JCGIRM Journal of Corporate Governance, Insurance, and Risk Management (JCGIRM)
2018, Volume 5, Series 2

pp 27-39

Do the Developments in Telecommunication Leads to the Solow Paradox on Economic Growth in Turkey?

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ABSTRACT

Telecommunications infrastructure is critical not only for domestic growth, but also for combining credit with international commodity and financial markets, such as the smooth flow of foreign investment, facilitating the positive value of net exports, and increasing the added value in the economy's GDP. In this study, fixed telephone lines in the period since the Republic of Turkey, is to investigate whether mobile phone and affect the economic growth of the telecommunications sector showing growth in internet connection. In our study, the penetration rate represents the development of telecommunications industry. Penetration rate is defined as the number of fixed line and mobile phone subscribers per 100 people. In order to measure the penetration rate in Turkey, we have used the ratio of the total number of fixed line, mobile subscribers and internet users to the population, taking into account the dates when mobile communication and the internet started. Economic growth is represented as the rate of change to Gross Domestic Product. The data used in this study cover an annual period 1935-2017. After investigating the stationarity of the series of variables, a causal relationship between the Toda-Yamamoto causality test and the penetration rate and GDP change rate series was examined. The findings of the analysis, the development of telecommunications in Turkey revealed that does not affect economic growth. According to this result, the Solow paradox is valid in the period examined in Turkey.

ARTICLE INFO

Keywords: Telecommunication Developments, Economic Growth, Solow Paradox, LM Unit Root Tests, Toda-Yamamoto Causality Test

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Article history:

Received 11 04 2018
Revised 23 06 2018
Accepted 26 09 2018

1. INTRODUCTION

Telecommunications infrastructure is critical not only for domestic growth, but also for combining credit with international commodity and financial markets, such as the smooth flow of foreign investment, facilitating the positive value of net exports, and increasing the added value in the economy's GDP. Recent developments in telecommunications technology are seen as an important tool for developing a solid commodity market and making information easy to use. All over the world, the telecommunications industry has made rapid progress since the 1980s. Countries that have completed the progress stages of Rostow have started and continue to develop in the field of telecommunications. Developing countries accelerated their infrastructure works after realizing the importance of telecommunications in economic growth. On the other hand, the Solow paradox highlights the dilemma between information and telecommunications technologies, although they are predicted to have growth-enhancing effects, but statistical data do not support this.

We can divide the effect of telecommunication on the economy of the country into two as direct and indirect. Direct impact can be listed as high-gain business opportunities, increase in demand for technical labour, transfer of technical skills to the local population, increased trade, market expansion with liberalization, diversity in purchasing preferences of consumers. In addition, service providers, mobile phones and wireless companies have created a competitive equipment market and accelerated technological development. With the establishment of call centres, customer service centres and mobile phone franchises, indirect employment has increased and a competitive labour market has emerged. In addition, telecommunication is a basic infrastructure component that enables the development of different sectors such as agriculture, education, industry, health, banking, defence, transportation and tourism. It is indispensable for daily activities promoting economic growth.

In this study, fixed telephone lines in the period since the Republic of Turkey, is to investigate whether mobile phone and affect the economic growth of the telecommunications sector showing growth in internet connection. The result of this study aims to make an important contribution to literature.

2. LITERATURE REVIEW

The relationship between telecommunications and economic growth has received wide attention from researchers in recent years. Ricketts (2002) states that telecommunication helps the coordination of information flow, provides opportunities to increase the efficiency of interaction and coordination, and thus affects the success of economic activities. It argues that a significant level of interaction and coordination is required for economic activities to be carried out successfully and efficiently. Alleman et al. (1994), on the other hand, argues that a modern telecommunications infrastructure is a precondition not only for local economic growth, but also for participating in increasingly competitive world markets and attracting new investments. All in all, to increase productivity in all sectors of telecommunications; facilitating the expansion of markets beyond borders to increase the efficiency of economies of scale; facilitating access to services by reducing the costs of services in the fields of management, education, health and banking; providing access to research positively influences economic growth through contributing to governance, which is a precondition for growth with greater participation, accountability and transparency.

The use of telecommunication services provides positive externalities, enhances creativity, learning and problem solving skills. The short-term impact is on employment and the long-term on connectivity, access, network security, talent/skills, market structures and firm governance. It certainly determines whether firms in developing countries can participate effectively and efficiently in the knowledge economy and compete in global e-markets.

In research on economic growth and telecommunications development in developed economies; Jipp (1963); Wellenius (1972); Marsh (1976); Shapiro (1976); Hardy (1980); Moss (1981); Norton (1992); Saunders et al. (1994); Lichtenberg (1995); Greenstein and Spiller (1996) found that there are positive relationships between telecommunications and economic growth. Moreover, these studies investigated the relationship between telecommunications and economic growth without considering the direction of causality between telecommunications development and economic growth. Although telecommunications development is found to be one of the factors affecting economic growth, its contribution varies between countries at different stages of development.

Cronin (1991); Cronin et al. (1993) investigated the causality relationship between telecommunications and economic growth using US data. The findings revealed that there is a two-way relationship between telecommunications infrastructure and economic growth. In a causality analysis conducted by Madden and Savage (1998), it was stated that there is a two-way relationship between telecommunications investment and economic growth in Central and Eastern European countries. Canning and Pedroni (1999); Jorgenson and Stiroh (1999); Triplett (1999); Schreyer (2000); Colecchia and Schreyer (2002); Pohjola (2002) have also conducted a series of studies revealing that the long-term economic growth of the United States has been realized by information and telecommunication technologies.

In their study, Roller and Waverman (2001) revealed that the contribution of telecommunications to economic growth is not independent from the level of telecommunications development. Roller and Waverman (2001) studied how telecommunications infrastructure affected economic growth over a 20-year period using data from 21 OECD countries. They predicted a micro model with a macro production function for telecommunications investment. They have reached a significant positive causal link in the presence of a critical mass of telecommunications infrastructure.

Dutta (2001) conducted a Granger causality test with the data of 1970-1993 period of 15 developed countries and 15 of them belonging to the variables of telecommunication and economic growth represented by the number of fixed and mobile lines per 100 people. It found a positive relationship between telecommunications infrastructure and economic growth. Pohjola (2002) did not find a positive and significant relationship between telecommunications investments and GDP growth in his study with the data of 42 developed and developing countries for the years 1985-1999. Chakraborty and Nandi (2003) showed that there is a two-way relationship between the intensity of use of telecommunication systems and GDP in both the short and long term in 12 developing countries in Asia. When these countries were divided into two groups with high and low degree of privatization, causality was bidirectional only for countries in the group with high degree of privatization.

Cieslika and Kaniewsk (2004) found in their study that a positive and statistically significant causality relationship between the telecommunications infrastructure and income at the regional level in Poland is from the telecommuni cations infrastructure to the income. Datta and Agarwal (2004) analyzed the relationship between telecommunications infrastructure and economic growth using the dynamic fixed effects model using the 1980-1992 data of 22 OECD countries. The findings revealed that telecommunications infrastructure indicators positively affect real GDP growth.

While Yoo and Kwak (2004) has found a two-way relationship between information technology investment and economic growth in South Korea during 1965-1998, Wolde-Rufael (2007), found a two-way relationship between information technology investment and economic growth in the USA during 1947-1996. Pazarlıoğlu and Gürler (2007) studied the relationship between telecommunications infrastructure investments and economic growth between 1990 and 2004 using the dynamic panel data method for the European Union core countries, member countries and candidate countries. It has been determined that the effect of telecommunication infrastructure investments on real GNP per capita is positive and significant. Sridhar and Sridhar (2007) investigated the relationship between telecommunications and economic growth using data from 28 developing countries. The study reveals that landlines and mobile phone use have a positive impact on national output. It turns out that the impact of telecommunications penetration rate on total output is significantly higher for developing countries than for OECD countries.

Shiu and Lam (2008) found a one-way relationship from GNP to telecommunications development in China. While the negative relationship from telecommunications to economic growth is achieved only in the rich eastern region of China, no relationship has been found in the low-income middle and western regions. Zahra et al. (2008) found that telecommunications infrastructure increased economic growth by using dynamic panel data analysis for 24 low, medium and high-income countries during 1985-2003, with an index for the number of fixed and mobile lines per 1000 inhabitants and internet users for telecommunications infrastructure. Yıldız (2012) searched the effect of OECD countries' investments in the telecommunications sector on economic growth in the period of 1990-2009 with panel data analysis. It has been found that telecommunications increase economic growth. Zeren and Yurtkur (2012) analyzed the impact of telecommunications infrastructure on economic growth in Turkey using the Geographical Weighted Regression Model. They found a positive relationship between telecommunications and economic growth.

Chavula (2013) analyzed the number of fixed lines per 100 people, the number of mobile lines and internet usage, which represent the development of telecommunications within the framework of the endogenous growth model with the data of the years 1990-2007 from 49 developing countries. They are concluded that the most important variable affecting economic growth is mobile lines. Güvel and Aytun (2013) studied the relationship between telecommunications infrastructure and economic growth for the period 1991-2009 using data from 138 countries included in five different income groups. They found that information and telecommunications technologies are a positive and significant factor on growth in all income groups except the non-OECD high income group. Kaur and Malhotra (2014) analyzed the relationship between the telecommunications infrastructure and GDP in India with the data for the period 1976-2012. As a result of the analysis, they determined a causality from telecommunications to GDP.

Pradhan et al. (2014) found a two-way relationship between the use of fixed lines, mobile lines and internet per 1000 people and the change in GDP per capita, representing the development of telecommunications with the panel Granger test for the G20 countries for the period 1991-2012. Özcan (2015) analyzed the relationship between the telecommunications industry and economic growth with panel causality analysis using the data of 24 OECD countries between 1975 and 2013. A causality relationship was found between variables in the countries studied.

It is clear from these studies that studies investigating how the developments in telecommunications lead to economic growth using Turkey data are rare. This is the main point of departure for this article.

3. DATA

In our study, the penetration rate represents the development of telecommunications industry. Penetration rate is defined as the number of fixed line and mobile phone subscribers per 100 people. In order to measure the penetration rate in Turkey, we have used the ratio of the total number of fixed line, mobile subscribers and internet users to the population, taking into account the dates when mobile communication and the internet started. Considering the rapid development of mobile communication and the internet in the last two decades, including the number of mobile phone subscribers and internet users to our definition of telecommunications is thought to be important to reflect the development of telecommunications in Turkey.

Economic growth is represented as the rate of change to Gross Domestic Product. The data used in this study were obtained from TÜİK and World Bank databases over an annual period covering the period 1935-2017. It has been made ready for econometric analysis by applying logarithms to the series in order to reduce the difference between the values of the data of the variables and to bring the series closer to the stationary. The GDP rate of change variable representing economic growth has negative values. After converting negative values to positive values, logarithms can be taken. The absolute greatest positive observation value in the series was added to all the values that make up the series and transformed into positive.

4. METHODOLOGY

The econometric analyses in the study were carried out in phases. First, volume root problem was investigated using ADF unit root test. The unit root problem requires a stationarity test and is very important for econometric analysis. Because time series data of many variables are faced with unit root problem. If the mean and variance of the observation values of a variable are independent of time, then the time series is considered to be stationary. If the time series consisting of observation values is not stationary, it means that it has a unit root. The fact that time series contains unit root causes traditional regression analysis to produce false results. In order to save a non-stationary time series from the unit root, it can be made stationary by taking the difference or differences of the series.

In unit root tests with structural break developed by Lee and Strazicich (2003, 2004), the alternative of the basic hypothesis should not be stationary with structural break. If the alternative to the basic hypothesis is determined as the existence of structural breaks, it means that the unit root with structural break in the series may exist. In other words, rejecting the basic hypothesis does not result in the rejection of the existence of the unit root, but the rejection of the unit root without a structural break. The rejection of the basic hypothesis causes the trend to be considered as static with structural break, while the difference is in fact stable with the series breakages.

Lee and Strazicich (2003, 2004), using the Lagrange Multipliers (LM) unit root test of Schmidt and Phillips (1992), developed an alternative to the Zivot-Andrews unit root test, the single-break, two-break unit root test as an alternative to the Lumsdaine-Papell unit root test. They solved the problem of evaluating the series as trend stationary with structural break.

For LM unit root test ; $y_t = \delta Z_t + e_t \quad e_t = \beta e_{t-1} + \varepsilon_t$ (1) the regression equation is used. Z_t; vector of exogenous variables, ε_t; *iid N* (0, σ^2) It represents the remains that show their characteristics.

Model A for unit root test with single break at level, D_t, $t \geq T_B + 1$ as 1, in other cases, for the shadow variable that takes a value of 0, in model number (1), it is created by typing $[1, t, D_t]'$ instead of Z_t. T_B is the time to break.

Model AA for unit root test with two break at level, D_{jt}, for *j* = 1, 2 $t \geq T_{Bj}$ +1 as 1, in other cases, for the shadow variable that takes a value of 0, in model number (1), it is created by typing $[1, t, D_t, \mathrm{DT_t}]'$ instead of Z_t.

Model C that allows single break at level and slope, $\mathrm{DT_t}$, $t \geq T_B + 1$ as $t - T_B$ in other cases, for the shadow variable that takes a value of 0, in model number (1), it is created by typing $[1, t, D_t, \mathrm{D_t}]'$ instead of Z_t.

Model CC, which allows two breaks in fixed term and trend, for *j* = 1, 2 DT_{jt}, $t \geq T_{Bj} + 1$ as $t - T_{Bj}$ in other cases, for the shadow variable that takes a value of 0, in model number (1), it is created by typing $[1, t, D_{1t}, \mathrm{D_{2t}}, \mathrm{DT_{1t}}, \mathrm{DT_{2t}}]'$ instead of Z_t.

Data generation, with breaks under basic hypothesis ($\beta = 1$), alternative hypothesis is β<1. LM unit root test statistic takes the form of $\Delta y_t = \delta' \Delta Z_t + \phi \tilde{S}_{t-1} + u_t$.

The structural break point is thus located in the clipping region (0.15*T - 0.85*T). Critical values for single break LM unit root test are provided from Lee and Strazicich (2004), and critical values for double break LM unit root test from Lee and Strazicich (2003). If the calculated test statistic is greater than the critical value, the unit root base hypothesis with structural break is not accepted.

The causality relationship between economic growth and penetration rate variables was determined by Toda-Yamamoto test. The Toda-Yamamoto causality test can conduct a causality research regardless of the same stationarity levels between time series and the cointegration relationship between variables. This method is used because it is suitable for the standard VAR model at different levels of the variables and minimizes the possibility of incorrectly determining the degree of integration of the series (Mavrotas and Kelly, 2001).

Two steps must be taken to implement the Toda-Yamamoto causality test. The first step is to determine the lag length (m) and the other is to choose the maximum degree of integration (dmax) for the variables in the system. Akaike Information Criterion (AIC), Schwarz Information Criteria (SC) and Hannan-Quinn (HQ) Information Criteria are used to determine the degree of delay of the VAR. Then the VAR model is estimated with the sum of the p = (m + dmax) lags. The standard Wald test is applied to the mVAR coefficient matrix (without applying to all delayed coefficients) to draw conclusions to the Granger causality test (Awokuse, 2003).

5. INTERPRETING THE FINDINGS

5. 1. ADF Unit Root Test Findings

ADF unit root test was applied to variables for the stationary test, which is the first step of econometric analysis. The findings of the ADF unit root test are given in Table 1.

Table 1: ADF Unit Root Test Findings

Variables	ADF		Results
	Trend-Intercept Level Value	**Trend-Intercept 1st Difference Value**	
lngrowth	-5.373214 (0.0001)	-	I (0)
lnpen	-2.042896 (0.5691)	-4.788488 (0.0011)	I (1)

lngrowth variable according to Table 1; stationary at the trend-intercept level value i.e. I (0), lnpen variable; trend-intercept is stationary at the 1st difference value, i.e. I(1).

5. 2. Lee - Strazicich Unit Root Test Results with Structural Break

The findings of the lngrowth and lnpen variables of the LM unit root test investigating the intrinsic single break are as in Table 2.

Table 2: Single Break LM Unit Root Test Results

	lngrowth Model A	**lnpen Model A**	**lngrowth Model C**	**lnpen Model C**
Test Statistics	-5.429299	-2.018410	-5.776237	-4.350204
Lag Length	1	6	2	7
Date of Breaking	1976	1959	1961	1984
Critical Values (%5)	-3.48700	-3.48700	-4.23111	-4.34371

The gross domestic product rate of change break dates are 1976 for Model A, 1961 for Model C, and the penetration rate breakage dates are 1959 for Model A and 1984 for Model C. When the test statistics of the variables are examined, it is seen that the test statistics for both models are greater than the critical value except for lnpen Model A. At the 5% significance level, the breakage dates in both models and the unit root base hypothesis with structural break are not acceptable except for lnpen Model A. This means that the unit root without structural break is rejected except for the Inpen Model A. The series of the variables of the study are stationary, with breaks except for lnpen Model A. This result reveals that the variables are I (1), except for Inpen Model A. Without structural break it means rejecting the unit root. The series of the variables of the study are stationary with the breakage, except for lnpen Model A. This result reveals that the variables are I(1).

Table 3: Single Break LM Unit Root Test Results

	lngrowth Model AA	lnpen Model AA	lngrowth Model CC	lnpen Model CC
Test Statistics	-6.2378	-2.0763	-7.5505	-6.0257
Lag Length	2	6	6	8
Date of Breaking	1947 1972	1959 2009	1945 1956	1985 1996
Critical Values (%5)	-3.5630	-3.5630	-6,1080	-6,2010

Table 3 contains the results of the LM unit root test investigating two structural breaks according to the basic and alternative hypothesis. The test statistics calculated in Model AA and Model CC of the variable lnpen are less than 5% critical values. In this case, the unit root base hypothesis with LM two break is not rejected. The calculated test statistics of the other variable, lngrowth, are absolutely greater than the 5% critical value. In this case, since the unit root base hypothesis with structural break cannot be accepted, it means rejecting the unit root without structural break. lngrowth series, the difference is stable with breaks. As a result of the LM unit root test, it is revealed that the lnpen variable is I(0) and the lngrowth variable is I(1).

The results of the ADF and LM structural break unit root tests prevent traditional cointegration tests to investigate the relationship between variables. Because traditional cointegration tests argue that the variables should be stationary at the same level. On the other hand, the ARDL test is applied to the stable states of the variables in the level and 1st difference, unlike traditional cointegration tests. However, in order to be able to apply the ARDL test, the dependent variable must be first aware, i.e. I(1) independent variable must be stationary at the level. Especially according to the ADF test findings of the variables of the study, this condition cannot be met.

5. 3. Toda-Yamamoto Causality Test Findings

The variables in our study were stationary at different levels as a result of the stationarity tests and the dependent variable was determined as I(0), requiring Toda-Yamamoto causality analysis. For this analysis, it is necessary to first determine the maximum lag length. Table 4 contains the maximum lag length determined according to the information criteria. The criteria in this table chose the ideal maximum lag length as 2.

Table 4: Determination of Maximum Lag Length Belong to lngrowth and lnpen Variables

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-146.6395	NA	0.171326	3.911565	3.972900	3.936078
1	122.9565	517.9081	0.000158	-3.077802	-2.893797	-3.004265
2	139.6822	31.25060	0.000113*	-3.412689*	-3.106013*	-3.290126*
3	140.6795	1.811023	0.000122	-3.333672	-2.904327	-3.162085
4	142.5012	3.211810	0.000130	-3.276346	-2.724331	-3.055734
5	148.5211	10.29729*	0.000123	-3.329503	-2.654817	-3.059866
6	153.2784	7.887033	0.000121	-3.349431	-2.552075	-3.030769
7	155.3159	3.270782	0.000128	-3.297787	-2.377761	-2.930100

After determining the maximum lag length, the standard VAR model was established by using the level values of the series of variables.

$$lngrowth_t = \beta_0 + \beta_{lnpen} lnpen + \mu_i$$

$\partial lngrowth_t$ / $lnpen$ > 0 ; the development in telecommunications affects economic growth,

$\partial lngrowth_t$ / $lnpen$ < 0 ; the development in telecommunications does not affect economic growth.

When determining the VAR model for economic growth and telecommunication variables, the lag length of the standard VAR model was determined as 2, since the lag length represents 2 lags. The degree of integration (dmax) is 1 since the economic growth variable is I(0) and the telecommunications variable is I(1). By adding the degree of integration (dmax) to the standard VAR model, the lag length is 3.

The new VAR model created by changing lag lengths was estimated by Seemingly Unrelated Regression (SUR) method. The SUR method was preferred because it takes into account the heteroskedastic (changing variance) in the error terms of the equations for causality analysis estimated in the model estimation part and the correlation between the error terms (autocorrelation).

The findings of the Toda-Yamamoto causality test for economic growth and telecommunications variables are shown in Table 5.

Table 5: Toda-Yamamoto Causality Analysis Findings of the lngrowth and lnpen Variables

Dependent Variable	**Direction of Causation**		
	lngrowth	**lnpen**	
lngrowth	-	1.338738 (0.7200)	lnpen $\nrightarrow$ lngrowth
lnpen	1.667546 (0,6442)	-	lngrowth $\nrightarrow$ lnpen

The values in Table 5 shows that there is a relationship between variables telecommunications and economic growth in Turkey. According to the results of economic growth and developments in telecommunications in Turkey and mutually influence each other. While our study findings support the results of Pohjola (2002), it is not compatible with the findings of the studies indicating that the developments in telecommunications in the literature will cause economic growth.

6. CONCLUSION

Wireless and fixed telecommunications are a service of general economic interest. It improves the knowledge, skills and personal environment of individuals and increases private sector productivity. Telecommunications is important as a technology to increase investment returns in other sectors, facilitate service trade and globalization, increase the national business environment and competitiveness, and improve public services.

Telecommunications infrastructure in Turkey, especially as a result of the increasing number of Internet users and mobile telecommunications, has made rapid development despite low incomes and high population density, especially in the 2000s. This development is even more pronounced for rural areas.

With the rapid development of the wireless band, mobile communication has evolved from simple voice communication services and text messaging with a widespread application network where traditional services are not available. Smartphones now allow users to surf the Internet, download music, access information services and organize events via teleconferencing. Despite these developments, the communication density over fixed telecommunications has dropped dramatically.

Although telecommunication development is found as one of the factors affecting economic growth, its contribution varies between countries at different stages of development. In this study, the development of telecommunications in Turkey focused on identifying the impact on economic growth. In order to measure the development of the telecommunication sector, the penetration rate, which is defined as the ratio of the total number of fixed lines, mobile phone subscribers and internet users per 100 people to the population, was used. Also, economic growth is represented by the rate of change to the Gross Domestic Product.

In our study, after investigating the stationarity of the series of variables, a causal relationship between the Toda-Yamamoto causality test and the penetration rate and GDP change rate series was examined. The findings of the analysis, the development of telecommunications in Turkey revealed that does not affect economic growth. This result with together, telecommunication development is not a factor that increases directly economic activities in Turkey. In the light of the literature and our findings examined in the study, while the effect of advances in telecommunications on economic growth is evident in developed countries, the effect in underdeveloped countries is not entirely clear.

The Solow paradox has been included in the literature in the 1980s when the effects of telecommunications technologies on economic growth began to be taken into account. This paradox points to the dilemma that statistical data do not support this effect, although it is thought that the growth-enhancing effects of information and telecommunication technologies will emerge. Results of our study revealed that the Solow paradox occurs in Turkey. This result is an important contribution to the literature.

Moreover, within the scope of the Regulatory Scorecard-2017 study conducted by the European Competitive Telecommunications Association (ECTA), where the effectiveness of the regulatory framework and market competitiveness in the telecommunications market is evaluated, Turkey is ranked 19th among the EU members and candidates from 22 countries. It shows that there is not a competitive telecommunications market in Turkey that will affect the extent of economic growth. The findings of our study overlap within this report. It is clear that the share of the sector in GDP will increase if a fast-paced infrastructure work in the telecommunications sector continues to increase. It is thought that with the infrastructure investments that will increase over time, the telecommunication sector will contribute to the economic growth.

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