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ORIGINAL RESEARCH

Impact of information technology on productivity and efficiency in Iranian manufacturing industries

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Abstract The aim of this paper is to assess the impact of information technology (IT) on the productivity and efficiency of manufacturing industries in Iran. So, the data will be collected from 23 Iranian manufacturing industries during "2002–2006" and the methods such as DEA and panel data used to study the subject. Results obtained by the above two methods represent that IT has a positive and statistically significant effect on the productivity of manufacturing industries. It will be more in high IT-intensive industries than the other industries. But, there is no significant difference between the growth of labor productivity in IT-producing and IT-using industries.

Keywords Information technologies (IT) · Efficiency · Data envelopment analysis (DEA) · Panel data · Productivity · Malmquist Productivity Index (MPI)

Introduction

The role of information technologies (ITs) in resurgence of the economic growth of many industrial countries has been experienced in second half of the 1990s and then considered by policymakers and economists. These technologies have direct effects on the growth of the IT-producing industries. They also increase the efficiency and productivity of IT-using industries (Farooquie et al. 2012).

IT causes to appear new models of E-businesses, save the costs, improve the quality and quantity of production and increase the competition in markets. According to the economic literature, IT will deepen the capital—the increase of services per capital unit. Thus, the firms tend to use IT in the production process. However, the results of experimental studies have shown that the effects of IT on the productivity are different and not the same.

Some studies have presented that the relationship between IT and productivity is not positive. But, most studies have concluded that IT affects the productivity and efficiency positively.

Most studies have investigated the productivity in all industries, but they do not break the industries down to similar groups. So, there is a possibility of aggregate error in estimation. In this study, industries have been segregated into IT-producing and IT-using groups based on actual index. Also, industries are divided into high IT intensive and low IT intensive. Therefore, the aggregate error will be very limited and bias error of parameters obtained by the models is less than the previous studies. It seems that previous studies may confirm the productivity paradox due to aggregate error. So, we examine the productivity paradox in a better condition.

Many authors have studied the impact of IT on productivity in different countries, but its effect on productivity is not completely clear and unique. This research is done in Iranian manufacturing industries. We are to compare the findings of this paper to others.

Most investigations have only used econometric models to assess the impact of IT on productivity, but we will cover both econometrics and mathematics models to evaluate the effects of IT on industries.

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The main objectives of this paper are:

1. To analyze the impact of IT on the labor productivity in Iranian manufacturing industries using panel data approach to test the productivity paradox hypothesis developed by Solow (1957).
2. To analyze the effect of IT on the productivity in IT-producing and IT-using industries and also high IT-intensive and low IT-intensive industries?
3. To calculate the individual efficiency in Iranian manufacturing industries using DEA model and ranking efficient units.

The authors try to answer the following questions:

1. Have the use of IT increased the labor productivity in Iranian manufacturing industries? In other words, does productivity paradox hypothesis exist in Iranian manufacturing industries?
2. Is there any difference between the impact of IT on IT-producing and IT-using industries?
3. Is the impact of IT on high IT-intensive and low IT-intensive industries the same?
4. Which industries are efficient in Iran?

This analysis will help the managers and policy makers to devise the strategy to apply and develop IT such as hardware, software and communication technologies in production process and provide new technologies for labor force to improve the efficiency and productivity.

Literature review

Productivity improvement has a crucial role in raising GDP per capita. Firms adapting and using IT can improve the production process and labor productivity. IT is a key driver of productivity and pioneer to accelerate the industry in economic growth.

ICT is a general-purpose technology (GPT) that has a wide range of effects throughout the entire economy, reshaping the whole systems of production and distribution (the information technology and innovation foundation, 2014).

IT diffuses throughout the economy; they engender extensive spill overs in the forms of externalizes and technological complementarities, and their evolution and diffusion span for decades (the information technology and innovation foundation, 2014).

Moreover, GPTs undergo rapid price declines and performance improvements and become pervasive as an integral part of most industries, products and functions. They enable downstream innovations in products, processes, business models and business organization (Satapathy and Mishra 2013).

In individual industries, the productivity can occur through three different ways: all firms innovate or adopt new technologies; less productive firms dying and being replaced by new and more productive firms, or by more productive firms gaining market share from less productive ones (the information technology and innovation foundation, 2014).

Firm-level research has shown that there are large and persistent gaps between the productivity of IT-using industries and traditional firms. The use of more and better "tools" by producers is the best way increasing the productivity. In other words, the use of appropriate machinery, equipment and software improves the productivity (Romer 1990). For example, Internet is an easy and friendly tool for the users when applying it in production, marketing and sales and after-sales processes.

Dedrick et al. (2003) have found that "productivity paradox as first formulated has been effectively refuted". In both firm and country level, more investment in IT is associated with greater productivity growth.

Most studies, since the mid of 1990s to 2014, have found positive effects of IT on productivity (Cardona et al. 2013).

The beneficial effects of IT on productivity have been from firms to industries and then entire economies and in both goods and services producing industries (Carol et al. 2008).

Hitt and Tambe (2006) have found that the spill overs of IT will nearly make double the impact of IT investments.

Perminov and Egorova (2005) have found that the growth rates in ICT-producing and ICT-using industries are much higher than non-ICT industries in Russia, though an essential delay of ICT spreading still takes place in Russia compared with developed countries.

Some studies have focused on the intensity of using IT in industries. They believe that the impact of IT is related to its intensity in industries, so that the productivity growth is higher in industries using IT than the other industries.

Badescu and Garces-Ayerbe (2009) have studied the impact of IT on Tunisian manufacturing industries using Stochastic Production Frontier. They have emphasized the positive impact of IT on the efficiency and believed that initial preparation for the emergence of IT effects is to invest in human capital and complementary concerns.

The summary of previous studies is shown inTable 1.

Fernandez-Menendez et al. (2009) have studied the impact of IT on technical efficiency using the data collected from 2,255 Spanish firms and data envelopment analysis (DEA) and concluded that IT will positively affect on Health and Care industries under certain conditions. These conditions are the amount of investments in IT and non-IT concerns. Therefore, based on theoretical issues and

Table 1 A summary of empirical studies about the impact of IT on the labor productivity in firm and industry level

Study	Sample	Period	Impact of ICT capital on the labor productivity
Weill (1992)	33	1982–1987	+
Loveman (1994)	60	1978–1984	×
Hitt and Brynjolfsson (1996)	1,109	1988–1992	+
Prasad and Harker (1997)	47	1993–1995	+
Shao and Lin (2001)	1,115	1988–1992	+
Lee and Menon (2000)	1,064	1976–1994	+
Menon et al. (2000)	1,064	1976–1994	
Shao and Lin (2001)	1,115	1988–1992	+
Ko and Osei-Bryson (2004)	83	1976–1994	*
Gholami et al. (2004)	22 Industry	1993–1999	+
Engelbrecht and Xayavong (2006)	29 Industry	1998–2003	LP growth of more ICT-intensive industries improved over time to the other industries
Badescu and Garcés-Ayerbe (2009)	341	1994–1998	*
Mouelhi (2009)	1,824	1998–2002	+
Fernandez-Menendez et al. (2009)	2,255	2004	+
This paper	23 Industry	2001–2006	LP growth of more IT-intensive and IT-producing industries is more than other industries

+ Positive relationship, × no effect, * under certain condition is positive

Source 7 initial references used by Ko and Osei-Bryson (2004) and others classified by authors

experimental studies, IT affects the efficiency via the following ways:

First, technical advance in ICT-producing industries leads to the increase of the productivity in all production factors; Second, the reduction of capital cost compared to other inputs will replace IT capital by other investments and so, the increase of IT capital leads to the growth of labor productivity in ICT-using industries. Thus, the amount of ICT capital per worker will be increased and grown due to the labor; Third, IT-using industries may generate external beneficial effects. For example, Internet transactions will generate great externalizes in society and economies. The more the increase of these transactions the less the costs and ecology protection.

Methodology

The impact of IT on labor productivity (economic approach)

Theoretical and empirical studies have indicated that three main variables affect the productivity:

1. Physical capital
2. IT capital
3. Human capital

In this paper, the authors utilize an applied approach use a theoretical model to test the productivity paradox in Iranian manufacturing industries.

First, the relevant literature is reviewed. The authors have focused on industry level studies. Then, we investigated the stylized facts about IT using between industries. In the third step, the impact of IT on productivity was modeled and estimated econometrically and mathematically. The research is primarily based on the data of Iran statistical center. The flow chart of the research methodology used is shown in Fig. 1.

To evaluate the effect of IT on labor productivity, Cobb–Douglas model extended is used in IT capital and human capital by Jorgenson (2002) and Mankiw et al. (1992).

$$y(t) = A(t)F(kict(t), k_0(t), h(t)) \quad (1)$$

where y is the production per capita and $kict$, k_0, h are IT, non-IT and human capital per capita, respectively. If we take the differential from Eqs. (1), (2) will be obtained as follows:

$$\frac{\mathrm{dy}}{\mathrm{dt}}\cdot\frac{1}{y} = \frac{\partial F}{\mathrm{dk}_{(\mathrm{ICT})}}\cdot\frac{\mathrm{dk}_{(\mathrm{ICT})}}{\mathrm{dt}}\cdot\frac{1}{y} + \frac{\partial F}{\partial k_0}\cdot\frac{\mathrm{dk}_0}{\mathrm{dt}}\cdot\frac{1}{y} + \frac{\partial F}{\partial h}\cdot\frac{\mathrm{dh}}{\mathrm{dt}}\cdot\frac{1}{y} + \frac{\mathrm{dA}}{\mathrm{dt}}\cdot\frac{1}{A} \quad (2)$$

Assume that input factors are competitive, pay to factors are equal to marginal returns and the technology is Hicks natural type.

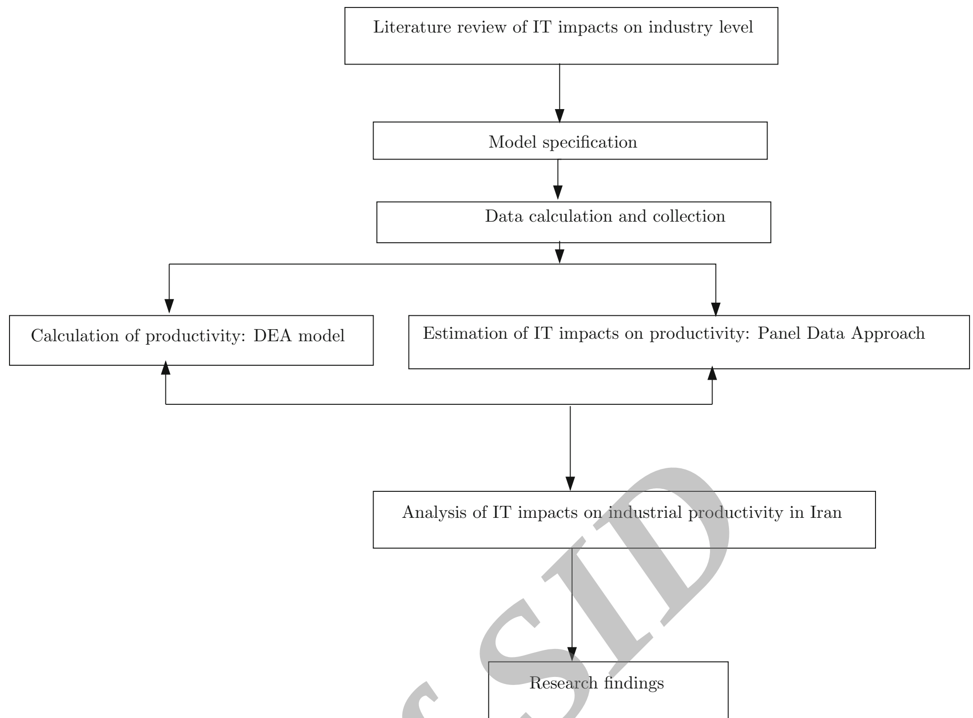
Then,

$$g = \frac{\mathrm{d}\ln \mathrm{A}}{\mathrm{dt}}, F_{(\mathrm{ICT})} = r_{(\mathrm{ICT})}, F_0 = r_0, F_h = r_h, F_L = w \quad (3)$$

$$\frac{\partial F}{\partial k_{(\mathrm{ICT})}}\cdot\frac{k_{(\mathrm{ICT})}}{y} = V_{(\mathrm{ICT})}, \frac{\partial F}{\partial k_0}\cdot\frac{k_0}{y} = V_0, \frac{\partial F}{\partial h}\cdot\frac{h}{y} = V_h \quad (4)$$

If we substitute Eq. (3) and (4) in Eq. (2) by some manipulations, Eq. (5) will be obtained as follows:

Fig. 1 Flowchart of the research methodology



$$y = V_{(\mathrm{ICT})}k_{(\mathrm{ICT})} + V_0 k_0 + V_h h + g$$
$$k_{(\mathrm{ICT})} = \frac{\ln k_{(\mathrm{ICT})}}{\mathrm{dt}}, k = \frac{\mathrm{d}\ln \mathrm{K_o}}{\mathrm{dt}}, h = \frac{\mathrm{d}\ln \mathrm{h}}{\mathrm{dt}} \quad (5)$$

Based on Eq. (5), there are four sources to explain the growth of labor productivity: IT capital, non-IT capital, quality of labor resource (human capital) and growth of total factor productivity.

The regression equation is based on an extended version of Cobb–Douglas function (Eq. 1). Labor productivity is regressed on non-IT capital per capita, IT capital per capita and the share of high-educated employment (undergraduate and above) from total employment and some binary (dummy) variables: take the value 1, if the industry is IT-producing and otherwise 0 (D1) and take the value 1 if industry is high IT-intensive and 0 otherwise (D2). So, two-way error correction components of panel data regression model are:

$$\ln y_{\mathrm{it}} = \alpha_0 + \alpha_0 \ln k_{\mathrm{ict,i,t}} + \alpha_1 \ln k_{0,i,t} + \alpha_2 \ln kh_{i,t} + \alpha_3 \ln k_{\mathrm{ict,i,t}} + \alpha_4 D_1 + \alpha_5 D_2 + \mu_i + \lambda_t + vit \quad (6)$$

The variables are defined previously: $i = 1, 2, \ldots, 23$ representing the manufacturing industries based on 2-digit International Standard Industrial Classification (ISIC) codes having more than 10 employee and $\mathrm{t} = 2{,}002, \ldots, 2{,}006$ representing the period of time. The data set includes the value added per capita, IT capital and non-IT capital per capita and human capital index. μ_i denotes the effect of unobservable individual, λ_t denotes the effect of unobservable time and vit is the remainder stochastic disturbance term (Baltagi 2005).

All data except employment have constant price (base year = 1997). IT investment includes only software and does not cover hardware and telecommunication parts. "ln" at the beginning of variables denotes the natural logarithm. In the next section, we are going to explain how to divide the industries and calculate the variables such as capital stock of IT and non-IT. The data source is the Statistical Center of Iran.

Classifying the industries by IT intensity

Industries use IT capital differently. Some industries are more depended upon IT capital than the others. So, in IT economic literature, the index of "IT intensity" was introduced by some IT economists. Stiroh (2002) uses ICT's share of capital services as a criterion to classify industries. Industries above the mean value of this variable are classified as "IT-intensive industries".

Ark et al. (2002) have used the same classification by some modifications. Engelbrecht and Xayavong (2006) have calculated the direct requirements of IT inputs for each industry using Input–Output table to classify the industries in New Zealand.

In this research, we use IT investment as a criterion to divide industries into "high IT intensive" and "less IT intensive". Industries above the mean value of this index are called as "high IT-intensive" and the others are "less

IT-intensive" group. Moreover, industries are divided to "IT-producing" and "IT-using" groups. The former are industries producing IT goods and the second using IT goods as inputs process. As noted above, some economists and analysts believe that LP growth in IT-producing industries are more than the others. Because, first, the innovation appears in IT-producing industries, then spreading and distributing to other sectors. So, we test this hypothesis by introducing binary variables (D2).

Preliminaries and development of the DEA models

Data envelopment analysis (DEA) is a nonparametric method for computing and assessing the relative efficiency of homogeneous decision-making units (DMUs) with multiple inputs and outputs (Tohidi and Khodadadi 2013). DEA provides efficiency scores not only for inefficient DMUs, but also for efficient projections of the units onto an efficient frontier (Saniee and Safi 2013). DEA introduced by Charnes et al. (1978) and extended by Banker et al. (1984) is a useful method for evaluating the relative efficiency of multiple-input and multiple-output units based on the data observed (Makui et al. 2008).

On the other hand, successful engineering managers require experience in business and engineering by applying engineering principles to business practice. Engineering managers usually focus on the production process to improve product quality and to decrease cost of production (Golrizgashti 2014). In today's technological world, almost every one depends upon the continues carrying out of a broad array of compound machinery, equipments and services for our everyday safety, security, mobility and economic welfare (Srinivasa Rao and Naikan 2014).

In DEA, CCR model is built on the assumption of constant returns to scale of activities. That is, if an activity (x, y) is feasible, then, for every positive scalar t, the activity (tx, ty) is also feasible. However, this assumption can be modified to allow extended types of production possibility sets by different postulates for the production possibility sets (Saati 2008). BCC model has its production frontiers spanned by the convex hull of the existing DMUs. The frontiers have piecewise linear and concave characteristics leading to variable returns to scale characterizations by:

(a) Increasing returns to scale
(b) Decreasing returns to scale
(c) Constant returns to scale.

In 1953, Sten Malmquist, a swedish economist and statistician, introduced the foundations of a productivity index now called by his own name. Malmquist DEA-based productivity index evaluates the changes of productivity during the time. It can be divided into two components: the first one evaluating the change in the technical efficiency and the other evaluating the technology frontier. Here, it is presented between the times "t and $t+1$".

Definition (Pareto-Koopmans efficiency) A DMU is fully efficient, if and only if, it is not possible to improve any input or output without worsening some other input or output (Cooper et al. 2002).

Consider $\mathrm{DMU_j}, (\mathrm{j} = 1, \ldots, \mathrm{n})$, where each DMU consumes m inputs to produce s outputs . Suppose that observed input and output vectors of $\mathrm{DMU_j}$ in the time t are $X_j^t = (x_{1j}^t, \ldots, x_{mj}^t)$ and $Y_j^t = (y_{1j}^t, \ldots, y_{sj}^t)$, respectively.

So, the production possibility set T_v in the period $k = t, t+1$ is defined by:

$$T_v^k = \left\{ (X^k, Y^k) \mid X^k \geq \sum_{j=1}^{n} \lambda_j X_j^k,\ Y^k \leq \sum_{j=1}^{n} \lambda_j Y_j^k, \times \sum_{j=1}^{n} \lambda_j = 1,\ \lambda_j \geq 0, j = 1, \ldots, n, k = t, t+1 \right\}$$

The above definition implies that BCC model in the period t is as follows:

$$\begin{aligned} & D_o^t(X_o^t, Y_o^t) = \text{Min}\ \theta \\ & \text{s.t} \quad \sum_{\mathrm{j}=1}^{\mathrm{n}} \lambda_{\mathrm{j}} \mathrm{x}_{\mathrm{ij}}^{\mathrm{t}} \leq \theta \mathrm{x}_{\mathrm{io}}^{\mathrm{t}}, \qquad \mathrm{i} = 1, \ldots, \mathrm{m} \\ & \sum_{j=1}^{n} \lambda_j y_{rj}^t \geq y_{ro}^t, \qquad r = 1, \ldots, s \\ & \sum_{j=1}^{n} \lambda_j = 1, \lambda_j \geq 0, \qquad j = 1, \ldots, n \end{aligned} \tag{1}$$

Moreover, BCC model in the period $t+1$ will be as follows:

$$\begin{aligned} & D_o^{t+1}(X_o^{t+1}, Y_o^{t+1}) = \text{Min}\ \theta \\ & \text{s.t} \quad \sum_{j=1}^{n} \lambda_j x_{ij}^{t+1} \leq \theta x_{io}^{t+1}, \qquad i = 1, \ldots, m \\ & \sum_{j=1}^{n} \lambda_j y_{rj}^{t+1} \geq y_{ro}^{t+1}, \qquad r = 1, \ldots, s \\ & \sum_{j=1}^{n} \lambda_j = 1, \quad \lambda_j \geq 0, \qquad j = 1, \ldots, n \end{aligned} \tag{2}$$

Continually, the first measure of the mixed periods defined as $D_o^t(X_o^{t+1}, Y_o^{t+1})$ for each $\mathrm{DMU_o}$ is calculated as the optimal value to the following linear programming problem:

$$
\begin{aligned}
&D_o^t(X_o^{t+1}, Y_o^{t+1}) = \text{Min} \quad \theta \\
&\text{s.t} \quad \sum_{j=1}^{n} \lambda_j x_{ij}^t \le \theta x_{io}^{t+1}, \qquad i = 1, \ldots, m \\
&\sum_{j=1}^{n} \lambda_j y_{rj}^t \ge y_{ro}^{t+1}, \qquad r = 1, \ldots, s \\
&\sum_{j=1}^{n} \lambda_j = 1, \lambda_j \ge 0, \qquad j = 1, \ldots, n
\end{aligned} \tag{3}
$$

Similarly, the other measure of the mixed periods as $D_o^{t+1}(X_o^t, Y_o^t)$, is calculated as the optimal value to the following linear programming problem:

$$
\begin{aligned}
&D_o^{t+1}(X_o^t, Y_o^t) = \text{Min}\, \theta \\
&\text{s.t} \quad \sum_{j=1}^{n} \lambda_j x_{ij}^{t+1} \le \theta x_{io}^t, \qquad i = 1, \ldots, m \\
&\sum_{j=1}^{n} \lambda_j y_{rj}^{t+1} \ge y_{ro}^t, \qquad r = 1, \ldots, s \\
&\sum_{j=1}^{n} \lambda_j = 1, \lambda_j \ge 0, \qquad j = 1, \ldots, n
\end{aligned} \tag{4}
$$

Färe et al. (1992) decomposed their Malmquist Productivity Index (MPI) into two components:

$$
\text{MPI} = \frac{D_o^{t+1}(X_o^{t+1}, Y_o^{t+1})}{D_o^t(X_o^t, Y_o^t)} \left[\frac{D_o^t(X_o^{t+1}, Y_o^{t+1})}{D_o^{t+1}(X_o^{t+1}, Y_o^{t+1})} \cdot \frac{D_o^t(X_o^t, Y_o^t)}{D_o^{t+1}(X_o^t, Y_o^t)} \right]^{\frac{1}{2}}
$$

The first part, $TE_o = \frac{D_o^{t+1}(X_o^{t+1}, Y_o^{t+1})}{D_o^t(X_o^t, Y_o^t)}$, evaluates the change in technical efficiency.

The second part, $TF_o = \left[\frac{D_o^t(X_o^{t+1}, Y_o^{t+1})}{D_o^{t+1}(X_o^{t+1}, Y_o^{t+1})} \cdot \frac{D_o^t(X_o^t, Y_o^t)}{D_o^{t+1}(X_o^t, Y_o^t)} \right]^{\frac{1}{2}}$, evaluates the technology frontier shift between the period t and $t+1$.

$\text{MPI} > 1$ denotes the productivity growth, $\text{MPI} < 1$ denotes the productivity decline and MPI = 1 corresponds to the stagnation.

Data description

Measuring IT and non-IT capital stock

Capital stock data of IT and non-IT is not published by official organizations. To calculate them, the following process has been conducted.

Calculating the investment average of industries

Accordingly, the total gross fixed capital formation (GFCF) of each industry will be divided into the number of employee in different years and the average investment is determined for each industry as follows:

$$
\bar{I}_{i,k,t} = \frac{I_{i,k,t}}{N_{i,t}} \tag{7}
$$

where $I_{i,t}$ is the investment of ith industry at t. $N_{i,t}$ is the number of employee of ith industry at the year t. $k = it, n$ represents the kind of capital stock, IT and non-IT capital.

Using the Eq. (7), we can obtain the average of investment growth rate by geometric method for each industry.

$$
\gamma = \sqrt[4]{\frac{\bar{I}_{i,k,85}}{\bar{I}_{i,k,81}}} - 1 \tag{8}
$$

Calculating the initial value of capital stock

To calculate the initial value, we use the perpetual inventory method (PIM) that is a common approach in empirical researches.

$$
K_{0,k} = \frac{I_{0,k}}{\delta_k + \gamma_k} \tag{9}
$$

where $K_{0,k}$ is the initial value of non-IT and IT capital, $I_{0,k}$ is the investment in 2002, δ_k is the depreciation rate assumed 5 and 10 % for physical and IT capitals, respectively.

Calculating capital stocks (IT and non-IT).

The next phase is the calculation of capital stock during “2002–2006” as follows:

$$
K_{t,k} = I_{t,k} + (1 - \delta_k) K_{t-1,k} \tag{10}
$$

Real capital stocks

The current value of non-IT capital and the value added have been adjusted by wholesale price index (base year = 1997) and IT capital by telecommunication index. So, the data used to estimate the model are real value.

Numerical examples and results

Econometrics results

We develop Eq. (6) using different techniques of panel data. First, we test “F test” and “Hausman test” to distinguish the best estimator between pooled, fixed and random effects. The statistical results show that the cross-section effect and time effect are statistically significant (Table 2). To test the validity and stability of parameters, the results of other techniques are presented in Table 3. Due to the short period (5 years), stationery tests of variables are ignored.

Table 2 ICT intensity of industries

Industry	ISIC code	IT producing	IT using	High IT intensive	IT share of investment 2006 (%)
1. Manufacture of food products and beverages	15	–	√	–	0.12
2. Manufacture of tobacco products	16	–	√	–	0.14
3. Manufacture of wearing apparel; dressing and dyeing of fur	18	–	√	√	1.31
4. Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear	19	–	√	√	0.87
5. Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	20	–	√		0.08
6. Manufacture of paper and paper products	21	–	√		0.68
7. Publishing, printing and reproduction of recorded media	22	–	√	√	11.87
8. Manufacture of coke, refined petroleum products and nuclear fuel	23	–	√		0.09
9. Manufacture of chemicals and chemical products	24	–	√	√	0.35
10. Manufacture of other non-metallic mineral products	26	–	√		0.19
11. Manufacture of basic metals	27	–	√		0.06
12. Manufacture of fabricated metal products, except machinery and equipment	28	–	√	√	0.55
13. Manufacture of office, accounting and computing machinery	30	√		√	0.4
14. Manufacture of electrical machinery and apparatus n.e.c.	31	–	√	√	0.39
15. Manufacture of radio, television and communication equipment and apparatus	32	–	√	√	0.7
16. Manufacture of medical, precision and optical instruments, watches and clocks	33	–	√	√	0.23
17. Manufacture of motor vehicles, trailers and semi-trailers	34	–	√	–	0.25
18. Manufacture of other transport equipment	35	–	√	–	0.21
19. Manufacture of furniture; manufacturing n.e.c	36	–	√	–	0.2
20. Recycling	37		√	–	0.54
21. Manufacture of electronic valves and tubes and other electronic components	321	√	–	√	0.92
22. Manufacture of television and radio transmand apparatus for line telephony and line telegraphy itters	322	√	–	√	1.24
23. Manufacture of medical appliances and instruments and appliances for measuring, checking, testing, navigating and other purposes, except optical instruments	331	√	–	√	0.27
Average		–	–	–	0.27

Source Statistical Center of Iran

All estimation indicate that the effect of the physical capital is negative. So, it seems that "descending return principle" applies to the physical capital in manufacturing industries of Iran. But, the impact of IT capital on labor productivity is positive and statistically significant. In other words, 1 % increase of IT capital per capita could improve the productivity about 8–18 %. By considering that the sign of IT variable does not change in equations, we can conclude that the productivity paradox does not apply in Iranian manufacturing industries and applying IT in business processes will increase the productivity.

The main result is that the coefficient of IT capital is always significant with and without firm-specified and time-specified effects. So, under any condition, the coefficient of IT is stable and significant. The effect of human capital is not statistically significant. It is because of

Table 3 Test cross-section and period fixed effects

Effects test	Statistic	d.f.	Prob.
Cross-section F	29.188229	(22, 85)	0.0000
Cross-section Chi-square	246.843957	22	0.0000
Period F	12.019245	(4, 85)	0.0000
Period Chi-square	51.551797	4	0.0000
Cross-section/period F	26.426076	(26, 85)	0.0000
Cross-section/period Chi-square	253.739944	26	0.0000

various reasons: (1) the share of high-skilled labor is low and most employees are low or medium skilled; (2) it may be due to the measurement error in human capital; (3) high-educated employee are used in lower levels.

It can be said that they are overqualified. The coefficient of the variable D_1 is statistically insignificant. Therefore, the productivity growth of IT-producing industries is not more than the others. But the coefficient of D_2 is significant indicating that the productivity growth of "high IT-intensive" industries is more than the others. So, It seems that

Table 4 The results of econometrics estimation

Method / Variable	Cross-section fixed and period fixed	Pooled EGLS (cross-section weights)	Pooled EGLS (cross-section weights)	Pooled EGLS (cross-section weights)	Cross-section fixed and period fixed	Period random effect	Period random effect
α_0	–4.9	–6.5	–6.4	–3.8	–7.3	–7.2	–6.7
$\ln kict$	0.128**	0.091*	0.086*	0.085**	0.14**	0.16*	0.18*
$\ln k_0$	0.01	–0.01	–0.01	–0.05	–0.05	–0.03	–0.02
$\ln h$	–	0.02	0.005	0.02	0.43*	–1.0	0.07
D_1	–	–	0.68	–	–	–	0.34
D_2	–	–	–	0.42*	–	0.62*	–
Adjusted R-squared	0.87	0.58	0.60	0.88	0.71	0.25	0.21

*,** Denotes the significant at 1 and 5 %, respectively

Table 5 Input and output 2002

DMUs	I_1 = IT	I_2 = n-IT	I_3 =HC	O = Productivity	Efficiency 2002 (I_1, I_2, I_3, O)	Efficiency 2002 (I_1, O)
1. Code 30	0.057828	29.61426	0.299	0.009279	0.0905	0.0570
2. Code 321	0.010612	14.87643	0.199	0.009907	0.3729	0.3135
3. Code 322	0.170305	18.72967	0.158	0.002463	0.1383	0.0176
4. Code 331	0.285801	33.69244	0.120	0.006485	0.0833	0.0110
5. Code 15	0.104235	35.67206	0.073	0.007839	0.1370	0.0309
6. Code 16	0.007654	28.38320	0.073	0.000129	0.6027	0.3920
7. Code 18	0.006630	16.44106	0.031	0.019571	0.7713	0.5932
8. Code 19	0.003662	120.9848	0.061	0.016529	1.0000	1.0000
9. Code 20	0.012538	6.066609	0.064	0.014646	0.4318	0.2845
10. Code 21	0.789970	13.58467	0.090	0.007220	0.1907	0.0040
11. Code 22	0.353588	123.2056	0.488	0.059463	1.0000	1.0000
12. Code 23	0.039679	114.5414	0.127	0.002285	0.1328	0.0756
13. Code 24	0.269396	23.41504	0.056	0.006024	0.1786	0.0116
14. Code 26	0.036762	23.16476	0.051	0.011141	0.1961	0.0922
15. Code 27	0.182712	11.09321	0.105	0.003417	0.2335	0.0164
16. Code 28	0.031344	17.31862	0.101	0.009586	0.1699	0.1056
17. Code 31	0.097748	190.4622	0.100	0.005537	0.1000	0.0318
18. Code 32	0.059808	45.41897	0.145	0.020296	0.0905	0.0668
19. Code 33	0.117271	15.59421	0.127	0.006724	0.1661	0.0270
20. Code 34	0.112789	32.77466	0.132	0.003178	0.0790	0.0266
21. Code 35	0.003000	3.455368	0.115	0.003428	1.0000	1.0000
22. Code 36	0.017788	8.053609	0.064	0.013602	0.3217	0.1976
23. Code 37	0.005497	2.590575	0.010	0.037117	1.0000	1.0000

Table 6 Input and output 2003

DMUs	I_1 = IT	I_2 = n-IT	I_3 = HC	O = Productivity	Efficiency 2003 (I_1, I_2, I_3, O)	Efficiency 2003 (I_1, O)
1. Code 30	0.045914	24.87436	0.289	0.007259	0.1453	0.0531
2. Code 321	0.058735	14.71862	0.216	0.009394	0.2456	0.0415
3. Code 322	0.119858	14.58876	0.136	0.001430	0.2478	0.0203
4. Code 331	0.217098	27.54596	0.111	0.005463	0.2849	0.0112
5. Code 15	0.212078	33.42568	0.079	0.006774	0.3942	0.0115
6. Code 16	0.004362	16.17662	0.085	0.000077	0.5591	0.5591
7. Code 18	0.007850	14.77483	0.031	0.013923	1.0000	0.3107
8. Code 19	0.004252	123.8098	0.059	0.015317	0.5736	0.5736
9. Code 20	0.037818	8.893384	0.070	0.012629	0.4566	0.0645
10. Code 21	0.709774	18.40471	0.086	0.006469	0.3688	0.0034
11. Code 22	0.083949	24.11664	0.119	0.009295	0.2668	0.0291
12. Code 23	0.069975	108.3128	0.143	0.002358	0.2168	0.0349
13. Code 24	0.264834	56.00641	0.045	0.005264	0.6889	0.0092
14. Code 26	0.035456	23.91602	0.055	0.009553	0.5657	0.0688
15. Code 27	0.163946	30.17150	0.111	0.003095	0.2843	0.0149
16. Code 28	0.042150	3.996962	0.100	0.007918	0.9045	0.0579
17. Code 31	0.360979	171.5931	0.090	0.032175	1.0000	1.0000
18. Code 32	0.064752	43.82792	0.147	0.003173	0.2142	0.0377
19. Code 33	0.093296	14.25642	0.117	0.005715	0.2733	0.0261
20. Code 34	0.089741	30.91810	0.124	0.002703	0.2550	0.0272
21. Code 35	0.011946	6.279590	0.137	0.002793	0.5757	0.2042
22. Code 36	0.018783	8.800082	0.069	0.010913	0.4632	0.1299
23. Code 37	0.002439	3.615127	0.032	0.026001	1.0000	1.0000

the more depended the industries on IT capital, the higher the productivity growth.

Then, the study indicates a significant positive contribution to the productivity of IT manufacturing industries. The findings of this paper confirm the results of Gholami et al. (2004) in Iranian manufacturing industries. They have found that IT has a positive effect on technical efficiency of the industries and estimated the production elasticity of IT about 0.06 (Table 4).

Econometric results represent that the impact of IT on the industrial productivity is average, and it does not measure IT effect on industry individually. So, to cover this deficiency and analyze carefully, DEA method is used to compare the findings of both methods mentioned.

DEA results

In continue, we use Data Envelopment Analysis method to evaluate 23 industries based on 2-digit ISIC during "2002–2006". Each unit has 3 inputs to produce 1 output.

First, the units are evaluated by the BCC model. As can be seen above, the first column of efficiency will be obtained by (I_1, I_2, I_3, O) and the second column of efficiency is based on (I_1, O).

A summery of the results are shown in Tables 5, 6, 7, 8 and 9.

The results of calculations represent that "Recycling" (code 37) and "manufacturer of electrical machinery" (code 31) are efficient all the time. (It is pareto-Koopmans efficient).

ISIC codes "18, 19, 20, 22, 35" are efficient in some years. Most industries are efficient by both 3 inputs (IT, n-IT, HC) and 1 input (IT). These confirm the econometric findings that the efficiency growth in high IT-using industries is more than the others. Furthermore, it is clear that there is a large inefficiency in the rest industries.

We, finally, look at the Malmquist Productivity Index. Table 10 reports the Malmquist Productivity Index based on (I_1, I_2, I_3, O) during the years (2002–2003), (2003–2004), (2004–2005) and (2005–2006).

The results of Malmquist Productivity Index (MPI) indicates that the productivity growth is not stable during "2002–2006". While industries by ISIC codes "30, 322, 331, 16, 21, 24, 28, 31, 33, 34" experience the productivity growth in 2003 compared to 2002. But the productivity of the most industries will be reduced in later years.

However, inefficiency of these industries is less compared to other industries. Moreover, the calculation of MPI

Table 7 Input and output 2004

DMUs	I_1 = IT	I_2 = n-IT	I_3 = HC	O = Productivity	Efficiency 2004 (I_1, I_2, I_3, O)	Efficiency 2004 (I_1, O)
1. Code 30	0.034877	23.14133	0.360	0.004645	0.2133	0.0506
2. Code 321	0.070342	19.40988	0.205	0.008835	0.2543	0.0251
3. Code 322	0.111714	18.34120	0.196	0.001200	0.2691	0.0158
4. Code 331	0.177678	25.88548	0.123	0.004384	0.2747	0.0099
5. Code 15	0.196407	36.58051	0.084	0.005712	0.3937	0.0090
6. Code 16	0.003444	20.21145	0.116	0.000654	0.5122	0.5122
7. Code 18	0.013642	15.12564	0.033	0.011244	1.0000	0.1293
8. Code 19	0.003630	36.23059	0.042	0.004537	0.8072	0.4860
9. Code 20	0.037761	9.324672	0.073	0.010379	0.5294	0.0467
10. Code 21	0.649979	21.93511	0.089	0.005673	0.3783	0.0027
11. Code 22	0.122006	26.12991	0.104	0.008645	0.3236	0.0145
12. Code 23	0.087865	176.0645	0.154	0.002482	0.2143	0.0201
13. Code 24	0.204832	53.41159	0.173	0.004293	0.1935	0.0086
14. Code 26	0.050970	28.03353	0.061	0.008161	0.5410	0.0346
15. Code 27	0.149689	40.74122	0.127	0.002646	0.2632	0.0118
16. Code 28	0.053411	7.589371	0.106	0.006402	0.6505	0.0330
17. Code 31	0.499534	170.7860	0.092	0.023251	1.0000	1.0000
18. Code 32	0.063027	42.24315	0.170	0.002710	0.1980	0.0280
19. Code 33	0.079166	15.33870	0.131	0.004591	0.3218	0.0223
20. Code 34	0.164879	39.07765	0.131	0.002258	0.2558	0.0107
21. Code 35	0.122064	13.55152	0.134	0.002841	0.3643	0.0145
22. Code 36	0.072232	9.298929	0.081	0.009231	0.5309	0.0244
23. Code 37	0.001764	4.936513	0.034	0.020108	1.0000	1.0000

based on three inputs (IT, n-IT, HC) and 1 input (IT) has almost the same results. That is, efficient industries also acts efficiently by the use of IT capital. In other words, the industries by adequate human and physical capital are successful in the use of IT capital. Industries 331, 15, 16, 21, 22 and 34 almost are able to fix or increase the labor productivity.

Table 11 reports Malmquist Productivity Index based on (I_1, O) between the year 2002–2003, 2003–2004, 2004–2005 and 2005–2006.

Findings

Contributions of IT in Iran are mainly derived by high IT-intensive industries. The effects of IT capital on labor productivity growth are much larger than physical capital. This is explained by both relatively larger sizes of IT share in total investment. Especially, most contributions are from high IT-intensive industries.IT can boost productivity by changing older and less productive business models to e-business models, e.g., online book selling replacing "bricks and mortar" bookstores and e-banking instead of traditional banking.

Iran should focus primarily on IT-using sectors. Because, IT-producing sectors do not have high potential to produce IT goods and most IT goods are imported from other countries.

In addition, the price of domestic IT goods is much more than the samples imported. So, encouraging IT-producing sector may hurt IT-using sectors, if the protective tariffs raise the local IT product prices for IT-using industries.Therefore, investing in these industries will limit the benefits.

In Iran, most industries are IT using and usually use IT in production processes. Promoting IT usage provides large benefits for the broader economy. The infrastructures such as laws and regulations are needed to enable and support it. Trade policy can play a crucial role in promoting and expanding IT. Almost, 25,000 web sites transact the goods and services in Iran and it seems that e-commerce account a remarkable volume of retail and wholesale transactions. Now, IT is used in banking, education, stock market, utility industries, governmental services and many other areas. IT- using industries will be able to take advantage of IT, if they could achieve larger economies of scale.

Why has the use of IT been the key driver of productivity? Principally, it is because of its greater impact on the

Table 8 Input and output 2005

DMUs	I_1 = IT	I_2 = n-IT	I_3 = HC	O = Productivity	Efficiency 2005 (I_1, I_2, I_3, O)	Efficiency 2005 (I_1, O)
1. Code 30	0.040880	22.12917	0.304	0.003894	0.1948	0.0398
2. Code 321	0.078851	399.6469	0.186	0.001508	0.0806	0.0206
3. Code 322	0.165259	22.80819	0.209	0.001143	0.1600	0.0098
4. Code 331	0.184870	32.63415	0.118	0.004117	0.1445	0.0088
5. Code 15	0.198228	38.02369	0.087	0.005126	0.1724	0.0082
6. Code 16	0.006078	33.58788	0.178	0.000115	0.2675	0.2675
7. Code 18	0.059396	16.50573	0.040	0.009882	0.3750	0.0274
8. Code 19	0.011031	90.01572	0.062	0.011681	0.2419	0.1474
9. Code 20	0.043113	1.331528	0.069	0.009347	1.0000	0.0377
10. Code 21	0.664785	28.21793	0.095	0.005530	0.1693	0.0024
11. Code 22	0.117234	24.52818	0.101	0.007691	0.1873	0.0139
12. Code 23	0.141364	173.1993	0.163	0.002428	0.0920	0.0115
13. Code 24	0.315797	52.98774	0.177	0.003937	0.0903	0.0051
14. Code 26	0.057059	31.42605	0.063	0.007522	0.2381	0.0285
15. Code 27	0.192435	67.95863	0.124	0.002438	0.1210	0.0084
16. Code 28	0.142719	11.38933	0.107	0.005758	0.3174	0.0114
17. Code 31	0.630717	171.2559	0.090	0.020561	1.0000	1.0000
18. Code 32	0.108083	47.29690	0.175	0.002705	0.0993	0.0150
19. Code 33	0.087542	22.44714	0.123	0.004325	0.1913	0.0186
20. Code 34	0.205124	64.06086	0.136	0.001963	0.1103	0.0079
21. Code 35	0.147283	15.79355	0.142	0.002355	0.2326	0.0110
22. Code 36	0.091856	11.81052	0.073	0.007870	0.3517	0.0177
23. Code 37	0.001626	4.849318	0.015	0.015381	1.0000	1.0000

productivity than non-IT capitals. Studies of the early 2000s have found that investment in IT capital cause to increase the productivity 3–8 times more than in non-ICT capital (Gilchrist et al. 2001).

Labor productivity in Iran manufacturing industries is inappropriate. Boosting the productivity is critical in Iran economy. Spreading and distributing new technologies can improve the labor productivity. By the use of new technologies, many benefits are largely driven through market forces, and digital regulation can significantly limit these benefits. IT laws in Iran is old and unclear. Laws need to be reviewed and updated. Many aspects of electronic transaction are not clear in laws and rules. This is a main barrier for investing in firms when using IT. So, managers and policy makers must try to correct the commercial and tax laws to support IT users.

Government should reduce the trade tariffs to import high-quality and reasonably priced IT goods to the country. Government should give tax cuts for IT-using industries to encourage them to use new technologies. This can result in energy saving when the government tries to remove subsides. Extensive use of new technologies by firms and industries can prevent the loss of energy mainly occurring due to the aging of technology used in production process.

Conclusion

In this paper, panel data and data envelopment analysis methods have been used to estimate and assess some industries in Iran. For this purpose, three types of relative evaluations are used: cross sectional, time series and panel data. The first compares a DMU to the others at a specified time and the second compares a DMU with itself at different times. For both types of evaluations, DEA is used by appropriate indices, namely, the efficiency score for cross-sectional estimations and Malmquist Productivity Index (MPI) for time series estimations. Panel Data techniques refer to the pooling of observations on a cross section of industries over several time periods. Panel data method is used to show the effect of IT capital on the productivity, averagely. In other words, panel data stack up the cross-section and time series data.

The results of panel data estimation indicate that the effect of physical capital is negative and the coefficient of human capital is not statistically significant. But the effect of IT capital is positive and statistically significant. The elasticity of labor productivity compared to IT capital is about 8–18 %. It has been found that IT impact on all estimation methods is stable and significant.

Table 9 Input and output 2006

DMUs	I_1 = IT	I_2 n-IT	I_3 = = HC	O = Productivity	Efficiency 2006 (I_1, I_2, I_3, O)	Efficiency 2006 (I_1, O)
1. Code 30	0.140039	35.48946	0.227	0.003544	0.1414	0.0111
2. Code 321	0.132486	364.8955	0.200	0.007818	0.1300	0.0118
3. Code 322	0.260763	24.62255	0.215	0.000916	0.2038	0.0060
4. Code 331	0.196152	32.68304	0.138	0.003901	0.1884	0.0079
5. Code 15	0.197713	40.40374	0.096	0.004629	0.2708	0.0079
6. Code 16	0.005262	27.59273	0.177	0.000097	0.2961	0.2961
7. Code 18	0.088079	15.57142	0.042	0.007515	0.6190	0.0177
8. Code 19	0.050999	78.63469	0.071	0.009282	0.3662	0.0305
9. Code 20	0.044472	15.04538	0.104	0.007035	0.3335	0.0350
10. Code 21	0.670856	30.18425	0.107	0.004764	0.2430	0.0023
11. Code 22	0.955757	24.50040	0.108	0.006947	0.2407	0.0016
12. Code 23	0.172387	169.8232	0.176	0.002262	0.1477	0.0090
13. Code 24	0.675030	104.9353	0.208	0.003304	0.1250	0.0023
14. Code 26	0.086186	37.21887	0.067	0.007234	0.3881	0.0181
15. Code 27	0.207051	89.24300	0.142	0.002042	0.1831	0.0075
16. Code 28	0.164942	13.17747	0.116	0.005303	0.3808	0.0094
17. Code 31	0.732004	164.0320	0.103	0.016306	1.0000	1.0000
18. Code 32	0.158551	45.62329	0.178	0.002246	0.1461	0.0098
19. Code 33	0.099503	23.83155	0.155	0.003986	0.2106	0.0157
20. Code 34	0.201603	42.40807	0.132	0.001717	0.1970	0.0077
21. Code 35	0.171132	21.13997	0.140	0.002099	0.2374	0.0091
22. Code 36	0.114774	18.39688	0.079	0.007411	0.3291	0.0136
23. Code 37	0.001558	5.018224	0.026	0.014486	1.0000	1.0000

IT information technologies, *n-IT* none information technologies, *HC* human capital

In this paper, It is considered that the possible impact of industries attributes and time-specified effects and new technologies rather than traditional inputs such as physical and labor inputs. The industry-specified effect captures all unobserved and time constant factors affecting the value added of industries. In application, it refers to as unobserved heterogeneity or industry heterogeneity. But time-specified effect represents unobserved factors that change over time and affects the value added in industries. There is information about industry-specified and time-specified effects. But, fortunately, these influences have been corrected by the advantages of panel data models. New technologies need high-skilled workers.

In other words, IT need fairly a long time within which the employee learn how to work and apply it in practice. So, IT capital impact could be negative in short term, when the labor does not have high skill to use IT (Badescu and Garces-Ayerbe 2009).

The first main point of this paper is that the model is consisted of industry-specified and time-specified effects. That is, the elasticity of labor productivity will be increased compared to IT capital, remarkably. It rises from 8 to 18 %. We can conclude, inherently, the characteristics of industries and the time is very important in learning and applying IT capital in production process. Econometrics results measure IT consequences, averagely.

DEA technique is able to calculate the effect of inputs (one or more) on the value added, individually. In this regard, DEA represents that few industries are efficient when using IT capital, appropriately. Most industries have a large inefficiency based on 3 inputs and 1 input (IT).

International experiences represent that IT advantages will be appeared only many years after the implementation of IT. The success of IT requires complementary factors such as reorganization of business models, high-quality management, high-level labor and economic competitive environment.

By an example, it have be shown that Malmquist Productivity Index (MPI) findings confirm the econometrics results. In other words, there is no statistical difference in productivity growth between IT-producing and IT-using industries. Also, the results, approximately state that “high IT-intensive” industries are more efficient than the others. That is, the inefficiency of these industries is less than the

Table 10 Malmquist Productivity Index based on (I_1, I_2, I_3, O)

DMUs	Malmquist 2002–2003	Malmquist 2003–2004	Malmquist 2004–2005	Malmquist 2005–2006
1. Code 30	1.20291545	1.24593890	0.88201651	0.61051573
2. Code 321	0.36682422	0.77572025	0.71396665	0.92149874
3. Code 322	1.21597294	0.75124057	0.83005839	0.93506698
4. Code 331	1.07586579	0.91254485	1.03605714	0.86486486
5. Code 15	0.93258427	0.94680851	0.96907216	0.91509434
6. Code 16	1.20634364	1.06828325	0.83617365	1.05346613
7. Code 18	0.96195868	0.94944289	0.86088563	0.96153846
8. Code 19	0.96380897	1.04563463	0.67671642	0.67195417
9. Code 20	0.65516450	0.95895373	3.97542400	0.16270543
10. Code 21	1.03909992	0.96703537	0.94072841	0.89743590
11. Code 22	0.19526807	1.12718355	1.02743305	0.94067797
12. Code 23	0.74992123	0.93190905	0.94797688	0.93010753
13. Code 24	1.19970410	0.30230902	0.97900720	0.85779817
14. Code 26	0.98044849	0.91549296	0.97260274	0.94805195
15. Code 27	0.81346459	0.87933856	1.01973982	0.88157895
16. Code 28	2.07477814	0.52727548	0.71049234	0.87662785
17. Code 31	1.71791138	0.54604980	0.64528464	0.54164657
18. Code 32	0.95890762	0.87599503	0.90765516	0.98404255
19. Code 33	1.08630547	0.91512626	0.89713125	0.85159951
20. Code 34	1.08022593	0.94631927	0.96232200	1.02816901
21. Code 35	0.58806285	0.48428178	0.87514987	0.79187646
22. Code 36	0.94995216	0.90679840	0.93798461	0.83402141
23. Code 37	0.13418112	0.14980903	0.18727288	0.17759963

Table 11 Malmquisti Productivity Index based on (I_1, O)

DMUs	Malmquist 2002–2003	Malmquist 2003–2004	Malmquist 2004–2005	Malmquist 2005–2006
1. Code 30	1.20841182	1.24593890	0.88201651	0.33911183
2. Code 321	0.29958456	0.85553011	0.90423293	0.62357705
3. Code 322	1.38847818	1.06691096	0.69448074	0.64727825
4. Code 331	1.29996650	1.21004060	0.96309334	0.94527339
5. Code 15	0.51334353	1.07592281	0.99125478	1.00247938
6. Code 16	1.22921599	1.06828325	0.83617365	1.05346613
7. Code 18	0.91808659	0.75501227	0.34068246	0.70755208
8. Code 19	0.95645131	1.04563463	0.64809091	0.34477614
9. Code 20	0.46955504	1.00119344	0.89923371	0.97505140
10. Code 21	1.10981854	1.09060137	0.97805820	0.99108328
11. Code 22	0.13551855	0.71170250	1.03750570	0.13174536
12. Code 23	0.62118162	0.81719716	0.64655400	0.82990564
13. Code 24	1.01511146	1.27929731	0.65940448	0.47559523
14. Code 26	1.02564394	0.74554699	0.90919936	0.69718046
15. Code 27	1.10788406	1.08927979	0.78884086	0.93266099
16. Code 28	0.79027611	0.82241252	0.41521356	0.87296933
17. Code 31	1.70004196	0.13331967	0.32194603	0.37981674
18. Code 32	0.89996355	1.02362140	0.61843788	0.70057727
19. Code 33	1.22971212	1.15846847	0.91412930	0.89077012
20. Code 34	1.23107849	0.57034292	0.81292185	1.01663965
21. Code 35	0.59236307	0.16617701	0.83965845	0.86833359
22. Code 36	0.96056529	0.35002189	0.80733585	0.81632391
23. Code 37	0.22071598	0.16066504	0.14256127	0.17759963

others. The scope of these results is limited to Iranian manufacturing industries and does not cover the services industries. It contains only large companies and so cannot be applied to small- and medium-sized firms, non-manufacturing industries and macroeconomic concerns.

Limitation and suggestions for future researches

The main limitation of the research is the industrials data after 2006 that is not available anymore. Statistical center of Iran is the only organization that publishes industrial data. It has not updated the data up to now. The findings of service sectors may differ from manufacturing sector. These results may vary based on sample size, period of time, industry type, industry size and complementary factors such as R ⋀ D and human capital. Productivity Paradox hypothesis can be done more robustly and quantitatively using growth accounting model or sample surveys. Many consequences and impacts of IT are unknown. Measuring the benefits of technology is a great problem. Many researchers have believed that lots of technology benefits are hidden. It may take several years to appear and measure beneficial technology. So, the researchers can perform many empirical studies about the effects of technology at firm, industry and country. These researches can resolve the doubts of managers and policy makers about the capabilities of new technologies and act as a bright light for business owners.

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