Privatization of telecommunications in Latin America, an analysis of its efficiency

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Abstract

This paper evaluates the efficiency of the telecommunications sector in Latin America. The great dynamism acquired by this sector has been due to external factors of change such as privatization processes that took place mainly during the nineties, technological changes, market liberalisation and internationalization of services and funds lender firms. In this regards, the purpose of this paper is to assess the evolution of telecommunications by valuing the two main responsible factors: privatization and technological advances.

In order to understand privatizations in economic policies carried out in Latin as well as to assess its efficiency and to what extent it accounted as a dynamic component in the telecommunications case, this work accounts privatizations as a changing element of economic policies in Latin America. A close look at the motivations and characteristics behind privatizations in the telecommunications sector in Latin America is shown. Finally, a measure on the results of the privatizations in terms of efficiency is obtained.

To measure the efficiency of the telecommunications sector at regional, country and company levels, methodology of Data Envelopment Analysis (DEA) is used, complemented with Index of Malmquist. The results indicate that the process of privatization and technological advances have been two distinguish elements for the development of telecommunications, improving the service provided to society, as well as their efficiency and productivity rates.

1. Introduction

Improvement of production efficiency and growth of the economy have been the fundamental arguments for reforms in the telecommunications sector in most of South America.

Belief that market competition would improve the provision of telecommunications services motivated upon Governments to make a strong wave of liberalisation of telecommunications in the late eighties and early nineties sector.

The telecommunications sector in the countries of South America has acquired great dynamism due to external factors change as internationalization, liberalisation and technological change; it is in this context that want to study the evolution of the telecommunications sector in the countries of South America.

This industry has been shaken by economic, technological, and political-regulatory forces that have generated more and better services to customers, increasing the level of welfare and allowing the development of economies.

For decades, the structure of the telecommunications sector was seen as a "natural monopoly" and more often like State monopoly.

Technology, economic and institutional changes that have transformed the telecommunications sector have allowed the reduction of costs in providing services, raising the productivity of the sector.

Technological convergence led to the digitization of telecommunications and subsequently increasing the capabilities of this digitization would lead to incorporate broadband services. This evolution has been due to the regulation of services in the telecommunications sector that have led the state monopoly to private, the transition to competition to end effective competition.

In this sector has been observed that there have been an increasing number of mergers and alliances to cope with the changing environment. In recent years, the region has developed a significant movement of companies in this direction for example, mergers and acquisitions of companies engaged in mobile, pay TV (cable and satellite), to the extent that is observed a concentration of two major mobile competitors in the regional level: Telefónica Group and Grupo Carso Telecom (Telmex).

Some research developed for the telecommunications analyse the measurement of efficiency and show that the technological and regulatory changes have been beneficial to the telecommunications sector.

Madden & Savage (1999) analyse the productivity of telecommunications, technology and innovation for 74 countries (1991-1995). Decomposition of Malmquist index shows some preliminary evidence that the developing countries can improve productivity through catch-up. Estimates of the model developed for this case support the hypothesis that Schumpeter market size promotes innovation.

Calabrese, Campisi & Mancuso (2002) use DEA methodology to measure the Malmquist index and thereby study the evolution of total factor productivity and labour productivity of 13 OECD countries for the period 1979-1998. Fink, Mattoo & Rathindran (2003) using an econometric model evaluates a set of 86 developing countries from different continents during the period 1985-1999, analyzing the impact of policy reforms in telecommunications. As a result they obtained that privatization and competition lead to improvements in performance.

Li & Xu (2004) analyse the with panel data the telecommunications sector between countries around the world for the years 1990-2001 to research the impact of privatization and competition in the telecommunications sector. With the result, privatizations have contributed greatly to improve the allocation of labour, capital, expansion of services and network penetration, also improve labour productivity and total factor productivity, but when privatization is partial, that is, the state retains control rights, the impact is not significant. Another important finding is that the complementary between privatization and competition allow greater penetration of the network and there is a greater containment in increasing prices.

In Inklaar, Timmer & Ark (2008) is claimed that market liberalisation has been beneficial for productivity growth in telecommunications, although does not happen in other service sectors. It also shows that increased investment in Information technology and communication, as well as the growth of human capital has contributed to the growth of labour productivity in the services market in European countries and the United States.

Lam & Shiu (2008) measure the productivity performance of the telecommunications sector in the area of the provinces of China, for this use the DEA methodology, as a result of various efficiency indices, being due mainly to the difference in operating environments there.

Ariff, Cabanda & Sathye (2009) evaluated 40 companies in Africa, America, Asia, Australia and Europe using the database of the International Telecommunication Union (ITU) to determine if the change of ownership affects the performance improvement the companies analysed. As a general conclusion shows significant improvement in the financial and productive performance after privatization.

Kahn (2009) makes use of the DEA methodology to evaluate the efficiency of the telecommunications industry in Taiwan before and after privatization (period 1966-2007), determining that the efficiencies determining that the efficiencies throughout the study period are inefficient.

Lam & Shiu (2010) study the telecommunications sector in different countries with the main objective to study the relationships between economic growth, telecommunications development and productivity growth. Among the conclusions reached, the diffusion of mobile telecommunications services is a significant growth of total factor productivity factor.

2. Methodology and data

With the purpose of characterise the production function has been chosen to model a single output and multiple inputs; is to measure the technical efficiency of the industry on an aggregated basis that is one wants to make inference on both the development of telecommunications and value added. Therefore, the variables used, both inputs like services provided are intended to be representative of the total aggregate sector. Calculate efficiency measures the efficiency of capital, of installed capacity and the labour force of sector to provide a volume of telecommunications services.

2.1. Data envelopment analysis DEA

The most well-known non-parametric method is Data- Envelopment Analysis (DEA are the acronym for Data Envelopment Analysis) developed by Charnes, Cooper and Rhodes (1978). This method generalises to measures of Farrell (1957).

The DEA method is an optimization technique constructed to measure the relative efficiency of a group of organizational units called in the literature decision making units ("Decision Making Units" - DMUs) in which the presence of multiple inputs and outputs make it difficult comparing its performance. The Data Envelopment Analysis provides a method for comparing the relative efficiency without the knowledge of the production function, that is, without the need to know a functional relationship of resources and products. The result of efficiency in the presence of multiple resources (input) and outputs (outputs) is defined as follows, $Efficiency = \frac{weighted\ sum\ of\ the\ outputs}{weighted\ sum\ of\ the\ inputs}$. It should also be specified that a DMU is efficient provided that no the following outcomes:

• Orientation _ output: a DMU is inefficient if any output can be increased without any input increases and decreases without any other output.

• Orientation _ input: a DMU is inefficient if possible decrease any input without any other input is increased without any output is decreased.

The DEA's models are used for the analysis of efficiency are:

• CCR Model (1978) developed by Charnes, Cooper and Rhodes that allows an objective assessment of the overall efficiency and identifies the sources of inefficiency; this model works with constant returns to scale.

• BCC Model (1984), developed by Banker, Charnes and Cooper distinguishes between technical and scale inefficiencies, estimating pure technical efficiency at a given scale operation and identifies whether these yields increasing, decreasing and constant returns to scale for future exploration. This model works with variable returns to scale, which allows the unit to be evaluated compared to similarly sized units.

The mathematical formulation of the original CRC model can be presented assuming first that there are n DMUs, each with m inputs and s outputs the result of relative efficiency of a DMU (being denoted by the subscript 0) are obtained by solving the model proposed by fractional Charnes, Cooper and Rhodes (1978):

$$\text{Max.} \quad h_o = \frac{\sum_{i=1}^{s} v_r y_{r0}}{\sum_{i=1}^{m} u_i x_{i0}}$$

s.t.

$$\frac{\sum_{r=1}^{s} v_r y_{rj}}{\sum_{i=1}^{m} u_i x_{ij}} \le 1; \qquad j = 1, 2,....,n \qquad \textbf{(1)}$$

$$v_r, u_i \ge 0 \qquad r = 1,2,...,s\,; \; i = 1,2,...,m$$

In this model, $y_{rj}, x_{ij} \ge 0$ are constants representing observed quantities in the rth output and the ith input unit j decision making. The variables $v_r, u_i \ge 0$ are the weighting factors which can obtain the scale measure of efficiency. The value h_o satisfies $0 \le h_o \le 1$ and efficiency in which h_o = 1 indicates maximum efficiency and $h_o \le 1$ indicates the inefficiency of the decision making unit. On the other hand, h_o results invariant to the units of measurement used in the input and output variables.

The fractional program can become one of linear programming using the following transformation:

$$\sum_{i=1}^{m} u_i x_{ij} = 1 \qquad j = 1, 2,\ldots,n \qquad \textbf{(2)}$$

By replacing this last equation model can be written as:

Max. $h_o = \sum_{i=1}^{s} v_r y_{r0}$

s.t.

$$\sum_{r=1}^{s} v_r y_{rj} - \sum_{i=1}^{m} u_i x_{ij} \leq 0; \qquad j = 1, 2,\ldots, n \qquad \textbf{(3)}$$

$$\sum_{i=1}^{m} u_i x_{i0} = 1$$

$$v_r, u_i \geq 0 \qquad r = 1, 2,\ldots,s\,;\ i = 1,2,\ldots, m$$

The solution of this model provides the weightings of inputs and outputs that maximize efficiency results in evaluation DMUo. To find the result of relative efficiency of all DMUs, the model must be solved many times as DMUs exist.

For comparison purposes of efficiency, DEA identifies the efficient reference group. Efficient DMUs are found by solving the dual model. The dual model (3) is as follows:

Min θ_0

s.t.

$$\theta_0 x_{i0} - \sum_{j=1}^{n} \lambda_j x_{ij} \geq 0; \qquad \text{i} = 1,2,\ldots, \text{m}$$

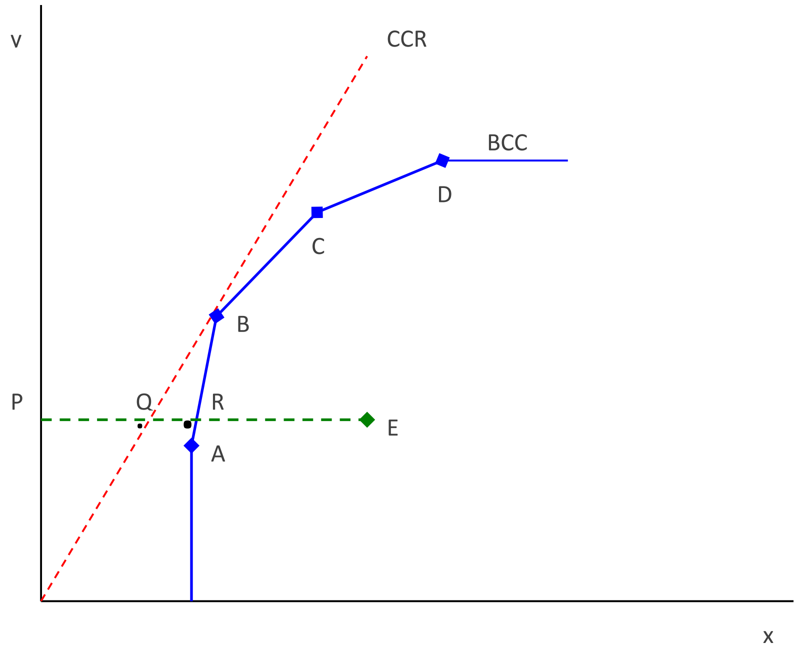
$$-y_{r0} + \sum_{j=1}^{n} \lambda_j y_{rj} \geq 0; \qquad \text{r} = 1,2,\ldots, \text{s}$$

$$\lambda_j \geq 0 \qquad \text{j} = 1,2,\ldots, \text{n} \qquad \textbf{(4)}$$

Figure 1 represents the solutions of the DEA methodology for the CCR and BCC models through a simplified case where the production technology employs an input x and an output and the line on which are the points A, B, C and D represent BCC DEA model, these points have the best reason output / input with this model and receive a score of efficiency equal to 1. These units, although they are technically efficient, have different returns to scale;

segmented, the straight line joining the origin with unit B represents the efficiency frontier determined by the CCR model and reflects the constant returns to scale.

Figure 1: Frontiers of Efficiency CCR and BCC



2.2 Malmquist Index

This index was developed from the initial ideas of Malmquist (1953), whose objective was to develop an index number to analyse the behaviour of consumers in relation to distance functions. Caves, Christensen & Diewert (1982) introduced the concept of Malmquist index, which is characterised by having the ability to measure change depending on the total factor productivity of a decision unit in different periods and decompose it into technical efficiency change and technology. After Färe, R, Grosskopf, S. & Roos, P. (1998) proposes an index with the same characteristics as Caves et al. (1982), but based on the composition of efficiency scores generated by DEA method.

The production possibility set defined by the production technology; considering that for each period t=1,...T, the production technology, S_t, can be represented by the transformation of the vector of inputs x_t in vector outputs y_t, through: $S_t = \{(x_t, y_t) : x_t \; can \; produce \; y_t\}$. Technological progress makes $S_t \subset S_{t+1}$ and making it clear that $(x_t, y_t) \in S_t$ and $(x_{t+1}, y_{t+1}) \in S_{t+1}$ but $(x_{t+1}, y_{t+1}) \notin S_t$.

For a given production technology, the distance function of the product may be defined, for the period *t*, as (Shephard, 1970) (FARE et al, 1994.):

$$D_t^o(x_t, y_t) = inf\left\{\theta : \left(x_t, \frac{y_t}{\theta}\right) \in S_t\right\} \quad \textbf{(5)}$$

Equation (6) is the inverse of the measurement of technical efficiency proposed by Farrell (1957):

$$D_t^o(x_t, y_t) = inf\left\{\theta : \left(x_t, \frac{y_t}{\theta}\right) \in S_t\right\} = (sup\{\theta : (x_t, \theta y_t) \in S_t\})^{-1} \quad \textbf{(6)}$$

where (6) a homogeneous function of first degree.

In the case of a single product, the distance function-product can be represented by:

$$D_t^o(x_t, y_t) = \frac{y_t}{F(x_t)} \quad \textbf{(7)}$$

where $F(x^t)$ is a function of production represented as:

$$F(x_t) = máx\{y_t : (x_t, y_t) \in S_t\}$$

The function (6) returns the smallest value for which the product can be divided, so that even belongs to the frontier of production defined by the production technologyS_t. As $\theta \leq 1$, dividing the product by the shortest possible θ, is calculating the greatest expansion of y_t, product x_t given the level of inputs and technology used.

The Malmquist index requires the existence distance functions, considering two different time periods to measurable increases in total factor productivity. As in (5) can be defined a distance function for period *t+1*. The distance function at time *t+1* is the maximum proportional change in the product in order that (x_{t+1}, y_{t+1}) is technically possible, with reference to the technology t , so:

$$D_t^o(x_{t+1}, y_{t+1}) = inf\left\{\theta : \left(x_{t+1}, \frac{y_{t+1}}{\theta}\right) \in S_t\right\} \quad \textbf{(8)}$$

can also define the distance in relation to the technology of the time *t+1*: $D_{t+1}^o(x_{t+1}, y_{t+1})$ and $D_{t+1}^o(x_t, y_t)$; wherein the distance between the observation period t and the production frontier _ product-oriented of the period *t+1* is represented by $D_{t+1}^o(x_t, y_t)$; therefore, the Malmquist index calculation involves calculating the following distance functions: $D_t^o(x_t, y_t)$, $D_{t+1}^o(x_{t+1}, y_{t+1})$, $D_t^o(x_{t+1}, y_{t+1})$ and $D_{t+1}^o(x_t, y_t)$.

If production is technically efficient, (x_t, y_t) are at the technological frontier and $D_t^o(x_t, y_t) = 1$; in case $D_t^o(x_t, y_t) < 1$, production is inefficient and technologically and (x_t, y_t) is inside the technological frontier, at time t. in particular, $D_t^o(x_t, y_t) \leq 1$ if and only if $(x_t, y_t) \in S_t$ and $D_t^o(x_t, y_t) = 1$ if and only if, (x_t, y_t) is efficient and is at the technological frontier

Caves et al. (1982) define the Malmquist index oriented product using the technology of period t as:

$$M_t^o(x_t, y_t, x_{t+1}, y_{t+1}) = \frac{D_t^o(x_{t+1}, y_{t+1})}{D_t^o(x_t, y_t)} \tag{9}$$

Equation (9) measures the change in productivity due to changes in efficiency between period *t* and *t+1* due to the production technology in period *t*. Distance functions for this equation are defined in period *t*.

In the same way, another Malmquist index is defined by the production technology of the period *t+1*:

$$M_{t+1}^o(x_t, y_t, x_{t+1}, y_{t+1}) = \frac{D_{t+1}^o(x_{t+1}, y_{t+1})}{D_{t+1}^o(x_t, y_t)} \tag{10}$$

According Färe *et al*. (1994), the reference time technology is arbitrary and these indexes did not necessarily result in the same value, ie, do not prioritise an index to the other, the index Malmquist productivity is defined as a geometric mean between both indexes (typically Fisher index)

$$M_o(x_t, y_t, x_{t+1}, y_{t+1}) = \{[M_t^o(x_t, y_t, x_{t+1}, y_{t+1})] \times [M_{t+1}^o(x_t, y_t, x_{t+1}, y_{t+1})]\}^{\frac{1}{2}} \tag{11}$$

$$M_o(x_t, y_t, x_{t+1}, y_{t+1}) = \left[\frac{D_t^o(x_{t+1}, y_{t+1})}{D_t^o(x_t, y_t)} \times \frac{D_{t+1}^o(x_{t+1}, y_{t+1})}{D_{t+1}^o(x_t, y_t)}\right]^{\frac{1}{2}} \tag{12}$$

The decomposition of index in two factors was proposed by Färe et al. (1989):

$$M_o(x_t, y_t, x_{t+1}, y_{t+1}) = \underbrace{\left[\frac{D_{t+1}^o(x_{t+1}, y_{t+1})}{D_t^o(x_t, y_t)}\right]}_{\text{Efficiency change}} \underbrace{\left\{\left[\frac{D_t^o(x_t, y_t)}{D_{t+1}^o(x_t, y_t)} \times \frac{D_t^o(x_{t+1}, y_{t+1})}{D_{t+1}^o(x_{t+1}, y_{t+1})}\right]\right\}^{\frac{1}{2}}}_{\text{Technological change}} \tag{13}$$

The variation of technical efficiency measures the change in the distance at which a production unit is the maximum potential output between *t* and *t+1*, with the aim of verifying if the production is nearer (catching up) or more away from the frontier production. The values can be lower, equal or greater than one, which indicates decrease, maintenance or improvement in technical efficiency respectively.

Technological change is an index that detects technical changes, ie, technological progress, between *t* and *t+1* and represents the displacement of the boundary between two time periods in relation to the use of inputs x_t and x_{t+1}. Technical progress is measured as a geometric mean of technological change in relation to x_t and x_{t+1}.

An increase in the first component (technical efficiency change) shows a recovery of production in relation to the efficient frontier, while the second component indicates improvement in technological innovation. Consequently, the Malmquist index enables to separate the catching up relative to the frontier of the displacements of the frontier. So that productivity can be influenced by technological progress and change in technical efficiency indicator, which go in opposite directions, cancelling each other, or act in the same direction, joining each other.

2.3 Calculation of Malmquist Index from the methodology of Data Envelopment Analysis (DEA)

The measure of productivity changes along the time, can be obtained by different techniques, depending on the approach may be used parametric or non-parametric techniques. The technique is then developed which is based on nonparametric deterministic frontiers applied to the DEA methodology.

The first to evaluate changes in productivity via DEA methodology were Färe et al. (1989), using this to calculate the Malmquist productivity index. Started from the idea that the change in productivity may be due to a combination of technology change along the time and the change in the efficiency of the unit individually, so that the index decomposed multiplicatively with the aim of obtain the two components.

Färe et al. (1989) were based on the fact that the distance function is identical to the inverse of the measurement of technical efficiency Farrell (1957), calculating the four distances functions constituting the index as solutions of linear programming problems being that these algorithms do not require specification of a particular form according to the distance.

Malmquist DEA methodology is the combination of the two methods, the measurement of productivity changes is done in two stages. First, the technological frontier is constructed through the application of the methodology DEA allowing obtaining distance functions and from these the Malmquist productivity index is obtained.

Therefore, the following linear programming problems must be solved to calculate $M_o(x_t, y_t, x_{t+1}, y_{t+1})$:

i. $[D_t^o(x_t, y_t)]^{-1} = max_{\theta\lambda}\theta$

s.t.

$-\theta y_{i,t} + Y_t\lambda \geq 0$

$x_{i,t} - X_t\lambda \geq 0$

$\lambda \geq 0$

ii. $[D_{t+1}^{o}(x_t, y_t)]^{-1} = max_{\theta\lambda}\theta$

s.t.

$-\theta y_{i,t} + Y_{t+1}\lambda \geq 0$

$x_{i,t} - X_{t+1}\lambda \geq 0$

$\lambda \geq 0$

iii. $[D_{t}^{o}(x_{t+1}, y_{t+1})]^{-1} = max_{\theta\lambda}\theta$

s.t.

$-\theta y_{i,t+1} + Y_t\lambda \geq 0$

$x_{i,t+1} - X_t\lambda \geq 0$

$\lambda \geq 0$

iv. $[D_{t+1}^{o}(x_{t+1}, y_{t+1})]^{-1} = max_{\theta\lambda}\theta$

s.t.

$-\theta y_{i,t+1} + Y_{t+1}\lambda \geq 0$

$x_{i,t+1} - X_{t+1}\lambda \geq 0$

$\lambda \geq 0$

2.4 Data

The considered variables were taken from World Telecommunication Indicators Database 2004, 2006, 2007 and 2009, built by the ITU (International Telecommunications Union) based on questionnaires sent BDT (Telecommunications Development Bureau) of the ITU to telecommunication ministries and agencies of the member countries. Yearbook of Statistics was also used for the years 2001-2006 and 2009 -2011.

Furthermore, were taken into consideration statistical database provided by the regulatory agencies.

The data available for this study cover the period 1995 - 2007, information obtained from the International Telecommunication Union, supplemented by data from regulatory agencies in each country included in the study.

Description of data:

The data used were taken from ITU databases1

- Total revenue from all telecommunication services

It is expressed in millions of dollars at an annual average rate of $.

This is the total (gross) telecommunication revenue earned from all (fixed, mobile and data) services within the country. This should exclude revenues from non-telecommunications services. Revenue (turnover) consists of telecommunication service earnings during the financial year under review. Revenue should not include monies received in respect of revenue earned during previous financial years, neither does it include monies received by way of loans from governments, or external investors, nor monies received from repayable subscribers' contributions or deposits. Revenues should be net of royalties.

- Main (fixed) telephone lines in operation

A main line is a (fixed) telephone line connecting the subscriber's terminal equipment to the public switched network and which has a dedicated port in the telephone exchange equipment. This term is synonymous with the term *main station* or *Direct Exchange Line (DEL)* that are commonly used in telecommunication documents. It may not be the same as an access line or a subscriber. The number of ISDN channels should be included. Fixed wireless subscribers should also be included.

- Percent of main (fixed) lines connected to digital exchanges

This percentage is obtained by dividing the number of main (fixed) lines connected to digital telephone exchanges by the total number of main lines. This indicator does not measure the percentage of exchanges which are digital, the percentage of inter-exchange lines which are digital or the percentage of digital network termination points. Respondents should indicate whether the main lines included in the definition represent only those in operation or the total capacity.

[1] The definitions of the data were established by the ITU. (DEFINITIONS OF WORLD TELECOMMUNICATION/ICT INDICATORS)

- Total full-time telecommunication staff

Total full-time staff employed by telecommunication network operators in the country for the provision of public telecommunication services, including mobile services. Part-time staff should be expressed in terms of the full-time staff equivalent.

- Total annual investment in telecom

Also referred to as annual capital expenditure, this is the gross annual investment in telecom (including fixed, mobile and other services) for acquiring property and network. The term investment means the expenditure associated with acquiring the ownership of property (including intellectual and non-tangible property such as computer software) and plant. This includes expenditure on initial installations and on additions to existing installations where the usage is expected to be over an extended period of time.

- Mobile cellular telephone subscribers (post-paid + prepaid)

Refers to the use of portable telephones subscribing to a public mobile telephone service and provides access to Public Switched Telephone Network (PSTN) using cellular technology. This can include analogue and digital cellular systems. This should also include subscribers to IMT-2000 (Third Generation, 3G).

3. Efficiency of the Telecommunication sector in South America

In the regional sphere, want to analyse the efficiency of the development of telecommunications infrastructure in the regulatory process experienced in the period 1991 - 2007 Furthermore, there will also be using this model to support the hypothesis of the convergence development of telecommunications infrastructure in South America.

Inputs:

- Investment in telecom, referred to as annual capital expenditure, this is the gross annual investment in telecom, including fixed, mobile and other services, for acquiring property and network., expressed in dollars at an annual average rate of $, this input is of type capital.

Staff, total full-time staff employed by telecommunication network operators in the country for the provision of public telecommunication services, including mobile services. Part-time staff should be expressed in terms of the full-time staff equivalent. Input of type labour.

Outputs: It is specified according to each model to be used:

- Model 1: Main (fixed) telephone lines in operation, it is used to evaluate the efficiency with which fixed telecommunications infrastructure is provided.
- Model 2: Main (fixed) telephone lines in operation and porcent of main (fixed) lines connected to digital exchanges, with this model aims to evaluate the quality of fixed telecommunications infrastructure.
- Model 3: Main (fixed) telephone lines in operation, Mobile cellular telephone subscribers and Percent of main (fixed) lines connected to digital exchanges; this model has three outputs, telecom operators, assessing the quantity and quality of fixed telecommunications, and number of mobile services provided.

Table 1. Efficiency of the Telecommunication sector in South America

Year	MODEL 1 Mean (SD)	MODEL 2 Mean (SD)	MODEL 3 Mean (SD)
1991	80,75	93,61	
	(27,55)	(17,73)	
1992	75,02	90,12	
	(28,45)	(16,67)	
1993	78,07	91,79	
	(28,54)	(13,18)	
1994	81,22	93,15	94,92
	(26,67)	(11,69)	(10,82)
1995	81,88	95,10	97,26
	(22,71)	(8,53)	(6,28)
1996	91,08	97,87	100,00
	(14,68)	(6,75)	()
1997	89,20	95,90	98,28
	(14,7)	(8,79)	(5,44)
1998	92,08	96,70	100,00
	(16,78)	(10,45)	()
1999	87,41	95,96	99,24

	(17,44)	(9,83)	(1,61)
2000	79,55	96,84	99,91
	(27,72)	(6,46)	(,28)
2001	68,20	96,19	99,63
	(30,59)	(6,61)	(1,17)
2002	71,60	96,31	98,64
	(28,21)	(6,57)	(2,81)
2003	76,32	98,25	98,48
	(28,49)	(3,82)	(3,74)
2004	73,62	96,54	97,33
	(27,67)	(6,65)	(4,85)
2005	74,63	97,58	98,13
	(25,39)	(3,52)	(3,84)
2006	79,82	99,51	98,33
	(22,49)	(3,60)	(1,74)
2007	83,12	98,69	99,65
	(20,15)	(2,98)	(2,01)

Source: prepared by the author, based on the ITU Database.

About the Model 1, it is stated that regional efficiency when providing the telecommunications infrastructure presents its best results for the year 1996-1999 which coincides with the years when the region presented privatization processes in each of the countries.

On the quality of the infrastructure (model 2) is seen through the results that it was strengthened by in the years after 1999, showing high efficiency values averaged over the region with a relatively low deviation.

The results obtained in model 3, where the data are presented for the year 1994 (entry of the mobile telecommunications market), the evaluation results are much better than the previous two models, coming to get in 1996 1998 the best results and efficiency for the region. This fact shows that the income of the mobile phone gave a strong boost to telecommunications in the region.

Table 2. Average change in productivity for the period 1994-2007

	Country	Index Malmquist	Technological change (TC)	Efficiencyl change (EC)
1	Argentina	1,0025	1,0511	0,9537
2	Bolivia	1,0141	1,001	1,013
3	Brazil	1,1274	1,2073	0,9338
4	Chile	1,0358	1,000	1,0358
5	Colombia	1,0263	0,9891	1,0376
6	Ecuador	0,9891	1,000	0,9891
7	Paraguay	0,9807	1,1244	0,8721
8	Peru	1,0535	0,9954	1,0583
9	Uruguay	1,0245	0,9911	1,0336
10	Venezuela	0,9671	1,0005	0,9666
	Mean	1,0221	1,0359	0,9893

Source: prepared by the author, based on the ITU Database.

The average values obtained from the Malmquist index for the period 1994-2007 show that the telecommunications sector in South America has achieved a productivity growth, averaging 2.21% per annum. Seven countries have improved performance being Brazil, the country with the best performance obtained 12.74%; followed by Peru with 5.35%in addition to Chile (3.58%).

Is observed that the "technological change" is causing the growth in efficiency, with a geometric mean of 3.6%. In half of the countries studied "change in technical efficiency" has decreased. These results suggest that it has made efforts to improve the telecommunications sector development through technological innovation.

4. Conclusions

Technological change has reduced the cost and increased the capacity of telecommunications networks. This has enabled the convergence of the telecommunications sector, the audio-visual sector and the Information technology and computing. The development of technologies with the greatest potential for adaptation via software allows operators to more easily adjust their services to the needs and demands of its users. In addition to removing the barriers to entry presented by the sector in South America.

The results suggest that a relationship exists between countries more competitive and technical efficiency. Also show association between innovation and monopoly structures. Although it may not say a causal relationship.

Productivity has advanced more in countries that began early liberalisation of the telecommunications market in front of others who have been slow to make market liberalisation. While there may be other circumstances that increase productivity, such as mergers, sales, incentives, etc.

Although Information technology is not the solution to the problems facing Latin American countries, if you can contribute in some way to its solution, in sectors such as education, health, etc., because it would be important to assess the relationship between ICT growth and economic development of these countries, this being a route still underdeveloped because they do not have sufficient statistical information for the region.

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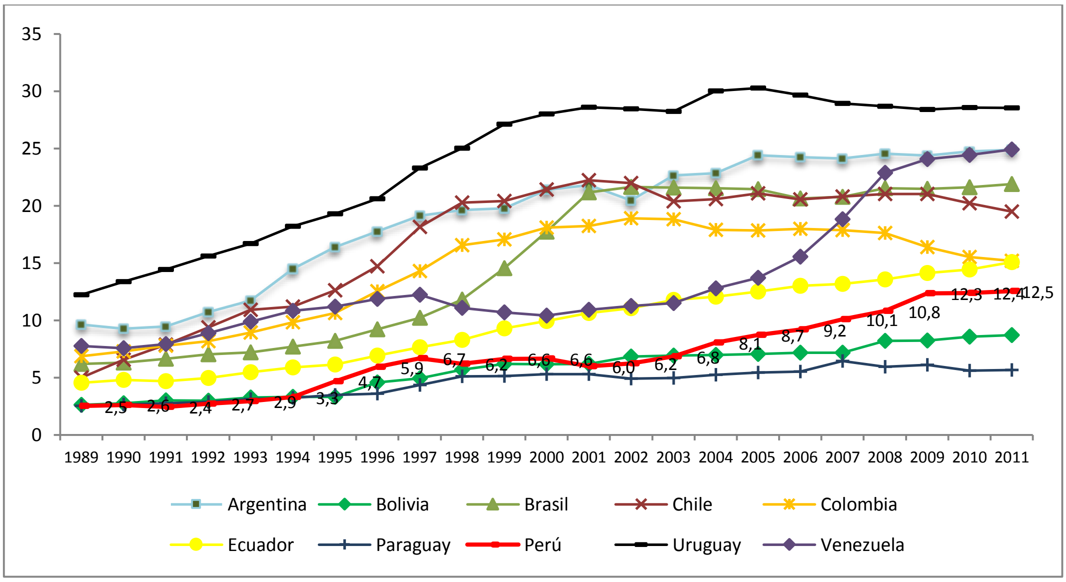
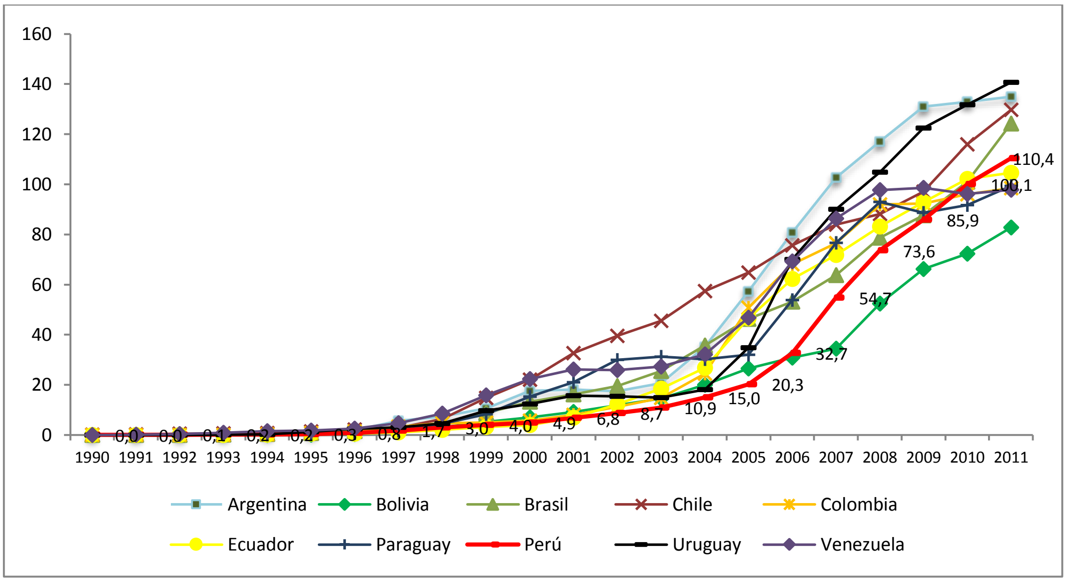
Annex

FIGURE A1: MAIN (FIXED) TELEPHONE LINES IN OPERATION (1989-2011)



Source: prepared by the author, based on the ITU Database and national regulators in the countries of South America.

FIGURE A2: MOBILE CELLULAR TELEPHONE SUBSCRIBERS (POST-PAID + PREPAID) (1990-2011)



Source: prepared by the author, based on the ITU Database and national regulators in the countries of South America.