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Effects of R&D and Technology Imports on Employment: The Case of Iran

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Abstract

Domestic innovations and technology imports play important roles in boosting relative demand for skilled labor force. These factors are in turn influenced by domestic R&D investments and international trade. Using a translog cost function, this paper studies the effect of technology imports and other factors including output level and physical capital stock on the shares of skilled labor force employment. The data for technology imports are gathered based on ISIC (International Standard Industry Classification) 2-digit codes for the period 1971-2013. Our translog cost function is estimated by seemingly unrelated regressions (SUR) method. The estimation results show that an increase in technology imports raises the share of skilled labor force and decreases the production cost. Moreover, our result indicates that domestic R&D has no effect on employment level of skilled labor force in Iran.

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1. Introduction

In recent years the structures of employment and wages have changed in many countries. For some economists, such changes have been due to new technologies imported via international trade. Utilization of modern technologies is particularly important from two perspectives: (i) consumers require new higher-quality products and technology utilization can meet this market demand reasonably; and (ii) recently, borders have vanished commercially and international competition has emerged. Since competition is increasingly growing in terms of prices, quality and diversity of products, firms are forced to use new technologies. In this regard, some part of required knowledge is produced by both public and private sectors and other part is transferred through global business in forms of foreign investments and technology imports. In other words, human skills are necessary to implement, adapt, accept and utilize a new imported technology physically and practically, playing a complementary role. Based on this, demand for skilled labor force has exhibited an increasingly growing trend and nature of wages has been affected by these very changes.

Present paper is aimed at evaluating effects of technology, including costs of R&D as an internal source of technology promotion and imports of technology (effect of international business), on share of skilled labor force employment. To this end, like other experimental works done similarly in this field, present work studies translog cost function. After reviewing theoretical foundations and background of the subject, a proper model of cost function is provided, by which abovementioned goal will be achieved. Next, the model estimation and analysis are presented. Finally, results and recommendations are provided.

2. Demand Shift from Unskilled to Skilled Labor Force

Economically, technology and effects it has on growth rate of production and employment is not a new topic. Based on endogenous growth models, domestic R&D along with technology imports can influence products of firms and be considered independent factors in describing performance of growth and employment (Tseng, 2008). R&D plays a particularly important role in increasing production capacities of a society since it is the major base of innovation and technical changes being made in production processes. When then bases of growth and development of most third world countries are pursued by industrializing activities of manufacturing, it is necessary to establish required industrial framework and base in first place, as a result of which technology imports becomes important. By importing new technologies, developing countries, which may lack the required production resources, forces, materials and technological equipment due to natural and technical reasons, can eliminate production restrictions, facilitate manufacturing of any types of needed products, and increase manufacturing productivities. Moreover, in case imported technologies and knowledge are naturalized in our country, the result is spillover of technology inwards from our business partners abroad, leading to transfer of skills and talents required by managers and employers, which, finally, has positive effects on employment. At the same time, because of intense competition with foreign firms, domestic enterprises have to invest extensively in R&D activates and/or in acquisition of new, advanced technologies in order to maintain their shares of both domestic and international markets, known as defensive innovation phenomenon (Wood, 1995).

These theories mainly focus on the fact that international business provides some modus operandi by which developed technology and knowledge enter a country from other parts of the world and the former can foster and naturalize them (Awokus ,2007). In fact, doing business speeds up the pace of technological changes in that country by transferring sets of knowledge and technology into the host country and its corporations from other areas around the world, which, in turn, increase productivity and manufacture there (Hassan, 2000). By enabling domestic firms to have access to required intermediate factors and foreign technologies, especially foreign capital goods, easily, technology imports leads to increased production and productivity in a country. This, according to Hassan (2000), makes it possible for firms in developing countries to have access to internationally basic knowledge in forms of tangible (capital goods) and intangible (innovative ideas) ones separately. Kondo (2001) argues that, in most developing countries, technology imports plays a highly important role in early steps of economic development while domestic technology development takes place during subsequent steps. This fact implies that strategies for technology development should be formulated with respect to development phases. Given materials already mentioned, it can be stated that technology imports and domestic R&D costs can influence firms' production through technology development in addition to traditional inputs (labor force and capital stock) of production.

Therefore, in case research into economic growth and employment pays no attention to these important factors, erroneous conclusions and forecasts will result. Importance of this issue becomes more evident when research is done quantitatively using econometric instruments. To omit these important factors influencing economic growth and employment results in biased estimation of the model coefficients being interpreted questionably. On the other hand, given that skills and technologies are considered as two complementary factors (technology utilization requires sufficient skills), adopting modern technology increases demand for skilled labor force and raises their wages. In this case, unskilled workers' wages might be lowered due to their low productivity, as clarified by diagrams 1 and 2 showing unskilled labor force, skilled labor force and their respective wages denoted by L, H, W_L and W_H, respectively.

As shown in diagram 1, prior to applying skill-oriented technologies, the firm had been at equilibrium point A where W_L/W_H and H/L indicate ratios of unskilled to skilled labor force wages and of skilled to unskilled labor forces, respectively. Also, the diagram shows isoquant curve for the firm's production as Y_0Y_0. But as indicated by diagram 2, after making technological changes, isoquant curve shifted toward origin of coordinates with some reduced slope. Now, the firm was able to produce the same quantity of a product using lower inputs. Isoquant production curve will shift toward the center of coordinates if such technological changes are skill-oriented ($y_0 y_{0\to} y_1 y_1$), decreasing L/H.

Once labor force numbers and wage rates have been adjusted, a new equilibrium is formed finally at B. Comparing ratios of H/L and W_L/W_H at points A and B indicates an increase in ($\frac{H}{L} \langle \frac{H'}{L'}$) and a decrease in ($\frac{W_L}{W_H} \rangle \frac{W'_L}{W'_H}$).

This analysis indicates that share of wages paid by a firm to skilled labor force increases as the demand for skilled workers increases:

$$\frac{W_H H}{W_L L + W_H H} \langle \frac{W'_H H'}{W'_L L' + W'_H H'} \qquad (1)$$

It should be noticed that demand shift to skilled labor force is the result of domestic technological changes and globalization phenomenon being the causes of introducing the technology to developing countries (Sasaki

& Sakura, 2005). The point is that, in some countries, lower reduction of wages paid to unskilled workers is observed due to enactment of Minimum wage Act and/or to Labor Union pressures, leaving them unemployed more than ever. For this reason, in the U.S., for example, advanced skill-centered technologies have caused the demand for skilled labor force to increase more than that for unskilled one in its flexible labor market so that demand curve is driven out. In such a case, at equilibrium point, increases in both relative wage and relative employment are observed for skilled group, leading to inequality of relative wages paid to two groups, and to fixed rate of unemployment. But this is not the case for inflexible labor market in Europe, except for U.L., where wage differences Remain fixed while unemployment rate increase remarkably.

In general, economists specialized in labor market sector perform analyses largely explicitly or implicitly by using a single-part model.

Standard method used in this area is estimating the relative demand function for labor based on skill-oriented technology changes. They argue that if an industry does not adopt or follow any technology changes, then it makes no change in relative wages because no skill-centered technological changes occur within that industry. Now, it is assumed that there exist two sectors in the economy that two products i and j, with product y being produced by skilled and unskilled workers (N_u, N_s) of production line. In this case, using a production function CES, we have:

$$y = A\left[a(\lambda_s N_s)^{1-\frac{1}{\delta}} + (1-a)(\lambda_u N_u)^{1-\frac{1}{\delta}}\right]^{\frac{\delta}{\delta-1}} \qquad (2)$$

Where A is technical parameter of function; λ_s and λ_u indicate intensities of using skilled and unskilled workers, respectively; (a) is technical parameter of mastery level; and δ is elasticity of substitution of production factors. Now, by applying shepherd's lemma, relative demands for labor force are obtained for both skilled and unskilled workers in sector I, when divided by, we have:

$$\frac{N_s^i}{N_u^i} = \left(\frac{a^i}{1-a^i}\right)^{\delta}\left(\frac{W_s^i}{W_u^i}\right)^{-\delta} \qquad (3)$$

This function indicates ratio of skilled to unskilled worker demands;

and (a) denotes SBTC. This equation or its translog have been used by many studies (Machin & Van Reenen, 1998). Term $\frac{a}{1-a}$ is a positive constant. In this case, only one sector i has been considered. Assuming that movement of labor force between sectors is impossible, each sector has a supply curve with a positive slope and relative supply be indicated as $\frac{N_s^i}{N_u^i}$. As shown by the equation, it clears that technology imports raises relative wages. Based on this analysis and on studies performed by Anderton & Brenton (1999), skilled labor force employment to total employment ratio is a function of capital stock (K), production (y), ratio of skilled to unskilled worker wages, and other factors (Z).

$$\frac{N_s}{N} = F\left(Y, K, \frac{W_s}{W_u}, Z \right) \tag{4}$$

$$Z = \left[R\delta D/Y, IMP/Y, EXP/Y, FDI \right] \tag{5}$$

Variable Z is a function of R&D/Y (R&D costs to production ratio), Imports/Y (imports to production ratio), Exports/Y (exports to production ratio) and FDI (Foreign Direct Investment), making transfer of function of labor force demand possible. Based on this study, there is a lagged relationship between R&D/y and N_s/N because of being vague of their simultaneously significant relationship. But in theory, we have:

$$\frac{\partial (N_S / N)_{it}}{\partial (R\&D / y)_{it-1}} > o \tag{6}$$

$$\frac{\partial (N_S / N)_{it}}{\partial (\mathrm{Im}\, port/ y)_{it}} > o \tag{7}$$

This means that technology and its spillover are skill – intensive.

3. Literature Review

Using statistical data on Colombia, Mexico and Taiwan, Tan and Batra (1997) studied effects of technology investment indices on wages of skilled employees across corporation. Their theoretical view was that, by deliberately investing in knowledge-producing activities, those corporations could increase their own technological potentials which were developed through domestic R&D, acquisition of foreign technology and know-how, and training and enhancement of levels of skills and exports. Size (number of employees) of corporate samples from Colombia, Mexico and Taiwan were 500 (186), 5072 (298) and 8408 (145), respectively. Based on results of their studies, compared to non-investing corporations, those investing in technology accounted for total technology-wage premium per skilled employees of 42% (Colombia), 54% (Mexico) and 32% (Taiwan). It should be noted that technology-wage premium is calculated as difference between averages wages paid by corporations investing in any types of technology and by non-investing ones. In all three countries, therefore, technology investment has had considerable effect on wages of skilled labor force, hence on labor force demand and supply through real wages.

In his study in the form of a research project, Hensson (1999) investigated demands by Swedish industries for specialized labor force. Following Berman, Bound and Grilliches, he decided to obtain function of labor force demand from translog cost function. Following a series of standard principles, Hensson extracted an econometric model derived from a heterothetic translog cost function, in which share of specialized labor force costs (PW) is given as follows:

$$P^{w} = b_0 + b_1 \ln\left(\frac{ws}{wh}\right) + b_2 \ln Y + b_3 \ln K + b_4 \ln S + b_5 T \qquad (8)$$

Where W_s is specialized labor force wage rate; W_u is non-specialized labor force wage rate; Y denotes real production; K indicates physical capital; S is scientific capital; and T shows technological changes made by international spread and transfer of technology regardless of changes in scientific or physical capital stocks. He concluded that scientific capital, measured by R&D cost share of value – added, had added to productive knowledge volume after a 3-yr lag. As for international trade, imports of new machinery and tools has led to dismissal of unskilled workers due to making use of new labor-saving techniques. In the past 35 years, thus, share of specialized labor force has been increasing constantly in Swedish industries due to investment in R&D and application of international technologies commercially.

In his paper titled “Technology diffusion, human capital and economic growth”, Mayer (2001) presented his research done on 53 developing countries by using a regression model and linked different production processes in such countries to different human capital stock and technology imports. On the basis of his research, results, imports of technological machinery into host developing countries and effects of their spillover have had quantitatively/ qualitatively positive effects on their labor markets, but their domestic R&D activities were trivial.

Seemingly, Gorg and Strobl (2002) were the only and first to focus on a low-income country in this field. In 1999s, they studied a group of manufacturing plant in Ghana to see whether technology imports or exports activity has been the cause of increased wages of skilled labor force or not. Their results showed that need for skilled labor force increased remarkably for technical reasons when foreign machinery was purchased. However, higher rate of participation in global product markets through exports played no direct role in creating skills within Ghanaian manufacturing plants.

Sasaki and Sakura (2005) investigated demand for academic labor force in Japan during 1988-2003 by using a translog cost function in their study, where share of specialized labor force costs was:

$$s_i^H = \alpha_i + \gamma \ln\left(\frac{w_i^H}{w_i^L}\right) + \mu \ln\left(\frac{K_i}{Y_i}\right) + \lambda \ln Z_i + \delta_t \qquad (9)$$

It is assumed that capital is fixed in short term and t is temporal effect. Also, structural factors such as SBTC and globalization are indicated by Z_i, changing production levels and industry costs. They used R&D expenditures as an approximate variable of effects of SBTC and imports by Eastern Asia in order to reflect globalization. Using above function, researchers analyzed major manufacturing Japanese sectors by employing panel data to examine relationships of share of academic labor force wages with SBTC and globalization. Experimental results indicated that SBTC and imports were considerably effective in raising wage shares and in increasing demand by Japanese manufacturing sectors for academic labor force.

Hai Yang and Hung A. Lin (2008) estimated effects of innovation and technology on employment by using ordinary least squares method and a demand model for Taiwan. Applying variables substituting innovation and technology including R&D costs, technology imports, and patents as well as control variables including wages and capital, they found that technology diffusion had a significantly positive effect on growth of employment. In addition, they demonstrated that technology application resulted in a shift in labor force in favor of higher – educated and skilled labor force.

In a research titled “Open trade and demand for skills”, Meschi and Taymaz (2009) evaluated, by employing a translog cost function, relationships among open trade, technology imports and demand for skilled labor force by using data on 17,462 Turkish corporations during 1980-2001. Results showed that domestic R&D costs and technology imports were increasing in 1980s when the trend of trade liberalization expanded in Turkey, leading to increased demand for skilled labor force, hence to the income differences between skilled and unskilled labor forces. For exports, however, regression results showed reduction of demand for skilled labor force. To justify this, researcher stated that development of exports results in decreased demand for specialized human force only when destination of exports is directly more industrialized countries (like EU as a business partner of Turkey).

In a research project, Vahidi (2000) evaluated how employment levels had been influenced by science and technology during 1971-1996.

To this end, he used different indices of science and technology in a regression function by ordinary least squares (OLS) method. Findings of his study indicated that index of technology imports to value – added ratio influenced levels of specialists’ employment while R&D costs to value – added ratio increased demand for skilled labor force only in industry sector and was insignificant at macro level.

During some research titled “Technology role in Iranian plant – based industries employment”, Basseri and Jahangard (2006) studied the role technology had played in national plant – based industries employment during 1995-2000 by applying translog cost function on the basis of Maximum Likelihood (ML) model. In their research, share of skilled labor force cost was obtained as:

$$S_W = \alpha_W + \beta_W \ln\left(\frac{w_W}{w_B}\right) + \beta_{WK} \ln\left(\frac{K}{VA}\right) + \beta_{WR} \ln\left(\frac{R}{VA}\right) + u \qquad (10)$$

Where W_W is the rates of specialized labor force wage; W_B is the rates of non-specialized labor force wage; K denotes physical capital; and R is a variable substituting technology. In above model, ratio of R&D costs to value – added and productivity of production forces have been considered as variables substituting technology. Moreover, physical capital’s being supplement to or substitute for labor force was tested based on the model. Results of the study indicated that R&D costs and productivity had positive effects (0.015 and 0.260, respectively) on demand for skilled labor force across industry as a whole and that improved technology increased rate of skilled labor force recruitment. Correlation (0.023) between physical capital and demand for skilled labor force signifies as complementary relationship between them. Also, effects of R&D costs to value – added ratio on demand for skilled labor force were significantly positive for wood industry, non – metal mineral industry and, in particular, for machinery and chemical industries while being insignificant for food and textile industries.

4. The Model

Investigated model is the result of studies performed by Hollanders – Weel (2002). Schöller (2007), and Senses (2010). First, total production function is defined as:

$$Y = F(L_H, L_L, K, T) \tag{11}$$

Where L_H, L_L, K and T indicate skilled labor force, unskilled labor force, capital and technology, respectively.

Assuming continuity of production function, cost function can be extracted. According of principle of duality, there is a cost function for any production function indicated as:

$$CV = CV(W_H, W_L, Y, \frac{K}{Y}, T) \tag{12}$$

Where W_H and W_L are exogenous wages for variable factors of skilled (L_H) and unskilled (L_L) labor forces, respectively; and ($\frac{K}{Y}$) denotes capital as fixed production input. Technology $T = T(\frac{RD}{Y}, \frac{MT}{Y})$ is also a linear function of R&D costs and technology imports, reflecting some variation of production function due to technological advancements (Taylor & Driffield, 2005; Mayer, 2001).

Cost function derived from production one in the form of translog cost function is defined as:

$$LnCV =$$

$$\alpha_{\circ} + \alpha_{Y} \ln Y + \sum_{j=1}^{1} \alpha_{j} \ln P_{j} + \sum_{j=1}^{m} \beta_{j} \ln Z_{j} + \frac{1}{2} \gamma_{YY} (\ln Y)^{2} + \frac{1}{2} \sum_{J=1}^{1} \sum_{K=1}^{1} \gamma_{jk} \ln P_{j} \ln P_{K}$$

$$+ \frac{1}{2} \sum_{j=1}^{m} \sum_{k=1}^{m} \delta_{jk} \ln Z_{j} \ln Z_{K} + \sum_{j=1}^{1} \zeta_{Yj} \ln Y \ln P_{j} + \sum_{J=1}^{1} \sum_{K=1}^{m} \zeta_{jk} \ln P_{j} \ln Z_{K} + \sum_{j=1}^{m} \eta_{Yj} \ln Y \ln Z_{j} + \theta_{T} T \tag{13}$$

$$+ \frac{1}{2} \theta_{TT} T^{2} + \theta_{TY} T \ln Y + \sum_{j=1}^{1} \theta_{TJ} T \ln P_{j} + \sum_{j=1}^{m} P_{Tj} T \ln Z_{j}$$

Variables presented in above model are logarithmic. P_j, Z_j and t denote prices of production factors, fixed production factors and index of technical changes, respectably. Above equation shows index of technical changes along with inputs and product levels independently. For this reason, mentioned index can be interpreted in two ways. First, technical changes can rise the product level for some fixed amount of inputs. In addition, in this paper, two indices of R&D to production ratio (RDY) and technology imports to production ratio (MTY) were used to evaluate effects of technology imports on employment of skilled labor force. As a result, above function is rewritten as:

$$LnCV = \alpha_{\circ} + \alpha_{Y} \ln Y + \alpha_{H} \ln w_{H} + \alpha_{L} \ln w_{L} + \beta_{K} \ln \frac{K}{Y} + \frac{1}{2} \gamma_{YY} (\ln Y)^{2} +$$

$$\frac{1}{2} \gamma_{HL} \ln w_{H} \ln w_{L} + \frac{1}{2} \gamma_{HH} (\ln w_{H})^{2} + \frac{1}{2} \gamma_{LH} \ln w_{L} \ln w_{H} + \frac{1}{2} \gamma_{LL} (\ln w_{L})^{2} +$$

$$\frac{1}{2} \delta_{KK} (\ln \frac{K}{Y})^{2} + \zeta_{YH} \ln Y \ln w_{H} + \zeta_{YL} \ln Y \ln w_{L} + \zeta_{HK} \ln w_{H} \ln \frac{K}{Y}$$

$$+ \zeta_{LK} \ln w_{L} \ln \frac{K}{Y} + \eta_{YK} \ln Y \ln \frac{K}{Y} + \theta_{R} \ln RDY + \phi_{HR} \ln w_{H} \ln RDY \tag{14}$$

$$+ \phi_{LR} \ln w_{L} \ln RDY + \frac{1}{2} \theta_{RR} (\ln RDY)^{2}$$

$$+ \theta_{RK} \ln RDY \ln \frac{K}{Y} + \theta_{RY} \ln RDY \ln Y + \theta_{M} \ln MTY + \phi_{HM} \ln w_{H} \ln MTY$$

$$+ \phi_{LM} \ln w_{L} \ln MTY + \frac{1}{2} \theta_{MM} (\ln MTY)^{2} + \theta_{MK} \ln MTY \ln \frac{K}{Y}$$

$$+ \theta_{MY} \ln MTY \ln Y + \theta_{MR} \ln MTY \ln RDY$$

Cost function equation is estimated simultaneously with demand share equations to estimate the model by SUR method and to increase efficiency of estimated parameters. The reason is that, firstly, demand share equations share the same parameters With cost function equation and, secondly, they may share some error terms since demand share equations have been derived from cost function one (Erkkila, 1990). Given that translog cost function is logarithmic, its derivation gives share of each input in total costs compared to logarithm of prices of production factors. Applying Shephard's lemma, cost shares are calculated as:

$$\frac{\partial \ln CV}{\partial \ln w_H} = \frac{\partial CV / CV}{\partial W_H / W_H} = \frac{W_H}{CV}\frac{\partial CV}{\partial W_H} = \frac{W_H L_H}{CV} = S_H \quad (15)$$

$$\frac{\partial \ln CV}{\partial \ln w_L} = \frac{\partial CV / CV}{\partial W_L / W_L} = \frac{W_{LS}}{CV}\frac{\partial CV}{\partial W_L} = \frac{W_L L_L}{CV} = S_L \quad (16)$$

Since W_{HS} and W_{LS} are the only variable costs in Eqs (15) and (16), CV is the sum of products of costs of variable factors by their respective ones:

$$L_H = \partial CV / \partial W_H \quad (17)$$

$$L_L = \partial CV / \partial W_L \quad (18)$$

$$CV = W_H L_H + W_L L_L = WL \quad (19)$$

So, S_{HS} and S_{LS} are given as:

$$S_H = \frac{W_H L_H}{W_L L_L + W_H L_H} = \frac{W_H L_H}{WL} \quad (20)$$

$$S_L = \frac{W_L L_L}{W_L L_L + W_H L_H} = \frac{W_L L_L}{WL} \quad (21)$$

$S_H + S_L = 1$

Based on equation (20), W_H or L_H increases whenever S_H increases, therefore, S_H can be regarded as relative demand for skilled labor force. Taking derivation of equation (14) with respect to ln W_H gives following equation:

$$\frac{\partial \ln CV}{\partial \ln w_H} = S_H = \alpha_H + \frac{1}{2}\gamma_{HL} \ln w_L + \frac{1}{2}\gamma_{HH} \ln w_H + \frac{1}{2}\gamma_{LH} \ln w_L + \zeta_{YH} \ln Y + \zeta_{HK} \ln \frac{K}{Y} + \phi_{HR} \ln RDY + \phi_{HM} \ln MTY \quad (22)$$

All parameters in equation (22) exist in equation (14), too. It is not possible to estimate this set of parameters by using 39-yr observations, therefore, following restrictions are exercised to reduce the number of parameters (Murty & Rao, 1993):

$$\gamma_{jk} = \gamma_{kj} and \delta_{jk} = \delta_{kj} \tag{23}$$

$$\sum_{j}^{l} \alpha_j = 1 \tag{24}$$

$$\sum_{j}^{l} \gamma_{jk} = \sum_{j}^{l} \gamma_{kj} = \sum_{j}^{l} \zeta_{jk} = 0 \tag{25}$$

$$\sum_{j}^{l} \zeta_{Yj} = \sum \theta_{Tj} = 0 \tag{26}$$

Since the sum of cost shares equals 1, ($\sum_{j}^{l} S_j = 1$), one of cost share equations is omitted to prevent variance covariance matrix of error terms from becoming 0. To impose such requirements on the system makes relative costs and prices in whole system. That is, by doing so, share of one input is omitted and, instead of n share, n-1 share are estimated along with translog cost function. Consequently, a form of cost function which can be estimated is summarized below:

$$\begin{aligned} Lncv &= \alpha_0 + \alpha_Y \ln Y + \alpha_H \ln(w_H / w_L) + \beta_K \ln \frac{K}{Y} + \frac{1}{2}\gamma_{YY} (\ln Y)^2 + \frac{1}{2}\gamma_{HH} \ln(w_H / w_L)^2 \\ &+ \frac{1}{2}\delta_{KK} (\ln \frac{K}{Y})^2 + \varsigma_{YH} \ln Y \ln(w_H / w_L) + \varsigma_{HK} \ln(w_H / w_L) \ln \frac{K}{Y} + \eta_{YK} \ln Y \ln \frac{K}{Y} \\ &+ \theta_R \ln RDY + \phi_{HR} \ln(w_H / w_L) \ln RDY + \frac{1}{2}\theta_{RR} (\ln RDY)^2 + \theta_{MR} \ln MTY \ln RDY \\ &+ \theta_{RK} \ln RDY \ln \frac{K}{Y} + \theta_{RY} \ln RDY \ln Y + \theta_M \ln MTY + \theta_{HM} \ln\left(\frac{wH}{wL}\right) \ln MTY \\ &+ \theta_{MY} \ln MTY \ln Y + \frac{1}{2}\theta_{MM} (\ln MTY)^2 + \theta_{MK} \ln MTY \ln \frac{K}{Y} + \varepsilon_t \end{aligned} \tag{27}$$

Where $\frac{W_H}{W_S}$ indicates ratio of skilled force to unskilled force wages;

$\frac{K}{Y}$ is intensity of capital spent on production; RDY shows the ratio of R&D costs to production; MTY is the ratio of technology imports to production; Y denotes production volume; and ε_t is the error term of model. Based on above model, physical capital's being supplement to or substitute for labor force can be tested. Since capital can be considered as a substitute for unskilled labor force and as a supplement to skilled one, it is predicted that higher coefficients of capital will increase S_H. On the other hand, given that all technology indices can be supplements to skilled labor force, technology effects are difficult to forecast, but an increase in demand for skilled labor force is expected.

5. The Methodology

Present research method is a descriptive – applied one estimating translog cost function by using econometric method for seemingly unrelated regressions (SUR). Functional form of translog cost was selected because of its superiority relative to others commonly used by research studies. Basically, any function has its own advantages and disadvantages. In econometric investigations, however, there exist some standards to evaluate models, among which we can point to flexibility, compatibility with theories, applicability and supporting facts. Based on this, one feature of flexible cost functions is that they have properties similar to those of production ones from which they are extracted.

Despite simplicity of estimating parameters, Cobb – Douglas production function lacks required flexibility since this model does not show three steps of neoclassic production and since partial elasticity of substitutions between two inputs is the same for any values obtained. In contrast, transcendental and translog functions are free from such limitations. Also, translog function is superior to transcendental one because of considering input interactions. Furthermore, it has enough parameters to estimate and calculate such many different economic effects as substitution elasticity, price elasticity, scale elasticity, rates of technical changes, total productivity of production forces, etc., which can be transformed into other cost functions under certain conditions beside exercising restrictions. Considering materials stated so far, it seems that translog function is the most appropriate model meeting flexibility condition (Greene, 2002).

In terms of standards of compatibility with theories and applicability, it is fair to say that translog function is more appropriate again. Why? Because all reviewed studies performed in relation to the demand for skilled labor force have used translog cost function successfully, including channels and Van Reenen (1992); Hollanders – Weel (2002); Sasaki and Sakura (2005); Fuentes and Gilchrist (2005); Schöller (2007); Conte and Vivarelli (2007); Meschi and Taymaz (2009); Yu Mei – Ci (2010); Senses (2010); and Srivastava – Mathur (2011). Therefore, it can be said that translog cost function is the most appropriate of all for models related to the subject of research.

Moreover, given that, in real world, all economic activities interact with each other and relate to institutions through trading inputs, products and services, investigation of hypotheses and theories at hand more carefully and more completely calls taking interactions of all activities and institutions with each other, including products and services markets, production factors markets, and external world, into account. For this reason, economic realities can be investigated with this function more concretely. After all, translog function has a drawback. When the number of model parameters increases with a higher proportion making more probable the problem with low freedom degrees. In this regard, one of the most important issues in solving such models is selection of method of estimating parameters existing in models, which influences obtained results extremely. Assuming that error terms in equations relate to each other, the system is estimated by SUR method, which is one of interesting application of generalized linear regression. This is because there exist usually some factors within economic relationships, not being considered in explanatory variables, but affect all equations. As a result, some correlation is formed between error terms of equations with no sufficient efficiency to make inter-parameter estimations with respect to OLS and 2SLS methods. Seemingly unrelated regressions method gives efficiency estimations for coefficients of equations system in two steps by taking unequal variances among equations and their error term relationships into account. In the first step, it estimates elements of covariance matrix of equations' error terms, next, estimates system parameters by GLS method. Present study uses mentioned method in order to obtain efficient estimations as well as to increase efficiency of estimated parameters.

Various journals of national accounts, Central Bank, yearbooks of Iranian Statistics Bureau, foreign commerce statistics yearbooks of customs office of I.R.O.I published in different years, time series of economic and social bank of planning and development research higher institution, and statistical books of planning and development center of Higher Education were used to prepare statistics about variables needed for Iran. Information about cots of domestic R&D were obtained by reviewing National Total Budget Act and economic reports of Budget and Planning organization for different years.

Therefore, the applied variables in this study are defined as follows:

- Physical capital: physical capital stock is calculated by the below formula:

$$K_t = K_0 + \sum_{i=1}^{t} (I_G - D_E)_t$$

In this formula, K_t is net value of capital stock in year t, K_0 is value of the primary capital stock at the beginning of period, I_G is gross investment in period t and D_E is value of depreciation in period t.

- Intensity of domestic R&D:

Accumulations of domestic R&D capital were prepared by using accumulations of domestic R&D costs, including governmental research budget. In this paper, intensity of mentioned variable, which shows intensity of development and application of technology in manufacturing, is presented as ratio of R&D costs to production.

- Intensity of technology imports:

Effect of technology on labor force employment, which is explained merely by variations of domestic R&D accumulations when no international business takes place. In case international business takes place, variations of employment are expressed by domestic R&D accumulations and technology imports.

A country is able to have access to international knowledge and technology in several ways. Bernstein and Mohnen (1998) and Wang (2010) consider imports of capital and intermediate goods, foreign direct investments, etc. as methods of international knowledge and technology transfer and spillover. Coe and Helpman (1995) believe that indirect profits are created by imports of products and services produced by trading partners. Wieser (2001) argues that there exists no sufficient information to be used to separate intangible knowledge from tangible one and, for this reason, most researches assume that all knowledge transferred among countries is tangible (exchanged capital – intermediate goods). For example, Akkoyunlu et al., (2006) consider imported capital intermediate goods as transferred knowledge. In this research, therefore, sum of values of capital and intermediate goods imports to production was used as index of technology imports intensity leading to the spillover of technology into our country.

6. Results

Coefficients of the model are estimated by using seemingly unrelated regression method. Table 1 shows parameters of translog cost function estimated by SUR method. As shown, the coefficient of detetmination and Durbin Watson statistics of proposed model are satisfactory. Based on results, coefficient of production logarithm is -1.11. Also, coefficients of the first and second powers of logarithm of capital to production ratio are -0.71 and 0.40, respectively. That is, costs are lowered by increasing utilization of physical capital, which is usually equipped with modern technologies, and by expanding manufacturing activities, resulting in economies of scale.

Coefficients of the first and second powers of technology imports logarithm are -2.16 and 0.05, respectively. This means that production costs decrease incrementally as technology imports increase. Also, coefficient of R&D costs logarithm is -0.89 not being significant statistically. This result can indicate some important points. Through technology introduction, in fact, developed countries have taken advantages of its knowledge spillover, increasing their R&D intensity. In other words, they did that through R&D groups doing a wide variety of research using knowledge produced by capital goods imports, which could achieve a new product and/or naturalize imported capital goods and produce them in their domestic firms. But in Iran, intensity of R&D decreased as a result of foreign technology transfer. This might be due to several reasons, one important among which is the thinkable point stated by Leaderman and Maloney mentioning Iran. They stated that, “In countries like Iran enjoying abundant natural resources, governments earn satisfactory revenues from leasing such resources or their monopoly in short term. So, unlike countries lacking natural resources such as Finland, the Netherlands and Sweden, they make little, or no, effort to invent and innovate”. Consequently, as foreign technology enters the country, firms imagine themselves rich of knowledge so that they do not have to do any research. As a result, they exploit imported technologies until they depreciate. This problem, of course, might be due to macroeconomic issues such as price deviations in favor of physical capital, especially imported physical capital. Negative coefficient of skilled labor force wages has an effect decreasing production costs. The reason is that relative prices of skilled labor force have been declining during study period, in particular, during post – Revolution times.

More importantly, cost function is used to obtain input demand equations. With production functions, it is difficult to obtain such equations due to the absence of input prices. With cost function, however, said equations are attainable because of making use of Shephard's Lemma.

Table 2 gives results from estimating equations for skilled labor force demand share.

Results shown in the table indicate that all estimated coefficients, except that of domestic R&D, are significant and supported statistically. To interpret results, it can be said that, keeping other conditions constant supposedly, a 1% change in production results in an increase in demand for skilled labor force by 0.15%. Also, wage coefficient has a significantly positive 0.05% effect. The reason is that economic firms are not much sensitive to raising wages of skilled labor force essentially demanded because of expanded international business and technology imports. Put it differently, an economic employer places more importance on productivity and pay off of working labor force than on its wages. Another point in said equation is the significantly positive relationship between demand for skilled labor force and intensity of capital utilization in production (ς_{KH}= 0.09). That is, keeping other factors constant presumably, increased capital to production ration increases skilled labor force employment share, supporting hypothesis of capital – specialty complementarity. Since some new investments are made in technological equipment, sign of mentioned coefficient signifies a reasonable relationship between demand for skilled labor force and capital. On the other hand, focusing on variables measuring domestic innovations and international technology transfer suggests that technology imports relates to the share of skilled labor force costs positively significantly, increasing demand for skilled labor force (θ_{MH} =0.01). These results are in agreement with the idea that imports from industrial countries involves transferring technologies being more specialty – centered than those previously used in domestic markets. Therefore, they lead to an increase in demand for specialized human force. But in short term, domestic R&D variable is not significant, therefore, it can be concluded that it is a weak determinant for skilled labor force employment (θ_{RH} =0.009) for several reasons. It can be argued that capital goods imports by developing countries entails increased demand by final product sector for skilled labor force. But R&D sector will exhibit increased relative demand for skilled labor force as imports of capital goods increases gradually and potential for knowledge imitation becomes stronger.

7. Conclusion

Many studies have investigated the relationships between technology and employment at an international level as well as at country level for some developing counties such as Malaysia, Turkey, China and India, These researches have used translog cost function to estimate endogenous growth theory. The results are mixed. Many of these studies confirmed existence of above mentioned relationship and some rejected it. In present study, the effects of domestic R&D and technology imports on skilled labor force are estimated in Iran by estimating a translog cost function.

Our translog cost function is estimated by seemingly unrelated regressions (SUR) method. The estimation results show that an increase in technology imports raises the share of skilled labor force and decreases the production cost. Moreover, our result indicates that domestic R&D has no effect on employment level of skilled labor force in Iran.

It might be due to the fact that in developing countries including Iran, industries mostly import their technologies from abroad, and are not engaged in R&D activities. In short term, it seems that an increase in skilled force employment is the result of imported technology rather than of domestic R&D activities. On the other hand, domestic R&D activities are a time-consuming process exhibiting its results in long term. Expansion of this process heavily depends on government protections. Experimental results from equations of demand share during the period under investigation show that demand for skilled labor force inputs increases as manufacturing activities and intensity of capital utilization, are expanded. This implies that physical capital supplements skilled labor force. Based on above mentioned results, following recommendations are provided:

1- According to the research results, domestic R&D activities have no significant effects on production costs and demand for skilled labor force. Since human capital and accumulation of domestic R&D are the most important factors to attract imported technologies, it is recommended that government protect domestic R&D activities of major economic units. Government can do this in many different ways such as using direct (subsidization, loans) and indirect (tax exemption) instruments.

2- Positive effects of capital – intermediate goods imports on demand for skilled labor force and reduction of production costs of large economic units of Iran shows the importance of expanding bilateral relationship between Iran and industrialized countries. This might lead to receiving advanced manufacturing technologies. Although, a considerable volume of capital and intermediate goods are imported from developed high-tech countries, these imports have not played a serious role in increasing employment of skilled labor force. This can be attributed to little attention being paid to domestic R&D activities and human capital. One should note that technology imports can narrow technological gaps and increase total productivity growth provided sufficient resources are invested in boosting R&D activities and human capital. As mentioned earlier, wages paid to skilled labor force have shown a declining trend, causing a large number of specialists to be attracted by foreign firms due to higher wages paid by them. Therefore, it is necessary to adjust the relative wages of skilled labor forces to encourage them to move to knowledge–based industries.

Table(s) & Diagram(s):

Table 1. Estimation of Translog cost function coefficient

Probability	t-statistic	Coefficient	Parameters
.000	20.05	30.31	$\alpha_{\circ}$
.000	-19.25	-2.51	α_W
.000	23.01	.26	γ_{WH}
. 000	-3.88	-.71	β_K
.000	-9.43	-1.11	α_Y
.32	-.97	-.89	θ_R
.32	.98	.007	θ_{RH}
.000	-8.25	-2.16	θ_M
.000	3.97	.05	θ_{MM}
.02	2.35	.4	δ_{KK}
.001	3.46	. 01	θ_{MH}
.000	4.01	.09	ζ_{KH}

Probability	t-statistic	Coefficient	Parameters
.000	8.08	.18	θ_{MY}
.000	11.50	.15	ζ_{YH}
000	-6.30	-.05	D_{WAR}

D.W=1.92, $\mathbf{R}^2$ =.98

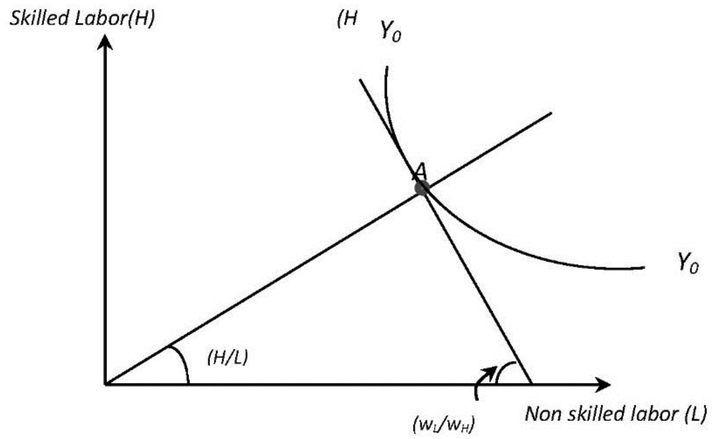
Source: Findings of the study

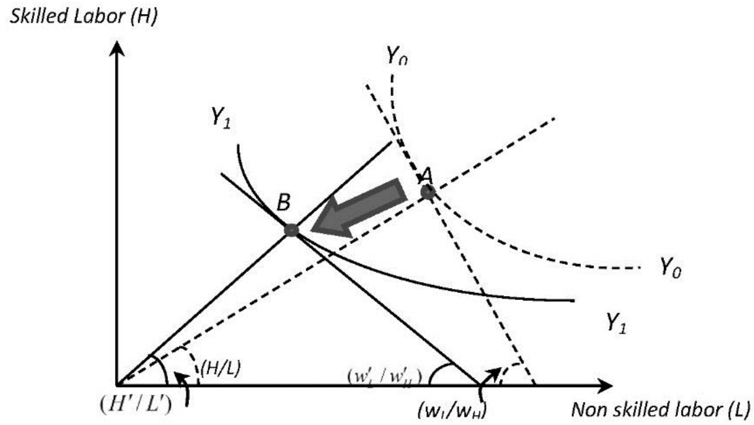
Table 2. Skilled labor force demand share equation

$$S_H = \alpha_H + \gamma_{WH} \, Ln \frac{W_H}{W_L} + \zeta_{KH} Ln \frac{K}{Y} + \theta_{RH} Ln \; RDY + \theta_{MH} Ln \; MTY + \zeta_{YH} LnY$$

θ_{MH}	θ_{RH}	ζ_{KH}	ζ_{YH}	γ_{WH}	α_H
.01	.009	.09	.15	.05	-2.53
(3.83)*	(1.15)	(3.89)	(9.29)	(14.02)	(-18.70)
D.W=1.75 , R^2 =.98					

* t-statistics are reported in the parentheses





Diagrams 1 & 2: Skilled Labor and non-Skilled Labor

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