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The Role of Foreign Direct Investment, Technology Transfer and Spillover Effects on Economic Growth: A GTAP model

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Abstract
The main objective of this paper is to investigate the effects of technology transfer through the imports of intermediate goods by developing countries developed countries with the emphasis on Iran economy. For this purpose, we used multi-sectoral and multi–regional computable general equilibrium GTAP model (multi-sectoral and multi-regional CGE model). The paper examined the effect of a ten percent productivity shock in high-tech industries of industrial countries on economic sectors of Iran. The result shows that technology transfer embodied in Iran's imports of intermediate goods leads to increase in outputs and decrease in prices. Factors such as absorptive capacity, structural similarity and effectiveness contributed to the spillover effects of technological improvements in Iran.

Keywords: Technology Transfer, Foreign Direct Investment, Spillover effects, Trade, Economic Growth, CGE Model, GTAP, Iran.
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1. Introduction

Technology transfers have strong impact on economic development and increase in international competitiveness level of the economy. It is well understood that economic growth results either from accumulation of factors of production or from improvements in technology or both. To encourage the generation of new knowledge, industrialized countries have elaborate systems of intellectual property rights (IPRs) in place and conduct majority of the world's research and development (R&D). Technologies resulting from such R&D spread throughout the world through a multitude of channels. At a fundamental level, one can draw a distinction between international trade in technology and other indirect channels of international technology transfer such as trade in goods and international movement of factors of production. This paper critically surveys the literature that explores the role of trade and foreign direct investment (FDI) as channels of international technology transfer. With respect to FDI, a distinction is made between wholly owned subsidiaries of multinational firms and international joint ventures. Furthermore, FDI is contrasted with arms length channels of technology transfer such as licensing. Taking into consideration the scarcity and high costs, of inputs, instead of increasing the consumption of stocks and new investments for production and economic growth, every country try to concentrate on available inputs, increase efficiency and productivity and utilize its existing capacity optimally (Shimizu, 1997). Improvement of methods and techniques is of immense importance. According to the new growth theories, technology is considered to be a public goods which is transferred among countries with low prices (for example: Grossman and Helpman, 1991; Rivera-Batiz and Romer, 1991). Technology is transferred to developing countries through exports of the intermediate and capital goods or by way of foreign direct investment (Coe et al., 1995). The effects of transfer and spillover of technology in the economies are generally studied by CGE model (Van Meijil and Van Tongeren, 1998; Das and Powell, 2000) and or GTAP model (Das, 2011). In this paper, we have followed Van Meijl and Van Tongeren (1999), assuming that technology is transferred from source to a target country by the way of importing intermediate goods and transfer of technology. Evaluating the effects of technology transference is done by GTAP model which uses a multi-sectoral and multi-regional CGE model. Moreover, the role of absorption capacity and structural similarity has been considered as two effective factors on transfer and spillover of technology in an empirical model. Given the importance of above statements, the main purpose of this paper is to investigate the effects of technology transfer through the imports of intermediate goods from developed to developing countries with the main emphasize on Iran economy.

The paper is structured as follows. Section 2 discusses transfer channels and spillover of technology. In section 3 the review of relevant literature is presented. In section 4 theoretical bases will be propounded. Section 5presents the methodology and model. Section 6 discusses empirical model and results of estimated model. Finally, in the last part (Section 7), the results are presented.

2. Transfer Channels and Spillover of Technology

Technology transfer channels are the medium between particular participants in the process. They include ways of gaining the technology (e.g. buying, lending) and other important factors related to the process (e.g. flow of people, documentation, products, and capital). Technology transfer is conducted through different channels and different entities. Depending on the means of creating and gaining of the technology its transfer can be considered either internal or external. Internal technology transfer is conducted mostly inside a single entity or its affiliates. This entity acts both as creator / innovator and user. The scope of internal process is limited by internal R&D resources and implementation capabilities. External technology transfer relies on external technology resources usually not related to buyer.

The scale of advancement in technology transfer depends on the advancement of R&D resources and the capabilities for technology implementation in the production process of the transferee. As a result there are several possibilities for gaining technologies related to specifics of technology transfer participants. While the importance of technology transfer from developed to developing countries are very well recognized, the important issues in this regards are transfer channels and its spillover in the economy of receiving technology. It is generally believed that there are three known channels through which technology can be transferred. These basic channels are: international trade, foreign direct investment and licensing (Keller, 2004). We shall explain below, these three transfer channels briefly. Most advanced technology transfer, especially in the low and middle-income economies, is conducted through international production co-operation, where the production factors flow is most complex including machinery, semi-finished goods and production factors (workforce, technology and capital). The spillover effects to other parts of the economy related to this form of technology transfer are also the largest. Foreign direct investments as one of most widely used channels of international production co-operation to large extend decide about the location and level complexity of technology transfer. Thus a long-term economic policy is needed.

2.1. International Trade

In new trade theories, international trade play a significant role in the technology transfer to receiving countries .It is argued that, international trade enables a country to use different kinds of intermediate and capital goods as required for its production and increase its productivity. It is also an important source of learning technology, Production and organizational methods and marketing. Countries may import technical equipment for producing new and innovative goods. The importing of modern technology helps technological development and spillover leading to increase in productivity and efficiency (Coe and Helpman, 1993; Ethier, 1982; Markusen, 1989; Grossman and Helpman, 1991). Countries can gain from international trade not only through imports but also through exports, where to compete in international markets, exporters are forced to reduce costs and increase their quality. Also exporters can gain through “learning by exporting” (Greenway and Kneller, 2007).

2.2. Foreign Direct Investment, Spillover Effects and Growth

In traditional neoclassical growth models of the Solow (1956) type, with diminishing returns to physical capital, and technological change being exogenous, FDI cannot affect the long-run growth rate. In the absence of international factor mobility, these theories predict that countries with the same preferences and technology will converge to identical levels of income and an asymptotic growth rate. Factor mobility reinforces this prediction. Capital will flow from capital-abundant countries to where it is scarce. In these circumstances, long-run equilibrium is characterized bythe identical equalization of capital labor ratios and factor prices. The new growth theories that have emerged since the mid-1980s have shifted attention away from the focus of earlier neoclassical modeling. Whereas the neoclassical theory treated technological progress as an exogenous process and focused on capital accumulation as the mainsource of growth, the new growth theory has focused on issues relating to the creation of technological knowledge and its transmission. It views innovation and imitation efforts that respond to economic incentives as major engines of growth. Therefore, it emphasizes the role of R&D, human capital accumulation, and externalities (Grossman and Helpman 1991, Lucas 1988, Romer 1990).

For a similar reason, technology transfer through trade has become a popular area of research (Krugman 1979). However, the fact that the interrelationship between FDI and growth has not been the subject of intensive studies is a surprising omission in light of the apparent empirical importance of the relationship. Externalities and their impact on long-run growth have been a common element in endogenous growth models. FDI can lead to increasing returns to scale in domestic production through spillovers. Despite the rarity of research in this area, the advent of endogenous growth theory has opened new research avenues to study the channels through which FDI can promote long-run growth.

Foreign direct investment is not only help transfer of technology but also managerial skills and technical knowledge. Spillover of technology from foreign firm residing in host country to the rest of the economy can occur horizontally and vertically. Horizontal spillover refers to a process during which technical knowledge spillovers from foreign firms to the rest of the economy. The inflow of foreign firms may cause technologically side effects for the domestic firms. Using new technologies by multi-nationals firms and imitating it by domestic firm is an important technology transfer channel (Wang and Blomstrom, 1992). Adopting new technology by domestic firms may be slow due to high costs and risks and uncertain result. However, observing the success of multi-nationals in using new technology persuades domestic firms to imitate it (Krespo and Fentora, 2006). Teaching by foreign firms to domestic and local firms is the second channel of the technology transfer (Meyer, 2003). Thirdly, competition resulting from presence of foreign firm, may force domestic firms to adopt better technology, increase their productivity and efficiency and reduce their costs. If foreign firms have better technology than the domestic one, competition pressure of foreign firms can force domestic firms to improve quality of goods use new management methods to increase their market shares. However, competition may have negative effect on local firms if it leads to crowding-out domestic investment

(Damijan et al., 2007).

Regardless of the channel through which technology spillovers occur, the fact that FDI often involves capital inflows along with technology transfer implies that one would expect appositive impact of FDI on growth in the host country. Yet there are several important caveats to this assertion. First of all, a positive correlation between the extent of FDI and economic growth in cross-country regressions may simply reflect the fact that FDI is attracted to countries that are expected to grow faster simply because it yields higher returns there. Thus, the causation could run from growth to FDI and simultaneous equation system estimation may be needed to resolve the issue. Second, multinationals often raise the required capital in the host country and in such as scenario, capital inflows associated with FDI may not be substantial. An optimistic view of FDI would then look to technology transfer and/or spillovers as the mechanism through which FDI may affect growth.

2.3. Technology Licensing

Technology licensing is not necessarily synonymous with technology transfer. The fact that two parties reach a deal on licensing does not mean that the subject matter of the deal is actually transferred. Because technology licensing concerns not only knowledge that is expressed in writing, but also knowledge in the form of practical know-how or trade secrets (generally kept secret). It becomes an actual transfer when the licensor delivers the technology and knowledge to the licensee and the licensee learns how to effectively use, adapt and where possible improve the technology and knowledge (Van Meijl & Van Tongeren, 1998). Ensuring the occurrence of knowledge transfer should be one of the major concerns of negotiators, in particular the licensees. Only when that occurs, an effective technology transfer takes place.

3. Review of Relevant Literature

Foreign Direct Investment (FDI), usually in form of green field's investment, mergers and acquisitions, or other cooperative agreements, has been a major source of skills, equipment, productivity and technological transfers, for the most part from developed countries to developing countries. This is based on the notion that domestic firms in developing countries benefit from the FDI externalities through improved productivity, employment, exports and international integration (Costa and

De Queiroz 2002; Lall 1997). In supporting the favorable disposition of countries toward encouraging FDI, advocates of free market economy claim that MNEs generate spillovers which benefit the host economy, which are usually reflected in improved productivity, know-how, and other benefits (Fosfuri et al., 2001).

According to Meyer (2004), spillovers are usually generated by non-market transactions, especially when knowledge is transferred to host country firms without any contractual relationship with the foreign MNEs.

The theory of the effect of trade policy regime on FDI, trade and growthin a given host country was first presented by Bhagwati (1978) as an extension to his theory of immiserizing growth and further developed by Bhagwati(1985 and 1994), Brecher and Diaz-Alejandro (1977), Brecher and Findlay (1983). Known as the 'Bhagwati hypothesis', it postulates that FDI inflows coming into a country in the context of a restrictive, import-substitution (IS) regime can retard, rather than promote growth. This is because in an IS regime, FDI mostly takes place in sectors where the host developing country does not have comparative advantage, hence, FDI becomes an avenue for foreign companies to maintain their market share and to reap the extra profit created by the highly protected domestic market.

On the other hand, under the export promotion (EP) regime, the main incentives for FDI in a given host country are the relatively low labour costs and/or the availability of raw materials. This allows the foreign investors to operate in an environment that is relatively free from distortions and to increase production of internationally competitive and export oriented product lines (Edwards 1998). In addition, since the production of firms in an EP regimeis not limited by the size of the domestic market, there are increased potential for foreign companies to reap economies of scale through international market penetration (Edwards, 1998; Kohpaiboon, 2002). It is imperative to know that, despite the unique advantages of FDI, local policies of the host country, especially in developing nations, often make pure Foreign Direct Investment unfeasible, so foreign firms choose licensing or joint ventures (Saggi, 2002).

In all, the relationships between the various channels of International Technology Transfer (ITT) are complex. While trade and FDI are often complements, FDI and licensing may be either complements or substitutes (Hoekman et al., 2004). In terms of technology transfer advantage of Trade and FDI, it is important to distinguish the direct effects on the affiliate in the host country and on the host economy, as well as the positive spillover effects through the demonstration to other producers in the host economy of new technologies and management methods. The third area of technology development (namely the deliberate development of new technologies by R&D) is also very crucial in technology transfers (Grossman and Helpman, 1995).

In relation to the direct effects of technology transfer by the multinational firm, the dominant model in contemporary literature is the Dunning Eclectic or Ownership, Location and Internalization (OLI) model (Markusen, 1995).According to this model, firm-specific assets (such as product patents and processes and know-how) can be used at no extra cost in more than one plant and therefore in more than one country. Furthermore, the preference for internal rather than arm's length transfer of technology across countries may be explained by the same public goods characteristic of knowledge capital that explains multi-plant production (Lloyd, 1996). According to Grandstand (1998), the resources of a firm can be classified as tangible (physical and financial capital) or intangible. Intangible resources are either disembodied (patents, licenses, brand names and designs) or embodied (for example, competences like management skills). While technology is 'a body'of knowledge about techniques, knowledge is an intangible firm resource and this special characteristic often make it expensive to acquire, although relatively inexpensive to use once acquired. Hence, Grandstand (1998) argued that technology is a 'special kind of knowledge' that shares the general properties of knowledge but also has special characteristics distinguishing it from other types of knowledge (Johnson 2006:11). He however linked technology to artifacts and science, with a high degree of modifiability, used for practical applications and is capable of being protected by patent rights.

4. Theoretical Basis

Complexities of technology transfer imply construction of the theoretical model. An interesting basis could be existing international trade and capital flows theories assuming differentiation of production factors supply (workforce, capital, and technology) across countries and regions. This can be extended by neo-technology theories like product life cycle theory, technology gap theory and production scale theory. They argue that the cause of foreign trade is possible thanks to existing differences of supply of production factors across countries. In technology gap theory foreign trade is possible thanks to differences in economic development across countries; in production scale theory the gain and competitive share is possible due to high specialization and decrease of costs per produced unit.

One of the theories, which can be applied in technology transfer analysis, is the Riverton's product life cycle theory. Vernon argues that reasons for foreign trade are technological advantages, which are embodied in innovations. Because the access to the core technologies is limited, innovations are spreading gradually and differently across countries from country innovator to country imitator (receiving country). One of the reasons for this is that countries differ in the levels of economic development and technology. Vernon's theory assume time as a factor of gradual evolution of product (from innovation, growth, maturity to decline); markets (from country innovator to country imitator) and production process (from complexity to standardization).

Dynamics of technology transfer depend also on the strategy of a particular firm innovator. Some firms prefer expansion by technology licensing others through foreign direct investment as the most appropriate and safest solution for securing the technology and to prolong the rent from the exclusivity of ownership.

According to product life cycle theory, production is being moved from the country innovator to country imitator at the product's maturity stage. In the first stage of product development the production process is being conducted in the country of innovator (because of specifics of supply of production factors and the character of local market demand). In the second stage, together with diffusion of products, some export activities are established to middle developed countries. In the third stage full technology diffusion takes place. Production process simplifies when the innovator fails to resist its oligopolistic position.

This often leads to move production to foreign countries in order to find relative cheaper production factors, to ensure better service of foreign markets and to internalize possessed technology.

Technical progress is the key factor in economic development and decreasing the technology gap between countries. The intensity of technology transfer depends mainly on innovation potential of a receiving country. The more advanced it is the more complicated the transfer will be.

The level of economic development is one of the main factors determining the intensity of technology transfer, to ensure the effects of the technology transfer and its intensity a strengthening the process by appropriate economic policy instruments. As we can see in Picture 3, there is a high correlation between the intensity of technology transfer and a country's innovation capabilities. As an example of the linkage between technology transfer and the economic policy; we can mention development path of some Asian countries like Korea, Taiwan, Hong-Kong, Singapore. These countries emerged in just a few decades as technology and production based powerhouses. Aggressive technology acquisition and its efficient use in production processes played key role in the economic development with a long-term goal to increase international competitiveness position.

Development of innovation potential followed the main policy of economic development, which could be broadly characterized as moving from import substitution to export promotion. Protection of local imports and strict import policies enabled to acquire basic technologies mainly through import (some were acquired by licensing and foreign direct investments conducted mainly through joint ventures, which were used as a vehicle to assimilate the technology). Once acquired technologies were further developed using local R&D capabilities, based on broad linkages between state and private research institutes.

Despite economic problems in the late 90-s Asian countries can be analyzed as example of transition from country imitator to innovator scheme. However, a very different international environment now precludes directly following this development path by other countries – like Central and Eastern Europe which faces a much more open market environment.

Borensztein, Gregorio, and Lee examine the role of FDI in promoting economic growth using an endogenous growth model. They analyzed FDI flows from industrial countries to 69 developing countries during 1970-1989. Their results al so show that FDI is an important vehicle of technology transfer, contributing more to economic growth than domestic investment. They make a case for a minimum threshold stock of human capital necessary to absorb foreign technologies efficiently.

Several others studies, including Feder, Ram, and Salvatore and Hatcher; have analyzed the export-led economic growth hypothesis. They argue that exports increase factor productivity because of better utilization of capacity and economies of scale. They also argue that exports are likely to alleviate foreign-exchange constraints and thereby facilitate importation of better technologies and production methods. Grossman and Helpman argue that open trade regimes go hand-in-hand with good investment climates, technology externalities, and learning effects.

5. Data, Methodology and Model

5-1. Data and Methodology

In this study, we have used social accounting matrices and GTAP database (7) to examine different scenarios. The countries surveyed are identified in six regions: Europe and North America (region one), Iran (region two), Turkey (region three), China, Japan, and India (region four), Southeast Asian countries (region five) and the rest of the world (region six). We have used North American and European countries in one group to show their relative superiority in technology and advanced export industries. Moreover, we integrated economic sectors in all regions to five sections i.e. high-tech industry, agriculture, mining, other industries and services. Land, labor, capital, and natural resources are the factors we considered for production.

5-2. Model

5-2-1. Introduction to the Global Trade Analysis Project (GTAP), Multiregional Computable General Equilibrium (MRCGE)

General equilibrium models encompass the entire economy in a multi-mode form. These sectors allocate the central role to price systems. These characteristics distinguish them from other modeling including economy input-output modeling (McDougall, 1995). MRCGE models are preferred due to their advantages compared to other models, including regional computable general equilibrium (RCGE). Its advantages are as follows: the model helps understand the relationships and connections between sectors, countries, and production factors on a global scale. Therefore, this model suggests that any change in one section of systems affects all components and countries. In other words, implementation of any policy or creating shock in any part of the system affects the whole economy through progressing and regressing relations (Fracois et al., 1997). Since this model takes into account spillover and technology transfer, it can affect several other regions through the relationship between sectors and economic factors, and affect the relationship needs of different regions. Thus, GTAP multi-regional model is a viable option to measure the spillover impact of foreign direct investment in Iran.

GTAP is a static model and does not consider the effects of dynamic technological change, population growth, and capital. Behavioral activities and inter-regional and cross-sectoral exchanges are composed of two basic equations: behavioral equations and accounting relation. Accounting relation includes the data in table of social accounting matrix and input-output and behavioral equations represent the behavior of economic factors in the model related to regional production, consumption, and savings. Its mathematical model consists of a set of non-linear equations derived from the theory of maximizing macroeconomic by Dagan and accounting relations. Each region consists of four economic factors: regional representative households, private households, government, and companies. Regional household is the owner of the primary and main factors of the manufacturing companies. The income of regional household is value-added of factors of production as well as different types of taxes and duties, and the allocation of this income to savings, private households, and government is according to Cobb-Douglas function. Government and private household purchase consumer goods and services required from domestic and foreign markets through receiving income from regional household. Private household demands are examined according to the functional form of constant price elasticity demand function by Hanoch. Thus, demand of private household has a non-geometric shape, which means that the cost ratio of different goods in household budget will not be fixed with change in income. Demand function for consumer goods of government is extracted by utility function of Cobb-Douglas and shows that the relative cost of different commodities is fixed. Companies use intermediate goods and basic inputs such as labor force, capital, labor and natural resources to produce goods and services, and by combining these factors, they produce different types of goods and services. There are five factors of production: labor, skilled labor, unskilled labor, capital, and natural resources. All of these elements, except natural resources and labor, have complete changes (full mobility) among various sectors. However, none of production factors are tradable i.e. they lack movement and mobility on an international scale. All entries and inputs have full employment and supply is fixed. Each department or agency in the economy produces a homogeneous output. Goods are sold in and out of each region. This is based on the assumption of perfect competition and constant returns to scale on all goods and market. According to GTAP model, production of all sectors, work, labor, capital, natural resources and all prices are identified within the framework of a model i.e., they are the indigenous. Two global sectors, such as global transportation and global banking complement our regional balance and our accounting relation. Transportation sector includes service values, which are index of difference between CIF and FOB prices for various commodities in various transportation ways. This sector plays the role of intermediary between supply and demand for international transport services. Global Banking is an intermediary factor between global savings and investment. Thus, if all the market is in equilibrium, all companies have zero earnings and balance has occurred on budget constraints, and according to Walras, savings must equal investment.

As this model is not cyclical, investment has no impact on production capacity of economic sectors; however, in subsequent periods, changes in investment affect production by influencing the final demand. The level of investment and savings are assumed equal. This means closure of macro economy in this model has a base closure based on savings or Neoclassical. Since in behavioral function of regional household, demand system is formed according to Cobb-Douglas function, saving is a constant part of regional household income and is used region for financial support of net investment in each region. The numbers used in GTAP model are the index of global price of exogenous factors of production and the weighted average of price of production factors in all regions. It should be noted that according to the type of research, one could assume different macro closures. Finally, solving the model has been in form of percent changes, and all computing is done by GEMPACK software according to Harrison Pearson (1996).

5-2-2.Production Technology in the GTAP Model

Figure 1 shows the tech tree in GTAP model. In top part of figure, intermediary inputs and the combination of production factors are shown by assuming shown Leontief technology (constant technical coefficients). In the next stage, the organization extracts optimal demand of intermediate external and internal goods with production function using constant elasticity of substitution (Armington, 1969). The main advantage of Armington's hypothesis is complete specialization in producing a product by one country is impossible. It should be noted that one of the main problems of the previous model in global trade is the assumption of full specialization of each country in the production of one commodity (Whalley, 1985). In the third stage, on the one hand, companies gain the optimal demand of the key elements by solving the minimization of the cost function with value added function, production function, and constant substitution. On the other hand, each representative extracts optimal demand of foreign intermediate goods with a production function with a constant elasticity of substitution. As this article is related to reviewing current technology spillover effects through imported intermediate goods, the resulting spillover in technology coefficients of companies is reflected by increased productivity. Suppose that optimal combination of any foreign intermediate good is due to the following objective function:

$$QF_{j,s} = AF_{j,r}\left(\sum_{r=1}^{R} \delta_r \left(QFM_{j,r,s}\right)^{-\rho f}\right)^{\frac{1}{\rho f}} \tag{1}$$

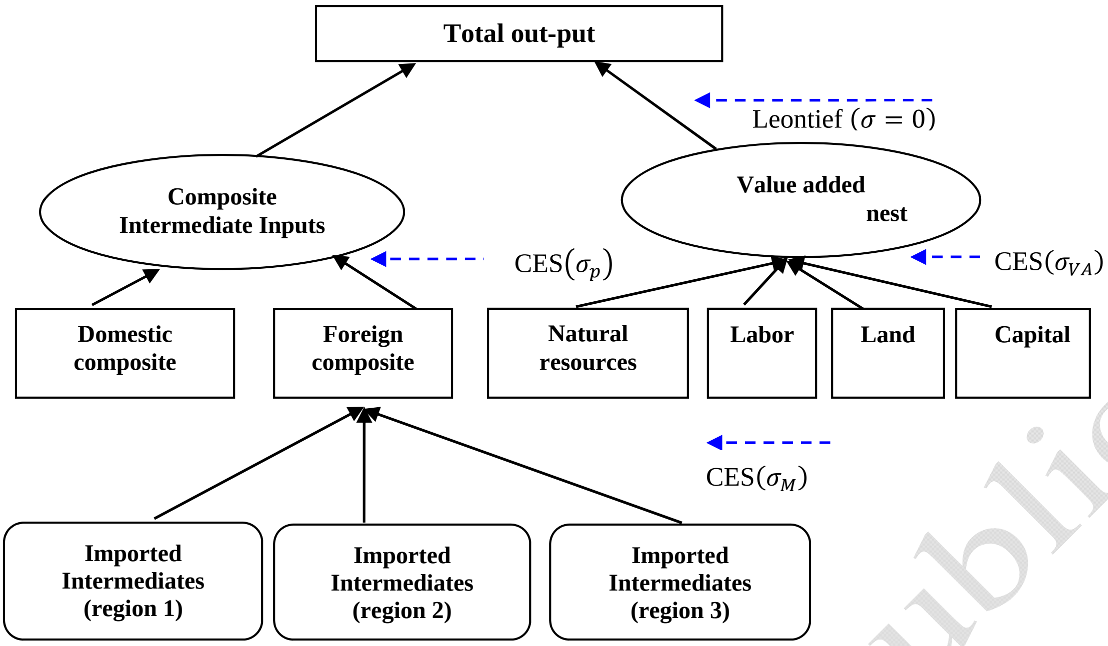

Figure 1. GTAP Technologic Tree
Source: Adapted from HERTEL and TSIGAS (1997, p.56)

$AF_{j,r}$ is the technology coefficient of intermediate good J in region r, $QF_{j,s}$ is combined product in area s, $ is the parameter of distribution, PF is succession parameter, and $QFM(i,j,s)$ is the demand of region r for intermediate good j is region s. Elasticity of substitution is constant among different factors of production and equals $\sigma_M = \frac{1}{1+\rho_f}$. In this paper, it is assumed that the growth rate $AF_{j,r}$ is 10% in mutual balance. This means that the main purpose of this paper is to examine if the coefficient of technology of intermediate good j, which is transported from region r to s, changes about 19%, what would happen and what impact it will have on the region s.

5-2-3.Knowledge Spillovers Through Trade

Most resources and relevant studies have focused on two dimensions of the relationship between trade and IT. The first dimension occurs when trade make changes in allocation of resources in the economy, whereas the second dimension is related to the role that trade plays in the international transfer of knowledge. In fact, as sources indicate, the importance of these two roles of trade is quite intertwined.

As most references that insist the role of trade in transfer of knowledge are based on closed endogenous-growth economy models, a brief explanation will help studying this issue. Traditional growth theory seeks to explain economic growth in terms of accumulation of resources. Capital accumulation is considered as a major determinant of economic growth and the natural conclusion of this study is that if the rate of capital accumulation does not distance from zero, growth will stop in long term.

5-3.Technology Spillover and Channels of Shock Transmission

In this study, we try to assess the impact of 10% technological improvements in developed European countries and North America on a country like Iran. In other words, the main question is that if 10% improvement technology occurs in advanced industrial countries in Europe and North America, what impact will it have on other regions such as Iran? Thus, we considered high-tech industries for two reasons: First, this sector has a great potential for technological progress compared to the other sectors, so that it can have dramatic effects on other sectors using it as intermediate goods. Second, the ratio of imports of advanced intermediate goods used by domestic sectors is relatively high, for example, 35% in agriculture, 94% in mining sector, 33% in light industry and brightness, 90% in heavy industries, and 81% in the service sector. Thus, it appears that import of advanced intermediate goods presents an important channel, through which technology could be transferred from developed countries to developing countries such as Iran.

As import of advanced intermediate goods was the highest from one area, in this study, we consider this region as the major source of technology transfer in other regions. Thus, if a technology improvement occurs in this region, it extends to the entire economy of the region and other regions through inter-setoral relationship and international trade (link 3). In our model, the coefficient of technology in region one endogenous, and in other regions, it is exogenous.

5-4. Modeling Technology Transfer Process and Transfer of Shock

Productivity parameters in spillover equations are closely related to the production function in GTAP model. The structure of production in GTAP model can be shown as follows:

$$Y/_{A_0} = min[AF_{i1}Q_{i1}, \dots, AF_{in}Q_{in}; QVA] \tag{2}$$

Where Y is production, Qij is intermediate goods, and QVA is the composition of the main factors of production or value-added function. Parameter is Hickian's neutral technology coefficient in the production function, and $AF_{i1}, \dots., AF_{in}$ are input-output coefficients. Technology improvements will be modeled by changes in AF coefficients. According to Van Meijl and Tongeren (1997), technological change in a country can be attributed to other endogenous changes in the country. Always one is expressed in terms of changes in technology of each intermediate good (Eq. 1). Trade spillover can be sown wit Equations 3 and 4 showed that relates productivity growth between the destination and source of technology to each other.

$$af_{ijs} = E_{ijrs}^{1-\delta_{rs}}.af_{ijr} \tag{3}$$

$$\gamma_{rs}(E_{rs}, \delta_{rs}) = \frac{af_{ijs}}{af_{ijr}} = E_{ijrs}^{1-\delta_{rs}} \tag{4}$$

af_{ijs} is technology growth rate of intermediate goods I used by sector j in the destination region, and E_{ijrs} is the knowledge in intermediate goods i manufactured in regions r imported to i area of the imported regions, shown by the following equation:

$$E_{irs} = \left(\frac{M_{ijrs}/Y_{js}}{M_{ijrr}/Y_{jr}}\right) \quad (5)$$

Where M_{ijrs} is the import of input i from region r is used in sector j of region s or the destination. M_{ijrr} is the domestic input i used in sector j of region r, Y_{is} is the production of part i in the region s, and Y_{ir} is the production of part j in the region r. The denominator in Relationship 4 shows coefficients of the source and destination of the product from inventor i in j manufacturing activities of the country of origin. Numerator in Equation 4 shows the correlation coefficients for the receiver and transmitter of goods from inventor I in activity j in the target country. Thus, we can write is the equation of productivity growth in the target area as follows:

$$af_{ijs} = \left(\frac{M_{ijrs}/Y_{js}}{M_{ijrr}/Y_{jr}}\right)^{1-\delta_n} . af_{ijr} \quad (6)$$

The main point about the effects related to technology spillover exchange is that adjustment capability and the ability to use the imported technology depend on the ability of the target area to absorb (Kohen and Levinhal, 1989) as well as structural similarities between trade partners (Hayami and Ruttan, 1985). Not only the imported technology, but also its effective use in the importer country is of utmost importance. In other words, the host country should have the technological absorption capacity and structural similarities with the country of origin to properly modify its production process to imported technology. In the following, we discussed ways to use these variables in the model.

5-5. Index of Absorption Capacity

The main purpose of this section is related to the absorption capacity of the destination region (h_s) in the capacity of absorption of the source of (h_r) region. Thus, we have used the following equation:

$$AC_{rs} = min\left[1, \frac{h_s}{h_r}\right] \quad (7)$$

If human capital in the country of destination is lower compared to the country of origin, the process of attracting new and foreign technology will be harder. We have used human capital as an indicator for skills and ability to absorb technology by the destination country to evaluate the absorption capacity. We have used index of Barro and Lee (1993) that is the average years of schooling in each country or region in this study.

5-6. Structural Similarity Index

Structural similarity is related to similarity in the factors of production between countries of destination and origin (Das, 2011). The rate of absorption of new knowledge and technologies by the destination country depends on the difference in this index. The index prided by Meijl and Tongern (1997) for structural similarities between source and destination countries is as follows:

$$ss_{rs} = exp\left[\left|\frac{I_r - I_s}{d\ max}\right|\right] \quad (8)$$

I_s and I_r reflect the structural features in the source and destination countries (Das, 2011), and $dmax$ is major absolute maximum distance between I_s and I_r of source and destination countries. Miguel Meijl and Trongeren (1997) used the ratio of land to labor, whereas Das and Pawel (2000), and Das (2002, 2011) used the ratio of capital to labor.

5-7. The Interaction Between the Indices of Absorption Capacity and Structural Similarities

Having high absorption capacity or high structural similarity in a technology-recipient country may not be enough for spillover technology. The country must not only be able to take advantage of new knowledge more effectively, but also structural similarities and high adsorption capacity are needed for successful technology transfer. Thus, Meijl and Trongeren (1997) used these variables in the technology spillover model (Figure 2).

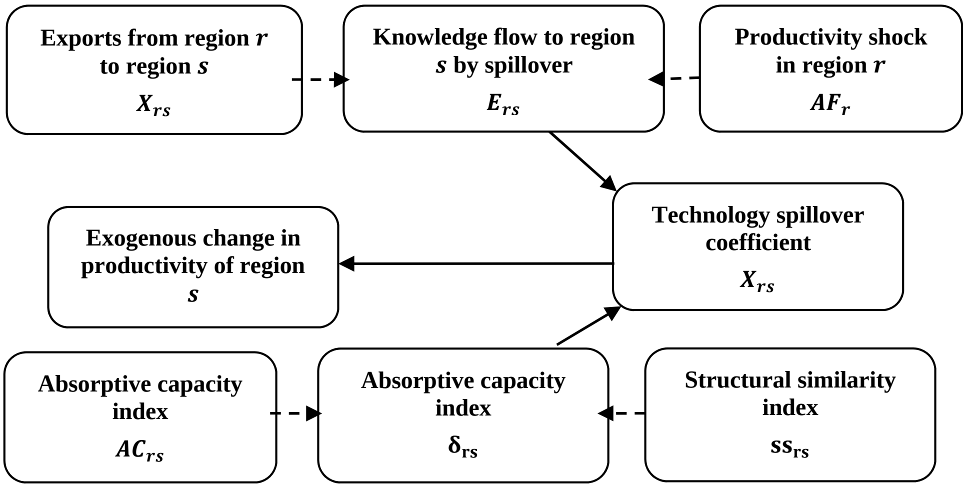

Figure 2. Technology Spillover Model
Source: Author

5-8. A Summary of the Indices of Each Area

Numerical value of various indicators is presented in Table 1 to identify the amount of absorption capacity and structural similarities, and to identify possible power of accepting foreign technology in every area.

Table 1. Summary of Indices for Each Region

	Structural similarity index	Absorption capacity	Barro-Lee index	M_{ijrs}/Y_{js}	Effectiveness
Region 1 (North America)	1	1	11/4	---	1
Region 2 (Iran)	0/39	0/28	8/6	0/09	0/24
Region 3 (Turkey)	0/48	0/58	7/01	0/15	0/5
Region 4 (China and India)	0/36	0/63	6/64	0/041	0/22
Region 5 (East	0/88	0/71	9/2	0/043	0/8

Asian)					
Region 6 (Rest of the World)	0/59	0/59	6/8	0/071	0/38

Source: Research Findings based on data from Statistical Centre of Iran, Statistical Yearbook, Various Issues and Central Bank of Iran, Annual Reports and Balance Sheets Various Issues.

The second column of the table above shows the imports of advanced intermediate goods by each region from one region. It is assumed that the region one is the major source of technology transfer to other regions. For example, the ratio of imports of advanced intermediate goods in total production of sector j in Iran is 0.09. Numerical value of absorption capacity index is extracted using Equation 6, and structural similarity index using Equation 6 and 7. Indicators of effectiveness that are the product of structural similarities and absorption capacity of each area are shown in the table.

6. Experimental Results

We examined the effects of technology spillover and 10% improvement shock of advanced industries of North American and European countries on the other regions with an emphasis on Iran. In order to have a clear vision about capacity to absorb and the ability to adjust the foreign technology in each region, the numerical values of different indices are shown in Table 2.

Table 2. Summary of Indices for Each Region

Indices	Absorption capacity Index	Structural similarity Index	Effectiveness Index
Region 1	1	1	1
Region 2	0/38	0/31	0/23
Region 3	0/81	0/78	0/39
Region 4	0/58	0/26	0/23
Region 5	0/78	0/82	0/79
Region 6	0/48	0/48	0/23

Source: Research findings based on data extracted from statistical center of Iran and Central Bank of Iran various issues.

Numerical value of index of absorption capacity is estimated using Equation 6, whereas the numerical value of the structural similarity index is estimated using Equation 8. Effectiveness index, which is defined as the product of absorption capacity and structural similarities, is estimated and the results are shown in Table 2. It can be stated that although effectiveness index of Iran is better than Turkey, as imports of advanced intermediate goods in Iran is more than in Turkey over (0.15 compared to 0.09), the effectiveness of Turkey is more than Iran. The effect of 10% improvement in efficiency of advanced technology industries in region one leads to a high productivity growth in Turkey compared to Iran, so the percentage changes is 3.6 and 2.81. To understand the impact of technology spillover and shock on the economy of Iran better, we have calculated this effect and offered the results presented in Table 3.

Table 3. Setoral Responses of the Economy of Iran to 10% Exogenous Technology Shock

	Prices	Production	Exports	Imports
Agriculture	-0/37	1/35	2/31	-2/82
Mining	-2/35	1/11	-1/21	-1/29
High-tech	-2/88	0/28	0/31	-3/65
Others	-1/11	1/14	3/21	-1/51
Services	-0/97	0/255	10/02	-3/59

Source: Research findings based on data extracted from statistical center of Iran and Central Bank of Iran various issues

It is expected that technological improvements leads to reduced prices and increased output not only in the relevant sector but also in other parts of by spillover and the intersection relationships both in the country of origin and the destination country. Thus, improving the efficiency in developed countries leads to an increase in production and the supply of goods in various sectors, particularly in the intermediate goods sectors and industries of importing countries. This in turn leads to an increase in output and supply and reduction in the price. Since improving productivity occurs in high-technology industries, the highest percentage of price change also occurs within the same section. Our results show that in Iran this leads to an increase in production and a decline in prices in almost all sectors and industries. For example, advanced industries' output has increased by 0.28 percent, and the price in this industry reduces up to 2.88 percent. Other sectors experience decreased production depending on the ratio of import of intermediate goods with high-tech. Moreover, sudden increase in production is experienced in almost all sectors. This change will enhance the competitiveness in Iran, which is shown in Table 2. With rising prices, competitiveness increases that ultimately leads to increased exports and reduced imports in different sectors. Since more production needs more intermediate goods, we expect imports to increase in various sectors by more production. In addition, there will be significant price drops. Altogether, the impact of price cuts is more than the effect of production, so imports face a great reduction.

7. Conclusion and Policy Recommendations

The aim of this study is to examine the effects of technology transfer through imports of advanced intermediate goods by developing countries from developing countries, with special emphasis on Iran's economy. In this regard, we have used GTAP model (multi-sectoral and multi-regional CGE model). The results show that a hypothetical improvement of technology in intermediate goods industries and advanced trading partner has a positive effect on improving the productivity of Iran by imports of intermediate goods. Our findings show that technology transfer in imports of intermediate goods to Iran leads to an increase in output and deflation. Factors such as absorption capacity, structural similarities, and efficacy result in the improvement of technology spillover in Iran. Despite the positive effects of spillover of technology imports, its value is relatively limited due to relatively low share and volatility of the imports of intermediate goods. These results indicate that Iran has a great potential to increase imports of intermediate goods.

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