>0</td>
<td>30</td>
<td>0</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td><strong>Total (MHz)</strong></td>
<td><strong>50</strong></td>
<td><strong>120</strong></td>
<td><strong>90</strong></td>
<td><strong>120</strong></td>
<td><strong>380</strong></td>
</tr>
</tbody>
</table>

Table 3.1. Spectrum Allocations per Band and per Operator in Chile

Some additional information regarding the policies established for the use of spectrum and for the operation of mobile services in Chile is provided in Appendix D.
4. Telecom Market in Sweden

In this chapter, the situation in the Swedish telecom market is described. A similar approach to the previous two chapters is taken in order to present the information relevant to the scope of this research project. The purpose is to contrast the scenario of the Swedish telecom market with the findings already obtained from the two Latin American ones presented previously.

Moreover, since it is known that the development of the mobile segment in this country is at high levels compared to the rest of the world in general, it will be useful to look at the approaches their operators have taken in the deployment of their networks to accommodate mobile broadband services. This will help establish which practices may be replicated by the actors in Ecuador, and which may not, in order to boost the development of their own market.

4.1. Relevant Statistics

Sweden is one of the leading countries in the world in many aspects, and the mobile telephony sector is not the exception. This is reflected in Figure 4.1, where it is observed that a high penetration rate was already reached by 2003, covering almost all the population in the country.

Since the market was already almost saturated by then, the growth in mobile subscriptions during the past decade has been sustained, but not so drastic, reaching a penetration rate of 143% in mid-2012, with a total of 13.7 million subscribers.

![Penetration of Mobile Services in Sweden](image)

*Figure 4.1. Number of Mobile Subscriptions in Sweden*

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64 Sources: Svenska Post och Telestyrelsen - www.pts.se; Statistiska Centralbyrån - www.scb.se
The continuous growth of the mobile market in this country came with an interesting evolution in the way subscriptions were distributed. As the market became saturated, with the amount of connections surpassing 100% of the population, it can be seen in Figure 4.2 that between the years 2005 and 2006 the number of postpaid subscribers started to dominate the market, relegating prepaid ones.

In this sense, whereas in 2003 the proportion of prepaid-to-postpaid subscriptions was of 58% to 42%, the tendency was inverted, posing a distribution of 32% to 68% by 2012. A total of almost 4.5 million prepaid and 9.2 million postpaid subscriptions were counted.

This phenomenon is justified by the fact that mobile operators looked for strategies to keep their customers. They started offering bundled services at convenient prices, supported by the launch of smartphones, which were subsided if purchased with a contract and by the introduction of mobile broadband that added value to the offerings in contract subscriptions.

Besides, it may be said that given the level of income in Sweden, reflected in an estimated GDP per capita of US $ 41,700 for 2012, a higher percentage of the population is able to afford the cost of this type of service on a regular basis, unlike what was observed for developing countries in the previous chapters.

![Prepaid vs. Postpaid Subscriptions in Sweden](source)

**Figure 4.2.** Comparison of prepaid and postpaid subscriptions in Sweden

The success of mobile broadband technologies in Sweden is deemed obvious in Figure 4.3. Considerable growth is observed since 2006, when barely 92,000

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65 Source: CIA Fact Book - www.cia.gov
66 Source: Svenska Post och Telestyrelsen - www.pts.se
subscriptions were registered, until a penetration rate of 65% was reached in mid-2012, with around 6.2 million connections in total. By that time, mobile broadband represented almost 66% of internet accesses in the country. Moreover, the regulator reported a major increase in the number of mobile subscriptions that included voice and broadband services in the past couple of years.

![Mobile Broadband in Sweden](image)

**Figure 4.3.** Penetration of Mobile Broadband Subscriptions in Sweden

As it can be deducted from Figure 4.4, the levels of ARPU have had a fluctuating behavior around the same number. This shows that even given the challenges operators have faced since the introduction of mobile broadband, especially the fact that voice revenues started to decrease, they were able to create pricing strategies that effectively capitalized on the highly increasing consumption of data on mobile devices.

In this context, ARPU increased in 2010 and 2011, reaching a peak of US $ 25.86, remaining at a fairly high level compared to the historical figures observed since 2003, at US $ 24.25. These figures are fairly high, compared to other regions of the world.

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67 Source: Svenska Post och Telestyrelsen - www.pts.se
About the revenues generated by operators, Figure 4.5 shows that they had a tendency to increase in 2010 and 2011. The performance of the market was the best seen since 2003, reaching revenues of over US $4 billion in 2011, with a growth rate of almost 20% with respect to the previous year. This represented a recovery from the poor performance of 2009, which may be associated to the low ARPU presented during that year.

Several factors contribute to the growth of the mobile market in Sweden lately. As mentioned before, mobile broadband remains a very attractive service to end users. The revenues from this type of service represented a higher percentage of the total, given that each customer was generating more traffic and that the amount of subscribers kept increasing. Additionally, the expansion of contract-based subscriptions and smartphone sales may be related as positive influences for the market.

68 Source: Svenska Post och Telestyrelsen - www.pts.se
69 NOTE: The financial data in this chapter was converted from SEK to US Dollars using the average exchange rates published by Sveriges Riskbank for the proper dates related to each case.
Fixed telephony has seen important changes in the past decade, as seen in Figure 4.6. It is important to note that the amount of circuit-switched telephone lines has reduced from around 5.5 million to 2.8 million since 2003. This sort of technology has been highly impacted by the introduction of packet-switched networks and fixed phone lines supported through IP telephony, which increased from 38,000 to 1.4 million in the same period of time.

Altogether, the number of fixed telephone lines installed in Sweden has experienced a constant decrease, standing at 45.22% at the end of the first half of 2012. It is clear that new technologies and the constant expansion of mobile

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**Figure 4.5. Revenues for Mobile Operators in Sweden**

**Figure 4.6. Number of Fixed Telephone Lines in Sweden**

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70 Source: Svenska Post och Telestyrelsen - www.pts.se
71 Source: Svenska Post och Telestyrelsen - www.pts.se
telephony has affected this segment of the telecommunications market in terms of total subscriptions.

The evolution of fixed internet services is depicted in Figure 4.7. It can be observed that they were experiencing an expanding trend until the year 2007. However, with the introduction of mobile broadband in the market and its positive evolution, fixed subscriptions have decreased ever since, to remain at a penetration rate of 34.2%, with almost 3.3 million connections in total.

![Fixed Internet Services in Sweden](image)

**Figure 4.7. Penetration of Fixed Internet in Sweden**

The disadvantage of fixed internet services in front of mobile broadband has taken place in spite of the wide range of services proposed by operators in this segment. Solutions like DSL, Cable Modem, and fiber optics and some others are offered as broadband technologies. Additionally, bundled services are available, including internet, TV, and fixed telephony. On the other hand, dial-up connections represented a significant share of the market before, while now are almost extinct, dropping to 200,000 connections only.

It is worth mentioning that, overall, the penetration rate of internet access in Sweden was at 99% of the population by the end of the first half of 2012, having almost reached 9.5 million subscriptions between fixed and mobile services, with an increasing trend compared to preceding years.

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72 Source: Svenska Post och Telestyrelsen - www.pts.se
4.2. Mobile Operators and Market Shares

The mobile market in Sweden began operations in 1992, with three operators launching GSM services. They have kept a pioneering position in the world, with the launch of the first LTE commercial network in the world in 2009. It is currently composed of four network operators that have entered the market at different stages. Their names are Telia, Tele2, Telenor, and Hi3G. They are all part of companies present in other countries around Europe and Asia. The distribution of market shares they held by mid-2012 are presented in Figure 4.8. Additionally, a significant number of MVNOs run operations through agreements to use capacity from the networks of the main MNOs. As a reminder, "market shares" refer to the total number of end user subscriptions to the services of each mobile operator.

![Operators in Sweden - Market Shares](image)

It can be seen that Telia dominates the market, closely followed by Tele2. These operators are considered incumbent actors, as they were among the first three operators to start services in 1992. Although the proportion of market shares held by each operator has remained almost at the same levels in the past few years, Hi3G has managed to increase their market shares and double them since 2007. This has seen the quotas of the other operators decrease. Given the distribution presented, the mobile market in Sweden has been rated at scores of a bit over 3,000 in the Herfindahl-Hirschman Index in recent evaluations, which reflects a market with good levels of competition. Some relevant facts about mobile operators in Sweden are presented in Appendix E.

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74 TeliaSonera Annual Report 2012
75 Source: Svenska Post- och Telestyrelsen - www.pts.se
76 PTS First Half 2012 Report
77 www.wirelessintelligence.com
4.3. Regulatory Body Structure

The legal structure for telecommunications in Sweden is quite simple. There is only one entity that acts as the regulatory authority. It is named Svenska Post- och Telestyrelsen (Swedish Post and Telecom Authority, or PTS).

For a long time, the regulatory responsibilities were a part of former public telecom company, Televerket, which had a frequency-management section, and a National Telecommunications Council. When the liberalization of the telecom market in Sweden began to take place, major modifications were made. Televerket disappeared and a new agency was created in 1992, under the name of National Telecommunications Board. It was a merger of the mentioned regulatory entities. Later on, in 1994, it changed its name to its current one\(^{78}\).

PTS is now responsible, according to its website, of "the electronic communications and postal services in Sweden. The term 'electronic communications' includes telephony, the Internet and radio". Also, it is mentioned that the main focus of their work is to ensure that the interests of the consumers are preserved and protected, to maintain fair competition in the market, to promote secure communications, and to maximize the use of limited resources (i.e., spectrum)\(^{79}\).

In this manner, PTS is in charge of awarding licenses both for the use of spectrum and for the delivery of telecommunications services, as well as issuing regulations and monitoring the operations of the actors in the market. It acts as a completely independent public agency, meaning that the Swedish Government has no influence on its decisions and actions.

4.4. Concession Licenses and Spectrum Allocations

In 2008, an auction was carried in order to allocate 190 MHz of spectrum in the 2.6 GHz band, destined by operators for the deployment of their LTE networks. The portions at stake were divided in 14 blocks of 10 MHz (2x5 MHz) FDD spectrum and 1 block of 50 MHz TDD spectrum, and the duration of the licenses is of 15 years. In the end, the regulator raised SEK 2.1 billion (approx. US $ 350.5 million). Additionally, operators were required to pay an administrative fee of SEK 25,000 per MHz\(^{80}\).

A summary of the allocations and the amounts of money invested by the bidders is presented in Table 4.1. It is important to mention at this point that the license acquired by Intel was later purchased by Operator Hi3G\(^{81}\). It is also

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\(^{78}\) Bohlin, E. "Assessment of spectrum management options: Evaluation of selected Swedish spectrum management cases". June 2008

\(^{79}\) http://www.pts.se/en-GB/About-PTS/Operations/

\(^{80}\) www.pts.se - "The PTS spectrum auction in the 2.6 GHz band has been concluded - total amount SEK 2.1 billions". May 2008.

\(^{81}\) www.4Gtrends.com - "3 could make Sweden first country to have dual-mode LTE services"
relevant to say that the licenses awarded in this band to Telenor and Tele2 were transferred to their joint venture, Net4Mobility in July 2012\(^\text{82}\).

<table>
<thead>
<tr>
<th>Bidder</th>
<th>Bandwidth Allocated 2.6 GHz Band</th>
<th>Auction Investment (US $)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Telia</td>
<td>40 MHz</td>
<td>93,900,000</td>
</tr>
<tr>
<td>Tele2</td>
<td>40 MHz</td>
<td>91,500,000</td>
</tr>
<tr>
<td>Telenor</td>
<td>40 MHz</td>
<td>89,000,000</td>
</tr>
<tr>
<td>HI3G</td>
<td>20 MHz</td>
<td>49,500,000</td>
</tr>
<tr>
<td>Intel</td>
<td>50 MHz (TDD)</td>
<td>26,600,000</td>
</tr>
</tbody>
</table>

Table 4.1. Spectrum Allocation in the 2.6 GHz Band after 2008 Auction\(^\text{83}\)

The 900 MHz had been used by operators Tele2, Telenor and Telia to provide GSM services for several years. They were due to apply for the renewal of their licenses, since their expiration date was on December 2010. Along with this process, HI3G requested the allocation of spectrum in this band. In this manner, the operators sent a joint proposal to the regulator in November 2008\(^\text{84}\).

After a long process, this band ended up being refarmed. Spectrum was distributed in a different way than before, to allow the participation of HI3G and to extend the amount of bandwidth allocated to operators to 70 MHz (2x35MHz). The new allocation only became effective in February 2011, given some legal issues faced by the regulator\(^\text{85}\).

Additionally, licenses were declared "technology neutral", meaning that broadband technologies, and not only GSM can now operate in the 900 MHz band. Their validity will expire in 2025. The current distribution is reflected in Table 4.2\(^\text{86}\).

<table>
<thead>
<tr>
<th>Operator</th>
<th>Bandwidth Allocated 900 MHz Band</th>
</tr>
</thead>
<tbody>
<tr>
<td>HI3G</td>
<td>10 MHz</td>
</tr>
<tr>
<td>Tele2(^\text{87})</td>
<td>25 MHz</td>
</tr>
<tr>
<td>Telenor</td>
<td>15 MHz</td>
</tr>
<tr>
<td>Telia</td>
<td>20 MHz</td>
</tr>
</tbody>
</table>

Table 4.2. Spectrum Allocation in the 900 MHz Band after License Renewals

A new spectrum auction was conducted in March 2011 to allocate six portions of 2x5 MHz in the 800 MHz digital dividend band, for operators to enhance their LTE networks. Bidders were able to access a maximum of 20 MHz (2x10MHz) during the process. The idea behind this was to allow at least three actors to hold spectrum licenses in this band, in order to keep competition in the

\(^{82}\) http://www.telenor.com/investor-relations/company-facts/spectrum-holdings/
\(^{83}\) www.pts.se - "The PTS spectrum auction in the 2.6 GHz band has been concluded - total amount SEK 2.1 billions". May 2008.
\(^{84}\) Markendahl, J. & Mölleryd, B. "Valuation of Spectrum for Mobile Broadband Services - Engineering Value versus Willingness to Pay". 2011.
\(^{85}\) GSMA - "900 MHz band refarming case study - Sweden". November 2011
\(^{86}\) GSMA - "900 MHz band refarming case study - Sweden". November 2011
\(^{87}\) Another operator, Swefour, had a 5 MHz license after the renewals for the 900 MHz. This license now belongs to Tele2.
market. Another condition was for operators to deal with possible interferences with TV signals at their own expense. The term of the licenses expires on December 31st, 2035. The total amount raised by PTS was SEK 2.05 billion (approx. US $ 323.4 million). A summary of the auction results is presented in Table 4.3.

<table>
<thead>
<tr>
<th>Bidder</th>
<th>Bandwidth Allocated 800 MHz Band</th>
<th>Auction Investment (US $)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Telia</td>
<td>20 MHz</td>
<td>134,500,000</td>
</tr>
<tr>
<td>Net4Mobility</td>
<td>20 MHz</td>
<td>73,800,000</td>
</tr>
<tr>
<td>Hi3G</td>
<td>20 MHZ</td>
<td>67,900,000</td>
</tr>
</tbody>
</table>

Table 4.3. Spectrum Allocation in the 800 MHz Band after 2011 Auction

One of the licenses awarded to Net4Mobility, the venture of Telenor and Tele2 was made to comply with the specific requirement of providing mobile broadband coverage in rural areas, for homes and businesses without that service. This rule had been previously established when the conditions for the auction were launched in the end of 2010. They paid an additional SEK 300 million (approx. US $ 47.2 million) during the auction, which was destined to be invested in the mentioned deployment condition.

For the 1800 MHz band, the regulator decided to renew licenses in February 2010. However, their condition was to reduce the amount of spectrum allocated in the previous licenses of the spectrum holders for this band. The idea was to liberate some spectrum for a later auction. There was an appeal to an Administrative Court, but it was rejected and finally dropped in May 2011, thus holding the regulator’s decision. In this manner, spectrum allocated to operators in this band before the 2011 auction totaled 35 MHz, and it was distributed as follows:

- Telia was left with 20 MHz (2x10 MHz), having held 46 MHz (2x23 MHz) before.
- Tele2 held 30 MHz (2x15 MHz), instead of their previous 48 MHz (2x24 MHz). It is worth mentioning that this operator had acquired an extra license from a former small actor, which left them with more spectrum.
- Telenor had their spectrum portion reduced from 36.8 MHz (2x18.4 MHz) to only 20 MHz (2x10 MHz).

The new spectrum auction for the 1800 MHz band took place in October 2011. A portion of 70 MHz (2x35 MHz) was assigned, divided in seven blocks of 2x5 MHz. Also, a band of 2x5 MHz was left license exempt, leaving it open for alternative applications or new actors. On the other hand, no spectrum caps were applied, allowing both operators already holding spectrum in this band and new bidders to participate. The way the auction was planned guaranteed

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88 www.pts.se - "PTS's invitation to auction of the 800 MHz band"
89 Source: www.pts.se - "Licenses in the 800 MHz band"
90 www.pts.se - "PTS's invitation to auction of the 800 MHz band"
91 Markendahl, J. & Mölleryd, B. "Valuation of Spectrum for Mobile Broadband Services - Engineering Value versus Willingness to Pay". 2011
that finally the total spectrum allocated to each of the winners would be in
consecutive bands. The licenses were set to have a duration of 25 years,
effective from January 1st, 2013\(^{92}\).

In the end, the participants in this auction were Telia, Hi3G and Net4Mobility,
representing the joint venture of Tele2 and Telenor. The result was that Telia
was awarded 2x25 MHz of spectrum, while Net4Mobility obtained 2x10 MHz
and Hi3G was unsuccessful during the bidding. The total amount of money
raised by PTS was SEK 1,349,999 (Approx. US $ 202.8 million). A summary
of the total spectrum allocation in the 1800 MHz band is depicted in Table 4.4,
including the portions assigned previous to and during the auction\(^{93}\).

\begin{table}[h]
\centering
\begin{tabular}{|c|c|c|}
\hline
Bidder & Bandwidth allocated & Auction Investment (US $) \\
\hline
Telia & 70 MHz & 138,200,000 \\
Net4Mobility & 70 MHz & 64,600,000 \\
\hline
\end{tabular}
\caption{Spectrum Allocation in the 1800 MHz Band after 2011 Auction}
\end{table}

Finally, it is necessary to mention that operators hold spectrum in the 2100
MHz band. The joint venture between Telia and Tele2 - Svenska UMTS-nät AB
(SUNAB), operator Hi3G, and operator Telenor have been awarded one 40
MHz (2x20 MHz) license each\(^{94}\). Their validity will expire in 2025 and they
were declared as "technology neutral" in April 2011\(^{95}\).

They were granted through a beauty contest held back in 2000 when the
regulator wanted to promote the introduction of UMTS services in the market,
along with the introduction of new actors. The outcome was controversial,
including the exclusion of Telia, the revocation of a license to French operator
Orange, and big delays in network deployments that led the licensees not to
meet the deadlines for their coverage requirements\(^{96}\).

After making an overview of the events that led to the current situation for
spectrum licensing in Sweden, it is helpful to summarize where it lead, by
presenting the allocations for each band and each operator in Table 4.5.

\begin{table}[h]
\centering
\begin{tabular}{|c|c|c|c|c|c|c|}
\hline
Operator & 800 MHz & 900 MHz & 1800 MHz & 2100 MHz & 2.6 GHz & Total (MHz) \\
\hline
Telia & 20 & 20 & 70 & 0 & 40 & 150 \\
Tele2 & 0 & 25 & 0 & 0 & 0 & 25 \\
Telenor & 0 & 15 & 0 & 40 & 0 & 55 \\
Hi3G & 20 & 10 & 0 & 40 & 70 (50 TDD) & 140 \\
SUNAB (Tele2 + Telia) & 0 & 0 & 0 & 40 & 0 & 40 \\
Net4Mobility (Tele2 + Telenor) & 20 & 0 & 70 & 0 & 80 & 170 \\
3GIS & 0 & 0 & 0 & 0 & 0 & 0 \\
\hline
\end{tabular}
\caption{Spectrum Allocation for each Band and Operator}
\end{table}

\(^{92}\) www.pts.se - "PTS invites interested parties to the spectrum auction for the 1800 MHZ band"
\(^{93}\) www.pts.se - "Licenses in the 1800 MHZ band"
\(^{94}\) GSMA - "900 MHz band refarming case study". November 2011
\(^{96}\) Bohlin, E. "Assessment of spectrum management options: Evaluation of selected Swedish spectrum
management cases". June 2008
Some additional information regarding the policies established for the use of spectrum and for the operation of mobile services in Sweden is provided in Appendix F.

<table>
<thead>
<tr>
<th>Total (MHz)</th>
<th>60</th>
<th>70</th>
<th>140</th>
<th>120</th>
<th>190</th>
<th>580</th>
</tr>
</thead>
</table>

**Table 4.5.** Spectrum Allocations per Band and per Operator in Sweden
5. Telecom Market Comparative Analysis

The current situation of the telecommunications markets in the three countries that are part of this research has now been described. Following the proposed research methodology, this is the point where a comparative analysis must take place, in order to document the similarities and differences found, aiming to identify the weaknesses of least developed markets and attempting to propose some guidelines for them to improve their level of development and performance. The comparison is carried out including the statistics that characterize the situation of the markets, complemented by the regulatory environment that influences their actors.

5.1. Penetration of Services and Market Performance

To begin this comparative analysis, the first statistical information to be analyzed is the amount of mobile subscriptions observed in each country and the penetration rates reached in the different markets. This provides a notion of the way they have evolved along the years. Figure 5.1. summarizes the way mobile subscriptions are distributed in each case, differentiating prepaid and postpaid ones. It also shows the GDP per capita per country, as it has an impact on the way subscriptions are distributed.

![Comparison Mobile Subscriptions](image1)

![Comparison GDP per Capita](image2)

**Figure 5.1.** Comparison of Mobile Subscriptions and GDP per Capita
It can be deducted from the figure that all these markets have exceeded 100% penetration rates, which at first glance may give a sense of maturity in every case. However, in the Latin American cases, there is a hidden under development. Unlike Sweden, not all the population is able to access mobile telephony services, while some subscribers actually own more than one mobile device. This is due to the ever existing inequalities in wealth distribution, where the power of acquisition for higher classes is significantly larger than for lower ones.

Moreover, given this situation and the levels of GDP per capita, end customers are very "price sensitive". In this manner, there is a predominance of prepaid subscriptions, again, differing from the case of Sweden. This poses a challenge for operators in Ecuador and Chile, which must try to reach a bigger percentage of the total population and also create strategies to retain the customers they already have, trying to encourage them to switch from prepaid to contract based subscriptions. This can turn out very tricky, as they must be sure to offer prices that are attractive while avoiding to compromise the profitability of their business.

For the penetration rate of mobile broadband subscriptions, again it can be observed in Figure 5.2 that there are significant differences. In the case of Sweden, it is quite high, with Chile at a medium level and Ecuador still quite behind them. However, as seen in previous chapters, the explosion of mobile broadband is a fact that applies to all three countries. The amount of data traffic crossing mobile networks has an expanding tendency and the number of subscriptions that include this service follow that trend, as reported by operators. Moreover, one thing the three markets have in common is that the number of mobile broadband connections have already surpassed the amount of fixed broadband lines.

![Comparison of Mobile Broadband Subscriptions](image)

**Figure 5.2.** Comparison of Mobile Broadband Subscriptions
The situation of mobile broadband presents a great opportunity for mobile operators in Latin America. However, operators in Ecuador still face challenges related to regulatory measures. The amount of spectrum allocated to them is still low compared to the other countries, as it will be discussed in the next section. The way spectrum has been handled in the country up until now poses a limitation for the development of the market, especially in terms of capacity. On the other hand, Sweden has more and more subscriptions that include both voice and broadband services given the quality of them, supported by good capacity in their networks. Chile has already followed that line, with their regulator promoting the allocation of more spectrum to operators.

The next topic for discussion is the volume of sales observed in the three markets. Figure 5.3 shows that, as expected, the level of income of the population of each country affects the ARPU for mobile services, which in the end affects the total revenues perceived by the mobile industry. Nevertheless, given the significantly higher amount of subscribers in Chile, the size of their market's income is almost comparable to Sweden. Again, Ecuador represents a smaller market, given its low ARPU and the number of subscribers it has, that stands between the figures observed for Sweden and Chile.

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**Figure 5.3.** Comparison of ARPU and Total Revenues for Mobile Operators
One important fact to mention here is that for all three countries, operators have reported bigger contributions of mobile broadband to their total revenues every year. This underscores the importance of these services in the future, as well as the necessity to provide them to as many customers as possible, with the highest possible quality. Another fact is that the challenge of overcoming potential revenue gaps due to the increasing data traffic and the complexity of charging customers properly, along with reduced benefits from voice services, is true for all the markets. Sweden, being a more developed market has been more impacted by this phenomenon than Chile and Ecuador, but operators there now have started to see this challenge and will very likely see more of its impact as the demand for mobile broadband is clearly increasing.

In the case of Ecuador, it is necessary to improve competition in the market in order to help increase its volume and development. As shown in Chapter 2, there is basically a duopoly with a very weak third competitor that belongs to the State. Actions should be taken in order to promote the entry of more private operators, like it was done in Sweden more than 10 years ago, and in Chile more recently. For instance, in the latter case, total annual revenues increased by 25% during 2012, the year that the 2 new MNOs and a couple MVNOs launched their services.

Regarding the penetration of fixed telephone lines, it can be said that Ecuador and Chile hold relatively similar levels, which are low when compared to Sweden. This can be noticed in Figure 5.4. In the first two cases, the amount of lines always stayed relatively low, especially in rural areas where it was complicated to deploy network infrastructure to support them. Once mobile telephony and new technologies came along, their necessity has been somewhat less crucial, thus remaining at low densities. On the other hand, Sweden had been able to cover a higher segment of the population with fixed telephony only to begin a decreasing trend in the past 10 years, for the same reasons mentioned above.

Actually, it is necessary to mention that despite its low penetration rate altogether, fixed telephony does have a fairly good level of lines available in urban areas in Ecuador and the Government still tries to promote new deployments in rural sectors, being this the only market of the three to show an increasing number of fixed telephones as the years went by. It will be interesting to see for how long this tendency will survive.
Finally, the penetration rates for fixed internet services are compared. Figure 5.5 confirms once again that Ecuador is still in low stages of development in their telecommunications segment when compared to the other two countries. An interesting observation from Chapter 4 is that in Sweden the expansion of fixed broadband stopped after 2007, right when mobile broadband started its explosion. This was backed up by the deployment of high speed networks supporting technologies like HSPA, which was of course impossible in Latin America, as operators there launched those kind of networks later.

On the other hand, the current Governments of Chile and Ecuador have National Broadband Plans that promote the expansion of fixed services in urban and especially in rural areas, which has been complemented by higher supply of them from providers and has seen significant expansions in the amount of connections available in the recent past. However, as mentioned before, mobile broadband subscriptions now outnumber fixed ones.
Overall, it can be concluded that the markets in Latin America, even for the case of Chile that possesses one of the highest developed ones, still lag behind the levels of penetration and quality offered in Europe, from where Sweden has been taken as an example. On the other hand, there are clear indicators that there are growing demands for new technologies and better connectivity, yielding great opportunities for mobile operators to offer new services and reduce the gap that has been sustained with respect to more developed countries. However, some regulatory issues may still be a barrier, like it will be evidenced in the next section.

5.2. Spectrum Allocation and Regulatory Environment

After the comparison of the three markets studied that was made in the previous section, it is clear that Ecuador is in disadvantage compared with its peers in terms of development. The structure of the regulatory authorities in the country and the approach of some of their policies may have had an impact in this outcome. For example, spectrum allocation to mobile operators is very limited compared to the other countries, as it can be seen in Figure 5.6.

![Comparison Spectrum Allocation](image)

Figure 5.6. Spectrum Allocation in Different Countries

The previous figure is a reflection of the restrictive nature of the decisions made by the Ecuadorian regulator. As stated by many researchers in this area, the liberalization of spectrum is a driver for the improvement of mobile communications, and with it, the overall development of a country, since it has proven to be directly related to the growth in GDP per capita\(^7\).

Moreover, given the obvious expansion of mobile broadband and the introduction of new technologies that have enhanced the rates for mobile data transmissions, it is imperative for the regulator to follow the steps of its peers in Chile and Sweden by allocating more spectrum in new bands other than the currently used 850 and 1900 MHz. In those countries, it has been observed that the access to mobile broadband has reached levels higher than in Ecuador, given the ability of operators to provide more capacity in their networks.

In this sense, it is important to mention the approaches taken by the regulator authorities in Chile and Sweden to allocate spectrum in the most possible fair manner to their operators, while attempting to guarantee benefits for the population and the interests of their countries.

In the first case, it may be said that beauty contests with very moderate financial bids were conducted, while attempting to get a commitment from the operators to carry their deployments according to certain criteria that suited the objectives of coverage proposed by the regulator. In the second case, spectrum auctions took place, allowing the regulator to properly charge operators for spectrum use while giving them enough freedom to use it efficiently and provide their services. A common fact for both countries is that they have managed to introduce new operators successfully, which is also positive for their markets, as it boosts competition.

The lines of action described above should be considered in the future by the regulator in Ecuador, as their license concession processes have been rather different. First, the country lost many benefits when the two private operators were introduced in the market, as they paid very small fees for their licenses and basically no major commitments were required from them. This situation changed completely when they renewed their licenses, being requested to pay very high amounts of money compared to the operators in other countries and with restrictions like price caps and spectrum caps. This may be a dangerous scenario, since it can potentially compromise the future of the mobile market in the country. Moreover, the Ecuadorian regulator has not found a clear approach to allocate spectrum to operators. Looking at the way they have managed this task in the past, it can be deducted that neither spectrum auctions nor beauty contests ever took place to award past concession licenses.

Another concern about the regulatory environment of Ecuador is that it may be regarded as having certain levels of political influences. Since the regulator now reports directly to the Ministry of Telecommunications, there may be a threat to have a conflict between what is best for the development of the market and what best suits the interests of the National Government.

For instance, a high amount of spectrum has been allocated for free to the State owned operator for the deployment of LTE services, in what seems to be an attempt to increase their competitive power and become a stronger force in the market, to try to break the existing duopoly of the private operators. However, this decision is somewhat harmful, as it compromises the successful entry of new technologies in the country, as it only depends on the action of one operator that has not been requested to meet any coverage goals, deadlines, or anything of the sort. Additionally, this should not be the means to boost competition in the market. The regulator should find a way to encourage the entry of new operators instead, following the example of Chile and Sweden in this aspect as well.
In the matter of integrating rural areas, it was noticed that both Chile and Sweden adopted policies in their concession licenses to make operators commit to deploy networks to offer services in remote areas with limited connectivity, whereas Ecuador has relied more on raising money from a percentage of operator revenues in order to fund projects developed by their national entity FODETEL. Although this agency has succeeded to connect certain areas in the past few years, especially since 2007, it is clear that the levels of development in the other countries are higher, which brings up the suggestion that maybe in upcoming licensing processes the regulator in Ecuador could enforce more commitment from operators to help FODETEL bring connectivity in remote places with their own deployments.

To summarize, the Ecuadorian market could be highly benefited by the acceleration of the process to carry an auction to allocate more spectrum for operators in more bands (e.g. 1700/2100 MHz, 2.6 GHz, 700 MHz) and to introduce new actors to the market. Also, it would be positive if the regulator operates with more freedom, away from the political influence of the Central Government. Finally, they should consider more participation of mobile operators in the implementation of networks to bring more connectivity for rural areas.

For the case of Chile, it could be observed that in spite of having a certain level of influence of the Executive Power, the regulator has managed to operate more independently and carry an approach more focused towards the improvement of the market. The effort to introduce what may be considered as a big amount of new operators (to now have a total of 5 MNOs) is still to be proven correct, as the size of the market may not support such a high number of suppliers of mobile services.

Sweden, on the other hand, is often considered to have a pioneer regulator authority. Perhaps one of the highlights of the recent decisions made was the introduction of service and technology free licenses, which allows operators to have more flexibility in the deployment of their networks. Latin American regulators and operators could benefit from taking into consideration the recommendations and guidelines proposed by PTS.
6. Alternative Mobile Broadband Deployment Strategies in Ecuador

The information and analysis conducted in the previous chapters has led to draw several conclusions and insights on the current situation of the mobile telecommunications market in Ecuador. One of the most relevant findings was that the spectrum allocated to mobile operators in the country is considerably low in comparison with other parts of the world. This causes a shortage of capacity in their networks, as they see more and more data traffic all the time, due to the increasing demand for mobile broadband services.

From a technical point of view, several approaches can be made in order to increase capacity in a wireless network. This includes improving spectral efficiency through the development of better technologies, the increase of bandwidth through the use of higher amounts of spectrum, or the implementation of more base stations. However, several challenges are nowadays identified with this task, including the limitations in spectrum allocation, the high costs of deploying base stations, and all the implications of developing and introducing new technologies in the market.

In this context, several alternative network deployment strategies have been proposed in previous research. This chapter aims to assess the possibility of applying them in the conditions set by the Ecuadorian market. The information drawn from previous chapters is used as a tool for the analysis. The options considered are network sharing, the use of secondary spectrum in TV white spaces, and offloading of traffic to local networks.

6.1. Network Sharing

The concept of network sharing implies that two or perhaps more operators split the costs of deploying their networks and divide ownership of the assets involved. Two main different approaches can take place, as explained in the following lines.

- **Passive Sharing**: It refers to sharing only the costs related to network infrastructure, but not capacity. This includes antenna towers, masts, wires, and other elements related to the build out of base station sites. This approach can be highly beneficial, as it has been proven that construction costs can represent a rather high fraction of total network deployment investments.\(^9^8\)

- **Active Sharing**: In this case, operators share active network equipment. Thus, they can split the costs of buying and implementing it, and they can even benefit from the aggregation of the spectrum each of them has been allocated in order to increase capacity.

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Of course, there could be the case where operators decide to cooperate both in construction of base station sites and in the implementation of their actual wireless networks.

The implementation of network sharing in Ecuador has started being encouraged by the regulator at least in the form of passive sharing, as they have issued the rules and guidelines operators should follow if they are to use this strategy. However, this document explicitly mentions that capacity sharing is not allowed. A few scenarios to encourage this sort of strategy are presented next.

It was seen in chapter 2 that Conecel and Otecel have around 2100 and 1300 sites respectively, while CNT Móvil has only 600 of them. On the other hand, the first two operators hold only a total of 35 MHz (2x17.5 MHz) each, while the third has now access to 110 MHz (2x55 MHz), which is excessive for an operator that has only 2% of market shares.

If active sharing was permitted, the situation described above could provide a good opportunity, since it remains unclear when the two private operators will be allocated more spectrum. An agreement could be reached, for Conecel and Otecel to share their network sites with CNT Móvil, with the latter sharing their spectrum with them. In this way, all the actors could benefit from an increased capacity in their networks while guaranteeing cost savings in new implementations.

Nevertheless, the significant gaps between the market shares of each operator could pose an obstacle in their willingness to cooperate with each other. Moreover, it is known that Conecel was declared a Significant Market Power and now rents part of their sites to the other operators. This represents a challenge to network sharing in the sense that the bigger actor may not see the necessity to collaborate with others, since it is already benefitting from the current rental agreements.

A second scenario could take place if Otecel and CNT Móvil partner up to equal the site density that Conecel has already achieved by committing to a passive sharing agreement. This would give both operators the opportunity to become more competitive by gaining some customers if they succeed in increasing the quality of their services, due to better coverage and capacity in their networks. Additionally, this may be a promising option for Otecel, especially if they are not allocated more spectrum in the near future. On the downside, still the gap in market shares they have with CNT Móvil could keep them from considering this possibility.

Another alternative for network sharing could be available if a new private operator entered the market. For instance, a new actor could partner up for passive sharing with CNT Móvil, which currently has the lowest density of sites, or even with Otecel. The case of Conecel getting involved with a newcomer is more complicated, as they probably will not want to jeopardize their leading position in the market.
In this context, both Conecel and Otecel could be interested in active sharing with a new operator if they do not obtain more spectrum soon enough and the traffic in their networks starts to saturate them. The new actor would benefit from cost savings in their own infrastructure while the incumbents would solve their capacity issues. Meanwhile, for CNT Móvil, cooperating with a newcomer would be beneficial only if they wanted to save costs while improving their site density, so passive sharing would be a good option.

One issue that may arise for the feasibility of network sharing in the presented scenarios is that, being a State-owned operator, CNT Móvil has access to a large budget for network investments, and might not be interested in lowering costs, but in ownership of their assets. By adding this fact to the dominant position of Conecel in the market, it can be concluded that perhaps the actor that could be more interested in network sharing strategies is Otecel. As a private operator, they must be more limited than CNT Móvil in their budget, while they can benefit from improving their capacity and coverage to become more competitive with Conecel, as mentioned earlier.

Basically, after looking at the different possible scenarios proposed for network sharing, it is clear that the current situation of the Ecuadorian market poses many difficulties, given the number of operators present, the distribution of their market shares, and the current regulations. In order for this strategy to be feasible, the allocation of spectrum for 4G services to Conecel and Otecel must take place, as it would introduce the necessity of significant network deployments.

Additionally, the sharing of network capacity should be permitted by the regulator, in order to give the opportunity to implement active sharing. The introduction of one or more new actors would provide great opportunities to implement this strategy in the country as well.

The case of Sweden in this matter has shown that sharing costs and resources can pose great opportunities for operators to save money in their network deployments that later contributed to their good financial shape. It also helped to overcome limitations in the situations of operators at one point or the other, like when Telia was not able to acquire 3G spectrum and formed an alliance with Tele2 to deploy a common network, for instance. This did not only aid operators individually. It also helped preserve competition in the market by allowing all the actors to have fairly equal conditions when implementing their networks for new services.

In this manner, it can be deducted that it is in the best interest of the regulator and operators in Ecuador to follow what was done in Sweden and consider network sharing for future network deployments, as increased competition is most likely to drive higher development in the market while the scenarios proposed can improve the opportunities of each operator to improve their business performance, given the reasons exposed in this section.
As another motivation, it must be noted that the regulator in Chile already noticed the benefits of this strategy and is now promoting passive sharing in their market. Several antenna tower companies started their business in the recent past, supplying mobile operators with infrastructure that they can share, yielding a more cost-efficient solution now that they are in the process of deploying their 4G networks.

6.2. Availability of Spectrum in TV Bands

Two bands have been used for the delivery of Pay TV services in Ecuador. The first band comprises frequencies in the range of 686-806 MHz, with a total of 20 channels available. It has been referred to as "Coded UHF". The second one includes frequencies between 2500 and 2686 MHz, with 31 channels available. It is used for Microwave Multipoint Distribution Service (MMDS). Currently, the mentioned bands have different levels of occupation in each province in the country, according to the number of Pay TV operators that deliver these services. Moreover, it was proven that these two bands are being underutilized, given that these operators are just a few. Table 6.1 shows the number of channels occupied in each province, along with the channels that could be utilized for mobile services in both bands.

<table>
<thead>
<tr>
<th>Province</th>
<th>686-806 MHz Band</th>
<th>2500-2686 MHz Band</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Channels Used</td>
<td>Channels Available</td>
</tr>
<tr>
<td>Pichincha</td>
<td>20</td>
<td>0</td>
</tr>
<tr>
<td>Guayas</td>
<td>20</td>
<td>0</td>
</tr>
<tr>
<td>Esmeraldas</td>
<td>-</td>
<td>20</td>
</tr>
<tr>
<td>Manabi</td>
<td>20</td>
<td>0</td>
</tr>
<tr>
<td>Los Ríos</td>
<td>-</td>
<td>20</td>
</tr>
<tr>
<td>Santa Elena</td>
<td>-</td>
<td>20</td>
</tr>
<tr>
<td>El Oro</td>
<td>-</td>
<td>20</td>
</tr>
<tr>
<td>Carchi</td>
<td>-</td>
<td>20</td>
</tr>
<tr>
<td>Imbabura</td>
<td>-</td>
<td>20</td>
</tr>
<tr>
<td>Santo Domingo</td>
<td>20</td>
<td>0</td>
</tr>
<tr>
<td>Cotopaxi</td>
<td>-</td>
<td>20</td>
</tr>
<tr>
<td>Tungurahua</td>
<td>20</td>
<td>0</td>
</tr>
<tr>
<td>Chimborazo</td>
<td>-</td>
<td>20</td>
</tr>
<tr>
<td>Bolívar</td>
<td>-</td>
<td>20</td>
</tr>
<tr>
<td>Cañar</td>
<td>-</td>
<td>20</td>
</tr>
<tr>
<td>Azuay</td>
<td>-</td>
<td>20</td>
</tr>
<tr>
<td>Loja</td>
<td>20</td>
<td>0</td>
</tr>
<tr>
<td>Sucumbíos</td>
<td>-</td>
<td>20</td>
</tr>
<tr>
<td>Pastaza</td>
<td>-</td>
<td>20</td>
</tr>
</tbody>
</table>

Saransig, F. "Elaboración del Plan de Liberación de la banda 686-806 MHz para su Incorporación a la Televisión Abierta, para la Superintendencia de Telecomunicaciones". August 2010.
From the previous table, it can be concluded that the utilization of spectrum for Pay TV services has saturated the two bands in question only in the provinces with major cities. Pichincha, Guayas and Manabí present complete saturation given that Quito, Guayaquil, and Manta are located there. There are a few other smaller parts of the country were one of the two bands is saturated, but the other remains with its channels free.

However, for a good portion of locations, both bands are completely clean, and could be exploited for other services at their fullest. It is also worth mentioning that Pay TV is usually a service available in urban areas, so in many cases, even for the provinces where all the channels are used, it is limited to the boundaries of the cities. The underutilization mentioned before becomes obvious.

In this context, in July 2012, the regulator decided to establish some frequency re-farming for these services. Hence, all Pay TV operators utilizing the 686-806 MHz and the 2500-2686 MHz bands will have to terminate their services once their concession licenses expire and apply for new ones to obtain spectrum in a new band. Both bands were declared exclusive for mobile services. However, the mentioned licenses have expiration dates due even in 2016 in some cases. This means that the process of fully liberating spectrum in these bands will still take a while.

Looking at this situation, it can be said that the regulator has taken the right decision to destine the two bands historically used for Pay TV services for mobile communications services instead. Although they have already allocated 30 MHz (2x15 MHz) of spectrum in the 700 MHz band to CNT Móvil for the deployment of their LTE network for rural areas, they should try to speed up the process of assigning similar resources to the other operators. Of course, the spectrum in this band should be first used for rural area network deployment, and then operators could take full advantage of it for urban locations as well, after the licenses held by Pay TV operators expire in 2016.

In this way, the path taken by Sweden could be followed, where operators were assigned spectrum in the 800 MHz band that was previously used for TV

<table>
<thead>
<tr>
<th>Province</th>
<th>Band 1</th>
<th>Band 2</th>
<th>Band 3</th>
<th>Band 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Napo</td>
<td>-</td>
<td>20</td>
<td>-</td>
<td>31</td>
</tr>
<tr>
<td>Orellana</td>
<td>-</td>
<td>20</td>
<td>-</td>
<td>31</td>
</tr>
<tr>
<td>Morona</td>
<td>-</td>
<td>20</td>
<td>-</td>
<td>31</td>
</tr>
<tr>
<td>Santiago</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zamora</td>
<td>-</td>
<td>20</td>
<td>-</td>
<td>31</td>
</tr>
<tr>
<td>Chinchipe</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Galápagos</td>
<td>-</td>
<td>20</td>
<td>31</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 6.1. Utilization of Spectrum for Pay TV services in Ecuador

100 The data belongs to 2010. The study referenced to obtain this data showed that there were no major changes in the number of Pay TV operators and channels they use in the recent past. This makes the numbers present valid for this research work.

services. That allocation helped the deployment of mobile broadband in rural areas be more cost-effective for operators, since at lower frequencies wave propagation is more favorable, thus providing better coverage and the need to deploy less base stations than at higher frequencies.

Additionally, a positive decision taken by the Ecuadorian regulator, CONATEL, was that of adopting the APT plan for the 700 MHz band, as it has been also embraced by other countries in the region, including Chile. This will help to promote the harmonization of services in Latin America. Some of the advantages will be the ease to have roaming for mobile services in the continent, and the fact that since there will be a big enough market utilizing the same frequencies for LTE services, the costs of mobile devices can be reduced given the fact that there will be a mass production of them to meet the customer demands. On the downside, efforts will have to be made in order not to have interferences among mobile operators of different countries near the borderlines between them.

After analyzing the status of the bands used for Pay TV services, and the potential they may have for allocation of spectrum for mobile operators, it is also necessary to look into the use of spectrum for public TV broadcasting. The UHF band used for this application in Ecuador comprises frequencies between 500 and 686 MHz, for a total of 31 channels of 6 MHz each. Different channel groups are used in each province, in order to avoid interferences. This leaves less channels available in each geographical area, with a total of 15 or 16 channels depending on the case\(^{102}\). Table 6.2 shows the status of this band.

<table>
<thead>
<tr>
<th>Province</th>
<th>500-686 MHz Band</th>
<th>Channels Used</th>
<th>Channels Available</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pichincha</td>
<td>16</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Guayas</td>
<td>16</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Esmeraldas</td>
<td>13</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Manabí</td>
<td>15</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Los Ríos</td>
<td>13</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Sta. Elena</td>
<td>11</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>El Oro</td>
<td>11</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Carchi</td>
<td>11</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Imbabura</td>
<td>8</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Sto. Domingo</td>
<td>9</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Cotopaxi</td>
<td>5</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Tungurahua</td>
<td>10</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Chimborazo</td>
<td>10</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Bolívar</td>
<td>3</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Cañar</td>
<td>11</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Azuay</td>
<td>11</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Loja</td>
<td>9</td>
<td>6</td>
<td></td>
</tr>
</tbody>
</table>

\(^{102}\) Saransig, F. "Elaboración del Plan de Liberación de la banda 686-806 MHz para su Incorporación a la Televisión Abierta, para la Superintendencia de Telecomunicaciones". August 2010.
Table 6.2. Utilization of Spectrum for TV Broadcasting in the UHF band in Ecuador

<table>
<thead>
<tr>
<th>Province</th>
<th>Channels</th>
<th>Users</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sucumbíos</td>
<td>4</td>
<td>11</td>
</tr>
<tr>
<td>Pastaza</td>
<td>4</td>
<td>11</td>
</tr>
<tr>
<td>Napo</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>Orellana</td>
<td>2</td>
<td>13</td>
</tr>
<tr>
<td>Morona Santiago</td>
<td>9</td>
<td>6</td>
</tr>
<tr>
<td>Zamora Chinchipe</td>
<td>4</td>
<td>11</td>
</tr>
<tr>
<td>Galápagos</td>
<td>16</td>
<td>0</td>
</tr>
</tbody>
</table>

It can be observed from the table that in the main provinces of Pichincha and Guayas, as well as in Galápagos, the band is fully saturated already. However, in smaller provinces, some more than others, there is spectrum that could become available for secondary use that could benefit mobile services. Even in cases where 2 channels are available, 12 MHz can already be utilized, which can be very useful for mobile operators. Moreover, significant amounts of secondary spectrum can be exploited in certain provinces. However, these are places with smaller demands for bandwidth from end users, and the benefit might not be quite significant.

Either way, given the data presented, it is clear that there is spectrum that is not being fully exploited in the UHF band, thus opening the opportunity for mobile operators to make secondary use of it to increase the capacity in their networks and accommodate the increasing data traffic demands of their end users, while coping with the spectrum scarcity they still suffer. The next section further analyzes the implications to adopt this deployment strategy in Ecuador.

6.3. Secondary Use of Spectrum - TV White Spaces

The use of secondary spectrum implies that some channels in the bands destined for TV broadcasting are not used, either at certain geographical locations, during certain time periods, or they are just free altogether. These bands are usually referred to as "TV White Spaces". Technologies like cognitive radio are applied in order to detect when those channels are available for mobile broadband services and provide operators the opportunity to add capacity to their networks without using the primary spectrum they have been allocated. Additionally, they aim to minimize the interference with primary television services and transmissions from different mobile users using these bands simultaneously.

In a previous study\footnote{Markendahl, J. & Mölleryd, B. "On Network Deployment Strategies for Mobile Broadband Services Taking into Account Amount of Spectrum and Fixed Line Penetration - Comparison of Network Deployment in Europe and India". February, 2011.}, the price paid for spectrum in India was considered rather high, resulting in a rate of approximately 5 €/MHz/Pop\footnote{The data belongs to 2010. The numbers presented are a good reflection of the level of saturation this band should have in the present.} for an average of
around 15 MHz. It was shown that for this level of spectrum cost, the use of TV White Spaces could reduce the total cost of network deployment, compared to using primary LTE spectrum alone. The total investments for network deployment included the costs for spectrum licenses, site construction, and the acquisition of active network equipment. More specifically, two scenarios for cost savings were presented.

The first scenario considered the total investments as a function of the amount of bandwidth used in the deployment. As it escalates, the high price paid for spectrum is a determinant factor that increases the overall costs if primary spectrum is used, in spite of the decreasing number of base stations needed. On the other hand, if secondary spectrum in TV white spaces is used, the same bandwidths can be achieved while ensuring a low investment for the whole implementation. The savings linked to the need of less base stations are straightforward in this case. The results apply both to incumbent and new ("greenfield") operators.

The same conditions are set for a second scenario, but in this case the total network deployment costs are compared while increasing the user demand to transmit data traffic, measured in Mbps/Km². The results show once again that for high spectrum prices, it results cheaper both for incumbent and greenfield operators to make use of TV white spaces for their implementations. Of course, prices increase proportionally to user demands.

The renewal of concession licenses for private operators in Ecuador saw them pay considerable amounts of money to the Government. The average rate results in 2.10 €/MHz/Pop for 17.5 MHz. These figures are not identical, but remain in the same order of magnitude of India, making it possible to apply the findings of the mentioned study to a certain level. Thus, it can be deducted that in the case of Ecuador, the secondary use of TV white space spectrum could help private operators have more cost efficient deployments. In the event of the entry into the market of new operators, this strategy could also benefit them.

Another driver to use secondary spectrum for mobile broadband deployment in Ecuador is the case that the allocation of spectrum to operators remains low. It has become clear from previous sections and chapters that especially the private mobile operators working in the country are suffering from a shortage of spectrum. Moreover, even though the regulator has determined that several new bands must be destined for mobile communications as a primary service, it is also true that they do not appear to have a clear strategy or plan to assign spectrum in those bands in the near future, although they are in the middle of studying this option.

Additionally, the previous section showed that there are some TV white spaces available for mobile operators to make secondary use of them, especially in

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105 The unit €/MHz/Pop represents the amount of money paid by an operator for the spectrum it was allocated, divided by the total number of Megahertz, and divided by the number of inhabitants of the country. The figures presented are an average of the individual allocations made to operators.
areas outside the main cities of the country. In this manner, this strategy may rise as a solution to provide better coverage and capacity in rural areas and in small cities where the demand from end users is high enough to require this sort of implementation.

However, this alternative strategy may have some barriers to enter this market. From chapter 2, it could be deducted that end users are very price sensitive, given the economic situation and the level of income in the country. It is very likely that devices equipped both with mobile broadband and cognitive radio technologies will be offered at high prices at least right after the latter come into the global market. And, of course, it will take a while before their prices go down and they become affordable for a majority of end users in Ecuador. Thus, even though operators may offer more capacity through the use of secondary spectrum in their networks, this is not beneficial if their customers are not able to afford mobile devices that support cognitive radio technologies.

Another challenge for secondary use of spectrum in Ecuador is the fact that the current Government is involved in many conflicts with the private media, including TV broadcasters. This has led to many controversies and to the proposition of a new Bill for media communications that, among other things, involves the nature of their licenses to use spectrum. It was sent in 2011 to the National Parliament, and it has not yet been approved. This provides uncertainty regarding what the regulations might be concerning the use of spectrum in this band in the next few years. More importantly, the introduction of new regulations to encourage the use of TV White Spaces can be delayed for a long period of time, leaving operators without this possibility in the near future.

Contrary to private operators, CNT Móvil would have no benefit from using TV White Spaces as a resource of spectrum and an enabler for cost savings in their network implementation for LTE, since they did not pay for the primary spectrum allocated to them to provide services with this technology. Moreover, the 70 MHz (2x35 MHz) they now hold are quite enough for their current demand. They will have to increase their subscriber base considerably in order to actually experience capacity shortages that could encourage them to use secondary spectrum.

The scenario to implement mobile networks making secondary use of spectrum is completely different in Ecuador than it is in Chile or Sweden, mainly because as seen in previous chapters, the investments made by operators to acquire spectrum in those countries were not as significant as the costs incurred by operators in Ecuador. Therefore, the total price for network deployment is not so strongly impacted by spectrum license fees and the cost-effectiveness of this strategy becomes less beneficial compared to using the primary licensed
spectrum available. Actually, in Sweden this strategy is not seen as necessary, given the high amounts of spectrum operators hold nowadays\textsuperscript{106}.

Moreover, in the case of Chile, where the average price paid for spectrum was rated at 0.014 €/MHz/Pop in the last couple of allocation processes carried, using a strategy to encourage secondary use of spectrum could mean higher costs than using licensed spectrum, since the cost of deploying a network with new cognitive radio technologies would impact the total investments. Nevertheless, it could be seen as an alternative for the new Chilean operators than came recently in the market, in case they are not allocated spectrum in the lower bands soon enough, since they complained they were granted resources only in higher bands that are related to the need for more base stations and higher deployment costs.

To summarize, this strategy can be a cost efficient solution for network deployment in the case of private operators in Ecuador. It could be used especially in rural areas and small cities where spectrum in TV bands is available for secondary use, to cope with capacity shortages may arise. However, the problem lies in when it will become a suitable option both from a marketing and sales perspective, regarding the prices of mobile devices, as well as from a regulatory point of view. This, in contrast to Chile and Sweden, where it is very likely not to be a suitable alternative, at least for now.

6.4. Offloading of Traffic to Local Networks

The concept behind this network deployment strategy is that the macro cell network relies on smaller cells that provide coverage and increased capacity in limited areas that demand higher data rates. For instance, this sort of base station can be installed inside an office building where many users need to access the mobile network, but the attenuation of the signals caused by the walls provides poor coverage and slow transmission rates.

Some of the options for this type of deployment include the offloading to femtocells, where licensed spectrum is used, and the offloading to Wi-Fi networks, in unlicensed bands. An important requirement is that some type of fixed connection is present, in order to provide connectivity from the small cells to the rest of the network.

If operators wanted to adopt this kind of solution for Ecuador, they could apply it mainly in urban areas of big cities like Quito or Guayaquil, given that the higher demands for mobile broadband are known to come from there. On the other hand, while it is true that the country suffers from low levels of fixed telephone lines and internet connections, a high percentage of the existing ones is located within those two cities. Additionally, as observed in Chapter 2, the number of fixed internet connections has seen significant growth since 2007. If

\textsuperscript{106} Markendahl, J. & Mölleryd, B. "On Network Deployment Strategies for Mobile Broadband Services Taking into Account Amount of Spectrum and Fixed Line Penetration - Comparison of Network Deployment in Europe and India". February, 2011.
that tendency persists, there is strong support for the idea of implementing offloading to local networks.

If they chose to use femtocells that need licensed spectrum, a good option would be to implement "narrowband femtocells". It is known that femtocells can provide high levels of capacity that are not always necessary if, for instance, 5 MHz of bandwidth are used. Considering this, 1 MHz could be enough to meet capacity demands of a significant number of users within the coverage area, as proven in the calculations made in previous studies. This is valuable for operators in Ecuador, given that, as mentioned all along this document, their spectrum allocations are currently rather low, at least in the cases of Conecel and Otecel.

The offloading of traffic to Wi-Fi networks could also be a suitable solution for urban areas in the main cities. Of course, the problem is that the implemented small cells might be harmed by interference from other networks, but there are no other technical limitations that could be mentioned in this case.

However, as explained in chapter 2, the unlicensed bands where Wi-Fi operates are subject to light licensing when utilized for commercial purposes, including a small registration process and a monthly fee of US $ 20 per link. The cost is significantly low, but given this constraint, operators should be sure of getting enough users in the places where they install these types of networks.

At this point, it is important to compare Wi-Fi small cells to femtocells that use licensed spectrum. It can be pointed out that the first may be proven as an easier solution, given the fact that Wi-Fi is a widely spread technology that may offer lower costs of deployment while providing significant amounts of spectrum. On the contrary, active equipment for femtocells could pose cost challenges but with the advantage of having a heterogeneous network that is totally controlled by the operator. This may translate in a more reliable solution with better performance in terms of higher capacity levels and less interference affecting data transmissions.

Moreover, as mentioned before, even a limited amount of spectrum would be enough to cover the level of end user demands in the Ecuadorian market through the deployment of femtocells. Therefore, it would be up to mobile operators to analyze which kind of offloading is more suitable to their needs. They must look into the tradeoff between a cheaper solution that provides ease of deployment and another that provides a higher quality service to their customers.

Of course, a rather effective solution to this problem, considering spectrum shortage, would be for operators to deploy femtocells in critical areas, where

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they know their customers will be more demanding and will really pay for the added value of high capacity. For instance, they could be implemented in office buildings for the use of Executives. For other parts of the cities, where the demands are smaller, capacity may be increased with Wi-Fi small cells.

The situation for offloading of traffic from macro cells to local networks in Ecuador contrasts with that of Sweden, where given the higher amount of spectrum allocated to operators and the higher availability of fixed lines, there is more flexibility to deploy femtocells without worrying so much about the quantity of bandwidth that may be consumed by them or by the feasibility to connect small cells to the network backbone. However, given the mentioned spectrum availability, operators in Sweden have not yet had the need to resort to offloading strategies. But as the number of mobile broadband connections continues to dramatically expand, as seen in Chapter 4, it would not be a surprise to see the necessity for this sort of implementation in the near future.

The case of Chile can be considered as a kind of mix between the other two countries. Whereas offloading of traffic may be restrained to urban areas, like in Ecuador, the fact that operators have been allocated rather good amounts of spectrum lately may delay the necessity to turn to this strategy. It is, nevertheless, more likely that the new actors will consider it as a solution if they see themselves with capacity shortages or other barriers given the fact that they have not yet been allocated spectrum in lower bands. Additionally, as LTE is just being introduced in the country, the necessity for offloading of traffic will depend on the levels of demand from customers for mobile broadband.

Looking at the analysis done in the two previous sections, it can be deducted that, for Ecuador, this strategy is the one that may face less regulatory barriers and delays, making it a good candidate for deployment in the near future from a legal point of view. The drawback is that it is constrained to urban areas where fixed lines are available. Also, it has been suggested that a hybrid solution between Wi-Fi small cells and femtocells may be used, according to the levels of demands of different kinds of customers and the places where they are more likely to go to.
7. Conclusions and Future Work

7.1. Conclusions

The present research project allowed to look into the characteristics of three mobile telecommunications markets with very different levels of development. From the situation observed in each case, it could be deducted that the way they have evolved has been affected by numerous factors. One of the most important is the way the national regulators are structured. In a market like Sweden, where PTS has complete freedom to operate far from political influences, they have been able to allocate significant amounts of spectrum while boosting competition, introducing new actors, and encouraging the implementation of new technologies ahead of the rest of the world. In Ecuador and Chile, more influence from their Governments has led to some decisions that did not always favor improvements in the market.

Another important factor is the correlation with the economic situation in each country, reflected in this document by the levels of income of the population through their GDP per capita. It was observed that Ecuador and Chile have stayed historically at low levels as far as fixed telephone lines are concerned, unlike Sweden, where GDP per capita is one of the highest in the world. Moreover, although high levels of penetration rates for mobile telephony exist for the Latin American countries presented, it is also true that not all the population can afford to access them. Instead, a small portion of the population possesses more than one mobile device. This is a reflection of unequal wealth distribution, to some extent.

On the other hand, one similarity that is worth to be mentioned is the explosion of mobile broadband in different regions of the world. For the case of the three countries, it could be confirmed that the demand for these services is becoming bigger, as the data traffic flowing through mobile networks has increased along with the expansion in the number of this type of subscribers. This observation only confirms the finding of a lot of previous research conducted by other authors.

Looking more closely into the Ecuadorian market, it is noted that since the last Government took office in 2007, the national regulator has become more influenced by it than it previously was, being now under the umbrella of the Ministry of Telecommunications. It is necessary for this agency to try and boost competition in the market, as it has proven to be key in for its development, as observed in Chile and Sweden.

CONATEL should try to preserve competition in the market and attempt to introduce new actors in it, as a clear state of duopoly is present, and the fact that it has assigned a significant amount of spectrum to CNT Móvil does not necessarily guarantee any modifications. Instead, it threatens with jeopardizing the correct entry of LTE in the country, by leaving it up to one actor to take full responsibility for it. In this sense, it is imperative that 4G spectrum is allocated to the private operators as soon as possible.
In the matter of the proposed alternative mobile broadband deployment strategies, it has once again been confirmed that the different situation of each country affects the feasibility of their implementation. Whereas in Sweden network sharing was a success, in Ecuador it is still doubtful to have the same result, given the structure of the market, the number of operators, and their uneven market powers. Also, there are regulatory constraints that make it difficult to adopt that strategy. Different scenarios have been proposed to implement this strategy, where it was observed that the operators with less market shares or potential new operators could be more interested to use it.

Another important finding was that more spectrum will become available, as the regulator has declared two bands previously used for Pay TV services will be re-farmed for mobile services. However, the constraint is that Pay TV operators will be allowed to use their licenses until they expire, which will deem the bands totally free by 2016 only. Besides, the regulator still does not have a clear picture of how to allocate spectrum to mobile operators within these new portions of spectrum.

The secondary use of spectrum in TV white spaces in Ecuador can see potential from the cost-efficiency point of view, given the high prices seen in the concession licenses of 2008. Nevertheless, the regulatory environment poses uncertainty regarding when a well structured legal framework could be ready, in order to adopt this strategy. Also, the potential price of mobile devices supporting cognitive radio could constrain the market opportunities for this strategy, given the highly price-sensitive nature of end users.

Additionally, the fact that spectrum in TV bands has more availability outside major cities for its potential exploitation to deliver mobile services was presented. In this sense, it was observed that this would be a good option mainly in parts of smaller cities where the demands for mobile broadband are big enough. The case of more rural areas could also be considered, as there is even more spectrum available for secondary use there.

On the other hand, offloading of traffic to local networks seems to be the easiest strategy to adopt in the near future, especially in urban areas where the density of fixed lines available may be enough to support the connection of femtocells or Wi-Fi networks to the infrastructure of mobile operators. It is suggested in this document that a hybrid solution between Wi-Fi small cells and femtocells may be used, to cope with the variety of demands from customers within the covered areas.
7.2. Future Work

The research done here must be complemented by similar type of work focused for other countries in different regions of the world, but also within Latin America. It would be interesting to see how much the conditions observed in Chile and Ecuador match those of their neighbors, in order to find the real feasibility of offering large scale solutions to cope with the increasing demand of mobile broadband in that part of the planet. If that happens to be the case, it would be easier to introduce the proposed deployment strategies in the region, since the technologies that support them, like cognitive radio or femtocells, could be offered to operators at better costs. In this way, better quality networks could be deployed at affordable prices both for market actors and for end users.

The work presented here had the purpose of presenting at a higher level the implications of considering different mobile broadband deployment strategies that could be used by mobile operators in Ecuador, but more efforts could be made in further research to look in more detail into the implementation of the proposed solutions. For instance, complete analyses of the costs saved by operators by using network sharing in the different proposed scenarios could be made. A detailed quantitative comparison between the use of femtocells with licensed spectrum and Wi-Fi small cells would also be relevant, in the sense that it could provide an idea of the real costs involved in these implementations, as well as the potential revenues they may provide. Moreover, a technical comparison could be conducted between these two option, in order to determine how much better performance the first one can provide, according to the levels of data traffic demands seen in the country.
8. References


Appendix A - Facts about Mobile Operators in Ecuador

Operator Conecel

Conecel is the operator to first deliver mobile telephony services in Ecuador, back in 1993. Thanks to their right choices on technology for their network deployment and to massive marketing campaigns, they have been able to develop a very large customer base and remain at the top of the market with an average of near 70% shares for a very long time. They have run a very good business, with revenues increasing every year and even surpassing the amount of US $ 1.5 billion in 2012.

This operator currently operates 2G and 3G services. Their 2G services are delivered through GSM/GPRS/EDGE technology in the band of 850 MHz, for which they have installed 1972 base stations, and in the band of 1900 MHz, with 1296 base stations installed since 2007. For 3G services, they started deploying an UMTS network in 2008. They have upgraded their services to HSPA+ technology since the end of 2011, with a total of 1244 base stations deployed. They run these services in the 850 MHz band. They own a total of 4512 base stations and 2073 civil sites. This vast deployment represents the largest in the country, allowing to provide the best coverage and to deliver capacity for their large customer base, composed of almost 12 million subscribers.

Operator Otecel

Otecel started their operations slightly after Conecel, during the same year. They have remained a big power in the market, with large investments in network deployments and fierce marketing strategies, following the same line of operations their competitor did. Nevertheless, the biggest mistake they made was to bet on CDMA when they started migrating their network to 2G technology. This cost them the loss of a significant amount of subscribers. In 2005, they realized their mistake and started deploying a GSM/GPRS/EDGE network, under the administration of Telefónica. In this manner, they have managed to retain an average of 28% of market shares. Their revenues have increased steadily as the years went by, reaching almost US $ 650 million in 2012.

Their GSM services are now delivered in the band of 850 MHz, for which they have installed 1310 base stations and in the band of 1900 MHz, with 674 base stations installed. For 3G services, they started deploying an UMTS network in 2008. They have upgraded their services to HSPA+ technology since the end of 2011, with a total of 1078 base stations implemented. They run these services on the 850 MHz band. They own a total of 3062 base stations and 1318 civil sites.

Operator CNT Móvil

This operator entered the market in 2003 under the brand name of Alegro. It was run by Telecsa S.A., the mobile subsidiary of state owned telecom company Corporación Nacional de Telecomunicaciones - CNT. A market strategy of low prices per minute of voice call aimed to gain customers as fast as possible. This was good for the market, because the private incumbent operators were forced to reduce their prices to remain competitive. However, the venture never did manage to take off and remained always below 4% of market shares.

Part of the reason for the failure of the company so far is that there were corrupted actions involved in the search for a strategic partner that would provide expertise and capital to start operations. Despite having better offers, particular interests of some of the parties involved in the negotiations resulted in the adoption of CDMA technology for voice services, even though GSM was widely known to be the choice of other operators around the world\textsuperscript{111}.

Another mistake made was the decision to enter the market before the network deployment stage was complete. Moreover, the supply of handsets was not enough for the demand of potential customers the company had when they began to operate. Of course, these facts led them to lose most of their potential customers and to disappoint the ones they managed to gain\textsuperscript{112}.

Nowadays, they own 229 2G CDMA base stations that operate in the 1900 MHz band. But, they ended up having to sign a roaming agreement with Otecel for voice services, which they still maintain. They also offer 3G CDMA-EVDO services.

In 2012, they started the deployment of their HSPA+ network in the 1900 MHz band. They now own 337 base stations with this technology. Also, they own a total of 595 civil sites\textsuperscript{113}.

Finally, they announced they will have an initial investment of US $30 million for the deployment of a new LTE network, due to begin by mid 2013. Initial tests are to be run in the 700 MHz band for rural areas and in the 1900 MHz band in urban areas\textsuperscript{114}.


\textsuperscript{114} CNT invertirá US$ 30mn en despliegue inicial de LTE previsto para mayo-junio". 17 January 2013
Appendix B - Other Regulations for Mobile Telephony Services and Use of Spectrum in Ecuador

The regulation of the telecommunications market in the country has become vital since the current Government took office in 2007. The priority is to promote the development of the country by making sure a larger percentage of the population has access to information and communication technologies (ICTs). This, of course, has set challenges for mobile operators, since they have had to cope with more strict regulations. The use of spectrum for the development of ICTs is especially encouraged for projects conducted by FODETEL in their efforts to grant universal access to broadband internet\textsuperscript{115}.

In spite of the mentioned interest of the Government to improve regulations, spectrum policies for telecommunications services can still be considered vague and weak in many cases. The regulators have focused more on the laws pertaining the use of spectrum for radio and TV broadcasting instead, as a part of a constant battle between the Government and the media. In the following, the main regulations that concern mobile operators are discussed.

Given that the market is practically dominated by a duopoly, the regulator has taken action with several decisions to attempt to boost competition, or even attract new actors. One of the new conditions, valid since 2008 dictated lower tariff caps in the prices of voice call minutes. Those caps are in part responsible for a substantial reduction in the prices of almost 50% since 2007\textsuperscript{116}. Nevertheless, it is considered that operators could still be able to raise the prices again, due to the weak policies in this matter. Table 2.2 presents the current tariff caps, compared to the caps prior to 2008.

<table>
<thead>
<tr>
<th>Operator</th>
<th>Price Cap Prior 2008 (US $)</th>
<th>Price Cap 2013 (US $)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concel</td>
<td>0.50</td>
<td>0.22</td>
</tr>
<tr>
<td>Otecel</td>
<td>0.50</td>
<td>0.22</td>
</tr>
<tr>
<td>CNT</td>
<td>0.49</td>
<td>0.22</td>
</tr>
</tbody>
</table>

Table 2.2. Average Tariff Caps for Prices of Voice Call Minutes

Another condition concerning prices is that, in 2012 the regulator decided to forbid the usual practice of operators to give a certain period of validity to credit tank ups. For instance, if an end user holds a contract subscription and does not fully use their credit for a specific month, it is cumulative and it can still be used in the subsequent month, according to the new regulation\textsuperscript{117}.

There is also an Interconnection Regulation. The operator that requests interconnection needs to cover the expenses associated to the provision of a radio link for the necessary transmission, unless the parts agree to share them. Neutrality in negotiations must be ensured. Interconnection prices are based on the costs incurred by the operators and their criteria for profitability. A negotiation between the parts must exist, in order to establish deadlines for the interconnection to be active, as well as penalties in case the

\textsuperscript{115} Navas, M. "Espectro abierto para el desarrollo - Estudio de caso: Ecuador". September 2011
\textsuperscript{116} Navas, M. "Espectro abierto para el desarrollo - Estudio de caso: Ecuador". September 2011
\textsuperscript{117} Informe SENATEL 2012 (SENATEL Annual Report 2012)
clauses of the contract are not respected. If an agreement is not reached, the regulator can intervene\textsuperscript{118}.

Additionally, in 2009 the regulator made the decision to implement number portability in the market. This measure allows mobile subscribers to keep their phone numbers even if they change their operator. This service is to be provided at free cost. The idea behind it was to encourage churning and to establish a better balance in market shares. Nevertheless, churn rates remained quite low, at an average of 2\% in the following years\textsuperscript{119}. Market shares were barely affected and have remained at the same levels.

Along the years, the Ecuadorian citizens have suffered the effect of criminality in public spaces. It became very common for burglars to steal mobile phones. In an attempt to diminish the amount of robberies, CONATEL decided, as of 2011, that every end user should register the number of their SIM Card and the IMEI code of their mobile terminal, along with their personal information, to their mobile service provider. Operators must be responsible for keeping a data base with that data, so that the users could report and cancel their line in case of being robbed.

On the topic of network sharing, the regulator has created a specific document that defines the guidelines for network infrastructure sharing. It addresses the rights and obligations of the parties involved in this sort of deal, specifying that they are free to mediate the terms of it. The regulator will only intervene in the case of disputes. It is clearly stated that passive site sharing is discussed, excluding active network equipment or capacity from its scope. That type of sharing must be addressed under a different legal framework. Additionally, under request of Otecel and Telecsa (CNT Móvil) in 2010, Conecel was declared as Significant Market Power in the market. The regulator established that this operator was obliged to allow the smaller operators to use their network infrastructure by subscribing contracts to rent part of their sites. Otecel has benefitted from this since 2011\textsuperscript{120}.

As far as 4G spectrum, several bands have been considered to be set for auction. They include bands in the frequencies of 700 MHz, 1700/2100 MHz (AWS band), 1900 MHz, and 2.5-2.6 GHz\textsuperscript{121}. For the 700 MHz band, considered digital dividend spectrum, Ecuador has now adopted the APT (or, A5) plan, which has proven to be the most effective way to use this spectrum and avoid interferences with TV services. Regarding this decision, CONATEL expressed the following: 

"The APT band plan, there is maximum efficiency in spectrum use, flexibility in the definition of the size of spectrum blocks, it avoids band guards for FDD and TDD LTE, allowing for more spectrum to be used for 4G technologies. Also, it is harmonized with the adoptions in the region for this band plan, which enhances international roaming opportunities and opens the market for cheaper, better mobile terminals"\textsuperscript{122}. 

\textsuperscript{118} Carrión, H. "Regulación e Inversión en Telecomunicaciones - Estudio de Caso para Ecuador". October 2007
\textsuperscript{119} Financial Reports for América Móvil and Telefónica 2009-2012
\textsuperscript{120} Telefónica Annual Report 2011
\textsuperscript{121} Navas, M. "Espectro abierto para el desarrollo - Estudio de caso: Ecuador". September 2011
\textsuperscript{122} www.conatel.gob.ec - "CONATEL aprueba regulación que permitirá a Ecuador vertiginoso crecimiento tecnológico"
The use of digital dividend spectrum in the 700 MHz band for mobile broadband services is due to the eventual switch from analog to digital television. In 2011, Ecuador decided to adopt the standard ISDB-Tb for this new technology. The transition should be completed between 2017 and 2021.

Another regulation for the use of spectrum is the fact that public companies are not requested to enter an auction, nor pay for it. They have direct access to it instead. Private operators argue that this distorts the market. In fact, some have considered it controversial that the Government owns a mobile operator at the same time that it manages spectrum policies in the country. This policy has already been reflected when the regulator awarded 70 MHz of 4G spectrum to CNT in 2012.

Concerning unlicensed bands, also defined as Industrial, Scientific and Medical (ISM) applications bands, Ecuador does have a small policy for their commercial use. In order establish radio links in this band, there is a registration process to follow for each link and a monthly fee of 20 dollars must be paid. Only those who already hold a concession license for their services (like ISPs or mobile operators) can register their links in this modality. The reason for this is that the Armed Forces of the country hold control over a certain portion of the 2.3-2.5 GHz band. ISM bands include the 2400-2500 MHz band, the 902-928 band, and the 5725-5875 MHz band. This procedure is often referred to as light licensing\textsuperscript{123}.

The policies regarding the use of white spaces of spectrum are not quite clear, but it can be said that it is not the right of the licensee to determine whether a third party can make secondary use of the portions of spectrum they are entitled to exploit\textsuperscript{124}. Therefore, it can be asserted that if cognitive radio technologies are to be used for mobile broadband, the operator must first discuss this intention with the regulator.

Finally, it is necessary to mention that a new Telecommunications Bill has been proposed by the current Government. It has been the focus of wide controversy and discussion, especially among media broadcasters. One of the main concerns for mobile operators should be the fact that the Ministry of Telecommunications will have more power over regulatory issues. As a matter of fact, it will officially become the representative of Ecuador towards the ITU. The law was proposed by the Executive Power in 2011. However, it has not been approved yet, due to the controversies and some actions of political parties opposite to the Government in the National Assembly, the Legislative Power in the country.

\textsuperscript{123} Navas, M. "Espectro abierto para el desarrollo - Estudio de caso: Ecuador". September 2011
\textsuperscript{124} Afonso, C. "Uso del Espectro en América Latina". June, 2011.
Appendix C - Facts About Mobile Operators in Chile

Operator ENTEL

ENTEL is the main telecommunications company in Chile altogether. It started services as a State-owned firm in 1964 until it was completely privatized in 1992. They have presence both in the fixed and mobile segments, with the latter representing most of its revenues in 2012. They do not only benefit from the provision of services to end users and companies, but have also signed a roaming agreement with MVNO Falabella, which is due to begin operations in 2013.

Currently, they provide mobile services in the 1900 MHz band. They launched their GSM network in 1997, being one of the first in Latin America to do so. The strategy was always to remain as a pioneer in the region, launching the first mobile data GPRS network in 2001, then expanding to 3G services in 2006 and finally launching the first commercial HSPA+ network in 2009. They have improved the latter network to HSPA+ Dual Carrier technology. Their latest investment is destined to deploy their 4G network, after being awarded a concession license in 2012.

Operator Claro

This actor entered the market in 1997 when they were awarded a license to operate in the 1900 MHz band. They went by the name of Smartcom for several years, and were in control of a Spanish company named Endesa. In 2005, América Móvil acquired the firm, which now works as Claro Chile. Besides, after the merger of Telefónica and Bell South, they were able to access one of the 800 MHz licenses they had, as the regulator didn't allow them to keep both.

Their presence in the telecom market of Chile is quite significant. They currently offer services for fixed broadband, fixed telephony, and Pay TV, aside of their mobile business. They compete with their fellow mobile operators, along with others, in those other segments as well.

Claro Chile now offers 2G and 3G services in the 800 MHz and in the 1900 MHz bands. By the end of 2012, they reported they were implementing their 4G LTE network. They actually announced the launch of the services of their network in a test phase for a limited number of users. Their network is estimated to be available for the public after the first 6 months of 2013.

125 ENTEL Chile Annual Report 2011
126 www.elmundo.es. “América Móvil compra el operador chileno Smartcom, filial de telefonía de Endesa”
Operator Movistar

This actor has been in the mobile market of Chile from the very beginning of its existence. It started operations as a company owned by Spanish operator Telefónica and by a group of Chilean investors. Both them and Bell South were awarded licenses to operate in the 800 MHz band. However, towards the end of 2004, Telefónica completed the acquisition of all the businesses of Bell South in Latin América. In Chile, this operation resulted in the fusion of these two companies into the now called Telefónica Móviles de Chile\(^\text{128}\), under the brand name "Movistar".

Since then, Telefónica Chile has consolidated as one of the leaders in the mobile market. They also have presence in the businesses of fixed telephony, fixed broadband, and Pay TV. In this sense, they plan to offer 4-play packs in the near future.

The company currently operates GSM technology for their 2G services in the 800 MHz and the 1900 MHz band. Additionally, they offer 3G services in the same bands since 2007, with their network supporting up to HSPA+ dual carrier technology. After being awarded a 2.6 GHz license in 2012, they have announced that they will start operating their 4G LTE network in September 2013\(^\text{129}\). Additionally, Movistar now has a new line of business, offering roaming agreements to new MVNOs. They have already signed a contract to deliver this service to Virgin Mobile, GTD Móvil (Telsur) and Netline. They all launched operations in 2012.

Operator Nextel

This operator was awarded two bands of spectrum in 2009 to provide 3G services in the 1700/2100 MHz band. They agreed to deploy their network within one year after their concession license became effective. However, they officially launched services in May 2012\(^\text{130}\). Given the strong competition from incumbents, and the fact that other operators, including MVNOs entered the market in the same year, their market share is still quite small. They managed to gain around 111,000 subscribers by the end of their first year as an MNO\(^\text{131}\).

Nextel holds a roaming agreement with ENTEL in order to provide services in the regions of Chile where they cannot offer coverage with their own network\(^\text{132}\). It is important to mention that Nextel was not new to the Chilean telecom market. The company has offered services as a trunking operator since the year 2000, as a subsidiary of Sprint Nextel from the United States.

\(^{128}\) www.prnoticias.com - "Telefónica compra Bell South Chile"
\(^{129}\) www.wayerless.com - "Chile: Telefónica compromete plena operación de su red LTE para Septiembre"
\(^{130}\) www.economiaynegocios.cl - "Nextel lanza servicios de telefonía móvil en Chile"
\(^{131}\) Source: Subsecretaría de Telecomunicaciones Chile - www.subtel.gob.cl
\(^{132}\) ENTEL Annual Report 2012
Operator VTR Móvil

This is also a new operator. They were allocated one portion of the 1700/2100MHz band of spectrum for 3G services in the same contest Nextel did, back in 2009. They followed the same process to enter the market, beginning their operations in May 2012, right after Nextel\textsuperscript{133}. Coming from the same challenging position as their fellow new actor, they were able to attract around 78,000 subscribers by the end of the year\textsuperscript{134}. The launch of their mobile services meant the addition of their presence in the Chilean telecom market, as they had already been offering services in the Cable TV segment.

Mobile Virtual Network Operators

When the regulator announced its plan to encourage the entry of mobile virtual network operators to the market, it was a motive of great expectation and also controversy. As a matter of fact, incumbent operators Claro, ENTEL and Movistar were accused of blocking the entrance of these new actors, and were charged with a fine by the regulator.

By the end of 2011, the regulator SUBTEL announced that 22 concession licenses were approved for MVNO services. The companies that entered the market in 2012 included Virgin Mobile, GTD Móvil and Netline, all holding roaming agreements to use the networks of Movistar.

Virgin Mobile is probably the company that caused the biggest impact, with a big marketing campaign targeted to young customers and offering prepaid plans. Surprisingly, their customer base managed to beat the performance of VTR Móvil, raising 103,000 subscriptions by the end of 2012\textsuperscript{135}. They had launched their services only in April of that year.

Falabella Móvil, owned by one of the most important retail stores in the country has announced it will launch services in 2013, under great expectations from the Chilean population. They will be using the network of ENTEL in order to operate\textsuperscript{136}.

\textsuperscript{133} www.telesemana.com - "VTR ya es oficialmente el sexto operador móvil de Chile
\textsuperscript{134} Source: Subsecretaría de Telecomunicaciones Chile - www.subtel.gob.cl
\textsuperscript{135} Source: www.subtel.gob.cl
\textsuperscript{136} www.rcrwireless.com. "Chilean Falabella to launch MVNO using ENTEL networks"
Appendix D - Other Regulations for Mobile Telephony Services and Use of Spectrum in Chile

The regulator in Chile has focused their efforts to make the mobile market as dynamic as possible and encourage competition, in order to develop it to levels that diminish the gap with the characteristics of mature markets in more developed countries. This is done while being aware of the correlation between the performance of a telecom market and the economic development in a country. Thus, their policies aim to consider the importance of trying to guarantee successful businesses for mobile operators, as well as to defend the rights of the Chilean people to high quality services at fair prices. Some of the most relevant regulations that affect mobile operators are described in this section.

For the prices of voice and data tariffs, there is no regulation specified. The operators are free to set the prices for their services. The only reason for the Chilean Government to intervene is if a situation with uncompetitive prices is detected. Action may be taken by the Tribunal for the Defense of Free Competition (Tribunal de Defensa de la Libre Competencia - TDLC)\textsuperscript{137}. Besides, this Tribunal has sentenced that operators can no longer establish different prices for on-net and off-net calls, beginning in January 2014\textsuperscript{138}.

Regarding interconnection tariffs, operators are obliged to comply with the denominated "Procedure for Tariff Establishment". It is stipulated that a techno-economic study to be delivered by each telephone company. The study consists in calculating the real cost the company will have in order to provide their interconnection services to other operators. It includes an assessment of the investments made in the network to provide interconnection.

Basically, this regulation tries to ensure that fair prices are offered between market actors and therefore, to the end users, while attempting to boost competition and "efficient companies" that maintain positive statistics, according to the regulator. Mobile operators are subject to this control given that the Chilean Government considers this market segment to have some special conditions that may lead to monopoly-like behaviors\textsuperscript{139}. The process takes place every 5 years, having the last one been held in 2009.

Chile is a country that possesses a very large amount of territory, while its population density is fairly low in certain regions. Traditionally, telephone operators have argued that it was difficult to provide their services to some remote regions, leading to the creation of a national long distance service that has active for many years. Of course, this meant end users were paying different prices when calling fixed lines in each

\textsuperscript{137} ENTEL Chile Annual Report 2011
\textsuperscript{138} ENTEL Chile 4th Quarter 2012 Report
\textsuperscript{139} www.subtel.gob.cl . "Procedimiento de Fijación Tarifaria"
region, given the need to use a long distance carrier. However, since late 2010 the regulator decided to start the elimination of long distance services, in order to establish a regime of uniform prices all over the country\textsuperscript{140}.

In a different approach, the regulator wanted to give end users more freedom to choose their services or change their operator at any time without any kind of constraints. In this context, number portability was implemented since December 2011 for fixed telephones and January 2012 for mobile users. This allows them to preserve their number even if they decide to subscribe to a different operator\textsuperscript{141}.

For a long time, some part of the Chilean population has been concerned about being exposed to high amounts of radiation coming from mobile base stations and other sources. This is why, after long debate, a new bill to regulate the installation of antennas and towers was approved in the beginning of 2012. One of the main objectives is to ensure that transmitting powers are compliant to the suggestions made by the World Health Organization, in order to preserve the environment and to protect citizens from an excess of exposure to radiation\textsuperscript{142}.

Besides, the rules regarding the deployment of antennas and towers will be more strict, limiting the size and amount of them that may be installed in each area, in order to preserve the ornament of public spaces. This also looks to encourage network infrastructure sharing between mobile operators, an initiative the regulator is promoting after looking at actors in developed countries that have reached this sort of agreement. The idea is to complete 4G network deployments faster than expected, reaching larger coverage areas with smaller investments\textsuperscript{143}. The introduction of network infrastructure (i.e., antenna towers) providers in the market as a consequence of this regulation, also seeks to encourage site sharing.

In the matter of digital dividend spectrum, it was announced in 2009 that the ISDB-T standard, or Japanese-Brazilian standard would be adopted by Chile for the implementation of digital television in the country. This coincides with the adoptions of several countries in the region. By the year 2017, the switch-off of analog television is expected, after the initial tests of digital TV started four years ago in the metropolitan area of Santiago and expanded to other regions in 2012. In this way, 700 MHz spectrum will be liberated, allowing mobile operators to use it for 4G mobile broadband services. The regulator decided to adopt the Asia-Pacific Telecommunity (APT) plan for this band, which is expected to promote spectrum harmonization in Latin America and a

\textsuperscript{140} www.subtel.gob.cl - "Queremos llegar al 2014 con todo Chile llamando a costo local, sin larga distancia ni diferencias para llamar entre compañías de telefonía móvil"

\textsuperscript{141} www.subtel.gob.cl - "Co-competencia y Calidad de Servicio: nuestra política modernizadora en telecomunicaciones"

\textsuperscript{142} www.subtel.gob.cl - ENTEL Chile Annual Report 2011

\textsuperscript{143} www.subtel.gob.cl - "Co-competencia y Calidad de Servicio: nuestra política modernizadora en telecomunicaciones"
reduction in the prices of mobile devices in the future, given their commercialization in many other countries that have adopted the same standard\textsuperscript{144}.

\textsuperscript{144} www.subtel.gob.cl - “Television Digital”; "SUBTEL docta norma técnica para uso de la banda de 700 MHz"
Appendix E - Facts about Mobile Operators in Sweden

Operator Telia

Operator Telia is one of the incumbent actors in the Swedish mobile market, having launched GSM services in 1992. They are the result of the privatization of the public telecom company in Sweden, Televerket, in 1993. In 2002, they merged with Finnish telecom company Sonera to form what now is known as TeliaSonera. The new company is now present in several countries of Europe and Asia.

In Sweden, Telia offers services for mobile and fixed telephony and broadband, as well as TV. Their mobile business offers 2G, 3G, and 4G technologies. It has generated revenues in the amount of 2.5 billion dollars in 2011, having increased by 3.6% in relation to the previous year. They have remained the market leader as far as market shares are concerned.

After they failed to acquire a license to offer UMTS technology in 2001, they entered into a network sharing agreement with operator Tele2, which was named Svenska UMTS-Nät AB (SUNAB). They both keep 50% ownership of this joint venture.

This company has followed a pioneering position in several of their decisions and strategies. Their most recent achievement is to have launched the first commercial LTE networks in the world in 2009, in the cities of Stockholm and Oslo.

Operator Tele2

Tele2 is the other incumbent operator that launched GSM services for the first time in 1992 in Sweden. When they started their operations, their name was Convik, but they decided to change it in 1993. They began their expansion to other countries around Europe and Asia in 1996.

Their approach has always been to offer the best possible pricing for customers. Their services include mobile communications, fixed broadband and fixed telephony. In the mobile segment, they have implemented networks for different technologies including 2G, 3G, and 4G, having generated a total of almost US $ 1.5 billion in 2012, having shown growth with respect to 2011.

In addition to their joint venture with Telia, they have established another one in 2009. It is called Net4Mobility and it is shared with Telenor, at 50% ownership each. Their goal was to roll-out 2G and 4G networks together. In this sense, they now own the first multiple operator core network in 2G in the world, having launched it in 2012. In addition to this, Tele2 also plans to roll-out their 4G network in the 800 MHz frequency.

145 http://www.teliasonerahistory.com/
146 TeliaSonera Annual Report 2012
147 http://www.teliasonerahistory.com/
148 http://www.teliasonerahistory.com/
149 http://www.en.tele2.ru/tele2_in_world.html
150 Tele2 2012 Annual Report
during 2013. Both operators act as MVNOs getting capacity from the network of Net4Mobility\textsuperscript{151}.

**Operator Telenor**

Telenor Sweden is part of an international company called Telenor Group, which is based in Norway. Having entered the Swedish telecom market in 2001\textsuperscript{152}, they completed the acquisition of former mobile operator Europolitan Vodafone (or, Vodafone Sweden) Sweden in 2006. Vodafone had been the third operator in the country at the time, position that has been kept until now by Telenor\textsuperscript{153}.

The history of this operator goes way back, having launched GSM services along with Tele2 and Telia in 1992, under the name of NordicTel. They later changed their name to Europolitan\textsuperscript{154}, which they held until Vodafone became a majority shareholder of the company\textsuperscript{155}.

Nowadays, Telenor offers services for mobile telephony and broadband, fixed telephony and broadband, as well as TV. Their mobile business comprises 2G, 3G and 4G technologies\textsuperscript{156}. In 2012, it generated revenues of about US $ 1.4 billion, an increase of 5.8% with respect to the previous year.

In addition to the joint venture for 2G and 4G deployment held with Tele2, Telenor is involved in another joint venture called 3GIS with operator Hi3G, which was meant to be used for the deployment of their 3G networks in the 2100 MHz band\textsuperscript{157}.

**Operator Hi3G Access**

This is the only operator that came in the market after 1992. Their entry took place after they were awarded a UMTS license in 2000\textsuperscript{158}. Like the other actors, it is part of an international company called Hutchison Whampoa Limited, which has mobile operators in several other countries in Europe and in Asia. They are more commonly known by the brand name “3”\textsuperscript{159}.

Unlike the other actors, only mobile services are offered, with their major deployment being their 3G network. They hold a joint venture agreement with Telenor, through which they have built and operated this network along the years, as mentioned in the

\textsuperscript{151} Tele2 2012 Annual Report
\textsuperscript{152} http://www.telenor.com/about-us/global-presence/sweden/
\textsuperscript{153} www.telenor.com - "Acquisition of Vodafone Sweden completed"
\textsuperscript{154} Bohlin, E. "Assessment of spectrum management options: Evaluation of selected Swedish spectrum management cases". June 2008
\textsuperscript{155} http://www.vodafone.com/content/index/media/group_press_releases/2003/press_release25_03.html
\textsuperscript{156} http://www.telenor.com/investor-relations/company-facts/business-description/telenor-sweden/
\textsuperscript{157} Bohlin, E. "Assessment of spectrum management options: Evaluation of selected Swedish spectrum management cases". June 2008
\textsuperscript{158} Hutchison Whampoa Ltd. Annual Report 2012
previous section. Additionally, they now offer LTE services, for which they launched the first dual-mode network in the world that supports FDD and TDD duplexing\textsuperscript{160}.

Despite being positioned as the fourth operator in the market, Hi3G has seen constant growth of its business ever since it began operations in Sweden. The year 2012 saw them accumulate US $ 865,000 in revenues, a growth of 6% compared to the previous year\textsuperscript{161}.

**Mobile Virtual Network Operators**

Sweden has the presence of a big amount of mobile virtual network operators in the market, with a total of 33. They represent 3.2\% of the market shares, as shown before in Figure 3.8. Telia has signed contracts to provide network capacity to 15 MVNOs, Tele2 has agreements with 5, Telenor with 10, and Hi3G with only 3\textsuperscript{162}.

\textsuperscript{160} www.teoecomlead.com - "ZTE and 3 Sweden conduct interactive video demo via TD-LTE at Mobile World Congress"

\textsuperscript{161} Hutchison Whampoa Ltd. Annual Report 2012

\textsuperscript{162} PTS Sweden First Half 2012 Report
Appendix F - Other Regulations for Mobile Telephony Services and Use of Spectrum in Sweden

The approach to the regulation of the telecommunications market taken by the Swedish regulator, PTS, is to try to interfere as little as possible in the operations of the different actors, as long as consumer rights are preserved, competition enforced, and resources properly exploited to maximize development. In this sense, the market in this country has seen more and more flexibility in the rules imposed to operators as the market kept evolving and became more mature. Some of the most relevant decisions made by the regulator are briefly discusses in this section.

The first obligation for operators wishing to enter the telecommunications market in Sweden is to notify the regulator before they begin to deliver their services to the public. There is a notification process involving an application in order to fulfill this requirement. As part of the effort to maintain competition, the Swedish regulator authority has established rules on the charges for interconnection between networks of different operators, given the high fees established especially to terminate calls by the bigger mobile actors. The goal of this decision was to provide lower prices of voice calls that were fair to consumers, through the avoidance of abusive actions from operators to set excessive prices for off-network calls. On the other hand, operators charge now in a "per minute" of call basis instead of per second, although they did that before. According to this, there is no regulation on the way operators charge for voice calls.

In the matter of the general policies for the use of spectrum, the regulator promotes the development of the market and the constant increase of benefits for the society. Thus, it has chosen to manage this resource according to some specific guidelines that may promote their goals. These concepts were established in 2006, following the tradition of Sweden to be a pioneer in spectrum regulation. According to PTS, they are as follows:

- "Licences to use radio transmitters should be as technology and service-neutral as possible"
- "When selection procedures are required, auctions should preferably be applied"
- "Where there is little risk or harmful interference and there are no other impediments, licence exemption should be introduced"

This line of reasoning may be corroborated by the nature of the spectrum allocation procedures discussed in the previous section. It could be seen that the spectrum licenses were generally awarded through auctions, giving operators the freedom to deliver either voice or broadband services and for either GSM, UMTS or LTE technologies.

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164 www.pts.se - "PTS decides on rules for mobile operators"
165 www.pts.se - "The price of mobile phone calls continues to drop"