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The economic impacts of foreign direct investment in oil and gas sector: A CGE analysis for iranian economy

Mehdi Nejati *, Mojtaba Bahmani

Department of Economics, Shahid Bahonar University of Kerman, Kerman, Iran

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ABSTRACTS

FDI not only increases capital supply in the host country, but can also improve the productivity of domestic firms through knowledge transfer. Dutch diseases and technology spillover can be some of the important effects of FDI in the oil and gas (OIG) sector. The Dutch disease refers to the problems associated with negative consequences of large increases in a country's raw materials such as oil and gas. However, affecting productivity depends on the absorptive capacity or the ability to adapt foreign technology by domestic firms. If Foreign direct investment (FDI) inflow is without productivity spillover, it may have negative effects on economy, especially if the destination of FDI is sectors such as Oil and gas sector(OIG). FDI not only plays a vital role in the development of this sector, but also significantly affects the macro and micro levels. Identifying the type and extent of these effects on economy requires quantitative and empirical evaluations. Therefore, the current research has tried to study the effects of FDI in the OIG sector on Iran's economy using a regional CGE model. The results showed that if FDI does not lead to productivity spillover, it causes Dutch disease in the economy of Iran. Production and employment have decreased in tradable and increased in non-tradable sectors. If FDI improves productivity of the firms, the impacts of Dutch disease will be reduced or eliminated. Therefore, production will be improved in all sectors, and consumer price index will decrease. In this regard, the absorptive capacity of domestic firms plays an important role in the extent of technology spillover and finally reducing the impact of Dutch disease.

Author statement

Mehdi Nejati: Methodology, Software, Formal analysis, Mojtaba Bahmani: Writing - original draft, Writing - review & editing, Resources.

1. Introduction

Foreign direct investment (FDI) is defined as an investment involving a long-term relationship and reflecting a lasting interest and is controlled by a resident entity in economy (foreign direct investor or parent enterprise) in a domestic economic enterprise other than the foreign direct investor [1]; P.345). In recent decades, most countries are seeking to remove barriers of foreign investment and adopt policies that can facilitate FDI inflow. According to UNCTAD annual report in 2018, the ratio of global FDI stock to GDP increased from %9.58 to %39.24 during 1990–2017. This ratio increased from %9.32 to %43.79 in developed countries and from %12.86 to %32.58 in developing ones.

FDI flow can have direct effects including increasing capital stock, providing accessibility to modern technology, improving employment, promoting production and tax revenues, increasing foreign exchange supply and increasing exports in the host country (for example, [2,3]. Foreign companies can indirectly affect the host country through affecting the productivity of local companies, which is known as "spillover effect" [4,5]. Productivity spillover of FDI means acquiring benefits from multinational firms such as technical knowledge, production and distribution technologies, and managerial and marketing skills [6,7], which increase the productivity of local firms. Technical knowledge can be transferred from foreign companies to local firms within an industry in the form of horizontal spillover [8–10] or through backward and forward linkages with local active companies in other industries in terms of vertical spillover [10–12].

The size of spillover depends on the absorptive capacity of the firms in the host country [8,13–15]. Therefore, improving the absorptive capacity indices in the host country facilitates technology transfer and spillovers. Furthermore, inflow of FDI may have negative effects on employment and production of tradable sectors such as agriculture and industry, which is known as Dutch disease. According to the work by Corden and Neary [16] Dutch disease refers to structural consequences

* Corresponding author.
E-mail addresses: mnejati@uk.ac.ir, mehdi.nejati@gmail.com (M. Nejati), mbahmani@uk.ac.ir (M. Bahmani).

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of change in sectoral composition in an economy. In the early literature on Dutch disease, boosting the production and export of energy and natural resources in resources-rich countries leads to an increase in income and demand. Subsequently, it will lead to an increase in relative price of non-tradable sectors (real exchange rate appreciation) and movements of production factors from lagging sectors to non-tradable and booming sectors.

Additionally, it reduces production and employment in non-booming tradable sectors and increases production and employment in non-tradable sectors [16,17]. However, today this term is used for all economic issues in developing countries which seek to explore natural resources or import a large volume of foreign funds such as foreign aid [18]; Vos, 1988; [19,20], direct and indirect foreign investments [21–24], remittances [25,26], or tourism [27,28]; Pratt, 2015; Pham et al., 2015).

Inflow of foreign capital to the OIG sector may have negative consequences such as Dutch disease and positive effects such as technology spillover or improving the productivity of domestic firms in Iran. Iran as an oil exporting country in two periods has been severely affected by Dutch Disease. The first time was the oil shock in 1973. The second time also happened during occurred between 2006 and 2009(Atashbar, 2013).

Nevertheless, the final outcome of FDI in the OIG sector depends on which effect is stronger. Therefore, evaluation of consequences of these effects needs an empirical study. Computable general equilibrium (CGE) models are suitable candidates for this evaluation. Using these models, we can analyze the effects of FDI inflow on all economic variables in micro and macro levels. As FDI is the capital flow from one region to another and is considered an international phenomenon, it seems that using multi-regional CGE models is more suitable than single regional CGE models. Therefore, in the present research, Global Trade Analysis Project (GTAP) model [29], extended to conduct a quantitative assessment of FDI inflow into the OIG sector in Iran. The GTAP model is continuously used by many CGE modelers around the world. Furthermore, it has the ability and capacity to accommodate a number of possible extensions (trade liberalization, direct foreign investment, different types of taxes, etc.) [30].

Considering the above discussions, the main aim of this article is to investigate the effects of direct FDI inflow to oil and gas sector on Iranian economy. For this purpose, GTAP model used to consider those effects in two different scenarios. The standard GTAP model has been developed in such a way that FDI is included as a factor of production in the production function of the firms. In addition, the horizontal and vertical spillover that resulted from FDI flows is included in the form of endogenous changes in the productivity of domestic firms in the economic sectors. In this way, the productivity of domestic firms is a function of the ratio of FDI to the total capital of each sector. We have also considered the absorption capability of the domestic firms as an effective factor in the firm productivity function. Salim et al. [31] shows the capability of domestic firm's absorption in Iran can enhanced the effects of FDI spillover, if the conditions for improving the absorption are prepared by government or other institutes.

The main differences of this research with other studies published yet, can be announced as following:

Firstly, one of the limitations of CGE in the literature of FDI modelling is the match between the theoretical CGE modeling and data requirements and availability. For example, in Iran the statistics for FDI exists in different sectors of economy, but the main limitation in this regard is the lack of data such as: sales, costs, revenue, volume of capital and employment of foreign companies active in Iran. Therefore, one cannot make a difference between the technology of the production of local firms and the active foreign companies in Iran. In this study, the above limitation has been reduced to some extent by modeling the international FDI flows as a simple capital flow between regions. Instead of discriminating between domestic and foreign firms in each sector, capital input in production function is divided into domestic and foreign capital (FDI). Secondly, in empirical studies and especially in the framework of CGE models, the effects of FDI in the oil and gas sectors have not been explored. The third contribution of our work is that, it specifies a two stage mechanism for FDI technology spillovers. In this mechanism, the productivity growth of domestic firms is considered as a function of horizontal and vertical spillovers of FDI. Fourth, in general equilibrium modeling, we added the absorptive capacity of local firms in the spillover functions as an effective factor in the amount of technology transfer.

In standard GTAP model, the FDI and the international technology spillover of FDI are not included, so we have extended the GTAP model in order to add the inflow and outflow of capital as well as its spillover effects to the model. For this purpose, in the following sections, first Dutch disease and the effects of FDI spillover and then FDI modeling and effects of FDI spillover modeling are presented. Model data and their features and finally the results of the simulation and conclusions are discussed.

2. Review of literature

2.1. Dutch Disease literature

According to the theoretical literature of Dutch disease, foreign capital inflow into any sector of economy improves marginal product and real wage of labor. Therefore, higher income in the receiving sector of the foreign capital leads to movement of primary factors from other sectors to this sector (resources movement effect) (Lartey, 2007), which will lead to direct deindustrialization. Indirect deindustrialization occurs when the ratio of non-tradable price to tradable price increases. The consequence of this effect is movement of labor from sectors such as agriculture and industry to non-tradable sectors [32]. According to Corden and Neary [16]; higher income leads to an increase in spending on all goods. Since, the price of tradable goods is determined in international markets and non-tradable goods in domestic markets, demand growth will have lower effect on the price of tradable goods.

However, increased demand for non-tradable goods leads to an increase their price, which will be more than the increase in the price of tradable goods. The higher price of non-tradable goods increases their profitability compared to tradable goods (spending effect). An increase in the relative price of non-tradable goods means real exchange rate appreciation. The amount of FDI impact on the exchange rate in a country might depend on the type of foreign capital such as direct and indirect investments and type of receiving sectors of this capital. Comunale [33] argues that if tradable/productive sectors are the destinations of FDI, competitiveness may be enhanced and exchange rate might decrease, and if FDI non-tradable sectors are the destinations, competitiveness decreases and exchange rate will increase. Since foreign portfolio investment is more related to investment in non-tradable goods, it will increase the exchange rate.

Dutch disease has been evaluated using various methods such as econometric methods and CGE models. This research refers to studies which have been conducted using CGE models. Benjamin et al. (1989) studied the effect of increase in oil revenues in Cameroon. The results showed that if the increase in oil revenues is directly spent on consumption, it will result in an increase in consumer price index and real wages. Furthermore, there is a significant increase in prices in various sectors, especially non-tradable sectors. Production has decreased in tradable sectors but growth in production has been observed in consumer and capital goods. The empirical evidences of Bandara' s study (1995) showed that non-tradable sectors and import-substitution industries are major winners and import-substitution agricultural industries are major losers of foreign investment inflow.

Clausen and Schurenberg- Frosch(2012) examined the foreign aid effects in Zambia by using a CGE model. If a small proportion of foreign aid is invested, the effects of foreign aid are small at macro level. If these funds are spent on things other than investment, Dutch disease will

occur, especially if production factors are completely mobile. If foreign aids lead to development in non-tradable sectors, the export-oriented sectors will be damaged by exchange rate appreciation and production factors of these sectors will move to non-tradable sectors Forsyth et al. (2014) examined the effect of an increase in mineral export. The results showed that exchange rate has increased and total exports have decreased in Australia.

The increase in exchange rate has led to a decrease in attractiveness of Australia as a tourism destination and an increase in the demand for outbound and domestic tourism. [4]; 2015), studied the effects of increase in the export of minerals in Niger under four spending strategies. These four spending strategies include: Bird in Hand, Boom-bust cycle, Permanent income hypothesis and Borrow now. The results showed that except for Bird in Hand strategy, exchange rate will increase in a short-term period. In other words, in the first stage, except in the mentioned scenario, Dutch disease exists, but if revenues earned by investments are not spent by government over time, Dutch disease will exist under all scenarios. Pratt (2015) showed that an increase in tourism, leads to an increase in value added in tourism-oriented and non-tradable sectors and a significant decrease in agriculture, mining, and manufacturing sectors. In other words, deindustrialization phenomenon has occurred.

Pham et al. (2015) studied the effect of increase in minerals export on Australia as well as some of its states. The results showed that the exchange rate has increased significantly, which is a symptom of Dutch disease. Therefore, the production of export-oriented sectors has decreased and the production of non-tradable sectors has increased. Furthermore, inbound tourism demand has decreased and outbound, domestic and interstate tourism demand has increased. Inchausti-Sintes (2015) evaluated positive tourism shock in Spain. The results showed that tourism has increased the real exchange rate and decreased the production and export in agriculture, energy, mining and industrial sectors. Additionally, production in non-tradable sectors has increased significantly. Altogether, Dutch disease caused by tourism has been proven in this study. Njoya and Seetaram (2017), showed that the effects of Dutch disease are in the forms of increasing exchange rate, decreasing employment and production in agricultural sector as well as increased imports.[1]

2.2. FDI spillover and absorptive capacity: a literature review

International trade and foreign direct investment are considered two major channels for technology transfer and spillover among countries [34,35]. Foreign direct investment not only transfers technology used in goods and services, but also transfers intangible assets such as management skills and technical knowledge [36]. Technology transfer and spillover can be done horizontally and vertically. Horizontal spillover refers to a process in which technical knowledge is transferred from foreign firms to local firms within an industry. Imitation by local firms, the competition between foreign and domestic firms, transferring skilled and trained labor forces from foreign firms to domestic firms as well as exports by foreign companies are factors which cause horizontal spillover to domestic firms [6,8,37–39]. The relationships among industries through backward and forward linkages are channels which can cause vertical spillover.

Backward linkages occur when foreign firms in downstream industries demand intermediate goods and raw materials from domestic firms in upstream industries [40]. Multinational firms may provide technical assistance for the improvement of the quality of goods, introduce innovation and create productive infrastructures for local suppliers as well assupport at the organizational and management levels [7,11]. According to Ref. [37] forward linkages cause an increase in technology spillover in local firms through multiple channels. Firstly, the purchase of intermediate goods and materials from foreign firms by domestic firms improves the quality of products and reduces their costs. Secondly, foreign direct investment in infrastructures and commercial services increases the productivity of their customers, who are domestic companies, directly. Thirdly, domestic firms may receive services in form of training and learning in sales techniques from foreign firms.

Productivity spillover caused by multinational firms depends on the absorptive capacity of domestic firms. This issue was first introduced by Cohen and Levinthal [13]. Dahlman and Nelson [41] define national absorptive capacity as “the ability to learn and implement the technologies and associated practices of already developed countries”.

Firms need a sufficient absorptive capacity to utilize foreign technology effectively. Higher absorptive capacity of domestic firms leads to higher effect of foreign direct investment on firm’s productivity [15,34].

Table 1
Empirical literature.

Authors	Level	AC Index	Results
Kokko et al. [47]	Micro	Technology Gap	Spillovers are present when the AC are moderate.
Borensztein et al. [42]	Macro	Human Capital	higher Spillover holds only when the host country has a minimum stock of AC
Liu et al. [48]	Micro	Technology Gap	spillover effect is negatively related to the technology gap
Kinoshita [36]	Micro	R&D	when the firm performs R&D actively are there positive spillovers
Girma and Wakelin [43]	Micro	Human Capital	large firms with higher skill intensity do not benefit from FDI but plants in the lower distribution of skill intensity lack the necessary absorptive capacity to benefit from FDI
[58]	Micro	R&D	Enterprises with higher R&D investment benefit more from FDI
Alfaro et al. [64]	Macro	Financial Development	countries with well-developed financial markets gain significantly from FDI
Girma [50]	Micro	Technology Gap	inverted- U shaped relationship between AC and spillovers
Kinoshita and Lu [67]	Macro	infrastructure	country will benefit spillovers from FDI if the country’s AC is high
Girma and Gorg [51]	Micro	efficiency gap	U-shaped relationship between AC and spillovers
Alfaro et al. [65]	Macro	Financial Development	countries with developed financial markets gain from FDI spillovers
Farole and Winkler [53]	Macro	financial freedom	well-developed financial markets might ease the domestic firm’s AC
Krammer [73]	Macro	Institutional quality	Transition Countries with better institutional quality benefits more from FDI
Yi et al. [74]	Macro	Institutional quality	Firms that operate in regions with high institutional quality are better able to absorb spillovers
Tang and Zhang [60]	Micro, Macro	R&D, Human Capital and Infrastructure	Better absorptive capacity, more spillover benefit from FDI
Shi et al. [70]	Macro	Infrastructure	inverted U-shaped relationship between infrastructure investmentAnd growth
Malikane and Chitambara [55]	Macro	Technology Gap	Spillovers are present when the Gap are Low and huge technology gaps presents an impediment to absorption of spillovers.

[1] Other studies such as Chand and Levantis (2002) and Khan and Gottschalk (2017) have assessed the Dutch disease.

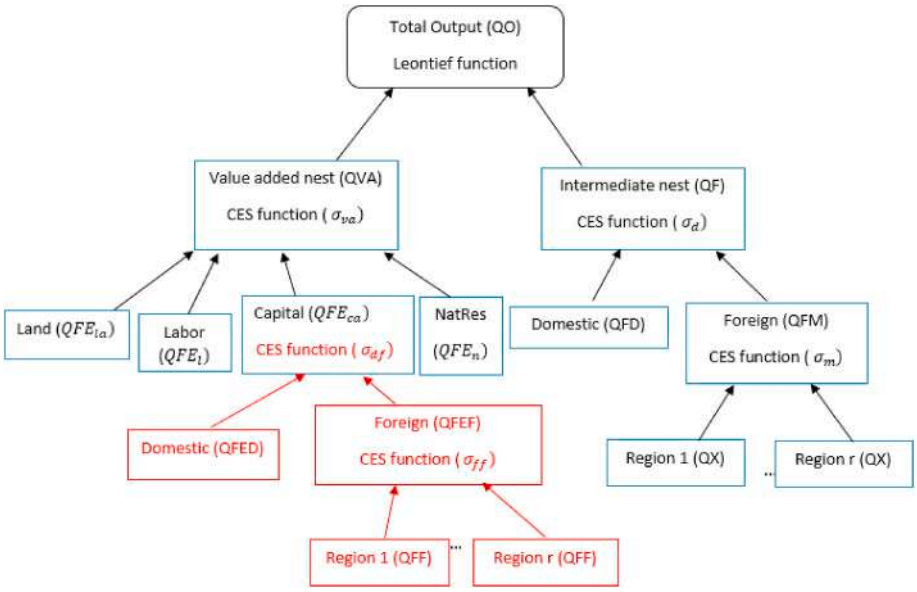

Fig. 1. Extended production structure in the GTAP model [29].

In empirical studies indicators such as human capital [35,42–45]; Tientao et al., 2016; [46], technology gap [47–54]; Gorodnichenko et al., 2014; [55], research and development expenditure [13,36,52, 56–62], intangible assets ([35,48,63] financial development level [64, 65]; Farole and Winkler, 20012; [54,66], infrastructural quality ([60, 67–70] and institutional quality in host country ([65,71–73]; Gorodnichenko et al., 2014 [74,75]; are used to capture the absorptive capacity of domestic firms.

The results of some studies on the relationship between absorptive capacity and benefits of foreign capital spillover effects are presented in Table 1. In total, empirical results showed that absorptive capacity plays an important role in marginal effects of FDI on total factor productivity of firms. However, there is no general consensus on the relationship between absorptive capacity level and marginal effects of FDI. Some studies see a high level of AC, and other studies see a moderate or high level of AC as beneficial.

3. FDI modeling in CGE models

FDI modeling in CGE models can be divided in two groups. The first group includes studies related to foreign direct investment in form of multinational companies. Two works by Petri [76] and Markusen et al. [77] introduced the modeling of foreign direct investment in form of multinational companies, which is the basis for the first group studies [78]. For the first time, foreign direct investment modeling was done by Petri [76] which became a basis for other works in this field. Goods are produced by multinational firms in Petri's model.

Multinational firms have subsidiaries across the world, and the varieties produced by each plant are different from those of other plants throughout the world. Furthermore, production technologies of foreign and domestic firms are different in each region, but the assumption of perfect competition and constant return to scale exists in all activities. By expanding the Armington assumption by Petri, there is a possibility that demand for different varieties is made by consumers based in the country of ownership and the location of production. Foreign varieties are provided not only by imports, but also by multinational firms 'subsidiaries within a country. Furthermore, domestic varieties can be purchased from domestic firms operating at home and from their subsidiaries operating abroad.

Capital allocation mechanism has three stages; capital is allocated to different sectors in the first layer, and regional capital in each sector is allocated to domestic and foreign direct investment in the second layer. Finally, the third layer indicates the allocation of foreign investment to different regions. Altogether, according to the principle of optimization, capital is allocated to activities which have the highest rate of return. Hanslow et al. [79] modeled foreign direct investment based on Petri's model [76] by adjusting GTAP model which is known as FTAP model.

FTAP is slightly different from Petri's framework. Firstly, on the demand side, the order of consumer preferences between ownership and regions of location is different. Secondly, in the structure of wealth distribution, each investor divides their wealth among bonds, natural sources, land, and capital based on a transformation function. Thirdly, firms with similar ownership in Petri's model are closer substitutes for each other, but in FTAP model, domestic and foreign firms in the same region, are closer substitutes for each other. Finally, unlike Petri's model, there is no perfect competition assumption and constant return to scale in the mentioned model, but it has large group monopolistic competition and increasing return to scale structures. Conducted empirical studies based on Petri's model include Dee and Hanslow [80]; Brown and Stern [78]; Verikios and Zhang [81],[2] Lee and Van der Mensbrugghe [82],[3]Bchir et al., [83]; and Dee et al. [84].

Markusen et al. [77].[4]developed a general equilibrium model to assess the effects of trade liberalization and foreign direct investment on the service sector. It is assumed that services are used as an intermediate input in production process which are produced by domestic and multinational firms with increasing return to scale technology. Production technologies of foreign and domestic firms are different. Domestic firms' services are produced by domestic skilled and unskilled labor force, but foreign firms' services are produced by domestic skilled and unskilled labor force as well as a combination of foreign factors (for example; specialized technical, management, and marketing expertise).

Also, they included the endogenous effect of FDI liberalization on productivity by using Dixit-Stiglitz monopolistic competition structure. An increase in FDI inflow into the host country and increasing the number of varieties of services will improve the productivity of firms.

[2] Developed model by Verikios and Zhang(2001) is known as FTAP2. That is the modified version of the FTAP Model.

[3] This study is a combination of the hypotheses of Petri and FATP models. It should be noted that in this model, the assumptions of constant return to scale and perfect competition exist for all sectors.

[4] Developed model by the mentioned authors is known as the Knowledge Capital Model.

But it did not become an empirical study using real data. Studies such as Rutherford et al. [85]; Copenhagen Economics [86]; Jensen et al. [87]; Rutherford and Tarr [88]; Rutherford and Tarr [89]; Jensen et al. [90]; Balistreri et al. [91], Deng et al. (2012, 2013), Bohringer et al. [92]; Latorre [93] are based on the model developed by Markusen et al. [94].

In addition to the aforementioned studies, the analysis of distinction between the technology of domestic firms and multinational companies in form of general equilibrium modeling can be found in studies such as Lakatos and Fukui [95]; Latorre et al. [30]; Latorre [96]; Latorre et al. [97]; Latorre and Hosoe [98]; Latorre and Yonezawa [99].The second group of studies has examined the effects of FDI as a simple international capital flow across regions in response to changes in rate of return of capital. The main feature of these models is that there are no foreign and multinational companies. Lejour et al. [100] evaluated the effect of FDI liberalization of services in 25 European countries using World Scan Model. To do this, they presented the structure of capital allocation across different sectors and regions like Dee and Hanslow's (2000) model.

In the first step, wealth is allocated across different sectors as a function of relative rate of return on capital. In the second step, sectoral capital stocks are distributed among different regions. Capital demand in production process has two levels; at the first level of the production tree, domestic capital is distinguished from foreign capital and at the second level, demand for foreign capital is made based on segregation of different regions. Other studies in this group include MIRAGE [83], MONASH [101], WorldScan [100] and DART [102].

4. Modeling FDI and technology spillovers in the GTAP model

In order to include FDI and technology spillovers to our modelling framework, we need to extend production technology in the GTAP model. Also, we should introduce supply mechanism for regional capital.

4.1. Extending the production technology

Fig. 1 show the structure of production in the GTAP model. At the top level of production nest, composite intermediate (QF_{ir}) and primary inputs composite (QVA_{ir}) are joined via a Leontief technology to produce a composite output QO_r. i and r denote sectors and regions, respectively.

$$QO_{ir} = AO_{ir} * \min\{QF_{ir}, QVA_{ir}\} \quad (1)$$

Right hand side of the production tree is the intermediate nest. In the first stage, firms choose among domestic and composite foreign intermediate inputs (using the Armington(1969) structure) by a CES function with $\sigma_d$as the elasticity or substitution parameter.

$$QF_{ir} = \left(\gamma_r (QFD_{ir})^{\frac{\sigma_d - 1}{\sigma_d}} + \left(1 - \gamma_r\right)(QFM_{ir})^{\frac{\sigma_d - 1}{\sigma_d}}\right)^{\frac{\sigma_d}{\sigma_d - 1}} \quad (2)$$

Where QF_{ir}, QFD_{ir} and QFM_{ir} are composite intermediate, domestic intermediate and foreign imported composite input demand in sector i in region r, respectively. γ_r is the positive constant distribution parameter. In second stage, imported intermediates are distinguished by region of origin by means of a CES function with $\sigma_m$as the elasticity of substitution between imports from various regions (equation 3).

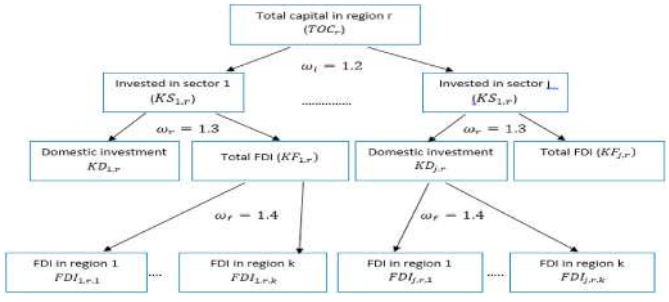

Fig. 2. Capital supply mechanism [76,79,100].

$$QFM_{ir} = \left\{\sum_{s \neq r} \rho_s (QXs_{isr})^{\frac{\sigma_m - 1}{\sigma_m}}\right\}^{\frac{\sigma_m}{\sigma_m - 1}} \quad (3)$$

Where, QXs_{isr} is denotes quantity of exports of commodity i from source s to destination r. Left hand side of the production tree is the value added nest. Primary factor composite in region r (QVA_{ir}) is produced combining the primary factors capital, labor, land and natural resources (NatRes). The production technology is based on a constant elasticity of substitution (CES) function as given below.

$$QVA_{ir} = AVA_{ir}\left\{\sum_i \delta_{ir}\left(QFE_{jir}\right)^{\frac{\sigma_{va} - 1}{\sigma_{va}}}\right\}^{\frac{\sigma_{va}}{\sigma_{va} - 1}} \quad (4)$$

Where QFE_{ir} are demand for primary factor j by sector i in region r, AVA_{ir} is technical progress parameter in production function, δ_{ir}s are distribution parameters with$\sum_i \delta_{ir} = 1$ and σ_{va} is the elasticity of substitution between primary factors. Due to lack of accurate data about production and employment of active foreign firms in Iran, FDI is considered as simple international capital flow. Therefore, there is no difference between technologies of domestic and foreign firms, and firms have not been separated to domestic and foreign firms. We assume that capital is a composite bundle of foreign (FDI inflow) and domestic capital (Similar to Ref. [100]. So, we added a two level CES function for input of capital in production. Capital demand by firms in each sector is made in two steps; at the first level, domestic capital is distinguished from foreign capital, and at the second level, demand for foreign capital is made based on segregation of different regions. Capital demand is made based on a CES function in both layers. Thus we can write the CES function for first and second nest as below.

$$QFE_{ca,r} = \left(\theta_r \left(QFED_{ca,r}\right)^{\frac{\sigma_{df} - 1}{\sigma_{df}}} + \left(1 - \theta_r\right)\left(QFEF_{ca,r}\right)^{\frac{\sigma_{df} - 1}{\sigma_{df}}}\right)^{\frac{\sigma_{df}}{\sigma_{df} - 1}} \quad (5)$$

With $QFE_{ca,r}$ denoting the demand for capital, and $QFED_{ca,r}$ is demand for domestic capital in region r. $QFEF_{ca,r}$ representing foreign composite capital demand in region r. $\theta_r$is the distribution parameter and σ_{df} denotes the substitution elasticity between foreign composite and domestic capital.

$$QFEF_{ca,r} = \left\{\sum_{s \neq r} \beta_s \left(QFF_{ca,s,r}\right)^{\frac{\sigma_{ff} - 1}{\sigma_{ff}}}\right\}^{\frac{\sigma_{ff}}{\sigma_{ff} - 1}} \quad (6)$$

$QFF_{ca,s,r}$ represents capital input demand from region s by region r. σ_{ff} and β_s are substitution elasticity between foreign capital among different regions and distribution parameter, respectively.

Substitution parameters for capital nest are derived from the World Scan model [100] which are 4 and 2 for the first and second layers, respectively.

4.2. Supply of capital

In the GTAP model, investment is only associated with equity rather than debt and there is no explicit financial market in the model. Global trust collects all regional households' savings and allocates them to investment. It is also assumed that capital has international mobility and capital markets are cleared globally [95]. We follow the modelling framework of petri (1997) and FTAP model [79] for the specification of

the supply of capital. The mechanism of capital supply allocation in region r take place in three stage. At the first stage, total capital of region r (TOC_r) is allocated among sectors based on a constant elasticity transformation (CET) function with elasticity ω_i (see Fig. 2).

$$TOC_r = \left(\sum_i \alpha_i KS_{i,r}^{\frac{\omega_i+1}{\omega_i}} \right)^{\frac{\omega_i}{\omega_i+1}} \quad (7)$$

Where, $KS_{i,r}$ is capital allocated to sector i in region r. α_i denoting the preferences of investors for different sectors and ω_i is the elasticity of transformation between sectors. The capital input of a region allocates across regions or sectors as a function of relative rate of return. Investor's preference is an important factor for investment decision. In the second layer, the allocated sectoral capital stock of source region is partitioned between domestic ($KD_{i,r}$) and foreign investment ($KF_{i,r}$).

$$KS_{i,r} = \left(\alpha_{i,d} KD_{i,r}^{\frac{\omega_r+1}{\omega_r}} + (1-\alpha_{i,d}) KF_{i,r}^{\frac{\omega_r+1}{\omega_r}} \right)^{\frac{\omega_r}{\omega_r+1}} \quad (8)$$

$KF_{i,r}$ Representing the sectoral investment in FDI capital by region r. $\alpha_{i,d}$ is the Investor's preference parameter for domestic and foreign investment in the source region.ω_r denoting the elasticity of transformation between home and foreign regions. Finally, foreign composite capital is allocated across regions of destination.

$$KF_{i,r} = \left(\sum_s \alpha_{i,r,s} FDI_{i,r,s}^{\frac{\omega_f+1}{\omega_f}} \right)^{\frac{\omega_f}{\omega_f+1}} \quad (9)$$

$FDI_{i,r,s}$ is FDI flow in sector i from region r into region s. $\alpha_{i,r,s}$ is the Investor's preference of region r for specific destination region and ω_f representing the elasticity of transformation between various host regions. All transformation parameters are derived from the FTAP model. 1.2, 1.3 and 1.4 are transformation parameters in the three layers of allocation process, respectively.[5]

Like in some other studies such as Latorre et al. [30]; Latorre [96]; Deng et al. (2012, 2013) and Latorre and Hosoe [98]; we have ignored the effects of barriers to FDI in CGE modeling. In other words, we do not simulate the effects of FDI through barrier reduction channel. In fact, simulation will be in form of an exogenous increase in FDI in the OIG sector. Firstly, there are no accurate data related to these barriers in Iran, and secondly, numerical estimates may affect the results of the simulation, and thirdly, the main purpose of this study is considering the effects of change in FDI inflow rather than change in barriers.

Iranian economy like the most developing countries is under special conditions that this conditions should be considered in the general equilibrium modeling.

Firstly, in general equilibrium modelling, a country is considering a small country compared with other countries. This means that domestic policies such as fiscal, monetary and foreign exchange policies do not have any effect on other regions. Thus Iran is a considered as a small country. However, in energy sector such as oil and gas ones, Iran can be considered as a very important country. Enhancement and reduction of energy export by Iran can have influence on prices. This subject is considered in closure of the model.

Oil and gas as significant profitable raw materials are not only the basis of the Iranian economy, but also they constitute strategic and political instrument that interact with the Iranian domestic and foreign policy and are often utilized in diplomacy by the policy makers [103]. From an international perspective, Iran is a player due to its notable oil and gas resources. According to British Petroleum, Iran disposes of 158 billion barrels proven oil reserves and 33.5 trillion cubic meter natural gas reserves. Now, Iran ranks in the 4th place with the regard to the size of oil its reserves, while standing on the first position in terms of its gas reserves. Secondly, one of the realities in Iranian economy is the unemployment in labor market, where it is not considered in the GTAP model. Therefore, the unemployment in Iran is considered as a real fact in the model.

4.3. Modeling FDI spillovers

Considering that FDI can lead to the transfer of technical knowledge or technology spillover in host countries, TFP growth in the OIG sector is considered as a function of FDI in Iran. The spillover function presented in this research is modified version of trade-based spillover function of Van Meijl and Van Tongeren (1999), and Das (2002, 2007, 2015). This method is based on the assumption that the host region can only benefit from technological change which is occurring in another regions (source) if it absorbs the FDI from the region where the technological change occurs initially. So, the size of FDI flow plays a vital role in technology transfer. The following function describes productivity growth of sector i(percentage change of AVA_{ir} in equation 4) as a function of θ_{isr} (horizontal spillovers), absorptive capacity in the host country and productivity growth in the source region.

$$\mathrm{ava_{ir}} = \theta_{isr}^{\left(1-\mathrm{ACI_r}^2\right)^2} \mathrm{ava_{is}} \quad (10)$$

$$\mathrm{EM_{sr}} = \frac{\mathrm{ava_{ir}}}{\mathrm{ava_{is}}} = \theta_{ir}^{\left(1-\mathrm{ACI_r}^2\right)^2} \quad (11)$$

Where $\theta_{isr} = \frac{\mathrm{FDI_{isr}}}{\mathrm{WK_{ir}}}$ denotes the share of FDI originating from region s relative to total capital of sector i in home region.$\mathrm{FDI_{isr}}$ denoting the FDI flow from region s to sector i in region r and $\mathrm{WK_{ir}}$ is capital stock in sector i of the region r. $\mathrm{ava_{is}}$ and$\mathrm{ava_{ir}}$ are TFP growth in the host and the home region in sector i and $\mathrm{ACI_s}$representing the absorptive capacity of the host country.$\mathrm{EM_{rs}}$ is the technology spillover coefficient and represents the percentage of the technical progress which spillover from the source to the host region. While, $\mathrm{EM_{sr}}$ is determined endogenously in the model, $\mathrm{ACI_s}$ as a parameter is determined exogenously outside the model.Transmitted Foreign technology into sector i could spill over to other sectors via vertical linkages (backward and forward) in the host region. Hence, we could define another transmission equation showing how productivity improvement in sector i affects productivity of sector j in the same region. In a similar manner to Javorcik [40]; we use two measure for vertical spillovers as follow:

$$BAC_{jr} = \sum_{i,j \neq i} HOR_{ir} * \gamma_{ji} \quad (12)$$

$$FOR_{jr} = \sum_{i,j \neq i} HOR_{ir} * \gamma_{ij} \quad (13)$$

$$\rho_{jr} = BAC_{jr} + FOR_{jr} \quad (14)$$

BAC(backward)serves as a proxy for linkages between multinational firms and local suppliers. The forward spillover (FOR) is a proxy for the linkages between foreign firms and domestic clients.$\gamma_{ij}$is the proportion of the output of industry i supplied to sector j.the definition for the second transmission equation is given by:

$$\mathrm{ava_{jr}} = \rho_{jr}^{\left(1-\mathrm{ACI_r}^2\right)^2} \mathrm{ava_{ir}} \quad (15)$$

Where in host region r, the growth rate of productivity in sector j is a function of vertical spillover (ρ_{jr}), absorptive capacity and productivity growth of sector i.Spillover mechanism of FDI have two stage. First, FDI inflow leads to enhance the productivity of recipient sector (Equation 10). In the second stage, productivity improvement in sector i affects productivity of other sectors (Equation 15). Fig. 3 show these

[5] It should be noted that in FTAP model, at first, wealth is allocated to Bonds, Land, Capital and Natural Resources and then Capital is allocated in three mentioned layers. In this research it is assumed that wealth in each region is Capital.

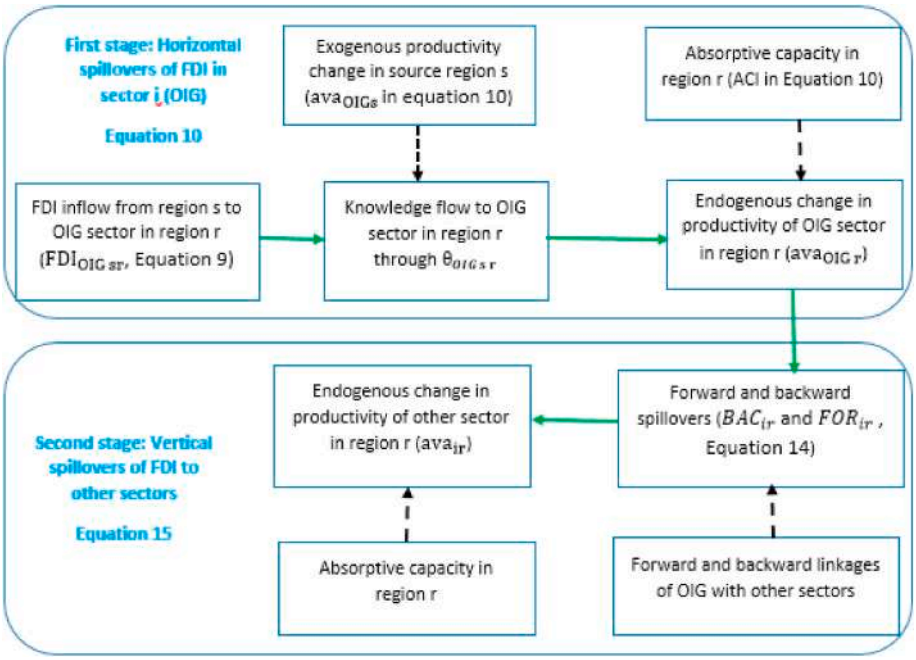

Fig. 3. Spillover mechanism of FDI in host region (green lines).

mechanisms.

The specification for ACI index follow Van Meijl and Van Tongeren (1999):

$$ACI_s = \min\left\{1, \frac{AC_s}{AC_r}\right\},\ 0 \le ACI_s \le 1 \tag{16}$$

According to the ACI_s index, if the host country has more similarity with the source country in terms of absorptive capacity, it will benefit more from advantages of the technical knowledge used in FDI. Zero ACI_simplying that the destination region is further away from source region and unit ACI_simplying that proximity between two regions is maximum. Various indices have been mentioned to determine absorptive capacity in empirical studies. Following the empirical studies related to technology spillover and absorptive capacity, we also used institutional quality (IQ_j), Infrastructural Efficiency (II_j), Financial Development (FD_j), and Human Capital in region j (HC_j) as indices for absorptive capacity. The following specification (Equation 17) implies imperfect substitutability of various measures of absorptive capacity. If the host country is at a desirable level of institutional quality, but has weak human capital, it will have low and insignificant absorptive capacity. Therefore, it cannot fully benefit from FDI advantages. Moreover, improving each of these indices has a positive effect on improving other indices, or in other words, they are synergistic.

$$AC_j = IQ_j II_j FD_j HC_j \quad j = r,\ s \tag{17}$$

Spillover function (equation 10 or 11) has several properties: 1- It is an increasing and concave function with respect toθ. In other words, the marginal benefits of FDI (MBF) are positive, but diminishing. These properties can be summarized as follow: $MBF = \frac{\partial EM}{\partial \theta} = A\theta^{A-1} \ge 0$, $\frac{\partial MBF}{\partial \theta} = A(A-1)\theta^{A-2} \le 0$ *with* $A = \left(1 - ACI^2\right)^2$

2- The relative level of absorptive capacity in the destination country affects the spillover coefficient (EM_{rs}). According to Equation 10, the maximum amount of technology spillover (highest productivity growth) that can be achieved in destination region equals the productivity growth of source region (Fig. 4). 3- At low level of absorptive capacity, EM is an increasing and convex function of ACI. By moving from a state of low to a state of high absorptive, the function changes from convex to concave (and increasing).

5. Data, parameters and scenarios

5.1. Data and parameters

The data used in conducting various scenarios include various types.

5.1.1- Information on social accounting matrix and elasticity of

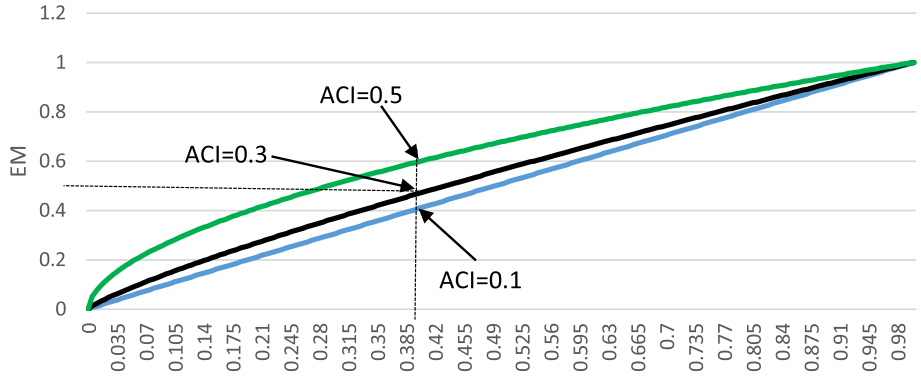

Fig. 4. EM as a function of θ

Table 2
Sectoral, Regional and Primary factor aggregation.

Sectors	1- Agriculture, hunting and fishing 2- Oil and Gas(extraction) 3- Mining and quarrying 4- Food, beverages and tobacco 5- Textiles, wearing apparel, leather, footwear 6- Wood and wood products, Paper; printing, publishing 7- Petroleum, Chemicals, rubber and plastics 8- Nonmetallic minerals 9- Basic and non-ferrous metals 10- Fabricated metals, motor vehicles, Other transport equipment, Electronics, other machinery, other manufacturing, recycling 11- Electricity, gas and water supply 12- construction 13- Services
Regions	1-Iran 2-Rest of World
Primary Factors	1-Land 2-Natural Resources 3-skilled Labor 4-Un Skilled Labor 5-Capital

Technical Assistance of Iran" (OIETAI), we estimated the $sfdi_{Iran}$and sfd^{i}_{Iran}.

In the next step, FDI is distributed in sectoral level based on equation (19).

$$FDI^{i}_{Iran} = sfd^{i}_{Iran} TFDI_{Iran} \quad (19)$$

FDI^{i}_{Iran} is the foreign capital stock in sector i and sfd^{i}_{Iran} is the share of FDI in sector i. Equation 20 is used to calculate the sectoral level of capital stock(VKB^{i}_{Iran}).

$$VKB^{i}_{Iran} = kb^{i}_{Iran} VKB_{Iran} \quad (20)$$

Table 3
Absorptive capacity index.

index	Institutional quality(IQ)	Infrastructure efficiency(II)	Financial market development(FD)	Average years of schooling(HC)
FDI source Regions	4.76	5.18	4.60	11.16
Iran(Destination Region)	3.79	3.96	3.28	8.30
Indices	0.796	0.765	0.713	0.744
ACI Index	Iran = 0.323		source Regions = 1	

Source: Authors Calculations

Table 4
Definition of sectors and their relative importance in the Iran economy.

Sectors	% on capital stock	% on output	% on FDI	Import to output	Export to output	Elasticity of substitution between imports and domestic goods
Agriculture, hunting and fishing	0.038	0.08	0.001	0.08	0.05	2.46
Oil and Gas(extraction)	0.053	0.17	0.723	0.003	0.62	5.58
Mining and quarrying	0.011	0.008	0.005	0.03	0.48	0.94
Food, beverages and tobacco	0.023	0.05	0.035	0.18	0.04	2.75
Textiles, wearing apparel, leather, footwear	0.002	0.009	0.004	0.76	0.12	3.76
Wood and wood products, Paper; printing, publishing	0.001	0.005	0.01	0.89	0.02	3.13
Petroleum, Chemicals, rubber and plastics	0.025	0.11	0.055	0.17	0.26	2.45
Nonmetallic minerals	0.009	0.015	0.004	0.15	0.1	2.9
Basic and non-ferrous metals	0.008	0.02	0.048	0.58	0.12	3.18
Fabricated metals, motor vehicles, Other transport equipment, Electronics, other machinery, other manufacturing, recycling	0.033	0.07	0.025	0.6	0.03	3.62
Electricity, gas and water supply	0.062	0.046	0.017	0.07	0.14	2.8
construction	0.005	0.077	0.019	0.01	0.011	1.9
Services	0.732	0.34	0.05	0.08	0.08	1.9
total	1	1	1	–		–

Source: Author's calculation based on GTAP9 Database

substitutions which are extracted from the GTAP 9 database. This database has been collected by a number of CGE modelers in Purdue University for 140 regions around the world and is consistent with dynamic and static CGE models. Furthermore, it has the required flexibility for disaggregating at sectoral and regional level.[6] Assessing the effects of various scenarios requires the aggregations of regions, sectors, and production factors which are presented in Table 2.

5.1.2-The amount of FDI inflow into different economic sectors of Iran. FDI inflow and outflow by source and host country are not available in GTAP 9. Nevertheless, total capital stock for each region is available in this database. In order to calculate the domestic capital stock (VKD) as well as FDI in such a way that is consistent with GTAP data, we computed the value of total FDI inflow in Iran, from equation 18.

$$TFDI_{Iran} = sfdi_{Iran} VKB_{Iran} \quad (18)$$

$sfdi_{Iran}$ is the share of FDI in total capital stock; VKB_{Iran} is the value of capital stock in Iran and $TFDI_{Iran}$ is the FDI stock in Iran. Based on the statistics declared by the "Organization for Investment Economic and

[6] Go to: http://www.gtap.ageco.purdue.edu/databases/v9/default.asp.

IIVKB VKB^{i}_{Iran} and kb^{i}_{Iran} are respectively the capital stock and the share of sector i of the total capital at the beginning of the period. Domestic capital stock in each sector (VKD^{i}_{Iran}) is calculated by subtracting FDI in each sector fromVKB^{i}_{Iran}.

5.1.3-Absorptive capacity parameters were extracted from various sources. Indices such as institutional quality, infrastructure efficiency and financial market development were extracted from the Global Competitiveness Report 2011–12 (Schwab et al., 2011). The numerical values or scores of indices are between 1 and 7, 1 being the worst and 7 being the best. For instance, countries whose scores move towards 1 are weak in terms of institutional quality, infrastructure efficiency, and financial development. Average years of schooling as an index for human capital are derived from the United Nation Development Program (UNDP) (Table 3).

5.2. Sectors and their relative importance

In this section, we have presented some of the economic indices related to different sectors using information and statistics related to the base year of 2011 in Iran in several tables. Table 4 shows the relative importance of each economic sector in Iran based on various indices. Services have the highest share in capital stock, in such a way that

Table 5
Cost structure of the sectors.

Sectors	labor	capital	Domestic intermediate	Imported intermediate	total
Agriculture, hunting and fishing	0.27	0.17	0.45	0.11	1
Oil and Gas (extraction)	0.012	0.95	0.026	0.012	1
Mining and quarrying	0.09	0.55	0.29	0.07	1
Food, beverages and tobacco	0.04	0.24	0.65	0.07	1
Textiles, wearing apparel, leather, footwear	0.08	0.1	0.46	0.36	1
Wood and wood products, Paper; printing, publishing	0.03	0.06	0.52	0.39	1
Petroleum, Chemicals, rubber and plastics	0.01	0.08	0.86	0.05	1
Nonmetallic minerals	0.12	0.29	0.46	0.13	1
Basic and non-ferrous metals	0.06	0.16	0.55	0.23	1
Fabricated metals, motor vehicles, Other transport equipment, Electronics, other machinery, other manufacturing, recycling	0.05	0.17	0.37	0.41	1
Electricity, gas and water supply	0.15	0.3	0.5	0.05	1
construction	0.13	0.23	0.58	0.06	1
Services	0.17	0.53	0.24	0.06	1

Source: Author's calculation based on GTAP9 Database

approximately 74% of the total capital stock belongs to this sector. OIG sector in Iran is such a vital sector that constitutes 17% of the total production and 58% of the total exports. Therefore, a decrease in production and exports in this sector can have significant effect on Iran's economy. Approximately, 72% of the total FDI stock of Iran has been concentrated in the OIG sector, which shows the high potential of this sector attract FDI. The shares of other sectors in attracting FDI are insignificant in Iran's economy. The highest proportion of import belongs to textiles and then basic metals. But, the OIG sector has attracted the highest proportion of exports.

The cost structure of all sectors is presented in Table 5. For instance, the highest cost share of the OIG sector is capital costs. Therefore, it can be said that FDI inflow into this sector will decrease the production costs and finally increase supply. The labor in the agriculture sector has a higher importance in production costs than in other sectors. Intermediate goods play a determining role in all sectors, except in the OIG sector.

Table 6 shows the percentage of production which is allocated to private consumption, exports, intermediate, and public consumption. Private consumption is one of the main components of demand in different sectors. Furthermore, high proportion of production in the petroleum, OIG, mining and quarrying sectors is exported. It seems that in these three sectors, export too will have a significant effect on evolution of production.

6. Results

6.1. Scenario 1: a 100% increase in FDI stock in the OIG sector

In this section, effects of FDI inflow into the Iranian OIG sector are studied in form of two scenarios. It is assumed that there is full employment in production factors and labor has full mobility across different sectors. However, there is no international labor movement. Also, capital as a production factor not only flows among sectors but also can flow from one region to another.

A. Macroeconomic results

The summary of the effects of this scenario on macroeconomic variables is shown in figure (5). FDI inflow at the first step, increases the capital stock and production in OIG sector, which leads to the improvement of exports.

Based on Table 4 the OIG sector constitutes approximately 17% of the total production and 58% of the total exports in Iran. Therefore, improving production and exports in this sector can play a key role in the total production and exports of Iran. As a result, FDI inflow has led to a 2.36% growth in GDP and a 1.97% increase in exports. One of the consequences of improving production and export of OIG is increase in regional household income. The findings show that the nominal and real income of households are increased by 5.3% and 3.24%, respectively. Furthermore, a higher amount of FDI has decreased capital productivity, which has led to a lower rental rate of capital (−1.46) and higher productivity and real wage of labor (2.09).

According to the Dutch disease literature, inflow of FDI leads to an increase in the price of goods in tradable and non-tradable sectors. Nevertheless, this increase in prices is higher in non-tradable sectors. Altogether, these effects lead to increase in the consumer price index (1.97%) and real exchange rate appreciation. The GTAP model does not contain nominal exchange rate, but the real exchange rate can be calculated using the price ratio of no-tradable goods to tradable goods, and the growth of exchange rate is considered as the difference between growth rate of prices in non-tradable and tradable sectors. One of the outcomes of this scenario is a real exchange rate appreciation of 2.15%. This means that FDI inflow has a positive effect on real exchange rate. The outcome of this effect is a decrease in competitiveness of domestic goods and finally an increase in imports (5.41%). Total export must be decreased by increase in exchange rate. The share of OIG and petrochemical product export in the total export is high. Therefore, export

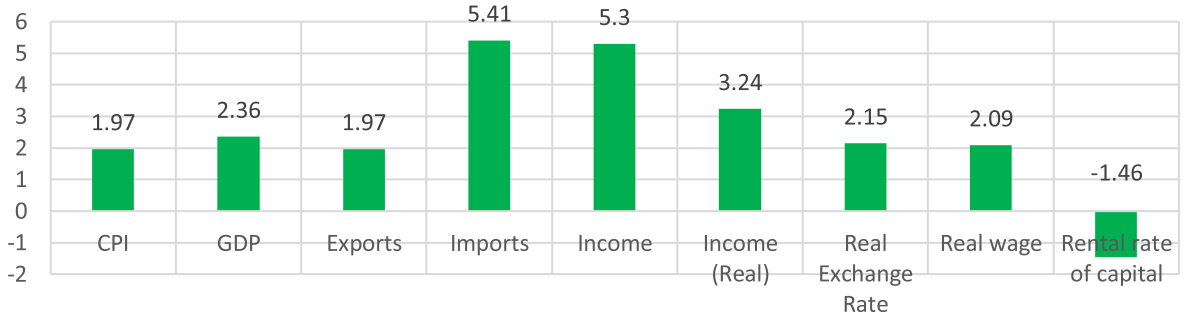

Fig. 5. Effects on macroeconomic variables (percent change).

Table 6
% of sectoral gross output devoted to.

Sectors	Private demand	Export	intermediates			Public demand	Investment
			NBTS	Devote to BTS	Devote to NTS		
Agriculture, hunting and fishing	0.42	0.05	0.46	0.00	0.02	0.00	0.05
Oil and Gas(extraction)	0.00	0.62	0.38	0.00	0.00	0.00	0.00
Mining and quarrying	0.00	0.48	0.34	0.00	0.18	0.00	0.00
Food, beverages and tobacco	0.76	0.04	0.13	0.00	0.07	0.00	0.00
Textiles, wearing apparel, leather, footwear	0.56	0.12	0.22	0.00	0.09	0.00	0.01
Wood and wood products, Paper; printing, publishing	0.07	0.02	0.42	0.00	0.49	0.00	0.00
Petroleum, Chemicals, rubber and plastics	0.17	0.26	0.34	0.00	0.22	0.00	0.01
Nonmetallic minerals	0.06	0.1	0.08	0.00	0.75	0.00	0.01
Basic and non-ferrous metals	0.00	0.12	0.43	0.00	0.45	0.00	0.00
Fabricated metals, motor vehicles, Other transport equipment, Electronics, other machinery, other manufacturing, recycling	0.16	0.03	0.19	0.00	0.11	0.00	0.51
Electricity, gas and water supply	0.26	0.14	0.45	0.00	0.15	0.00	0.00
construction	0.004	0.011	0.005	0.00	0.12	0.00	0.86
Services	0.4	0.08	0.11	0.01	0.14	0.2	0.06

Source: Author's calculation based on GTAP9 Database.

Table 7
Simulation results of Scenario1: Effects on sectoral variables.

Sectors	output	price	import	export	Private consumption	Labor Demand
Agriculture, hunting and fishing	−0.17	2.54	5.79	−10.1	1.17	−0.36
Oil and Gas(extraction)	5.38	−1.16	1.07	8.03	4.74	4.28
Mining and quarrying	−1.17	1.28	1.01	−2. 9	3.76	−1.71
Food, beverages and tobacco	0.37	2.37	6.39	−10.6	1.84	−1.11
Textiles, wearing apparel, leather, footwear	−1.93	1.32	4.2	−9.3	2.48	−3.42
Wood and wood products, Paper; printing, publishing	0.10	1.13	2.09	−6.46	4.1	−1.08
Petroleum, Chemicals, rubber and plastics	1.1	−0.28	1.33	0.26	4.19	−0.24
Nonmetallic minerals	0.61	2.19	7.05	−10.1	3.44	−0.56
Basic and non-ferrous metals	−1.64	1.65	2.41	−11.2	4.03	−3.72
Fabricated metals, motor vehicles, Other transport equipment, Electronics, other machinery, other manufacturing, recycling	−0.07	1.59	6.6	−11.35	3.75	−1.67
Electricity, gas and water supply	−0.41	1.48	5.17	−8.1	3.72	−1.76
construction	3.12	2.64	7.99	−9.57	3.09	2.9
Services	1.14	2.73	7.7	−8.5	3.54	0.03

has been improved despite the real exchange rate appreciation. Finally, it can be said that FDI inflow into the OIG sector has revealed the Dutch disease effects at macro level.

b. Sectoral results

FDI inflow leads to new equipment and machinery inflow into oil and gas sector which increase the extraction capability Off course according to Bhattacharya [104] there is always a tussle going on between the human ingenuity and depletion. That indicates the influence of technology on oil and gas extraction. Furthermore, The FDI inflow into the OIG sector increases the capital stock and production in this sector and decreases the rental price of capital, leading to a negative growth in prices in OIG sector. Higher output and profitability in this sector requires more labor. Labor is transferred from other sectors to the OIG sector (indirect resources movement effect). The findings show that production and employment have increased and prices have decreased in these sectors (Table 7).

However, production in NBTS does not necessarily have a decreasing trend. Changes in production in these sectors result from the combined effect of many factors:

Higher income from increasing production and sales of OIG expands the demand for all goods including tradable and non-tradable goods (spending effect). This effect stimulates the production of all sectors and increases prices (especially the price of non-tradable goods). Based on Fig. 4, the real income of households has improved by 3.24%. Therefore, it is expected that demand and production will increase in all sectors.

1. An increase in prices in all sectors (and more strongly in NTS) leads to the appreciation of real exchange rate. However, it has a negative effect on competitiveness of tradable goods and reduces their production and consequently their export.
2. It is expected that labor movement from NBTS to BTS restricts the production in NBTS.
3. An increase in price and profitability in NTS leads to the movements of factors from NBTS to NTS (direct resources movement effect), which is one of the effective factors on decreasing NBTS production.
4. Structure of the demands for various goods plays an effective role in changing the production of the sectors. Table 6 shows the demand structure for different sectors. For instance, considering that 75% of the produced nonmetallic minerals are purchased by NTS as intermediate goods, improving the production in NTS has a positive effect on the production of nonmetallic minerals. This positive effect may neutralize negative effects of resources movement or exchange rate growth. In sectors which are export-oriented, or a high percentage of their production is exported, increasing exchange rate will negatively effect on their production.
5. It seems that the linkages between NBTS to BTS and NTS are effective on the production evolution of NBTS. For example, the OIG sector supplies about 80% of intermediary goods used in the petroleum sector. Therefore, increasing OIG production improves petroleum production.
6. Volume of trade in the initial equilibrium as well as the elasticity of substitution between domestic and imported goods in each sector. In sectors with high elasticity of substitution, increase in domestic price will make their substitution with imported goods easier, leading to a

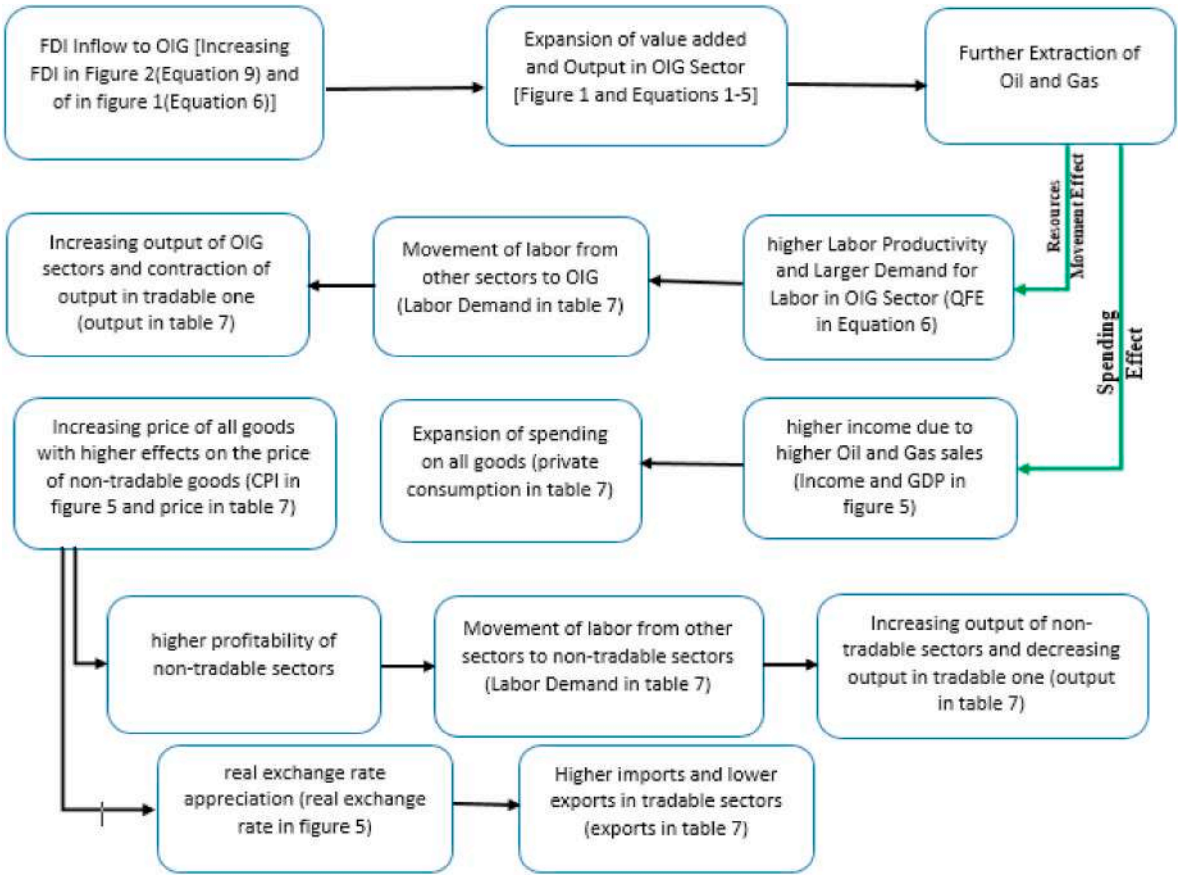

Fig. 6. A general algorithm for Dutch Disease.

reduction in their production. Fig. 6 show the summary of Dutch disease processes.

Findings of the first scenario show the Dutch disease effects in the Iranian economy. Production of NTS has increased especially in the construction sector, while it has decreased significantly in textile, mining and basic metal industries. The Improved income of the regional households and consequently, higher demand made by them have led to an increase in food products. Positive growth of prices in all sectors except BTS and petroleum has led to a decrease in export and an increase in import of various products. Since most of the demanded intermediate goods in the petroleum sector are supplied by the BTS sector, and 86% of the costs of this sector are due to the purchase of these intermediate goods, the growth of petroleum prices is negative. Findings of this scenario are consistent with finding of Benjamin et al. (1989) and Bandara (1995).

6.2. *Scenario 2: scenario 1 + 5% shock to ava_{ir} in the OIG sector in ROW*

A-Macroeconomics Results

In this scenario, we shock the total factor productivity coefficient of the rest of the world in the OIG sector by 5%. It seems that if FDI inflow is accompanied by technology spillover, the effects of Dutch disease decrease significantly. Consumer price index has decreased compared to the first scenario. Therefore, competitiveness has been improved and import has not increased but export has increased more than before. Real wages due to the negative growth of prices, show a higher growth (Fig. 7).

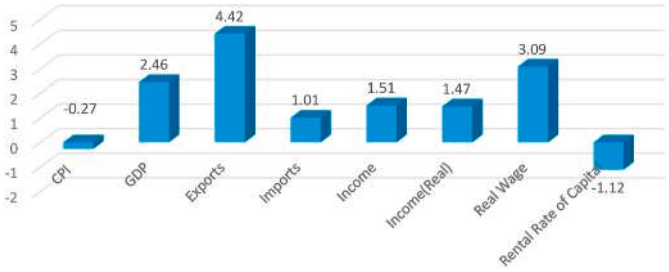

Fig. 7. Effects on macroeconomic variables (percent change).

Productivity growth in the rest of the world is 5%, and the productivity of the OIG sector in Iran has increased by 2.23%, affecting the productivity of all sectors through backward and forward linkages. Therefore, it seems that the effects of Dutch disease have almost disappeared in most sectors, in such a way that, production has increased in all sectors and sectors which have stronger links with OIG have experienced a higher improvement in production. For instance, petroleum production has increased by 11.28% which is higher than it is in the first scenario. Technical advances and the consequent increase in OIG production in the rest of the world have led to a decrease in the growth of OIG production compared to the previous scenario. Lower growth in oil and gas production and consequently, a lower increase in household income has led to a lower increase in the consuming demand of households. Labor movement and employment decrease have not occurred in most tradable sectors; rather, employment has increased.

Considering the numerous sanctions on Iranian economy that the reduction of oil extraction and lowering the share of oil and gas export is one of their outcomes, the FDI inflow leads to inflow of equipment's and

B Sectoral results

Table 8
Simulation results of Scenario2: Effects on sectoral variables.

Sectors	output	price	import	export	Private consumption	Labor Demand
Agriculture, hunting and fishing	0.25	0.68	2.17	−2.5	0.52	0.11
Oil and Gas(extraction)	5.43	−11.9	5.26	2.13	7.97	0.53
Mining and quarrying	0.25	0.26	0.77	−0.26	1.58	0.003
Food, beverages and tobacco	0.4	0.62	2.3	−3.25	0.8	−1.26
Textiles, wearing apparel, leather, footwear	3.26	−1.1	1.1	5.2	1.28	2.98
Wood and wood products, Paper; printing, publishing	1.75	−0.72	1.07	2.33	1.88	0.94
Petroleum, Chemicals, rubber and plastics	11.28	−8.26	−5.35	25.4	5.23	13.6
Nonmetallic minerals	0.37	0.12	2.9	−3.5	1.68	−1.06
Basic and non-ferrous metals	0.19	−0.17	0.98	−1.9	1.84	−1.38
Fabricated metals, motor vehicles, Other transport equipment, Electronics, other machinery, other manufacturing, recycling	0.56	−0.03	1.79	−2.25	1.71	−0.97
Electricity, gas and water supply	3.17	−2.16	2.2	4.95	2.76	2.8
construction	0.98	0.68	2.53	−2.95	1.39	−0.16
Services	0.96	0.61	2.63	−1.86	1.63	−0.53

machinery for extracting more oil and gas. Enhancement of extractions leads to the absorption of production factors and labor to this sector.

Altogether, due to technology spillover resulted from FDI, it can be said that the effects of Dutch disease will decrease or disappear completely (Table 8).

7. Conclusion and policy recommendations

According to World Investment Report (2018), Inflows of FDI to the Iran increased by nearly 50% to $5 billion. Following the lifting of sanctions in 2015, the country's rich reserves started to attract significant FDI in the exploration and production of oil and gas. This show that, Iran have a great potential for attracting of FDI in the oil and gas sector. Inflow of foreign capital to the OIG sector may have negative or positive consequences such as Dutch disease and productivity spillovers. There are limited studies on the role of FDI in technology spillover in Iran.

Nevertheless, the aim of this study is to assess the effects of direct and indirect of FDI inflow to oil and gas sector on Iranian economy. For this purpose, GTAP model used to consider those effects in two different scenarios. The standard GTAP model has been developed in such a way that FDI is included as a factor of production in the production technology of the firms. The first scenario shows a 100% growth of FDI and the second scenario shows the productivity growth of domestic firms due to technological progress in the rest of the world along with FDI growth. The modeling mechanism in the second scenario separates the effects of productivity spillover horizontally (within sectors) and vertically (across sectors). Also, marginal gain of FDI is considered as a function of the absorptive capacity of domestic firms.

The findings of the first scenario confirm the improvement of production and employment in BTS and NTS. However, production behavior is not the same in NBTS. Therefore, production has increased in some tradable sectors such as petroleum and food sectors and it has decreased in some sectors such as agriculture and mining. Negative growth of employment in NBTS shows the effect of resource movement. Another interesting result is an increase in the prices and real exchange rate and consequently an increase in imports and a decrease in export are evidences of Dutch disease in Iran's economy. Evidences, show that by increasing the FDI, the ratio of non-tradable to tradable sectors increases. From perspective of Dutch Disease, this finding is in line with Benjamin et al. (1989), Bandara (1995) and Manzoor et al. [105].

The findings of the second scenario show that foreign technology spillovers through FDI channel can significantly decrease the effects of Dutch disease, in such a way that, in this scenario the production of all sectors has increased, and the price has decreased in most sectors. Altogether, the findings of the second scenario show the high importance of technology spillover which is analogous to the results shown by Lejour et al. [100]; Marzban and Nejati [106]; Deng et al.(2013) and Nejati [107].

Also, if Iran has an absorptive index higher than 0.31, it will benefit more from the positive effects of technology spillover. Based on Fig. 4 and equation (15) and Table 8 results, it can be said that the effect productivity spillovers will be higher with increasing the Iranian firm's absorptive capacity. In the other words, as the capability of a firm in absorbing the externality of FDI be higher, the effect of spillover will be higher and the effect of Dutch disease will be lower.

Several important implications can be concluded in this research. Firstly, incentive policies to attract FDI in the OIG sector, in addition to improving production and exports of OIG, increase the income. Secondly, it seems that improving the quality of infrastructures, developing financial organizations and increasing human capital can provide a suitable ground to attract foreign technology and knowledge. It eliminates the negative effects of the Dutch disease and allows the host country to enjoy the benefits of foreign technology.

There is room for future research. Since FDI is a long-term phenomenon, its inflow can have long-term effects on the economy. Thus, a more comprehensive investigation may be achieved using a dynamic CGE model to evaluate the effects of this phenomenon. Furthermore, inflow of foreign machinery and capital equipment's can have a positive or negative impact on the environment, therefore, in addition to economic evaluation, environmental impact assessment is also useful, which necessitates the use of environmental CGE models.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Abbreviations

Non Booming Tradable Sectors (NBTS)
Booming Tradable Sectors (BTS)
Non-Tradable Sectors (NTS)
Oil and Gas (OIG)
Foreign Direct Investment (FDI)
Computational General Equilibrium (CGE)
Gross Domestic Product (GDP)
Total Factor Productivity (TFP)
Gross Domestic Product (GDP)
Consumer Price Index (CPI)

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