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The Effect of Firm's Use from Information Technology (IT) on Total Productivity

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Abstract

Our basic aim in this paper concerns the question that if overusing the Information Technology by service and manufacturing firms can increase the total productivity resulting from this kind of technology regarding the Iran's economic structure and conditions. For this purpose, we primarily evaluate the productivity resulting from the rate of firms' use of IT for the different firms. To do this, we use Data Envelopment Analysis model and DEAP software. This model's inputs and outputs involve the rate of firms' use of IT and parameters of their performance, respectively. Next step, we divide different firms into three groups (based on the percent of spent costs on their Information Technology as firms with high, medium and low investment on IT, respectively). Then we analyze how the rate of IT spent costs effect on firms' productivity by KW test. The results of these analyses show that when the rate of IT investments in firms is medium, increasing this kind of investment to high level of IT capital can decrease the productivity of the mentioned firms significantly. But when the rate of IT's initial investment is low, any increasing of IT's investment up to medium and high level won't effect on firms' productivity significantly.

Keywords: Productivity, Information Technology (IT), Data Envelopment Analysis (DEA), KW test
JEL Classification: D24, L63.

1. Introduction

It has been recently made significant attempts about introducing the importance and initial concepts of productivity that its measurement aims at finding the tool for improving the firms' economic and productive condition by this method. There are different indices for

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productivity's measuring, so that each index is made based on the different definitions of productivity. Productivity literally means production's power and fertility and its economical concept is the amount of goods or produced services rather than each firm of usable services in firm with no drop in quality, but Stigle & Mondel define it more applicably, i.e., "productivity is the ratio between return to the productive functions relative to spent inputs" and "productivity is the ratio of firm's production return, relative to spent units that it has been compared with the same ratio of base period". (Sayemiri, 2006)

So regarding our mentions and the presented definitions, we can consider the productivity as one of the important and basic concepts of economics, such that we also can introduce it as one of the most important upcoming problems and challenges in our present economics that it moves toward being more competitive, because productivity is defined and developed just in competitive area. The most important parameters of studying the firms' productivity problems in an economics are the labor, capital or total productivity of production factors. But one of the most important production factors that its application and the productivity resulting from it, has had different results in various empirical works, is Information Technology's (IT) use in production process. On this basis, we want to study how the rate of IT's use can influence on this factor's productivity in firms. For this purpose, we not only choose the basic indices of IT by using the Entropy index, but also we gather the information related to the rate of IT's use by manufacturing firms in frame of a questionnaire from the different firms. By this questionnaire, we can compute their productivity by DEA model. Thus we prepare the variables that have been considered as a criterion of performance of above firms in order to compute the productivity resulting from firms' use of IT.

Regarding the importance of productivity and the necessity of dealing with the productivity problem resulting from IT which has been used by manufacturing or service firms in different levels, so we have to apply precise techniques in order to evaluate mentioned productivity and its effect of the rate of using IT by firms. After presenting the theoretical discussions about this topic in next section of this paper and the related practical works in section 3, we describe the used method and technique for evaluating and studying the mentioned effect in fourth section. Finally, we consider the productivity's measurement and analyzing the results obtained from applying above technique in section 5 and then we represent the conclusion and gathered discussions.

2. Theoretical Framework

IT has a deep and simultaneous influence on all economic parts as a technology with a general aiming, so Information Technology advances can make a very strong wave in all the economy (Rahmani, 2007). Increasing changes in IT has caused the functional and operational methods' change in Institutions. Personal computers not only cause works to be performed in due time, but also they're connected with each other inside the firms and departments, so employees can carry out their jobs accurately and efficiently by information exchange in company or department. Internet has also created the area in which information can be exchanged between organizations and centers. So the firms and units can be efficient in their productions by getting the newest information, methods and technologies and they also can reach to the highest level of productivity by applying the specific production factors. On this basis, Dasgupta (1999) believes that "most of the manufacturing firms spend their time, money and future on IT".

Thus, regarding these mentions, we can consider the productivity resulting from firms' use of IT as one of the economy's basic and important concepts. As our expectations, firms' investment in the more expansive level and their overusing of this kind of technology can increase the productivity of using IT in industry level. But as we mentioned in previous section, productivity carries its importance just in competitive area and can develop and increase simultaneously by overusing the IT's productive factor just in this area. On the other hand, productivity in each manufacturing firm is affected by existence of situation and conditions and it's influenced by the work culture of that firm. So productivity and its increasing methods will be different regarding the differences in each firm's conditions. One of these different situations that exist in different firms is the quality and manufacturing or services companies' use of sources and factors for producing services and productions. According to these points, the most important source and factor is IT that it can be used under the different conditions and work culture. So we can say that the rate and quality of IT's use will affect productivity resulting from this technology and this effect differs in various manufacturing firms that they have different conditions.

In fact, it must be mentioned that investment and using the IT in firms' production process will always affect productivity of Labor, capital and the total productivity of production factors and will increase them as one of the most important production factors (Mahmoudzadeh, 2010). IT has the features similar to the knowledge goods' features that can distinguish this production factor and its influence on production process from other factors because it's also used in production process as a technical factor. Some features such as being uncompetitive and unlimited development capability of investment in this production factor cause the knowledge goods and its obtained technologies like IT to be produced just one time and also can be duplicated easily with a trifling amount of marginal cost. These mentioned features of production factor create the external economies in production and then manufacturing firms will have increasing return to scale conditions (Jahangard, 2006). Finally, according to these conditions for firm, total productivity of production factors will improve by benefiting by increasing the production level.

But one of the most important points here is the productivity resulting from IT itself that not only it's used in firms but also it's applied in investments that these firms perform in the mentioned production factor. So the basic aim in this paper is this concept and aspect of productivity. It seems that the effect of rate in manufacturing firm's use of IT and their investment on this kind of technology in this aspect of production productivity is different from other aspects of the mentioned concept. As we mentioned in previous section, the productivity resulting from IT is affected by the prevailing status and area in productive conditions of each manufacturing firm. So most of the factors such as environmental factors like work culture in economy, official structure and mutual relationships that exist in firm's administrative structure and also the rate of production factor's specialization in labor force in producing the production and suitable or optimal use of IT and many other factors can be effective in the rate, quality and influence of the mentioned productivity from this technology.

Although companies and firms invest expansively on IT, but in fact the effect of this kind of investment on this production factor's productivity in firms is unknown. Most of the companies and firms spend more time and money for this kind of investment, but in fact they aren't fully sure and aware of the effects on their productivity that this ignorance is called "productivity paradox". Different studies in this topic represent various results that we will deal with them in next section. So some of these studies show that the more investment on IT, the more productivity resulting from it in firms' production. However, others conclude the reverse relationship between these two concepts.

On this basis, we focus on studying the topic that if increasing the rate of firms' IT investment and their use of this kind of technology can significantly effect on the productivity obtained from this kind of investment in Iran's economy and between different industries by using the technique in section 4 that we represent it with details. Also, the kind of relationship between them is important. Is the productivity of this production factor increased by overusing the mentioned technology? Or will it face with decline?

3. Research's Background

Recently, more investments have been made toward IT's substructures and the demands have been increased on manufacturing firms' and consumers' behalf for using the Information Technology's application. It seems that these IT investments will have the positive effects on firms' productivity. But as we will observe, there are more studies that they have concluded the negative effects of IT investments on productivity. As a result, evaluating the effects of IT investments and its application on total productivity of firms is important. Some studies have shown that IT doesn't have the significant effect on firms' productivity and some others have found the negative relationship between them.

Dasgupta (1999) has studied the productivity of different services or manufacturing firms by DEA model and then he has applied KW statistic for testing the problem that whether high level of investment in IT can increase the firms' productivity or not. The results show that IT investment doesn't have the significant effect on productivity by using the CCR model, but there is the negative effect on IT productivity in BCC model. Both CCR and BCC models have negative effect on productivity in manufacturing firms. Dasgupta states the reason of these effects as the lack of coordination and conformity of IT's huge investment with the services or manufacturing firms' needs. Myung Ko & Muata (2008) have found the complicated and vague relationship between IT investment and productivity resulting from it in hospitals. They have found that the relationship between IT investment and productivity isn't clear and it is exposed to changes. So that the rate of IT investment's effect has conditioned to the amount of none-IT investment's assets, labor force and time. Chein H. Wang (1997) have studied the effect of IT investment on productivity by using the two- stage DEA model and by measuring the marginal effect of IT investment on productivity. They have concluded that the rate and degree of IT investment can be effective in productivity of this production factor for firms, but after some steps, the marginal effect of IT investment in high level will be decreased.

Kazuyuky Motohashi (2008) has shown that IT has significant and positive effect on productivity of firms that has made serious reforms in their structure. Firms' entrance and exit and also their possession structure's change effect on total productivity of economics, so some firms that have entered in economy after these reforms, have used IT efficiently. But IT investment doesn't have significant effect on firms before these reforms. This result shows that increasing IT investment isn't enough for increasing the productivity, so it should be along with changing in structure and firms' renovation. Bernard Beaudreau (2010) has studied the productivity paradox problem by engineering approach so that his findings show that Information and Communication technology (ICT) isn't productive both in firm and industry level and ICT investment can't increase the production's output, however he concludes that ICT investment can increase the firm's profitability.

But against these researches' findings that have found the negative and insignificant effect between IT investment and productivity, there are other studies that they've found the significant and positive effect between them. Fathi et al. (2007) have represented the pattern for clarifying the effective factors in creating the productivity paradox in which the affection of effective interfering factors on the relationship between IT and firms' performance has been studied. For this purpose, They have done the extra- analysis from 585 performed studies about the relationship between IT and firms' performance in order to recognize the effective interfering factors in the mentioned relationship by setting each interfering factor as independent variables and their effect's test on relationship between IT and firms' performance (as a dependent variable). The results have shown that some parameters like different methods of Data Analysis, Data gathering's time, using the various variables for measuring the firms' performance and development of IT, the fulfillment of studies in industries and different economic parts, using different sample number in research, are effective and important parameters, so they create the productivity paradox.

Rahmani & Hayati (2007) have used the panel Data method in studying the relationship between spillovers of Information and Communication Technology (ICT) and growth of total productivity in production factors for 69 countries. They have studied both the effect of ICT investment into the country and the effect of ICT spillovers in international level on total growth of productivity in production factors. They also divide the internal ICT investment into two components for the more precise studying of the mentioned relationship as: The supply of IT investment such as total accumulation of investment, software, hardware, official equipment, internal costs and the other component is the supply of communications' investment. The results of their research show that both the internal ICT investment and the international ICT spillovers have the significant and positive effect on development of productivity.

Thus, Mahmoudzadeh & Asadi (2007) have studied the relationship of both IT investment and none- IT investments and with growth of labor factor's productivity for researching about the effect of IT on growth of the productivity in labor force by considering the labor force's productivity's function. Their results show that both mentioned investments have the significant and positive effect on growth of labor's productivity. But against their null hypothesis, the significant effect of none- IT investment is more than IT investment. Azar et al. (2007) have used the DEA model for evaluating the relative efficiency of the present firms in stock exchange in which the evaluation indices of IT such as budget information systems as a percentage of selling, the total value of organization's payers as a percentage of selling, the percent of budget devoted to employees' training are inputs of DEA model and the efficiency of the mentioned IT indices has been evaluated in terms of outputs such as five- year compound growth of selling or income, five-year compound growth of net profit, the rate of investment return. Their results shows that eight firms out of 102 controversial units (the present firms in Stock exchange) are efficient based on CCR models and 19 firms are also efficient based on BBC models. Thus, the number of efficient units about both CCR and BCC models regarding both "Input-oriented" and "Output- oriented" approaches is equal and this shows accurate logic definition of DEA models.

Diego Martinez (2009) has found the positive relationship between Communications and Information Technology (ICT) changes and development of IT's productivity in US during the time of 1980- 2004. He considers six variables in studied model that three variables are related to ICT and three others are none- ICT variables. So the study considers their effect on growth of productivity in two sub- periods 1980-1994, 1995- 2004. The results of research show that the effects of none-ICT investment are close to zero and the major share of effect is accepted by ICT investment. Thus the positive relationship between ICT technical changes and growth of productivity has become stronger during the period of 1995- 2004.

Finally, Dimelis & Papaioannou (2010) have studied the ICT effect on growth of productivity in two groups of American and European countries by using the Panel Data method and with two approaches as GMM and pooling data for the period of 1980- 2000. This study has been performed in industry level of the mentioned countries. The results of research show that the effect of ICT on industries' productivity in two groups is positive and significant during the mentioned period by using the pooling Data approach. But they have realized that the effect of ICT on the productivity of European countries' industries before 1990s has been stronger by GMM approach. But this effect has become weaker after 1990s, whereas the effect of ICT on productivity in these years is more and strong in American industries.

4. Research Method

4.1 DEA Model

As we study the productivity of resulting from the Information Technology's use by firms and companies in this research, now we want to study the DEA model in this part briefly that it's used for measuring the rate of productivity. Data Envelopment Analysis (DEA) is a technique that not only calculates both the rate of the productivity with combining all of studied units and making or solving the "n" model, "n" function in the mentioned unit by creating the virtual unit with the highest efficiency and comparing it with inefficient units, but also it applies all of gathered observations for measuring this productivity. DEA method is used as one of the nonparametric methods for this purpose (Mehregan, 2008).

One of the main hypotheses in DEA model is that each manufacturing unit uses the different inputs for different outputs, such that each of them has different scales of valuating. But it assumes that all the units apply the similar inputs for producing the similar outputs. Thus, one of the most important advantages in Data Envelopment Analysis method is the ability of combining and comparing some variables with different scales of measurement, because it applies variables for comparing, such that each variable is compared just with its homogenous variable in all of the determinant units. As we have selected 12 different indices of IT as input by Entropy index -that it will be explained in next section-, in addition to several outputs for measuring units' productivity, it seems that using the DEA model is better because of the number of outputs and inputs in this work.

DEA model has primarily been used by Farrell for estimating efficiency in agriculture part and then it has been developed by "Charnes, Cooper & Rhodse". In spite of increasing the Data Envelopment Analysis models gradually, but the basis of all of them is hidden in both main BCC and CCR models that we represent them briefly later. We assume that there are “n” production units for evaluating the productivity, so each one has inputs and outputs as "m" and "s", respectively. We show the enveloping form in CCR model as follows:

$$\text{Min } Y_0 = \theta$$
$$\text{St: } \sum_{j=1}^{n} \lambda_j Y_{rj} \geq Y_{r0} \qquad (1)$$
$$\sum_{j=1}^{n} \lambda_j X_{ij} \leq \theta X_{i0}$$
$$\lambda_j \geq 0 \text{ and } \theta \text{ is free in sign}$$

where X_{i0} & Y_{r0} are i'th input and r'th output for the studied manufacturing unit, respectively. λ_j in fact, is the shadow price of applied inputs and outputs in j'th unit. Thus, θ is presented as weights given to inputs in the mentioned unit and in fact, this model are searching the way for minimizing these weights for the mentioned unit. So it compares this unit with other units. It means that everything this model does is by comparing mentioned unit with other units; it determines weights of inputs in this unit such that this weight is the minimum amount, so we can consider it for that unit's inputs regarding its position rather than other units.

Of course, this model considers the rate and weight of all units' outputs as a constant number for this purpose that this approach is called CCR (input- oriented) model. But an important point here is that the minimum weight given to a unit's inputs regarding the unit's conditions between other units equals or smaller than one, if θ =1, so the unit is efficient and it operates on the efficient frontier, and if $\theta \leq$1, so the studied unit is inefficient in comparison to other units and it operates under the efficient frontier.

Banker, Charnes & Cooper (1984) entered the hypothesis of variant return to scale into DEA model by changing CCR model into BCC that we represent its enveloping form as follows:

$$\text{Min } Y_0 = \theta$$
$$\text{ST: } \sum_{j=1}^{n} \lambda_j Y_{rj} \geq Y_{r0} \qquad (2)$$
$$X_{i0}\,\theta - \sum_{j=1}^{n} X_{ij} \lambda_j \geq 0$$
$$\sum_{j=1}^{n} \lambda_j = 1 \quad \text{where } \lambda_j \geq 0 \text{ and } \theta \text{ is free in sign}$$

According to this form, existing the third restriction in the mentioned model, i.e. $\sum_{j=1}^{n} \lambda_j = 1$, indicates the hypothesis of variant return to scale in DEA model. Thus, by solving the model for "n" units, we can say that one unit in this model is efficient if there's an equality of θ =1. Therefore, all auxiliary variables related to restrictions are zero in its considering, otherwise the mentioned unit will be inefficient.

4.2 IT indices

We use different models for evaluating the rate of investment and firms' use of IT that they've been represented by international organizations for evaluating the electronic readiness of different countries. Mentioned organizations and institutes have defined some targets for themselves from electronic readiness based on their definition in each model, so they have represented a list of IT measurement indices regarding these targets. Electronic readiness means acceptance ability, using and applying IT and its related applications in societies (Fathian, 2008). We will refer to the list from these models, targets and their performing method in the following. We study 18 different models in this research and 267 indices of IT have been extracted from these models, so they've been used by business units. Thus we distinguish 112 indices of IT between them. It has been used the Entropy method for selecting between these different indices that we'll explain how this selection will be done. But we refer to some ICT models before choosing the indices that applied by these models in this research.

4.3 Evaluation Models of Electronic Readiness

So far, many models have been presented and applied for evaluating the electronic readiness by different organizations and institutes, but each organization have used different indices, targets and orientations for this evaluation regarding their definition of electronic readiness. One of the most famous models is "Partnership on Measuring ICT for Development", which it presents the IT indices in three different versions such that it gives different indices in each version regarding the targets defined by it. Creating the universal information base and comparable indices is this model's aim. On this basis, this model's indices are comparable among all countries. But in next versions, this model's aim is evaluation of IT's penetration in developing countries and it presents some indices that are especial to these countries and proportional to their conditions. Thus, Information Telecommunication Union (ITU) is the first organization that has measured ICT development in different countries and it aims at numerical and precise division of societies based on electronic readiness. So this model focuses on ICT equipment and substructures in societies. Another important model represented by "United Nations" measures the rate of East Asia countries' ICT application and it has shown the indices with more focus on business unit. Finally, other different models have been designed by "United Nations and World Bank" with African countries' cooperation that they aim at measuring the rate and influence of IT in the mentioned countries.

4.4 Choosing the Main Indices of IT by Using the Entropy Method

We have extracted 267 indices of IT used by business units after studying the mentioned models. There existed 112 different indices among them related to business units. Here we mainly study a question in addition to productivity's evaluation resulting from business units' use of IT, i.e. Does overusing of IT, increase the firms' total productivity?. For this purpose, we should measure the rate of business units' use of IT that it needs evaluating indices of IT. So, here we select the IT's evaluating indices by using the Entropy method among 112 different indices extracted from models. We reemphasize that these indices are selected among business part's indices presented by different international models.

For choosing the main indices, we should use some methods in which there is no need to numerical amounts for indices, because we don't know the rate of using each IT index by firms and we will gather the related data after selecting the indices and by planning the questionnaire. On this basis, the proper criterion for assigning the main indices is the frequency of each index in models. As Entropy method considers the frequency for assigning the indices and because of the more priority of some of them with high frequency for being selected as the main indices (Hanafizadeh, 2007), we apply this method for determining them in IT. Entropy method assigns the significant coefficient for indices regarding their frequency that these coefficients are used as a criterion for arranging IT indices. We primarily should formulate the determining matrix for assigning the significance coefficients that it shows the frequency of each index among different models.

Figure 1: Determining Matrix, for Assigning the Significance Coefficient of each Indicator

model / indicator	$\mathbf{M_1}$	$\mathbf{M_2}$	$\mathbf{M_3}$	......	$\mathbf{M_{18}}$	**Frequency of indices**
	a_{11}	a_{12}	a_{13}		$a_{1\,18}$	$\sum_{j=1}^{18} a_{1j}$
i_2	a_{21}	a_{22}	a_{23}		$a_{2\,18}$	$\sum_{j=1}^{18} a_{2j}$
i_{112}	$a_{112\,1}$	$a_{112\,2}$	$a_{112\,3}$		$a_{112\,18}$	$\sum_{j=1}^{18} a_{112\,j}$

The rows in the right side of Figure 1 shows the list of 112 different indices (i_1, i_2,… , i_{112}) and the columns also contains 18 studying models, (M_1, M_2, …., M_{18}). Thus, the amounts of each a_{ij} are zero (0) or one (1). So that if it equals one, it means that i'th index belongs to j'th model, otherwise a_{ij} will be zero (Hanafizadeh, 2007). The last column, i.e., the frequency of indices has been obtained by summing columns in each of rows and it shows the frequency of each index among different models. We can use this column for calculating the frequency coefficients in each index as follows:

$$P_{ij} = \frac{a_{ij}}{\sum_{j=1}^{18} a_{ij}} \qquad i= 1, 2,\ldots, 112$$
$$j= 1, 2,\ldots,18 \qquad (3)$$

where P_{ij} is the frequency coefficient of i'th index that it's applied in calculating the Entropy index as follows:

$$E_i = -M(\textstyle\sum_{j=1}^{18} P_{ij}\, lnP_{ij}) \qquad (4)$$

In this formula, M is a constant number and it equals $M = \frac{1}{\ln 18}$ and keeps the amount of E_i between 0 and 1 (Asgharizadeh, 2007). This formula (E_i) is used in statistic calculations and it's known as "Entropy of probability distribution"(P_{ij}). Entropy index uses the natural logarithm of frequency coefficient of each indicator (lnP_{ij}) as the weight of that indicator in E_i coefficient's calculation such that it will be used in significance coefficient's determination of IT indices. We extracted 42 indices with non- zero coefficient of E_i after calculating the Entropy index for each of IT indices and they are transferred to next step for their significance coefficient's determination. The significance coefficient in each of the 42 selected indices is computed by the following formula:

$$\lambda_i = \frac{E_i}{\sum_{i=1}^{112} E_i} \tag{5}$$

The expression $\sum_{i=1}^{112} E_i$ has been estimated in our research after calculating all of E_i 's amounts for IT indices. We create the confidence interval with %99 confidence level, based on the number of IT indices that they must be selected, in order to make ensure from significance indices' selection. This step is performed by the number of models and all 267 studied indices:

$$\mu - \frac{\sigma}{\sqrt{n}}\, t_{0.05} \leq \text{the number of indices that they must be selected} \leq \mu + \frac{\sigma}{\sqrt{n}}\, t_{0.05} \tag{6}$$

where, μ is the mean of the number of indices in different models, $\mu = \frac{267}{18}$ equals 14/83 and σ is standard deviation of the changes in the number of indices in different models, so $\sigma = 4.485$, $\sqrt{n} = 4.242$ .Finally the resulted calculations show the confidence interval as follows:

$$11/97 \leq \text{the number of indices that they must be selected} \leq 17/67 \tag{7}$$

It means that the number of IT indices which are selected based on 18 models and 267 under-studied indices shouldn't be more than 18 indices. We inevitably should select the first 18 indices with high significance coefficients among 42 indices which had non- zero significance coefficients based on their coefficient's amounts, so it's called "Screening test" (Hanafizadeh, 2007). This test has been done in the following figure and we select the first 18 indices as the main indices of IT, by ordering 42 IT indices according to higher significance coefficients, so these indices have been illustrated along with their significance coefficients.

Graph1: Significance Coefficients of IT Indices

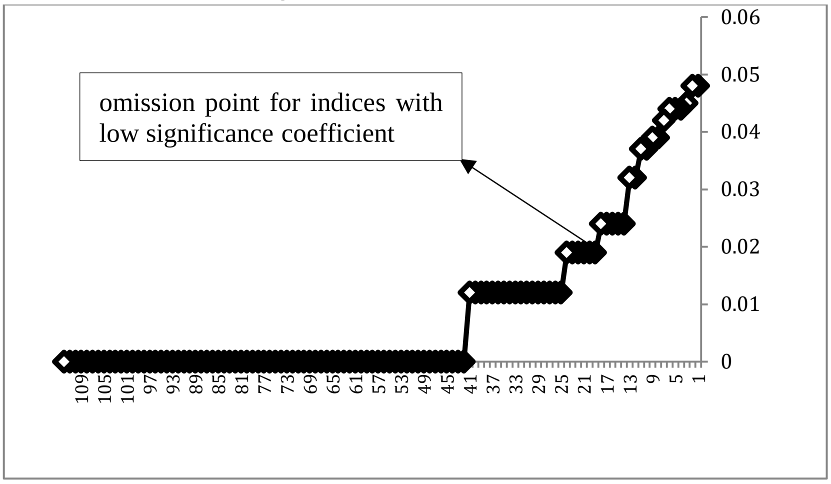

Table1 in appendix contains the list of these indices, so they are arranged based on their significance coefficients. In fact, we have omitted the last five indices from the list when analyzing with two reasons that they all have the same significance coefficient equals 0/024. The first reason is that they were not suitable for this research's application. Here we study the rate of firms' application in IT, whereas these indices consider the application's and the relative rate's obstacles from ICT's imports. Second reason of these indices' omission is that the under-studied units don't have ability to present proper information and statistics about these indices, especially about ICT application's obstacles. As a result, we choose 12 indices for studying in this research by omitting above indices. According to this result, each of twelve indices is used as input in this research, i.e., DEA model. It has been collected the information related to the rate of firms' application of these indices after selecting the main IT indices by planning the questionnaire and its sending by stock organization to participant units in this organization. According to it, information related to 58 participant units of this organization has been used in this research. Thus, these companies contain: services or manufacturing firms and industrial or banking units that their list has been presented in Table3 in appendix.

After receiving the indices' information, they have been considered and analyzed as DEA model's inputs. Also model's outputs such as companies' cash profit, net worth of company's stock and market value of under-studied units are indices of performance of present services or manufacturing units of stock organization, so we can consider them as variables which depict the total productivity resulting from firms' use of IT. So the information obtained from these variables is related to the units which are members of stock organization and stocks in Tehran and also they have completed the sent questionnaire by this organization. Therefore the applied DEA model contains 12 inputs and 3 outputs in this study. So, finally we have evaluated the productivity resulting from firms' use of IT by this method and by above outputs and also DEA model. Then we apply the Kruskal-wallis (KW) statistic for studying how the rate of use of IT and investment toward it can effect on productivity of this production factor in firms (Dusgupta, 1999). So this statistic can test the effective differentiation between the two or more groups statistically by effectiveness ranking in mentioned groups independently. So the zero hypotheses in this test are as follows:

H_0: All of the studied groups have the same influence.

H_1: At least one of the studied groups has different influence.

And statistic form in this test is presented as follows:

$$T = \frac{12}{N(N+1)} \sum_{i=}^{k} \frac{R_i^2}{n_i} - 3(N+1) \quad (8)$$

where N is the number of all observations or the total number of studying units, K is the total number of studying groups, so here we have divided all observations into three groups as: units with high, medium and low IT investments, respectively. n_i is the number of observations or units in i'th group and R_i is the sum total of units' ranks in i'th group that they have been concluded by DEA model. As a results of test, if T> χ^2(K-1, 1-α), so zero hypothesis (H_0) is rejected, in this case, at least one of the groups has different effect. We can perform "multiple comparisons" among the groups for recognizing the different between which groups, such that groups i and j have different effects if:

$$\frac{R_i}{n_i} - \frac{R_j}{n_j} > t_{1-(\frac{\alpha}{2})} \left[S^2 \frac{N-1-T}{N-K}\right]^{1/2} \left[\frac{1}{n_i} + \frac{1}{n_j}\right]^{1/2} \quad (9)$$

where,

$$s^2 = \frac{1}{N-1}\left[\sum_{all\,ranks} R(X_{ij})^2 - N\frac{(N+1)^2}{4}\right] \quad (10)$$

and $R(X_{ij})$ is shown all of the obtained ranks from under-studied units by DEA model at above formula. If this formula is assigned for multiple comparisons among groups, so it shows that there is a significant difference between i and j groups' influence. So it means that IT investment has the significant effect on firms' productivity. On this basis, we primarily measure the productivity resulting from IT investment by DEA model and by using the resulted data in questionnaire. Then we will do the IT investment effect's test on firms' productivity by the mentioned statistic.

5. Results' Analysis

Table 2 in appendix represents the results of DEA model's analysis. As we see in this table, we have analyzed the productivity in 58 under-studied companies with four different approaches of the constant return to scale (CCR) in input- and output-oriented state in addition to variant return to scale approach (BCC) in both input- oriented and output- oriented state. According to mentioned table, we can observe that the results obtained from two different approaches as constant return to scale and also variant return to scale for 58 under-studied companies are identical and equal. Therefore, we analyze the productivity just for the first approach, i.e. the constant return to scale and for both input-oriented and output-oriented state. As we see in the results of table 2, companies and firms that their Malmquist index in both input-oriented and output-oriented state equals one (1) in constant return to scale approach, are identical and constant. So it shows that these companies apply IT perfectly in each condition rather than other firms and companies, and they have the most productivity than other firms with their application's rate of technology for better function of company. The number of these firms is 17 that they have been specified by dark color in results' table. In other words, %29 of the present companies has efficient condition in this research and they perfectly use of rate of existent IT in company in order to develop their performance. So it means that the rest or %71 of the under-studied companies in this research couldn't get the needed productivity from IT application and they have worst condition than 17 mentioned companies.

But our next aim concerns the question, i.e., "Does overusing and high IT investment by services or manufacturing companies, increase the productivity and development of these companies' performance in Iran economy? As we previously saw, for this purpose we use KW statistic, so in this case we need to divide the under-studied companies in different groups based on the rate of their investment on IT. The last column in table 2 in appendix shows the rate of performed costs' percentage by firms on IT relative to firm's total costs. Here we divide the present firms into three different groups based on their IT investment's rate. We consider these companies as firms with high IT investment with the percent of their IT costs more than two (%2) ($2 \leq K$), medium IT investment with the percent of their costs between one (%1) and two (%2) ($1 \leq K < 2$) and also firms with low IT investment with the percent of their costs between zero (0) and one (%1) ($0 \leq K < 1$), respectively. We divide these companies based on the amounts of IT costs' percent related to 58 under-studied units in this research. According to this division, the number of present companies in each group is parallel with each other as much as possible, so we can get the better results in this analysis. Table3 in appendix shows this kind of companies' division in terms of the amounts in their IT cost's percent.

At first, we analyze the KW test based on the obtained results in studying the rate of different companies' productivity by using the DEA (Data Envelopment Analysis) model. This analysis is done for studying the existence of important and significant difference between three mentioned groups' influence on companies' productivity. This test is performed by Minitab 16 software and its results are presented in table1. As we see in table1, KW statistic, i.e., "T" variable in both input-oriented and output-oriented CCR state is so that we can reject the zero hypothesis for this test ($T > \chi^2$ (K-1, 1-α)), it means that at least one of the studying groups in this test has different conditions than other groups. In other words, in this study we can especially say that at least in one of the mentioned groups, the rate of units' investment toward IT has different effect on the rate of these units' productivity rather than other groups. So, up to now according to the results in table1, we have proved that the rate of IT investment in Iran's industry and economy has significant effect on productivity resulting from this kind of technology in services or manufacturing companies. In fact, in this purpose we divided companies based on high, medium and low IT investment, respectively and by studying the effect of this investment on each group's productivity in order to get the above mentioned result.

Table1: KW Test's Results for Three Groups with High, Medium and Low IT Investment by 95% Probability Level

Test's result	Statistic: χ^2 (K-1,1-α)	KW statistic: T	Results / test's approach
There is a significant difference in three different under-studied groups' effectiveness	0/102	2/22	Input-oriented CCR
There is a significant difference in three different under-studied groups' effectiveness	0/102	4/48	Output-oriented CCR

Resource: Research’s Calculations

Now, after getting this important result, we should analyze that how is the orientation of this influence. Does this kind of companies' investment have positive effect on these companies' IT productivity? Or does it have negative effect? In other words, whether high IT investment increase firms' productivity or it will be decreased? In this study, we precisely want to show that whether companies in high IT investment group are exactly companies with the rate of high productivity or not. Or it's possible that companies with high productivity would place in low IT investment group. So we can conclude that above effectiveness is negative. In this study, we do a multiple comparison among three under-studied groups based on the results of KW test and by using the formula (9) for examining this important aim.

Table2: the Results of Multiple Comparisons in Groups Based on KW Test's Results

CCR & output-oriented	CCR & input-oriented	Groups / Approaches
0/155> 0/102	1/4175> 1/016*	High & medium investment
0/082< 0/100	0/105< 1/378	High & low investment
0/072< 0/083	0/012< 1/168	Medium & low investment

*The left and right sides in above inequality are equal in computed amounts for the left and right sides in formula (9), respectively.

As we see at above table, the results are confirmed with those that we deal with them by KW test. It means that at least in one group, IT application's effectiveness on firms' productivity is different from other groups. The results in table 2 shows that there is a significant difference between two groups' effectiveness with high and medium IT investment on services and manufacturing firms' productivity in both input-oriented and output-oriented CCR approaches. We can observe that most of the companies in a group with medium IT investment have a higher productivity ranks in comparison with companies in a group with high IT investment, by considering the computed ranks for services and manufacturing firms in table 2 in appendices that has been done for studying these firms' productivity by using the "Data Envelopment Analysis" (DEA) model. According to this difference, the results of multiple comparisons in mentioned groups at above table show it as a significant difference. It means that we can statistically conclude that high IT investment decrease the firms' productivity than the medium IT investment state. So there is a negative relationship between IT investment and the productivity resulting from it in high levels of above mentioned investment and this relationship is statistically important and significant. It seems that, as Dusgupta says, the most important reason in this negative relationship is the lack of conformity and coordination in IT huge investment with services and manufacturing firms' needs. In other words, most of the studied units at this paper, because of prevailing conditions and environmental factors in their activity area, they can't properly use the assets of IT investments and some costs that they’ve done in this field. So existing this kind of investment is possible in services and manufacturing companies can decrease their production costs and increase the total productivity of production factors. But the most important point here is that by exceeding IT investment by firms, regarding the present environmental conditions in these units' activity area, they can't properly use this technology according to the rate of present investment.

According to the resulted information by questionnaire about environmental condition and studied companies' substructure factors in this research which can effect on quality of these companies' use from present rate of IT investment, it shows that some important factors place in falling position in both units with high IT investment and its low or medium level. These factors are employees' educational degree and their expertise in these companies' IT department which are their most important substructure factors in IT application quality. So it will naturally result in the above mentioned negative relation.

But the results from comparison of two groups with high and low IT investment at above table shows that there isn't a significant difference in above mentioned two groups' investment effect on the participant units' productivity of these two groups. In fact, regarding the computed ranks for units' productivity measurement (according to table2 in appendices), we observe that the number of firms in low IT investment group with high productivity ranks is more than units in high IT investment group with relatively high ranks. It means that average productivity in low IT investment group is more than another group, but this difference between two groups isn't statistically significant. On the other hand, increasing IT investment from its low level to high investment level will be along with units' productivity decline, so it indicates that there is a negative relationship between IT investment in the mentioned levels and the productivity resulting from it. Of course, this negative relationship isn't statistically significant. Finally, comparing two groups' results with medium and low IT investment is a little different from previous states. So we can conclude that increasing IT investment from its low level to medium investment level is along with increasing units' productivity according to computed ranks in table2 of appendices. In other word, there is a positive relationship between IT investment by firms and the rate of their productivity. but in low level of mentioned investment, Unfortunately, this positive relationship isn't statistically significant according to the results in table2. It means that increasing this kind of investment when it is in its low level, can't significantly effect on increasing the productivity resulting from Information Technology (IT).

6. Summary and Conclusion

So, as a conclusion and final results for this study, we can say that increasing IT investment by services and manufacturing firms in Iranian economy's area will increase the productivity in all economy or in its special part, under the condition that the rate of this kind of investment in society or in a certain part is in falling levels. But this effectiveness won't be significant and important, but increasing IT investment can significantly cause the productivity decline in all economy or in the certain part under the condition that the rate of this kind of investment is in its high levels.

Appendices

Table1: Main Indices of IT, Selected by Entropy Method

Row	IT's Indices	S.C*
1	Units that access to Internet	0.048
2	Units that have a Web-site	0.048
3	Units that use from Computer	0.045
4	Total staffs in Unit that use from computer	0.044
5	Total staffs in unit that use regularly from computer for accessing to internet	0.044
6	Units that receive order by internet	0.044
7	Units that have a Local Area Network	0.042
8	Units that have an Intranet Network	0.039
9	Units that give order by Internet	0.039
10	Units that have a Extranet Network	0.037
11	Units that use from Internet for different activities like (Bank activities, Ads and giving information to customers, Sending and Receiving Emails, etc.)	0.037
12	Units that use from different connections like (Analogue	0.032
	Modem, ISDN, ADSL, etc.) to connect Internet	0.032
13	Units that connect to Internet by different modes of access like	0.024
14	(fixed, mobile) broad band, Narrow band, etc.	
15	Barriers of use of Computers for unit	0.024
16	Barriers of use of Internet for unit	0.024
17	Barriers of E-Business for unit	0.024
18	ICT goods imports as percentage of total imports of unit	0.024
	ICT goods exports as percentage of total exports of unit	

Resource: Researches' Results

Table 2: Results of Firm's Productivity and their IT Cost Percentage Measuring

DMU	Name of Firm	CCR and Input-Oriented	CCR and Output-Oriented	BCC and Input-Oriented	BCC and Output-Oriented	IT cost percent in Firm
1	Saderat Bank of Iran	0.882	0.900	0.882	0.900	40
2	Packaging Industries of Iran	1.000	1.000	1.000	1.000	0.5
3	Pardis Investor Company	0.340	0.440	0.340	0.440	4
4	Khorasan Steel Company	1.000	1.000	1.000	1.000	1
5	Sadid Equipments and Tube	0.461	0.527	0.461	0.527	0.0001
6	Alvand Tile Industries	0.516	0.588	0.516	0.588	0.8
7	Amin Pharmacy Company	0.639	0.694	0.639	0.694	0.7
8	Ghorji Bisquit Company	0.919	0.720	0.919	0.720	3
9	Razak Laborator Company	1.000	1.000	1.000	1.000	1
10	Osveh Pharmacy Company	1.000	1.000	1.000	1.000	0.5
11	Pars Tile Company	0.359	0.554	0.359	0.554	1.6
12	Oroumieh Cement Company	0.672	0.589	0.672	0.589	0.01
13	Soliran Company	0.952	0.424	0.952	0.424	0.04
14	Ghol-Ghohar Ironstone Company	1.000	1.000	1.000	1.000	0.5
15	Iran Tractor and Smithy	1.000	1.000	1.000	1.000	1
16	Shahrood Cement Company	0.787	0.664	0.787	0.664	0.05
17	Pars Industrial Smut Company	0.559	0.592	0.559	0.592	0.5
18	Khavar Elater Company	0.471	0.488	0.471	0.488	10
19	Gas and Glass Company	0.363	0.458	0.363	0.458	0.01
20	Iran Tractor(Motor) Making Company	0.466	0.498	0.466	0.498	1
21	Power Trans Company	0.726	0.669	0.726	0.669	2
22	Magsal Agricultural & Poulteral Company	1.000	1.000	1.000	1.000	0.0001
23	Petrochemical Industry Investor Company	0.634	0.660	0.634	0.660	25
24	Sina-Darou Laborator	1.000	1.000	1.000	1.000	0.5
25	Iran Mineral Company	1.000	1.000	1.000	1.000	0.7
26	Iran Radiator Company	0.611	0.658	0.611	0.658	0.8
27	Darou-Pakhsh Factories	1.000	1.000	1.000	1.000	1
28	Aboureyhan Pharmacy Company	1.000	1.000	1.000	1.000	0.5
29	Barez Industrial Group	0.362	0.492	0.362	0.492	0.052
30	Tayen Cement Company	1.000	1.000	1.000	1.000	1.9

Continuous of Table 2

DMU	Name of Firm	CCR and Input-Oriented	CCR and Output-Oriented	BCC and Input-Oriented	BCC and Output-Oriented	IT cost percent in Firm
31	Irans' Behshahr Group of Investment	0.339	0.443	0.339	0.443	2
32	LoabIran Company	0.471	0.544	0.471	0.544	0.3
33	Rouzdarou Pharmacy Company	0.554	0.742	0.554	0.742	1
34	Kavian Steel Company	0.527	0.585	0.527	0.585	0.3
35	Fouro Silica Company	0.513	0.493	0.513	0.493	5
36	Fiber Production of Iran	1.000	1.000	1.000	1.000	1
37	Saipa Lizing Rayan Company	0.438	0.551	0.438	0.551	2
38	Iran Lent Tormoz Company	0.712	0.853	0.712	0.853	1
39	Iran Carton Company	0.764	0.880	0.764	0.880	0.05
40	Iran Aluminium Company	0.507	0.639	0.507	0.639	50
41	Chadromlou Mineral & Industrial Company	1.000	1.000	1.000	1.000	0.0001
42	Midle East Tide Water sea services	1.000	1.000	1.000	1.000	1
43	Alborz Investment Company	0.529	0.736	0.529	0.736	1.02
44	Shahin Plastic Manufacturing Company	0.618	0.339	0.618	0.339	0.5
45	Pars Drug Company	0.727	0.743	0.727	0.743	0.08
46	Iran Mineral Materials Production Company	1.000	1.000	1.000	1.000	1
47	Iran Smith Minerals Development Factory	0.548	0.701	0.548	0.701	1.5
48	TousGhostar Urban Investment Company	0.380	0.457	0.380	0.457	1
49	Absal Factory	0.350	0.564	0.350	0.564	1
50	Arak Machinist Factory	0.296	0.048	0.296	0.048	1
51	Nirou Kolor Company	1.000	1.000	1.000	1.000	1
52	Shahid Ghandi Transmission Cables	0.812	0.868	0.812	0.868	0.3
53	Iran Khodro (Mehvarsazan) Industrial Firm	0.335	0.495	0.335	0.495	0.2
54	Sahand Tire Company	0.329	0.482	0.329	0.482	0.02
55	Gilan Pakat Company	0.449	0.591	0.449	0.591	1
56	Kosar Pharmacy Company	0.926	0.914	0.926	0.914	0.0005
57	Hafez Tile Factories	0.836	0.823	0.836	0.823	20
58	Iran Industrial Sea Company (Sadra)	0.331	0.162	0.331	0.162	0.01

Resource: Research’s' Results

Table3: Making Group of Firms by their IT Cost Percentage

DMU	Name of Firm	IT cost Percentage in Firm	Group
40	Iran Aluminium Company	50	Group I (Firms with High IT Investment)
1	Saderat Bank of Iran	40	
23	Petrochemical Industry Investor Company	25	
57	Hafez Tile Factories	20	
18	Khavar Elater Company	10	
35	Iran Fouro Silica Company	5	
3	Pardis Investor Company	4	
8	Ghorji Bisquit Company	3	
21	Power Trans Company	2	
31	Irans' Behshahr Group of Investment	2	
37	Saipa Lizing Rayan Company	2	
30	Tayen Cement Company	1.9	Group II (Firms with Medium IT Investment)
11	Pars Tile Company	1.6	
47	Iran Smith Minerals Development Factory	1.5	
43	Alborz Investment Company	1.02	
4	Khorasan Steel Company	1	
9	Razak Laborator Company	1	
15	Iran Tractor and Smithy	1	
20	Iran Tractor(Motor) Making Company	1	
27	Darou-Pakhsh Factories	1	
33	Rouzdarou Pharmacy Company	1	
36	Fiber Production of Iran	1	
38	Iran Lent Tormoz Company	1	
42	Midle East Tide Water sea services	1	
46	Iran Mineral Materials Production Company	1	
48	TousGhostar Urban Investment Company	1	
49	Absal Factory	1	
50	Arak Machinist Factory	1	
51	Nirou Kolor Company	1	
55	Gilan Pakat Company	1	

Continuous of Table 3

DMU	Name of Firm	IT cost Percentage in Firm	Group
6	Alvand Tile Industries	0.8	Group III (Firms with Low IT Investment)
26	Iran Radiator Company	0.8	
7	Amin Pharmacy Company	0.7	
25	Iran Mineral Company	0.7	
2	Packaging Industries of Iran	0.5	
10	Osveh Pharmacy Company	0.5	
14	Ghol-Ghohar Ironstone Company	0.5	
17	Pars Industrial Smut Company	0.5	
24	Sina-Darou Laborator	0.5	
28	Aboureyhan Pharmacy Company	0.5	
44	Shahin Plastic Manufacturing Company	0.5	
32	LoabIran Company	0.3	
34	Kavian Steel Company	0.3	
52	Shahid Ghandi Transmission Cables	0.3	
53	Iran Khodro (Mehvarsazan) Industrial Firm	0.2	
45	Pars Drug Company	0.08	
29	Barez Industrial Group	0.052	
16	Shahrood Cement Company	0.05	
39	Iran Carton Company	0.05	
13	Soliran Company	0.04	
54	Sahand Tire Company	0.02	
12	Oroumieh Cement Company	0.01	
19	Gas and Glass Company	0.01	
58	Iran Industrial Sea Company (Sadra)	0.01	
56	Kosar Pharmacy Company	0.0005	
5	Sadid Equipments and Tube	0.0005	
22	Magsal Agricultural & Poulteral Company	0.0001	
41	Chadromlou Mineral & Industrial Company	0.0001	

Resource: Research's' Result

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