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MASTER

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MASTERS FINAL WORK

DISSERTATION

THE IMPACT OF THE TELECOMMUNICATIONS SECTOR ON ECONOMIC GROWTH

RUI FILIPE CARDOSO PEDRO

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Abstract

The objective of this work is to study whether the evolution of the telecommunication sector has any significant impact in the economic growth of Portugal and other regions of the world.

The telecommunications sector is one of the sectors that gained a relevant role in economic development worldwide. The acknowledgement of this sector has increased since the 90's, with the development of several technologies that contribute to the rising of the consumption of this type of good and the evolution of its dynamic and structure.

Countries equipped with the more advanced telecommunications systems have been rapidly moving into post-industrial, information-based economic growth.

In this work the methodology used is panel data, with an empirical analysis of both developed and developing economies in the past two decades.

Keywords: Telecommunication Sector, Economic Growth, Information Technology

JEL Codes: O47, L96, O33

Resumo

O objetivo desta dissertação é estudar se a evolução do sector das telecomunicações tem qualquer impacto significativo no crescimento económico de Portugal e outras regiões do mundo.

O sector das telecomunicações é um dos sectores que ganharam um papel relevante no desenvolvimento económico mundial. O reconhecimento deste sector tem aumentado desde os anos 90, com o desenvolvimento de várias tecnologias que contribuem para a subida do consumo deste tipo de bem, a evolução da sua estrutura e dinâmica.

Países equipados com os sistemas de telecomunicações mais avançados conseguiram evoluir rapidamente para uma era pós-industrial, com o crescimento económico baseado na informação.

Neste trabalho, a metodologia utilizada é a de dados de painel, com uma análise empírica dos mercados desenvolvidos e em desenvolvimento nas últimas duas décadas.

Palavras-Chave: Setor das Telecomunicações, Crescimento Económico, Tecnologias da Informação

Códigos JEL: O47, L96, O33

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1. Introduction

Over time, telecommunications have suffered a huge transformation. The only constant pattern that persists on this type of sector is change. Together with technology, the telecom industry has been expanding rapidly and, although more slowly in recent years partly due to the recent global financial crisis, it is still growing every year (as we can see in Figure 1 in Appendix B). Additionally, this expansion has also been provoked by a reduction of costs (Leff, 1984) and also increasing capacity (Nadiri and Nandi, 2003). The liberalization and introduction of competition in this type of market has also helped growth and the technological development.

Despite the fact that the growth of the telecommunications sector has started some years earlier in the high income economies, since the beginning of the millennium countries with less developed economies, categorized as lower middle income and low income, have shown the higher rates of growth. Nevertheless, we assist in all type of income groups and regions a continuous growth over the time (see Figure 2 and Figure 3 in Appendix B).

There are several ways in which telecommunications can contribute to economic and societal development, direct and indirectly, but we would like to emphasize at least four of them: first, business retention; second, economic diversification; third, enhancement of quality of life; and fourth increasing business competitiveness (Pradhan et al, 2014).

Another important input to this subject, also defended by many authors, is that "if the telephone does have an impact on a nation's economy, it will be through the improvement of the capabilities of managers to communicate with each other rapidly over increased distances” (Hardy, 1980, page 279).

Telecommunications have gained much interest in economic research, because of the existence of network externalities, that means it increases the value with the increase of the number of users (see, for instance Kim et al, 1997 and Roller & Waverman, 2001). Others authors developed their research by looking at the direction of causality, as defended by Jipp (1963), between telecommunications and economic growth (see Cronin et al, 1991 and Pradhan et al, 2014).

In this perspective, some of the questions that we intend to answer are: first, seek whether the telecommunications sector is relevant to promote economic growth; second, whether there any evident different patterns in growth in different geographic zones or income groups provoked by the telecommunications sector; and third, study whether the recent international financial crisis impacted the evolution of the telecommunications sector.

To pursue our objectives, we construct an econometric analysis of the relationship between economic growth and the telecommunications, with the use of a panel data approach for 150 countries described in table V of Appendix B, for the period of 2000 to 2014. However, some countries were excluded, due to the lack of data. Our data includes the following five groups by geographical area: Worldwide, Africa, Americas, Europe, Asia & Oceania. Furthermore, we perform analysis for the following groups of income level and state of development: High Income, Upper Middle Income, Lower Middle Income, Low Income, Developed and Developing (Less Developed). These sub-groups are based on the classification of the International Telecommunications Union (ITU) which follows the classification of the United Nations for statistical purposes, namely the M49.

The main conclusions reached are the following: (1) the telecommunications sector play a significant and important role in economic growth; (2) the differences between regions are significant, with the middle income countries, especially the upper middle income countries, producing a higher impact on economic growth by the investment on telecommunications than other type of income groups, and the developed countries having a higher impact on economic growth than those in development; (3) results also show that the correlation between telecommunications and the economic growth is not simply due to reverse causality, since the lagged values of telecommunications are statistically significant, which supports the point that this relationship is not due to reverse causality.

The remainder of this dissertation is organized as follows. In Section 2, a revision of the telecommunications sector theories is presented, together with some references regarding economic growth. Section 3, describes the sample and methodology. The tests and results are described in Section 4, and Section 5 concludes.

2. Literature Review

Many different theoretical models have been proposed to study economic growth, so the literature on this subject is very large, principally over the last two decades.

This work focuses on one aspect in particular, that is the debate on whether the contribution of the telecommunications sector is one of the reasons that move economic growth, despite the recent financial crisis. Therefore, we will review in the following the most important findings on the relationship of Economic Growth with Telecommunications.

One of the first studies that confirm a clear positive correlation is the work of Jipp A. (1963). Using data for different countries, the author identified for the first time a positive link between the *per capita* GDP and the indicators of telephone density, also named as *Jipp Curve*, but this statistical correlation does not prove causality.

Years later, another also pioneering study was the work of Andrew P. Hardy (1980), which investigates the telephone's role as a contributory agent in economic development. Using statistical information for 60 countries over 13 years, and applying cross-lagged correlation techniques to the time series, he determines and confirms that the telephone can contribute to economic development.

After this contributions, many are the studies that have analyzed the relationship between economic growth and telecommunications sector, with several types of analysis, applications and different economic schools of thought. For example, Lichtenberg (1995), Greenstein and Spiller (1996) and Madden and Savage (1998), explain different causes and contributions of telecommunications sector on economic growth.

Lichtenberg F. (1995), for the period of 1988-91, studied the contributions of capital and labor deployed in information systems at a firm level. The main conclusions are that the estimation of the production function suggests the existence of a considerable excess returns to capital and labor in information systems, but with a larger size and significance of the excess returns to capital.

Greenstein, S. M. & Spiller, P. T. (1996), examine a more specific question, the investment by local exchange telephone companies in optical fiber cable (lines and signal software), defending that it plays an important role in local telephone networks by bringing digital technology. In their main conclusions, we can see a confirmation of consumer demand being sensitive to investment in technology, especially the optical fiber cable, and also that the growth in consumer surplus and the business local revenues are increased by the investment in this infrastructure.

Madden G. & Savage S. J. (2000), continue the same line of thinking and study the relationship between gross fixed investment, telecommunications infrastructure investment and economic growth for Central and Eastern Europe. Conclusions confirm evidence of growth preceding investment, indicating an accelerator type mechanism.

However, these approaches have some limitations as they did not include more complex and structural models and also neglected a bidirectional causality analysis of telecommunications and economic growth. On the one hand, some authors argued that the bidirectional causality between telecommunications and economics plays an important role. Although there already exist some inconclusive results on the direction of causality, in the seminal work of Cronin et al (1991) was discovered a two-way relationship between both variables in the United States, and more recently Pradhan et al (2014), raised again this possibility by confirming a difference between the short-run and the long-run results. Cronin et al (1993a, 1993b), additionally indicated that investment in this infrastructure was a reliable predictor of national productivity.

On the other hand, using structural models helps analyzing better the correlation of the development of telecommunications sector and economic growth, since controlling for some macroeconomic variables they allow to isolate the direct effect of infrastructure on growth. Examples of applications of these models are for instance Dholakia and Harlam (1994), Roller and Waverman (2001), Datta and Agarwal, (2004) and Shiu and Lam, (2008, 2010), which will be discussed in the following.

In Dholakia R. R. and Harlam B. (1994), investment in the telecommunications infrastructure is justified because of the positive influence on economic development. Results of an econometric analysis of data from 50 states of the United States of America suggests a very strong influence when it is viewed as the only developmental input as well as when it is compared with other infrastructures. Findings also suggests that it is not a question of simple trade-offs between investment in one input with that of another. Instead, investment has to be made in multiple infrastructures.

In the contribution of Roller and Wavermen (2001), a model is estimated by nonlinear general methods of moments for a sample of 21 OECD countries over a 20-year period, and, to pick up economy wide effects, the micromodel is estimated with the macro production function. Results show that telecommunications infrastructure has a positive effect on economic growth, and also that increases in this type of infrastructure could create higher growth effects than in less-developed non-OECD countries.

Datta and Agarwal (2004) use a dynamic panel data method in order to investigate the long run relationship between telecommunications and economic growth, correcting for omitted variables bias, in a single equation cross-section regression; the results show a significant and positive correlation, after controlling for a number of other factors. Later the works of Ding et al (2008) and Batuo (2015) follow the same methodology, analyzing China and Africa, respectively.

Shiu and Lam (2008) construct a dynamic panel data to study the effect of the telecommunications infrastructure on the regional economic growth across China. Results indicate a positive relationship between the two variables, and that causality is found only in the affluent provinces. Nevertheless, in the central and western provinces the improvement in telecommunications infrastructure by itself is not sufficient for stimulating growth. Years later, Shiu and Lam (2010), using data from 105 countries and also applying a dynamic panel data to investigate this relationship, indicate that there is a bidirectional relationship between gross domestic product and telecommunications for the European and High Income Countries.

The main conclusions of the vast empirical literature around this relationship is that "telecommunications infrastructure does itself lead to growth because its products – cable, switches, and so forth – lead to increases in the demand for the goods and services used in their production" and also "the economic returns to telecommunications infrastructure investment are much greater that the returns on just the telecommunication investment itself." (Roller and Waverman, 2001, page 909).

More recently, the work of Chakraborty & Nandi (2011) confirm that the impact on economic growth is expected to be higher when the investment is in telecommunications infrastructure rather than in other types of infrastructure.

Nevertheless, few studies compare the relationship worldwide. Can we say that all regions are sensitive to this relationship? Can we confirm the same relationship for the income distribution in general? Many defend that the impact is higher in countries with competition and privatization of the telecommunications sector than in those without it, and also that countries in the upper-middle income group can contribute for a higher economic growth than others (Shiu and Lam, 2010).

In the present work, therefore, an empirical analysis on recent data from most countries worldwide is performed, expecting to shed some light on the current global picture.

(Table III, in Appendix A, presents a brief summary of the literature review, where the main objectives and conclusions achieved are presented)

3. Empirical Analysis

This chapter has the main goal to describe the choice of the economic model and the database construction. First, the various empirical models used in the cited literature are reported, and the choice of the variables determining growth is discussed together with their expected effect. After this discussion, the model chosen for this study is presented, with a detailed discussion and justification of the chosen regressors. Finally, the total available sample is described, together with a proposal of sub-samples for a specific analyses by region and income groups.

3.1The model

Among the large amount of models that exists to study the relations between economic growth and telecommunications, the methodology used in this work follows the works of Batuo M. (2015), Ding et al (2008) and Datta and Agarwal (2004); using dynamic panel data following Islam (1995), these works take into account the correlation between previous and subsequent values of growth, analyzing the telecommunications impact on economic growth in Africa, China and OECD countries, respectively. All this studies follow the growth equation approach by Barro (1991) and Barro and Sala-i-Martin (1997), in which the determinants of growth are examined including the conditional convergence hypotheses.

Conditional convergence occurs when the partial correlation between the variable growth and the initial level is negative Barro (1992). The growth equation, as we can see in Ding and Haynes (2006) and Ding et al (2008), including the telecommunications penetration, in the static specification of the model has the following form:

$$GRTH_i = \alpha_0 + \beta_1 Ln(GDP)_{i,0} + \sum_{j=2}^{n-1} \beta_j X_{i,0} + \beta_n TEL_{i,0} + \varepsilon_i \qquad (1)$$

Where: i - Indexes countries; $GRTH_i$- Annual growth rate of real GDP *per capita* for i; $X_{i,0}$- Other conditioning variables; $TEL_{i,0}$- Telecommunications penetration for i;

Although there is an unrealistic hypothesis of identical aggregate production functions across countries, Islam (1995) uses a dynamic panel data model that allows for unobservable individual effects. So the dynamic approach of the model, including country effects, has the following specification:

$$Ln(GDP)_{i,t} = \alpha_0 + \beta_1 Ln(GDP)_{i,t-1} + \sum_{j=2}^{n} \beta_j X_{i,t} + \beta_n TEL_{i,t} + \mu_i + \eta_t + v_{it} \quad (2)$$

Where: i - Indexes countries; t - Indexes time; η_t - The unobserved time-effects; v_{it}- The transitory error term; μ_i - Independent term that capture the country fixed effects;

Following this approach, Datta and Agarwal (2004) used a panel data similar to Islam (1995), which includes the lagged growth rate and a lagged GDP *per capita*:

$$GRTH_{it} = \alpha_0 + \gamma GRTH_{i,t-1} + \beta_1 Ln(GDP)_{i,t-1} + \sum_{j=2}^{n} \beta_j X_{i,t} + \beta_n TEL_{i,t} + \mu_i + \eta_t + + v_{it} \quad (3)$$

In the same study, the same growth equation is extended to include the effects of telecommunications penetration on growth:

$$GRTH_{it} = \alpha_0 + \beta_1 GRTH_{i,t-1} + \beta_2 Ln(GDP)_{i,t-1} + \beta_3 POP_{i,t} + \beta_4 G^C/Y_{i,t} + \beta_5 I/Y_{i,t} + + \beta_6 OPEN_{i,t} + \beta_7 TEL_{i,t} + \mu_i + \eta_t + v_{it} \quad (4)$$

In our empirical study, we chose the equation below, whose specification is explained in the following:

$$GRTH_{it} = \alpha_0 + \beta_1 GRTH_{i,t-1} + \beta_2 Ln(GDP)_{i,t-1} + \beta_3 POP_{i,t} + \beta_4 Ln(G^C/Y)_{i,t} + + \beta_5 Ln(I/Y)_{i,t} + \beta_6 Ln(OPEN)_{i,t} + \beta_7 Ln(TEL)_{i,t} + \mu_i + \eta_t + v_{it} \quad (5)$$

where the dependent variable is the rate of growth of real gross domestic product *per capita* ($GROWTH_{it}$), measured at current international prices.

The first independent variable is the one period lag of the rate of growth of real gross domestic product *per capita* ($GROWTH_{i,t-1}$), where GDP is in the logarithmic scale.

The second variable is the logarithm of the one period lag of the real gross domestic product *per capita* ($GDP_{i,t-1}$). The inclusion of this variable has the main goal to test the convergence, so a negative sign is expected, in other words, to measure the effect of past levels of GDP on subsequent growth, a higher level of past GDP leads to lower subsequent growth.

Next we include the rate of growth of the population (*POP*), whose expected sign is negative, as a lower population growth relates to higher GDP *per capita*.

The fourth explanatory variable is the share of government consumption in GDP (G^c/Y) as the ratio of government purchases to real GDP, and is measured in logarithm. The expected sign is negative as defended by Barro (1991), "government consumption lowers savings and growth through the distorting effects of taxation or government-expenditure programs". Additionally, a fifth variable is included that measures the share of fixed investment in GDP (I/Y), also in logarithm, and has a positive expected sign.

Next, we have the measure of the extent to which the country is integrated into the global economy (*OPEN*), which is calculated in logarithm and measured by the total of imports and exports in proportion of real gross domestic product. The expected sign is positive, according to the economic theory.

As seventh, we have the crucial variable of our study, the telecommunications penetration (*TEL*), which is measured as logarithm of the total of fixed telephone subscriptions (per 100 people), fixed broadband subscriptions (per 100 people), mobile cellular subscriptions (per 100 people) and internet users (per 100 people). The application of the logarithm follows Batuo (2015), and is justified because of the exponential pattern of this variable over time. Other variables were also included to measure the total of the telecommunications penetration, namely the fixed broadband subscriptions (per 100 people), mobile cellular subscriptions (per 100 people) and internet users (per 100 people), justified by the fact of being well developed technologies[1]. The expected sign for telecommunication variable is positive.

The explanatory variables chosen, follows the works of Datta and Agarwal (2004) and Batuo (2015) and where chosen to perform a full comparative analysis to different regions and income groups, as mentioned in Section 3.2.. Also following this works, we we will also perform the estimation of a two other specifications, in order to confirm that the results are not simply due to reverse causality; variable TEL is therefore introduced in its lagged values at *t-1* and *t-2*, giving rise to the following two alternative models:

$$GRTH_{it} = \alpha_0 + \beta_1 GRTH_{i,t-1} + \beta_2 Ln(GDP)_{i,t-1} + \beta_3 POP_{i,t} + \beta_4 Ln(G^C/Y)_{i,t} + \\ + \beta_5 Ln(I/Y)_{i,t} + \beta_6 Ln(OPEN)_{i,t} + \beta_7 Ln(TEL)_{i,t-1} + \mu_i + \eta_t + v_{it} \quad (6)$$

$$GRTH_{it} = \alpha_0 + \beta_1 GRTH_{i,t-1} + \beta_2 Ln(GDP)_{i,t-1} + \beta_3 POP_{i,t} + \beta_4 Ln(G^C/Y)_{i,t} + \\ + \beta_5 Ln(I/Y)_{i,t} + \beta_6 Ln(OPEN)_{i,t} + \beta_7 Ln(TEL)_{i,t-2} + \mu_i + \eta_t + v_{it} \quad (7)$$

If the causal relationship is reversed, that is if growth influences telecommunication rather than vice-versa, then the lagged values of telecoms should not be significant. On the other hand, if the lagged telecom variables are significant, this confirms that telecommunications affect growth.

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[1] Jacobsen (2003) uses the personal computers and Koutroumpis (2009) uses the broadband for estimation.

In summary, the control variables used, the unit of measure and expected signs of impact are described in Table I:

Table I– Summary of the variables presented in the study

Variable	Name	Unit of measure	Exp. sign
Annual growth rate of the real GDP *per capita*	*Growth*	Annual %	
One year lag of growth rate of real GDP *per capita*	$Growth_{t-1}$	Annual %	Positive
Real GDP *per capita* measured in purchasing power parity	*GDP*	Real	Negative
Annual rate of growth of population	*POP*	Annual %	Negative
Share of government consumption in GDP	G^c/Y	% of GDP	Negative
Share of fixed investment in GDP	I/Y	% of GDP	Positive
Level of integration into global economy	*Open*	% of GDP	Positive
Telecommunications penetration	*Tel*	Real	Positive

Sources: Own elaboration, based on economic theory

3.2The sample

As already mentioned, the objective of this empirical study is to test the existence of a positive link between the telecommunications sector and economic growth. To analyze this contribution, data were retrieved from the World Banks's World Development (WDI) database, for the period 2000-2014, over 150 countries. Table II, presents a summary of indicators for the whole sample. Table IV of Appendix B presents detailed descriptive statistics for each country.

Table II – Descriptive statistics for panel - 150 countries, time period: 2000-2014

Variable	N	Mean	S.Dev.	Min	Max
GROWTH	2250	0,08	0,14	-0,64	2,95
GDP pc	2250	11 912	17 317	106	116 613
POP	2250	0,01	0,01	-0,02	0,15
G^c/Y	2250	0,15	0,05	0,02	0,43
I/Y	2250	0,23	0,09	0,01	1,46
OPEN	2250	23 390 703	71 740 876	39 655	849 140 548
TEL	2250	120,19	92,92	0,06	447,12

Sources: World Development Indicators – World Bank
Note: N is the number of observations

This work will focus initially on the analysis of the total sample, and later on further subgroups divided by the following geographical areas: Africa (43); Americas (31), Europe (42) and Asia & Oceania (34). The inclusion of Oceania in Asia is justified for being a small sample to study. Furthermore, we will analyze the data for the following income groups and state of development, as rated by WDI and the ITU that follows the UN M49 database: High Income (49), Upper Middle Income (42), Lower Middle Income (35); Low Income (24); Developed (39); Developing (111). The countries included in each of the above groups are displayed in Table V of the Appendix B.

4. Estimation Methods and Results

To analyze whether the telecommunications influence economic growth, a panel data set is used, having cross-sectional and a time series dimension. There are several advantages of using panel data[2]:

- Controlling unobserved heterogeneity – The techniques of panel data estimation can take such heterogeneity explicitly into account by allowing for individual-specific effects;
- Better suited to study the dynamics of change;
- Possibility to study more complex behavioral models;

In our analysis, we will consider the estimation of equations (5), (6) and (7), for the sub-groups mentioned before. The method of estimation employed is a GMM estimator, namely the difference GMM estimator, which was introduced by Holtz-Eakin, Newey, and Rosen (1990) and developed by Arellano and Bond (1991), designed for dynamic panel data models with few time periods and many individuals. Using linear GMM, the difference GMM executes the estimation after first-differencing the data, eliminating the fixed effects. This estimating procedure allows for the use of a set of internal instrumental variables, to deal with endogenous regressors, created from past observations of the instrumented variables (Roodman, 2008). Also, the robust estimation allows to deal with the presence of heteroskedasticity and serial correlation in the errors.

The most recent lags of the instrumented variables are indeed the best instruments, but they may be correlated with the error term, and this means that their validity can be

[2] For a depth information, see e.g. Gujarati (2004:637) and Baltagi (2005)

compromised. In order to test if that is the case, the Hansen test is performed, using the *J* statistic, where a high *p* value confirms the validity of the chosen instruments, and by consequence of the GMM results. However, in some cases the lags may turn out to be weak instruments for the first differenced model, especially if the autoregressive parameter is close to one. In these situations, an appropriate alternative is the system GMM estimator of Blundell and Bond (1998), where additional moment conditions are obtained from a level equation. A key condition to ensure that our estimation is consistent is that serial correlation of first order but not of second order should occur in the first difference model. These conditions can be tested using the Arellano-Bond test for autocorrelation. If a higher serial correlation is detected, than our instruments must be reviewed and redefined using older lags of the variables.

The software used for estimation is Stata 12.0 and the command performed is *xtabond2* developed by Roodman (2006). The estimation is based on a two-step difference GMM estimator, with robust standard errors. Two-step difference GMM estimator is more efficient than one-step, providing the finite-sample correction to the covariance matrix proposed by Windmeijer (2005).

In summary, we perform a difference GMM in a two-step procedure with a robust estimation of the variance-covariance matrix, which means standard errors are robust to both heteroscedasticity and arbitrary patterns of autocorrelation within individuals.

4.1The results

The estimation results for equation (5) are reported in Table VII in Appendix C, where we show the coefficient values, standard error in parentheses and significance reported at the 1%, 5% and 10% levels by ***, ** and *, respectively. Table VIII and Table IX show the estimation of equations (6) and (7), in order to confirm that the results are not simply due to reverse causality. We perform the estimation of the model as described above, for the overall worldwide sample and for each of the proposed sub-group by region, income level and development stage, in order to make a complete comparative analysis.

The first overall picture of our results show confirmation of correct specification of the various aspects of the models: in the Arellano-Bond test for autocorrelation of the errors we reject the null hypothesis in AR (1), but we do not reject it in AR (2), as expected. Secondly, the Wald Test, which tests the global significance of the regression, is statistically significant. The Hansen *J* statistic, which is used to determine the validity of the over-identifying restrictions in the GMM model, confirms that our instruments are valid in all estimated models. The coefficients signs, when statistically significant, are according to our expectation as described before.

Starting to analyzing the first specification as in equation (5), we find that the past levels of Growth ($GRTH_{i,t-1}$) are statistically significant in the total sample and almost all sub-groups (with the exception of Americas, Asia & Oceania and Lower Middle Income). The sign is according to the economic theory, despite the recent financial crisis, which could be the reason for the lack of significance in some of the estimations.

Next, we have the past level of GDP *per capita*, which shows a negative coefficient, significant at 1% level in all the estimations. This supports the convergence hypothesis, that means that countries with higher levels of GDP *per capita* have a tendency to grow at a slower rate and that countries with a lower levels of GDP *per capita* grow faster. The share of government consumption in GDP which is measured by the variable G^c/Y is negatively and significantly associated with economic growth, result that is in line with Barro (1990:121), where it is argued that government consumption diminishes savings and the economic growth through the distorting effects of taxation or government-expenditure programs.

The population growth (*POP*), the share of fixed investment in GDP (I/Y) and the level of integration into global economy (*OPEN*) are not statistically significant in the total sample, although they are significant in some sub-groups with smaller samples. For example, the population growth is only significant, with a negative impact, in America and Asia & Oceania, which could indicate that in general it is not a very relevant determinant of economic growth. The share of fixed investment in GDP has a positive and significant impact in Europe, Lower Middle Income and Developed countries. Finally, the level of integration into global economy is positive and statistically significant in Europe, High Income and Developed Countries, fact that in the case of Europe could be linked with the European Union being highly open. Nevertheless, an unexpected negative sign appears in America, Upper and Lower Middle Income, but it is only significant at a 10% level, and becomes non-significant in the models where we consider further lags of the telecom variable.

Finally, we verify that the Telecommunications Penetration is statistically significant at 1% level to explain economic growth in all groups and sub-groups of panels. In fact, this proves that there is a strong impact of telecommunications penetration on economic growth. The estimated coefficient indicates, for the total sample, that for an increase of 10 subscriptions (per 100 people) the growth rate of GDP *per capita* will increase by 0,18%. However, when we analyze the sub-groups findings, some differences are found between regions, income groups and stage of development. For regions, Europe shows a larger size of the influence of telecoms on economic growth than other regions, with Asia & Oceania being the region with smaller influence. As for the income group, results show that countries with Upper Middle Income can more easily influence economic growth by investing in this type of good, compared to countries in other income groups. By the level of development, results show that in Developed countries telecoms have a much higher impact on economic growth than in those in Development, and this could be due to technology changes being more easily accessed by the developed countries. Therefore, we can globally affirm that the telecommunications has a positive influence to the economic growth.

However, as already mentioned, in order to confirm that this relationship between telecommunications and economic growth is not due to reverse causality, we use the lagged values of the telecommunications and estimate equations (6) and (7), with the summary of the results showed in Table VIII and Table IX of Appendix C. Results show that telecommunications penetration does still have a positive impact even in its lags. This is confirmed by the coefficient of the one-lagged and the two-lagged values of the telecommunications penetration being positive and significant at the 1% level, although with a smaller magnitude when compared to the current value, with this result also being in line with the works of Datta and Agarwal (2004) and Batuo (2015). The only exceptions is the estimation of the effect for Low Income countries, where telecommunications are not statistically significant if lagged.

In summary, by the AR and Hansen tests results we have confirmation that our instruments are valid, and there is no evidence of serial correlation of second order in our first-difference estimation. Moreover, as expected, the results clearly confirm that telecommunications have a positive and solidly significant relationship with growth. Overall, the results are according to the initial expectations and do not underpin the economic theory. Finally, we verify that some variables are statistically significant to explain economic growth only in some sub-groups of our sample of countries, and maybe this could depend on issues such as aging population, the ability of capital accumulation, and markets obstacles.

5. Conclusions

In this work, we explore the empirical relationship between telecommunications and economic growth with a sample of 150 countries, classified according to different regions of the world, different income levels and different state of development, over the period 2000 to 2014, and following the works of Batuo M. (2015), Ding et al (2008) and Datta and Agarwal (2004), using a dynamic panel data model.

The method of estimation employed is a difference GMM estimator, introduced by Holtz-Eakin, Newey, and Rosen (1990) and developed by Arellano and Bond (1991).

The telecommunications is both statistically significant and positively correlated to the GDP *per capita* growth for the overall worldwide model. When we analyze specific sub-groups of regions of countries, we see that Europe is the region where telecoms contribute more to the economic growth; likewise, in the analysis by income group, the upper middle income countries are those where the effect on economic growth is larger. This conclusion is consistent with the findings in Lam and Shiu (2010). For what concerns the countries' level of development, results show that developed countries have a higher estimated impact than those in development, and such result could be explained by the constant technological changes being more easily accessed by the developed countries than those in development, and also due to the rapid spreading of information and a reduction of costs. The results also show, with the exception of Low Income countries, that the correlation between telecommunications and the economic growth is not simply due to reverse causality, since the lagged values of the telecommunications variable are statistically significant. The lagged GDP *per capita* has a negative and significant estimated effect on growth in all the samples, which supports the convergence hypothesis, that means countries with higher levels of GDP *per capita* have a tendency to grow at a slower rate.

However, in the contribution that we made in the present work to the discussion on the interactions between the telecommunications and growth, there are some limitations in the analysis that we would like to point out: (1) we analyze the telecommunications penetration as a whole, and we could also seek, inside this infrastructure, which type of consumption good is more relevant to the economic growth by testing them separated as individual or grouped, for example groups of voice and internet; (2) some variables are not statistically significant in most of the models estimated in the sub-groups, and other variables were not available, such as those used in Ding et al. (2008), for example the share of total employment to total population and the human capital among others.

For further studies, we can also seek to investigate how the evolution of the telecommunications sector changes the composition of revenues of the market. The competition in local services where not analyzed and could explain some of the divergences between the sub-groups of estimation, namely whether the market structure is a monopoly, duopoly or in full competition. Last but not least, we could analyze if the difference on findings are due to the insufficiency of some countries' infrastructure, and if less developed countries are behind other due to this insufficiency.

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Appendix A – Literature review summary

Table III - Literature review summary

LITERATURE	MAIN CONCLUSIONS
Hardy (1980)	Telephones *per capita* had a significant impact on GDP, while the spread of radios did not.
Cronin et al (1991)	Relationship between telecommunications and economic growth is a result of reverse causality
Dholakia & Harlam (1994)	Positive relationship and that is not a question of simple trade-offs between investment in one input.
Lichtenberg (1995)	Considerable excess returns to capital and labor information systems
Greenstein & Spiller (1996)	Telecommunications infrastructure has a positive and significant effect on employment growth in the USA
Madden & Savage (1998)	Positive contribution to development of economies and evidence of a bi-directional relationship
Roller & Waverman (2001)	Positive effect of telecommunications infrastructure on economic growth
Datta & Agarwal (2004)	The results show a significant and positive correlation between telecommunications infrastructure and growth
Ding et al (2008)	System GMM estimation is more likely to produce consistent and efficient estimates than OLS and fixed-effect estimation. Positive relationship between telecommunications and regional economic growth
Shiu and Lam (2008)	There is a unidirectional relationship running from real GDP to telecommunications at the national level and improvement in telecommunications infrastructure alone is not sufficient for stimulating growth in all regions.
Shiu & Lam (2010)	Bidirectional relationship between real GDP and telecommunications. However, when the impact is measured separately, the relationship is no longer restricted.
Pradhan,et al (2014)	Find a bidirectional causality between development of telecommunications infrastructure and growth.
Batuo (2015)	Investment in telecommunications is subject to increasing returns, demonstrating that an increase in telecommunications investment produces further growth.

Appendix B – Sample Statistics

Figure 1 - World Growth rate of GDP pc and Telecommunications from 1995-2014

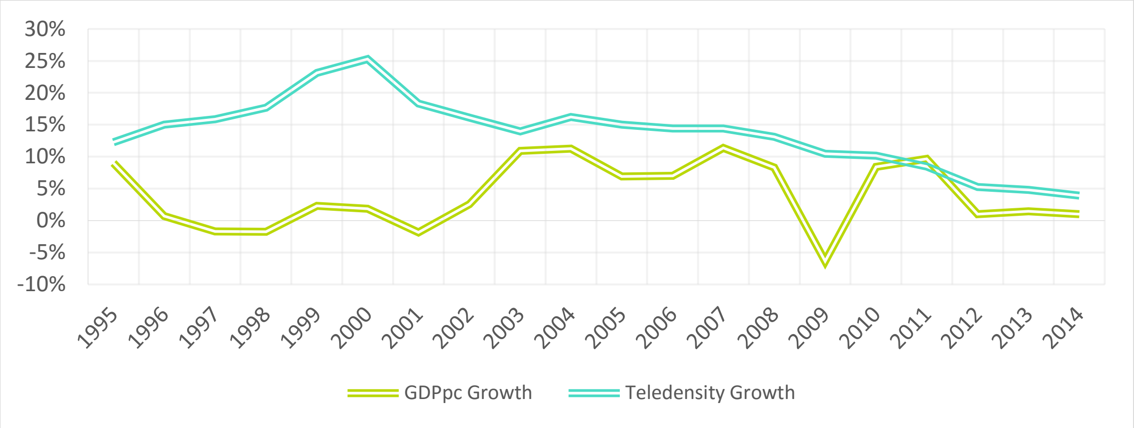

Figure 2 - World Telecommunications subscribers (per 100 people) from 1995-2014

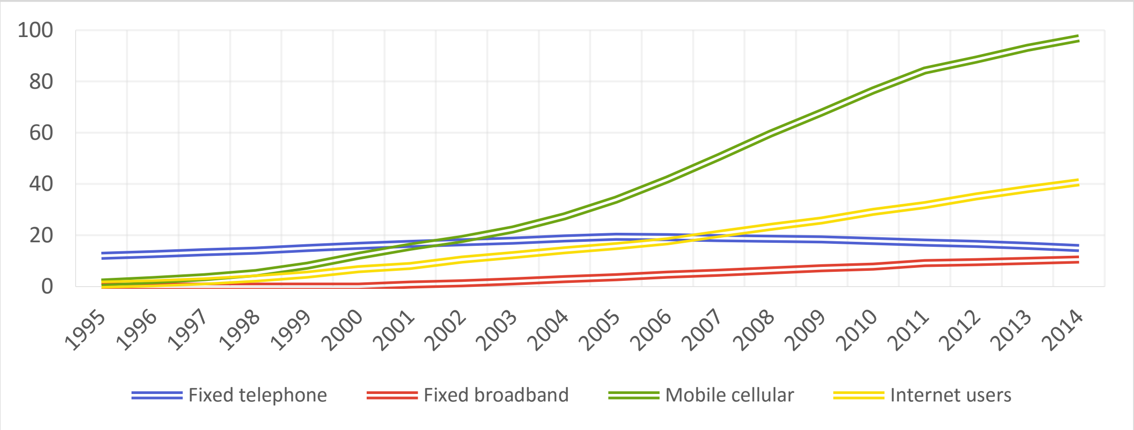

Figure 3 - Average Telecommunications subs. (per 100 people) from 1995-2014

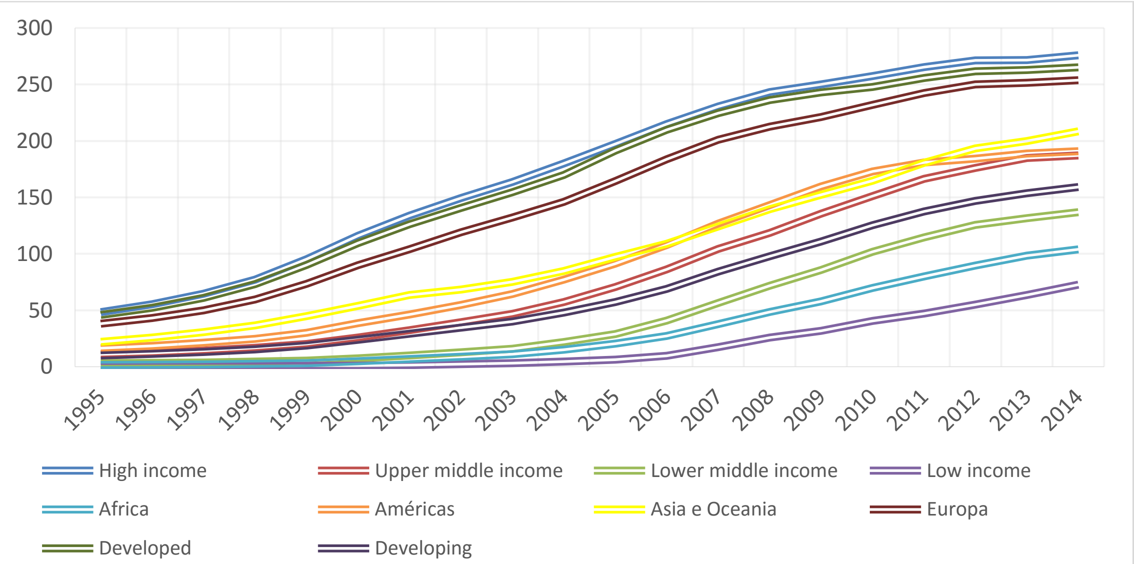

Table IV – GDP per capita and Total of Telecommunications by state of development

State DEVT	***Country***	***GDP per capita***		***CAGR %***	***Telecomunic. Subscribers***		***CAGR %***
		2000	***2014***	***00-14***	***2000***	***2014***	***00-14***
-Developed Countries (39)	Albania	1 176	4 589	10,2	5,64	179,54	28
	Australia	21 665	61 996	7,8	143,39	282,34	5
	Austria	24 517	51 148	5,4	162,21	298,75	4,5
	Belarus	1 273	8 025	14,1	29,93	258,86	16,7
	Belgium	23 207	47 300	5,2	134,7	275,93	5,3
	Bulgaria	1 609	7 851	12	50,62	239,2	11,7
	Canada	24 124	50 185	5,4	152,21	249,71	3,6
	Czech Republic	5 995	19 502	8,8	89,97	255,77	7,7
	Denmark	30 744	61 331	5,1	175,28	296,44	3,8
	Estonia	4 070	20 148	12,1	107,62	305,55	7,7
	Finland	24 253	49 865	5,3	164,99	276,08	3,7
	France	22 466	42 547	4,7	121,1	285,17	6,3
	Germany	23 719	47 767	5,1	148,39	299,28	5,1
	Greece	12 043	21 627	4,3	114,64	248,74	5,7
	Hungary	4 620	14 022	8,3	74,27	251,85	9,1
	Iceland	31 737	52 037	3,6	191,54	296,65	3,2
	Ireland	26 236	54 321	5,3	130,71	254,91	4,9
	Italy	20 051	35 180	4,1	145,1	273,49	4,6
	Japan	37 300	36 153	-0,2	133,08	290,21	5,7
	Latvia	3 351	15 692	11,7	54,23	236,97	11,1
	Lithuania	3 297	16 490	12,2	55,35	265,29	11,8
	Luxembourg	48 992	116 613	6,4	149,5	329,47	5,8
	Macedonia	1 875	5 453	7,9	32,85	208,55	14,1
	Moldova	354	2 245	14,1	18,88	204,5	18,6
	Netherlands	25 921	52 139	5,1	175,79	291,71	3,7
	New Zealand	13 641	44 380	8,8	134,93	269,18	5,1
	Norway	38 147	97 430	6,9	177,75	272,49	3,1
	Poland	4 493	14 337	8,6	53,42	247,03	11,6
	Portugal	11 502	22 124	4,8	123,27	245,62	5
	Romania	1 668	10 012	13,7	32,19	199,59	13,9
	Russian Fed.	1 772	13 902	15,9	26,05	270	18,2
	Slovak Rep.	5 403	18 501	9,2	64,02	235,6	9,8
	Slovenia	10 228	24 002	6,3	115,69	247,31	5,6
	Spain	14 788	29 719	5,1	116,51	251,86	5,7
	Sweden	29 283	58 900	5,1	188,57	293,66	3,2
	Switzerland	37 813	85 611	6	185,69	319,78	4
	Ukraine	636	3 065	11,9	23,62	221,42	17,3

State DEVT	*Country*	*GDP per capita*		*CAGR %*	*Telecomunic. Subscribers*		*CAGR %*
		2000	*2014*	*00-14*	*2000*	*2014*	*00-14*
DC	Unit. Kingdom	26 401	46 279	4,1	160,38	304,92	4,7
	United States	36 450	54 398	2,9	151,68	268,46	4,2
Developing Countries (111)	Algeria	1 757	5 484	8,5	6,32	122,81	23,6
	Angola	606	5 233	16,6	0,76	86,42	40,3
	Antigua & Bar.	10 095	13 432	2,1	84,14	229,79	7,4
	Argentina	7 669	12 751	3,7	46,01	262,04	13,2
	Armenia	621	3 874	14	19,21	190,56	17,8
	Azerbaijan	655	7 886	19,4	15,2	210,72	20,7
	Bahamas, The	21 241	22 217	0,3	56,99	212,23	9,8
	Bahrain	13 591	24 855	4,4	62,53	306,85	12
	Bangladesh	407	1 087	7,3	0,65	92,2	42,4
	Barbados	11 568	15 366	2	60,97	285,5	11,7
	Belize	3 364	4 884	2,7	28	99,01	9,4
	Benin	370	903	6,6	1,77	107,2	34,1
	Bhutan	778	2 561	8,9	2,91	122,81	30,7
	Bolivia	1 007	3 124	8,4	14,31	145,03	18
	Botswana	3 333	7 153	5,6	23,3	195,73	16,4
	Brazil	3 729	11 729	8,5	33,94	230,07	14,6
	Brunei Dar.	18 155	40 980	6	61,89	197,38	8,6
	Burkina Faso	227	713	8,5	0,75	81,88	39,8
	Burundi	129	286	5,9	0,62	32,06	32,5
	Cambodia	300	1 095	9,7	1,37	144,51	39,5
	Cameroon	583	1 407	6,5	1,5	91,36	34,1
	Central Afr. R.	245	352	2,6	0,45	28,59	34,5
	Chad	166	1 025	13,9	0,23	42,51	45,4
	Chile	5 229	14 566	7,6	60,03	238,86	10,4
	China	955	7 587	16	19,75	173,85	16,8
	Colombia	2 472	7 918	8,7	25,91	190,6	15,3
	Comoros	372	810	5,7	1,55	61,21	30
	Congo, D. Rep.	397	438	0,7	0,06	56,49	63,3
	Congo, Rep.	1 036	3 147	8,3	2,97	115,63	29,9
	Costa Rica	4 062	10 415	7	34,06	221,61	14,3
	Cote d'Ivoire	649	1 546	6,4	4,8	122,62	26
	Cyprus	14 307	27 246	4,7	85,06	215,23	6,9
	Dominica	4 820	7 252	3	43,23	230,4	12,7
	Dominican R.	2 802	6 147	5,8	22,17	145,79	14,4
	Ecuador	1 451	6 346	11,1	15,08	170,43	18,9
	Egypt, Arab R.	1 461	3 366	6,1	10,99	157,26	20,9
	El Salvador	2 260	4 102	4,4	24,15	193,65	16

State DEVT	*Country*	*GDP per capita*		*CAGR %*	*Telecomunic. Subscribers*		*CAGR %*
		2000	*2014*	*00-14*	*2000*	*2014*	*00-14*
Developing Countries (111)	Eq. Guinea	1 970	18 918	17,5	2,27	87,69	29,8
	Gabon	4 115	10 772	7,1	14,19	182,9	20
	Gambia, The	637	441	-2,6	4,09	138,26	28,6
	Georgia	692	4 430	14,2	15,32	211,37	20,6
	Ghana	265	1 442	12,9	1,97	134,97	35,2
	Grenada	5 118	8 574	3,8	39,15	191,53	12
	Guatemala	1 650	3 667	5,9	14,4	143,6	17,9
	Guinea	340	540	3,3	0,85	73,83	37,5
	Guinea-Bissau	281	616	5,8	1,1	67,17	34,1
	Guyana	960	4 028	10,8	21,15	133,39	14,1
	Honduras	1 138	2 434	5,6	8,48	120,37	20,9
	H. Kong SAR	25 757	40 216	3,2	171,46	400,46	6,2
	India	452	1 577	9,3	3,98	95,86	25,5
	Indonesia	780	3 500	11,3	5,87	157,49	26,5
	Iran, Islamic R.	1 664	5 443	8,8	16,79	175,67	18,3
	Israel	21 052	37 206	4,2	143,49	257,22	4,3
	Jordan	1 774	4 831	7,4	23,79	201,49	16,5
	Kazakhstan	1 229	13 155	18,5	14,61	266,23	23
	Kenya	409	1 368	9	1,66	117,82	35,6
	Korea, Rep.	11 948	27 989	6,3	167,69	298,36	4,2
	Kyrgyz Rep.	280	1 280	11,5	8,81	174,8	23,8
	Lao PDR	324	1 751	12,8	1,1	94,77	37,4
	Lebanon	5 335	8 149	3,1	48,72	205,29	10,8
	Lesotho	416	1 034	6,7	2,57	98,05	29,7
	Liberia	183	458	6,8	0,3	79,13	48,9
	Macao SAR	14 128	96 075	14,7	88,07	447,12	12,3
	Madagascar	246	467	4,7	0,95	46,07	32
	Malawi	156	362	6,2	0,97	39,73	30,4
	Malaysia	4 005	11 307	7,7	63,01	241,08	10,1
	Mali	267	842	8,5	0,63	157,07	48,4
	Mauritania	477	1 371	7,8	1,46	106,39	35,9
	Mauritius	3 861	10 003	7	46,17	218,06	11,7
	Mexico	6 650	10 351	3,2	30,52	154,86	12,3
	Mongolia	474	4 202	16,9	12,61	146,83	19,2
	Morocco	1 328	3 190	6,5	13,81	198,91	21
	Mozambique	275	623	6	0,86	76,16	37,8
	Namibia	2 059	5 343	7	11,77	138,13	19,2
	Nepal	231	702	8,2	1,4	101,17	35,8
	Niger	160	431	7,3	0,24	47,01	45,9

State DEVT	Country	GDP per capita		CAGR %	Telecomunic. Subscribers		CAGR %
		2000	2014	00-14	2000	2014	00-14
Developing Countries (111)	Nigeria	378	3 203	16,5	0,54	120,63	47,2
	Oman	8 711	19 310	5,9	21,03	242,04	19,1
	Pakistan	535	1 315	6,6	2,34	90,86	29,9
	Panama	4 062	12 712	8,5	34,04	225,86	14,5
	Paraguay	1 546	4 713	8,3	21,38	156,41	15,3
	Peru	1 967	6 549	9	14,58	159,41	18,6
	Philippines	1 040	2 873	7,5	14,24	177,22	19,7
	Rwanda	216	698	8,7	0,74	75,06	39,1
	Saudi Arabia	8 809	24 406	7,6	23,76	278,97	19,2
	Senegal	475	1 067	6	5,03	119,4	25,4
	Sierra Leone	157	793	12,3	0,87	79,02	38,1
	Singapore	23 793	56 007	6,3	157,55	291,79	4,5
	South Africa	3 099	6 472	5,4	35,01	208,27	13,6
	Sri Lanka	875	3 853	11,2	7	144,1	24,1
	St. Kitts and N.	9 224	15 739	3,9	56,6	245	11
	St. Lucia	4 975	7 648	3,1	37,84	186,87	12,1
	St. Vincent	3 673	6 673	4,4	28,52	198,42	14,9
	Sudan	353	1 876	12,7	1,22	97,97	36,8
	Suriname	1 856	9 680	12,5	27,44	234,79	16,6
	Tajikistan	139	1 113	16	3,6	117,93	28,3
	Tanzania	308	955	8,4	0,95	68,1	35,7
	Thailand	2 016	5 970	8,1	17,56	196,26	18,8
	Togo	266	630	6,4	2,71	71,22	26,3
	Tonga	1 927	4 114	5,6	12,52	117,33	17,3
	Tri. & Tobago	6 431	21 317	8,9	45,47	251,48	13
	Tunisia	2 248	4 329	4,8	14	187,67	20,4
	Turkey	4 215	10 304	6,6	58,42	174,05	8,1
	Uganda	261	715	7,5	0,94	71,27	36,2
	U. A. Emirates	34 208	43 963	1,8	104,59	302,28	7,9
	Uruguay	6 872	16 738	6,6	50,89	278,51	12,9
	Uzbekistan	558	2 053	9,7	7,36	132,39	22,9
	Vanuatu	1 470	3 148	5,6	5,89	83,2	20,8
	Venezuela, RB	4 785	12 518	7,1	36,09	189,04	12,6
	Vietnam	433	2 052	11,7	4,37	207,91	31,8
	Zimbabwe	535	931	4	4,53	104,01	25,1
Average - DC (39 C.)		16 842	36 330	5,6	110,66	264,15	6,4
Average - LDC (111 C.)		3 679	8 602	6,3	24,68	161,46	14,4
Average - Total (150 C.)		7 101	15 811	5,9	47,04	188,16	10,4

Legend: DC – Developed Countries; LDC – Less Developed Countries (Developing Countries);
Source: Own elaboration with World Bank Development Indicators, 2016

Table V – List of Countries considered by Continent, Sub-Region and Income Group

Area	***Sub-Region***	***Country***	***Income Group***
Americas (31)	*Caribbean*	Antigua and Barbuda	HI
		Bahamas, The	HI
		Barbados	HI
		Dominica	UMI
		Dominican Republic	UMI
		Grenada	UMI
		St. Kitts and Nevis	HI
		St. Lucia	UMI
		St. Vincent and Gren.	UMI
		Trinidad and Tobago	HI
	Latin America	Argentina *	UMI
		Belize	UMI
		Bolivia	LMI
		Brazil	UMI
		Chile	HI
		Colombia	UMI
		Costa Rica	UMI
		Ecuador	UMI
		El Salvador	LMI
		Guatemala	LMI
		Guyana	UMI
		Honduras	LMI
		Panama	UMI
		Paraguay	UMI
		Peru	UMI
		Suriname	UMI
		Uruguay	HI
		Venezuela, RB	UMI
	North Amer.	Canada	HI
		Mexico	UMI
		United States	HI
Africa (43)	*North Africa*	Algeria	UMI
		Egypt, Arab Rep.	LMI
		Morocco	LMI
		Tunisia	LMI
	Sub-Sah.	Angola	UMI
		Benin	LI
Africa (43)	*Sub-Saharan*	Botswana	UMI
		Burkina Faso	LI
		Burundi	LI
		Cameroon	LMI
		Central African Rep.	LI
		Chad	LI
		Comoros	LI
		Congo, Dem. Rep.	LI
		Congo, Rep.	LMI
		Cote d'Ivoire	LMI
		Equatorial Guinea	UMI
		Gabon	UMI
		Gambia, The	LI
		Ghana	LMI
		Guinea	LI
		Guinea-Bissau	LI
		Kenya	LMI
		Lesotho	LMI
		Liberia	LI
		Madagascar	LI
		Malawi	LI
		Mali	LI
		Mauritania	LMI
		Mauritius	UMI
		Mozambique	LI
		Namibia	UMI
		Niger	LI
		Nigeria	LMI
		Rwanda	LI
		Senegal	LI
		Sierra Leone	LI
		South Africa	UMI
		Sudan	LMI
		Tanzania	LI
		Togo	LI
		Uganda	LI
		Zimbabwe	LI

Legend: HI - High Income; UMI - Upper Middle Income; LMI - Lower Middle Income LI - Low Income
*Note: * Temporarily unclassified for WDI and classified the same as Brazil by similar GDP per capita*

Area	*Sub-Reg.*	*Country*	*I.G.*
Asia &Oceania (34)	*Middle East*	Bahrain	HI
		Iran, Islamic Rep.	UMI
		Israel	HI
		Jordan	UMI
		Lebanon	UMI
		Oman	HI
		Saudi Arabia	HI
		United Arab Emirates	HI
	Northeast Asia	China	UMI
		Hong Kong SAR	HI
		Japan	HI
		Korea, Rep.	HI
		Macao SAR	HI
		Mongolia	LMI
	South Asia	Bangladesh	LMI
		Bhutan	LMI
		India	LMI
		Nepal	LI
		Pakistan	LMI
		Sri Lanka	LMI
		Tajikistan	LMI
	Southeast Asia	Brunei Darussalam	HI
		Cambodia	LMI
		Indonesia	LMI
		Lao PDR	LMI
		Malaysia	UMI
		Philippines	LMI
		Singapore	HI
		Thailand	UMI
		Vietnam	LMI
	Oceania	Australia	HI
		New Zealand	HI
		Tonga	LMI
		Vanuatu	LMI
Europe	*European Union*	Austria	HI
		Belgium	HI
		Bulgaria	UMI
		Cyprus	HI

Area	*Sub-Reg.*	*Country*	*I.G.*
Europe (42)	*European Union*	Czech Republic	HI
		Denmark	HI
		Estonia	HI
		Finland	HI
		France	HI
		Germany	HI
		Greece	HI
		Hungary	HI
		Ireland	HI
		Italy	HI
		Latvia	HI
		Lithuania	HI
		Luxembourg	HI
		Netherlands	HI
		Poland	HI
		Portugal	HI
		Romania	UMI
		Slovak Republic	HI
		Slovenia	HI
		Spain	HI
		Sweden	HI
		United Kingdom	HI
	Other Europe	Albania	UMI
		Armenia	LMI
		Azerbaijan	UMI
		Belarus	UMI
		Georgia	UMI
		Iceland	HI
		Kazakhstan	UMI
		Kyrgyz Republic	LMI
		Macedonia, FYR	UMI
		Moldova	LMI
		Norway	HI
		Russian Federation	UMI
		Switzerland	HI
		Turkey	UMI
		Ukraine	LMI
		Uzbekistan	LMI

Source: Own elaboration

Appendix C – Estimation Results

Table VI - Correlation matrix for total samples, time period: 2000-2014

	Growth	$Growth_{t-1}$	*GDP*	*POP*	G^c / Y	I / Y	*Open*	*Tel*	Tel_{t-1}	Tel_{t-2}
Growth	1.0000									
$Growth_{t-1}$	0.1133	1.0000								
GDP	-0.2425	-0.1335	1.0000							
POP	-0.0112	0.0120	-0.3036	1.0000						
G^c / Y	-0.1068	-0.1178	0.3435	-0.2691	1.0000					
I / Y	0.1126	0.0954	0.1849	-0.0646	0.0820	1.0000				
Open	0.0843	0.0767	-0.0852	-0.0067	-0.1552	-0.0063	1.0000			
Tel	-0.1518	-0.0855	0.8174	-0.3554	0.3223	0.2471	-0.0140	1.0000		
Tel_{t-1}	-0.1709	-0.1068	0.8227	-0.3543	0.3306	0.2409	-0.0184	0.9927	1.0000	
Tel_{t-2}	-0.1841	-0.1208	0.8283	-0.3567	0.3348	0.2322	-0.0228	0.9841	0.9932	1.0000

Table VII – Summary of results of estimation of equation (5), where Tel $_t$

Growth	*World*	*Africa*	*Americas*	*Europe*	*Asia & Oceania*	*High Income*	*Upper M. Income*	*Lower M. Income*	*Low Income*	*Developed*	*Less Developed*
$Growth_{t-1}$	0.116*** (0.330)	0.153** (0.072)	0.038 (0.058)	0.188*** (0.044)	-0.005 (0.089)	0.107** (0.046)	0.136* (0.081)	0.044 (0.062)	0.306** (0.140)	0.253*** (0.057)	0.113** (0.049)
GDP_{t-1}	-0.038*** (0.004)	-0.102*** (0.015)	-0.033*** (0.010)	-0.058*** (0.008)	-0.035*** (0.007)	-0.058*** (0.007)	-0.089*** (0.010)	-0.062*** (0.014)	-0.155*** (0.041)	-0.081*** (0.011)	-0.033*** (0.005)
POP	0.008 (0.089)	0.493 (0.615)	-4.534*** (1.674)	-0.148 (0.214)	-0.347** (0.156)	-0.287 (0.250)	-0.400 (0.503)	0.388 (0.901)	0.463 (1.753)	0.048 (0.168)	-0.110 (0.361)
G^c/Y	-0.060*** (0.010)	-0.045*** (0.016)	-0.092*** (0.024)	-0.049 (0.040)	-0.113*** (0.021)	-0.099*** (0.015)	-0.045*** (0.014)	-0.090*** (0.026)	0.016 (0.015)	0.003 (0.020)	-0.058*** (0.014)
I/Y	-0.004 (0.007)	-0.015 (0.022)	0.006 (0.017)	0.043*** (0.015)	-0.013 (0.012)	0.006 (0.008)	-0.016 (0.013)	0.032** (0.016)	-0.007 (0.012)	0.033*** (0.007)	-0.004 (0.009)
Open	-0.001 (0.010)	-0.020 (0.019)	-0.042* (0.023)	0.058*** (0.015)	-0.003 (0.010)	0.018* (0.010)	-0.030** (0.015)	-0.026* (0.013)	0.031 (0.022)	0.033*** (0.008)	-0.011 (0.013)
Tel_t	0.018*** (0.003)	0.036*** (0.006)	0.022*** (0.008)	0.044*** (0.010)	0.019*** (0.004)	0.061*** (0.013)	0.066*** (0.009)	0.026*** (0.006)	0.030*** (0.010)	0.079*** (0.015)	0.015*** (0.003)
Wald chi2	204.98	77.75	112.23	182.10	145.66	315.36	187.49	57.60	28.30	268.31	148.72
Prob>chi2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
AR (1)	0.000	0.005	0.019	0.004	0.037	0.019	0.020	0.026	0.036	0.002	0.000
AR (2)	0.415	0.317	0.347	0.108	0.130	0.623	0.530	0.605	0.275	0.102	0.728
Hansen-J	0.863	0.480	0.322	0.143	0.654	0.168	0.641	0.948	0.357	0.515	0.205
Countries	150	43	31	42	34	49	42	35	24	39	111
Obs.	1950	559	403	546	442	637	546	455	312	507	1443

*Notes: standard error in parentheses; *** significance at the 1% level; ** significance at the 5% level; * significance at the 10% level.*

Table VIII – Summary of results of estimation of equation (6), where Tel $_{t-1}$

Growth	*World*	*Africa*	*Americas*	*Europe*	*Asia & Oceania*	*High Income*	*Upper M. Income*	*Lower M. Income*	*Low Income*	*Developed*	*Less Developed*
$Growth_{t-1}$	0.125*** (0.038)	0.263*** (0.089)	0.081 (0.053)	0.168*** (0.070)	0.183 (0.141)	0.090 (0.098)	0.224** (0.100)	0.055 (0.071)	0.200 (0.166)	0.295*** (0.064)	0.126** (0.056)
GDP_{t-1}	-0.036*** (0.004)	-0.109*** (0.018)	-0.045*** (0.009)	-0.072*** (0.012)	-0.030*** (0.007)	-0.101*** (0.014)	-0.094*** (0.011)	-0.068*** (0.014)	-0.130** (0.061)	-0.087*** (0.010)	-0.033*** (0.005)
POP	-0.041 (0.083)	0.785 (0.954)	-3.268*** (1.326)	-0.158 (0212)	-0.070 (0.073)	-0.111 (0.110)	-0.491 (0.485)	0.678 (1.196)	2.302 (2.161)	0.077 (0.171)	-0.227 (0.428)
G^c/Y	-0.066*** (0.011)	-0.057*** (0.019)	-0.083*** (0.020)	-0.033 (0.038)	-0.003 (0.018)	-0.060*** (0.018)	-0.042*** (0.015)	-0.084*** (0.023)	0.004 (0.018)	0.001 (0.018)	-0.066*** (0.015)
I/Y	0.001 (0.007)	-0.014 (0.030)	0.012 (0.016)	0.032*** (0.013)	0.012 (0.012)	0.025*** (0.010)	-0.017 (0.013)	0.041** (0.019)	0.008 (0.015)	0.041*** (0.008)	0.002 (0.009)
Open	-0.002 (0.010)	-0.026 (0.028)	-0.041* (0.022)	0.045*** (0.015)	0.013 (0.008)	0.033*** (0.012)	-0.027 (0.018)	-0.024* (0.014)	0.015 (0.023)	0.038*** (0.009)	-0.013 (0.014)
Tel_{t-1}	0.015*** (0.002)	0.036*** (0.007)	0.265*** (0.007)	0.051*** (0.013)	0.007*** (0.003)	0.075*** (0.020)	0.062*** (0.010)	0.025*** (0.006)	0.022 (0.015)	0.072*** (0.012)	0.014*** (0.003)
Wald chi2 *Prob>chi2*	177.59 0.000	71.78 0.000	133.09 0.000	184.86 0.000	72.85 0.000	381.06 0.000	163.57 0.000	61.13 0.000	16.45 0.021	299.19 0.000	126.84 0.000
AR (1)	0.000	0.006	0.019	0.035	0.028	0.034	0.035	0.044	0.144	0.009	0.000
AR (2)	0.388	0.370	0.638	0.227	0.805	0.738	0.678	0.964	0.722	0.522	0.701
Hansen-J	0.870	0.478	0.310	0.307	0.173	0.168	0.727	0.960	0.380	0.522	0.201
Countries	150	43	31	42	34	49	42	35	24	39	111
Obs.	1950	559	403	546	442	637	546	455	312	507	1443

*Notes: standard error in parentheses; *** significance at the 1% level; ** significance at the 5% level; * significance at the 10% level.*

Table IX – Summary of results of estimation of equation (7), where Tel $_{t-2}$

Growth	*World*	*Africa*	*Americas*	*Europe*	*Asia & Oceania*	*High Income*	*Upper M. Income*	*Lower M. Income*	*Low Income*	*Developed*	*Less Developed*
Growth$_{t-1}$	0.081** (0.038)	0.276*** (0.096)	0.102** (0.048)	0.144** (0.062)	0.253* (0.149)	0.084 (0.058)	0.338*** (0.109)	0.090 (0.072)	0.161 (0.174)	0.137*** (0.052)	0.115** (0.047)
GDP$_{t-1}$	-0.039*** (0.005)	-0.084*** (0.016)	-0.070*** (0.010)	-0.066*** (0.010)	-0.027*** (0.008)	-0.068*** (0.008)	-0.090*** (0.012)	-0.057*** (0.013)	-0.069 (0.047)	-0.068*** (0.009)	-0.028*** (0.005)
POP	-0.445 (0.366)	0.815 (0.713)	-2.298* (1.216)	-0.170 (0.227)	-0.144*** (0.052)	-0.178 (0.111)	-0.684* (0.383)	-0.287 (0.903)	1.640 (1.974)	0.053 (0.082)	-0.261 (0.419)
G^c/Y	-0.063*** (0.011)	-0.050*** (0.015)	-0.062*** (0.022)	-0.027 (0.030)	-0.027 (0.026)	-0.091*** (0.011)	-0.044** (0.017)	-0.086*** (0.029)	-0.004 (0.011)	-0.023 (0.019)	-0.061*** (0.014)
I/Y	0.010 (0.008)	0.004 (0.023)	0.026 (0.018)	0.045*** (0.014)	0.011 (0.010)	0.011 (0.007)	-0.010 (0.013)	0.050*** (0.017)	0.008 (0.012)	0.052*** (0.005)	0.007 (0.008)
Open	0.030*** (0.009)	-0.018 (0.027)	-0.008 (0.017)	0.046*** (0.013)	0.007 (0.009)	-0.002 (0.007)	-0.015 (0.010)	-0.021 (0.014)	0.028 (0.031)	0.040*** (0.006)	-0.008 (0.014)
Tel$_{t-2}$	0.011*** (0.03)	0.024*** (0.006)	0.034*** (0.007)	0.040*** (0.011)	0.007** (0.003)	0.047*** (0.009)	0.052*** (0.009)	0.018*** (0.005)	0.006 (0.013)	0.041*** (0.010)	0.009*** (0.003)
Wald chi2	169.46	66.22	132.83	154.70	111.52	283.77	113.88	67.54	22.63	404.70	121.56
Prob>chi2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.000
AR (1)	0.000	0.003	0.034	0.023	0.032	0.029	0.011	0.015	0.060	0.001	0.000
AR (2)	0.054	0.478	0.518	0.114	0.973	0.134	0.504	0.891	0.748	0.292	0.180
Hansen-J	0.169	0.408	0.336	0.314	0.215	0.971	0.573	0.955	0.218	0.511	0.194
Countries	150	43	31	42	34	49	42	35	24	39	111
Obs.	1800	516	372	504	408	588	504	420	288	468	1332

*Notes: standard error in parentheses; *** significance at the 1% level; ** significance at the 5% level; * significance at the 10% level*