The Impact of Information Technology on Increase Labor Productivity in Small Manufacturing Firms

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Abstract

In this paper, we will study around the impact of IT 'information technology' on increase labor productivity in small manufacturing firms in Semnan province in Iran over the 2001-2007. A few models were run by using pooling data technique covering manufacturing units at two digit level of ISIC classification. In this study, first we estimate the growth rate of TFP by Solow method. The results indicated that all of the factors, the growth rate of IT-capital, Non-IT-capital, human capital, TFP, have positive and meaningful effect on the growth rate of labor productivity in small manufacturing firms in Semnan. The tow period-lagged growth rate of IT-capital has positive and meaningful, but not significant effect on the growth rate of labor productivity. Non-IT-capital effecting has more than IT-capital. The growth rate of TFP is most influential factor affecting labor productivity.

JEL classification: L86, O31, O32, Q55.
Keywords: Information technology, Labor productivity, IT-capital, Small manufacturing firms.

1. Introduction

The rapid development of IT and the expanding of its effectiveness areas in all facets of human life has created ambiguous environment for science thinkers. As IT has changed the people's operation method, organizations and governments also has changed the economic and social Affairs. In the economic aspect, the importance of rapid access to the right information is considered as a key success in the global competition arena. IT as a tool for creating value has important roles in the commercial activities (Babaloyan, 2009, p1).

Technology revolution is known with rapid improvement indicators in equipment and software quality also with great reduction of prices. (Pohjola, 2002).The maximizing profit's workshop with observing relative price through replacement of equipments, software and services reacts compared to other goods and services until with using of rapid advancement of technology could provide a field for increasing of IT Share in GDP production and capital volume despite the intense reduction in IT price and finally maximize his interests. On the other hand IT impact on labor productivity was one of the discussed topics in the economy from the 1990s to onward. Several studies have done from the theoretical and experimental aspect in different countries. Despite more studies have emphasized about the positive impact of IT on labor productivity but in some cases results were not expected and there are some doubts about the productivity puzzle (Mahmoud zadeh and Asadi, 2007, p154). In productivity literature the productivity indicators is obtained part of added value's division on a amount of certain input .So labor productivity is defined as the proportion of workforce Number's added value that this ratio is the indicate the average of created added value by each individual workforce. Also the term IT is used for some techniques description which helps us in capturing, storing, process, retrieving, transmitting and receiving the information. Although IT is a new term but in terms of conceptual has old dating back (Binaie, 2005, p18).

So according to the importance of this field the present research is studying around the IT impact on labor productivity in small manufacturing firms of Semnan province. In this regard, the researchers are seeking to answer the following assumptions: -There is a meaningful relationship between IT-capital and labour productivity in small manufacturing firms in Semnan. -Non-IT-capital effecting on labor productivity is more than IT-capital in small manufacturing firms in Semnan.

2. Literature Overview

Brynjolfsson and Hit (2000), studied about the ICT impact on TFP growth on a sample of 527 large U.S. firms in the period 1987-1994. Their findings show that the computer capital efficiency is normal in the short period- with one-year delay. In the longer period for example 5 to 7 years their efficiency will increase even up to fifth again as much. Based on their findings the interests arising from ICT could not increase only the labor productivity but also will increase the TFP growth. The ICT impact on TFP growth

will be maximize with a delay for about 4 to 7 years.

Kim (2002), has done a study about the impact of ICT on labor productivity in Korean firms in the period 1999-2000.In this research he has obtained the production elasticity of IT equal to 0.0434 and the production elasticity of non-IT is equal to 0.1057 which both are significant. In this paper, the hypothesis which stated that the effectiveness of IT investment on labor productivity is positive is confirmed. Atrostic and et al (2002), they with studying around the impact of ICT on labor productivity of 667 Danish firms in the two temporal periods 1995-1997 and 1997-1999 showed that the labor productivity of firms with having the communication network has reduced.

Hazhbarkiyani, Bagheri (2004) have investigated relationship between the ICT"Information and communication technology" with wage and labor productivity in Tehran industries. They tested the relationship between ICT and labor productivity with the helping of Cobb - Douglas production function as ordinary least squares method. They used of three substitute variables instead of ICT independent variable which include: the ratio of computer users to the total workforce or PCLR, the ratio of users of internet to the total workforce or INTLR and the ratio of manufacturing firms which are use of internet to the total manufacturing firms or INTR. PCLR and INTLR variables do not have any effect at 5% level on labor productivity but INTR has had significant relationship with labor productivity.

Kiyani (2004) examined the impact of ICT on labor productivity in the 39 big manufacturing firms in Tehran. This paper shows that the estimated coefficients despite the positive effect are not significant. With reducing the sample to 14 active industries in E-Commerce, the e-commerce positive effect on productivity was confirmed. In this research is used of internet users' percentage criterion in 39 manufacturing firms and the e-commerce effect on productivity has been confirmed, but the effect of employees ratio indicator who are users Has not been confirmed.

Jahangard Esfandyar (2005) has been studied about the effect of IT on production of factory industries. In this paper with the purpose of estimation the IT production factor elasticity has used of results of industrial manufacturing firms surveying which have more than ten employees from Statistical Center of Iran in the period 2000-2001 in the form of ISIC four-digit codes with modeling of panel data and he estimated the industry transcendental production function. The results of this study indicate that IT investment increases the production but the mode of influence is different in various industries.

Najarzadeh Reza and et al (2007), in their research examined the ICT effect on economic growth of OIC 'Organization of the Islamic Conference '. Among the 57 Islamic countries, 33 countries were selected which the statistics and variables information for the two periods 1996-2000 and 2000-2004 were reported for them as stable and coherent in the statistical sources. In order to estimate the model is used of panel data with constant effects. The results of model's estimation show that there is a strong and significant relationship between the economic growth and ICT in these countries until 2004.

Mahmoud zadeh and Asadi (2007), in their research for studying about the effects of ICT on the labor productivity growth in the Iran's economy have been used of Pujola and CoA pattern and Time series data for 1971-2003 also Ordinary least squares method. The results of their research showed that total productivity growth, ICT per capita capital growth, non-ICT per capita capital growth and human capital have positive and significant effect on labor productivity growth in Iran's economy and total productivity has the most effect on labor productivity growth in comparison with other variables.

Fueki and Kawamoto (2009) in their study examine the relationship between IT and productivity gains by employing the ''augmented'' growth accounting framework for Japanese industry-level data from 1975 through 2005. In particular, they estimate ''purified'' technology change at industry level by accounting for cyclical mismeasurement of inputs. We find that the post-2000 increase in overall TFP growth does indeed appear to arise from an increase in technological change. Furthermore, the pickup in technology growth has occurred not only in the production of IT but also in the industries that use IT intensively. Our results suggest the possibility that stories of IT as a general purpose technology (GPT) could apply to Japan as well as to the United States.

Spyros Arvanitis and Euripidis N. Loukis (2009) in their paper, they studied about the evaluation and comparison on the effects of ICT capital, human capital and organizational activities on labor productivity in the Greece and Switzerland Firms. They used of data from 2005 which has obtained from questionnaire distribution in a sample. The results of this study indicate that for both countries the physical capital, ICT, human capital and organizational oriented operations have Significant and positive relationship. The changes of oriented organizational do not have any relationship. Also the impact of Intranet is more than internet in both countries. As well obtained results indicate that the Swiss firms are more efficient in creation, application and in combination of new production factors than Greek firms.

Hans Peter Grüner (2009), he will want the answer to this question that why the Similar technologies has not increased the labor productivity with the same amount in Europe? So he has presented some reasons based on Radner developed model (1992) from hierarchical data collection. The results show that IT-induced reorganization could not help the workers or managers and could

not have any benefits for them unless there are appropriate compensatory payments. On the other hand management or labor likes the more limited regulations which could increase the reorganization value.

Rim Ben Ayed Mouelhi (2009), has used of a simple theoretical framework and panel data between 1998 and 2002 which is provided from Tanzania's National Statistics Center for studying on the effects of ICT application on the performance of manufacturing firms in Tanzania. The results suggest that in the Tanzania Firms there are significant technical inefficient. Despite a certain technology if the firms use of their resources efficiently so could increase their production about 30 percent. The ICT impact on performance is too much. The firms which are use of ICT almost intense are more efficient about 5 % than that firms which do not use of it. Evidences show that achieving to Interests arising from investment in ICT is required the supplementation investments and changing in human capital. It means that in a firm the combination usage of ICT and human capital will increase the performance more and more in comparison with a time that each of them are applied separately.

Mahmoud zadeh (2009), in another article he has been evaluated the ICT effects on total productivity with using of simple and compositional indicators of the substructure, user and overflow dimensions in 34 same countries by using of panel data method in the period 1995-2003. The results indicate that human capital, ICT capital, economic openness and savings rate have positive and significant effect on total productivity. The productivity elasticity is between 0.01 and 0.07 in proportion to productivity. The average of productivity elasticity is 0.032 in proportion to human capital. The non-ICT capital does not have any effect on productivity.

Fallahi and et al (2011), in their paper studied on the determinant factors of labor productivity in Iran's firms. Analysis is based on descriptive statistics and cross sectional regression models on a sample of 12299 Industrial firms. The results show that labor productivity has direct relationship with wages, paid constant capital to workforce, export orientation, R&D activities and the workforce training. Paul-Antoine Chevalier, Remy Lecat, Nicholas Oulton (2012), studied on the cointegration process between productivity, globalization and IT in French firms in the 1990s and 2000s with using of A Cobb-Douglas production function. In this paper productivity is as dependent variable. The cointegration speed was decreasing during the 1990s. This fact is described essentially on Technology border with increasing of productivity speed. Evidence shows that it is possible IT and Globalization have an impact on most manufacturing firms. Paul-Antoine

Chevalier, Remy Lecat, Nicholas Oulton (2012) in their article studies the firm-level productivity convergence process in the 1990s and the 2000s in France. The speed of convergence has slowed during the course of the 1990s, a fact which is explained principally by the acceleration of the productivity of firms on the technological frontier. Evidence is presented that information technology and globalization may have had a bigger impact on the most productive firms.

3. Data and productivity measurement

The investigated society in this paper is the industries of Semnan province according to two separate groups of two-digit ISIC codes. Among the 23 two-digit code which is dedicated to industrial activities, the 11 activity code will be examined. Considered units are the small industrial manufacturing firms of Semnan Province with 10 to 49 employees. The timeframe of this paper is from 2001 to 2007 and among 2336 small manufacturing firms have been studied on 1671 manufacturing firms with 35363 employees "From Statistical Yearbook of Semnan Province, years 2001 to 2007" .The related statistics on added value, investment value and the total workforce is extracted from Statistical Yearbook of Semnan Province in years 2002 to 2007 and the related statistics on IT investment and the Number of skilled labor is provided from Statistical Center of Iran "Surveys of industrial manufacturing firms". All data are divided to CPI index according to constant prices of year 2004 and their amount was calculated according to constant price. the CPI index is extracted from Central Bank of the Islamic Republic of Iran's site According to constant price of year 2004 for years 200 to 2007 also is estimated for years 2001 to 2003. Finally all data are divided to the total of workforce and growth rate of all variables was calculated. Also the total productivity growth of production factors is calculated through Solow residual method. Solow residual method is just about the weighted average difference of factors growth from production growth. As mathematical language the total productivity of production factors is defined as (Amini, 2005):

$$\Delta Ln\, A = \Delta Ln\, Y - \alpha \Delta Ln\, K - \beta \Delta Ln\, L \Delta Ln\, A = \Delta Ln\, Y - \alpha \Delta Ln\, K - \beta \Delta Ln\, L \qquad (1)$$

Where:

$\Delta Ln\, A \Delta Ln\, A$ Is the total productivity growth of productivity factors, $\Delta Ln\, Y \Delta Ln\, Y$ is the growth of real value added based on current price, KK is the growth of investment value based on current price, L the number of workforce, $\alpha\alpha$ the share of capital factor in added value, $\beta\beta$ is the share of labor factor in added value.

In the perfect competition conditions is considered to each factor about its final productivity. α α And $\beta\beta$ are indicated the production elasticity of labor and capital (Amini, 2005) .If the assumption of being same or equally with constant efficiency compared to scale be applied then we will have this relation $\beta = 1 - \alpha\beta = 1 - \alpha$ and just only need the $\alpha\alpha$ parameter estimation. For calculating the $\alpha\alpha$ the Cobb - Douglas production function is estimated as follows:

$$Ln\,Y = a + \alpha Ln\,K\; Ln\,Y = a + \alpha Ln\,K \qquad (2)$$

Where: YY represents add value and k investment value. The result of $\alpha\alpha$ estimation for industrial groups is in table 1 and the estimation result of factors' total productivity growth for example for 15 industry groups is presented in table 2.

Table 1: The amount of $\alpha\alpha$ "Production elasticity of capital" for various industrial groups

ISIC code	15	17	21	24	25	28	29	31	33	34	36
α	0.77	0.49	0.65	0.93	0.56	0.4	0.82	0.4	0.52	0.66	0.5

Table2: the total Productivity of production factors for the 15 Activity code in different years

1380	1381	1382	1383	1384	1385	1386
-	-0.55	-0.17	0.48	-0.91	0.23	0.75

4. Estimation Methodology

For investigating the effects of IT on labor productivity is used of Pujola pattern (2001-2002) and CoA (2002-2003). According to this model the production function is as follows:

$$Y = AF(K_n, K_{it}, H, L) \qquad (3)$$

Where:

Y is the added value, K_{it} K_{it}: IT capital services, K_n K_n: refers to other capital services, H: saving of human capital,LL: Labor services. The total productivity of factors is measured through A. By doing the logarithm of equation (3) and the extraction of production factors so we have:

$$lnY = lnA + v_n lnK_n + v_{it} lnK_{it} + v_h lnH + v_l lnL lnY = lnA + v_n lnK_n + v_{it} lnK_{it} + v_h lnH + v_l lnL \qquad (4)$$

With assuming of complete competition in factors and product market the total share of inputs is equal to unit.

$$v_n + v_{it} + v_h + v_l = 1\; v_n + v_{it} + v_h + v_l = 1 \qquad (5)$$

$AllAll$ v_i v_i Is expressed respectively the share of production factors. Labor productivity is defined as ratio of added value to employed labor:

$$y = \frac{Y}{L} y = \frac{Y}{L} \qquad (6)$$

By replacement of equation (6) in equation (4) and with first order differential of equation so we will have:

$$\Delta\, lny = \beta_1 \Delta\, lnk_n + \beta_2 \Delta\, lnk_{it} + \beta_3 \Delta\, lnh + \beta_4 \Delta\, lnA$$
$$\Delta\, lny = \beta_1 \Delta\, lnk_n + \beta_2 \Delta\, lnk_{it} + \beta_3 \Delta\, lnh + \beta_4 \Delta\, lnA \qquad (7)$$

In equation (7), labor productivity growth is related to the three factors: The first factor, a capital which itself is divided into two parts IT and non-IT. It is thought that with increasing of per capita capital the labor productivity increases. The second factor,

the labor quality growth is measured the effect of labor succession with higher final productivity. The third factor, total productivity growth of production factors is examined the effect of technical changes and other factors which increases the production growth. Finally the following equation is estimated for studying on the relationship between IT and labor productivity:

$$\Delta\, lny = v_n \Delta\, lnk_n + v_{it} \Delta\, lnk_{it} + v_h \Delta\, lnh + \Delta\, lnA \quad \Delta\, lny = v_n \Delta\, lnk_n + v_{it} \Delta\, lnk_{it} + v_h \Delta\, lnh + \Delta\, lnA \quad (8)$$

Where:
$y = \frac{Y}{L} y = \frac{Y}{L}$ is the ratio of added value to employment, $k_n = \frac{K}{L} k_n = \frac{K}{L}$: Non-IT capital stock variable to employment, $k_{it} = \frac{K_{it}}{L} k_{it} = \frac{K_{it}}{L}$: IT capital stock variable to employment and hh: is the human capital variable "The proportion of skilled workers 'bachelor or higher' to total employment".Being higher of this ratio express the more ability of skilled labor is for applying the new technologies which will increase the labor productivity. The $\Delta\, lnA \Delta\, lnA$ substitute variable will be of Solow residual.

5. Result

In this paper has been used of Panel data method for estimating the model and hypotheses testing. After the model's initial estimation was observed that the coefficient variable of IT investment growth is not significant. Also we achieved a well estimation by creating two lags in IT investment growth variable and re-estimating of model. According to calculated F for this pattern which Prob=0.98 and is high of 0.1 so the Null hypothesis is accepted in 99% assurance level. Consequently this assumption that expressed the being equal of ratio of origin from width is considered for various industrial groups.
According to F-test results the estimation of model is as follow:

$$\Delta\, lny = -0.04 + 0.277 \Delta\, lnk_n + 0.06 \Delta\, lnk_{it}(-2) + 0.279 \Delta\, lnh + 0.72 \Delta\, lnA$$

$$\Delta\, lny = -0.04 + 0.277 \Delta\, lnk_n + 0.06 \Delta\, lnk_{it}(-2) + 0.279 \Delta\, lnh + 0.72 \Delta\, lnA \quad (9)$$

(-2.22) (5.84) (4.08) (5.05) (10.89)

R^2=0.98 D.W=2.12 F=135.98 prob (F) =0.0000

In the estimated method the calculated T-statistics for all variables which are mentioned in parenthesis indicate that all of them were significant in 99% assurance level and are effective on labor productivity growth. Statistic F, F=135.89 and prob=0.000 show that here the total regression is significant statistically. The coefficient of model's determination is R^2=0.98 which indicate that 98% of dependent variable changes is explained by independent variables. Durbin- Watson statistic is 2.12 that this figure is close to 2 and shows that in our model there in not autocorrelation. Thus statistics indicate that the model is estimated well.
$\Delta\, lnk_n \Delta\, lnk_n$ Variable coefficients 'non-IT capital growth' , $\Delta\, lnk_{it} \Delta\, lnk_{it}$ 'IT capital growth with two lags' , $\Delta\, lnh \Delta\, lnh$ ' represents the human capital growth' , $\Delta\, lnA \Delta\, lnA$ 'Total productivity growth of production Factors' are calculated to be 0.227, 0.06, 0.279, 0.72 respectively that all are positive and are significant statistically. The total productivity growth variable of production factor is calculated to be 0.72 has the most effect on labor productivity growth also IT capital growth variable about 0.06 has the lowest effect on it. So the total productivity, non-IT capital, human capital and IT capital have the most or the lowest effect on labor productivity respectively. IT capital through capital deepening has positive role in productivity growth but its effect level is negligible compared with non-IT capital. This result is compatible with empirical evidences in many countries. According to low volume of IT capital like computer software from total capital obtained result is as expected.

As was observed t-statistics amount for IT capital growth variable with two lags is obtained about 4.08 and shows that there is a significant relationship between the IT investment growth and labor productivity growth in small manufacturing firms of Semnan province so the first hypothesis is confirmed. On the other the coefficients variables of non-IT capital and IT capital growth is obtained about 0.277 and 0.06 respectively also both of them are significant statistically then the second hypothesis based on this issue that IT investment has more effect on labor productivity compared to non-IT investment does not accepted.

6. Conclusions

The obtained coefficients for all variables were positive and are significant statistically. The coefficient variable of total productivity growth of production factors is obtained 0.72 more than other and the coefficient variable of IT capital growth is obtained 0.06 less than other. So the growth variable of total productivity has the most effect on labor productivity growth statistically also the IT capital growth variable has the lowest effect on it statistically. Then total productivity, Non-IT capital, human capital and IT capital have the most until and the lowest effect on labor productivity respectively. The results indicate that there is a significant relationship IT investment growth and labor productivity growth in small manufacturing firms of Semnan province. The coefficients variables of non-IT capital and IT capital growth is obtained respectively 0.277 and 0.06 and both of them are significant statistically. But the coefficient variable of non-IT capital is greater than the coefficient variable of IT capital growth and this shows that non-IT capital has the more effect on labor productivity compared to IT capital in small manufacturing firms of Semnan province. The obtained result in this paper is similar to that results which Spyros Arvanitis, Euripidis N. Loukis (2009) achieved to this about the Greek and Swiss firms. Also Fueki and Kawamoto (2009) achieved to this similar results is studying on the relationship between IT and productivity of Japanese industries and found that total Productivity of production factors is caused by the increasing of technological changes.
According to the findings of this paper are offered some following suggestions:

- The encouragement and supporting of investment in the IT section be performed through foreign and domestic sources until electronic contexts situation become better and achieving to a field for IT maturation usage.
- Impact of IT on productivity growth, in addition the special attention to this section requires the complementary policies such as increasing of non-IT investment and skilled workforce. Some countries that not only attention to IT production section but also has special attention to complementary factors such as correct management, appropriate policy making and regulating and so on could use of IT advantages.
- Demand for IT products is necessary for developing of this sector and the influence of IT on economic activities. To inform people, awareness, public education especially countries industrial managers will increase the demand for IT products also will create the economic positive consequences.
- Due to the positive effect of IT on labor productivity the economic user training especially in the public sector can be effective in increasing of labor and production productivity.
- Due to the obtained results in this paper the small industrial manufacturing firms can have good performance about the increasing of growth and productivity in industry and economy section so to achieve this purpose it is necessary provide some IT facilities for these manufacturing firms. Given that investment in IT does not have good or appropriate results and is obtained with time-lag, it is necessary the industry leaders and the managers of small industrial units move toward more usage of IT with patience and more tolerance.

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