The Impact of Broadband Access on GDP per Capita : The Case of OECD Countries

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Abstract

This paper investigated the possible relationship between the access of broadband and GDP per capita in 34 OECD countries for a 5-year period between 2009 to 2014. The data was collected from OECD's website as of April 2016. The relationship between broadband access and economic outputs at the macro-economic level was studied to add more knowledge and empirical evidence to the broadband studies, which have been conducted only on historical data. Correlation and regression analysis were conducted on the data to explore the relations and impact of fixed broadband and wireless mobile broadband subscriptions on the GDP per capita in the seven allocated regions of the OECD countries. The findings confirmed that broadband penetration contributed to the growth of GDP per capita in some regions, while it had a negative impact on others, which was in line with some of the earlier literature. The results revealed a better understanding of the differences in behavioral pattern of each region regarding the broadband access that had a strong negative impact on some of the developing countries' GDP such as region three and five (East Europe and Middle East), while other developed countries like region four (West Europe) did not demonstrate the growth of GDP by the contribution of broadband. Finally, we recommended using a disaggregated dataset for future research to get more insights.

Keywords : **broadband access, GDP, economic growth, OECD**

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Generally acknowledged as a crucial enabler of economic activity, broadband directly or indirectly enhances innovation, productivity, employment, economic growth, and ultimately, national competitiveness (ITU Broadband Commission, 2011). The explosive diffusion of broadband technology has been indistinctly tied to the emergence of the Internet (Katz, 2010). According to the Internet World Stats (2016), there were 3.3 billion users of the Internet as of November 30, 2015. The seven different world regions representing the Internet users were : Asia (48.2%), Europe (18.0%), Latin America and Caribbean (10.2%), Africa (9.8%), North America (9.3%), Middle East (3.7%), Oceania and Australia (0.8%) (Internet World Stats, 2016). Thus, the total number of people who are going online is increasing at a substantial rate. The International Telecommunication Union (ITU) reported that by 2013, the number of households that were connected to the Internet reached 750 million households, equivalent to 41% households globally, of which half were in the developing world with an Internet penetration of 28% (Sanou, 2013). OECD (Organization for Economic Cooperation and Development) (2001) defined broadband as an always-on Internet access with transmission speeds equaling to or exceeding 256 kbps for downstream connections and 64 kbps for upstream connections.

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Nearly all OECD areas have switched to broadband Internet access except for only 3% of the total subscribers, who are still using dial-up links. The OECD's origins dated back to 1960, when 18 European countries plus the United States and Canada joined forces to create an organization dedicated to economic development (OECD, 2016).

Moreover, some factors and developments such as digital convergence - meaning the same network platforms offering voice, video, and data - encourage the users to upgrade fixed networks. The recent end users' inclination of streaming medias online and receiving online contents on smartphones demand fundamental infrastructure and network to handle such huge traffic. ITU's ICT facts and figures for 2013 declared that as of 2013, the total number of fixed broadband subscriptions in developing countries exceeded the developed countries (Sanou, 2013). However, there is still a broad gap between developing and developed countries in terms of fixed broadband penetration rates, 6.1% in developing countries, less than 1% in Sub-Saharan Africa, and 27.2% in developed countries (Sanou, 2013). In fact, the marriage of technology and broadband services has boosted the take up rate, and progressively, it is moving the adoption from household to the individual users, thanks to the online contents provided mainly on diverse types of devices (Sanou, 2013).

In terms of mobile broadband subscriptions, the world has soared from 268 million subscriptions in 2007 to 2.1 billion in 2013, echoing an average annual growth rate of 40%, making mobile broadband the most dynamic ICT market (Sanou, 2013). Access to high-speed broadband (at least 10 Mbit/s) is highest in some of the Asian economies, including the Republic of Korea, Hong Kong (China), and Japan, and in several European countries like Bulgaria, Iceland, and Portugal (Sanou, 2013).

Whilst Internet connectivity is the main outcome of the broadband services, companies and industries are riding on this technology to develop new products and services fostering the economy and information exchange. As Internet connectivity stabilizes and speed increases, the workforce develops skills and capabilities in the utilization of available resources succeeding to a better communication between companies and end users, which eventually spans numerous businesses and industries leading to feasible profits and general growth in the economy. Nevertheless, the impact of broadband on the telecommunication industry comes from the development and deployment of the infrastructure ; the essential benefits of broadband networks result in externalities in the other sectors of the economy (Koutroumpis, 2009).

The ICT-related innovations are evolving and changing the landscape of the market and how science and technology are carried out. Broadband is one of the enablers in transferring the knowledge across the globe, disseminating code-based information, and bridging the gap between business and science (Van Welsum & Vickery, 2007). Van Welsum and Vickery (2007) argued that broadband brings down the barriers to product and process innovation, advances startups, increases business cooperation, and assists the small companies in their research and development efforts. That is why many governments and public organization and agencies have allocated and invested a fair amount of budget in the broadband initiatives.

It was indicated in the OECD's (2007) report that many governments deemed that broadband has an impact on globalization, and it influences how economies work in terms of the global allocation of resources, particularly for the developing countries (Van Welsum, 2008). In this regard, the telecommunication technology and Internet service providers are heavily investing in infrastructure & research and development. During a six-year period, between 2004 and 2010, the U.S. telecommunications and cable TV companies invested over U.S. $97.7 billion in broadband deployment, Chinese companies capitalized U.S. $7.44 billion in broadband since 2009, and the Malaysians devoted U.S. $1.6 billion in the same industry since 2009 (Katz, 2010).

The economic impact of telecommunication on growth has gained considerable attention from scholars and business practitioners alike. Broadband has been studied from different angles to confirm and analyze its influence on the economy in different markets. The studies varied based on the availability of data and empirical methods. The primary results of previous studies were mainly a positive and significant link between telecommunications infrastructure and growth (Koutroumpis, 2009).

Accordingly, investment on broadband infrastructure can intensify the growth in the economy in several ways

such as the equipment, the drilling, and the ductwork leading to increases in the demand of goods and services (Koutroumpis, 2009). However, the infrastructural investment is not considerable compared to the values originated from the use of the network itself. The services derived from the broadband network include telephone and its variations such as VoIP and videophones, high-speed Internet, and other complementary entertaining services like video streaming and online gaming.

Referring to the above brief look at the earlier research studies in the areas of telecommunication and broadband, there has not been a study - as per our knowledge - that has been conducted on the latest dataset of the broadband access. Previous research studies were mostly carried out on old data related to broadband penetration. Accordingly, the current paper investigates the latest data of the broadband access from 2009 to 2014 in OECD countries to analyze whether there is a relationship between broadband penetration and economic growth in 34 OECD countries. The rationale for surveying the new dataset is to find out the likely contribution of broadband to the GDP per capita in the OECD countries. The remainder of the article is structured as follows : looking at the literature and exploring the previous studies on broadband and their findings, taking a deep dive into analyzing the data and interpreting the results, and finally, concluding the discussion by presenting the findings and offering avenues for future research.

Literature Review

As the telecommunication technology has experienced fundamental transformation during the past 20 years, the focus of the historical studies was essentially on the telephone networks rather than the Internet and broadband. Since broadband networks gained momentum just in the past two decades, the earlier studies evaluated the impact of the telecommunication industry – per se telephone – on the economy and on the GDP per capita. The growth domestic product (GPP) is a monetary measure of the value of all final goods and services produced in a period, quarterly or yearly. The findings of Gruber, Hätönen, and Koutroumpis (2014) showed that the increased rollout of broadband infrastructure paid off by taking into account two effects: a broader primary rollout of broadband to households, and a higher performance broadband in terms of speed. The findings of Fornefeld, Delaunay, and Elixmann (2008) asserted broadband penetration's strong impact on GDP, employment, and productivity in all economic sectors. The authors highlighted that in the most advanced-knowledge European countries, 0.89% of their gross value added came from the annual broadband-related growth, whereas this value was merely 0.47% in countries that had less-developed broadband penetration (Fornefeld, Delaunay & Elixmann, 2008).

Recent studies focused on calculating the numerical impact of the broadband investment on GDP growth, for instance, in Europe, the broadband infrastructure's impact on GDP was somewhat 0.63%, which counted for 16.92% of the total growth for EU countries from 2002 to 2007 (Koutroumpis, 2009). While in U.S., Greenstein and McDevitt (2009) indicated that U.S. broadband accounted for $28 billion of the GDP in 2006, roughly $20 to $22 billion associated with household use. The authors recognized that out of this amount, the deployment of broadband infrastructure created approximately $8.3 to $10.6 billion of new GDP, accounting for 40% to 50% of measured GDP (Greenstein & McDevitt, 2009).

Broadband first emerged in most countries in 1999 and 2000. There were some early adopters - Canada in 1997 and the United States in 1998, and some late adopters - Greece in 2003, Hungary in 2001, and Ireland in 2002 (Czernich, Falck, Kretschmer, & Woessmann, 2011). Katz (2010) highlighted several reasons to study the impact of broadband inclusive of broadband's fast-paced deployment, shorter adoption life cycle compared to voice telecommunications, lack of historical data availability due to the fact that few countries with understanding of its economic potentials started the collection of statistics at the beginning of its diffusion process, broadband economic impact going hand in hand with the adoption of information technology, and finally, researchers of the developing world faced with limited data to understand the economic impact of broadband.

The impact of broadband can be divided into four different types (Katz, 2010) that the first three are direct

benefits, and the final one is indirect: (a) construction and deployment of the broadband creating jobs and acting over the economy through multipliers; (b) the effect of spillover externalities influencing consumers and enterprises alike, which the broadband's adoption within firms leads to multifactor productivity gains contributing to the GDP growth; (c) residential adoption contributing to the household real income as a function of multiplier; (d) the indirect benefits to the households in terms of consumer surplus – consumer surplus is defined as the difference between what they would be willing to pay for broadband services and its price, enhancing access to information, entertainment, and public services.

In fact, broadband is not only a foundation for other businesses, it is a technology platform, or as Qiang, Rossotto, and Kimura (2009) indicated :

> Broadband is not just an infrastructure. It is a general-purpose technology that can fundamentally restructure an economy. Thus, examining the overall economic impact is a logical way to assess the implications of broadband diffusion because it takes a more comprehensive view than looking only at impacts on individuals, firms, or communities. (p. 39)

The current broadband market is quite competitive as the subsistence of the wire line telecommunication relies heavily on the quality of the services provided to the end users (Rajeswari, Srinivasulu, & Thiyagarajan, 2016). In fact, the quality of the telecommunication service industry is the competitive advantage and unique differentiator of the telecommunication firms, which implies the criticality of the service quality attributes and its contribution to the enhanced performance of the DSL Services (Rajeswari et al., 2016). The research on the impact of broadband has a wide outlook extending from the collective impact of broadband on GDP growth to various impacts on industrial sectors, the increase in exports, and changes in intermediate demand and import substitution (Katz, 2010).

Whilst the studies have proven the positive impact of broadband on GDP growth, it has also generated varied results. Due to the limitation of data availability, the analyses have predominantly focused on OECD countries (generally Western European and North American) and various states in the United States (see Table 1 to check five previous studies conducted to measure the impact of broadband on GDP, which was compiled by Katz, 2010).

The above literature demonstrates that broadband penetration has an impact on GDP growth. Nonetheless, the

Table 1. Past Research of Broadband's Impact on GDP Growth

Author (s)	Country / Region	Data	Effect
Crandall, Litan, and Lehr (2007).	United States	48 States of the U.S. for the period of 2003 to 2005.	Did not obtain statistically significant results.
Thompson and Garbacz (2008)		46 U.S. States during the period of 2001 to 2005.	A 10% increase in broadband penetration was associated with 3.6% increase in efficiency.
Czernich, Falck, Kretschmer, and Woessmann (2009)	OECD	25 OECD countries between 1996 and 2007.	The adoption of broadband raised per-capita GDP growth by 1.9% - 2.5% points.
Koutroumpis (2009)		2002 to 2007 for 22 OECD countries.	An increase in broadband penetration of 10% yielded 0.25% increase in economic growth.
Qiang et al. (2009)	High Income Economies	1980 to 2002 for a high income subset of 120 countries.	10% broadband penetration yielded an additional 1.21% points of GDP growth.
Qiang et al. (2009)	Low & Middle Income Economies	1980 to 2002 for the remaining 120 countries (low and middle income).	10% broadband penetration yielded an additional 1.38% in economic growth.

Source: Compiled from Katz (2010)

contribution to GDP has a wide range from 0.25% to 1.38% for every increase in 10% of penetration. In fact, these variances and inconsistencies are due to the usage of different datasets together with model specifications, or even, in some cases, because of methodological shortfalls (Katz, 2010). Considering the inconsistent results of the previous research on the contribution of broadband on the GDP, the purpose of this research is to analyze broadband's contribution to the economic growth of the OECD countries using a recent dataset, that is, from 2009 to 2014.

This empirical study aims to fill the research gap by investigating the economic impact of broadband access in 34 OECD countries that are located in seven different regions of the world. The relationship between broadband access and economic outputs at the macro-economic level will be studied to add more knowledge and empirical evidence to the broadband studies, which have been conducted only on old datasets.

Consequently, this paper will focus on two main questions: (a) what are the impacts of broadband access on economic output such as GDP per capita? (b) how the impacts of broadband access on economic output are different between seven different regions namely, North America, South America, East Europe, West Europe, Middle East, Asia, and Oceania?

Methodology

(1) Data : The aim of this section is to examine and identify certain relationships between the data for the broadband penetration and the economic output as GDP per capita. The dataset used for this study entails annual data from 34 OECD countries for the five-year period between 2009 and 2014 (OECD, 2014). This period is the latest available data for the broadband penetration and it does manage to capture a very important part of the growth of broadband networks in the OECD sample.

Telecommunications growth literature included studies with richer datasets, especially in the time domain, sometimes reaching or even exceeding 20 years of observations (Koutroumpis, 2009). For the telephony studies and its impact, there are a lot of historical data to research and validate, however, the available data for broadband is not consistent and in a coherent time series format – in terms of continuous years – which imposes a limitation for having a panel data.

The research data for the present study is collected from OECD's website as of April 2016, which includes fixed broadband subscriptions, wireless mobile broadband subscriptions, and GDP of the OECD countries. Although GDP's range of data was quite broad, from 1960 to 2015, only the period of 2009 to 2014 is selected for this study.

The five-year period of data for GDP is chosen to be in parallel with the broadband data that was just available from 2009 to 2014. Hence, this study analyzes the five-year period of 2009 to 2014 for the broadband and GDP. Moreover, the collected data from OECD's website for fixed broadband subscriptions and wireless mobile broadband subscriptions had 210 data points for each variable. Out of the 210 data points, six were discarded in fixed broadband subscriptions and wireless mobile broadband subscriptions because they were the total subscriptions of each year between 2009 and 2014. Consequently, the six data points are deducted from each independent variable, making the data point 204 for each variable. Hence, there was no missing or unusual data in the dataset.

The collected GDP data from OECD's website - illustrated in million USD – had 3618 data points ranging between 1960 to 2015, for which some data points were missing in some countries (i.e. Australia's GDP was only available from 1970 to 2015). However, this matter did not have any impact upon the analysis of the current research as the selected period for analysis was from 2009 to 2014, and all the data for this period was present. Therefore, there was no missing or unusual data for the selected period under this study.

OECD (2016) defined GDP as the standard measure of the value of final goods and services produced by a country during a period minus the value of imports. While GDP is the single most important indicator to capture these economic activities, it provides only a limited measure of people's material living standards (OECD, 2016).

Stipulated by the OECD Broadband Portal, broadband penetration is measured as the number of broadband subscribers per 100 inhabitants (OECD, 2016). Furthermore, broadband access refers to technologies that provide access to the Internet at download speeds of 256 kbit/s or greater (OECD, 2016). It includes both fixed broadband technologies and wireless broadband technologies. Fixed broadband technologies correspond to DSL, cable modem, fiber-to-the-home, and other fixed technologies (such as broadband over power-line and leased lines). Wireless broadband penetration technologies correspond to satellite, terrestrial fixed wireless, as well as terrestrial mobile wireless (OECD, 2016). Accordingly, the research model is formed by the broadband access which entails two independent variables - fixed broadband subscriptions and wireless mobile broadband subscriptions - and GDP per capita as the dependent variable.

(2) Data Analysis : Multiple regression analysis is used to investigate the relationship between fixed broadband subscriptions and wireless mobile broadband subscriptions on the GDP per capita in 34 OECD countries. These countries are divided into seven regions namely North America, South America, East Europe, West Europe, Middle East, Asia, and Oceania. Each region includes specific countries, which are separated based on geographical location.

These seven regions were selected based on the composition of macro geographical (continental) regions, geographical sub-regions, and selected economic and other groupings factors of the United Nations (United Nations Statistics Division, 2013). In fact, the OECD area is selected for this study because it comprises of countries with the strongest economic developments throughout the world, which determined the seven regions containing 34 countries:

Region 1 - North America with two countries : Canada and United States.

Region 2 - South America with two countries : Chile and Mexico.

Region 3 - East Europe with six countries : Czech Republic, Estonia, Hungary, Poland, Slovak Republic, and Slovenia.

Region 4 - West Europe with 18 countries: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherland, Norway, Portugal, Spain, Sweden, Switzerland, and United Kingdom.

Region 5 - Middle East with two countries : Israel and Turkey.

Region 6 - Asia with two countries : Japan and Korea.

Region 7 - Oceania with two countries: Australia and New Zealand.

Descriptive analysis and multiple regressions are conducted on each region to analyze the data collected from the OECD's website. To run the multiple regression analysis on the data, some tests were completed (Tabachnick & Fidell, 2001) including multicollinearity, normality, outliers, heterogeneity, linearity, and independence of residuals to meet the assumptions. These are required to check the relationship between the dependent variable and the independent variables. The results demonstrate that most of the data was normally distributed and nearly concentrated in the center of histograms, determining that the requirements for conducting multiple regressions analysis were met. The literature presented in this paper indicates that the presumed economic impacts of broadband were actual and mostly measurable.

Nevertheless, some of the results have been restricted to some specific countries or with outdated dataset. Because of the widespread benefits of broadband, the best way to look at its impact is by focusing on economic growth. Most of the studies used econometric models and endogenous growth model to test the impact of broadband penetration on the average growth rate of per capita GDP. The complication of such models entails a

lengthy process and proficiency. Due to these factors and time constraints, a macro-level analysis is conducted using multiple regression analysis. In addition, segregating the 34 OECD countries into seven different regions sheds light on developing countries where empirical evidence is lacking. For the analysis, the GDP per capita between 2009 and 2014 was used as the dependent variable and regressed onto the penetration of fixed broadband subscriptions and wireless mobile broadband subscriptions between 2009 and 2014 for the OECD countries. The next section is the discussion and interpretation of the results to find the responses to the research questions.

Analysis, Results, and Findings

The results are presented by the order of the seven regions, North America, South America, East Europe, West Europe, Middle East, Asia, and Oceania, respectively.

(1) Region 1 – North America : Referring to the Table 2, the correlation between GDP per capita of North America and fixed broadband subscriptions is significant with a *p* - value of 0.003, indicating a strong negative relationship (-0.733) between GDP and fixed broadband subscriptions. The GDP of North America also has a significant correlation with wireless mobile broadband subscriptions with a *p* - value of 0.001, presenting a strong positive relationship (0.788) between GDP and wireless mobile broadband subscriptions.

The model summary depicts the value of *R* square that explains the GDP per capita using the two independent variables of Region 1. Due to lack of space, the model summary tables are not presented in the article, however, the results are described. The model 2 that contains the variables - wireless mobile broadband subscriptions and fixed broadband subscriptions can explain 98% of the GDP per capita in North America.

The coefficient table (Table 3) illustrates the beta value, that is, the degree by which the independent variables – namely fixed broadband subscriptions and wireless mobile broadband subscriptions – contribute to the prediction of the dependent variable, that is, GDP per capita in North America. Regardless of its positive or negative sign, the variable with the largest value is the one with the strongest contribution in predicting and explaining the dependent variable, in this case, GDP (Bagheri, 2014).

As can be inferred from the Table 3, both variables - wireless mobile broadband subscriptions and fixed broadband subscriptions have a significant *p* - value of 0.000. The regression analysis of North America discloses that the largest beta value is for wireless mobile broadband subscriptions (0.679) followed by fixed broadband

Table 2. Correlation Analysis - North America

Correlations[a]				
		GDP PER CAPITA IN MILLION USD	**Fixed Broadband Subscriptions**	**Wireless Mobile Broadband Subscriptions**
Pearson Correlation	GDP PER CAPITA IN MILLION USD	1.000	-.733	.788
	Fixed Broadband Subscriptions	-.733	1.000	-.178
	Wireless Mobile Broadband Subscriptions	.788	-.178	1.000
***p* - value**	GDP PER CAPITA IN MILLION USD	.	.003	.001
	Fixed Broadband Subscriptions	**.003**	.	.289
	Wireless Mobile Broadband Subscriptions	**.001**	.289	.
N	GDP PER CAPITA IN MILLION USD	12	12	12
	Fixed Broadband Subscriptions	12	12	12
	Wireless Mobile Broadband Subscriptions	12	12	12

a. Selecting only cases for which Region = North America

Table 3. Regression Analysis - North America

Coefficients[a,b]						
Model		Unstandardized Coefficients		Standardized Coefficients	*t*	*p* - value
		B	Std. Error	Beta		
1	(Constant)	-2954890.839	3189713.138		-.926	.376
	Wireless Mobile Broadband Subscriptions	201933.384	49821.943	.788	4.053	.002
2	(Constant)	48478563.624	3707357.104		13.076	.000
	Wireless Mobile Broadband Subscriptions	173981.555	11087.685	.679	15.691	**.000**
	Fixed Broadband Subscriptions	-1610165.591	113983.416	-.612	-14.126	**.000**

a. Dependent Variable : GDP PER CAPITA IN MILLION USD

b. Selecting only cases for which Region = North America

subscriptions (0.612). This shows that the GDP per capita is affected by both independent variables in Region 1. Hence, an increase in wireless mobile broadband subscriptions by 100% increases the GDP by about 6%, which is also similar in the case of fixed broadband subscriptions.

(2) Region 2 – South America : The correlation table of South America (Table 4) presents the *p* - value of 0.055 for fixed broadband subscriptions and 0.434 for wireless mobile broadband subscriptions of which none is significant. Hence, there is no correlation between the GDP per capita of South America and wireless mobile broadband subscriptions and fixed broadband subscriptions. The results indicate that there is no relationship between GDP and broadband in South America. Correspondingly, the regression analysis is not viable for the Region 2.

Table 4. Correlation Analysis - South America

Correlations[a]				
		GDP PER CAPITA IN MILLION USD	Fixed Broadband Subscriptions	Wireless Mobile Broadband Subscriptions
Pearson Correlation	GDP PER CAPITA IN MILLION USD	1.000	-.485	-.054
	Fixed Broadband Subscriptions	-.485	1.000	.794
	Wireless Mobile Broadband Subscriptions	-.054	.794	1.000
***p* - value**	GDP PER CAPITA IN MILLION USD	.	.055	.434
	Fixed Broadband Subscriptions	.055	.	.001
	Wireless Mobile Broadband Subscriptions	.434	.001	.
N	GDP PER CAPITA IN MILLION USD	12	12	12
	Fixed Broadband Subscriptions	12	12	12
	Wireless Mobile Broadband Subscriptions	12	12	12

a. Selecting only cases for which Region = South America

(3) Region 3 – East Europe : The results for East Europe's correlation in Table 5 demonstrates that the variable - fixed broadband subscriptions has a robust *p* - value of 0.000 and its Pearson correlation is - 0.577, demonstrating a medium negative relationship between GDP and fixed broadband subscriptions ; whereas, the variable - wireless mobile broadband subscriptions does not have a significant *p* - value (0.147) and there is no relationship between GDP and wireless mobile broadband subscriptions in East Europe.

Table 5. Correlation Analysis - East Europe

Correlations[a]				
		GDP PER CAPITA IN MILLION USD	**Fixed Broadband Subscriptions**	**Wireless Mobile Broadband Subscriptions**
Pearson Correlation	GDP PER CAPITA IN MILLION USD	1.000	-.557	.180
	Fixed Broadband Subscriptions	-.557	1.000	.320
	Wireless Mobile Broadband Subscriptions	.180	.320	1.000
***p* - value**	GDP PER CAPITA IN MILLION USD	.	.000	.147
	Fixed Broadband Subscriptions	**.000**	.	.028
	Wireless Mobile Broadband Subscriptions	.147	.028	.
N	GDP PER CAPITA IN MILLION USD	36	36	36
	Fixed Broadband Subscriptions	36	36	36
	Wireless Mobile Broadband Subscriptions	36	36	36

a. Selecting only cases for which Region = East Europe

Table 6. Regression Analysis - East Europe

Coefficients [a,b]						
Model		**Unstandardized Coefficients**		**Standardized Coefficients**	***t***	***p* - value**
		B	**Std. Error**	**Beta**		
1	(Constant)	1127867.533	222971.474		5.058	.000
	Fixed Broadband Subscriptions	-38676.308	9889.770	-.557	-3.911	.000
2	(Constant)	1152897.994	201698.189		5.716	.000
	Fixed Broadband Subscriptions	-47555.057	9435.682	-.685	-5.040	**.000**
	Wireless Mobile Broadband Subscriptions	4529.011	1542.179	.399	2.937	**.006**

a. Dependent Variable: GDP PER CAPITA IN MILLION USD

b. Selecting only cases for which Region = East Europe

The model summary of East Europe designates two models of which the *R* Square value of model 2 is 0.453. This value shows that both independent variables can predict 45% of the GDP per capita in East Europe.

By looking at the beta value under the standard coefficients table in Table 6, it can be noticed which variables contribute to the prediction of the dependent variable. Both variables - fixed broadband subscriptions and wireless mobile broadband subscriptions have significant *p* - values of 0.000 and 0.006, respectively. The beta value also shows that the variable - fixed broadband subscriptions has a significant negative beta coefficient (-0.685) compared to the variable - wireless mobile broadband subscriptions at 0.399.

(4) Region 4 – West Europe : Referring to Table 7, the analysis of West Europe's data shows that the *p* - value of the variable - fixed broadband subscriptions is not significant (0.500), while the variable - wireless mobile broadband subscriptions has a significant *p* - value of 0.010.

The Pearson correlation value demonstrates that there is no relationship between GDP per capita and the variable - fixed broadband subscriptions in West Europe (0.000). The GDP per capita has a weak negative relationship (-0.225) with wireless mobile broadband subscriptions. Therefore, the results indicate that there is a weak relationship between GDP and broadband in West Europe.

As the *p* - value of the variable - wireless mobile broadband subscriptions is only the significant one, the model summary has just one model, containing the wireless mobile broadband subscriptions variable. The model

Table 7. Correlation Analysis - West Europe

Correlations[a]				
		GDP PER CAPITA IN MILLION USD	**Fixed Broadband Subscriptions**	**Wireless Mobile Broadband Subscriptions**
Pearson Correlation	GDP PER CAPITA IN MILLION USD	1.000	.000	-.225
	Fixed Broadband Subscriptions	.000	1.000	.424
	Wireless Mobile Broadband Subscriptions	-.225	.424	1.000
***p* - value**	GDP PER CAPITA IN MILLION USD	.	.500	.010
	Fixed Broadband Subscriptions	.500	.	.000
	Wireless Mobile Broadband Subscriptions	**.010**	.000	.
N	GDP PER CAPITA IN MILLION USD	108	108	108
	Fixed Broadband Subscriptions	108	108	108
	Wireless Mobile Broadband Subscriptions	108	108	108

a. Selecting only cases for which Region = West Europe

Table 8. Regression Analysis - West Europe

Coefficients [a,b]						
Model		**Unstandardized Coefficients**		**Standardized Coefficients**	***t***	***p* - value**
		B	**Std. Error**	**Beta**		
1	(Constant)	1359540.443	219685.389		6.189	.000
	Wireless Mobile Broadband Subscriptions	-8190.735	3449.218	-.225	-2.375	**.019**

a. Dependent Variable: GDP PER CAPITA IN MILLION USD

b. Selecting only cases for which Region = West Europe

summary table displays the *R* square with a weak value that is not substantial (5%) in explaining the GDP per capita of West Europe. The regression analysis of West Europe demonstrates that the variable - wireless mobile broadband subscriptions has a significant *p* - value of 0.019 (Table 8). The beta value shows that wireless mobile broadband subscriptions variable has a weak beta coefficient of - 0.225.

The results indicate that fixed broadband subscriptions have no impact on the GDP of West Europe ; nevertheless, wireless mobile broadband subscriptions have a weak impact on the GDP per capita of the West European countries.

The above results show that wireless mobile broadband subscriptions have a negative relationship with GDP in West Europe. Therefore, an increase in wireless mobile broadband subscriptions by 100% decreases the GDP by 2%. This might be due to two facts : most European countries are not adopting the Internet at the same time, and the broadband usage is not fairly distributed among the European countries.

(5) Region 5 – Middle East : Middle East's analysis in Table 9 displays that the *p* - value of the fixed broadband subscriptions is significant (0.000) ; also, the variable - wireless mobile broadband subscriptions has a significant *p* - value (0.005).

The Pearson correlation value demonstrates a very strong negative relationship between GDP per capita and fixed broadband subscriptions in Middle East (-0.952). The GDP per capita also has a strong negative relationship (-0.711) with wireless mobile broadband subscriptions.

Multicollinearity happens when the VIF is greater than 10. In the case of this analysis, the VIF is not greater than 10, but the Person Correlation *"r"* is higher than 0.9, indicating that the two variables have a considerably

Table 9. Correlation Analysis - Middle East

Correlations[a]				
		GDP PER CAPITA IN MILLION USD	**Fixed Broadband Subscriptions**	**Wireless Mobile Broadband Subscriptions**
Pearson Correlation	GDP PER CAPITA IN MILLION USD	1.000	-.952	-.711
	Fixed Broadband Subscriptions	-.952	1.000	.878
	Wireless Mobile Broadband Subscriptions	-.711	.878	1.000
***p* - value**	GDP PER CAPITA IN MILLION USD	.	.000	.005
	Fixed Broadband Subscriptions	**.000**	.	.000
	Wireless Mobile Broadband Subscriptions	**.005**	.000	.
N	GDP PER CAPITA IN MILLION USD	12	12	12
	Fixed Broadband Subscriptions	12	12	12
	Wireless Mobile Broadband Subscriptions	12	12	12

a. Selecting only cases for which Region = Middle East

Table 10. Regression Analysis - Middle East

Coefficients [a,b]						
Model		**Unstandardized Coefficients**		**Standardized Coefficients**	***t***	***p* - value**
		B	**Std. Error**	**Beta**		
1	(Constant)	2047930.423	139792.632		14.650	.000
	Fixed Broadband Subscriptions	-73105.278	7443.016	-.952	-9.822	**.000**

a. Dependent Variable: GDP PER CAPITA IN MILLION USD

b. Selecting only cases for which Region = Middle East

Table 11. Regression Analysis - Middle East

Coefficients [a,b]						
Model		**Unstandardized Coefficients**		**Standardized Coefficients**	***t***	***p* - value**
		B	**Std. Error**	**Beta**		
1	(Constant)	1607203.343	286508.761		5.610	.000
	Wireless Mobile Broadband Subscriptions	-22695.229	7094.540	-.711	-3.199	**.010**

a. Dependent Variable: GDP PER CAPITA IN MILLION USD

b. Selecting only cases for which Region = Middle East

high relationship, which makes it a collinearity case. The implication is that there is too much collinearity between the two variables. To handle the collinearity case, the highly-correlated predictor is removed from the model and the correlation is conducted by the independent variables separately. Since variables supply redundant information, one of the independent variables is removed from the model.

The new test conducted separately on each independent variable declares that the *R* square has a value of 0.906 for the variable - fixed broadband subscriptions in Middle East. This value shows that the independent variable can predict 90% of the GDP per capita in Middle East. The *R* square value of wireless mobile broadband subscriptions is 0.506, which means that the wireless mobile broadband subscriptions can explain 50% of the GDP per capita in the Middle East.

The regression analysis of the Middle East for the variable - fixed broadband subscriptions (Table 10) has a

significant *p* - value of 0.000. The beta value also shows that the fixed broadband subscriptions variable has a strong beta coefficient (-0.952). The results indicate that the fixed broadband subscriptions have a strong impact on the GDP per capita in the Middle East.

The Table 11, which presents the regression analysis of the variable - wireless mobile broadband subscriptions, reveals a significant *p* - value of 0.010 and beta coefficient of - 0.711. The regression analysis demonstrates that fixed broadband subscriptions have a stronger impact on the GDP per capita in Middle East as compared to the wireless mobile broadband subscriptions.

The variables - fixed broadband subscriptions and wireless mobile broadband subscriptions - both have negative coefficients, which negatively impact the GDP.

Table 12. Correlation Analysis - Asia

Correlations [a]				
		GDP PER CAPIT IN MILLION USD	**Fixed Broadband Subscriptions**	**Wireless Mobile Broadband Subscriptions**
Pearson Correlation	GDP PER CAPITA IN MILLION USD	1.000	-.912	-.157
	Fixed Broadband Subscriptions	-.912	1.000	.456
	Wireless Mobile Broadband Subscriptions	-.157	.456	1.000
***p* - value**	GDP PER CAPITA IN MILLION USD	.	.000	.312
	Fixed Broadband Subscriptions	**.000**	.	.068
	Wireless Mobile Broadband Subscriptions	.312	.068	.
N	GDP PER CAPITA IN MILLION USD	12	12	12
	Fixed Broadband Subscriptions	12	12	12
	Wireless Mobile Broadband Subscriptions	12	12	12

a. Selecting only cases for which Region = Asia

(6) Region 6 – Asia : The analysis of Asia's data in Table 12 shows that the *p* - value of the variable - fixed broadband subscriptions is significant at 0.000, whereas the wireless mobile broadband subscriptions variable does not have a robust *p* - value (0.312). The Pearson correlation value demonstrates that there is a strong negative relationship between GDP per capita and fixed broadband subscriptions in Asia (-0.912). The results indicate that there is no relationship between GDP and wireless mobile broadband subscriptions in Asia.

The *"r"* value or the Person correlation of the fixed broadband subscriptions variable is higher than 0.9, indicating that the two variables have a high relationship, making it a collinearity case, which implies that the variables supply redundant information ; thereof, the correlation is conducted by the independent variables separately as done in the previous case.

The new test conducted on each independent variable separately declares that the *R* Square has a value of 0.831

Table 13. Regression Analysis - Asia

Coefficients [a,b]						
Model		**Unstandardized Coefficients**		**Standardized Coefficients**	***t***	***p* - value**
		B	**Std. Error**	**Beta**		
1	(Constant)	12081116.237	1306467.969		9.247	.000
	Fixed Broadband Subscriptions	-287138.788	40902.031	-.912	-7.020	**.000**

a. Dependent Variable: GDP PER CAPITA IN MILLION USD

b. Selecting only cases for which Region = Asia

for the fixed broadband subscriptions variable in Asia. This value shows that fixed broadband subscriptions can predict 83% of the GDP per capita in Asia. As the *p* - value of the wireless mobile broadband subscriptions variable is not significant (0.312), there is no *R* square value or regression analysis of this independent variable.

Asia's regression analysis of the fixed broadband subscriptions variable (Table 13) shows that it has a significant *p* - value of 0.000. The beta coefficient displays that fixed broadband has a strong value (-0.912), indicating that fixed broadband subscriptions have a significant impact on the GDP per capita in Asia.

(7) Region 7 – Oceania : The results for Oceania's correlation in Table 14 show that the fixed broadband subscriptions variable does not have a robust *p* - value (0.066) and its Pearson correlation is -0.461. The wireless mobile broadband subscriptions variable is not significant either (0.110), with a *r* - value of 0.383. The values specify that there is no relationship between GDP and broadband in Oceania.

Since there is no correlation between GDP and fixed broadband subscriptions and wireless mobile broadband subscriptions in case of Oceania, the regression analysis is not conducted for this region, that is, Region 7.

Table 14. Correlation Analysis - Oceania

Correlations[a]				
		GDP PER CAPITA IN MILLION USD	**Fixed Broadband Subscriptions**	**Wireless Mobile Broadband Subscriptions**
Pearson Correlation	GDP PER CAPITA IN MILLION USD	1.000	-.461	.383
	Fixed Broadband Subscriptions	-.461	1.000	.534
	Wireless Mobile Broadband Subscriptions	.383	.534	1.000
***p* - value**	GDP PER CAPITA IN MILLION USD	.	.066	.110
	Fixed Broadband Subscriptions	.066	.	.037
	Wireless Mobile Broadband Subscriptions	.110	.037	.
N	GDP PER CAPITA IN MILLION USD	12	12	12
	Fixed Broadband Subscriptions	12	12	12
	Wireless Mobile Broadband Subscriptions	12	12	12

a. Selecting only cases for which Region = Oceania

Discussion and Conclusion

The focus of this paper is on measuring the effects of broadband penetration on GDP per capita in the OECD countries. Due to some restraints, merely correlation and regression analysis are conducted to test the data which was collected from OECD's website as of April 2016. The data constitutes the latest dataset on the broadband access, inclusive of the fixed broadband subscriptions and wireless mobile broadband subscriptions, and GDP for a five-year period from 2009 to 2014.

The Figure 1 presents the impact of broadband which can be divided into four different types (Katz, 2010). Furthermore, the Table 1 lists previous studies which were conducted to measure the impact of broadband on GDP compiled by Katz (2010). The Table 2 to Table 14 present the results of correlation analysis and regression analysis of the seven regions under this study.

The results are in line with previous literature confirming that broadband access has an impact on the GDP of OECD countries and corroborates with the results of Czernich et al. (2009), Fornefeld et al. (2008), Greenstein and McDevitt (2009), Koutroumpis (2009), Katz (2010), Qiang et al. (2009), and Thompson and Garbacz (2008) in terms of broadband penetration's contribution to GDP. However, the relationships vary among the seven different regions.

In North America, both fixed broadband subscriptions and wireless mobile broadband subscriptions have a strong relationship with GDP. The *R* square shows that fixed broadband subscriptions and wireless mobile broadband subscriptions can strongly explain GDP growth, and the strong value of the beta coefficient also demonstrates the strong effect of fixed broadband subscriptions and wireless mobile broadband subscriptions on GDP in North America. In South America, no relationship between broadband access and GDP is detected. In East Europe, fixed broadband subscriptions have a medium relationship with the GDP and no relationship is observed with wireless mobile broadband subscriptions. The *R* square can moderately predict the GDP per capita. Moreover, the regression results display the impact of both fixed broadband subscriptions and wireless mobile broadband subscriptions on the GDP of East Europe.

Nevertheless, the Western European countries' GDP has a weak correlation with the wireless mobile broadband subscriptions and no relationship is found with the fixed broadband subscriptions, and a very weak *R* square value is observed. The results indicate that the fixed broadband subscriptions have no impact on the GDP of West Europe, although the wireless mobile broadband subscriptions have a weak impact on the GDP.

Middle East's data shows a strong relationship between GDP per capita and fixed and wireless broadband. The *R* square value is also strong in predicting the GDP per capita in the Middle East. The regression analysis demonstrates that both fixed broadband subscriptions and wireless mobile broadband subscriptions have a strong impact on the GDP per capita in the Middle East.

Asia's GDP demonstrates a strong correlation with the fixed broadband subscriptions, but it does not show any relationship with the wireless mobile broadband subscriptions. Its *R*-value shows that the fixed broadband subscriptions can strongly predict GDP. Hence, fixed broadband subscriptions have a strong impact on the GDP per capita in Asia. Finally, Oceania's results specify that there is no relationship between GDP and broadband in the last region.

In a nutshell, this study demonstrates that Region 2 and Region 7 – South America and Oceania – do not demonstrate any relationship between broadband access (fixed broadband and wireless mobile broadband) and GDP per capita. The GDP has a strong negative relationship with fixed and wireless broadband of North America ; medium negative relationship with fixed broadband of East Europe ; weak negative relationship with wireless mobile broadband of West Europe ; strong negative relationship with fixed and wireless mobile broadband of Middle East ; and lastly, a strong negative relationship with the fixed broadband of Asia.

The fixed broadband subscriptions and wireless mobile broadband subscriptions have a strong negative impact on Regions 1, 3, 5, and 6 – North America, East Europe, Middle East, and Asia. The Western European countries' GDP (Region 4) is negatively affected with the wireless mobile broadband subscriptions rather than fixed broadband subscriptions.

The findings of this research - that is, the negative impact on the GDP associated with broadband access are similar to the results of Crandall et al. (2007) and Thompson and Garbacz (2008). However, the availability of broadband services may have indirect benefits on economies, such as reducing inefficiency and improving productivity of other inputs. While broadband may not show a direct impact on the overall GDP, it could be responsible for allowing an economy to be less inefficient than it would otherwise be with less of this service (Thompson & Garbacz, 2008).

In conclusion, the results indicate that some of the developing countries, such as Regions 3 and 5 experienced a negative impact of the broadband, while some of the developed countries like Region 4 did not demonstrate growth of GDP by the contribution of broadband.

Managerial Implications

This paper has some strong implications for managers and policymakers. The main apparent one is that broadband access contributes to the economy and its well-being. The results of the current study confirm that broadband

access has an impact on the GDP and it sends out an important message to regulators, managers, policymakers, and telecommunication operators to consider the significance of broadband accessibility to public and its economic influences on the economy.

Considering the fact that the last decade was more about the materialization of broadband as a fundamental economic enabler, the next decade would be about the incorporation of fixed broadband and wireless mobile broadband into the day-to-day services and integration of the Internet into the self-service technology platform and devices to facilitate public services. Hence, the regulators and policymakers should keep in mind that the next step could be not only increasing the penetration of broadband, but also investing in complementary factors like education and training of the general workforce. Furthermore, governments could offer financing and subsidization of broadband by direct stimuli, tax incentives, or other supporting approaches to assist telecommunication operators in building and upgrading broadband network.

In the meantime, it is important that regulators be beware of the time which takes to witness the broadband economic results or the tipping point of broadband services. This would be the required time for a nation to have large enough broadband access which could influence different business sectors in the long run, resulting in high productivity and finally direct contribution to the country's GDP. Thereof, it is critical that authorities provide some incentives to accelerate the investment in broadband penetration and speed upgrades.

Although the economic impacts vary by the regions, the broadband investment and its deployment requires comprehensive policy considerations such as training and company relocation to increase the outcomes. This implies that the authorities need to first focus on the penetration of internet then moving to the next phase of increasing the speed to further boost the economic development. The current research adds value to the key decision making criteria and process of broadband plan, formulating policies in favor of facilitating the broadband penetration in the developing and emerging economies.

Limitations of the Study and Scope for Future Research

The limitation of this study is a better understanding of broadband's impact is needed by using a time series data panel and exploring the network externality effects associated with its use by the implementation of an econometrics model. Productive inefficiency may well vary across the industries explored in the earlier studies and are affected disproportionately by broadband's productivity enhancement (Thompson & Garbacz, 2008).
Consequently, we recommend future research to entail a preferably more disaggregated dataset examined by methods capable of revealing relative inefficiency to provide answers and suggestions as to where broadband may be more effective in terms of growth of GDP.

References

Bagheri, M. (2014). Luxury consumer behavior in Malaysia: Loud brands vs. quiet brands. *Procedia-Social and Behavioral Sciences, 130*, 316-324.

Crandall, R. W., Litan, R. E., & Lehr, W. (2007). The effects of broadband deployment on output and employment: A cross-sectional analysis of U.S. data. *Issues in Economic Policy, Number 6.* Washington, DC: The Brookings Institution.

Czernich, N., Falck, O., Kretschmer, T., & Woessmann, L. (2009). B*roadband infrastructure and economic growth* (CESifo Working Paper No. 2861). Retrieved from www.ifo.de/DocCIDL/cesifo1_wp2861.pdf

Czernich, N., Falck, O., Kretschmer, T., & Woessmann, L. (2011). Broadband infrastructure and economic growth. *The Economic Journal, 121* (552), 505-532.

Fornefeld, M., Delaunay, G., & Elixmann, D. (2008). *The impact of broadband on growth and productivity.* Retrieved from http://ec.europa.eu/information_society/eeurope/i2010/docs/benchmarking/broadband_impact_2008.pdf

Greenstein, S., & McDevitt, R. C. (2009). *The broadband bonus: Accounting for broadband Internet's impact on U.S. GDP* (National Bureau of Economic Research (NBER) Working Paper No. 14758). Cambridge, MA: NBER.

Gruber, H., Hätönen, J., & Koutroumpis, P. (2014). Broadband access in the EU: An assessment of future economic benefits. *Telecommunications Policy, 38* (11), 1046-1058.

Internet World Stats. (2016). *Internet world stats usage and population statistics.* Miniwatts Marketing Group 2001-2016. Retrieved from http://www.internetworldstats.com/stats.htm

ITU Broadband Commission. (2011). *Broadband : A platform for progress. A report by the broadband commission for digital development.* Retrieved from http://www.broadbandcommission.org/Documents/publications/Report_2.pdf

Katz, R. L. (2010). Data requirements to measure the economic impact of broadband (pp. 24-26). In *8th World Telecommunication/ICT Indicators Meeting of the International Telecommunication Union*, Geneva, Switzerland.

Koutroumpis, P. (2009). The economic impact of broadband on growth : A simultaneous approach. *Telecommunications Policy, 33*(9), 471- 485.

OECD. (2001). *The development of broadband access in OECD countries.* Paris : Head of Publications Service, OECD.

OECD. (2014). *The development of fixed broadband networks* (OECD Digital Economy Papers No. 239). Paris : OECD Publishing. doi: 10.1787/5jz2m5mlb1q2-en

OECD. (2016). *Gross domestic product (GDP) (indicator)*. doi: 10.1787/dc2f7aec-en

Qiang, C. Z. W., Rossotto, C. M., & Kimura, K. (2009). Economic impacts of broadband. In, *Information and communications for development 2009 : Extending reach and increasing impact.* Retrieved from http://siteresources.worldbank.org/EXTIC4D/Resources/IC4D_Broadband_35_50.pdf

Rajeswari, S., Srinivasulu, Y., & Thiyagarajan, S. (2016). Service quality in the telecommunication industry: analysis with special reference to DSL services. *Indian Journal of Marketing, 46* (2), 7-21. DOI: 10.17010/ijom/2016/v46/i2/87245

Sanou, B. (2013). *The world in 2013: ICT facts and figures. International Telecommunications Union*. Retrieved from https://www.itu.int/en/ITU-D/Statistics/Documents/facts/ICTFactsFigures2013-e.pdf

Tabachnick, B. G., & Fidell, L. S. (2001). *Using multivariate statistics* (4th ed.). Needham Heights, MA: Allyn & Bacon.

Thompson, H. G. Jr., & Garbacz, C. (2008). Broadband impacts on state GDP: Direct and indirect impacts. Paper presented at the *International Telecommunications Society 17th Biennial Conference*, Canada.

United Nations Statistics Division. (2013). *Standard country and area codes classifications* (M49). Retrieved from https://unstats.un.org/unsd/methodology/m49/

Van Welsum, D. (2008). Broadband and the economy (Ministerial Background Report, DSTI/ICCP/IE (2007) 3/FINAL). *Report prepared for the OECD Ministerial Meeting on the future of the Internet Economy,* Seoul, Korea, June 17-18, 2008.

Van Welsum, D., & Vickery, G. (2007). Broadband and the Economy. *Background paper for the 2008 Information, Computer, and Communications Policy Conference on the Future of the Internet Economy*, October 4 - 5, Ottawa, Canada.