THE EFFECTS OF R&D CAPITAL STOCKS OF TRADE PARTNERS ON TFP

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ABSTRACT

This study seeks to answer the question of whether the research and development (R&D) capital stocks of the industrial countries, namely Iran’s trade partners, is significantly effective on total factor productivity level. To answer the aforementioned question, the total factor productivity equation is estimated considering the independent variables of the R&D capital stocks of trade partners, human capital and the degree of openness to trade with the partners and the dependent variable of total factor productivity level, using Ordinary Least Squares Method (OLS) and the set of time-series data between the years 1992-2009. The main hypothesis explains that the R&D capital stocks of Iran’s trade partners has a significant effect on total factor productivity level. The results indicate that the R&D capital stocks of trade partners, human capital and the share of imports of gross domestic product (GDP) have respectively the most positive effect on total factor productivity.

KEYWORDS: Total Factor Productivity, R&D of trade partners, human capital, trade

The examination of the economic growth components in developed countries and some of the developing countries which have outrun other similar countries shows that the growth share of total factor productivity level in the acceleration of economic growth has outrun the share of human capital and labor force.

Developed countries have largely invested in R&D activities promoting new technologies, products and materials therein. One might question whether the benefits of R&D are exclusive to the investing countries or not, or whether it is possible for developing countries, like Iran, to boost their productivity through trading with the countries which enjoy a great proportion of knowledge in production, resulting from research and development, via importing intermediate goods and capital equipment, and also inquiring for the related information, failing to do so would burden them with heavy costs. Thus, this study seeks to answer whether the R&D capital stocks of a country’s trade partners is significantly effective on its TFP level. In economy planning, assessing economic growth resources, identifying effective factors on these resources, determining their share and procedures are emphasized. According to the latest theories of economic growth, one of the resources of economic growth in every country is its increase of domestic knowledge. Furthermore, the most recent international trade theories recognize the use of the accumulated knowledge lying in the import of goods resulting from the R&D activities of trade partners as one of the ways through which domestic knowledge can be boosted: and, the aim of the present research is to examine the level of effect of the R&D capital stocks of trade partners on TFP as one of the indices of economic growth. So, the main hypothesis of the present study can be best explained as the R&D capital stocks of Iran’s trade partners significantly affect total factor productivity of the country. As a secondary hypothesis to this piece is that the more open Iran’s economy is to the foreign trade, the stronger the impact of the stocks of R&D capital of the Iran’s trade partners on TFP of Iran’s economic factors would be.

Since the previous studies about Iran investigated the positive effects of the R&D capital stocks of Iran’s trade partners on the country’s economy through the international trade between Iran and OECD members, this research attempts to analyze the importance and intensity of the effect of the above-mentioned, with the difference being Iran’s international trade with a number of its major partners among other industrialized countries during the years 1992-2009 including Germany, France, Italy, Japan, Russia, the UK, Belgium will be examined. Also, according to the fact that after the Islamic Revolution of Iran, and due to the economic sanctions, Iran-Iraq War, and the country’s disaffiliation with the United States, Dubai became a major trade partner for Iran and since then, it has been functioning as a junction to transport the commodities of the industrial countries. As a result, in this study, the UAE is considered to be central, and its R&D capital stocks has been deemed to be indicative of other OECD members’ average (Shahabadi, 2001).

The order following which this research intends to proceed shall be: a review of the literature as the second, an introduction of the model and data as the third, a presentation of the estimates as the fourth, and the conclusion and suggestions as the fifth chapter.
A REVIEW OF THE LITERATURE

Theoretical Basis

Research and development can boost the productivity rate by raising the level of innovation, and also, by increasing the potential of technological simulation to pave the way for new R&D fields of trade partners, and consequently, improve the capacity of technology transmission. To bring the statement to a finale, it is possible to conclude that technological simulation plays a pivotal role in those countries which lag behind the developed ones (Shahabadi, Rahmani, 2012).

A Model: The Role of International R&D in the Increase of the Productivity of the Developing Countries

Based on the latest theoretical arguments on economic growth, Coe, Helpman and Hoffmaister (2008) assume that the concept of international trade plays an important role in the R&D spillovers from developed to less developed countries. The truth is that nowadays most of the R&D expenditures are paid for by the developed countries. The reason why they meticulously concentrate on these activities is that they lead to the technological advances of the production process and the improvement of the quality of new products. In addition, the rate of return on the investments in the field of R&D is by far higher than those of structures and industrial machinery and equipment. In a study conducted by Coe, Helpman and Hoffmaister, it was pointed out that for a developing country to benefit from the international trade, it is necessary that it attracts those trade partners who are capable of preparing and providing the products and information it lacks. It also depends on the accumulated knowledge of the trade partners which seeks to emanate itself in the form of their products and technology. Therefore, should a developing country trade with industrial countries which have a better stocks of technical knowledge, it will gain more benefits than when it does the same trade with its developing partners, considering the products and direct technical knowledge it can import. Moreover, recent advances in the theories of international trade and economic growth have recognized the ways through which the productivity of different countries relate to each other. The Four ways that Grossman and Helpman (1991) determine are as follows:

1- International trade provides a wider range of varieties of intermediate products and capital equipment for the developing countries by using which they can improve the productivity of their own resources.

2- International trade attempts to incentivize the foreign countries to master new methods of production, product design, and organization. The improvement of each of the aforementioned dimensions helps make a more efficient use of the domestic resources, thus adjusts the mix of products in a way that every input enjoys the value added per unit.

3- The international contacts of a country makes it possible to copy the foreign technology and to modify it in conformity with the domestic use. This function has played a basic and important role in the economic development of Japan and the newly industrialized East-Asian countries.

4- International trade can indirectly increase the productivity by developing the new technology or imitating its foreign kind.

International trade stands as the best means of transmitting productivity. However, apart from the first way explained above, the rest three work through foreign direct investments (Coe & Helpman, 1995). Theoretically, foreign trade helps to increase the domestic productivity through two ways as follows:

1- Through transmission the products which have the foreign knowledge internalized, and;

2- Providing the possibility to freely access the information of the foreign countries. Unless the access becomes feasible, other countries will be burdened with heavy costs.

These ways are both important to the developing countries which are far behind the technology frontiers. The country which seeks to benefit from the foreign trade through the aforementioned ways needs trade partners which can supply it with appropriate products and information. It needs to be mentioned that such capabilities depend heavily on the exporting country’s accumulated knowledge lying in its products, technology and organizational methods. As a result, in comparison to its trade with a developing country, a country’s trade with an industrial partner would provide more advantage due to the better commodities it can import and the direct technology it can gain access to. Subsequently, by calculating the weighted average of the stocks of the domestic R&D capital of trade partners for every developing country, proxy of the degree of openness to trade is determined based on the estimate of the ratio of imports from industrial countries to GDP. Theoretically, the more the stocks of R&D of the trade partners, the
higher TFP level; and also, the more open a country’s economy, the higher its productivity (Coe et al., 1995).

As discussed in the recent theories on the economic growth and international trade, the model used by Coe, Helpman and Hoffmaister in their article is based on Grassman and Helman’s (1991) work and also on the general form of Cobb-Douglas Production Function, the dynamic economic scale, monopolistic competition and the existence of vertical- and horizontal-differentiated intermediate inputs. For example, the Cobb-Douglas Production Function is as follows:

\[
(1) \quad Y = AK^\alpha L^\beta V^\gamma D^{1-\beta-\gamma}
\]

The equation above expresses that TFP level in developing countries is dependent on the domestic R&D capital stocks, and on the R&D capital stocks of the trade partners, the degree of openness of the developing country’s foreign trade in relation to the industrial countries and the number of their trained labor force. So, if the logarithm of the production function is taken, the result will be as follows:

\[
(2) \quad \log Y = \log A + \beta \log K + \gamma \log L_V + (1 - \beta - \gamma) \log D
\]

Where \( Y \) is production, \( A \) is a fixed parameter, \( L_V \) is the labor force used to produce the final output \( Y \), \( D \) is the CES indicator of the intermediate inputs, \( K \) is the capital, and \( \gamma \) and \( \beta \) are the parameters between 0 and 1.

In equilibrium, the equation will be:

\[
(3) \quad D = n^{\frac{1}{\beta - \gamma}} L_D
\]

Where \( n \) is the number of accessible intermediate inputs, \( L_D \) is the labor force used to create the intermediate inputs, and \( \beta > 1 \) is the elasticity substitution.

Now, by assigning a value to the intermediate inputs and the demands for them, it will turn to:

\[
(4) \quad \log Y = \log A + \beta \log K + (1 - \beta) \log L + \left[ \frac{(1-\beta-\gamma)}{(\beta - 1)} \right] \log n
\]

Where \( \beta \) is a fixed effect, and \( L \) equals \( L_V + L_D \).

Now, the equation is:

\[
(5) \quad F = \frac{\gamma}{(\alpha_0 L^{1+\beta})}
\]

Where \( F \) stands for the total factor productivity, and \( L_D \) for the labor force directly used in research and development.

Therefore, the equation shall be:

\[
(6) \quad \log F = \log B + \left( \frac{1-\beta-\gamma}{(\beta-1)} \right) \log n
\]

Where \( n \) is also reflective of the stocks of R&D capital. Hence, by using the Cobb-Douglas production function, it becomes clear that TFP depends on the R&D capital stocks, and as the international trade increases the access to various intermediate and capital products, \( n \) will be of a greater amount if the economy is open, which means the increase in the international trade does have an impact on the level of TFP.

Although, theoretically, the total factor productivity depends on the domestic R&D capital stocks and the R&D capital stocks of the trade partners, the domestic R&D capital stocks were not considered to be a variable in the mentioned model due to the lack of information about that of the developing countries. On the other hand, since the productivity also depends on the quality of the human capital and, due to the scarcity of correct criteria to qualify them, the secondary school enrollment rate was used as a proxy instead of the missing variable.

It’s also been said that a more trained labor force can contribute to increasing the level of productivity by more efficiently using the resources and attracting the knowledge of the trade partners. Thus, it can be concluded that the total factor productivity depends on the spillovers of the R&D capital stocks of the trade partners, the degree of openness to trade with industrial countries, educational capabilities and the time trends, considering the other variables. The simplest model can be referred to as follows:

\[
(7) \quad \log F_{it} = \alpha_0^i + \alpha_5 \log S_{it} + \alpha_6 M_{it} + \alpha_7 E_{it} + \alpha_8 \log T_{it} + \mu_{it}
\]

Where \( i \) and \( t \) stand for the country index and the time period. \( F \) is the total productivity of factors; \( \alpha_0^i \) is the parameter of the country specified; \( S \) is the R&D capital stocks of trade partners; \( E \) is the secondary school enrollment cost; \( M \) is the share of import from the industrial countries toward the GDP of a developing country; \( T \) is the time trend; \( \mu \) is the error term; \( \alpha_4 \) is the elasticity of TFP toward the R&D capital stocks of trade partners; \( \alpha_5 \) is the elasticity of TFP toward human capital; and \( \alpha_6 \) is the elasticity of TFP toward the share of import.

As argued that the R&D capital stocks of the trade partners can both directly and indirectly impact the productivity, it is probable that the interaction
between the stocks of the R&D capital of the trade partners and the share of import (M_{it}S_{it}), and those with the school enrollment rate (E_{it}S_{it}) leads us to estimate the following model:

\[ \log TFP_{it} = \alpha_0^M + \alpha_1^S \log S_{it} + \alpha_2^M M_{it} + \alpha_3^M E_{it} + \alpha_4^{SM} M_{it} \log S_{it} + \alpha_5^{SM} E_{it} \log S_{it} + \alpha_6^{T} T_{it} + \mu_{it} \]

Where \( i \) is the index of the country; \( t \) is the time index; \( \log TFP \) is the logarithm of total productivity of factors; \( S \) represents the R&D capital stocks of trade partners; \( M \) is the share of imports from industrial countries in developing country GDP; \( E \) stands for the human capital; \( T \) is the time trend; \( \alpha_0^M \) is the elasticity of TFP toward the R&D capital stocks of trade partners; \( \alpha_1^S \) is the elasticity of TFP toward the share of imports; \( \alpha_2^M \) is the elasticity of TFP toward human capital; \( \alpha_5^{SM} \) shows the elasticity of TFP toward the interaction between the availability of the R&D capital stocks of the trade partners; \( \alpha_6^{T} \) indicates the interaction between the availability of the R&D capital stocks of trade partners, and the human capital; \( \mu \) is the error term.

Provided that the estimated interaction between the R&D capital stocks of trade partners is positive, which is \( \alpha_5^{SM} > 0 \), then we’ll have a greater impact from the foresaid factors on the productivity when the degree of trade openness with foreign countries is higher. Also, there shall be a heavier impact from the foreign trade on the productivity when the R&D capital stocks of trade partners are of higher quantities. Similarly, about the educational interactions, and under the circumstance which shows that \( \alpha_6^{SE} > 0 \), the impact of the spillovers of the R&D capital stocks of the trade partners on the productivity will be heavier when the domestic labor force is more trained. Also, the effect of education on the productivity will be greater when the R&D capital stocks of trade partners is of a higher amount.

**Experimental Studies**

In this chapter, we intend to review some of the previous studies conducted in the field:

Coe et al. (2009) investigated the effect of the institutions and the international R&D spillovers on the total factor productivity level of OECD members during the years 1970-2004. As it comes from the results, the positive impact of the domestic and foreign R&D capital stocksis confirmed. Additionally, the article maintains that although the human capital is positively effective on the total factor productivity, the domestic and foreign R&D capital stocks is still of paramount significance and measurable in terms of its impact on the TFP, even if the effect of the human capital is considered to be fixed. A resultant statement could be that the institutional differences regarding the degree of impact in the matter of the R&D spillovers are determinants of the TFP thereof.

Nishioka and Ripoll (2012), through their article, named “Productivity, trade and the R&D content of intermediate inputs”, attempted to assess the relation between the industry-level TFP and available in the imported intermediate goods. The experimental results of this study show that the R&D spillovers is almost limited when in the channel of the intermediate goods. In fact, this channel is solely related to the high-R&D industries.

Schiff and Wang (2008), in their article, evaluated the share of the openness of economy and R&D toward the productivity through trade for the technology diffusion from the north to the south. The results show that:

1- in comparison to the R&D content of trade, the degree of the openness of economy has a greater impact on the total factor productivity level in developing countries; and,

2- in developing countries, the impact of foreign R&D gained through trade on the total factor productivity level is significantly weak (nearly zero) in the industries which have low rates of R&D. And, in those which have a high R&D rate, it can be positive.

Crespo et al. (2004), in a study, investigated the effects of the technology spillovers resulting from the international trade, considering the technology gap which exists between different countries. By using the model suggested by Benhabib and Spiegel(1994), they concluded that the domestic R&D capital stocks, and the human capital are pretty much considerable in attracting the technology of the trade partners, in a way that those countries which enjoy a higher potential of human capital can excel at gaining the advantages of the international technology spillovers.

Coe et al.(1997) try to evaluate whether smaller developing countries, via trade with industrial countries which are rich in their R&D activities, can gain profit or not. Therefore, a developing country can increase its productivity through importing various intermediate products and foreign-technology-made capital facilities, and also through mastering the new technology and accessing the new materials, such as production processes or organization methods. For a
developing country to be able to benefit from the foreign trade, it seems essential that it have those trade partners which are capable of preparing and supplying the products and information it lacks.

Komeyjani and Shahabadi (2001), in their study assessed the role of the stocks of the domestic R&D capital, and the stocks of the foreign R&D capital of the trade partners in the total productivity of the production factors of Iran through foreign trade during the years 1969-2000. The trade partners on whom the research was carried out include 22 members of the OECD and the UAE. This article claims that on the condition that the international trade is achievable, the country can use more inputs provided by its trade partners to boost its level of productivity. The results show that the variable of the stocks of the foreign R&D capital has a significant impact on the ratio of the imports to the country’s GDP, and also, on the ratio of the educated employees to the total productivity of the production factors. The stock of foreign R&D capital has a stronger impact on the growth of total productivity of the production factors when compared to its domestic kind. In other words, the more a developing country possesses more human capital and a more open economy, the more influential the stocks of the foreign R&D capital will be on total productivity of the production factors.

Behboodi and Mamipoor (2009) in an article investigated the effects of the knowledge spillovers resulting from the international trades on total productivity of the production factors in Iran during the years 1996-2005. This examination was carried out on the basis of a clear-cut division between the economic sections using the Panel Data method. In this study, the following sections will be considered separately: industry and mining, agriculture, and construction (housing). The results show that the domestic R&D expenditures of the economic sections have had a dramatic effect on the total productivity of the production factors. Also, in terms of the impact of the knowledge spillovers via the import of the intermediate and capital goods, it can be concluded that importing both the intermediate and the capital goods are positively effective on the total productivity of the production factors, with the difference being that the impact which the import of the capital goods leaves on the total productivity of the production factors is greater than that of import of the intermediate ones. Additionally, foreign direct investment has had a positive, significant effect on the total productivity of the production factors. The human capital also implies the probability of an expectable impact.

In another article penned by Shahabadi and Rahmani (2012) the role of the domestic and foreign R&D via the import of intermediate and capital goods in increasing the total productivity of the production factors of the industry sector of Iran’s economy has been assessed during the years 1959-2008. The results indicated that the stocks of the domestic research and development capital, the stocks of the foreign R&D capital, and the human capital (the ratio of the educated to the employed) have had positive and statistically meaningful effects on increasing of the total productivity of the production factors of Iran’s industry sector. However, the positive impact of the stocks of the domestic research and development on the total productivity of the production factors has been weaker and not statistically meaningful. Also, if the industry sector of Iran’s economy enjoys a bigger population of the educated, employed people, which refers to the time when its human capital is higher, the foreign R&D stocks will have a stronger influence on the total productivity of the production factors in this sector.

**MODEL SPECIFICATION**

To work out what the present study seeks to answer, the model suggested by Coe, Helpman, and Hoffmaister (1997) will be used involving the variables of interaction between the R&D capital stocks of trade partners, human capital, and the degree of openness to trade with trade partners and also the dependent variable of TFP level. To do so, the domestic R&D expenditures of the trade partners are considered as an index of trade partners of R&D capital stocks, the import share from GDP as an index of the degree of openness to trade with the trade partners and the high school enrollment rate as one of the human capital. To test the hypothesis, the model was estimated using OLS method and the time series data:

The required data for this study has been extracted from WDI, Iran’s Customs, Central Bank of Iran and MSTI.

**RESULTS**

To test the effectiveness of the R&D capital stocks of trade partners on the level of TFP, the aforementioned equation was embedded using the OLS method. In addition, to avoid the estimate of a spurious regression, the stationary of the variables of the total factor productivity were examined using the augmented Dickey-Fuller test. the results show that all variables are stationary at levels.
To avoid the probable problems in regression before estimating it, diagnostic tests were carried out, such as the White test to detect the heteroscedasticity, the Durbin-Watson test statistic to detect the presence of autocorrelation, and the normality tests of residuals. The results diagnostic tests showed that there did not exist any problem in the specification.

The results of estimation indicate that the R&D capital stocks of trade partners has a positive and significant effect on TFP level, and each 1% increase in the R&D capital stocks of trade partners results in 0.35% increment at TFP level. In the long run, the share of imports shall have a significantly positive impact on TFP. Therefore, we can say that by every 1% increase in the share of import of the trade partners to Iran’s GDP, it will lead to 0.026% increment in TFP level. Also, human capital is positively and significantly effective on the TFP level, which means that the higher the human capital, the higher TFP level; and each 1% increase of human capital will lead to a 0.044% increment in TFP level. Furthermore, the results of the estimates show that the variable of the interaction of the import share and the logarithm of R&D capital stocks of trade partners has a significantly negative impact on TFP level, which means that should Iran’s share of import from the trade partners increase, the impact of the R&D capital stocks of the trade partners on TFP level becomes weaker. In addition, there is a negative and statistically significant relation between the interaction of human capital and the logarithm of the R&D capital stocks of trade partners and TFP, meaning that by increasing the human capital in the country, the effect of the R&D capital stocks of the trade partners on TFP level will go down. The results gathered from the variable of time trend are indicative of a positive and significant relation with TFP level. The quantity of $R^2$ statistic shows that 88% of the changes at TFP level shall be explained through the other variables included in the specification, making it feasible to claim that the chosen variables were properly selected for the purpose of estimating the model.

According to the theories of endogenous growth and international trade, the boost in the competitiveness strength and the growth of TFP of the countries depends on the technological advances; a principal which can come true by the realization the international R&D spillovers through the import of intermediate products and capital equipment. As construed by the recent theories of international trade, should the international trade becomes practical, the country’s economy shall be able to achieve intermediate products, capital equipment, and copy the technology of
the trade partners for domestic use, and promote the level of total factor productivity. According to these theories, the R&D capital stocks of trade partners enjoys a special hierarchy in TFP growth. The our results indicate that the independent variable of the R&D capital stocks, human capital and the share of import in GDP has a positively significant impact on TFP level, yet the effect of the interaction between the import share and the logarithm of the R&D capital stocks of trade partners on TFP level is negative.

CONCLUSION

That a majority of the R&D expenditures are paid for in the industrial countries appears to be an undeniable fact. The maximum attention paid to the R&D activities in these countries is certainly the reason why they achieve technological advances, production-process improvement, new product creation and TFP promotion. Now, it can be concluded that by transmitting these capital stocks(including consistency, attraction, function, development and diffusion) from these countries, an important step can be taken to boost Iran’s TFP. After all, taking the present estimates into account, it is seriously essential that the supervision on the selection process be well established to choose the trade partners with high rates of R&D capital stocks aiming at attracting and localizing the technology. To serve this purpose, the country’s human capital should be boosted, the labor force should be incentivized to be innovative, and finally, the results gained from the R&D spillovers of the trade partners should be used to produce new products.

REFERENCES


