Esra Kabaklarli
Selçuk University
Economics Department, Alaaddin Keykubat Kampüsü, Konya,
E-mail: etalasli@selcuk.edu.tr

Burak Sencer Atasoy
Senior Research Associate
Turkish Treasury, Ankara
E-mail: burak.atasoy@hmb.gov.tr

BROADBAND INFRASTRUCTURE AND ECONOMIC GROWTH: A PANEL DATA APPROACH FOR SELECTED COUNTRIES

Preliminary communication
UDK: 004.7:338.1
JEL classification: L86, O47, C33
Accepted for publishing: October 31, 2019

Abstract

The world economy is increasingly becoming digital. The internet not only provides a faster and more reliable communication along the supply chain, but also expands the market for the firms by creating better opportunities to communicate with new customers. As literature stresses, broadband infrastructure stimulates total factor productivity by reducing the transaction costs of communication, leading to a higher GDP growth. In this paper, we analyze the effect of broadband subscriptions on GDP per capita using data for 57 countries covering the 2001-2016 period .By employing the dynamic GMM (Generalized Method of Moment) estimator between the years 2001-2016 for selected countries, we found the positive relationship between the broadband infrastructure and economic growth for these countries. The results indicate that the number of internet users also promotes GDP per capita. In this respect, states are advised to direct resources to broadband infrastructure with an aim to provide high quality, accessible and affordable telecommunication.

Keywords: Broadband, economic growth, GMM (Generalized Method of Moment)

1. INTRODUCTION

Broadband telecommunication infrastructure and information and communications technology (ICT) are vital to countries' economic growth, social development, and technology intensity (Markova, 2009). Enabling greater access to the broadband infrastructure results in more firms and households to benefit from technological advancements. In addition, broadband access is also very important part for the adoption of other complementary ICTs. Firms with access to broadband obtain a digital platform that can be used compatibly with a range of hardware and software technologies. They also have a larger incentive to implement new ICTs due to a greater rate of return on investment than those connected to slower internet.

Many of the developed and developing countries the state undertake the responsibility of broadband investment as natural monopoly. The structure of the telecommunications market changes during the stages of development for each country. In the beginning of the economic development, it is usually said that the structure of the market is a natural monopoly through liberalization into an oligopolistic market, and then finally into a market of monopolistic competition. Competition in telecommunication sector leads to low call charges for customers and increases the total welfare (Kovačević et al, 2017). Low population density and distances made the cost of providing high-speed wired connections uneconomic for incumbent telecoms operators. State broadband infrastructure investment is important for rural areas.

Investing on broadband connectivity and broadband speed promotes economic growth owing to the fact that its components and products such as cable, switches, fiber optic cables lead to increases in the demand for the goods and services used in their production. Since internet connects several sectors of the economy such as health, tourism, education, and manufacturing through back-up and forward-linkages thereby creates spillover effects, the economic benefits of broadband infrastructure investment are much bigger than the cost of investment (Markova, 2009) Many of the broadband strategies that have been taken by governments find to enable internet access for all households nationwide . Currently more than half of the world's households (53.6 percent in 2016) now have access to the Internet at home, compared to less than 30 percent in 2010 (ITU,2017).

This paper proceeds as follows. Section1 provides a brief overview of the nexus between telecom infrastructure and economic activity. Section 2 briefly depicts the literature. Section 3 includes econometric analysis and presents its results. Section 4 concludes.

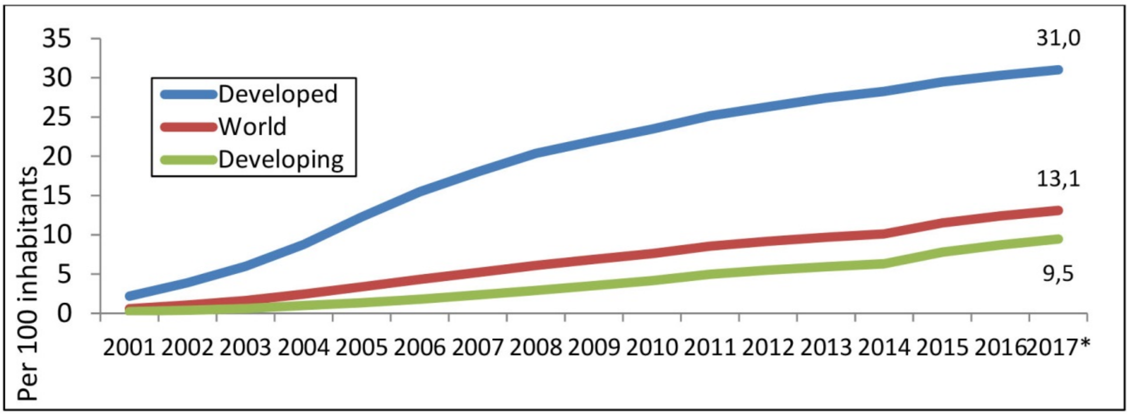
2. BROADBAND INFRASTRUCTURE AND ECONOMIC ACTIVITY

Digital transformation have three waves which are driven by innovation and digital technologies. The first of these waves, telecommunications technology, enables remote access of information by using fixed and mobile broadband. The second wave entails the dispersing of the internet, marketplaces and search engines which facilitate the networking of customers and sellers. The third wave involves the artificial intelligence, big data, internet of things and sensors (Katz, 2017)

Internet has been widely used by local and rural firms and there are many economic benefits of internet access. Broadband, or high-speed internet connection, is a necessity for doing business anywhere in the world. Future advantages of broadband usage to economy comprise of efficiency gains through digital economy, e-trade, e-logistics, better management, and increased efficiency through telecommuting. Broadband infrastructure enables greater availability of public services such as e-government services and applications, health care, and improved access to educational opportunities, and digital learning (Shideler et al, 2007). Broadband infrastructure affects economic growth and improves automation through operational productivity, such as decreasing of transaction costs. In the same way, broadband infrastructure and high speed internet access provides new business opportunities, promoting employment and entrepreneurship (Katz, 2017).

One of the advantages of improving the telephone and internet system is decreased costs-leading to ease in doing business. For that reason, broadband technology and high speed internet provides significant advantage to firms in terms of efficiency. Firms located in rural areas gain from broadband infrastructure since they can access to foreign markets via internet (Mack, 2014). Access the international resources through broadband access technologies can improve the living standards of small businesses and marginal communities (Markova, 2009).

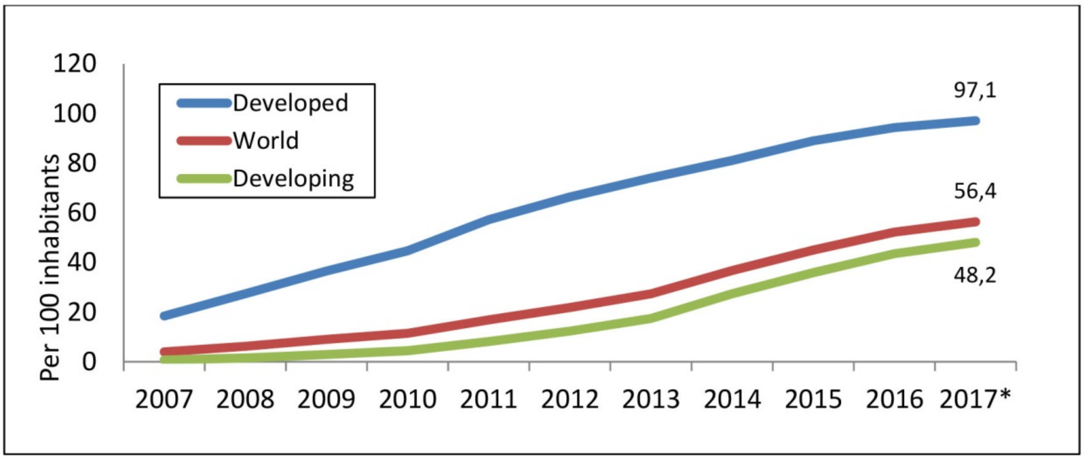
There are many important cases showing the importance of internet access in rural areas, hotels and restaurants. Catalan villages tend to build their own high-speed broadband networks which name is Guifi.net, a wireless community network that connects15,000 homes, hotels in Spain covering 63,000 km of wireless links (Zorina,2016). Hotel owners report that the first thing guests ask for is Wi-Fi, indicating that they see internet more important than the breakfast. Since remote rural locations are often not economically feasible for telecommunication companies to invest, farmers and local business owners, seeing broadband as an essential tool for them, find their own solutions (Financial Times, 2017).



Source: TU World Telecommunication /ICT Indicators database, The developed/developing country classifications are based on the United Nations, see: http://www.itu.int/en/ITU-D/Statistics/Pages/definitions/regions.aspx

Figure 1 Fixed broadband subscriptions per 100 inhabitants, 2001-2017*

Figures 1 and 2 show fixed and mobile broadband subscriptions per 100 inhabitants for the years between 2001-2017, respectively. Both figures denote data for developed and developing countries separately. Mobile-broadband charges as a percentage of GDP per capita reduced between 2013 and 2017 worldwide through digital innovation (ITU, 2017a). In developed countries, the share of households with the fixed broadband internet at home is three times higher than in developing countries. Similarly, people with mobile broadband subscriptions are nearly half of their peers in developing countries. Therefore, we can say that there is a huge difference between developing and developed countries in terms of fixed or mobile internet subscription.



Source: ITU World Telecommunication /ICT Indicators database, The developed/developing country classifications are based on the United Nations, see: http://www.itu.int/en/ITU-D/Statistics/Pages/definitions/regions.aspx
Note: * Estimate

Figure 2 Active mobile-broadband subscriptions per 100 inhabitants, 2007-2017*

3. LITERATURE REVIEW

DeStefano et al (2017) finds that firms with access to broadband increase their investment in complementary hardware and software technologies. Gaining access to advanced internet technologies appears to increase the rate of return on certain types of ICTs, thereby leading to a greater investment of these technologies. Advanced and fast broadband internet technology boosts the productivity of telecom markets, diminish transaction costs in various product and factor markets, and promotes economic growth. Shideler et al (2007) conclude that broadband access has a significant positive impact on employment growth since telecommunications infrastructure reduces costs and ease market access which leads to job creation.

To estimate the effect of broadband lines / population ratio and other explanatory variables on economic growth and employment Crandall et al (2007) find a strong link between broadband access and economic growth. The authors stress that the effect of broadband is most significant in explaining employment growth in education, health care, and financial services. Czernich et al (2011) investigate the impact of broadband infrastructure, on economic growth using panel data for OECD countries during the 1996–2007 period. They find that a 10 percentage point rise in broadband penetration increase GDP per capita growth by 0.9–1.5 percentage points. Similarly, Ng et al, (2013) estimate the effect of broadband diffusion on economic growth in the panel of 10 ASEAN countries and find a positive relationship between broadband infrastructure and economic growth.

Katz and Koutroumpis (2013) tested the impact of digitization on economic growth. By employing the digitization index as a proxy of technology progress, they find that a 10 point increase in the digitization index stimulates GDP growth by 3 percentage points. Katz et al (2010) calculated the impact of investment in broadband technology on German employment and economic output. The authors conclude that broadband technology stimulates economic output and employment through a multiplier effect.

Katz and Callorda (2018) using an econometric model for 75 countries showed that fixed broadband has had a significant impact on the world economy during the period (2010-2017). An increase of 1 per cent in fixed broadband penetration yields an increase in 0.08 per cent in GDP. According to the mobile broadband model, an increase of 1 per cent in mobile broadband penetration yields an increase in 0.15 per cent in GDP.

Literature on broadband and economic growth mostly pointed out broadband as an essential input for the transformation to a knowledge-based economy. Wireless and fixed broadband infrastructure play an important role in protecting against cybersecurity threats, and providing map updates for automated driving and software updates for mobile phones. In the future, it is expected that cars will need wireless infrastructure on highways (ITU, 2017b).

4. DATA AND METHODOLOGY

4.1. Data

In the empirical part of the study, we analyze the effect of broadband subscriptions on GDP per capita using data for 57 countries covering the 2001-2016 period. The definitions of variables and their sources are denoted in Table 1. The description of our data set and the correlations between variables are denoted in Tables 2 and 3, respectively.

Table 1 Data Sources and Variable Definitions

Abbreviation	Variable	Source
Broadband	Fixed broadband subscriptions (per 100 people)	International Telecommunication Union
Phone	Fixed telephone subscriptions (per 100 people)	International Telecommunication Union
Gfcf	Gross fixed capital formation (% of GDP)	World Bank
Internet	Individuals using the Internet (% of population)	International Telecommunication Union
Labor Force	Labor force, total	World Bank
GDP per Capita	GDP per capita (constant 2010 US$)	World Bank
Trade	Trade (% of GDP)	World Bank
Population	Population, total	World Bank

Table 2 Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Broadband Users	912	14.95854	12.5825	0.000197	45.1347
Phone Users	912	33.14708	17.4931	1.842964	74.74272
Gross Fixed Capital Formation	912	22.80521	5.607214	2.000441	45.51477
Internet Users	912	50.81991	27.91951	0.660146	98.24002
Labor Force	912	3.82E+07	1.18E+08	158414	7.87E+08
GDP per Capita	912	25733.73	20020.69	593.1272	91617.28
Population	912	7.90E+07	2.34E+08	284968	1.38E+09
Trade Openness	912	97.96982	68.87221	19.79813	442.62

Table 3 Correlations Between Variables

	GDP per Capita	Broadband	Phone	Gfcf	Trade	Internet	Labor Force	Population
GDP per Capita	1							
Broadband	0.68	1						
Phone	0.8264	0.5767	1					
Gfcf	0.1121	0.0444	0.0036	1				
Trade	0.234	0.2261	0.2301	0.0212	1			
Internet	0.7556	0.8411	0.5824	-0.0664	0.2343	1		
Labor Force	0.2366	-0.1341	-0.2712	0.1639	-0.456	-0.1729	1	
Population	-0.2279	-0.1721	-0.2332	0.4540	-0.2302	-0.2410	0.9809	1

4.2. The Dynamic Panel GMM Estimator

In the empirical part of the study we employ the dynamic GMM estimator which was introduced by Arellano Bond (1991) and advanced by Arellano and Bover (1995) and Blundell and Bond (1998). Dynamic models include lagged dependent variable as a regressor which introduces endogeneity. Dynamic panel GMM estimators solve the endogeneity problem by adding lagged values of dependent variable as regressors and independent variables as instruments to the regression. Furthermore, the GMM estimator solves the autocorrelation problem caused by including the lagged value of dependent variable as a regressor by differencing the lagged value of the dependent variable.

The derivation of the Arellano-Bover/Blundell-Bond estimator is denoted below:

$$y_{it} = \alpha_i + \sum_{j=1}^{p} \rho_j y_{it-j} + \beta X_{it} + u_{it} \tag{1}$$

Equation (1) shows the standard dynamic panel estimator. α_i is the time-invariant unobserved individual effects, y_{it} is the dependent variable, y_{it-j} is the lagged dependent variable, X is the vector of independent variables, and u_{it} is the error term. Taking the first-difference of both sides eliminates fixed effects and bias related to time-invariant unobserved heterogeneity.

$$\Delta y_{it} = \alpha_i + \gamma_j \sum_{j=1}^{p} \Delta y_{it-j} + \beta \Delta X_{it} + \Delta u_{it} \tag{2}$$

Equation (2) denotes the difference GMM estimator introduced by Arellano and Bond (1991). This methodology involves estimating equation (4) by using lagged values of the independent variables as instruments denoted in equation (3). It should be noted that instruments should be uncorrelated with the first difference of the error term.

$$Z = \{\mathrm{y}_{it-1}, \mathrm{y}_{it-2}, \dots \dots, \mathrm{y}_{it-n}, \mathrm{X}_{it-1}, \mathrm{X}_{it-2}, \dots \dots, \mathrm{X}_{it-m}\} \tag{3}$$

However, there are two possible problems related to the difference GMM specification. First, first-differencing could amplify the impact of measurement errors on the dependent variables (Griliches and Hausman, 1986). Second, instruments denoted in equation (3) might be weak for first-differenced equations (Arellano and Bover, 1995). To overcome these problems, Arellano and Bover (1995) and Blundell and Bover (1998) proposed employing the first-differenced variables as instruments for the equations in levels in a system of equations denoted in equation (4).

$$\begin{bmatrix} y_{it} \\ \Delta y_{it} \end{bmatrix} = \delta \begin{bmatrix} y_{it-j} \\ \Delta y_{it-j} \end{bmatrix} + \beta \begin{bmatrix} X_{it} \\ \Delta X_{it} \end{bmatrix} + u_{it} \tag{4}$$

The system GMM estimator generates more efficient estimates than the difference GMM estimator (Blundell and Bover, 1998). However, there is still unobserved heterogeneity in the model. To remove the remaining unobserved heterogeneity, the model is assumed to have the orthogonality conditions shown in equation (5). This involves instrumenting the differenced equations with lagged levels and level equations with lagged differences.

$$E\left[\Delta X_{it-j}(\alpha_i u_{it})\right] = E\left[\Delta y_{it-j}(\alpha_i u_{it})\right] = 0 \tag{5}$$

Two critical assumptions need to hold for the consistency of the system GMM estimator. First, there should not be autocorrelation in the error term. This condition could be tested by employing the Arellano–Bond test for serial correlation. Second, the error term and instruments should not be correlated. The exogeneity of instruments could either be tested by employing the test of overidentifying restrictions proposed by Sargan (1958) or Hansen's J test (Hansen, 1982), depending on the use of one-step and two-step system GMM estimators. Finally, since two-step GMM estimators usually have lower bias and standard errors, it may lead to higher significance levels compared to the one-step estimations. To address this issue, I use the standard error correction proposed by Windmeijer (2005).

4.3.Unit Root and Cointegration Tests

To avoid getting spurious results we analyze the stationarity of the series. In this respect, we employ the second generation CIPS unit root tests developed by Pesaran (2007). The null hypothesis of the CIPS test is non-stationarity. As seen in Table 4, all series are nonstationary and become stationary after taking their first differences. Thus, the CIPS test implies we should employ variables in their first differenced forms.

Table 4 The CIPS Unit Root Test Results

	Series		First Differenced Series	
	Intercept	Intercept + trend	Intercept	Intercept + trend
GDP per Capita	1.568	3.123	-5.956***	-3.048***
Broadband	-0.530	2.005	-11.637***	-8.591***
Phone	3.115	3.781	-4.660***	-8.663***
Gfcf	1.435	3.849	-2.721***	-7.616***
Trade	2.105	3.142	-3.236***	-4.111***
Internet	1.817	5.213	-4.995***	-12.736***
Labor Force	-1.058	2.894	-5.783***	-7.634***
Population	-2.111	3.092	-6.789***	-7.562***

*, **, *** indicate that statistics are significant at the 10%, 5% and 1% level of significance, respectively. For the CIPS test the null hypothesis is nonstationarity.

However, there might be a cointegration relationship between series. Cointegration allows employing nonstationary variables in levels without creating a spurious relationship if a linear combination of them are integrated of order zero (Atasoy, 2017). To test cointegration, I employ the Durbin-Hausman test proposed by Westerlund (2008). The Durbin-Hausman test uses panel (DHp) and group (DHg) tests to take cross-sectional dependence into consideration. The null hypothesis for both the DHp and DHg assert that there is no co-integration between variables. The DHp imply that the autoregressive parameter is the same for all cross-sections wheras the DHg permits the autoregressive parameter to differ across cross-sections. For both tests, we conclude that there is co-integration if the null hypothesis is rejected. Table 5 denotes the results of the Durbin-Hausman test. Since both tests reject the null hypothesis of no-cointegration, we confirm the co-integration relationship between the series. Therefore, we proceed by employing variables in levels.

Table 5 Westerlund Durbin-Hausman Test Results

	Value
DHg	5.94***
DHp	5.32***

*, **, *** indicate that statistics are significant at the 10%, 5% and 1% level of significance, respectively. The null hypothesis is no cointegration.

4. 4. Estimation Results

Table 6 denotes the results generated by the Arellano-Bover/Blundell-Bond estimator. In our model it is assumed that trade openness, gross fixed capital formation and the lagged value of GDP per capita are endogenous. Accordingly, GDP per capita increases as fixed broadband subscriptions increase. This result indicates that it is possible to promote GDP by extending the coverage of broadband connection. In this respect, the governments could either promote broadband use by giving effective incentives to the private sector or build a high quality network by using budget revenues. Contrary to broadband connection, fixed telephone subscriptions has a fairly limited effect on GDP per capita as the coefficient of phone users per 100 people is significant in only two specifications. Finally, the number of internet users also seems to effect GDP per capita positively, despite losing significance when regressed alongside with phone users.

Table 6 Estimation Results

	(1)	(2)	(3)	(4)	(5)
Lagged GDPPC	0.9423***	0.9427***	0.9449***	0.9388***	0.9501***
	(0.0046)	(0.0046)	(0.0053)	(0.0061)	(0.0033)
Broadband Users	0.028***	0.017**	0.077***	0.0902**	0.054***
	(0.0032)	(0.0083)	(0.0015)	(0.0448)	(0.0014)
Phone Users	0.0381	0.0383**		0.0404	0.0451***
	(0.0235)	(0.0192)		(0.0351)	(0.0032)
GFCF	0.038***	0.038***	0.051***	0.039***	0.033***
	(0.0003)	(0.0003)	(0.0002)	(0.0004)	(0.0002)
Internet	0.0041**	0.0047	0.0053***	0.0031***	
	(0.0022)	(0.0101)	(0.0002)	(0.0002)	
Labor Force	0.037**		0.102***		0.035**
	(0.018)		(0.0012)		(0.019)
Trade Openness	0.002***	0.018***	0.027***		0.022***
	(0.0001)	(0.0001)	(0.0001)		(0.0001)
Population		0.004		0.0014	
		(0.0010)		(0.0011)	
Constant	0.2608***	0.3471***	0.4017***	0.3300***	0.2789***
	(0.0424)	(0.0331)	(0.0559)	(0.0490)	(0.3990)
Observations	854	854	854	854	854
# of groups	57	57	57	57	57
# of instruments	25	25	24	23	24
Time dummies	Yes	Yes	Yes	Yes	Yes
Hansen p-value	0.36	0.41	0.37	0.51	0.45
Sargan p-value	0.18	0.21	0.19	0.26	0.22
AR(2) p-value	0.52	0.50	0.44	0.55	0.66

Windmeijer (2005) corrected robust standard errors in parentheses. The dependent variable is Natural Logarithm of GDP Per Capita. The table also includes time dummies, number of groups, number of instruments, Hansen and Sargan over-identification tests, and AR(2) test of the error terms. *, **, and *** denote statistically significant coefficient at the 10%, 5% and 1% levels, respectively. Lagged value of GDP per capita, trade openness and gross fixed capital formation are treated endogenous.

In line with our expectations, labor force and gross fixed capital formation have powerful positive effect on GDP per capita. Trade openness is also found to have a stimulating effect on GDP per capita, in line with the literature. Thus, policy makers could prop labor, capital and trade openness with a well-defined digitalization strategy that aims to achieve a widespread use of high speed internet, the broadband network in particular. In this respect, governments could speed up this process by directing both public and private resources to broadband infrastructure with an aim to provide high quality, accessible and affordable telecommunication.

5. CONCLUSION

In this paper we examined the effect of broadband use on GDP per capita for 57 countries by using data for the 2001-16 period and employing the system GMM estimator. It is found that broadband telecommunications infrastructure promotes GDP per capita. It is also found that fixed telephone use has a positive effect on GDP per capita, but its effect is somewhat weaker than the effect of broadband use. Finally, the results indicate that the number of internet users also promotes GDP per capita.

We also included other variables such as labor force, gross fixed capital formation and trade openness that are likely to affect GDP. In line with the literature, these variables are found to affect GDP per capita positively. Therefore, it is crucial for policy makers to supplement the traditional growth model that combines labor and capital under an open economy with the components of digital economy such as broadband internet use. In this respect, they are advised to direct resources to broadband infrastructure with an aim to provide high quality, accessible and affordable telecommunication.

Broadband infrastructure is essential to countries' economic development. When we look at the literature there is a big consensus that broadband internet is compulsory for a digital economy and fosters sustainable economic development and job creation. Therefore many countries have identified broadband as a critical input to broader efforts in building a knowledge-based economy. If we think the future jobs and industry 4.0, we see that broadband infrastructure will be most important factor to build future technologies and digital economy. Governments must provide incentives for investment in high-speed broadband networks in rural areas to stimulate job creation and restoring rural development.

REFERENCES

Arellano, M., & Bond, S. (1991). Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. *The Review of Economic Studies*, 58, 277-97.

Arellano, M., & Bover, O., (1995). Another look at the instrumental variable estimation of error-component models. *Journal of Econometrics*, 68, 29-51.

Atasoy, B. S., (2017). Testing the environmental Kuznets curve hypothesis across the U.S.: Evidence from panel mean group estimators. *Renewable and Sustainable Energy Reviews*. Elsevier, vol. 77, 731-747.

Blundell, R., & Bond, S. (1998). Initial conditions and moment restrictions in dynamic panel data models. *Journal of Econometrics*, 87, 115-43.

Crandall, R W. & William L. & Robert E. L (2007). The effects of broadband deployment on output and employment: A cross-sectional analysis of U.S. data. The Brookings Institution: Issues in Economic Policy 6 (July)

Czernich, N. & Falck O.& Kretschmer, T. & Woessmann L. (2011), "Broadband Infrastructure And Economıc Growth" ,*The Economic Journal*, 121 (May), 505–532.

DeStefano, T. & Backer K. D. & Moussi, L. (2017), Determınants of Dıgıtal Technology Use By Companıes, OECD Scıence, Technology And Innovatıon Polıcy Papers June 2017 No. 40

FT (Financial Times), How Catalan villages built independent broadband networks 26 September 2017 FT.

Griliches, Z., & Hausman, J. A., (1986). Errors in variables in panel data. *Journal of Econometrics*, 31, 93-118.

Hansen, L. P. (1982). Large sample properties of generalized method of moments estimators. *Econometrica*, 50, 1029-1054.

ITU International Telecommunication Union (2017a), https://www.itu.int/en/ITU-D/Statistics/Pages/ICTprices/default.aspx , access date:17.07.2019

ITU International Telecommunication Union (2017b), Measuring the Information Society Report Volume 1 , Switzerland.

Katz, R. L. (2017). Social and economic impact of digital transformation on the economy (GSR-17 Discussion Paper). Retrieved from: https://www.itu.int/en/ITU-D/Conferences/GSR/Documents/GSR2017/Soc_Eco_impact_Digital_transformation_finalGSR.pdf.

Katz, R. and Callorda, F (2018) The economic contribution of broadband, digitization and ICT regulation, International Telecommunication Union ITU Publicaitons.

Katz, R. L. and Koutroumpis, P. (2013). Measuring digitization: A growth and welfare multiplier. Technovation, 33(10), 314-319.

Katz, R. L., Vaterlaus, S., Zenhäusern, P., and Suter, S. (2010). The impact of broadband on jobs and the German economy. Intereconomics, 45 (1), 26–34.

Kovačevıć, D & Krajnovıć, A & Čıčın-Š. D (2017), Market Analysis of The Telecommunications Market The Case of Croatia, *DIEM Dubrovnik International Economic Meeting 2017*, Crotia

Mack, E. (2014a). Businesses and the need for speed: The impact of broadband speed on business presence. Telematics and Informatics, 31, 617-627.

Markova, E. (2009) Liberalization and Regulation of the Telecommunications Sector in Transition Countries, *Springer*, Germany

Ng, T. L. & Chun T. & Lim, Y. S. (2013) Broadband penetration and economic growth in ASEAN countries: a generalized method of moments approach, *Applied Economics Letters,* 20:9, 857-862

Pesaran M. H. (2007). A simple panel unit root test in the presence of cross-section dependence. *Journal of Applied Econometrics*, 22 (2), 265-312.

Sargan, J. D. (1958). The estimation of economic relationships using instrumental variables. *Econometrica*, 26, 393-415.

Shideler, David, Narine Badasyan, and Laura Taylor (2007)The Economic Impact of Broadband Deployment in Kentucky.‖ Federal Reserve Bank of St. Louis, *Regional Economic Development*, 3 (2): 88- 118.

Westerlund, J. (2008). Panel cointegration tests of the Fisher effect. *Journal of Applied Econometrics*. 23 (2), 193-233.

Windmeijer, F. (2005). A finite sample correction for the variance of linear efficient two-step GMM estimators. *Journal of Econometrics*, 126, 25-51.

Zorina, A. (2016).From a competing to a collaborative crowd: Tactics for co-creation with innovative bottom-up communities,*Organizational Dynamics*,45 (2). 80-93.