European Union Telecommunications Infrastructure: Downfall in the Fixed Telephone Subsector

This paper aims to evaluate fixed telephone subsector’s impact on economic growth in the European Union for the 1990–2017 years’ time span. Also, the presence of structural break in each European country data is checked since this telecommunications infrastructure subsector shows decline since the beginning of the 2000s. This research results show that between these phenomena there is no statistically significant long run relationship. In the countries without structural break statistically significant short run relationship was not found too, while in the remaining countries with structural break some evidence of short run relationship was found.

**Keywords:** European Union, telecommunications infrastructure, economic growth, cointegration, short run, structural break, Chow test.

**JEL Classifications:** O11/O33/O52.

**Introduction**

From theoretical approach infrastructure is one of the main factors of either country’s or region’s economic growth. This phenomenon consists of physical and organizational structures and services which are essential for economic growth. In general, infrastructure can be divided into three major sectors: transport, telecommunications and energetics. According to Dash and Sahoo (2010),...
infrastructure contributes to economic growth through: 1) direct investments on infrastructure, which create production facilities and stimulates economic activities; 2) transaction and trade costs reduction, which help to improve competitiveness; and 3) provision of employment opportunities and physical and social infrastructure to the poor. However, lack of relevant infrastructure can disable proper economic growth and/or poverty reduction.

Telecommunications sector is being considered one of the major sectors of infrastructure. The positive impact of telecommunications infrastructure on economic growth was found in literature (Seethepalli, Bramati & Veredas, 2008; Sahoo & Dash, 2009; Dash & Sahoo, 2010; Sahoo, Dash & Nataraj, 2012; Urrunaga & Aparicio, 2012; Pradhan, Arvin & Hall, 2016; Imran & Niazi, 2011; Mohanty & Bhanumurthy, 2018; Donou-Adonsou, Lim & Mathey, 2016). However, most of those recent researches were made using developing countries data so such results are mostly plausible due to the reason that infrastructure is one of the major determinants of economic growth, particularly in developing countries.

Research object: telecommunications sector’s fixed telephone subsector in the European Union countries for 1990–2017. This subsector was chosen due to the two main reasons. First, because of emerging mobile telephone and broadband internet subsectors, which are close substitutes for fixed telephone subsector, this telecommunications subsector started to decline in the early 2000s. This situation implies that fixed telephone subsector could have lost its impact on economic growth. Second, there is a need to evaluate fixed telephone subsector’s impact on economic growth in the developed countries because recent researches in this field were made mainly on the developing countries basis. Under such circumstances the usual telecommunications infrastructure and economic growth relationship could be different or there could be no relationship between them at all.

The aim: to test whether there is long run or short run relationship between telecommunications sector’s fixed telephone subsector and economic growth and to see if there is structural break in this telecommunications subsector’s time series data.

The scientific problem: what is the type (long run or short run) and the form of the relationship between telecommunications sector’s fixed telephone subsector and economic growth in the presence of the possible structural break?

The research methods: the first part of the paper consists of short infrastructure as a phenomena and telecommunications sector theoretical and empirical literature analysis. The second part of the paper consists of recent situation in the European Union analysis, research data properties, methodology and the empirical research. At the end of the paper conclusions and research shortages are provided.

The objectives of the article: 1) To analyze scientific literature and to find properties of infrastructure, telecommunications sector and relationship between it and economic growth; 2) To analyze current situation in telecommunications sector’s fixed telephone subsector and to describe this paper’s research methodology; 3) To make empirical research in the European Union countries for 1990–2017 and provide conclusions about the results.
The Concept of Infrastructure

The concept of infrastructure is quite new in scientific research. It started with seminal work of Tinbergen (1962) where the first difference between infrastructure and superstructure was made. After this work there was vast of other theoretical research articles in this area with different infrastructure definitions and classifications. According to some scientists (Hansen, 1965; Aschauer, 1989; Sturm, Jacobs & Groote, 1995; Buhr, 2003; Prud’homme, 2004; Baldwin & Dixon, 2008; Grubesic, 2009; Torrisi, 2009) it can be concluded, that infrastructure as a whole and its elements should be durable non-movable good which is built during the long span of time. Other infrastructure features are conditional absence of substitutes in the short run and ability to be one of the major factors which helps to produce goods or provide services for country’s economy.

In theoretical literature there are two most common infrastructure categories: economic and social infrastructure. With the reference to Fourie (2006), economic infrastructure could be defined as infrastructure that promotes economic activity, such as roads, highways, railroads, airports, seaports, electricity, telecommunications, water supply and sanitation. According to Gabdrakhmanov and Rubtsov (2014), social infrastructure could be understood as a complex of municipal entity, constructions and institutions which provide the necessary material and cultural living conditions of the population on a certain territory, like institutions of science and art, of the general and vocational education, health and social security and construction of sports and recreational facilities. However, economic infrastructure is a more common type of infrastructure in the empirical research.

Telecommunications Infrastructure’s Impact on Economic Growth

As it has been already mentioned in the introduction, telecommunications sector is being considered as one of the major sectors of infrastructure. Telecommunications sector consists mainly of two subsectors – fixed and mobile telephone. Nowadays the third subsector of fixed broadband internet is developing rapidly but since it is a new subsector and sometimes there is not enough statistical data for its analysis, there is not a lot of empirical research in this field yet. In the recent empirical researches scientists (See-thepalli et al., 2008; Sahoo & Dash, 2009; Dash & Sahoo, 2010; Sahoo et al., 2012; Urrunaga & Aparicio, 2012; Pradhan et al., 2016; Imran & Niazi, 2011; Mohanty & Bhanumurthy, 2018; Donou-Adossou et al., 2016) usually build one united measure of telecommunications sector which consists of both fixed and mobile telephone subsectors. The proxy for these subsectors, fixed and mobile telephone subscriptions data was used. All these empirical researches showed positive telecommunications sector’s impact on economic growth. The elasticity coefficient in those researches ranged from 0,02 to 0,94.

Meanwhile Egert, Kozluk and Sutherland (2009a; 2009b) and Estache, Speciale and Veredas (2005) examined just fixed telephone subsector’s impact on economic growth. The results showed positive impact too, with 0,12 and 0,19 elasticity coefficients respectively. At this point it should be mentioned, that in all these
empirical researches except Egert et al. (2009a; 2009b) the background of researches was mainly the developing countries.

**Current Situation in the European Union**

While infrastructure and economic growth relationship from theoretical point of view is quite clear in the background of the developing countries, in practice situation could be contrary. During the last two recent decades fixed telephones subsector started to become less important part of the telecommunications sector in the European Union because such substitutions like mobile phones and broadband internet were created. During the two recent decades the number of mobile phones and broadband internet subscriptions emerged rapidly in the European Union, meanwhile the number of fixed telephones subscriptions started to decline in the early 2000’s. Figure 1 shows the recent situation in European Union’s fixed telephone subsector in all 28 countries. Fixed telephone subsector is portrayed as several fixed telephones subscriptions per capita.

As it can be seen from Figure 1, the decline of fixed telephone subscriptions per capita in most of European Union’s countries started between year of 1999 and 2006. The exact year of the decline differs across the countries, but after the peak point it is seen clear declining pattern until the end of the given time span. Such situation could imply that in European Union telecommunications infrastructure, namely fixed telephones subsector, could have different impact on economic growth than in the previously analyzed empirical researches. Moreover, in every of the 28 European Union’s countries could be a structural break in such relationship due

![Fixed telephone subscriptions per capita in European Union in 1990–2017](image)

*Fig. 1. Fixed telephone subscriptions per capita in European Union in 1990–2017*

*Source: calculated by authors using data from Eurostat and The World Bank statistical databases and Worldometer statistical website.*
to the steady downfall in the data which could be seen in Figure 1.

**Theoretical Framework**

In theoretical literature in case of infrastructure it is said that infrastructure is long lasting long run period good. Due to this assumption one aim of this article is to test whether there is long run relationship between telecommunications sector’s fixed telephone subsector and the economic growth in European Union during the 1990–2017 years’ time span. In case of non-existing long run relationship, it will be tested whether the short run relationship between these phenomena exists. The second aim of this article is to test whether there is a structural break in fixed telephone subsector’s impact on economic growth. Because this aim is the second in a row, it will be tested using either long or short run period approach, depending on the outcome of the first aim’s testing. Finally, in case of structural break, fixed telephone subsector’s impact on the economic growth will be evaluated in both periods, before and after the structural break.

The main model is based on the general production function form of:

\[
\frac{Y}{L} = A \cdot f\left(\frac{K}{L}\right)
\]

(1)

where: \(Y/L\) – output to labour ratio; \(K/L\) – capital to labour ratio; \(A\) – expression of the technological progress. Further it is used Cobb-Douglas type production function, so equation (1) becomes to:

\[
\left(\frac{Y}{L}\right)_t = A \left(\frac{K}{L}\right)_t^{\beta_1} e^{\nu_t}
\]

(2)

where \(e\) is base of natural logarithm and \(u_t\) is stochastic disturbance term. After subsequent substitutions of

\[
RGDP_t = \left(\frac{Y}{L}\right)_t \quad \text{and} \quad INF_t^{\beta_1} = \left(\frac{K}{L}\right)_t
\]

equation (2) takes form of:

\[
RGDP_t = A \times INF_t^{\beta_1} e^{\nu_t}
\]

(3)

Finally, natural logarithm is taken of equation (3) which leads to equation (4) and after substitution \(\beta_1 = \ln A\) comes the final model (5) for this article’s empirical research.

\[
\ln RGDP_t = \ln + \beta_1 \ln INF_t + u_t
\]

(4)

\[
\ln RGDP_t = \beta_1 + \beta_2 \ln INF_t + u_t
\]

(5)

Model depicted as equation (5) is used for testing both assumptions about the fixed telephone subsector’s impact on economic growth, either in the long or in the short run or in the presence of the structural break. The main interest of this analysis is \(\beta_2\), which is elasticity coefficient, sign, size and statistical significance. It must be mentioned, that such (5) equations are tested for each of 28 countries individually if the particular country’s data meet all econometric modelling requirements.

**Research Data**

Research data consists of two ratio variables, namely real general domestic product (RGDP) per capita, which is equivalent to economic growth and fixed telephone subscriptions per capita, which is equivalent to telecommunications...
sector’s fixed telephone subsector. Research data covers 1990–2017 years’ time span and all 28 European Union countries at that time. RGDP data was taken from United Nations statistics division and is measured in constant 2010 prices in national currency. Population statistics were taken from Eurostat database and it is the total population of the country on 1 January, except France data from 2014 to 2017, which was taken from Worldometer statistical website. Fixed telephone subscriptions data was taken from The World Bank statistical database. It is worth mentioning, that according to the World Bank statistical database, fixed telephone subscriptions refer to the sum of active number of analogue fixed telephone lines, voice-over-IP (VoIP) subscriptions, fixed wireless local loop (WLL) subscriptions, ISDN voice-channel equivalents and fixed public payphones.

Econometric Analysis Tools

In order to achieve both article’s aims, econometric analysis tools should be used. All econometric calculations in this article are made using Gretl program. All of regression analysis is based on ordinary least squares (OLS) method, using the standard 0.05 level of significance value. In order to get elasticity coefficients, natural logarithms of relevant time series data were taken. To test, whether there is evidence of the long run relationship between the variables, Engle-Granger two step cointegration test developed by Engle and Granger (1987) is used. The cointegration regression equation form is the same as equation (5), with no time trend variable being added. If the long run relationship is found, error correction mechanism (ECM) will be used.

To test, whether there is structural break in the data, Chow test (Chow, 1960) of structural break is used. The possible structural break point in the country’s data time series is set by this rule: next year after the fixed telephone subscriptions per capita variable’s peak value is considered as a possible structural break year.

Time series data type is used in this analysis, so the presence of unit roots should be tested first. In this research the main test to test for unit roots is augmented Dickey-Fuller test (ADF) (Dickey & Fuller, 1979) and the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) (Kwiatkowski, Phillips, Schmidt & Shin, 1992) test is chosen as the supplementary test, because sometimes unit roots testing results could be equivocal due to the test specifications or the fact, that relevant time series data exhibits near unit root process. ADF test is used under test down from maximum lag conditions, while KPSS test is used with fixed lag length. Maximum lag length for both tests is calculated using Schwert (1989) $l_{12}$ and $l_f$ formulas for ADF and KPSS tests respectively. It should be mentioned, that in case of structural break modelling, sample size could not allow to use max lag value suggested by $l_{12}$ formula. In such case maximum lag value was decreased by 1 unit until it was able to execute ADF test.

In order to avoid equivocal situations in unit root testing, the following unit root testing procedure is used:

1. For original logged RDGP per capita, fixed telephones subscriptions per capita and first differenced (if needed) fixed telephones subscriptions per capita data ADF and, if needed,
KPSS tests are executed with constant and trend. Then it is executed $\Phi_3$ test (Dickey & Fuller, 1981). If $\Phi_3$ test's $H_0$ is accepted, ADF; and if needed KPSS tests are executed just with constant; if $\Phi_3$ test's $H_0$ is rejected, usual $t$ statistic test is used to check the presence of deterministic trend in the data. If trend is found, conclusions about unit root are made from ADF, and if needed KPSS tests with constant and trend specification; but if there is no deterministic time trend, then ADF, and if needed, KPSS tests are executed just with constant and corresponding conclusions about unit roots are made.

2. For the logged first differenced (if needed) RGDP data it is made significance test to test, whether time series mean is statistically equal to zero. If it is so, ADF, and, if needed, KPSS tests are executed using without constant (ADF) and around the level (KPSS) test specifications; if no, then ADF, and, if needed, KPSS tests are executed using with constant (ADF) and around the level (KPSS) test specifications.

It should be noted, that testing original logged time series data supplementary KPSS test is done just then ADF test results show, that data has no unit root. Meanwhile in testing logged first differenced time series data, supplementary KPSS test is used in cases then ADF test results show that there is unit root in the data. Such preferences are made due to two reasons: 1) according to Wooldridge (2013), the notion of cointegration could be applied when two series are I(1), but a linear combination of them is I(0); 2) to model short run model, both variables should be either I(0) or first differences of I(1) variables, which means that either in original data or first differences of variables should be no unit roots. If KPSS test is used, its results are superior to ADF test results. It should be noted that further than I(1) testing is not executed, because regression with higher order than I(1) variables results does not has economic sense.

In order to avoid misleading regression results, first order autocorrelation, heteroscedasticity and normality of residuals tests are made. Breusch-Godfrey (Breusch, 1978; Godfrey, 1978) test is used for testing for the first order autocorrelation, White test (White, 1980) is used to test whether there is heteroscedasticity in model's residuals and Doornik-Hansen (Doornik & Hansen, 2008) test is used for testing normality of the residuals. If either first order autocorrelation or heteroscedasticity, or both is found, heteroscedasticity- and autocorrelation-consistent standard errors (HAC) remedial measure is used. For non-normal residuals case there is no straight remedial measures. In such case there are two possibilities: to apply asymptotic theory or to threat regression results with grain of salt.

**Testing for Long Run Relationship**

As it was mentioned before, in order to check the presence of the long run relationship both variables should be I(1). Since the original sample size is 28 observations for original and 27 observations for the first differenced data, according to Schwert (1989) $l_{12}$ and $l_4$ formulas, maximum lag for ADF test was 8 and for KPSS test it was 2. Fixed telephone subscriptions per capita variable for unit roots was tested first, and RGDP per capita variable
was tested second. After unit root tests were taken, the presence of cointegration was tested. Table 1 shows summary results of this procedure.

As it can be seen in Table 1, not all the selected time series were eligible for long run relationship, that is, cointegration testing. 11 out of 28 countries data were not eligible for cointegration testing due to the reason that order of integration of fixed telephone subscriptions per capita variable was higher than 1. 2 more countries time series were not eligible for cointegration testing due to that those countries RGDP per capita variable was integrated of order 0.

Due to the data limitations, the presence of long run relationship between fixed telephone subscriptions subsector and economic growth was tested just in 15 European Union countries. The results are contrary to the theoretical scientists' assumption that infrastructure is long run good. Only in Greece it was found long run relationship between economic growth and this telecommunications infrastructure sector's subsector, while in the remaining 14 countries no evidence of long run relationship between these phenomena were found. Due to such results it can be concluded that in this case empirical results are contrary to theoretic scientists' opinion about the nature of infrastructure phenomenon. In addition to that, there was no sense to model Greece data.

### Structural Break and Short Run Relationship

For structural break testing are eligible all countries from Table 1 except countries which are listed in the „cointegration does not exists” column and also Portugal, in which value of fixed telephones subscriptions per capita variable was growing during all analyzed time span. Germany and Lithuania logged RGDP per capita time series were differenced, so all variables in these regressions are described in the same logged first differences form, and these countries can be tested for structural break. Table 2 shows possible structural break year for each country and Chow test results.

As it can be seen from Table 2, 16 countries were eligible for structural break testing. Results show that Chow test results distributed equally. In 8 of those countries there was found structural break and in 8 of those countries there was not any structural break. In such situation reliable conclusion, whether there is structural break or not, cannot be made. Due to this reason further short run modeling was made in two ways: one modeling for countries with structural
break; and another modeling for countries without structural break.

Table 3 provides short run fixed telephone sector’s impact on economic growth in countries without structural break. As it can be seen, only in Bulgaria elasticity coefficient was statistically significant, but its value was negative. Meanwhile all 7 remaining countries elasticity coefficients were statistically insignificant, which leads to conclusion, that in this case there is no statistically significant relationship between fixed telephone subscriptions subsector and economic growth.

Results in Table 4 are very interesting. As it can be seen, even though Chow test showed that there should be structural break, both Greece and The Netherlands elasticity coefficients – before and after the possible structural break – are statistically insignificant, which implies that Chow test results in those countries cases were erroneous and these two countries in fact should be in Table 3 countries group. In the remaining countries interesting results were found too. In 4 out 6 countries statistically significant elasticity coefficient was found before the structural break and in the remaining 2 countries statistically significant elasticity coefficients were found after the structural break. Except of France, all
those elasticity coefficients were higher than 2, which is at least two times more than it was found in previous scientific empirical research.

Conclusions

Almost all article’s results are contrary to the previous theoretical and empirical researches’ results. Due to the econometric data properties, not all 28 European Union countries time series were eligible for further modeling. First, in this case almost any long run impact of fixed telephones subscriptions subsector on economic growth was not found. Such results can be explained by the nature of fixed telephone subscriptions subsector variable. Notwithstanding the fact, that from theoretical perspective it usually takes time to install new fixed telephone subscriptions sector facilities or even to develop the suitable network for it, such feature may not be reflected in the proxy variable for this telecommunications subsector. This could be one of the reasons why this article’s research data did not capture long run impact on economic growth.

Results about structural break are mixed. At first it was found that there was an equal number of countries with and without the structural break. After more precise analysis it was found, that in two countries cases Chow test results were erroneous. This means that there are 10 countries with no structural break and only in 6 countries cases such break was found. As it was mentioned, results in this case are contrary to analyzed scientists’ empirical researches results, because, except Bulgaria’s case, there was no statistically significant fixed telephone sector’s impact on economic growth.

In all 6 structural break case countries it was found statistically significant impact on economic growth either in pre- or post- structural break time spans. However, except one negative elasticity coefficient in France, all other coefficients were at least twice larger than in analyzed empirical researches.

Such interesting results could be occurred due to some reasons. First, this article’s research field was based mainly on the developed countries data, where...
infrastructure is already built. In such type of countries infrastructure’s impact on economic growth may be measured not through its installing aspect, but through the level of its usage. Second, while analyzed authors in their researches put telecommunications sector, in this article it was analyzed just fixed telephone subscriptions subsector’s case, so the results could be different due to this reason too. Third, analyzed telecommunications subsector in the European Union showed the sign of decline, so that means it could exhibit different relationship with economic growth than the basic infrastructure theory suggests. Such decline may be caused by rapidly growing mobile telephone and fixed broadband internet subsectors, which are main substitutes for fixed telephone subsector. Finally, some of the models had non-normal residuals and according to the initial sample size of 28, 27 for the first differenced data and even smaller sample sizes in cases of structural break, these results should be treated carefully.

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The paper submitted October 14, 2019
Prepared for publication December 1, 2019
Teoriniu požiūriu infrastruktūra, kaip visuma, yra vienas iš svarbiausių tiek šalies, tiek regiono ekonominio augimo veiksnių. Infrastruktūra iš esmės sudaryta iš trijų pagrindinių sektorių: transporto, telekomunikacijų ir energetikos. Remiantis straipsnyje minėtų autorių (Seethepalli ir kt., 2008; Sahoo ir Dash, 2009; Dash ir Sahoo, 2010; Sahoo ir kt., 2012; Urrunaga ir Aparicio, 2012; Pradhan ir kt., 2016; Imran ir Niazi, 2011; Mohanty ir Bhanumurthy, 2018; Donou-Adonsou ir kt., 2016) duomenimis, telekomunikacijų sektoriaus poveikis ekonomikos augimui teigiamas, ypač daugiausia dėmesio skiriant besivystančioms šalims. Šiuose tyrimuose telekomunikacijų sektoriaus atspindį jungtinis rodiklis, susidedantis iš fiksuoto ir mobilaus ryšio telefonų subsektorius.

Šiame straipsnyje analizuojamas 1990–2017 m. Europos Sąjungos telekomunikacijų sektoriaus mažėjimo tendencija fiksuoto ryšio telefonų subsektorius poveikis ekonomikos augimui dėl to, jog šis sektorius pastaruoju metu patiria nuosmukį. Esant tokioms aplinkybėms, verta įvertinti jo daromą įtaką ekonomikos augimui. Remiantis tyrimo rezultatais, statistiškai reikšmingos šio subsektoriaus įtakos ekonomikos augimui nenustatyta. Nesant struktūrinio lūžio, įtakos trumpuoju laikotarpiu irgi nebuvo nustatyta teigiama įtaka, tačiau gauti elastingumo koeficientai mažiausiai 2 kartus viršijo kitus tyrimo rezultatus. Tokius rezultatus galėjo nulemti tai, jog tyrimo duomenų ekonometriniai ypatumai, dėl kurių nebuvo įmanoma atlikti modeliavimo 12 iš 28 tirtų pasirinktų šalių.