

Candelaria, José Alberto

Conference Paper

A panel data analysis of temporary and permanent effects of fixed broadband penetration over economic growth

2015 Regional Conference of the International Telecommunications Society (ITS): "The Intelligent World: Realizing Hopes, Overcoming Challenges", Los Angeles, USA, 25th-28th October, 2015

Provided in Cooperation with:

International Telecommunications Society (ITS)

Suggested Citation: Candelaria, José Alberto (2015) : A panel data analysis of temporary and permanent effects of fixed broadband penetration over economic growth, 2015 Regional Conference of the International Telecommunications Society (ITS): "The Intelligent World: Realizing Hopes, Overcoming Challenges", Los Angeles, USA, 25th-28th October, 2015, International Telecommunications Society (ITS), Calgary

This Version is available at:

<https://hdl.handle.net/10419/146312>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.

A panel data analysis of temporary and permanent effects of fixed broadband penetration over economic growth

José Alberto Candelaria

jose.candelaria@ift.org.mx. Centro de Estudios, Instituto Federal de Telecomunicaciones
México, D.F.¹

Abstract

This article presents an econometric analysis for the effects of fixed broadband penetration on the growth rate of GDP per capita for a panel of 35 developed and developing countries over an annual period of 33 years (1981 – 2013). The article contributes to the telecommunications literature by distinguishing between temporary and permanent impacts of fixed broadband penetration on economic growth. Our methodology consists of two models, the first one is a fixed effects panel data model which is used as a benchmark, and it controls for contemporaneous and one-period lagged effects of the penetration variable on economic growth. The possibility of an endogeneity issue due to reverse causality is addressed by considering a two-stage instrumental variables (IV) fixed effects model. In a first stage we instrument the fixed broadband penetration variable with fixed telephony subscribers and the internet users for every 100 inhabitants. Then, in a second stage we use the generated fitted values in a panel regression to determine the impact over the growth rate of GDP per capita. Our approach includes as an explanatory variable the Standard and Poor's 500 real index to control for the business cycle of the global economy. Finally, we verify the existence of positive and statistically significant temporal and permanent effects of fixed broadband penetration variable over economic growth.

Keywords: Fixed Broadband Penetration · Economic Growth · Panel Data Fixed Effects · Instrumental Variables · Temporal and Permanent Effects .

JEL Classifications C23 C26 O47

¹**Disclaimer:** The content of this article is of the author's sole responsibility. It does not represent the views of the Instituto Federal de Telecomunicaciones (IFT) or its staff. Any inquiries related to the article's content and all permission to cite should be directed to the author.

1 Introduction

The information and telecommunications technologies (ICT) have evolved to play a critical role on the development of the global information economy (Crandall *et.al.*, 2007) and for the diffusion of knowledge. Specifically, the fixed broadband as a wide bandwidth data transmitter is considered a key component of the knowledge economy (Lee and Brown, 2008). This is because of its capability of carrying integrated traffic consisting of voice, video and data. Also, it has accelerated the diffusion of ideas and it has made geographical distances insignificant. We use World Bank data ² to estimate a panel data fixed effects regression in order to capture the temporal and permanent effects resulting from an increase in fixed broadband penetration over the growth rate of GDP per capita. Furthermore, we develop an instrumental variables (IV) approach in order to address the possible endogeneity problems due to reverse causality in our model. Also, we specify two more versions of the IV fixed effects model, the first one by using a subsample time, and the second just considering the high income countries of our sample. We find that the temporal, or one-time, effect at the year of broadband introduction is a relevant factor for economic growth, while the permanent effect is smaller though positive and stable.

The paper is organized as follows. Section 2 presents a literature review of broadband penetration and economic growth. Section 3 describes our sample and variables used. Section 4 presents the methodology. Section 5 estimates the model. And finally in section 6 we conclude.

2 Literature Review

The effects of fixed broadband penetration over economic growth have been studied by numerous authors throughout the last years. The relevance of fixed broadband consists on its ability to spread knowledge -for instance, from research centers to companies and individuals- which magnifies its effects over time after its creation. The diffusion of knowledge has chiefly been considered as a trigger of economic growth through the development of a telecommunications infrastructure. Thus, broadband is mainly considered as a catalyst for the development of markets or industrial sectors relying on information and data as inputs. In current times a prerequisite for the access to knowledge is the existence of an adequate infrastructure of general telecommunications networks, and specifically of fixed broadband. Following the pioneers of endogenous economic growth theory (Barro, 1990; Mankiw, Romer and Weil, 1992; Romer, 1989, 1990)

²<http://data.worldbank.org/>

some authors have assessed the impact of broadband penetration on the average growth rate of GDP per capita (Qiang, Rossotto and Kimura, 2009; Scott, 2012). Quiang *et.al.* (2009) analyze this association for the 1980 to 2006 period distinguishing between developed and developing countries; and finding that a 10% increase in the number of broadband subscribers in developed countries results in a 1.21% increase in the growth rate of GDP per capita. On the other hand, a 10% increase in the number of subscribers in developing countries results in a growth of 1.38% in the growth rate of GDP per capita. A similar analysis is conducted by Scott (2012) who analyzes a richer dataset, obtaining smaller results than the ones of Quiang *et.al.* (2009). Then, a 10% increase in broadband penetration would result in an expansion of 1.35% of the growth rate of GDP per capita for developing countries, and of 1.19% for developed countries.

Another research line is the study of the effect of broadband penetration over economic development. Kolko (2010) analyzed the association among public policies designed to increment broadband disposal and economic development. By using United States' data the author finds a positive correlation between broadband penetration and employment, and even a stronger association for technology intensive industries. Katz (2009) assesses the economic impact of broadband technology in terms of job creation and development in Latin America. Based on a broadband gap estimation for 2008 of 11 millions lines for the region, the author estimates that the impact on employment resulting for addressing that gap would result in 378,000 new jobs. Katz *et.al.* (2010) estimate the impact of broadband infrastructure investments on the German economy based on two government's programs (the National Broadband Strategy and the ultra-broadband evolution, 2015-2020), particularly on employment and output. The results indicate that a total investment of 36 billion euros would generate 968,000 new jobs, allocated into 541,000 jobs necessary for the construction of the broadband network and 427,000 jobs derived from externalities as new business creation. Moreover, both effects would approximately generate a total of 170.9 billion euros of additional GDP.

Some other authors are critical of the measure of the effects of broadband penetration over economic growth. Holt and Jamison (2009) note that an economic analysis should consider the fact that broadband usually replaces other communication technologies, such as dial-up modems. In a counterfactual scenario where dial-up connectivity is not replaced by broadband technology the contribution of the previous ICT to economic growth would keep to be significant (Greenstein and McDevitt, 2009). Arvin and Pradhan

(2014) use a multivariate framework instead of the traditional bivariate framework in order to find Granger causality relationships between broadband penetration, degree of urbanization, foreign direct investment (FDI) and economic growth for a data set of G-20 countries. The authors find a short-run bidirectional causality between broadband penetration and economic growth in the presence of FDI and urbanization exclusively for developed countries within G-20. On the other hand, for the rest of the countries of the group the authors find a one directional way causal relationship: economic growth leads to broadband penetration. Bojnec and Fert (2012) analyze the effects of broadband availability on economic growth by using a cross-country panel data for 34 OECD nations over the years 1998 – 2009. Their study uses three different broadband availability related variables: standard access lines per 100 inhabitants, access channels per 100 inhabitants and total broadband per 100 inhabitants. They do not find a positive and statistically significant impact of total broadband per 100 inhabitants on the real growth rate of GDP per capita, while the most relevant and significant variable is the access channels per 100 inhabitants.

Other authors as Dimelis and Papaioannous (2011) present a comparison of the effects of ICTs over different industries and decades for the US and EU by applying a generalized method of moments approach. The authors find that the ICT effect is positive but not statistically significant for the 1980's decade. On the other hand, during the 1990's the impact increased significantly reflecting a positive association with output growth. However that effect was effectively realized on the second half of the decade, reflecting that a time learning period is necessary to effectively exploit the investment in telecommunications technology.

Furthermore, some concerns among authors are the reverse causality and the spurious correlation problems which may be present in the relationship between the growth rate of GDP per capita and broadband penetration. In that respect some authors as Czernich *et.al.* (2009) use an instrumental variable (IV) approach by suggesting that the penetration of an underlying technology infrastructure network as the extension of traditional fixed telephone and TV-cable network have influence on the deployment of fixed broadband. The authors use a panel data of 25 OECD nations for 1996 to 2007 period, concluding that an increase in broadband penetration would promote an annual growth rate in a range of 0.9% to 1.5% in GDP per capita. Other authors as Koutroumpis (2009) use a simultaneous equations model that endogenizes broadband investment and incorporates three equations: demand, supply and output. The result establishes that the coefficient of broadband penetration variable is positive and statistically significant implying that a 10% increase in accessibility to this technology would result in an increase of

0.38% in economic growth when fixed effects are not specified, and 0.26% when they are specified. On the other hand, Atif *et.al.* (2012) compare the results obtained from a static fixed effects model and a dynamic linear model for a panel data of 31 OECD nations for 1998 to 2010. The authors use a basic macroeconomic model for GDP as a function of capital stock and labour using a Cobb-Douglas function. They conclude that an increase of 10% in broadband penetration would result in an increase of 0.035% of the growth rate of per capita GDP.

3 Data

In this paper we use an annual panel of 35 developed and developing countries for a period of 33 years (1981 – 2013). The countries are: Argentina, Australia, Austria, Belgium, Brazil, Canada, Chile, China, Colombia, Denmark, Finland, France, Germany, Greece, Indonesia, India, Ireland, Iceland, Israel, Italy, Japan, Korea, Luxembourg, Mexico, Netherlands, Norway, New Zealand, Peru, Portugal, Spain, Sweden, Switzerland, Turkey, United Kingdom and the United States. The regressors we use are: fixed broadband penetration per 100 people, gross capital formation to GDP, total government expenditure on education to GDP, mobile cellular subscriptions per 100 people, research and development expenditure to GDP, growth rate of population ages 15 – 64. The data are taken from World Bank’s World Development Indicators catalog. The Standard & Poor’s 500 index is deflated by using US consumer price index (CPI). The fixed broadband technology is the one that offers a high speed access to the public internet. Also, the downstream speeds must be equal to, or greater than, 256 kbits. In this regard, it includes cable modem, DSL, fiber-to-the-home/building and other fixed broadband subscriptions.

4 Model Framework

Our approach considers the temporary and permanent effects of fixed broadband penetration over the growth rate of GDP per capita. The main purpose is to individually assess each effect over economic growth. In this regard, the importance of lasting effects lies on the fact that the impact of broadband penetration over economic growth occurs over time rather than all at once. The model is the following:

$$GDPpc_{it} = \alpha_i + \beta_1 K_{it} + \beta_2 H_{it} + \beta_3 FB_{it} + \beta_4 FB_{it-1} + \beta_5 Mob_{it} + \beta_6 RD_{it} + \beta_7 RD_{it-1} + \beta_8 n_{it} + \beta_9 S\&P_t + u_{it} \quad (1)$$

Where $GDPpc_{it}$ means the real growth rate of GDP per capita in country i at time t ; K_{it} is the gross capital formation to GDP; H_{it} is total government expenditure on education to GDP; FB_{it} and FB_{it-1} represent contemporaneous and one-period lagged fixed broadband penetration per 100 inhabitants, respectively; Mob_{it} is the mobile cellular subscriptions per 100 inhabitants; RD_{it} and RD_{it-1} stand for the contemporaneous and one-period lagged research and development expenditure to GDP; n_{it} is the growth rate of population ages 15 – 64 years and $S\&P_t$ is the Standard & Poor's 500 deflated index.

The investment in ICTs has been significant since the middle of the 1980's and through the beginning of the XXI century (OECD, 2009), just before the sinking of the Nasdaq index generated by the dot-com bubble collapse in 2001. Furthermore, since the 1960's and 1970's the ICT has represented a leading movement of progress and technical innovation through computerization and information technology and it has triggered a long wave of economic development (Bernard et.al., 2013). Then, the inclusion of $S\&P_t$ variable in our model controls for the business cycle of the global economy. On the other hand, n_{it} represents a *proxy* for the annual growth rate of workforce.

The variance of the error term in (1) associated with countries with larger population might be larger than for error terms associated with countries with smaller population. For instance, the growth rate of population ages 15 – 64 or the mobile penetration per 100 inhabitants of countries with larger population might be more volatile than for countries with smaller population. Then, giving equal weight to all observations generates biased standard errors when heteroskedasticity is present. This in turn leads to bias in test statistics and confidence intervals. In order to solve the heteroskedasticity problem we apply an analytic weight to transform the dependent and independent variables. In this case, we have the model (1) where the variance of u_i is thought to be proportional to the weight a_i . Then, it is assumed to be proportional to αa_i , where α is a positive constant. Gould (1999) details the alpha as the average value of the inverse of a_i ; *i.e.* $\alpha = \sum_k (1/a_k) / N$. Thus, the $Var(u_i) = k\alpha a_i \sigma^2$, where k represents a constant of proportionality which is not a function of the scale of weights. If we divide (1) by the $\sqrt{a_i}$ we obtain $Var(u_i/\sqrt{a_i}) = k\alpha \sigma^2$, which represents the constant part of the variance of the error term, $Var(u_i)$.

The estimated model considered is a panel data fixed effects model. The reason is that fixed effects models provide a means for controlling for omitted variable bias. For instance, the deployment of a telecommuni-

cations network in a particular country is directly related with country's size in square kilometers. In this regard, we expect that the effects of the omitted variables are time-invariant.

An important complication in empirically studying the impact of fixed broadband on economic growth is the potential of endogeneity bias as a result of reverse causality. The issue of endogeneity due to reverse causality is critical since fixed broadband penetration could be a function of economic growth. We address this problem by performing an instrumental variables (IV) approach. In this respect, broadband technologies as the asymmetric digital subscriber line (ADSL) base its data transmissions over copper telephone lines. Also, the digital subscriber line (DSL) uses existing telephone wiring, known as the plain old telephone system. The DSL system represents the 42% of global broadband customers and it still dominates in Europe and the rest of the world (Frenzel, 2013). Then, we can assume that the extension of the fixed telephony copper network is a necessary infrastructure for the deployment of fixed broadband. Then, we use the number of subscribers to fixed telephony per 100 inhabitants as an instrument. Furthermore, given that a necessary condition to have access to fixed broadband is to be connected to the internet, we consider that the internet users per 100 inhabitants is another good determinant for fixed broadband penetration. Thus, in a first stage we regress fixed broadband penetration on fixed telephony penetration and internet penetration.

$$FB_{it} = \beta_0 + \beta_1 FTel_{it} + \beta_2 Int_{it} + e_{it} \quad (2.1)$$

In equation (2.1) the variables $FTel_{it}$ and Int_{it} stand for the number of subscribers to fixed telephony per 100 inhabitants and internet users per 100 inhabitants, respectively. The generated fitted values are used in a second stage panel data fixed effects model.

$$GDPpc_{it} = \alpha_i + \beta_1 K_{it} + \beta_2 H_{it} + \beta_3 FB_{it}^{IV} + \beta_4 FB_{it-1} + \beta_5 Mob_{it} + \beta_6 RD_{it} + \beta_7 RD_{it-1} + \beta_8 n_{it} + \beta_9 S\&P_t + u_{it} \quad (2.2)$$

In (2.2) FB_{it}^{IV} represents the fixed broadband penetration fitted values. We utilize a deterministic one-period lagged fixed broadband penetration variable, FB_{it-1} .

5 Results

Table 1 shows model (1) panel regression estimates for the determination of the growth rate of GDP per capita as a function of broadband penetration. Contemporaneous fixed broadband penetration has a statistically significant positive effect on economic growth. Hence, a 10 percent increase in fixed broadband penetration increases annual per-capita GDP growth by 3.07 percentage points. On the other hand, the one-period lagged fixed broadband penetration has a negative effect on the growth rate of GDP per capita significant at a 99% confidence level. The permanent effect of fixed broadband penetration over economic growth is calculated by subtracting the one-period lagged coefficient from contemporaneous coefficient, *i.e.* $(0.307 - 0.306) = 0.001$. That means that an increase on fixed broadband penetration will have a yearly permanent effect over economic growth equal to 0.01 percentage points. Furthermore, the temporal, or one-time, effect at the time of technology introduction, when $t = 0$, is calculated as the difference between the contemporaneous effect and the permanent effect, *i.e.* $\beta_3 - (\beta_3 + \beta_4) = -\beta_4 = -(-0.306) = 0.306$. Thus, at the year of fixed broadband introduction, the one-time effect will be positive and statistically significant.

Regarding the rest of the explanatory variables, we have that physical capital accumulation as a proportion of GDP (K_{it}) is positive and statistically significant at a 99% confidence level. On the other hand, total government expenses on education (H_{it}) is not statistically significant. The technology life cycle theory (Bayus, 1998) states the existence of a technology development timeline which implies a recovery time period for initial costs and investments. In this regard, the one-period lagged research and development coefficient has a positive and statistically significant effect over economic growth. While the contemporaneous coefficient has a negative and statistically significant effect at a 99% confidence level. The growth rate of population ages 15–64 (n_{it}) has a negative and statistically significant effect over economic growth. Lastly, another telecommunications indicator, the mobile cellular subscribers per 100 inhabitants (Mob_{it}) shows no significant impact.

Table 1. Panel data fixed

effects results

Variables	Fixed Effects
α_i	-8.527** (3.777)
K_{it}	0.355*** (0.0656)
H_{it}	-0.137 (0.538)
FB_{it}	0.307** (0.131)
FB_{it-1}	-0.306*** (0.116)
Mob_{it}	-0.0132 (0.0156)
RD_{it}	-8.645*** (2.821)
RD_{it-1}	9.854*** (2.817)
n_{it}	-1.827*** (0.545)
$S\&P_t$	0.749*** (0.177)
Observations	319
R^2	0.728
Robust standard errors in parentheses	
*** p<0.01, ** p<0.05, * p<0.1	

Results of the two-stage instrumental variable model (equation 2.2) are reported in Table 2. The third column shows the results when we control for time fixed effects. In the second column we observe that

the instrumented contemporaneous fixed broadband penetration effect is slightly shorter than in the first model. Then, a 10 percentage points rise in broadband diffusion increases economic growth in 1.88 percentage points. Furthermore, the one-period lagged fixed broadband penetration coefficient is negative and statistically significant at a 95% confidence level. In this regard, the fixed broadband permanent effect resultant from the difference between contemporaneous and one-period lagged coefficients is 0.088. This result is larger than the obtained in the non-instrumental variable model. On the other hand, the temporal effect at $t = 0$ is 0.100. In the case of time fixed effects model the contemporaneous and one-period lagged fixed broadband penetration coefficients are not statistically significant.

The impact of gross capital formation to GDP is positive and statistically significant at a 99% confidence level (second column, Table 2). As in the first model, the one-period lagged research and development investment coefficient is positive and statistically significant, while the contemporaneous coefficient has a negative impact over the growth rate of GDP per capita. The RD_{it} coefficient is not statistically significant for the time fixed effects model (third column, Table 2). Standard & Poor's 500 real index shows a direct relation with economic growth; *i.e.* an upward movement in economic cycle positively affects the growth rate of GDP per capita. As in first model the growth rate of population ages 15 – 64 is negative and statistically significant.

Table 2. Panel Data IV Fixed Effects Results

	(1)	(2)
Variables	FE-IV	FE-IV
α_i	-9.929** (4.006)	88.91 (118.3)
K_{it}	0.375*** (0.0690)	0.341*** (0.115)
H_{it}	-0.196 (0.536)	-0.418 (0.469)
FB_{it}^{IV}	0.188** (0.0787)	0.0691 (0.0876)
FB_{it-1}	-0.100** (0.0414)	-0.0514 (0.0726)
Mob_{it}	-0.0199 (0.0173)	0.00529 (0.0206)
RD_{it}	-8.762*** (2.831)	-4.745 (3.090)
RD_{it-1}	9.509*** (2.839)	6.597** (2.851)
n_{it}	-1.557*** (0.529)	-1.925** (0.834)
$S\&P_t$	0.780*** (0.180)	-15.51 (20.02)
Observations	321	321
R^2	0.731	0.803
Year FE	NO	YES
Robust standard errors in parentheses		
*** p<0.01, ** p<0.05, * p<0.1		

In Table 3 we consider two versions of model (2.2), the first one uses a subsample time and the second

targets in high income countries. In this regard, the first year of fixed broadband introduction in a country is 1998, in Canada. Then, for the subsample time specification we can identify positive and significant effects of the contemporaneous instrumented fixed broadband penetration on the growth rate of GDP per capita. The result is larger than in the previous specification, while the standard error is smaller. The effect is not statistically significant when just considering high income countries (see third column, Table 3). The one-period lagged fixed broadband penetration coefficient is negative and statistically significant for both model versions. Again, the permanent effect of the subsample time model version is larger than in the non-instrumental variable model. It is equal to 0.086. On the other hand, the temporal effect when considering a time subsample is larger (0.106) than for the IV fixed effects model with the complete time sample (0.100).

Table 3. Panel Data IV Fixed Effects

Results, w/ Subsample

	(1)	(2)
Variables	FE-IV (1998 – 2013)	FE-IV (HIC)*
α_i	-7.883 (4.958)	-13.95* (8.068)
K_{it}	0.341*** (0.0833)	0.495** (0.205)
H_{it}	-0.430 (0.586)	-0.462 (0.643)
FB_{it}^{IV}	0.192** (0.0783)	0.120 (0.0792)
FB_{it-1}	-0.106** (0.0415)	-0.0849* (0.0443)
Mob_{it}	-0.0173 (0.0168)	-0.00969 (0.0164)
RD_{it}	-8.316*** (2.778)	-7.940*** (3.021)
RD_{it-1}	8.841*** (2.777)	9.232*** (2.856)
n_{it}	-1.475*** (0.531)	-2.088** (0.947)
$S\&P_t$	0.751*** (0.186)	0.758*** (0.147)
Observations	320	246
R^2	0.732	0.495
Year FE	NO	NO
Robust standard errors in parentheses		
*** p<0.01, ** p<0.05, * p<0.1		

* High Income Countries

6 Conclusions

This article proposes a panel data fixed effects model to estimate the temporal and permanent effects of an increase in fixed broadband penetration on the growth rate of GDP per capita. In contrast to other researches we consider a larger time span which includes economic turning points as the information technology bubble during 1999 – 2001 period and the global financial crisis of 2007 – 2008. In this regard, we consider the Standard & Poor’s 500 deflated index as explanatory variable to control for the economic business cycle. Furthermore, in order to address possible endogeneity problems due to reverse causality we specify an IV fixed effects model by instrumenting the fixed broadband penetration variable with fixed telephony subscribers per 100 people and the number of internet users for every 100 inhabitants.

Our results suggest that at the year of broadband introduction at $t = 0$, there is a strong one-time stimulus on economic growth. In the first model, the contemporaneous fixed broadband penetration has a positive and statistically significant effect on the growth rate of GDP per capita. Also, the permanent effect is positive and significant (0.001). On the other hand, for the two model versions of our second approach the permanent effect has a positive impact over economic growth. It is larger when considering the complete time sample. Still, the temporal effect has a positive impact at the year of the technology introduction. The overall result indicates that fixed broadband penetration is a significant factor in the determination of the growth rate of GDP per capita for our sample of 35 developed and developing countries. Then, we consider that it is important to separately analyze the one-time and permanent effects of broadband penetration. Furthermore, we consider that government’s policies should advocate for the diffusion and deployment of fixed broadband.

Like any research, the findings of this article should be viewed in the light of its limitations. For instance, the suggestion that there exists an immediate positive effect after a discrete growth in broadband penetration could be influenced by the fact that at this point of time there already exists a prior knowledge to comprehend the utilization of the technology in most countries, specially in developed ones. In other words, there is a general belief that broadband adoption has a positive association with productivity, performance and satisfaction (Hill *et.al*, 2014). However, if it would be the case that a completely new

telecommunications technology could arrive, it would take a time window to observe the benefits from its investment and introduction for the well-being of the general population.

Acknowledgements

Feedback from Jesús Zurita and Luis Enrique Candelaria is gratefully acknowledged.

References

- [1] Atif, Syed Muhammad, James Endres, and James Macdonald. (2012). 'Broadband Infrastructure and Economic Growth: A Panel Data Analysis of OECD Countries'. Munich Personal RePEc Archive. http://mpira.ub.uni-muenchen.de/42177/1/MPRA_paper_42177.pdf.
- [2] B. Mak Arvin & Rudra P. Pradhan (2014). 'Broadband penetration and economic growth nexus: evidence from cross-country panel data'. *Applied Economics*, 46:35, 4360-4369, DOI: 10.1080/00036846.2014.957444
- [3] Barro, R., (1990). 'Government spending in a simple model of endogenous growth'. *Journal of Political Economy* 98, s103-s117
- [4] Barro, R. J. (1991). 'Economic Growth in a Cross Section of Countries'. *Quarterly Journal of Economics* 106 (2): 407-43.
- [5] Bayus (1998). 'An analysis of product lifetime in a technologically dynamic industry'. *Management Science* 44(6) pp. 763-775.
- [6] Bernard, L., Gevorkyan, A. Palley, T. and Semmler, W. 'Time Scales and Mechanism of Economic Cycles: A Review of Theories of Long Waves'. Political Economy Research Institute. University of Massachusetts Amherst. Working Series. Number 337.
- [7] Bojnec, Š., Fert, I., (2012), 'Broadband availability and economic growth'. *Industrial Management & Data Systems*, Vol. 112 Iss 9 pp. 1292 - 1306 Permanent link to this document: <http://dx.doi.org/10.1108/02635571211278938>

- [8] Crandall, R.; Lehr, W. and Litan, R. 'The Effects of Broadband Deployment on Output and Employment: A Cross-sectional Analysis of U.S. Data'. Issues in Economic Policy. The Brookings Institution. Number 6, July 2007.
- [9] Czernich, N., Falck, O. Kretschmer, T. and Woessmann, L. (2009). 'Broadband Infrastructure and Economic Growth'. CESifo working paper, No. 2861. Leibniz Information Centre for Economics. December, 2009.
- [10] Dimelis, S. and Papaioannous, S. 'ICT growth effects at the industry level: A comparison between the US and the EU'. Information Economics and Policy 23 (2011) 37–50.
- [11] Frenzel, L. February, 2013. 'What's The Difference Between Cable And DSL Broadband Access?' in Electronic Design. Available from <<http://electronicdesign.com/communications/what-s-difference-between-cable-and-dsl-broadband-access>> . [23 September 2015].
- [12] Gould, W. January, 1999. 'What is the effect of specifying aweights with regress?' Available from: <<http://www.stata.com/support/faqs/statistics/analytical-weights-with-linear-regression/>> . [18 September 2015].
- [13] Greenstein, S. & McDevitt, R.C.(2009). 'The broadband bonus: Accounting for broadband Internet's impact on USGDP. Workingpaper, Northwestern University Kellogg School of Management, January. Retrieved February 23, 2009, from: /<http://www.kellogg.northwestern.edu/faculty/greenstein/images/htm/Research/WP/Broadband%20Bonus%20-%20Greenstein&McDevitt.pdf>S.
- [14] Hill, S.; Troshani, I.; Burgan , B. 'Broadband adoption in regional and urban households'. The Journal of Computer Information Systems; Spring 2014; 54, 3; ABI/INFORM Complete. pg. 57.
- [15] Holt, L. and Jamison. 'Broadbandand contributions to economic growth: Lessons from the US experience'. Telecommunications Policy. 33 (2009) 575-581.
- [16] Katz, R. 'Estimating Broadband Demand and its Economic Impact in Latin America'. Proceedings of the 3rd ACORN-REDECOM Conference Mexico City, May 22-23rd, 2009.
- [17] Katz, R., Vaterlaus, S., Zenhäusern, P. and Suter, S. 'The Impact of Broadband on Jobs and the German Economy'. Intereconomics 2010
- [18] Kolko, J. 'Does Broadband Boost Local Economic Development?'. Public Policy Institute of California. January, 2010.

- [19] Koutroumpis, P. (2009). 'The Economic Impact of Broadband on Growth: A Simultaneous Approach'. *Telecommunications Policy* , 33, 471-485.
- [20] Lee, S. & Brown, J. (2008). 'The Diffusion of Fixed Broadband: An Empirical Analysis '. NET Institute*. Working Paper #08-19 September 2008. www.NETinst.org
- [21] Mankiw, N.G., Romer, D., Weil, D.N., (1992). 'A contribution to the empirics of economic growth'. *Quarterly Journal of Economics* 107, 407 – 437.
- [22] OECD (2009). 'ICT investment over the business cycle', in OECD Science, Technology and Industry Scoreboard 2009, OECD Publishing. http://dx.doi.org/10.1787/sti_scoreboard-2009-17-en
- [23] Qiang, C., Rossotto, C., and Kimura, K. 'Economic Impacts of Broadband'. *Information and Communications for Development* 2009. Chapter 3. 2009.
- [24] Romer, P. M. 'Capital Accumulation in the Theory of Long-Run Growth', in Robert J. Barro, ed., *Modern Business Cycle Theory*. Cambridge, Mass.: Harvard University Press, 1989.
- [25] Romer, P. M. 'Endogenous Technological Change', *Journal of Political Economy*, vol. 98 (October 1990), pp. S71–S102
- [26] Scott, C. 'Does Broadband Internet Access Actually Spur Economic Growth?'. December, 2012.