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How Much Has Information and Communication Technology Contributed to the Economic Growth of Iran?

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ABSTRACT

In recent decades, different studies have increasingly emphasized the role of productivity improvement in economic growth, especially in developing countries including Iran. In this context, information and communication technology (ICT) is considered as one of the main factors which influences productivity and efficiency. From the supply-side point of view, international experiences in economic growth imply that ICT deployment plays a significant role in value-added creation, especially in economic sub-sectors which are more ICT-intensive. Therefore, the present study aimed to evaluate the ICT impact on economic growth in Iran in a quantitative framework by using provincial data. In addition, parametric and non-parametric approaches (i.e., panel data and data envelopment analysis techniques) were applied to understand the average effect of ICT on economic growth (known as ICT productivity), as well as the relative status of provinces in terms of ICT contribution to economic growth (known as economic efficiency). The results of the estimations indicated that ICT could positively contribute to the economic growth and the relative economic efficiency of provinces in value-added creation. Finally, the efficiencies of provinces collapsed significantly upon omitting ICT from the basic model.

1. Introduction

Since the 1990s, information and communication technology (ICT) has extensively contributed to the stimulation of gross domestic product (GDP) and labor productivity growth in both developed and developing countries. However, the economic impacts of ICT in developing and less-developed countries differ from those in developed countries. This contribution is made, directly and indirectly, by affecting total factor productivity (TFP), embodied technological progress, and labor productivity as the main transmission mechanisms of ICT impact. According to Piatkowski (2003) and Pohjola (2002), ICT can stimulate economic growth through four major channels as follows.

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- Producing ICT goods and services;
- Increasing the TFP of production in the ICT sector, which contributes to aggregating TFP growth in an economy;
- Using ICT capital as an input in producing the other goods and services;
- Contributing to economy-wide TFP through increased productivity in non-ICT producing sectors due to the production and use of ICT (spillover effects)

A large body of well-established evidence can be found in studies regarding the impact of ICT on the economy at macro, micro, and industry levels. For instance, the International Monetary Fund (2001) confirmed the positive impact of ICT on economic growth in certain South-East Asian countries in the late 1990s. In addition, Piatkowski (2003, 2004) studied ICT capital impact on economic growth and labor productivity in Bulgaria, the Czech Republic, Hungary, Poland, Slovakia, Slovenia, Romania, and Russia.

Iran, as an emerging economy, has also attempted to benefit from ICT application in recent years. Now, Iran has partially liberalized its ICT sector by numerous private sector operators competing in the mobile telephone, data services, and internet sectors. However, the fixed-line market has remained a government monopoly. It should be noted that the privatization program of Iran was launched during the late 1990s.

Toward the 2025 Vision of Iran, Iranian authorities are seeking to invest in the ICT industry, along with other technologies such as Bio, Nano, aviation, and oil and gas. In spite of the considerable growth in ICT figures (e.g., in International Broadband and Internet Penetration rate) during the recent years, the current situation of ICT in Iran is undoubtedly extremely lower compared to global norms. For instance, the share of ICT value added in the economy of Iran was about %1.5 (2016), which is not considerable at all. Table 1 presents the ICT sector value-added shares in GDP of Iran.

Table 1. ICT sector value added shares in the economy (%) of Iran

Sub-sector/Year	2012	2013	2014	2015	2016
Telecommunication	1.08	0.93	1.07	1.06	1.14
IT and other information services	0.24	0.22	0.24	0.31	0.25
ICT manufacturing	0.07	0.08	0.09	0.11	0.11
Software publishing	0.01	0.01	0.01	0.01	0.02
ICT sector	**1.41**	**1.25**	**1.41**	**1.49**	**1.52**

Note. ICT: Information and communication technology. Source: Iran National Statistics Center (2017)

Focusing on the detailed indices of ICT sector reveals that although Iran has fairly developed in some aspects of the information society (e.g., broadband subscriber, Fig. 1), the

general position of Iran in international society demonstrates no remarkable improvement (Table 2).[1]

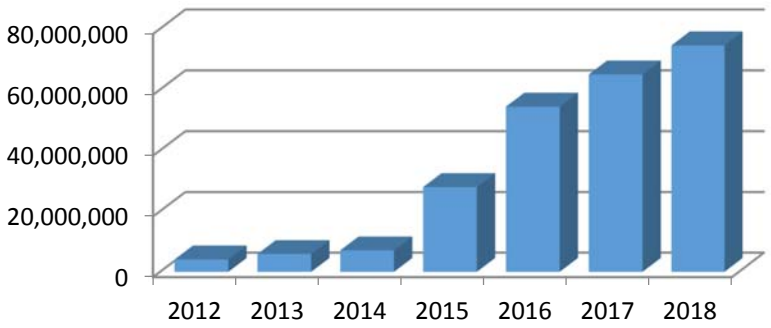


Fig. 1. Broadband subscribers in Iran (per person)
Source: Iran Information Technology Organization

Table 2. ICT development position of Iran among international societies

Index	Year	Upper Bound Score/Metrics	Sample No.	Iran Index Value	Iran Position (Rank)
IDI[2]	2017	10	176	5.58	81
EGDI[3]	2018	1	193	0.6	86
NRI[4]	2016	7	139	3.74	92
E- Waste[5]	2017	Kg	178	7.8	105
B2C & E-C[6]	2018	100	151	70.9	49

Note. ICT: Information and communication technology

The low position of Iran among international societies led its policymakers to pay attention to ICT sector development. Accordingly, significant growth is targeted for the components of ICT infrastructures within the 6th development plan of Iran (2016-2020) in a way that seems somehow ambitious. For instance,

- Household access to broadband internet from %55 (2016) to %80 (2020);

1. Data are collected from Iran Information Technology Organization (ITO) documents.
2 . ICT Development Index (Source: International Telecommunication Union -ITU).
3 . E-Government Development Index (Source: United Nations- UN).
4 . Networked Readiness Index (Source: World Economic Forum-WEF).
5 . Electronic Waste per capita Index (Source: United Nations- UN).
6 . Business to Consumer & Electronic Commerce Index (Source: United Nations Conference on Trade and Development-UNCTAD)

- Delivery of all government services through e-government from %20 (2016) to %100 (2020);
- Rural access to broadband internet from %30 (2016) to %90 (2020);
- Development of transit capacity (per second) from 5 (2016) to 30 (2020)

Thus, seeming to run the first phases of ICT deployment, Iran has attempted to procure its infrastructures. At present, this question arises that whether ICT can stimulate the economic growth of Iran. Therefore, the role of ICT in the economy of Iran should be historically analyzed, followed by deciding about whether ICT contributes to the economic growth of this country, which is considered as the main theme of the current study. Accordingly, the present study sought to gauge the effect of ICT deployment at the macro level on productivity and efficiency of production in Iran.

The remaining parts of the current study are organized as follows. Section 2 includes a brief review of the literature. Further, quantitative evaluations about the main theme of the study are presented in Section 3. Finally, Section 4 focuses on discussing the results, followed by providing the main finding of the study in Section 5.

2. A brief review of the literature

During the last decades, a number of studies have attempted to discuss the economic impacts of information and communication technology (ICT). These studies can be classified into three main categories as follows.

- Studies delving into the macroeconomic impact of ICT (e.g., Dimelis and Papaioannou, 2010; Dedrick et al., 2013; Chung, 2018; Liao et al., 2016; Oyerinde and Bankole, 2019);
- Studies dealing with the industry-level impact of ICT (e.g., Stiroh, 2004; Van Ark and Inklaar, 2005; Pieri et al., 2018; Gupta and Kumar, 2018; Castelnovo et al., 2018);
- Studies discussing the firm-level impact of ICT (e.g., Forth and Mason, 2003; Atrostic and Nguyen, 2005; Asongu and Biekpe, 2018).

The current study was grouped into the first category which aimed to evaluate the ICT impact on macroeconomic variables such as consumption, growth, productivity, and efficiency at a national level. Within this category, different studies exist (e.g., Gordon, 2000, 2003; Wolff, 2002; Oliner and Sichel, 1994, 2000, 2002; Strobel, 2018; Van Roy et al., 2018; Stanley et al., 2018). Considering the main theme of the study, the growth accounting literature considering ICT, as one of the inputs, was used for the theatrical backbone of the study. Therefore, the aggregate production function of the economy was taken into account as follows (Pohjola, 2002).

$$Y_t = Y(Y_t^{ICT}, Y_t^0) = A_t F(ICT_t, K_t, L_t) \qquad (1)$$

where, Yt = real output and Y^{ICT} and Y^0 are real outputs which are attributed to ICT and the other goods and services. Furthermore, ICT, K, and L stand for inputs including information and communication technology, as well as the capital, and labor, respectively. Finally, A

denotes technology level assuming Hicks-neutral technology. Accordingly, Equation (2) is obtained as the basic model for estimation by taking the logarithm from Equation (1).

$$\ln Y = \ln A + \alpha_c \ln ICT + \alpha_k \ln K + \alpha_n \ln L \quad (2)$$

3. Quantitative evaluation

As discussed earlier, the present study evaluated the effect of information and communication technology (ICT) on economic growth applying parametric and non-parametric approaches such as panel data and data envelopment analysis (DEA) techniques. Additionally, it delved into understanding the average effect of ICT on economic growth (known as ICT productivity), as well as the relative situations of provinces in terms of ICT contribution to economic growth (known as economic efficiency). Thus, the current study covered a panel of 28 provinces (2007-2013) depending on the availability of data.

The method of measuring ICT contribution to growth and productivity relied on the original work by Solow (1957), as well as Jorgenson and Griliches (1968), which was later extended by Jorgenson and Stiroh (2000) and Bloom et al. (2010). In the present study, a production function was employed in which provincial gross domestic product (GDP) was regarded as a function of capital stock (K)[7], the labor force (L)[8], and ICT (Eq. 2). As regards ICT index, provincial IDI data were extracted through the International Telecommunication Union method[9]. In the first step of quantitative evaluation, panel data method was utilized, followed by estimating the following functional form (e.g., pooled data and method of the moment) based on the results of primary tests. The results are provided in Table 3, where L and D represent logarithm and the difference value of variables, respectively.

$$D(LGDPit) = \alpha i + \gamma t + \beta 1\ D(LKit) + \beta 2\ LLit + \beta 3\ LIDIit + ui + \varepsilon it \quad (3)$$

Table 3. Estimation results

Dep. Variable: D (LGDPit)			
Variables(s)	Coefficient	t. stat	Prob.
D (LKit)	0.29	90.19	0.00
LLit	0.26	11.63	0.017
LIDIit	0.07	17.24	0.00
J-statistic		27.9	
Prob. (J-statistic)		0.31	

7 . Source of Provincial capital stock data is: Mozayani, A.H, Estimating provincial Capital Stock Data in Iran's Economy, Quarterly Journal of Fiscal & Economic Policies, Forth coming (in Farsi).
8 . Source of Provincial labor force data is: Iran National Statistics Center.
9 . Source of Iran Provincial IDI data is: Iran Information Technology Organization.

The estimation results represent a meaningful impact of ICT on the national product which can be interpreted as ICT productivity based on the estimated functional form. It is worth noting that based on the estimation coefficients of the present study, the relative effect of ICT on economic growth is extremely smaller than those of capital and labor.

In the second step of quantitative assessment, the DEA method was employed as a non-parametric technique. Therefore, by taking the capital, labor, and ICT as the inputs, along with GDP as the output of the system, two common BCC[1] and CCR[1 0] approaches[1] were used through Anderson-Peterson technique. Regardless of the relative position of provinces in economic efficiency, the results of DEA estimation indicate that the average efficiency of provinces is 52 and 85% in CCR and BCC approaches, respectively. In addition, ICT is proved to have a considerable impact on GDP efficiency both in both approaches (Fig. 2-3). However, upon omitting ICT from the inputs, the average efficiency decreases from 52 to 43% in CCR approach (Fig. 2) and from 85 to 59% in BCC approach (Fig. 3). These results shed light on the crucial role of ICT in the efficiency of provinces in the non-parametric approach.[1] [2]

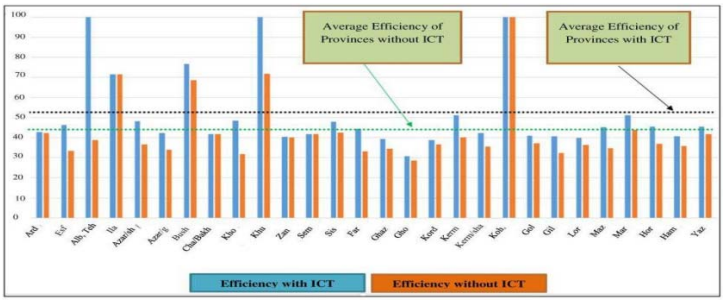
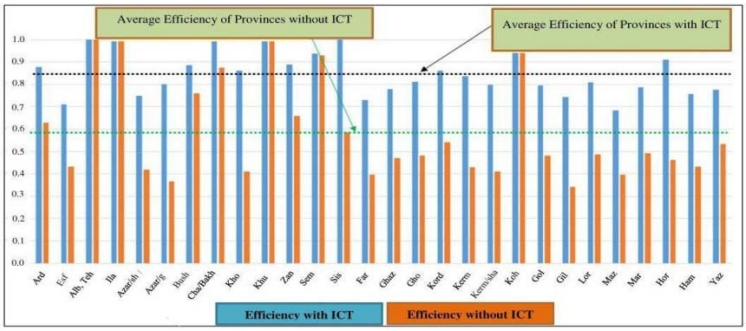


Fig. 2. The average efficiency of provinces with/without information and communication technology in CCR, Source: The author's calculation.



1 . Banker, Cooper, Charnesb (BCC)
1 . Cooper, Charnes , Rohdes (CCR)
1 . We used 'Efficiency Measuring System (EMS)" software for DEA & "E-views (8)" software for panel data estimation.

Fig. 3. The average efficiency of provinces with/without information and communication technology in BCC approach, Source: The author's calculation

4. Discussion

The review of the economic history of countries suggests that since the 1990s, information and communication technology (ICT) has played a significant role in facilitating economic growth. In this regard, different studies confirm the positive effect of ICT on growth processes at macro and micro levels, along with industry levels. Even before the emergence of ICT, the impact of improved access to information and effective communication on economic growth was observed in several economies such as Japan, Korea, Hong Kong, and Taiwan (Vu, 2011).

In the present study, applying parametric and non-parametric quantitative approaches on data related to Iran demonstrated that ICT could improve productivity and the efficiency of production. However, the average efficiency decreased considerably by removing ICT as an explanatory variable.

These results seem to be rooted mostly in the essence of the economy of Iran highly relying on the service sector. This sector is the prominent sector of the economy of Iran, as well as the most ICT-intensive one as compared to the other economic sectors such as industry, agriculture, and the like. However, based on national statistics of Iran, more than 50% of national income is supplied by the service sector (Table 4). Therefore, any improvement in ICT infrastructures and deployments of Iran is probably expected to intensify the growth process in the service sector which is the prominent and most ICT-intensive economic sector when compared to any other sector.

Table 4. The relative status of the economic sector of Iran (2010-15)

Index/Economic Sectors	Oil	Agriculture	Industry and Mining	Services	Other Sectors
Share in GDP	10-20	5-8	20-25	50-53	4-15

Note. GDP: Gross domestic product; Source: Central Bank of Iran

Further, the productivity indices of the economic sectors of Iran were evaluated to ensure the robustness of the analysis. The point which is worth noting is the relatively great level of productivity in the communication sector (as a sub-sector of the services) compared to the other sectors. As illustrated in Figs. 4-6, communication is absolutely the most productive sector in Iran in terms of total factor productivity in addition to labor and capital productivity[1] . This analysis is in line with our previous finding about ranking the most ICT-intensive sectors in Iran (Table 5).

1 . Data Source: Iran National Productivity Organization (Pending on availability of data).

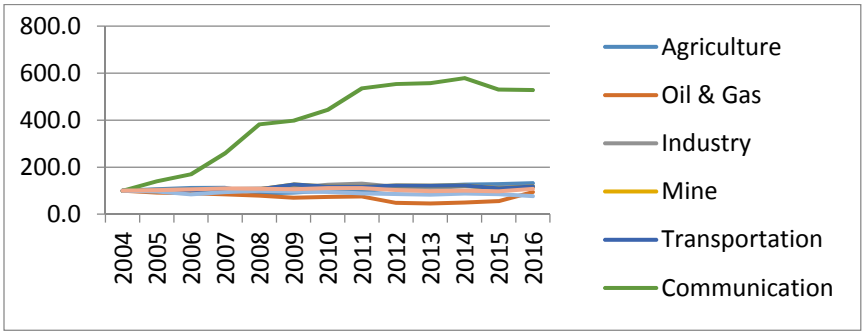


Fig. 4. Total factor productivity index (2004=100), Source: Iran National Productivity Organization

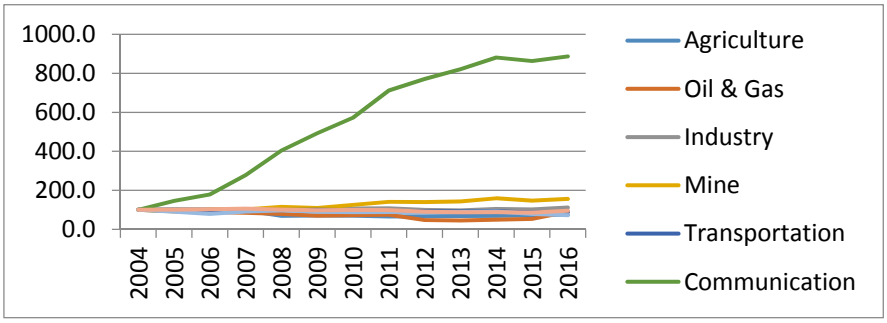


Fig. 5. Capital productivity index (2004=100), Source: Iran National Productivity Organization

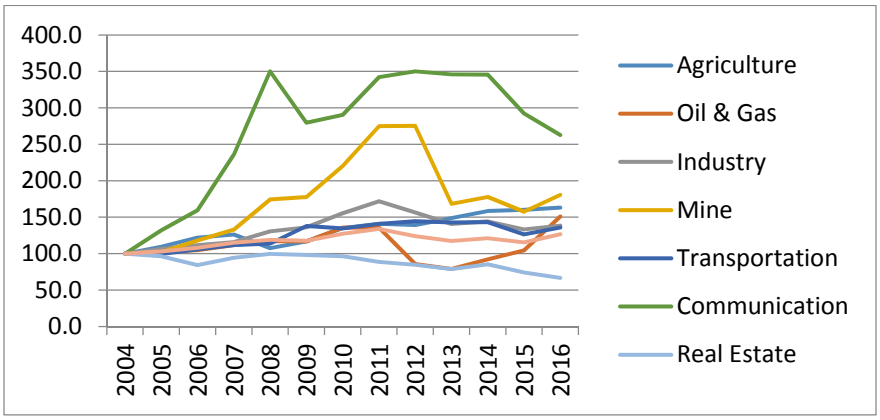


Fig. 6. Labour productivity index (2004=100), Source: Iran National Productivity Organization.

Table 5. Economic sector ranking of Iran based on ICT intensiveness criteria

Rank	Economic Sectors
1	Communication, transportation, and storage
2	Whole and retail sale
3	Post and telecommunication
4	Property and real estate
5	Social, personal, and household services
6	Industry
7	Agriculture

Note. ICT: Information and communication technology, Source: Mozayani and Moradhassel (2013).

5. Conclusion

In general, the present study attempted to have a general overview of the economy of Iran from an information and communication technology (ICT) point of view as the stylized facts. To this end, the study discussed that although Iran, as a developing country, has no proper place within the global society, it has sought to develop its ICT sector and utilization from ICT capabilities during the recent years.

In addition, two parametric (panel data) and non-parametric (data envelopment analysis) techniques were applied on Iran provincial data for 2007-2013 in order to have a quantitative evaluation of the ICT contribution of Iran to the economic growth. Further, the study aimed to find ICT impact on economic productivity and efficiency through growth literature. Based on the results, ICT, as a production input, could improve productivity, along with the efficiency of production, indicating that ICT contributed to the economic growth of Iran.

Furthermore, the obtained results mainly stem from the essence of the economy of Iran which heavily relies on the service sector as the most ICT-intensive and prevailing sector of the economy of Iran. Eventually, the communication sector (as a sub-sector of the services) had a relatively greater level of productivity (total factor/labor/capital) compared to the other sectors. This result sheds light on this theorem that ICT could be considered as an enabler in stimulating the economic growth in Iran.

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