An empirical Study of the Role of Institutional Reforms and other Factors on Telecommunication Technology Proliferation

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Abstract: Telecommunications proliferation is influenced by a number of factors. These factors can be roughly classified as either factors not within the decision-maker's control (some researchers call these parameters or state variables) or certain factors often called decision variables or controllable factors. These are variables over which the decision-maker has control. From considering the results of many of the available literature studies, there is general consensus that supports the notion that telecommunication (telecom) technology and cellular phones are beneficial for economic growth and social welfare. There are, however, many factors that may severely limit these expectations. One is for example that true wireless communication remains expensive. Another is that besides the lack of an adequate fixed line infrastructure, factors like general economic freedom and trade freedom are often lacking in many developing countries. This paper is an empirical study of the role of institutional reforms and other factors on telecommunication technology proliferation. In this paper, the main factors determining telecommunication technology proliferation are empirically explored and the results are presented and discussed.
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1. Introduction

Many aspects of the role of telecommunications technology in societies have been considered in the literature. One of the relationships that draws a lot of attention is the role that telecommunications and information technologies play in stimulating economic growth and social development.

The factors that influence the success of the proliferation of telecommunications and IT applications thus have to be identified in order to determine the typical profile of a successful country. The motivation for this is the need to identify some of the main factors that influence telecommunication development and growth. If the literature on the subject is to be believed, this development and growth have desirable effects on economic growth and social development in a country.

Through application of multiple regression analyses and the interpretive linear response surface analysis technique, this paper is an empirical study of the main factors that positively influence broadband proliferation using a data set containing a spectrum of developed and developing countries. The data used are from sources like the World Bank reports, ITU reports and others. The paper examines whether and how factors such as innovation , efficiency , competition , availability of fixed line infrastructure, mobile lines , institutional environment, general infrastructure, economic freedom, trade freedom, freedom from corruption, number of mobile operators and gross national income per capita influence broadband proliferation from a global perspective.

This paper begins with a brief review of literature (background), followed by a description of the research methodology employed, including an overview of the linear response surface analysis

technique, empirical experiments (illustrative examples and interpretation of findings), conclusions and future work.

2. Background

Many aspects of the role of telecommunications technology in societies have been considered in the literature. One of the relationships that draws a lot of attention is the role that telecommunications and information technologies play in stimulating economic growth and social development.

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Researchers have explored the relationship between communications technologies and economic growth and development. These attempts at measuring the link between telecommunications technologies and economic growth have concluded that telecommunications is both a cause and a consequence of economic growth (Alleman et al., 1994).

Some of their findings are that telecommunications infrastructure per se does not ensure economic growth but that lack of telecommunications infrastructure can seriously hinder economic growth in a country. They also agree that to derive greater economic benefits from communications technologies, there is a need to invest in telecommunications infrastructure and the maintenance of such infrastructure as well as to adopt institutional reforms such as promoting private property, regulation, financial freedom, investment freedom, and so forth.

The rapid expansion of the telecommunications sector especially cellular and wireless technology in many developing countries has generated a lot of interest from researchers as they explore poverty alleviation strategies in these economies. The severe lack of fixed-line telecommunications infrastructure is believed to retard the economic growth potential of a country. Many people are of the opinion that telecommunications is one of the driving forces behind the economic growth and social development of a country. Certain researchers have attempted to quantify these models and relationships to try to find the main forces that influence and stimulate economic growth.

An overview of some of the theoretical considerations underpinning the relationship between telecommunications and economic growth is furnished below.

The earliest studies involve those of researchers such as Jipp (1963), Bebee and Gilling (1976) and Hardy (1980). Hardy (1980), using data from 45 countries, which were divided into two groups of developed and developing countries, was one of the first researchers to investigate the impact of telecommunications infrastructure on economic growth. He concluded that there was a larger effect of telecommunications on the less developed countries than the developed ones. Jipp (1963), using data for different countries, discovered a positive relationship between the two. Bebee and Gilling (1976) concluded that the effect of telecommunications on growth depends on different stages of the development of the country or region under consideration.

The relationship between mobile phones and landlines has also interested a number of researchers with some suggesting a substitution effect while others suggest a complementary relationship. Both complementarity and substitutability have been proved to be true for certain regions and for some subsets of the population. These researchers include Rodini et al. (2003), Ward and Woroch (2004), Ingram and Sidak (2004), Ahn and Lee (1999), Banerjee and Ros (2004), Waverman et al. (2005), Garbacz and Thompson (2007), and Thompson and Garbacz (2007).

There has also been some interesting findings reported by researchers exploring the relationship between economic growth and "good" management of the radio frequency spectrum and they have discovered that there is a positive correlation between these aspects. The effect of the scarcity of radio frequency spectrum on mobile telecoms and hence economic growth was investigated by Hazlet and Muñoz (2009a) and Hazlet and Muñoz (2009b). Hazlet and Muñoz (2009a) evaluated spectrum allocation policies in Latin America and empirically found that more liberal use of the spectrum such as making more of the spectrum available to mobile telephone networks had positive societal and economic implications. Hazlet and Muñoz (2009a) found that allocating more bandwidth to mobile operators increased competition and resulted in reduction of costs and the accrual of social welfare benefits.

Most of the empirical studies to determine the factors affecting mobile proliferation have found deregulation, market competition, GDP and technological innovation as the most important factors. Bohlin et al. (2010) empirically discovered that per capita income, urbanization, Internet/Broadband penetration and regulation are the main drivers of the diffusion of mobile communications. Gamboa and Otero (2009) examined the diffusion of mobile telephony in Colombia based on the Gompertz and Logistic models and they concluded that the diffusion of mobile telephony is better characterized by the logistic models. A similar approach was adopted by Barros and Cadima (2000) who investigated the impact of the diffusion of cellular technology on the fixed line network. They found that the mobile phone diffusion negatively influenced the fixed line penetration rate.

In the next paragraph, a description of the research methodology is given.

3. Research Methodology

The methodology used in this research was an empirical investigation where data were collected for 160 countries, of which 48 are situated in Africa. The paper describes some empirical analyses based on information published in World Bank reports, ITU reports and others. Some of the relationships explored for this global dataset were the telecommunications

proliferation (MLT) relative to factors such as total fixed lines (FLT), freedom from corruption (FC), gross national income per capita (GNIC), etcetera. The empirical analysis entailed some regression studies and applications of the linear response surface analysis technique. The LRSA described by Bruwer and Hattingh (1985) is briefly explained in the next section.

The LRSA method aims at interpreting regression findings by looking at the space or region of experience defined as the convex hull of the data points (taking the independent variables).Thereafter the regression function (linear in this case) is evaluated over this convex hull by linear programming applications. The objective is to find points in the convex hull where the regression function attains a minimum/maximum. These results are then displayed graphically.

In simpler terms, LRSA is a technique that explores the behaviour of a linear function over a region of experience. The linear function may often be the estimated regression function or the model that empirically fits the available observations. The region of experience in this research is obtained by investigating the region defined as the convex hull of the data. This investigation is carried out by solving a sequence of linear programs.

The LRSA technique can be summarised as consisting of the following six steps:

- Obtain a regression model that is "satisfactory".
- Determine the area of experience of the regression model by identifying the convex hull of the available points.
- Identify the variable (often a state variable) for which the influence on the dependent variable have to be investigated.
- Select a specific level for this variable.
- Optimise the regression function over the convex hull where this variable is at a specific level. Obtain maximum and minimum values. Select another level and repeat the procedure.
- Graph the optimum values (maximum and minimum) of the regression function against different levels of the chosen variable.

The vertical distances between the maximum and the minimum piecewise linear graphs are an indication of the relative importance of other independent variables not fixed in the linear program. The reader is referred to Bruwer and Hattingh (1985), Terblanche (2001), and Terblanche and Hattingh (1999) for a detailed analysis, including the mathematical formulation of the LRSA method.

4. Empirical Experiments

Exploratory models that relate MLT (telecommunications proliferation) as a response variable to factors like trade freedom, institutional reforms, gross national income per capita, and others, were investigated.

A hypothetical linear function of the form:

MLT = f (FLT, TELCOST, MO, TF, ILC) was fitted to the data where the acronyms have the following meanings:

MLT: Mobile subscribers (Total); FLT: Fixed telephone lines (Total); TELCOST: Telecommunications Cost;

MO: number of mobile operators (MO is used as a measure of telecommunications deregulation/liberalisation).

TF: Trade Freedom;

ILC: Intensity of Local Competition;

A good fit characterised by an R-squared of 82.34% and an adjusted R-squared of 80.77% was obtained. The detailed regression results (preliminary) appear in Appendix A.

Applying the LRSA technique, illustrative graphs were obtained with both maximum and minimum values given in the tables. (These graphs are later depicted as Figures 1 to 7.) First an illustration is given of the typical LP model that is considered. The example has MLT as the dependent variable and illustrates the graph for FLT as a parameter.

Table 1. For min graph

[FLT]	MO	TELCOST	TF	ILC	(MLT_S	MLT
4.800	3.000	8.970	57.800	0.000	0.018	13169.610
44815.540	3.000	7.492	83.116	1.254	0.129	96385.410
89626.290	3.000	6.977	80.597	2.445	0.275	205704.400
134437.000	3.000	6.461	78.077	3.636	0.422	315024.100
179247.800	3.000	5.946	75.558	4.827	0.568	424343.100
224058.500	3.000	5.431	73.039	6.018	0.714	533662.000
268869.300	3.000	4.915	70.519	7.209	0.861	642981.700
313680.000	3.000	4.400	68.000	8.400	1.007	752300.700

FLT is one of the main factors affecting mobile proliferation, as measured by MLT. This can be seen from the t-value for FLT in the regression. It is high (20.54). In the graph, the max and min graphs are very close to each other. This indicates that other factors have relatively weak influence (in comparison with FLT).

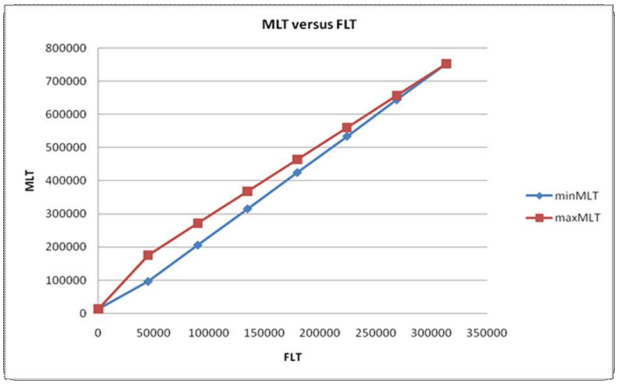

Figure 1. MLT versus FLT

Table 2. For max graph

[FLT]	MO	TELCOS	TF	ILC	(MLT S)	MLT
4.800	3.000	8.970	57.800	0.000	0.018	13169.610
44815.540	5.584	31.273	9.431	5.161	0.235	175753.400
89626.290	5.153	26.794	19.192	5.701	0.364	271844.500
134437.000	4.723	22.315	28.954	6.241	0.493	367935.600
179247.800	4.292	17.836	38.715	6.781	0.621	464026.700
224058.500	3.861	13.358	48.477	7.320	0.750	560118.500
268869.300	3.431	8.879	58.238	7.860	0.878	656209.600
313680.000	3.000	4.400	68.000	8.400	1.007	752300.700

One aspect that is noticeable is that the distance between the min and max graphs is slightly greater at low FLT values. This means that other factors could cause (for a given low FLT value) greater than expected MLT values for countries that have better values for MO, TP, ILC, etcetera.

These countries have then managed what is often termed a "substitution effect" where mobile technology improved the proliferation effect.

Table 3. For min graph

FLT	[MO]	TELC	TF	ILC	(MLT_	MLT
127.100	0.000	49.500	64.600	4.000	0.010	7528.26
775.143	5.857	7.143	86.011	1.086	-0.007	-
1072.686	11.714	5.386	86.855	3.147	0.010	7316.86
1370.229	17.571	3.629	87.698	5.209	0.027	19903.07
1667.771	23.429	1.871	88.542	7.271	0.043	32489.27
5036.599	29.286	0.520	88.943	8.935	0.069	51740.21
19325.550	35.143	0.610	87.771	9.188	0.127	94688.97
33614.500	41.000	0.700	86.600	9.440	0.184	137637.7

MO is a factor influencing proliferation of mobile technology as measured by MLT. It has a t-value on the regression of 2.89 significant at the 0.0045 probability level. The graphs display a relatively large distance between the min and max graphs especially at low MO values (like 5 to

10). At high values of MO such as 30+, the graphs are close to each other and predict a narrow band of low MLT values. It does not seem desirable to have such high values of MO.

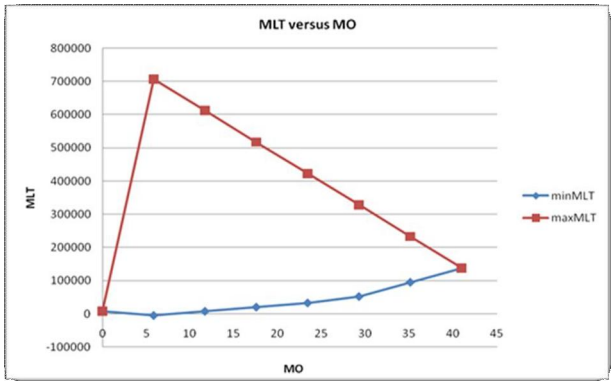

Figure 3. MLT versus MO

Table 4. For max graph

FLT	[MO]	TELCO	TF	ILC	(MLT_	MLT
127.100	0.000	49.500	64.600	4.000	0.010	7528.266
292622.4	5.857	4.122	69.399	8.478	0.945	706085.3
249454.5	11.714	3.552	72.265	8.638	0.818	611344.1
206286.5	17.571	2.981	75.132	8.799	0.692	516602.8
163118.5	23.429	2.411	77.999	8.959	0.565	421861.5
119950.5	29.286	1.841	80.866	9.119	0.438	327120.3
76782.49	35.143	1.270	83.733	9.280	0.311	232379.0
33614.50	41.000	0.700	86.600	9.440	0.184	137637.7

Values of MO in the range 5 to 10 do not automatically predict high MLT levels but possess the potential for high proliferation. This potential can be realised according (to the model) by doing other things right in terms of the other factors involved in the model. This means that other factors like FLT, TF, ILC, and etcetera have to be at "good" levels to realise the potential.

5. Conclusion

The empirical study carried out in this paper, illustrates that some of the main determinants of telecommunication proliferation are:

FLT, TELCOST, MO, TF, ILC.

The following conclusions can be drawn from these findings:

- FLT has a positive strong effect. There are some indications of substitution at low levels of FLT.
- The number of mobile operators also affects MLT. Too many mobile operators seem to be detrimental for attaining high values of proliferation in the MLT sense. However, at average values of MO such as 5 to 15, it seems as if MO is an enabling factor making it possible to achieve high values of MLT, especially for countries that have high values and good fixed line infrastructure.
- TELCOST has an influence on MLT and opportunities exist for countries with low cost and good fixed line infrastructure.

- Trade Freedom at higher levels allows higher proliferation of MLT, especially for countries with good fixed line infrastructure, and lower TELCOST values.
- ILC correlates well with MLT and higher values of ILC especially when also associated with high values of FLT, and low TELCOST.

6. Future work

This is a work in progress paper and we plan to introduce different measures of telecommunication proliferation in further analysis.

We also plan to explore the policy implications of these analyses.

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