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The Effects of Nanotechnology Implementation in Manufacturing on Production Costs and Employment: An Input-Output Simulation

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Abstract

Implementation of a new technology generally affects the economy indices such as production costs and employment. Although the implementation of nanotechnology may influence the economy through several ways, this paper focuses on its impact through production process. To do so, it is attempted to measure the effects of implementation of the nanotechnology in the manufacturing process of different products on the production costs and labour force employment. A simulation based on the input-output (I-O) analysis is employed. To this end, the latest survey base I-O table of Iran for the year 2001 as well as the related data from official centers is used as database. It is expected the results of the paper make a forecast on implementation of this technology in the economy.

Keywords: Nanotechnology Effects, Production Costs, Labour Force Employment, Input-Output Simulation.

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Introduction

Recently, the people witnessed the emergence of a new phenomenon named *nanotechnology* in different parts of their lives. With respect to the level of changes, it seems it would be the cause of the next economic revolution of the world that will affect all aspects of the people's lives. Since this phenomenon started in the last decade of the 20th century, it is too early to judge the results of its implementation in any part of their lives perfectly. However, a few aspects of the results can be anticipated to somewhere.

As it will be reviewed in the next section, the implementation of nanotechnology affects the production process. Thus, due to these effects, it seems this phenomenon leads to several changes in the economic and social affairs of the people. Among many effects, decrease in the costs of production and the employment for labour force generally take into account two positive and negative results of implementation of a new technology, respectively.

Although this study failed to find any research in terms of economic investigation on nanotechnology implementation in production process in economic resources, there are considerable studies on the impact of a new technology on the production cost in one or several sectors of an economy. Using detailed cost data to estimate two stochastic frontier models of the cost of providing retail services for clients who use the branch bank teller and those who use an information technology based approach, Okeahalam (2005) suggested that benefits can be obtained by reducing inefficiency and by extending new technology. Johnston *et al.* (2004) estimated that cost-effectiveness of the technology transfer project, in terms of a cost per disability adjusted life year, averted. They found that technology transfer project in South Africa also caused the practitioners to learn novel procedures that could help future patients and improve cost-effectiveness. Pompe and Brandt (2001) is another study that provided comparison of the costs and capabilities of low- medium- and high-pressure powder injection moulding processes by the company's MEDPIMOULD™ technology.

In addition, there are some studies into the effects of technological changes on composition and level of labour force employment. Using a Chenery-type decomposition analysis of employment change and labour demand functions, Rhys (2008) has demonstrated that the technological change has a negative impact on both the level and skill composition of manufacturing employment in South Africa. Fabrice and Harris (2007) concluded the empirical work has suggested that in response to a positive technology shock, employment shows a persistent decline. Based on Greenan (2003) analyses, technological changes influence the skill changes and the employment behavior of firms through organisational change. The relationship of technology on productivity and employment was studied by Corley *et al.* (2002) as well. Addison and Teixeira (2001) provided a critical review of the impact of technical changes on the structure of relative wages and employment. Martin (1999) concluded that widespread use of information technologies facilitates occupational restructuring, the sum of which is slowing down the growth in information employment. By a survey in the related literature, Carnoy (1997) reviewed the impact of the new technologies' effects on labour force employment and the composition of skills demand.

However, while it seems the reduction in production cost due to implementation of a new technology may have pleasure for people, reduction in job creation may lead to some concern about unemployment for labour force. Although it is possible like other new technologies like machines, computer and internet implementation, a considerable number of new jobs are created in the countries, this paper interest to investigate the results of this technology changes on these variables in the economy. To see the result of this phenomenon on the production cost and unemployment crisis, it is required to study the result of implementation of a similar technology. Thus, an I-O analysis is employed to simulate the implementation of nanotechnology on these indices.

This paper contains of six sections. The following section is allocated to a general overview of the nanotechnology impacts upon an economy. A theoretical study of technological change is presented in the third section. The fourth section covers methodology and database specification. The result of using the methodology and database are discussed in the fifth section. And finally, the conclusion of the research will end the paper.

A general overview of the nanotechnology

Nano, the *small* of Grecian language is the word that is frequently used for a one billionth of a quantity in many sciences like physics. Since dimensions of an atom are about 10 nano meters, this word is popular in studying atoms and molecules as well. It is used in the field of sciences and was originated by Richard P. Feynman's classic talk on December 29th 1959 at the annual meeting of the American Physical Society at the California Institute of technology (Nanotechnology website (not dated) and Wikipedia (not dated)).

Later, Feynman's idea was followed by Eric Drexler (Wikipedia (not dated)). This attempt has been continued by others, thus the carbon tubes as the first products of nanotechnology implementation in the production process were obtained in 1991. Since 1991, several products have been generated through nanotechnology implementation in the food products process, clothes, transistor motors and in many other goods and services. However, although the uses of these products are not popular now, today there are many countries that do investment on this phenomenon.

In a very simple definition, nanotechnology is the engineering of functional systems at molecular scale and is used to build things bottom up, with atomic precision (Center for Responsible Nanotechnology, not dated. a). The main difference of nanotechnology compared with other ones lies in materials scale and structure of this technology. Thus, it is in relation with the production process which is an important effect of implementation of this phenomenon.

Nanotechnology vastly improves the manufacturing process. This improvement leads to reduce the production cost of commodities. So it is expected, like a computer that can make unlimited copies of data files with little or no cost, nanotechnology be able to make products as cheap as the copying of files. In fact, this is why it is sometimes seen as the next industrial revolution (Center for Responsible Nanotechnology, not dated. a).

Several studies about nanotechnology have been carried out in assessing its economic benefits in production process. For instance, water will be one of the major restrictions of the world in future, so almost half the world's population lacks access to basic sanitation, and almost 1.5 billion will have no access to clean water. In such situation, nano-manufactured water costsextremely low. In addition, an entire supercomputer can fit into a cubic millimeter, and cost a small fraction of a cent. Environment and mining are two other problems that more compact, cheap manufacturing allows improvements to be deployed rapidly at low cost (Center for Responsible Nanotechnology, not dated. b). Nano-products can be prepared and applied with cost effective and will conduct electricity at a higher rate than it is currently possible (West 2008). It can also bring down the farm production costs through prices and more efficient use of inputs like water, fertiliser nutrients to the plants, and eliminating wastes (Nanowerk News 2008). There are also many other researches such as Bowers and Cernac (2008), that reported nanotechnologies reduce production cost through more effective use of inputs.

Another result of nanotechnology implementation is about the high quality of its products. It is generally concerned with producing new and/or improved materials. In addition to many high-quality products at very low cost, it will allow making new nano-factories at the same low cost and at the same rapid speed. For example, nano-factories can create products vastly more powerful than they are now. Electrical power can be with 10 times the efficiency and about 10^8 times the density. Computers can be 10^{12} times smaller and use 10^6 times less power. Materials can be about 100 times stronger. This means that most human-scale products would consist almost entirely of empty space, reducing weight, material requirements, and cost (Center for Responsible Nanotechnology, not dated. c).

It is notable that apart from many ad hoc characteristics such as durability, hardiness and strength as well as non-harm environmental effects of nano products that are related to the quality of nano products, implementation of the nanotechnology has a considerable effect on the production procedure as well. On the other hand, it is expected that the implementation of this phenomenon lead to a new relationship among the production factors.

A theoretical study

I-An input-output analysis and nanotechnology

The demand for product is classified into intermediate and final devices in an ordinary I-O table. Whereas the intermediate demand is made to produce new commodities, the final demand originates by domestic or foreign institutes. Worth remarking that, in fact, all products are demanded by final demand directly or in the form of other products, indirectly.

In a similar classification, the nanotechnology implementation effects on an economy can be classified into two devices. A part of its implementation effects could be traced back to the technological changes of production sectors in the production process of commodities. Since any change in the production procedure generally affects the economic factors' relationship, it is expected the implementation of this phenomenon lead to a new interrelationship among production factors.

Worth remarking that it is expected the new technology have different effects on the relationship of production factors. As the first effect, it is expected the new technology affect the relationship of production factors through types and amount of raw materials that are required for a certain level of products. The second effect of implementation of a new technology is related to the level and the composition of primary factors that are required for a certain level of products. Another effect of the new technology relays on the share of primary factors and intermediate goods and services in the inputs that are required for the products. And finally, the new technology affects the ratio of imported goods and services to the intermediate inputs for products.

The second group of nanotechnology effects on an economy is due to the above-mentioned ad hoc characteristics of nano products. In fact, this category of features is a result of the quality of products that influence the final demand part of an I-O table. On the other hand, the second group characteristics of nanotechnology effects on an economy are related to the quality of commodities that affect the economy through final demand that contains the exogenous part of an I-O model.

II- A Microeconomical analysis

Based on the Leontief production function technology that runs in the I-O model, the production factors composition is fixed over all levels of products. The production factors composition is valid for a certain technology. On the other hand, any change in the production technology will bring about changes in the production function too.

The new production function has a Leontief form as well. However, it would have a different curve and consequently a different isoquant product curves. With respect to the intermediate and primary factors price constancy presumption, the two groups of these curves can be shown simultaneously.

Fig. (1) displays a very simple isoquant product curves concern with before and after technology change. Collecting two cases together, the broken lines and solid lines are assumed to be associated with the phase before and after a technology improvement, respectively. Each function has its special expansion path that shows the composition of production inputs. The diagonal parallel lines are the budget-income isoquant curves.

In Fig. (1), items In_1 to In_4 denote the size of production costs and Q_1 to Q_4 the level of products, in which $In_4 > In_3 > In_2 > In_1$ and suppose $Q_3 \geq Q_4$ and $Q_1 \geq Q_2$. As it is shown, although $In_4 > In_3$, due to new technology implementation, $Q_3 \geq Q_4$ and although $In_2 > In_1$, yet the implementation of the new technology leads to $Q_1 \geq Q_2$. On the other hand, with respect to production factors price constancy, an improvement in the production technology leads to a new production function that enables the producer to attain a certain level of product for a lower cost. This phenomenon is available by reduction in consumption of intermediate and primary factors that are required for a certain level of products. As a result, it also leads to a change in the composition of production factors as well.

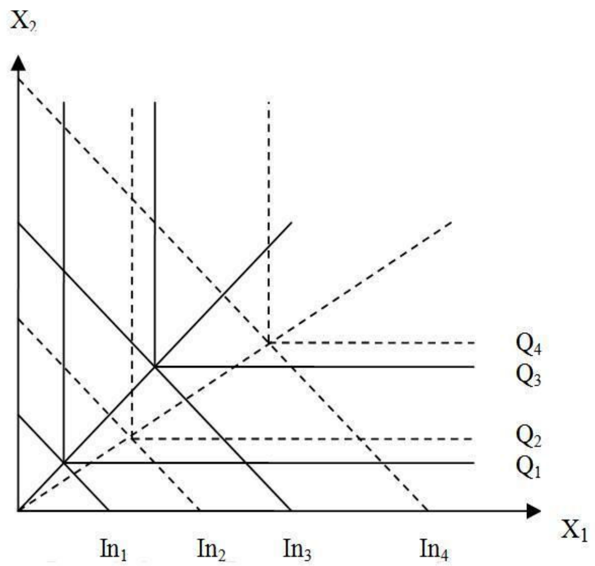

Fig. (1): Isoquant product curves concern to technology change

Methodology

A standard price model is employed to measure the result of change in the production technology. Irrespective to the alteration of the quality of products that may be attained due to using a higher technology, the paper focuses on the effect of the technology improvement on price of products and employment. To meet the above mentioned effects of implementation of the new technology, the standard price model is developed.

To this end, the following extended price model is employed to study different effects on the price of products:

$$P = [I - A^{'}.(I - \hat{b})]^{-1}.(A^{'}.\hat{b}.p_m + \bar{Y}) \qquad (1)$$

where $\hat{b}$ denotes the diagonal matrix of share of imports in supply of sectors, $A^{'}$ the transpose of *A*, the technical coefficient matrix, *P* the column vector of price indices for sectors, p_m the price index for imports and $\bar{Y}$ the share of primary factors in the production inputs.

To show the effects of new technology, as the first step, we start to study the effects of a new technology on the decrease in the intermediate consumption of production sectors. Thus, although a reduction in the intermediate consumption affects its share in total inputs, by ignoring other changing, it is assumed the new technology only affects the technical coefficient elements of the model.

In the given case the new technology affects all intermediate inputs of sectors with the same ratio, $A^{'}$ the transpose of the technical coefficient of the relationship (1) changed as the relationship (2). In which, c_is show the effects of the new technology on the technical coefficients of a sector that is expected to be less or equal to one.

$$\begin{bmatrix} c_1 & 0 & \cdots & 0 \\ 0 & c_2 & \cdots & 0 \\ \vdots & \vdots & & \vdots \\ 0 & 0 & \cdots & c_n \end{bmatrix} \times \begin{bmatrix} a_{11} & a_{21} & \cdots & a_{n1} \\ a_{12} & a_{22} & \cdots & a_{n2} \\ \vdots & \vdots & & \vdots \\ a_{1n} & a_{2n} & \cdots & a_{nn} \end{bmatrix} = \begin{bmatrix} c_1a_{11} & c_1a_{21} & \cdots & c_1a_{n1} \\ c_2a_{12} & c_2a_{22} & \cdots & c_2a_{n2} \\ \vdots & \vdots & & \vdots \\ c_na_{1n} & c_na_{2n} & \cdots & c_na_{nn} \end{bmatrix} = \hat{c}.A^{'} \qquad (2)$$

Thus, with respect to this assumption, the relationship (1) changes as follows:

$$P^{'} = [I - \hat{c}.A^{'}.(I - \hat{b})]^{-1}.(\hat{c}.A^{'}.\hat{b}.p_m + \bar{Y}) \qquad (3)$$

As the second step, it is assumed the new technology changes the share of domestic and foreign goods and services in the supply of products. To consider this change, it is assumed b_is change into $b_i^{'} = b_i.d_i$. With respect to the value of d_is the result of the new technology may lead the country to more self sufficient, $d_i < 1$, or more dependent, $d_i > 1$, to the foreign countries.

Thus, the second assumption of the model changes the relationship (3) as follows:

$$\begin{aligned} P^{''} &= [I - \hat{c}.A^{'}.(I - \hat{b}^{'})]^{-1}.(\hat{c}.A^{'}.\hat{b}^{'}.p_m + \bar{Y}) = \\ &[I - \hat{c}.A^{'}.(I - \hat{d}.\hat{b})]^{-1}.(\hat{c}.A^{'}.\hat{d}.\hat{b}.p_m + \bar{Y}) \end{aligned} \tag{4}$$

$\hat{d}$ is the diagonal matrix of d_is.

In addition, the new technology affects the primary factors of production sectors. Its implementation causes two different changes concerning the primary factors of the model. In one side, it may change the ratio of primary factors to each other. In the other side, it changes the share of primary factors in total input of the sectors. Thus, the third step stresses to consider these effects as well. To do so, let us decompose $\bar{Y}$ the share of primary factors into some devices:

$$\bar{Y} = \begin{bmatrix} k_1 & l_1 \\ k_2 & l_2 \\ \vdots & \vdots \\ k_n & l_n \end{bmatrix} \times \begin{bmatrix} v \\ w \end{bmatrix} \tag{5}$$

k_i and l_i denote the level of capital stock and labour force that is required for a unit product, respectively. v and w refer to the prices of capital stock and labour force, respectively.

Using the new technology may affect the value of k_i and l_i of the sectors. Let e_i and f_i denote the coefficients to measure the change in these factors due to implementation of the new technology. Consequently, $l_i^{'} = e_i.l_i$ and $k_i^{'} = f_i.k_i$. Thus:

$$\bar{Y}^{'} = (k^{'}.v + l^{'}.w) = (\hat{f}.k.v + \hat{e}.l.w) \tag{6}$$

$\bar{Y}'$ refers to the column vector of the share of primary factors after new technology implementation, including k' and l' the two column vectors in which k_i' and l_i' are the size of capital stock and labour force of sectors after the new technology implementation, respectively. Finally, $\hat{f}$ and $\hat{e}$ denote the diagonal matrices of f_i and e_i, respectively.

Thus in the third step, the relationship (1) to measure the effect of new technology implementation on the prices of sectors is as follows:

$$P''' = [I - \hat{c}.A'.(I - \hat{d}.\hat{b})]^{-1}.(\hat{c}.A'.\hat{d}.\hat{b}.p_m + \hat{f}.k.v + \hat{e}.l.w) \qquad (7)$$

To examine the result of the new technology on the prices of sectors, values of $\hat{c}, \hat{d}, \hat{f}$ and $\hat{e}$ would be specified.

A similar process is required to measure the change in the employment level of sectors. To do so, we consider *b*, the share of imports in supply of sectors in a general employment relationship:

$$L = \hat{l}.Q = \hat{l}.(I - (I - \hat{b})A)^{-1}.(I - \hat{b}).F \qquad (8)$$

L denotes the column vector of L_i, the level of employment in different sectors, $\hat{l}$ the diagonal matrix of direct employment coefficient of labour force, *Q* the column vector of total products of sectors and *F* the final demand of sectors.

Irrespective to the change that may happen in the construction of final demand of sectors, like the price model, the implementation of a new technology can influence this relationship in four ways. Considering the above mentioned effects changes the relationship (8) into the relationship (9):

$$L' = \hat{e}.\hat{l}.[I - (I - \hat{d}\hat{b}).A.\hat{c}]^{-1}.(I - \hat{d}\hat{b}).F \qquad (9)$$

where L' is a column vector that contains the size of labour force of sectors after the new technology implementation.

Implementation of the model

The model is employed to study the effects of nanotechnology implementation in Iran. A 17 to 17 sectors I-O table of Iran for the year 2001 is used as database (Central Bank of I.R. Iran 2006). Using the employment data of sectors for the years 1986, 1991 and 1996, the number of labour force of sectors is estimated for the year 2001.

The results of change in technical coefficients using the relationship (3) are simulated in table (1). In the case in which the new technology affects only the technical coefficient of sectors, a 5% reduction in intermediate inputs of all sectors leads to a reduction in the Producer Prices Indices (PPI). However, the differences of PPI for different levels of c_is demonstrate that the effects of reduction in the technical coefficient of sectors on the PPI are decreased.

Using the relationship (4) enables the researcher to study the result of change in the share of imports due to nanotechnology implementation. It is notable, although using a new technology may affect the amount of imports in two ways, however it is more expected that a higher technology lead to a reduction in the share of imports. To this end, table (2) shows the results of a new technology implementation on PPI when the new technology leads to a reduction in technical coefficient and imports shares in supply. It shows the effects of Reduction in the size of the Imports Shares in Supply (RISS) on the PPI for three levels of c_i s. The column differences explore the change in PPI as a result of 0.05 RISS.

Table (1): Simulation of the result of change in the technical coefficients on PPI

Row	c_is	*PPI*	differences	Row	c_is	*PPI*	differences
1	1	1	-	11	0.5	0.783	0.0177
2	0.95	0.973	0.0265	12	0.45	0.766	0.0169
3	0.9	0.948	0.0252	13	0.4	0.750	0.0163
4	0.85	0.924	0.0241	14	0.35	0.734	0.0156
5	0.8	0.901	0.0230	15	0.3	0.719	0.0151
6	0.75	0.879	0.0219	16	0.25	0.705	0.0145
7	0.7	0.858	0.0210	17	0.2	0.691	0.0140
8	0.65	0.838	0.0201	18	0.15	0.677	0.0134
9	0.6	0.819	0.0192	19	0.1	0.664	0.0130
10	0.55	0.801	0.0184	20	0.05	0.652	0.0125

It is notable, although compared with the reduction in c_is, the RISS has small effects on the PPI, as it is expected, and its effect is dependent to the size of c_is. Due to nonlinearity form of $\hat{d}$ in relationship (4), a 0.05 RISS has different effects on the PPI. As a result of a comparison between the change in PPI through different columns of table (2), it is explored the effects of RISS on the PPI has a controversy relationship with the level of imports shares. However, although the size of c_is affect the impact of RISS on the PPI, as it is demonstrated in table (2), its effect has no unit trend on PPI. So a comparison in the amount of differences in PPI reveals a reduction in the value of c_is from 0.95 to 0.50 leads to an increase in the effects of RISS on PPI, whereas a reduction in the value of c_is from 0.50 to 0.05 leads to a considerable decrease in the level of differences in similar cases of d_is.

Table (2): Simulation of the result of reduction in technical coefficient and the imports share on PPI

Row	d_is	c_is=0.95		c_is=0.50		c_is=0.05	
		PPI	differences	*PPI*	differences	*PPI*	differences
1	1	0.9735	-	0.7830	-	0.6518	-
2	0.95	0.9734	-0.000105	0.7827	-0.000379	0.6517	-0.00005262
3	0.90	0.9733	-0.000106	0.7823	-0.000381	0.6516	-0.00005264
4	0.85	0.9732	-0.000107	0.7819	-0.000382	0.6516	-0.00005265
5	0.80	0.9731	-0.000108	0.7815	-0.000384	0.6515	-0.00005267
6	0.75	0.9729	-0.000109	0.7811	-0.000385	0.6515	-0.00005269
7	0.70	0.9728	-0.000110	0.7807	-0.000387	0.6514	-0.00005271
8	0.65	0.9727	-0.000111	0.7804	-0.000388	0.6514	-0.00005273
9	0.60	0.9726	-0.000112	0.7800	-0.000390	0.6513	-0.00005274
10	0.55	0.9725	-0.000113	0.7796	-0.000391	0.6513	-0.00005276
11	0.50	0.9724	-0.000114	0.7792	-0.000393	0.6512	-0.00005278
12	0.45	0.9723	-0.000115	0.7788	-0.000395	0.6512	-0.00005280
13	0.40	0.9722	-0.000116	0.7784	-0.000396	0.6511	-0.00005282
14	0.35	0.9720	-0.000117	0.7780	-0.000398	0.6511	-0.00005284
15	0.30	0.9719	-0.000118	0.7776	-0.000400	0.6510	-0.00005285
16	0.25	0.9718	-0.000119	0.7772	-0.000401	0.6510	-0.00005287
17	0.20	0.9717	-0.000120	0.7768	-0.000403	0.6509	-0.00005289
18	0.15	0.9716	-0.000122	0.7764	-0.000404	0.6509	-0.00005291
19	0.10	0.9714	-0.000123	0.7760	-0.000406	0.6508	-0.00005293
20	0.05	0.9713	-0.000124	0.7756	-0.000408	0.6508	-0.00005295

The effects of different factors are examined in relationship (7). With respect to its form, it can be deduced that the effect of a new technology implementation on the PPI can be decomposed into three devices. Table (3) demonstrates a case in which c_is and d_is are equal to one. On the other hand, the new technology has affected only the e_is or f_is or both of them. As it can be seen, due to linear form of these factors in the model, first the effect of a specified decrease in the value of e_is and f_is are constant for any level of these factors, secondly, the effects of a specified reduction in the value of these factors on the PPI is independent of the others. However, a reduction in the value of f_is has more impact on the PPI in comparison with e_is.

Table (3): Simulation of the result of reduction in labour force and capital stock coefficient on PPI

Row	e_is/ f_is/ e_is & f_is	e_is		f_is		e_is & f_is	
		PPI	differences	*PPI*	differences	*PPI*	differences
1	1	1	-	1	-	1	-
2	0.95	0.991	-0.009154	0.963	-0.037361	0.953	-0.046516
3	0.90	0.982	-0.009154	0.925	-0.037361	0.907	-0.046516
4	0.85	0.973	-0.009154	0.888	-0.037361	0.860	-0.046516
5	0.80	0.963	-0.009154	0.851	-0.037361	0.814	-0.046516
6	0.75	0.954	-0.009154	0.813	-0.037361	0.767	-0.046516
7	0.70	0.945	-0.009154	0.776	-0.037361	0.721	-0.046516
8	0.65	0.936	-0.009154	0.738	-0.037361	0.674	-0.046516
9	0.60	0.927	-0.009154	0.701	-0.037361	0.628	-0.046516
10	0.55	0.918	-0.009154	0.664	-0.037361	0.581	-0.046516

To investigate the effects of reduction in technical coefficient and RISS as well as e_is and f_is, table (4) demonstrates the effects of e_is and f_is on PPI in the case in which c_is and d_is are equal to 0.75, 0.5 and 0.25. As it is shown, implementation of more efficient technology that leads to more reduction in c_is and d_is, leads to more reduction in PPI. This is due to c_is and d_is that are located as constant item and multiplier for e_is and f_is in the relationship (7), where a reduction in the value of these parameters leads to a reduction in PPI and consequently the size of their differences.

Table (4): Simulation of the result of reduction in labour force and capital stock coefficient on PPI

Row	e_is & f_is	c_is & d_is=0.75		c_is & d_is=0. 50		c_is & d_is=0. 25	
		PPI	differences	*PPI*	differences	*PPI*	differences
1	1	0.878	-	0.779	-	0.701	-
2	0.95	0.835	-0.042	0.741	-0.038	0.666	-0.035
3	0.90	0.793	-0.042	0.703	-0.038	0.631	-0.035
4	0.85	0.751	-0.042	0.664	-0.038	0.596	-0.035
5	0.80	0.709	-0.042	0.626	-0.038	0.561	-0.035
6	0.75	0.667	-0.042	0.588	-0.038	0.527	-0.035
7	0.70	0.625	-0.042	0.550	-0.038	0.492	-0.035
8	0.65	0.583	-0.042	0.511	-0.038	0.457	-0.035
9	0.60	0.541	-0.042	0.473	-0.038	0.422	-0.035
10	0.55	0.499	-0.042	0.435	-0.038	0.387	-0.035

Table (5) measures the reduction in employment for labour force due to using a new technology. As it is shown, the effects of a 5% Reduction in Labour Force Coefficient (RLFC) due to a new technology implementation are displayed for different levels of c_is and d_is. Due to linear relationship of e_is with the size of labour force employment in relationship (9), a 5% RLFC has a constant effect on employment reduction in different levels of e_is. However, the effects of RLFC on the reduction in labour force employment are dependent to the value of c_is and d_is.

Table (5): Simulation of the result of reduction in labour force coefficient on employment reduction

Row	e_is	c_is & d_is=1		c_is & d_is=0.75		c_is & d_is=0. 50	
		Employment Reduction	differences	Employment Reduction	differences	Employment Reduction	differences
1	1	0	-	1230826	-	2339816	-
2	0.95	801808	801808	1971093	740267	3024634	684817
3	0.90	1603617	801808	2711360	740267	3709451	684817
4	0.85	2405425	801808	3451627	740267	4394269	684817
5	0.80	3207233	801808	4191894	740267	5079086	684817
6	0.75	4009042	801808	4932161	740267	5763904	684817
7	0.70	4810850	801808	5672428	740267	6448721	684817
8	0.65	5612658	801808	6412695	740267	7133539	684817
9	0.60	6414467	801808	7152962	740267	7818356	684817
10	0.55	7216275	801808	7893229	740267	8503174	684817

Table (6): Simulation of the result of RISS on the labour force employment

Row	d_is	c_is =1		c_is =0.75		c_is =0. 50	
		Employment Changes	differences	Employment Changes	differences	Employment Changes	differences
1	1	0	-	-1723181	-	-3102598	-
2	0.95	128934	128934	-1625947	97234	-3027634	74965
3	0.90	259068	130134	-1528101	97846	-2952382	75252
4	0.85	390420	131352	-1429637	98465	-2876841	75541
5	0.80	523008	132588	-1330547	99090	-2801010	75831
6	0.75	656850	133842	-1230826	99721	-2724886	76124
7	0.70	791966	135116	-1130467	100359	-2648468	76418
8	0.65	928374	136408	-1029465	101003	-2571754	76714
9	0.60	1066094	137720	-927811	101654	-2494742	77012
10	0.55	1205146	139052	-825500	102311	-2417430	77312

And finally table (6) investigated the effects of reduction in d_is on labour force employment. To do so, it is assumed e_is is constant on one. As it is expected c_is and d_is have contrary effects on the labour force employment. So any decrease in the value of d_is has a positive effect on the number of labour force employment. Thus, in the case, e_is is equal to one, a decrease in d_is leads to an increment in the level of employment. On the other hand, the new technology that does not change the technical coefficient, any RISS leads to an increase in the level of employment. However, for the cases in which the new technology leads to reduction in the size of c_is to 0.75 or 0.50, the results of simulation demonstrated up to 50% reduction in d_is cannot compensate the reduction in employment for labour force.

Conclusions

It was concluded the world would be witnessed to some changes through popularity using the nanotechnology in future. Irrespective to its change in the level of consumption and the quality of commodities or environmental effects, like any other technology, it is expected implementation of nanotechnology will have some positive and negative effects on the social and economic aspects of the people's life through production process. However, among all impacts, this paper focuses on employment and Producer Prices Indices.

Based on the result of the research, implementation of the nanotechnology affects the production cost through several ways. It was demonstrated an improvement due to this technology in the technical coefficients lead to a reduction on the PPI of the economy. Implementation of the nanotechnology affects the PPI through the share of imports in the supply of products. However, like the technical coefficients it has nonlinear relationship with PPI. Moreover, the result of the research demonstrates the change in labour and/or capital stock contribution due to nanotechnology implementation which has/have a direct linear relationship with PPI as well.

In addition, a related model was developed to simulate the effect of nanotechnology implementation on labour force employment. Like PPI, the results of simulation of the model demonstrates, the change in the size of labour force direct coefficients due to the nanotechnology implementation which has a linear direct effect on the size of employment of labour force, in which the size of this change is related to the values of c_is and d_is. However, unlike PPI, the sizes of employment for labour force have contrary effects to the changes in c_is and d_is.

And finally like any new technology it seems the nanotechnology implementation leads to a change in the structure of labour force and the quality of capital stock. On the other hand, it is anticipated the implementation of nanotechnology needs more technical labour. Thus it is recommended the future research focus on the effect of nanotechnology implementation on the structure of labour force and new jobs that may be created due to this technology.

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