

The Impact of E-Commerce on Labour Productivity in Iranian Manufacturing SMEs

Sarvenaz Hojabr Kiani, Elsadig Musa Ahmed

Chinnasamy Agamudai Nambi Malarvizhi Faculty of Business, Multimedia University, Malaysia

Abstract: This study determines the impact of E-commerce (EC) on labor productivity of Iranian manufacturing SMEs through analyzing and calculating interrelated issues. The model is based on both econometrics and growth accounting approach to fill the gaps of previous studies. On the first step, this research fulfills the gap of growth accounting by transforming the model to parametric model and providing statistical analysis. And on the second step, it closes the gap of econometric estimation of the Cobb-Douglas production function by calculating productivity indicators. This research applies Intensive growth theory to express growth in output per worker. Model has six EC measurements: number of employees using computer, number of employees using internet, using internet to gather and offer information, e-buying and e-selling and uses two years panel data. Labor productivity of the Iranian manufacturing SMEs in this study showed significant increase in the usage of some of the EC measurements where there wasn't any effect on the others. The results showed that e-selling, using internet to offer information and number of employees using internet had positive impact on labor productivity indicated by highly significant coefficients of EC. Three other measures of EC (number of employees using computer, e-buying and using internet to gather information) did not have any significant impact. This can be appointed to the quality of labor involved in these manufacturing SMEs. There are unskilled labors and family owners in these enterprises who still follow traditional methods in some of their production and other systems which can be the reason that the effect didn't show up in some cases.

Key words: E-commerce • SME • Labor Productivity • Human capital • Panel data

INTRODUCTION

Nowadays, convergence between information and businesses offers new kind of business which is called Electronic-commerce (EC). Depending on the way of usage; 1.5 billion people's life and their socio-economic standings are under influence of internet [1]. Due to the fact that the outcome of this technological progress could be higher employment, lower inflation, productivity growth and may be Gross Domestic product (GDP) growth, some experts have called such circumstances as a New Economy. New Economy describes an economy which intensely uses innovative or new technologies [2] such as EC. EC has been accepted as one of the potential measures which could improve effectiveness and efficiency of the firms operation [3]. It can be a major component in countries' performance and competitiveness which could lead to the economic growth [4].

Small and Medium Enterprises (SME) as the backbone of the private sector can have a considerable contribution to economic development of developed and developing countries. The majority of manufacturing enterprises in Iran are SMEs [5]. During 90th, some Iranian SMEs tried to have EC in their business by using online transaction and communication; or even providing diligent online services [6]. SMEs globalization through E-commerce and rapid changes in technology generates many new opportunities for businesses. This matter has, also, some risk for business environment [7].

Due to the regional strategic importance of Iran in the Middle- East, adaptation and using EC could make more benefits for Iranian SMEs and affect their productivity which is Iranian government's concerns [8]. Moreover, increasing productivity of SMEs through adoption of EC, can affect many economic factors such as production, trade, competition and employment. Therefore, most

developing countries including Iran are seeking for a road map to increase productivity and reach higher economic growth.

The importance of SMEs in Iran revealed when unexpected reduction in the oil price occurred after mid-July 2008. Iran experienced GDP growth, in spite of that its economy was based on oil resource. It is believed that the GDP growth in Iran was the result of high performance of non-oil sector. Therefore, the government decided to rely more on private investment and developing of non-oil sector. Manufacturing industry of Iran had highest average labor productivity growth (9.9 percent) compared to the other industries during 2000- 2005.

In populous Asian economies, like Iran, where they have plenty of unskilled or low skilled labor, there is a tendency to use more labor in production which is relatively cheap and has higher supply. Yet, nowadays production lines are increasingly globalized and there is no justification for low skilled labor intensive production with little capital usage. Production lines and supply chains are designed to demand more skilled labors with higher productivity.

The developed countries experience great contribution of ICT on the economic growth and some studies show the impressive impact of EC in terms of productivity growth [9, 10]. This transforming technology has not had the same result in developing countries. For example, Malaysian economy is input-driven instead of being TFP driven, according to Elsadig [11]. Therefore, it is impossible to expect the same result of ICT and EC usage in different countries. The existing literatures on developing countries are mostly about the contribution of ICT on different economic factors [11-14]. Moreover, comparing to developed countries, where there is a high level of data availability, literature on this subject in developing countries, such as Iran is restricted by lack of information and data. According to Mohamad *et al.* [15, 16], most of the studies on developing countries are based on upstream issues which are e-readiness, adoption and diffusion [17, 18 and 6], yet there are limited reported studies and research on downstream aspect of EC, namely impact. Although, some studies [19, 20] have been done based on EC, lack of concern on quantitative approaches is visible. Therefore, there is a gap between empirical and theoretical studies on downstream issues on EC in developing countries like Iran. Yet, there is no comprehensive study about the impact of EC on economic factors in these countries including Iran. This issue

reveals the importance of having individual research on each country. According to OECD [21], EC has three stages; E-readiness, E-intensity and E-impact. E-impact is what this study looking at and is the value added potentially created by EC. Statistics are needed to evaluate whether and to what extent EC makes a difference in terms of efficiency and/or the creation of new sources of wealth.

Maliranta and Rouvinen [22], Hagen and Zeed [23] and Farooqui [24], studied the impact of ICT on productivity and used capital and labor in their models in which there is no mention of human capital and material. Atrostic and Nguyen [25, 26]; Criscuolo and Waldron [27], OECD [4] expanded the model by using the material in their models but still have a gap for human capital usage. Hojabr Kiani and Bagheri [28] used the proxy of capital at the industry level to estimate the impact of ICT on labor productivity and wage in Tehran province industries in Iran. They selected their sample from three-digit ISIC codes. The short comings of the study is: (1) they only worked on Tehran provinces, (2) due to the lack of data they distributed a limit number of questionnaires (i.e. for only one province), (3) their proxy of capital stock was calculated by using depreciation rate at country level and (4) due to the lack of data then they worked with cross sectional data for the year 2002. This study has shown the impact of ICT on industry level, but doubts have been raised about microeconomic view and labor market in particular and especially on EC point of view.

In developing countries, SMEs increasingly try to use technology as an effective factor and strategy to reach international markets [29] and EC has a great potential for growth simulation, cost reduction and job creation [19,20]. SMEs have critical role in countries' economy including developing countries. SMEs are contributing in economic growth, social structure and employment; so they are becoming important in economical environment. Moving through globalization and new technologies like internet and E-commerce can create new opportunities for SMEs [30]. There are several studies nothing that E-commerce can bring about advantages such as cost reduction [31,32] or even increase competitiveness [33] and lead-time reduction [32]. Some researchers claim that E-commerce can reduce inventory overheads and supply real-time to SMEs [34].

The Industry sector in Asia has been main driver of Asian aggregate labor productivity. Iran, being a member of Asian Productivity organization (APO), has enjoyed labor productivity growth which was much higher than

employment rate [35]. The purpose of this paper is to study the impact of EC on labor productivity in Iranian SMEs. The paper organized as follows: next section gives a brief review of literature. In section 3, methodology and models are explained. In section 4, data collection and estimation procedures are described. Section 5, includes results and discussion. Finally, the last section is devoted to the conclusion of the paper.

Literature Review: Over two centuries ago, the term productivity was used by Quesnay (1766) and from that time it has been applied to various situations in different levels in relation to economic systems [36]. Productivity represents one of the most important basic variables governing economic production activities [37]. According to Quah [38] knowledge-driven new economy can effect production (supply side) and consumption (demand side). The growth accounting model assumes that investment in ICT has its impact on output through capital-deepening. This means that labors have access to communication equipment are more efficient compared to those who do not have access. In this framework ICT capital is an additional input in production function.

Nowadays, ICT and especially EC, becomes a common issue in both developed and developing countries [39]. Also, EC becomes important for enterprises in their economies and development. EC activities require more artists, designers, writers or even editors. This informatics revolution makes the possibility of outsourcing jobs which could be a good opportunity for employments and help to develop countries [20]. In fact, EC is a part of the widespread transformation process which is created by information and communication technology. EC is part of investment in ICT. Cohen and Kallirroi [40], concentrated on the basic elements of ICT, emphasized and reminded that they are also applied to EC project evaluation.

The first wave of empirical analysis on the impact of ICT or EC on productivity showed no signs of computer's impact on production increase. The growth accounting methodology has been used in many studies related to direct effect of ICT or EC on production. Growth accounting framework attempts to break down the growth in output into that stemming from changes in inputs and that from productivity. Typically the framework is based on a production function [41]. Based on this approach; the outputs can be obtained, using the services of different inputs. The cost minimizing firm will continue to use its inputs, until marginal cost of each factor equals to the

marginal product of the factor. Under the growth accounting framework, all incomes are treated as payments to production factors. Given this condition, growth rate of output equals to the average weighted growth of production factors, plus the growth which is not taken into account. The ignored growth is total factor productivity (TFP). Therefore, as is mentioned by many researchers, total productivity remains as a measure of our ignorance, i.e. part of the growth that is not explicitly taken into account by the firm's costs. This is really the portion that is called Solow's residual [42- 44]. This issue led to a well-known claim by the Nobel Prize winner Robert Solow [45], known as Productivity Paradox: "You can see computer age everywhere, but productivity".

Despite of huge investment in U.S and other countries in late 1990's, due to the productivity paradox, the productivity benefit of the investment was not significant [46]. For this phenomenon, economists and IT researchers have different claims and reasons. According to David [47], existing considerable time lags between investment and its return is the main reason for the productivity Paradox due to the structural changes in firm or industry, while Griliches [48] points to measurement problem (especially in services sector). Oliner and Sichel [49, 50] believe that investment in IT Compared to total investment has been insignificant, despite of increase in IT investment. Brynjolfsson and Hitt [51] blame the smallness of the sample size due to the shortage of information.

Recently some analysts claim that in growth accounting models, computed coefficients of the costs (income) share, are smaller than their corresponding coefficients, estimated econometrically. In other words, if the coefficients are estimated (econometrics) instead of computed (growth accounting), ICT capital deepening (more capital per labor) is an important factor for the growth of labor productivity in econometric models. This different result may be related to the ICT spillover effect which is hidden in growth accounting approach, while in econometric models appears in estimated elasticizes. Since, ICT goods and services are both the ICT industries' output and inputs [52], production and using the ICT, increases the productivity in the sectors that do not produce ICT and hence increase total productivity (spillover effects). The methodologies for measuring ICT share in productivity growth are mainly based on the initial work of Solow [45], Jorgenson and Griliches [53] which accordingly have been expanded by Oliner, Sichel [50] and Jorgenson and Stiroh [54]. One of

these methodologies is Inclusion of e-commerce measures, such as, sale, purchase and sale and purchase over computer mediated networks in economic models [27,55,25, 26,22,56,23 and 24].

There are four sources of labor productivity growth. The first one is ICT capital deepening, i.e. the share weighted increase of ICT capital services per hour worked. The second source is the share weighted deepening of other capital. The third component is the improvement in labor quality which is defined as the difference between the growth rates of labor services and hours worked multiplied by labor's income share. The fourth source is a general advance in multi-factor productivity which increases labor productivity point for point [57]. Van Leeuwen and Wiel [43] tried to justify the difference between results based on the growth accounting and econometrical model, by defining and adding the ICT spillover variable as a separate independent variable. According to the researchers, ICT can increase productivity through three well-known mechanisms: First, rapid increase in technical improvement in ICT related industry can have considerable share in growth, providing that ICT related industries expand more rapidly than other sectors. Second, ICT can be a stimulant for labor force in production process. Low prices of ICT related goods and services, can encourage its use and this cause capital deepening and increases labor productivity. Third, by spillover effect of technology, ICT can increase productivity. Spillover effect emerges when social return of investment is greater than private return, the case which is suitable for investment in information technology. The researchers then refer to the two empirical growth accounting approaches at industry or macro-level and micro-level studies, mostly using firm level data, which both are based on production function. However, empirical evidence on the ICT s' share in productivity are different in the two approaches.

The evidence based on firm's data magnifies the importance of the capital deepening, as it is confirmed in the studies by Brynjolfsson and Hitt [58]; Van Leeuwen and Wiel [43]. Then, a question may arise as; which part of the productivity is channelized through TFP (indirect) and which part is related to capital deepening (Direct)? In reply to the above mentioned question (which is a controversial issue among analysts), Van Leeuwen and Niel [53] applied econometric technique at firm-level data of Netherlands services' market and analyzed the extent to which omitting the ICT spillover indicator had been

effective in obtaining the contradictory results from the industry and firm-level studies. They estimated a generalized model by using panel data at firm-level and showed that spillover effect is significant factor. Some studies show that EC had an impressive performance particularly in terms of productivity growth [10]. Bresnahan *et al.* [59] found that hardware capital had significantly positive effect on productivity, using 331 firm's panel data in U.S. they report the positive effects of the ICT capital and skill on value added.

Waldron and Criscuolo [27] studied the impact of various measures of e-commerce on productivity in a research titled e-commerce and productivity. This research is very similar to the work done by Clayton *et al.* [55] at firm-level in England. It covers only the manufacturing sector due to the lack of information on the capital stock in services sector. They found a positive effect on firm productivity associated with use of computer networks for trading. However, there is an important difference between e-buying and e-selling in their study. E-buying has positive impact on output growth while e-selling typically has negative impact. They claim that this is likely due to pricing effects, since at least part of the gain from investment in electronic procurement by firms comes from the ability to use the price transparency which is offered by e-procurement to secure more competitive deals.

Most of the researches in developing countries are about e-readiness and adoption and there is a lack of study on impact issue [15, 16]. According to the literature there is still a gap in studies and researches on the impact of EC in developing countries [19, 20 and 4] including Iran.

The results of the growth model estimations with ICT investments as an explanatory variable using Panel Data method in the context of the OPEC member countries by Hosseini Nasab [60] show that ICT has significant effect on the economic growth of these countries. The coefficient measuring the effect of the ICT investment on economic growth was positive, indicating that ICT investments had a positive impact on the economic growth of the OPEC member countries. Brynjolfsson and Hitt [58] had research on ICT investment and they found that this investment has direct effect on labor's productivity but had an important influence on Total Factor Productivity (TFP) which will be on its climax after a time period of 4-7 years. According to Hoq *et al.* [61] e-commerce has a significant impact on business productivity. Due to its simple applications, EC has a large

economic impact and it gives the opportunity for changes in technology. This increases competition and innovation, which are likely to boost overall economic efficiency. Criscuolo and Waldron [27] use both value-added per employee and sale per employee as dependent variable to study the impact of e-commerce.

Growth accounting is an approach used to explore the sources of economic growth. Applying this approach decomposes output growth into growth coming from separate components of the production function; it reveals that some of the growth may be driven by the growth of total factor productivity. In this article, Cobb-Douglas production function using panel-data approach for multiple regressions will be utilized to have more accurate results, compared to other studies in the literature at firm level, which usually employ cross-sectional data.

MATERIALS AND METHODS

As stated in the literature, one way to study the impact of EC or ICT on output or its growth is to introduce an appropriate measure of EC or ICT as an additional explanatory variable to a multiple regression equation of output. Therefore, the growth accounting framework developed by Solow [62,45], which were finally brought to fruition by Kendrick [63] and further advanced by Denison [64], Griliches and Jorgenson [65] Denison and Edward [66], Jorgenson *et al.* [67], Dollar and Sokoloff [68] and Elsadig [11,12,69,70,71,72] is applied in this research. The model in spirit is similar to those are used by Criscuolo and Waldron [27], Clayton *et al.* [55] and Erken *et al.* [73], Elsadig [11, 12, 69, 70, 71, 72].

From the past studies it has been found that there is a gap between empirical and theoretical studies on downstream issues and lack of quantitative and comprehensive analysis of the impact of EC on SMEs contribution to Iranian productivity and employment. In this regard, the main problem believed to be facing the SMEs contribution to Iranian productivity and employment is a low level of productivity and employment. Therefore, to overcome the problem this study focused on downstream issue, namely, impact and contributes to the available literature by examining the applications of EC of Iranian manufacturing SMEs through both extensive and intensive growth theories.

This research applies intensive growth theory to express growth in output per worker as a function of related variables.

In this study, the number of employees using internet, number of employees using computer, using internet to gather information, using internet to offer information, e-buying and e-selling activities in industrial sector of Iranian SMEs will be our EC measurements and capital-labor ratio (i.e. per capital or capital deepening), per capita materials and per capita human capital are independent variables (IV) and the targeted variable labor productivity is dependent variable (DV). The considered productivity model is based on both econometrics and growth accounting approaches to fill these approaches gaps. On the first step, this research fulfills the gaps of growth accounting by transferring the model to parametric and providing statistical analysis. And on the second step, it closes the gap of econometric estimation of the Cobb-Dauglas production function by calculating productivity indicators which is just mentioned in the studies of Elsadig [11, 12, 69, 70, 71 and 72].

Estimation of Capital Stock for Iranian Manufacturing SMEs One of the novelties of this study is to fill the gap of missing data for capital stock in Iranian data offering organizations like Central Bank of Iran (CBI) or Statistical Center of Iran (SCI). Data for stock of capital at firm level is not available for Iran as well as many developing countries. Based on acceleration theory of investment, the following approach for rough estimation of 378 selected sample of Iranian manufacturing SMEs is used¹. The approach could be used for any extended sample or population of Iranian SMEs, as well as other developing countries capital stock estimation at firm level or any aggregation level such as industry, sector.....

Consider the following relation between gross investment and capital stock:

$$I^G = \Delta k_t + \lambda K_{t-1} \quad (1)$$

Where, I^G is gross investment, Δk_t is growth of capital stock (i.e. $K_t - K_{t-1}$) which is equal to net investment, I^N and λ is the rate of depreciation.

If for a period of time gross investment, I^G , does not fluctuate much(i.e. the condition of relatively stable period), one can assume that the capital output ratio is

¹ As will become clear in next section, sampling for this research is stratified random sampling optimized by Neiman assignment approach.

fixed. This assumption is one of the basic assumptions in economic growth theories, which seems to be fairly reasonable in this study, because at least for short period in the past the trend of gross investment in Iranian SMEs has been relatively stable. Therefore, this study assumes the capital-output ratio, $\frac{K}{Q}$, is constant α . Given this assumption and substituting K in equation (1) we have:

$$I_t^G = \alpha \Delta Q_t + \lambda \alpha Q_{t-1}$$

$$I_t^G = \alpha Q_t - \alpha Q_{t-1} + \lambda \alpha Q_{t-1}$$

Or:

$$I_t^G = \alpha Q_t + (\lambda - 1) \alpha Q_{t-1} \quad (2)$$

If equation (2) is estimated as a multiple regression equation without an intercept, the estimated value of α can be used to calculate series of K_t , the capital stock of Iranian SMEs using $K_t = \alpha Q_t$.

To estimate capital stock for our sample of 378 SMEs (i.e. 756 observation for our two years panel) using equation 2, running at least 378 regressions is necessary. In order to save time and space, this study used data for 150 groups of 4 digit ISIC codes of our sample covering time series of gross investment and output for 12 years (i.e. years that trend of investment was stable) and estimated α coefficients running 150 regression. Assuming that capital-output ratios, α , are the same for members of each groups of 150 codes, capital stocks were estimated for 756 observations using relation $K_t = \alpha Q_t$ ($t = 1, 2, \dots, 756$).

Since the labor productivity is defined as $(\frac{Q}{L})$, both sides of Cobb-Douglas production function, after including human capital to endogenize, is divided by L. The logarithmic form of the resulting equation becomes:

$$\ln \left(\frac{Q}{L} \right) = \alpha_0 + \alpha_1 \ln \left(\frac{K}{L} \right) + \alpha_3 \ln \left(\frac{M}{L} \right) + \alpha_4 \ln \left(\frac{H}{L} \right) + (\alpha_1 + \alpha_2 + \alpha_3 + \alpha_4 - 1) \ln L + U$$

(3)

$i = 1, 2, \dots, 378$
 $t = 1, 2$

Where:

Q/L is labor productivity measured as Gross Value of Output (GVO) per labor, α_0 is α constant, K/L is capital per labor (i.e. capital deepening), M/L is material per labor, H/L is human capital per labor, \ln is natural logarithm, U

is error term (i.e. disturbance), M/L are elasticities². In this study I number of SMEs is 378 and t is year 2006 and 2007.

Although one can check for the property of constant returns to scale³, by testing the significance of the estimate of term $(\alpha_1 + \alpha_2 + \alpha_3 + \alpha_4 - 1)$, the common practice in the literature is to assume that the Cobb-Douglas production exhibits constant returns to scales at least in most of the studies of the impact of EC or ICT on productivity.

Since estimated coefficient of \ln in equation (3) in this study turned out to be insignificant, constant returns to scale is accepted⁴. Therefore, equation (3) could be written as:

$$\ln \left(\frac{GVO}{L} \right) = \alpha_0 + \alpha_1 \ln \left(\frac{K}{L} \right) + \alpha_3 \ln \left(\frac{M}{L} \right) + \alpha_4 \ln \left(\frac{H}{L} \right) + U$$

(4)

Adding some measure of EC (numerical or dummy), the equations will be estimated.

Model for Estimation with Numerical Variable Measures of EC: Adding some numerical measure of EC which appears as $\left(\frac{EC}{L} \right)$ in equation (4), the panel-data regression equation:

$$\ln \left(\frac{GVO}{L} \right)_{it} = \alpha_0 + \alpha_1 \ln \left(\frac{K}{L} \right)_{it} + \alpha_3 \ln \left(\frac{M}{L} \right)_{it} + \alpha_4 \ln \left(\frac{H}{L} \right)_{it} + \alpha_5 \ln \left(\frac{EC}{L} \right)_{it} + U_{it}$$

(5)

$i = 1, 2, \dots, 378$
 $t = 1, 2$

Where: GVO/L is labor productivity, is α_0 a constant, K/L is capital per labor (i.e. capital deepening), M/L is material per labor, H/L is human capital per labor, EC/L is numerical measure of EC per labor (number of employee using internet divided by total number of employee, number of employee using computer divided by total number of employee), \ln is natural logarithm, U is error term (i.e. disturbance) and $\alpha_1, \alpha_3, \alpha_4, \alpha_5$, are elasticities.

Equation (5) indicates that labor productivity is function of per-capita capital $\left(\frac{K}{L} \right)$ or capital-deepening, per capita materials (i.e. materials input per labor), per capita human capital (i.e. human capital per labor) and per capita EC (i.e. EC per labor) measure.

² Note: α_1 is coefficient of labor in C-D production function before dividing by L.

³ Production function is linearly homogeneous i.e. exhibits constant returns to scale (in other words is homogenous of degree one), if when inputs increase by a constant $(\alpha_1 + \alpha_2 + \alpha_3 + \alpha_4 - 1)$, output also increase by λ . In (3) this will be true if equals zero.

⁴ After estimating equation (3) coefficient $(\alpha_1 + \alpha_2 + \alpha_3 + \alpha_4 - 1)$, came out to be insignificant.

As mentioned earlier, this study follows the research done by Elsadig [70,71] and fills the gap in the literature. The first step provides statistical analysis of the estimation to attain the coefficients of the explanatory variables used by an econometric approach. The second step plugs the parameters of the variables into the model to compute productivity indicator, TFP intensity, by calculating residual of the model. After estimating elasticities from model (5), natural logarithm of TFP/L can be calculated as:

$$\ln\left(\frac{TFP}{L}\right)_{it} = \ln\left(\frac{GVO}{L}\right)_{it} - (\alpha_1 \ln\left(\frac{K}{L}\right)_{it} + \alpha_3 \ln\left(\frac{M}{L}\right)_{it} + \alpha_4 \ln\left(\frac{H}{L}\right)_{it} + \alpha_5 \ln\left(\frac{EC}{L}\right)_{it}) \quad (6)$$

$i=1, 2 \dots 378$

$t=1, 2$

Model for Estimation with Dummy Variable Measures of EC: In this case, since EC measure is dummy variable and takes values either 1 or 0, using ln for linear transformation of Cobb-Douglas production function is impossible, therefore we have:

$$\ln\left(\frac{GVO}{L}\right)_{it} = \alpha_0 + \alpha_1 \ln\left(\frac{K}{L}\right)_{it} + \alpha_3 \ln\left(\frac{M}{L}\right)_{it} + \alpha_4 \ln\left(\frac{H}{L}\right)_{it} + \alpha_5 EC_{it} + U_{it} \quad (7)$$

$I=1, 2 \dots 378$

$t=1, 2$

Where: all of the variables are defined as before, except for EC. Now EC is a dummy variable which takes value 1 for the firms using internet to gather information (and otherwise 0), using internet to offer information (and otherwise 0), having e-buying (and otherwise 0) and having e-selling (and otherwise 0). Ln is natural logarithm; u is error term, $\alpha_1, \alpha_3, \alpha_4$, are elasticities and α_5 is coefficient of dummy variable.

After estimating elasticities and α_5 from equation (7), natural logarithm of TFP/L can be calculated as:

$$\ln\left(\frac{TFP}{L}\right)_{it} = \ln\left(\frac{GVO}{L}\right)_{it} - (\alpha_1 \ln\left(\frac{K}{L}\right)_{it} + \alpha_3 \ln\left(\frac{M}{L}\right)_{it} + \alpha_4 \ln\left(\frac{H}{L}\right)_{it} + \alpha_5 EC_{it}) \quad (8)$$

$i=1, 2 \dots 378$

$t=1, 2$

Data Collection and Estimation Procedure: The data used in this study are secondary data developed by Statistical Center of Iran (SCI) based on a survey conducted by this department for the period of 2006 and 2007⁵. In this study, the population is Iranian Small and Medium Enterprises (SMEs) among manufacturing industry firms. Following

the definition of Statistical Center of Iran (SCI), firms among 10 - 100 employees are the target SMEs of this research. Since the questionnaires among approximately 12,000 firms have been distributed by statistical center of Iran and the raw data is available for two years to select the sample, this study will use appropriate sampling method. This data consist of Gross Value of Output, total number of employed persons as well as the number of skilled and unskilled labor which is considered to be a good measure of human capital since most of the workers are family owners who do not perceived regular salaries. This data also includes total number of SMEs, EC facilities, wages and salaries.

Although a panel of two years is a short panel, the following studies could justify the usage of such a short panel; Atrostic and Nguyen [25,26] (2 years panel), Maliranta and Rouvinen [22] (3 years panel), Maliranta and Rouvinen [56] (2 years panel), Criscuolo and Waldron [27] (2 years panel), Farooqui [24] (4 years panel), Gujarati and Porter [74] (2 years panel), Wooldridge [75,76] (2 years panel).

This study uses the probability type sampling method, namely, Stratified Sampling. In a stratified random sample, first the population is divided into subpopulations called strata. Then, one sample is selected from each of these strata. The collection of all samples from all the strata gives the stratified random sample [77].

One type of panel model has constant coefficients, referring to both intercepts and slopes. If, in this research, there are neither significant SME effects nor time effects, all the data can be pooled and then an Ordinary Least Squares (OLS) regression model could be run. This model is called pooled regression or common effect model.

Another type of panel model would have constant slopes but intercepts that differ according to the cross-sectional (group) unit- for example, the SMEs. While the intercept in cross-section (group) is specific, for example, it differs here from SME to SME in it may or may not change over time. These models are called Fixed Effects Models (FEM), due to fixed and not random differences. Still there exists another type of fixed effect model which could have constant slopes, but the intercepts vary over time. In this case, the model would have no significant SME differences, but might have different time effects. There is another fixed effect panel model where the slope coefficients are constant, but the intercept varies over SME as well as time. Another type of fixed effect model has differential intercepts and slopes. This kind of model has intercepts and slopes that both

⁵ Note that only this two year data for EC measures is available from SCI.

vary according to the SME. There is also fixed effects panel model in which both intercepts and slopes might vary according to SME and time.

All of the fixed effects models can be formulated using dummy variables. So, they are called Least Squares Dummy Variable (LSDV) model. To avoid falling into the dummy-variable trap the number of dummy variables should be one less than the number of cross-sectional units, i.e. $n-1$ [74].

The first step in estimating panel data models is to choose between pooled and fixed effects models. To do so, restricted F (i.e. Leamer F statistics) test is used [74, 78-80].

$$F = \frac{RRSS - URSS}{URSS/NT - N - K} \quad (9)$$

“This is a simple Chow test with the restricted residual sum of squares (RRSS) being that of OLS on the pooled model and the unrestricted residual sum of squares (URSS) being that of the LSDV regression” [78, p. 13]. In (9), N is the number of cross-sectional units, T is number of times and K is number of independent variables.

One problem with LSDV approach arises when there are too many cross-sectional units, which here it is due to the large number of SMEs. In this case, the model has too many dummy variables which produce multicollinearity and also the degree of freedom of model is reduced significantly. To overcome this problem, one can eliminate dummy variables by differencing sample observations around their sample means. This approach produces what is called within group estimators [74, 79, 78 and 81]. Another approach is to use the first difference of variables in both sides of regression equation. This is called first difference method. Since here there is a short panel with only two time periods, it is very important to state the following:

“It may be pointed out that the first difference and fixed effects estimators are the same when we have only two time periods, but if there are more than two periods, these estimators differ” [74, p.602]. To support the above statement, Gujarati and Porter [74] claim that “the reasons for this are rather involved” and refer to Wooldridge [75]. There is another model called random effect model (REM). Here, the difference in intercepts (or slopes), is random rather than being fixed.

As mentioned before, the first step in panel data regression analysis is to choose between pooled regression model and FEM using Leamer F statistic. Now if one chooses FEM, the second step is to select between FEM and REM. Hausman test, which is very popular and is explained in detail in many econometrics text books including Greene [79], Davidson and Mackinnon [82], Baltagi [78,81], could be used to choose between FEM and REM. To use a time series for prediction, assumption of stationary for variables is required. A variable is stationary if its mean, variance and covariance do not change over time, i.e. the main characteristics are stable. If variables of time series model are non-stationary i.e. they have unit-root, then the usual t , F and R^2 are not valid. In this case, probability of having spurious (non-sense) regression is high i.e. we may conclude there is a relation between unrelated variables. But there are some cases where there are valid regression results among non-stationary variables. In this case it is said that the variables are cointegrated [74, 83].

Although, unit-Root and Cointegration test have become very popular but tests for them are for time-series but not for Cross-sectional series. For a short panel like this research with only two time dimension Unit-Root and Cointegration tests is not required [78, p.237 and 247]. Moreover, for large N and very small T (i.e. large cross-section and very small time, like the case of this study), usual panel procedure ignoring unit-root and cointegration is recommended [74, 83].

RESULTS AND DISCUSSION

Following the explained procedure, using first measure of EC equation 5 was estimated.

According to the results of EC measure defined as the number of employees using internet, Leamer F statistic is 5.473 with prob (p-value) 0.00 which indicates rejection of the common effects model in favor of Fixed Effects Model (FEM). Hausman chi-squared test has value 70.141 with prob 0.00 which indicates rejection of the Random Effects Model (REM) in favor of the FEM. But, based on model selection criterion, REM is selected, which produces more reliable results [78, 84].

Finally, White test indicates that estimated equation faces heteroskedasticity problem. Therefore, Generalized Least Square (GLS) is used to remove

⁶ In panel data regression analysis, assuming different intercepts is much more popular than assuming different slopes. Concerning this research due to the lack of data there are a limited number of studies in the literature who have used panel data approaches (i.e. FEM or REM). However all of these models are constructed to have different intercepts.

Table 1: Calculated TFP intensity and its rates of growth due to usage of EC

EC measure	TFP intensity per labor		Rate of growth Percent
	ln(TFP/L)	TFP/L	
Number of employees using internet	7.393	1624.56	9.08
Number of employees using computer e-selling e-buying	8.315	4083.60	18.20
Using internet to offer information Using internet to gather information	6.958	1051.56	-0.28

Source: research findings. Note that, the missing values in table belong to the cases of EC measures with no impact on labor productivity.

heteroskedasticity. The final results using Estimated Generalized Least square (EGLS) method is reported in Table 1 appendix.

Taking a close look at the results, one can see that all of the coefficients are significant at 5 percent or less (i.e. with confidence 95 percent or over) except for the coefficient of human capital which is significant at 10 percent (i.e. 90 percent confidence). These results show that EC (number of employees using internet) has positive impact and capital stock per labor, materials per labor and human capital per labor all have positive impacts on labor productivity of Iranian manufacturing SMEs. These results are perfectly consistent with related theories.

The results can be interpreted as follows: one percent increase of the capital per labor would increase labor productivity by 0.51 percent. One percent increase of materials per labor would increase labor productivity by 0.152 percent. One percent increase of human capital per labor would increase labor productivity by 0.061 percent.

The most important and promising results is the highly significant coefficient of EC measure, which indicates that, one percent increase in one of the EC measures (i.e. the number employees using internet) would increase labor productivity of Iranian manufacturing SMEs by 0.014 percent. In other words, increase in number of employees using internet would increase labor productivity. This result is consistent with the result of positive impact of EC on labor productivity confirmed by many studies in the literature.

Following the procedure used in previous section, equation 5 estimated using another EC measure (i.e. number of employees using computer) and the final results reported in Table 2 appendix.

According to the results of this EC measure, Leamer F statistic is 5.539 with prob (p-value) 0.00 which indicates rejection of the common effects model in favor of Fixed Effects Model (FEM). Hausman chi-squared test value is 67.805 with p-value 0.00 indicating rejection of the Random Effects Model (REM) in favor of FEM. But, like previous section, in terms of model selection criterions, REM which is more reliable model is selected.

White test indicates that estimated equation faces heteroskedasticity. Therefore, model estimated using Generalized Least Square (EGLS) method. The coefficients of capital per labor and materials per labor are highly significant with p-value 0.000. The coefficient of human capital per labor is significant at 10 percent level (i.e. confidence 90 percent). But the coefficient of EC measure is not significant meaning that the usage of computer does not have any impact on labor productivity of Iranian manufacturing SMEs.

Interpretation of the results of Table (2) is as follows: one percent increase of capital per labor would increase labor productivity by 0.510 percent. One percent increase of materials per labor would increase labor productivity by 0.156 percent. One percent increase of human capital per labor would increase labor productivity by 0.062 percent. Finally, EC measured by number of employees using computer does not have any impact on labor productivity of Iranian manufacturing SMEs.

Following the procedure used in previous sections, equation (7) estimated with probably most accurate and reliable EC measure (i.e. e-selling) and the final results reported in Table 3 appendix.

The reported results show that, Leamer F statistic is 5.560 with prob (p-value) 0.00 which indicates rejection of the common effects model in favor of Fixed effects Model (FEM). Hausman chi-squared test has value 65.663 with prob 0.00 which indicates rejection of Random Effects Model (REM) in favor of FEM. Model selection criterions also like Hausman test selected FEM.

White test indicates that estimated equation faces heteroskedasticity. Therefore, Estimated Generalized Least Squares (EGLS) method is used. Looking at the results, it can be seen that all of the coefficients are highly significant (with prob 0.000). These results indicate that EC (e-selling) capital per labor, materials per labor and human capital per labor all have positive impacts on labor productivity of Iranian manufacturing SMEs. These results are perfectly consistent with both related theories and empirical findings.

The results can be interpreted as follows: one percent increase in the capital per labor would increase labor productivity by 0.368 percent. One percent increase in the materials per labor would increase labor productivity by 0.215 percent. One percent increase in the human capital per labor would increase labor productivity by 0.09 percent.

As mentioned earlier, perhaps e-selling could be considered as one of the best, accurate and reliable measures of e-commerce. The coefficient of EC variable is positive; indicating that manufacturing SMEs using internet for electric sale have higher labor productivity in average. The coefficient of EC when is a dummy variable, can be used to calculate the growth rate of dependent variable in level (which would be the rate of growth of labor productivity here) and calculate the impact of EC on labor productivity. To do so we have:

$$\text{Rate of labor productivity growth due to e-selling} = e^{0.395} - 1 = 0.484 - 1 = 0.484$$

Therefore, SMEs having e-selling could raise their labor productivity by 0.484. This result is consistent with the results of positive impact of EC on labor productivity confirmed by most of the studies in the literature. According to the results of another measure of EC (i.e. e-buying), which is reported in table 4 appendix, Leamer F statistic is 5.560 with prob(p-value) 0.00 which indicates rejection of the common effects model in favor of the Fixed Effects Model (FEM). Hausman chi-squared test has value 68.039 with prob 0.00 which indicates rejection of the Random Effects Model (REM) in favor of FEM. But, based on the model selection criterion, Random Effects Model (REM) is selected.

Finally, White test indicates that estimated equation faces heteroskedasticity problem. According to econometrics knowledge, if there is heteroskedasticity or autocorrelation (also called spherical errors) in panel data models, one should use Generalized Least Square (GLS). It can be seen that all of the coefficients are significant at 6 percent or less (i.e. with confidence 94 percent or more), except for the coefficient of EC measure which is not significant. These results show that EC (e-buying) does not have any impact on labor productivity of manufacturing SMEs in Iran. On the other hand, capital per labor, materials per labor and human capital per labor all have positive impacts on labor productivity of Iranian manufacturing SMEs.

The results can be interpreted as follows: one percent increase in the capital per labor would increase labor productivity by 0.510 percent. One percent increase in materials per labor would increase labor productivity by 0.164 percent. One percent increase in human capital per labor would increase labor productivity by 0.070

percent. EC measured by e-buying does not have any significant impact on labor productivity of Iranian manufacturing SMEs.

Following the same procedure, equation (7) is estimated with another measure of EC, using internet to offer information and the final results are reported in table 5 appendix.

The reported results show that, Leamer F statistic is 5.468 with prob (p-value) 0.00 which indicates rejection of the common effects model in favor of Fixed Effects Model (FEM). Hausman chi-square test has value 67.154 with prob 0.00 which indicates rejection of Random Effects Model (REM) in favor of FEM. Model selection criterions also like Hausman test selected FEM.

White test indicates that estimated equation faces heteroskedasticity. Therefore, Estimated Generalized Least Squares (EGLS) method is used. It can be seen that all of the coefficients are highly significant (with prob 0.000). These results indicate that, EC (using internet to offer information, capital per labor, materials per labor and human capital per labor all have positive impacts on labor productivity of Iranian manufacturing SMEs. These results are perfectly consistent with both related theories and empirical findings.

The results can be interpreted as follows: one percent increase in the capital per labor would increase labor productivity by 0.384 percent. One percent increase in materials per labor would increase labor productivity by 0.204 percent. One percent increase in human capital per labor would increase labor productivity by 0.092 percent.

Using internet to offer information like e-selling can be considered as one of the best, accurate and reliable measures of e-commerce. The coefficient of EC variable is positive; which indicates that manufacturing SMEs using internet to offer information have higher labor productivity in average. The coefficient of EC when is dummy variable can be used to calculate the rate of growth of dependent variable in level (which is rate of growth of labor productivity here) and calculate the impact of EC on labor productivity. To do so we have:

$$\text{Rate of labor productivity growth due to using internet to offer information} = e^{0.164} - 1 = 1.178 - 1 = 0.178$$

Therefore, SMEs using internet to offer information could raise their labor productivity by 0.178. This result is consistent with the results of positive impact of EC on labor productivity confirmed by most of the studies in the literature.

According to the results of the last measure of EC (i.e. using internet to gather information), Leamer F statistic is 5.501 with prob(p-value) 0.00 which indicates rejection of the common effects model in favor of the

Fixed Effects Model (FEM). Hausman chi-squared test has value 71.409 with prob 0.00 which indicates rejection of the Random Effects Model (REM) in favor of FEM. But, based on the model selection criterion, Random Effects Model (REM) is selected.

Finally, White test indicates that estimated equation faces heteroskedasticity problem, therefore, Generalized Least Square (GLS) is used. It can be seen that all of the coefficients are significant at 8 or less percent (i.e. with confidence 92 or more percent) except for the coefficient of EC measure which is not significant. These results are sign of invalidity of the hypothesis that EC (using internet to gather information) has positive impact on labor productivity of manufacturing SMEs in Iran. On the other hand, capital per labor, materials per labor and human capital per labor all have positive impacts on labor productivity of Iranian manufacturing SMEs.

The results can be interpreted as follows: one percent increase in the capital per labor would increase labor productivity by 0.510 percent. One percent increase in the materials per labor would increase labor productivity by 0.153 percent. One percent increase in the human capital per labor would increase labor productivity by 0.063. EC measured by using internet to gather information does not have any significant impact on labor productivity of Iranian manufacturing SMEs. Equation (6) and (8) are used to calculate TFP intensities based on estimated coefficients. The results of calculations are summarized in following table.

Calculations show that the highest growths of TFP belong to e-selling, using internet to offer information and number of employees using internet, respectively. This order of impacts on TFP intensity is exactly same as the results of EC measures impacts on labor productivity; therefore, the reliability of models is confirmed.

CONCLUSION

As developing countries like Iran mostly used capital and labor without proper adaptation of new technology over the past years, so that limited skilled labor might be source of restriction on the utilization of capital. There is a need for skilled labor to carry out the new technologies (such as EC) with the intention that available capital stock can be used efficiently. Labor productivity of the Iranian manufacturing SMEs in this study showed significant increase in the usage of some of the EC measurements where there wasn't any effect on the others. This can be appointed to the quality of labor involved in these manufacturing SMEs. There are unskilled labors and family owners in these enterprises who still follow

traditional methods in some of their production and other systems which can be the reason that the effect didn't show up in some cases.

Labor productivity may depend on physical capital or new technology which can be the skill of workers or even on human capital and the quantity and quality of workers co-operation. In the environment where most of the labors are unskilled controlling this situation is difficult. This condition may cause some situation to be observed of no effect.

Contribution of the capital stock per labor, material per labor and human capital per labor in all of the six EC measurements is positive. Contribution of the capital deepening to the labor productivity of Iranian manufacturing SMEs was positive and highest among the others. The material per unit of labor performed lower compared with the capital per unit of labor. This is because the manufacturing sector highly relies on imported materials. As the largest cost of the manufacturing SMEs are the raw materials, so the problem of material input besides the problem of labor and capital can be issued as the main problems. This can make the productivity slow in some parts in general and also for other productivity indicators such as labor productivity, capital deepening, material per labor and TFP in particular.

According to the results of the study, among the measures of EC two best, most accurate and reliable measures, namely, e-selling and using internet to offer information have positive impact on labor productivity indicated by highly significant coefficients of EC. The coefficient of EC (measured by e-selling) is positive, which indicates that Iranian manufacturing SMEs using internet for selling electronically have higher labor productivity in average. The rate of growth of labor productivity due to e-selling is equal to 0.484 percent. Therefore, Iranian SMEs having e-selling could raise their labor productivity 0.484 percent.

The coefficient of EC (measured as using internet to offer information) is positive, which indicates that Iranian manufacturing SMEs using internet to offer information have higher labor productivity in average. The rate of labor productivity growth due to using internet to offer information is equal to 0.178 percent. Therefore, Iranian manufacturing SMEs using internet to offer information could raise their labor productivity by 0.178 percent. Notice that the impact of e-selling is much higher than using internet to offer information. This finding seems reasonable because, offering information may not lead to higher selling, (while e-selling can rise selling directly) which could directly raise labor productivity.

The coefficient of EC/L (measured by number of employees using internet per total labor) is highly significant (i.e. significant at 5 percent level). This is an indication of EC impact as, one percent increase of number of employees using internet (per total labor) increase labor productivity by 0.014 percent.

The above results are very important and promising. These findings, which are proof of positive impact of EC on labor productivity of Iranian manufacturing SMEs. But, on the other hand, three other measures of EC, namely, e-buying, using internet to gather information and number of employees using computer did not have any significant impacts on labor productivity according to the results of estimations. The results that these three measures of EC did not show any significant impact on labor productivity may be justified by following reasoning.

First, improper usage of computer in Iranian manufacturing SMEs. Second, well known claim by Nobel Prize winner Robert Solow [45], known as productivity paradox: "you can see computer age everywhere, but productivity". Therefore, the usage of computer may not increase Iranian manufacturing SMEs. Third, in the case of computer usage technology may not be effective on productivity, being input driven instead. According to Elsadig [12], economic growth in many countries has been input- driven rather than being TFP (technology) driven. The coefficients of material per labor, capital per labor and human capital per labor are all significant in all of the regression equations of the model using different measures of EC. These results indicate that all of the inputs of production have positive impacts on labor productivity.

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Appendix

Table 1: Estimation results of the impact of EC (Number of Employees Using Internet) on Labor Productivity

Independent Variable	Random Effects- Estimated Generalized Least Squares (EGLS)			
	Coefficient	Standard Error	t-Statistics	Prob
Constant	7.234	0.799	9.053	0.000
$\ln \frac{K}{L}$	0.510	0.018	28.129	0.000
$\ln \frac{M}{L}$	0.152	0.041	3.658	0.000
$\ln \frac{H}{L}$	0.061	0.037	1.654	0.098
$\ln \frac{EC}{L}$	0.014	0.007	1.992	0.047
Leamer F	5.473			0.000
Hausman chi-squared	70.141			0.000

Source: Estimated by using equation No. 5

Table 2: Estimation results of the impact of EC (Number of Employees Using Computer) on Labor Productivity

Independent Variable	Random Effects- Estimated Generalized Least Squares (EGLS)			
	Coefficient	Standard Error	t-Statistics	Prob
Constant	7.093	0.800	8.868	0.000
$\ln \frac{K}{L}$	0.510	0.018	28.003	0.000
$\ln \frac{M}{L}$	0.156	0.042	3.717	0.000
$\ln \frac{H}{L}$	0.062	0.037	1.668	0.096
$\ln \frac{EC}{L}$	0.009	0.011	0.838	0.402
Leamer F	5.539			0.000
Hausman chi-squared	67.804			0.000

Source: Estimated by using equation No. 5

Table 3: Estimation results of the impact of EC (E-selling) on Labor Productivity

Independent Variable	Fixed Effects- Estimated Generalized Least Squares (EGLS)			
	Coefficient	Standard Error	t-Statistics	Prob
Constant	8.071	0.057	140.893	0.000
$\ln \frac{K}{L}$	0.368	0.0002	1702.651	0.000
$\ln \frac{M}{L}$	0.215	0.003	71.913	0.000
$\ln \frac{H}{L}$	0.090	0.002	36.498	0.000
$\ln \frac{EC}{L}$	0.395	0.028	14.051	0.000
Leamer F	5.560			0.000
Hausman chi-squared	65.663			0.000

Source: Estimated by using equation No. 7

Table 4: Estimation results of the impact of EC (E-buying) on Labor Productivity

Independent Variable	Fixed Effects- Estimated Generalized Least Squares (EGLS)			
	Coefficient	Standard Error	t-Statistics	Prob
Constant	6.956	0.792	8.777	0.000
$\ln \frac{K}{L}$	0.510	0.018	28.041	0.000
$\ln \frac{M}{L}$	0.164	0.041	3.946	0.000
$\ln \frac{H}{L}$	0.070	0.036	1.925	0.055
$\ln \frac{EC}{L}$	-0.173	0.146	-1.186	0.236
Leamer F	5.560			0.000
Hausman chi-squared	68.039			0.000

Source: Estimated by using equation No. 7

Table 5: Estimation results of the impact of EC (Using Internet to Offer Information) on Labor Productivity

Independent Variable	Fixed Effects- Estimated Generalized Least Squares (EGLS)			
	Coefficient	Standard Error	t-Statistics	Prob
Constant	8.052	0.061	132.463	0.000
$\ln \frac{K}{L}$	0.384	0.006	64.078	0.000
$\ln \frac{M}{L}$	0.204	0.003	77.094	0.000
$\ln \frac{H}{L}$	0.092	0.003	33.811	0.000
EC	0.164	0.002	79.850	0.000
Leamer F	5.468			0.000
Hausman chi-squared	67.154			0.000

Source: Estimated by using equation No. 7

Table 6: Estimation results of the impact of EC (Using Internet to Gather Information) on Labor Productivity

Independent Variable	Random Effects- Estimated Generalized Least Squares (EGLS)			
	Coefficient	Standard Error	t-Statistics	Prob
Constant	7.076	0.792	8.928	0.000
$\ln \frac{K}{L}$	0.510	0.018	28.091	0.000
$\ln \frac{M}{L}$	0.153	0.042	3.662	0.000
$\ln \frac{H}{L}$	0.063	0.037	1.715	0.087
EC	0.127	0.100	1.31	0.191
Leamer F	5.501			0.000
Hausman chi-squared	71.409			0.000

Source: Estimated by using equation No. 7