**Information and Telecommunications Technology and Economic Growth in Iran: Causality Analysis**

*Abstract*

Iran as a developing country undertakes the policy measures to increase the contribution of telecommunication in GDP. However, there is a little known about the relationship between these two variables in Iran. Therefore, this study investigates the relationship between ICT development and Iran economic growth by using the Vector Error Correction Model (VECM). The results indicate that there is a unidirectional causality running from ICT development to economic growth in the long run, while the reverse does not hold. The findings also suggest no causality relationship between these variables in the short run. In terms of policy the more resources should be allocated to ICT-industry sector and promoting ICT using likely can solve the reverse causality under condition of Iran economy.

*Keywords***:** ICT-lead growth, causal relationship, Iran’s ICT.

*JEL Classification***:**

1. **INTRIDUCTION**

Over the past decade, most developing countries look for ways to increase their ICT infrastructures capacity due to encourage the rate of economic growth and to narrow the gap of economic activity with the developed countries. As argued by Lee, Gholami & Tong (2005) a developing country may has huge investment on ICT infrastructure due to this idea that jumping onto the ICT bandwagon move with great speed to economic boosting. However, far too little attention in these country has been paid to examine whether this ICT investment contribute to the prosperity. Although, studies in the context of developed economies imply the strong role of ICT investment on economic growth besides the existing causal relationship in one or both directions, given conditions in developing economies is different. Therefore, it is desirable for any developing country by focusing on ICT development strategy to carry out a careful empirical analysis on causal relationship between ICT development and economic growth.

Since 1995, Iran witnessed an increase in telecommunication infrastructure capacity and development of information technology due to enjoy the benefit of ICT contribution. But, does ICT development leads to economic boosting? Or opposite direction holds? It is important to examine the relationship and the direction of link between these two variables in condition of Iran economy. Although, a few studies in Iran at firm level show the contribution of ICT on productivity (Gholami, Moshiri, & Lee, 2004 and Moshiri & Jahangard, 2007), contribution of ICT to economic growth emerges once there is a causal relationship between them in the whole economy. Considering the significant expansion of Iran’s telecommunications sector in recent years, there has been a lack of empirical studies on its causal relationship with economic growth and this is the gap this study aims to fill it.

The primary purpose of this study is to examine empirically the relationship and causality between telecommunication infrastructure developments and gross domestic production (GDP) growth in Iran. To do so, the Granger causality test with time series analysis tools enables us to determine the direction of causality and there is a feedback effect between them. Moreover, we can find out whether the relationship between variables is long or short-run. The incentive for this study is arose from the fact that the resources should be allocated to ICT sector to increase GDP growth or should be allocated to other most important industries for boosting national economy which in turn will generate advanced ICT levels.

The rest of the paper is organized as follows: next section reviews the empirical works on ICT pay off in economies boosting and causality direction between them. Section 3 gives an overview of telecommunication infrastructure in Iran. Section 4 of the paper discusses the econometric methodology used as well as collected data. Section 5 presents the empirical results, and section 6 deals with the conclusion.

1. **LITERATURE REVIEW**

**(2.1) Studies on ICT development and economic growth**

From the beginning of 1980s, when the information age was initiated, the world witnessed plenty of researches by applying numerous methodologies to evaluate the contribution of ICT to economic prosperity. Although, the preliminary studies have reported little evidence on the contribution of ICT to economic growth and total factor productivity in the 70s and 80s in the U.S economy (Oliner & Sichel 1994, Jorgenson & Stiroh, 1995), the collaboration between ICT and productivity growth was revealed over the second half of the 90s in the U.S economy (Jorgenson, 2001 and Jorgenson & Stiroh, 2000). Furthermore, several studies (e.g. Oliner & Sichel, 2000 and 2002, Baily & Lawrence, 2001, and Jorgenson, Ho & Stiroh, 2004 and 2007) have revealed that the effect of ICT using on other industries (capital deepening) is more effective than ICT production itself.

Beside the studies in the U.S, other researchers examined this approach by considering an individual country or a group of countries. Most developed and industrialized countries found similar conclusions through similar researches that ICT plays a key role in the second half of the 90s, for example, Niininen (2001) and Jalava & Pohjola (2002) in Finland; Oulton (2002) in U.K.; RWI and Gordon (2002) in Germany; Gretton, Gali & Parham (2001) and Simon & Wardrop (2002) in Australia; Kegels, van Overbeke & van Zandweghe (2002) in Belgium; Miyagawa, Ito, & Harada. (2002) in Japan; Armstrong, Harchaoui, Jackson, & Tarkhani (2002) and Khan & Santos (2002) in Canada, Cette, Kokoglu, & Mairesse (2002) in France; Van der Wiel (2002) in Netherlands; and Kim (2002) in South Korea. In general, an implication of these studies is that there is a clear positive link between ICT development and economic growth but it takes a long time to become visible in macroeconomic level. ICT capital growth accelerates productivity growth but with long lags between 5 to15 years (Basu & Fernald, 2007).

From another perspective, relationship between ICT and economic can be scanned through cross-country comparisons that most of them magnify the gap between developed economies to developing one. The earlier significant studies for comparison of OECD and European Union countries included Daveri (2000, 2002), Colecchia and Schreyer (2001), Van Ark, Melka, Mulder, Timmer, and Ypma (2002), Daveri (2002), and Timmer, Ypma, and Van Ark (2003). These studies showed that ICT’s contribution to economic growth in US and Canada has been larger than other countries, meanwhile, there is a different growth contribution of ICT between European Union countries. On the other hand, the major comparing studies between developed and developing countries (Dewan & Kraemer, 2000; Pohjola, 2001) indicate that in contrast to developed countries, developing ones did not experience significant returns from ICT development. At the same time, different studies focused only on developing countries consistent with the results which reported a limited impact of ICT development on economic growth for developing countries, Avgerou (1998), Wang (1999) in Taiwan, Meng & Li (2002) in China. In Mideast area Nour (2002) by using data from Egypt and some of the Persian Gulf countries reported that the correlation between ICT development and economic growth was positive but was not significant. However, unlike the most developing countries, the East Asian and South East Asian countries have benefited successfully from ICT in their economic and social development (Jussawalla & Taylor, 2003). According to Kuppusamy, Pahlavani, and Saleh (2008) ICT investment has had a positive and significant long-run relationship with economic growth in Australia, Malaysia and Singapore.

Piatkowski (2002) claims that ICT investment in less developed countries is not large enough to assess their impact on output growth. Therefore, due to short of capital investment and lack of knowledge as well as the existing lag behind ICT diffusion, the role of the ICT investment in developing countries is not so clear (Meng & Li, 2002). Elsewhere, Lee, Gholami & Tong (2005) suggest that some threshold of ICT capital must be gained before their effect becomes measurable. Thus, they suggest to developing countries to promote use of ICT and provide the environmental conditions to sustain the effective use of ICT. Furthermore, Grace, Kenny, and Qiang (2003) added that some less developed countries endanger to fall into a poverty trap in the case that ICT threshold effects come true, that is, if development of ICT is related to the income level and if income growth is affected by a threshold of ICT capital, then low income countries less likely benefit from opportunities provided by ICT development.

By reviewing the abovementioned literature it can be concluded that 1- ICT contribution gap is evident among countries. ICT contribution to economic growth and total productivity growth in the US and Canada is more than other countries while in Europe, it has been more sporadic. In other regions except new industry countries in South East Asian, apparently other developing countries were not able to take advantage of ICT in order to speed up the rate of output growth and productivity in their countries. 2- In spite of the general view of ICT contribution in developed economies, it is expected to observe a lag between the investment in ICT and its impact on the whole economy, in other word, the ICT effect on GDP or productivity takes a long time to become visible. 3- Additionally, some studies find that the most positive impact of ICT on growth is not as straightforward as it seems, since, it is reported that the effect of ICT using on other industries (capital deepening) is more effective than ICT production itself. However, the length of lag and spillovers to occur is not clear. 4- The contribution of ICT is visible when a significant threshold ICT capital is achieved. The various results from different countries and regions keep fresh the debate about how is the contribution of ICT on economic growth (Qiang, Pitt & Ayers, 2003).

**(2.2) Causal analysis studies on ICT development and economic growth**

Pervious part of literature reviewed the relationship between telecommunications and economic growth exclusive of considering the direction of causality. Actually, causality studies target the link between ICT development and economic growth by investigating the existence of causal relationships as well as the direction of causality. Moreover, the importance of reverse causality is due to the fact that there is a bilateral relationship between better communication system and higher income. That is, the better communication systems lead to higher incomes, and higher incomes in turn may improve communication systems.

Preliminary work on causality tests between ICT development and economic growth carried out by Cronin, Parker, Colleran, & Gold (1993) that have reported a bidirectional causal relationship between them in the U.S. economy. Later studies also confirmed this bidirectional causal relationship (Cronin, Parker, Colleran, & Gold, 1993, Wolde-Rufael, 2007). In addition, another work suggested that investment in telecommunications infrastructure in U.S. is causally related to the nation's total factor productivity (Cronin, Colleran, Herbert, & Lewitzky, 1993).

An earlier cross-country study (Madden & Savage, 1998) on causality test also reported a bidirectional relationship between ICT development and economic growth in Central and Eastern Europe countries. In another major study on a panel of data for 30 countries that divided into two same groups of industrialized and developing economies, Dutta (2001) generally confirms both directions of causality but causality direction of ICT infrastructure to economic activity was stronger than opposite direction. Five years later, Datta and Mbarika (2006) have reported evidence of causality running from ICT infrastructure to service‐sector growth by a panel of data for 90 countries that divided into three same groups of low income, middle income and high income.

One of the most significant current discussions in the causal relationship between ICT development and economic growth is that bidirectional or unidirectional of causality dependents on the level of income, ICT infrastructure or other factors. A large scale study that examined the causality for 105 countries (Shiu and Lam, 2008) revealed bidirectional causality in high income level and European countries but unidirectional causality in countries with lower income levels that runs from economic growth to ICT development. They suggest that less-developed countries should create the environmental conditions called “critical mass” by promoting greater ICT penetration rates. In another study, Shiu and Lam (2010) also confirmed their pervious results, in particular, by assessing the mobile’s effect on economic growth. Chakraborty and Nandi’s (2003) by panel data of 12 Asian’s developing countries in two categories, high and low degree of privatization, pointed out that causality was bidirectional only for the high degree of privatization group but for the other group ICT development led economic growth. As a result, various factors of each country such as level of development, the degree of ICT adoption of non ICT industry and the usage of ICT may be determined the causality and its direction between ICT development and economic growth (lee & Becker, 2011).

 However, the subject of reverse or direction of causality between ICT development and economic growth is also difficult to deal with. For example, Yoo and Kwak (2004) found a bidirectional causal relationship in South Korea, Cieslik and Kaniewsk’s (2004) reported that causality ran from ICT infrastructure to income at the regional level in Poland. While, Shiu and Lam (2008) in China identified the existence of one-way direction from economic growth to ICT development. Elsewhere, in a study based on a data panel of ten Latin American countries conducted by Veeramacheneni, Ekanayake, and Vogel (2007) showed that the seven out of ten countries have bidirectional Granger causality in the short-run, in two other countries economic growth Granger causes ICT, and one country alone has causality running from ICT to economic growth. Recently, two similar studies by Lee & Becker (2011) in one hand and Lee, (2011) on the other hand has been done about European Union member countries and three of the Northeast Asian countries (China, Japan and South Korea) respectively. They concluded that the Granger causality test could not support the causality direction from ICT to growth in short-run. Totally, findings of causality analysis in current empirical studies were different among the countries and it supports the idea that special conditions of each country influence the results of the causality direction between these two variables.

Putting all together, the mixed results from empirical causality studies in current literature indicate either bidirectional, unidirectional or non-casual relationship between ICT development and economic growth. In more developed countries and regions with a higher level of income and ICT infrastructure, generally bidirectional causality is evident. Moreover, some findings indicate that the direction of causality is dependent on various factors of each country such as the level of income, ICT infrastructure, privatization, and so on. However, the subject of reverse or direction of causality in less developed countries is still under debate. Thus, it is desirable for any developing country with ICT development strategy to carry out a careful empirical causality analysis, since the results of the causality test can help the national planer to make policies of allocation restricted resources for boosting national economy. On the assumption that, empirical evidence supports causality running form ICT infrastructure to economic growth in short and long run, then the resources should be allocated to ICT-industry sector. While, for causality evidence in the opposite direction more resources should be allocated to other most important industries for boosting national economy, so the ICT-industry sector will benefit from economic growth.

1. **OVERVIEW OF IRAN’S TELECOMMUNICATION**

The economy of Iran known as a resource-rich and labor-rich economy in the Middle East is a transition economy with a large public sector and exports which are dominated by oil and gas. In spite of the serious national problems, Iran has a high potential of becoming one of the world's largest economies, hence it has defined a twenty- year vision, a plan for long-term sustainable growth.

“Being the first rank in economy, science, and technology in the region, keeping pace with the increasingly progressive growth of science... “(Vision, Iran 1404/2025)

It is clear that based on this statement, information, knowledge and technology are increasingly becoming the key drivers for socio-economic development in Iran. It is acknowledged that in the new information age, the government has recognized the crucial role that ICTs can play in facilitating and accelerating economic growth.

As a result of serious investment in the telecommunication system in Iran since 1995, the number of telephone lines and cellular phones has grown rapidly. According to the databases of the International Telecommunications Union (ITU) (2011), the mobile penetration rate from 0.03% in 1995 has reached to 71% in 2009, with a total of over 52.5 million subscribers. This rate was more than 91% in 2010 (World Bank, 2011). According to the Knowledge Assessment Methodology (KAM) index produced by the World Bank in 2012, Iran has made improvement on providing infrastructure information yet it possessed the rank of 94 among 146 countries. In addition, reports have pointed out that the ICT sector in Iran faces a number of important challenges such as instability of government’s rules, United Nations sanctions, lack of consistent strategies and cohesive plans that hinder ICT strategy efforts (Digital Review of Asia Paciﬁc, 2007- 2008 and 2009–2010).

 All in all, Iran as a developing country with a number of significant economic challenges, tries to enjoy contribution of telecommunication investment. But does telecommunication development lead to economic boosting? Or opposite direction holds? As a matter of fact, it is difficult to determinate contribution of ICT infrastructure and the causality direction of ICT development and economic growth based on the current literature. Here, the empirical evidence causality test enables us to determine this cause and effect relationship under the condition of Iran’s economy.

1. **DATA and METHODOLOGY**

**(4.1) Data**

To estimate the causality tests time series data about ICT development and economic growth in Iran is needed. But since, the lack of sufficient data both qualitatively and quantitatively is a common problem to most developing countries and Iran too, the data of Teledensity was applied as a proxy of ICT infrastructure. Teledensity refers to total number of fixed-line and mobile phone subscribers per 100 persons which are collected from the databases of the International Telecommunications Union (ITU). As a proxy of economic growth the data of real GDP (in local currency) is applied in our estimation too. This time series is taken from the databases of World Bank (World Development Indicators). Additionally, the annual data from 1975 to 2009 (35 observations) were applied according to their yearly time-series availability.

**(4.2) Methodology**

To examine any statistical relationship between Teledensity and real GDP in Iran, causality testing framework is adopted which includes the cointegration estimation approach. The procedure for estimation begins with a unit root test to investigate the order of integration of time series. Two standard tests were performed based on the work of Dickey and Fuller (1979) and Phillips and Perron (1988). Moreover, cointegration analysis was considered to examine any existing long-run relationship between the variables in the case that the time series show integration of the same order (more than zero). Cointegration analysis is investigated by using the Juselius-Johansen approach (Johansen, 1988; Johansen and Juselius, 1990). The results of the cointegration analysis will define the methodology to follow in the data analysis. In general, in the absence of cointegration, the Granger (1969, 1986, 1988) causality test involves Vector Autoregression (VAR) models, while at the presence of cointegration the Vector Error Correction Model (VECM) is applicable to estimation. In addition, the VECM approach allows us to determine the direction of causality among variables in both short and long run. Furthermore, Variance Decompositions (VDCs) and Impulse Response Functions (IRFs) analysis were applied as an indicator of the dynamic properties of the system and the degree of exogeneity among the variables beyond the sample period, while VECM can indicate only the Granger causality within the sample period. These tools investigate how a variable respond to unit standard error shock in others variables and determines the proportion of the forecast error variance of a variable due to innovations of others variables at different forecast horizons. Noted that the result of the both analyses is roughly the same.

1. **EMPRICAL RESULTS**

As stated earlier, the presence of non-stationarity can be tested by conducting unit-root tests. This study applied two standard tests that called the Fisher-Augmented Dickey- Fuller (Fisher-ADF) and Fisher- Phillips Perron (Fisher-PP) tests.

The results of test statistics in Table 1 show that the levels of both series, Real GDP and Teledensity, are non-stationary. After first differencing we could not find any evidence that the variables are non-stationary, that is, both series are integrated of order 1, I(1).

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| TABLE 1: Tests of the Unit Root Hypothesis |
|  | Aug Dickey-Fuller taste |  | Phillips-Perron test |
| variables | levels | First differences |  | levels | First differences |
| Real GDP | 1.117 | -5.024\* |  | 1.201 | -4.649\* |
| Teledensity | 2.387 | -4.680\* |  | 6.748 | -7.230\* |

Two variables are in natural logarithms. The optimal lag is automatically selected based on the Schwarz Info Criterion (SIC) for Fisher-ADF regressions. For the Fisher-PP tests, estimators based on kernel-based sums of the covariances have been used to correct for autocorrelation. (\*) represents the rejection of the null hypothesis of non-stationarity at the 1% level of significance. We can generally conclude that the series has integration of order 1.

Having confirmed the existence of unit roots for Real GDP and Teledensity, the next step checks the results of Johansen-Juselius cointegration tests. Johansen method has two separate tests, the “trace” test and the “maximum eigenvalue” test which are presented in Table 2. The both of statistic values are greater than the critical values. So the null hypothesis of no cointegration can be rejected at the %1 level. This provides evidence for the existence of one cointegration vector that imply these two variables are bound together by long-run equilibrium relationship. In other words, there is a force of equilibrium that keeps ICT development and economic growth together in the long-run. A significant outcome of this technique is that once the variables are cointegrated, the possibility of the spurious estimation is ruled out and at least one channel of Granger causality between two variables is active, in the either short or long-run.

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| TABLE 2: Results of the Johansen cointegration test |
| H0 | H1 |  | Trace Statistic |  | Max-Eigenvalue Statistic |
| $$r=0$$ | $$r>0$$ |  | 23.387\* |  | 21.521\* |
| $$r\leq 1$$ | $$r>1$$ |  | 1.866 |  | 1.866 |

r indicates the number of cointegrating vecter. (\*) For the both trace and maximum eigenvalue test statistics, the probability value for rejection of the null hypothesis of no cointegration is employed at the 1% level.

Although, the results of cointegration teste imply the presence of causality between Real GDP and Teledensity, it cannot identify the direction of Granger causality between them. As mentioned before, for purposes of causality tests, due to the results of the cointegration analysis in this case, the Granger causality can be captured by the VECM approac.

According to this technique the long-run causality is implied through the significance of the t-statistics of the lagged error correction terms while, the chi-squared statistics of coefficient on the lagged endogenous variables by conducting Block Exogeneity Wald test indicate the evidence for the short-run Granger causality. The hypothesis in this test is that the lagged endogenous variable does not Granger-cause the dependent variable.

The empirical results of the estimated VECM are presented in Table 3. As can be seen, the significant of t-statistics for error-correction terms show evidence of unidirectional causality between Real GDP and Teledensity that running from latter to former. However, the results of chi-squared statistics significant level cannot be rejected the null hypothesis regarding no causation at both way of directional relationship between Real GDP and Teledensity in the short-run.

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| TABLE 3: Granger Causality Results Based on Vector Error-Correction Model (VECM) |
| Dep.Variable |  | Ind.Variable |  | chi-squared statistics |  | T-Statistic: ECTt-1 |
| ΔReal GDP |  | ΔTeledensity |  | 0.562 |  | -0.528\* |
| ΔTeledensity |  | ΔReal GDP |  | 0.647 |  | -0.061 |

 Two variables are in first differences (denoted by Δ) of natural logarithms with the exception of the lagged error-correction terms (ECTt-1) generated from Johansen order of cointegration tests conducted in Table 2. Diagnostic tests (not reported) conducted for various orders of serial correlation, heteroskedasticity, functional form, and normality were overall found to be satisfactory. (\*) indicates the Significant at 1% level.

While, the VECM analysis determine the exogeneity or endogeneity of a variables and also the direction of Granger causality within the sample period, the VDCs can help us to carry out an out-of-sample causality test. VDCs measures the contribution of each shock in the system. Table 4 shows the analysis of VDCs that indicates Teledensity variable is relatively exogenous. As it is reported (table 4) after 5-year, less than 50 percent of the forecast error variance of Real GDP is explained by its own shocks (compared to 99 percent in the case of Teledencity). Furthermore, a cross-check of variance decompositions indicates that while Teledencity explains more than 50 to 83 percent of the variance of Real GDP, at the same time, Real GDP explains less than 1 percent of the variance of Teledencity.

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| TABLE4: Variance Decompositions and Relative Exogeneity Results |  |
|  |  | Relative Variance in: Real GDP |  | Relative Variance in: Teledencity |
| Period |  | ΔReal GDP | ΔTeledencity |  | ΔReal GDP | ΔTeledencity |
| 1 |  | 100.000 | 0.000 |  | 0.0645 | 99.935 |
| 2 |  | 99.039 | 0.961 |  | 0.042 | 99.958 |
| 3 |  | 90.507 | 9.4923 |  | 0.081 | 99.919 |
| 4 |  | 69.508 | 30.492 |  | 0.193 | 99.807 |
| 5 |  | 49.899 | 50.101 |  | 0.356 | 99.644 |
| 6 |  | 37.404 | 62.596 |  | 0.518 | 99.482 |
| 7 |  | 29.213 | 70.787 |  | 0.640 | 99.360 |
| 8 |  | 23.698 | 76.302 |  | 0.715 | 99.285 |
| 9 |  | 19.898 | 80.102 |  | 0.757 | 99.243 |
| 10 |  | 17.092 | 82.907 |  | 0.781 | 99.219 |

Two variables are in first differences (denoted by Δ) of natural logarithms. Figures in the first column (priod) refer to number of year. All other figures are Percentage of Forecast Variance Explained by Innovations in both variables.

In addition, Impulse Response Functions (IRFs) analysis essentially maps out the responsiveness of Real GDP to shocks to Teledensity which are presented in Figures 1. The result suggests that, one standard deviation shock to Teledencity, Real GDP response positively and has persistent effect on it. Therefore, the IRFs appear to be broadly consistent with the earlier VDC results that ICT development more often leads (at the long run) economic growth in condition of Iran economy.

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Real GDP

Teledencity

Standard Deviation

Years After Shock

FIGURE 1: Impulse responses of Real GDP and Teledencity from a one-standard deviation shock to Teledencity

1. **CONCLUSION**

This study examined the causal relationship between ICT development and economic growth in Iran based on the causality analysis among natural logarithms of real GDP and Teledencity by cointegration and error-correction modeling techniques over the period of 1975 to 2009.

The overall result of estimation indicates that there is a one-way causal relationship from Teledencity to Real GDP in the long-run while the reverse does not hold and ICT is relatively exogenous. However, the results did not support the null hypothesis regarding no causation at both way of directional in the short-run.

These findings address the problem of reverse causality in Iran economy while this feedback relationship seems to be supported by the empirical evidence available in context of the developed economy. Besides the reverse causality issue, an underdevelopment of other complementary factors may be a possible reason for a lack of causality in short-run. This implies that an improvement in telecommunications infrastructure alone is not sufficient for stimulating growth. It is important to keep in mind the fact that economic growth involves very complex relationships among many variables.

In terms of policy making, based on the results of this study that empirical evidence supports causality running form ICT infrastructure to economic growth in long run, the more resources should be allocated to ICT-industry sector. On the other hand, promoting ICT-use and creating the environmental conditions to support effective use of ICT can likely solve the reverse causality or this feedback problem in Iran economy.

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