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Examination of Iran's Factor Content of Trade using International Input–output Tables

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Abstract

Numerous models are proposed to model international trade and promote it. Vanek, instead of designing a trade pattern based on the production, introduced a pattern based on the factor content of trade. In the present study, apart from the Heckscher-Ohlin-Vanek (HOV) theorem, we attempt to determine the factor content of Iran's trade without factor price equalization by using internal input-output tables. Net trading is positive only for 7 sectors of Iran's economy, including oil and gas. It is negative for 91 percent of sectors that accounts for 78 percent of the economy. Moreover, Iran's factor content of trade is positive for 50 percent of industries, negative for 48%, and it is zero for two ones. In general, the factor content of trade for raw and mineral materials, services, electricity, gas and water infrastructure sectors are positive. In contrast, the factor content of trade is negative for activities like manufacturing of machinery and equipment and in general for sections that require intermediate investment and high-tech goods. Sign and rank tests are employed to assess the validity of HOV theorem. The sign test was found to be satisfied for 67% of cases. Rank test showed satisfaction in about 47% of the cases.

Keywords: Factor Content of trade, Heckscher-Ohlin-Vanek Model, Factor Price Difference, International Input-output Tables.
JEL Classification: Y10: P45: O53: F14

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1. Introduction

The international trade plays an important role in economic growth. Accordingly, many theories and models are dedicated to modeling international trade. The previous theories have many difficulties to show how countries have different productivities to use production factors. Eli Heckscher (1919) and Bertil Ohlin (1933) proposed factor proportions theory to answer such a defect. According to this theory, international trade was explained based on differences in resource endowments.

The empirical examination of Heckscher-Ohlin (H-O) did not satisfy the expectations. In order to develop the H-O theory, Vanek (1968), instead of expressing the trade model based on the production factor differences (relative abundance of factors), introduced it based on factor content of trade. It determines the role of factor production in imported and exported goods. For example, how many factors are exported by exporting a specific good, like labor and capital? Like this, by importing goods and services, how many production factors, directly or indirectly, are entered to the country? In experimental economics literature, H-O model is proposed based on production factors, then it is developed by Vanek, the Heckscher-Ohlin model improved it to consider linkage among sectors within the countries. In order to consider the intersection connections among sectors, input-output model should be used that HOV model is based on it. One of the major characteristics of HOV model is its consideration of technical coefficients of economic sectors or what is called *pre/post linkage sectors*. Hence, expanding the H-O model from two countries, two goods, and two production factors to a general model which have hypothesis of many countries, many products and several production factors is another advantage of the HOV model.

Testing the countries, factor content of trade is crucial to determine the type of factor that is intensive in exported goods. So, Iran needs an appropriate production, export and import models to its business relations. We try to realize whether or not the labor force and other factors affect the factor content of trade. How is the sign of Iran's factor content of trade in different sectors and activities? Which activities have relative factor abundance that we export the factor services? Which ones have negative factor content of trade? And which factors are imported? Hence, in order to answer such questions, we should be able to investigate the factor content of trade to improve it, and to use the internal factor market potential especially the labor force. Given that in accordance with the government economic policy, what can be proposed in order to improve and change the factor structure?

In the present study, by using the HOV model and by considering the intersection sectors coefficient, we try to evaluate the Iran's factor content of trade in different activities to determine the influence of capital and labor force factors in exported and imported goods and services. So we use international input-output tables. The national tables, in contrast to the international ones consider all exported goods as the final goods, so there is no role for the intermediate goods. In addition, assumption of factor price equalization in the standard HOV model has always raised some criticisms. By setting this assumption aside, in this paper, we attempted to increase the model's power of prediction.

In the following literature review, we will investigate different point of views and various estimation methods on the factor content of trade. The results and tests of these studies will be evaluated in the following sections. In methodology, the mathematical model of factor content of trade will be developed and sign and rank tests will be employed to measure the HOV performance. Input-output tables of the World Bank are used in order to estimate Iran's net trade and factor content trade, which include 100 activities and 188 countries data.

2. Literature Review

The formulation of the HOV model led to numerous applied studies started from Leontief (1956) and continued by Leamer (1980), Trefler (1993, 1995), and Davis and Weinstein (2001) along with other studies. Choi and Krishna (2004) declare that models of international trade based on the specific-

factors are the basic international trade model. Marshall's (2011) model shows the importance of relative factor abundance in trade model that China's recent growth is compatible with the HOV prediction. Dasgupta, Ghosh, Chakraborty, and Mukhopadhyay (2017) measured the India's factor content of trade and found that the factor intensity and a relative advantage are determined by the factor contents.

In contrast, some empirical studies show that the standard HOV model will fail. Trefler and Zhu (2000) believe that although this theory predicts the Saudi Arabia's crude oil export, we can hardly believe in its capability to explain the international trade models. Feenstra and Hanson (2000) show that the factor content of trade is much less than the HOV model in prediction. By evaluating Croatia's factor content of trade, Jošićt (2017) declares that most of the empirical HOV theory tests are subjected to failure. Sorg-Langhans, Struck and Velic (2018) also posit that international trade theories, including the HOV model, will encounter various issues in explaining different phenomena.

Following Trefler (1995), several studies were conducted to map out some strategies to improve Vanek's factor content prediction. Trefler and Zhu (2000) express that the standard factor content definition does not seem to be appropriate for considering modern technologies. Cabral, Falvey and Milner (2006) indicate that what is predicted by HOV framework will be improved significantly in case the technological heterogeneity being considered. Given that, Trefler and Zhu (2010) declare that technological differences, traded intermediate inputs, and the definition of factor contents of trade that are compatible with the Vanek's prediction does not exists. Fisher (2011) shows that factor conversion matrix is an appropriate adaptation in order to consider international productivity difference. Nioshioka (2012) finds that production techniques differ substantially across countries and factors, but differ less across industries within a country. In contrast to such opinions, Lai and Zhu (2007) notice that, more the difference of initial resources, the better the performance of factor content prediction will be. Ciaian, Kancs, and Pokrivcak (2008) set aside factor price equalization and technological difference to determine factor content of European countries. Egger, Marshal, and Fisher (2011) claim endowments differences are ten times as important as technology differences. Brustein and Vogel (2017) also take into account the technology among countries as different.

Some other studies also considered the factor price equalization as a failure of HOV model. Choi (2004) maintains that the measured factor content of trade is significantly different from factor content of trade prediction. Levchenko and Zhang (2016) by evaluating the Ricardian productivity difference discovered that there is a factor price difference which should be considered. Morrow (2017) expresses that the presence of transportation costs and incomplete substitution of factors are reasons for factor price differences. Adao, Costinot and Donaldson (2017) state that the HOV models are established based on the factor price equality assumption. Hence, the factors of different countries are in fact assumed as the complete substitution of each other. In contrast, in the model of Jakel and Smolka (2017), the equality of factor price is assumed based on the effective factor price. Morrow and Trefler (2017) state that, the difference in endowments and their prices are two major factors for trade modeling. Like that, Zimring (2019) shows that data supports the HOV theorem and believe that whatever other forces shape trade patterns; relative factor abundance does play a role.

Some other strategies are also devised to improve HOV performance. Choi (2004) declares that using the national input-output tables (NIOT) would lead to the deviation of prediction. Kwok (2006) believes that U.S. input–output tables are one source of failure. There is a large improvement when using input–output tables from many countries. Also, Milner, Lu and Yu (2010) by evaluating different measurement methods, discovered how difference in measurement contributes to the benefits of trade. Foster and Stehrer (2011) also claim that the presence of intermediate goods is an important part of trade.

Dietzenbacher and Los (2011) suggest that the latest wave of globalization leads to increase the proportion of intermediate inputs in the flow of trade. So, International trade theories have attracted much attention. Using the world input-output tables (WIOT) is essential for considering trade in intermediate inputs. Puzzello (2012) declares that details of countries' input–output structure is the key to the factor content of trade calculation. Fisher and Marshal (2016) believe that in technology matrix relies on the local factor price. They argue that technology matrix of America resulted in Trefler's (1993) failure.

Empirical research focused on Iran international trade is limited. Karimi (2006), by using NIOT finds that economic activities are based on relative advantages. Taghavi, Jahangard and Safavi (2011) peruse HOV model in Iran by using NIOT. They conclude factor content was negative for 67 percent of activities and was positive for 33 percent. Furthermore, most exporting industries use land, Natural recourses and labor.

Bazzazan (2012) investigates whether or not the Leontief Paradox is satisfied in foreign trade in Iran. The results, based on HOV model, show that the Leontief paradox was fulfilled and Iran export is capital intensive. Sabzealizad, Banoi, and Bahrami (2014), by evaluating Iran's factor content of trade conclude that Iran has no relative advantage in labor as labor services are imported. In terms of capital, in most activities, factor content is negative except natural resource oriented activities.

By analyzing these studies, we can perceive that despite the overall accuracy of standard HOV model, it performs poorly. Some restrictive assumptions, including the factor price equalization, U.S. technology and the use of NIOT are among the failure factors of this model. In present study, despite previous especially researches focus on Iran international trade, we use values units of production factors instead of their physical unites. Furthermore, to consider intermediate inputs, in our sample, we use Iran's WIOT and all its trade partner countries. Most importantly, we evaluate our prediction power, using sign and rank tests. Studies focus on Iran, have such defects.

3. Methodology

3.1 From Trade in Goods to Trade in Factor Services

The theoretical question of Ricardo about the factor productivity differences was replied by the Heckscher–Ohlin theorem. According to H-O model, countries are endowed with different factor supplies. In contrast to the Ricardo's theory, which considers factor productivity differences as the cause of international trade, in H-O, differences in endowments and in relative price of goods are quite important in explaining the factor content of trade (Blaug, 2009).

Bowen, Leamer and Sveikauskas (1987) conducted one of the studies on the H-O model. They believe that, in fact, the trade of goods is an indirect trade of production factors, known as international trade in factor services. Hence, if the contribution of production inputs in exported and imported goods and services are defined, we can realize that a country export benefits from the abundance factor. The model was first conceived by Eli Heckscher (1919) in a published paper 'The Effect of Foreign Trade on the Distribution of Income' and was developed by Bertil Ohlin in 1933. Following them, Vanek (1968) re-interpreted the model to consider factor services trade, stating that, the model predicts that net export of factor services will be the difference between a region's endowment and the world's endowment. His contribution leads to relating factor endowments, factor input requirements and factor trade, the so-called Heckscher-Ohlin-Vanek (HOV) equation. The Hechscher-Ohlin-Vanek model is used based on the framework of input-output tables to assess the factor content of trade (Artal-Tur, Llano-Verduras and Requena-Silvente, 2010).

3.2 HOV Model Assumptions

The model includes of many countries, indexed by i = 1,…,C; many industries (products or activities), indexed by j=1,…,N; and many factors, indexed by ℓ, $\ell = \ell_1, \ell_2, ..., \mathrm{M}$. Technologies are identical across countries. Free flow of international

trade with no restrictions or limitations is considered. That is, transportation costs, tariffs or other obstructions have no control to restrict trade flow. Tastes are identical and homothetic across countries. There exists perfect factor production mobility within each country though international mobility is not possible. Goods and factor markets are perfectly competitive and the number of goods (N) is more than the number of factor production (M): $(N \geq M)$ (Feenstra, 2004).

Let $i = 1,...,N$ be the index per country and $g = 1,...,\mathrm{G}$ is the index of products. The $(M \times N)$ matrix $\mathrm{A} = \left[\mathrm{a}_{il_j} \right]$ denotes the amounts of labor, capital, land, and other primary factors needed to produce one unit of output. This matrix should include both direct primary factors to use in production processes, and indirect primary factors used through the intermediate inputs. The rows measure different factors ℓ, $\ell = \ell_1, \ell_2, ..., \mathrm{M}$, while its columns measure different industries j=1,…,N.

$$A = \begin{bmatrix} a_{1l_1} & a_{2l_1} & a_{3l_1} & ... \\ a_{1l_2} & a_{2l_2} & a_{3l_2} & ... \\ \vdots & \vdots & \vdots & \vdots \\ a_{1l_M} & a_{2l_M} & a_{3l_M} & ... \end{bmatrix}_{M \times N} \quad (1)$$

Let the $(M \times N)$ be direct factor requirements by $\tilde{A}$.

$$\tilde{A} = \begin{bmatrix} \tilde{a}_{11} & \tilde{a}_{12} & ... & \tilde{a}_{1N} \\ \tilde{a}_{21} & \tilde{a}_{22} & ... & \tilde{a}_{2N} \\ \vdots & \vdots & \vdots & \vdots \\ \tilde{a}_{M1} & \tilde{a}_{M2} & ... & \tilde{a}_{MN} \end{bmatrix}_{M \times N} \quad (2)$$

The elements of the direct factor requirements matrix are achieved by dividing the factor earnings into the output of that section. In practice, the indirect factors are measured by using the input-output matrix. B is the so-called input-output coefficients matrix. The elements of this matrix show the value of input, goods, or purchased services to produce one unit of output.

$$B = \begin{bmatrix} b_{11} & b_{12} & ... & b_{1N} \\ b_{21} & b_{22} & ... & b_{2N} \\ \vdots & \vdots & \vdots & \vdots \\ b_{N1} & b_{N2} & ... & b_{NN} \end{bmatrix}_{N \times N} \quad (3)$$

b_{ij} shows, the amount of i section outputs used as an input to produce a unit of production in section j. Now, given the proposed hypotheses, we have the following equations (Taghavi, et. al. 2011):

$$\begin{aligned} A &= \tilde{A} + BA \\ A(I - B) &= \tilde{A} \\ A &= \tilde{A}(I - B)^{-1} \end{aligned} \quad (4)$$

3.3 Vanek's Equation

So, we compute the total factor requirements matrix (A). It is clear that products include intermediate inputs (BQ), final consumption (D), and trade (T). Therefore:

$$Q^i = BQ^i + D^i + T^i \quad (5)$$

By using the above equation and by applying $GNP = C + I + G + X - M$ and I-O table, the net trade of each country is estimated as follows:

$$T^i = (I - B)Q^i - D^i \quad (6)$$

It shows that net export is the difference between GDP and domestic demand. Net product is defined as gross product minus intermediate inputs. Hence, the relationship between net product and gross domestic product is as follows[2]:

$$Q^i (I - B) = \mathrm{Y}^i \quad (7)$$

Where $Q^i{}_{N \times 1}$ is gross product vector, $(C + I + G) = D^i{}_{N \times 1}$ is the final demand vector, and Y^i is the net product of the country i. In order to calculate the factor

[2] By assuming $X - M = T$, we have $X - M = Q - BQ - D$. Net production $X - M = Q - BQ - (C + I + G)$

$\Rightarrow (C + I + G) + (X - M) = \mathrm{Q} - \mathrm{BQ} = \mathrm{Y}$

content of trade, the equation (6) is multiplied by $\tilde{A}(I-B)^{-1}$ and simplified as:

$$\tilde{A}(I-B)^{-1}T^{i}=\tilde{A}Q^{i}-\tilde{A}(I-B)^{-1}D^{i} \quad (8)$$

Where $AT^{i}=V^{i}-AD^{i}$. V^{i} is country i's total factor. By considering w (world), s^{i} (country i's demand to world demand) and P (price index) and by world trade balance, world production equates world consumption:

$$\frac{D^{i}}{D^{w}}=s^{i}\Rightarrow AD^{i}=s^{i}AD^{w}$$
$$s^{i}=\frac{P'D^{i}}{P'D^{w}}\rightarrow s^{i}=\frac{P'Y^{i}}{P'Y^{w}}=\frac{GDP^{i}}{GDP^{w}} \quad (9)$$

In case all countries have the same technology matrix A, under full employment assumption, county i's factor content of trade (V^{i}) should be equal to the real factors in the production process (left hand of the equation (10)):

$$AY^{i}=\tilde{A}(I-B)^{-1}Y^{i}=V^{i} \quad (10)$$

Given that, as can be seen in equation (11), factor content at world level (V^{w}) should be equal to the real factor in the world production process:

$$AY^{w}=\tilde{A}(I-B)^{-1}Y^{w}=V^{w} \quad (11)$$

As preferences are homothetic, the vector of final demand goods (D^{i}), under a clear market condition, is equal to the world production vector Y^{w} multiplied by the share of country i in world consumption (s^{i}):

$$D^{i}=s^{i}Y^{w} \quad (12)$$

By multiplying both sides of equation (12) by technology matrix, we have:

$$AD^{i}=s^{i}V^{w} \quad (13)$$

Considering equation (6) and subtracting equation (13) from equation (10), the HOV model is as follows:

$$A(Y^{i}-D^{i})=AT^{i}=F^{i}=V^{i}-s^{i}V^{w} \quad (14)$$

For each factor, we have:

$$F_{\ell}^{i}=V_{\ell}^{i}-s^{i}V_{\ell}^{w} \quad (15)$$

In this study, in order to determine Iran's and world's factor content of trade, factor price difference is considered. In addition, the value of each factor services is a criterion to measure factor content of trade instead of physical units of factors.

If ℓ_1 factor satisfies the following,

$$if:\frac{V_{\ell_1}^{i}}{V_{\ell_1}^{w}}>s^{i}\Rightarrow F_{\ell_1}^{i}>0$$

This means, ℓ_1 factor endowment in country i's relative to the world, exceeds country i's share of world GDP, then we say this country has ℓ_1 abundant. In that case, the ℓ_1 factor content of trade should also be positive and conversely if factor ℓ_1 is scarce in country i. In the case when ℓ_1 factor endowment in country i's relative to the world equal country i's share of world GDP, the factor is neither imported nor exported. Therefore, there are three modes for F as follows:

Relative abundance

$$\rightarrow\frac{V_{\ell}^{i}}{V_{\ell}^{w}}>\frac{GDP^{i}}{GDP^{w}}=s^{i}\Rightarrow F_{\ell}^{i}>0$$

Relative shortage

$$\rightarrow\frac{V_{\ell}^{i}}{V_{\ell}^{w}}<\frac{GDP^{i}}{GDP^{w}}=s^{i}\Rightarrow F_{\ell}^{i}<0$$

No trade

$$\rightarrow\frac{V_{\ell}^{i}}{V_{\ell}^{w}}=\frac{GDP^{i}}{GDP^{w}}=s^{i}\Rightarrow F_{\ell}^{i}=0$$

If $F_{\ell}>0$ within an economic activity, we enjoy having a relative abundance in that productive factor than other countries and exported that factor, similarly, if $F_{\ell}<0$, other countries have a relative abundance in that factor than our country and our country imported the factor. Then, for each economic section, we will have a vector of factor content of trade as follows:

$$F_{\ell}^{i}=\begin{bmatrix}f_{\ell_1}\\ f_{\ell_2}\\ f_{\ell 3}\\ \vdots\end{bmatrix}_{N\times 1} \quad (16)$$

3.4 Rank and Sign Test

In order to test the HOV model, we calculate the left side of equation (15), the data of T and A matrixes, and computing factors information (right side of equation (15)), then they will be compared.

Leamer (1980) applied the Vanek's interpretation of the H-O model. If one factor is abundant relative to the others, the factor content of net export should be positive and if a factor is scared in a country, the factor content of net export should be negative. Net factor content of trade is equal to the effective factor minus GDP share of each country relative to the world. Hence, the first complete test of the HOV theorem was developed by Bowen, Leamer and Sveikaukas (1987). They proposed two tests of equation (15)(Feenstra, 2004):

Sign test:

$$sign\ (F_\ell^i) = sign\ (v_\ell^i - s^i v_\ell^w) \quad i = 1,...,C, \quad \ell = 1,...,M \tag{17}$$

Rank test:

$$F_{\ell_2}^i > F_{\ell_1}^i \Leftrightarrow (V_{\ell_2}^i - s^i V_{\ell_2}^w) > (V_{\ell_1}^i - s^i V_{\ell_1}^w) \quad i = 1,...,C, \quad \ell = 1,...,M \tag{18}$$

The first compares the sign on the left and right of (15). With M factors and C countries, there are MC observations in total, and we are interested in what percentages of these have the same sign on the two sides. Thus, the number of similar sign in both side of the equation shows that the sign of predicted factor content of trade is similar to the sign of measured factor content of trade. The more the correspondence of these signs, the higher is the prediction power of the HOV model. Therefore, the result of the sign tests is between 0 and 1.

The rank test involves a pairwise comparison of each country factors. There are $M(M-1)/2$ pairs for each of C countries. If ℓ factor content of trade exceeds ℓ' factor content of trade, then we check whether the relative abundance of ℓ also exceeds the relative abundance of ℓ'. Again, similar to the sign test, the rank test results are also between 0 and 1 (Feenstra, 2004).

3.5 Statistical Resources

If a country's input-output table is used individually, all export of that country will be considered as the final product (Dietzenbacher & Los, 2011). This problem is completely evident in the studies which used Iran's limited data. The use of the world input-output tables is vital in order to consider the trade of intermediate goods. Given the aforementioned facts, in the present study, the latest input-output table of the World Bank 2015, published in 2019, including 189 countries and 15909 sections is used for measuring the factor content of the Iranian trade to make the obtained results more compatible with reality (Timmer, Dietzenbacher, Los, Stehrer, & Vries 2015). We are interested in evaluating factor content of trade in all Iran's economic activities. So, based on WIOT, Iran economy is classified into 100 industries and 149 products.

4. Empirical Results and Analysis of Findings

Based on the proposed model, within the theoretical framework and WIOT, we compute Iran's factor content of trade, by using the HOV model which includes 100 industries which are mentioned in Tables 1 and 2. In Table 1, the net trade of Iran's industries is estimated for the year 2015. The net trade of extraction of crude oil and natural gas, manufacture and distribution of gas, breeding bee and silkworm, manufacture of basic copper, water transport, short-stay accommodation and public management are positive. The net trade for the services of self-owned dwelling activities and governmental hospital activities are zero. The net trade of other industries is also negative which account for 91% of economic activities and 78.01% of domestic production. This fact shows the high import volume for Iran's activity. In addition, the export composition is indicative of the dominance of oil and gas sections and even in agriculture sections, so the country has been a net importer.

Table 1: Net Trade of Industries (Million Rial-current Prices)

Industries	Net trade	Industries	Net trade
Farming	-110,688,075	Transport via railways	-12,011,656
Gardening	-344,617	Land transport of passengers	-25,809,309
Forestry	-18,708,387	Land transport of freight	-149,415,896
Agricultural & animal husbandry service activities	-30,988,047	Transport via pipelines	-16,178,318
Farming of animals	-136,468,456	Water transport	1,482,355
Breeding bee and silkworm	3,452,051	Air transport	-26,300,635
Farming of poultry	-51,970,644	Supporting transport services	-31,398,915
Fishery	-3,254,769	Post and Telecommunications	-2,565,170
Extraction of coal and lignite	-1,854,937	Short -stay accommodation	1,138,350
Extraction of crude oil and natural gas	232,197,748	Restaurants	-7,897,856
Extraction of iron metal minerals	-12,675,800	Cinema, radio, television, & other arts activities	-4,700,064
Extraction of copper stone	-7,179,906	Publishing, printing and reproduction of recorded media	-3,246,081
Extraction of rock, sand and clay	-14,592,936	Manufacture of radio, television & communication equipment & apparatus	-36,750
Extraction of other metal and non-metal minerals	-4,159,721	Banks	-87,444,956
Making food products and drinks	-92,529,699	Other financial intermediation	-30,480,368
Manufacture of vegetable and animal oils & fats	-22,816,509	Insurance	-30,021,116
Manufacturing other transport equipment	-66,725,301	Self-owned dwelling activities	0
Manufacturing public machinery	-2,000,702	Leased residential building activities	-497,658
Manufacturing private machinery	-766,070	Leased non-residential building activities	-104,609,267
Manufacture of tobacco products	-328,690	Real estate activities on a fee or contract basis	-1,844,089
Manufacture of textiles	-31,074,513	Computer & related activities	-5,740,875
Manufacture of wearing apparel; dressing & dyeing of fur	-7,858,680	Public management	1,089,577
Tanning & fabricating of leather; manufacture of luggage, handbags, saddlery, harness & footwear	-2,955,571	Research and development	-7,557,709
Manufacture of wood & products of wood & cork	-42,893,955	Other business activities	-6,198,455
Manufacture of paper and paper products	-39,852,359	Veterinary Activities	-1,160,914
Manufacture of coke, refined petroleum products & nuclear fuel	-115,205,251	Rental of machinery and equipment without operator and personal and household goods	-3,863,046
Manufacture of chemicals & chemical products	-109,091,218	Public Order Activities	-21,055,373
Manufacture of medical & surgical instruments	-13,714,323	News agency activities	-784,832
Manufacture of plastics and rubber products	-77,502,860	Municipal service activities	-3,559,632
Manufacture of glass & glass products	-6,522,015	Defense activities	-1,226,662
Manufacture of other non-metallic mineral products	-121,658,854	Compulsory social security activities	-3,399,042
Manufacture of basic iron & steel	-292,020,060	Governmental hospital activities	0
Manufacture of basic copper	2,352,827	Private primary education	-119,983
Manufacture of basic aluminum	-14,075,473	Governmental primary education	-134,284
Manufacture of other basic metal & casting metals	-28,155,912	Governmental general secondary & technical & vocational secondary education	-175,722
Manufacture, repair and installation of manufactured metal products, except machinery and equipment	-97,471,718	Private general secondary & technical & vocational secondary education	-212,216
Manufacture of office, accounting, and computer machines	-13,957,423	Governmental higher education	-2,858
Manufacturing home appliances	-48,891,235	Private higher education	-2,434,652
Manufacturing electronic machines and unclassified devices elsewhere	-43,526,843	Governmental adult & other education	-5,212,782

Manufacturing motor vehicles and other transport equipment, parts, and accessories	-190,156,814	Private adult & other education	-2,274,070
Manufacture of furniture	-8,836,196	Private hospital activities	-2,711,179
Manufacture of optical instrument & photographic equipment & watches & clock	-11,352,292	Private medical & dental practice activities	-1,538,963
Production, collection and distribution of electricity	-73,964,914	Other governmental health & treatment activities	-423,631
Manufacture & distribution of gas	40,305,768	Other public health services	-2,883,352
Collection, purification & distribution of water	-16,218,395	Social work activities	-606,464
Manufacturing n. e. c. & recycling	-8,197,312	Religious and political services	-3,058,539
Dwelling constructions	-39,765,611	Library, museum, and other cultural activities	-518,083
Other constructions	-47,525,492	Sporting & other recreational activities	-3,049,203
Repairing motor vehicles, motorcycle, personal and household goods	-29,922,864	Other service activities	-965,013
Wholesalers and retailers	-262,497,532	Reimport	-10,052,668

Resource: research findings

In order to investigate the types of factors used in industries, we must compute each industry's factor content of trade. Table 2 shows the estimation of factor content of trade for each economic activity. As shown in the table, the factor content of 50 industries was positive, 48 industries were negative, and for two other industries of self-owned dwelling activities and governmental hospital activities were zero. This means that Iran enjoys a relative abundance of factors in 50 economic sections and is considered as an exporter. In contrast, in 48 industries, Iran imported the factors and in these activities, other trade partner countries benefit from a relative abundance of factors and exported these factors to this country.

In agriculture, Iran has the relative abundance of capital and labor factors only in forestry, breeding bee and silkworm, and farming of poultry and other five sections (farming, gardening, agricultural and animal husbandry service activities, farming of animals, and fishery) have negative factor content of trade and are considered as factor services importer. In mining extraction section, the factor content of trade for extraction of iron metal minerals, copper stone, rock, sand, and clay and other metal and non-metal minerals was positive and there is the relative abundance of factors in these industries. In contrast, the factor content of trade was negative in extraction of crude oil and natural gas, coal and lignite. Therefore, in contrast to the previous studies, we have negative factor content of trade in extraction of crude oil and natural gas and the country is the relative importer of capital and labor services in this section.

In manufacturing section, 12 industries have positive and 16 industries have negative factor content of trade. We could refer to the making food products and drinks, manufacture of wearing apparel, dressing and dyeing of fur, plastics and rubber products, chemicals and chemical products, iron, steel and aluminum with positive factor content of trade, such that the country, by exporting these products, actually exported labor and capital services. Moreover, factor content of trade for short-stay accommodation, office, accounting, and computer machines, cinema, radio, television, and other arts activities, home appliance, motor vehicles and other transport equipment, parts, and accessories, and transport equipment is also positive. In contrast, leased non-residential building, vegetable and animal oils and fats, fabricating of leather, luggage, handbags, saddlery, harness and footwear, glass and glass products, wood and products of wood and cork, paper and paper products have negative factor content of trade. Moreover, other non-metallic mineral products, copper, other basic metal and casting metals, textiles, furniture, tobacco products, repair and installation of manufactured metal products, except machinery and equipment, medical and surgical instruments, and electronic machines and unclassified devices elsewhere show a negative factor content of

trade and the country by importing such products actually entered the labor and capital services.

In the infrastructures, like production, collection and distribution of electricity, manufacture and distribution of gas, and collection, purification and distribution of water, the factor content of trade is positive and we have relative abundance of labor and capital. In transportation industries, factor content of trade in land transport of freight, transport via pipelines, water transport, supporting transport services and post and telecommunications are positive, and by exporting goods and services in these industries, labor and capital services are exported. Furthermore, in other transportation industries, namely railways, land transport of passengers and air transport, we observed a negative factor content of trade and the country imported capital and labor services by importing in these industries.

In other service-producing sectors, the country has a positive factor content of trade in general like cinema, radio, television, and other arts activities, publishing, printing and reproduction of recorded media, computer and related activities, leased residential and non-residential building activities, real estate activities on a fee or contract basis, municipal service activities, education (except private higher education and adult education). Also, it has a relative abundance of capital and labor factors in some industries like library, museum, and other cultural activities, health and treatment (except private hospital activities), veterinary activities, sporting and other recreational activities, rental of machinery and equipment without operator and personal and household goods and public order activities. In contrast, in wholesalers and retailers, short-stay accommodation, restaurants, public management, insurance, banks, and other financial intermediation, research and development, news agency activities, religious and political services, defense and compulsory social security activities, social work activities, and other service-producing activities, the country has a negative factor content of trade.

Table 2: Factor Content of Trade (Occupation and Capital) in Major Economic Sections

Industries	F_L	F_K	Industries	F_L	F_K
Farming	-11085	-114590	Transport via railways	-651.59	-5307.16
Gardening	-21.10	-143.83	Land transport of passengers	-3.89E+09	-1.16E+10
Forestry	14062	41703	Land transport of freight	8.32E+06	2.49E+07
Agricultural & animal husbandry service activities	-22613	-179679	Transport via pipelines	0.00004	0.00014
Farming of animals	-734.77	-7440.70	Water transport	78908	233990
Breeding bee and silkworm	8687	33283	Air transport	-1104.21	-8993.66
Farming of poultry	0.90964	9.20981	Supporting transport services	1.93E+07	5.71E+07
Fishery	-0.00069	-0.00587	Post and Telecommunications	0.44682	3.63933
Extraction of coal and lignite	-0.00002	-0.00006	Short -stay accommodation	-195424	-2142485
Extraction of crude oil and natural gas	-0.00002	-0.00009	Restaurants	-3.22E+08	-3.45E+09
Extraction of iron metal minerals	0.00002	0.00001	Cinema, radio, television, & other arts activities	32047	95037
Extraction of copper stone	0.00004	0.00010	Publishing, printing and reproduction of recorded media	8.07E+07	6.44E+08
Extraction of rock, sand and clay	10448	31849	Manufacture of radio, television & communication equipment & apparatus	-9E-07	-5.44E-06
Extraction of other metal and non-metal minerals	462.41	1525.74	Banks	-3.73108	-29.73067
Making food products and drinks	2.19E+06	2.21E+07	Other finantial intermediation	-1.20E+09	-3.23E+09
Manufacture of vegetable and animal oils & fats	-13073	-132359	Insurance	-4304.39	-12891.61

Manufacturing other transport equipment	2.11E+07	1.71E+08	Self-owned dwelling activities	0	0
Manufacturing public machinery	-3001	-29327	Leased residential building activities	911.95	6527.10
Manufacturing private machinery	-45.04	-567.96	Leased non-residential building activities	2.84E+08	1.55E+09
Manufacture of tobacco products	-0.00008	-0.00027	Real estate activities on a fee or contract basis	-4.22E-06	4.18E-06
Manufacture of textiles	-54448	-166426	Computer & related activities	6.98E+07	5.37E+08
Manufacture of wearing apparel; dressing & dyeing of fur	107.16	330.99	Public management	-1.92E+06	-5.65E+06
Tanning & fabricating of leather; manufacture of luggage, handbags, saddlery, harness & footwear	-2518.19	-8347.29	Research and development	-3.49E+08	-9.32E+08
Manufacture of wood & products of wood & cork	-5385.85	-5260.27	Other business activities	4.01E+06	7.51E+06
Manufacture of paper and paper products	-6.54E+07	-1.90E+08	Veterinary Activities	5.79	46.35
Manufacture of coke, refined petroleum products & nuclear fuel	-12344	-36362	Rental of machinery and equipment without operator and personal and household goods	1.86E+08	1.52E+09
Manufacture of chemicals & chemical products	399753	1179310	Public Order Activities	665149	-423846
Manufacture of medical & surgical instruments	-1882.85	-8312.69	News agency activities	-512.36	-5617.26
Manufacture of plastics and rubber products	5.16E+06	1.53E+07	Municipal service activities	86.13	684.34
Manufacture of glass & glass products	-55813	-171558	Defense activities	-0.00055	-0.00094
Manufacture of other non-metallic mineral products	-150004	-494950	Compulsory social security activities	-0.02804	-0.22394
Manufacture of basic iron & steel	2.40E+06	6.92E+06	Governmental hospital activities	0	0
Manufacture of basic copper	-1665.67	-4955.64	Private primary education	1.38E+09	4.20E+09
Manufacture of basic aluminum	25827	75784	Governmental primary education	4.10E+08	8.12E+09
Manufacture of other basic metal & casting metals	-3.39E+06	-1.01E+07	Governmental general secondary & technical & vocational secondary education	1.49E+07	2.57E+08
Manufacture, repair and installation of manufactured metal products, except machinery and equipment	9.71E+07	2.90E+08	Private general secondary & technical & vocational secondary education	7.14E+09	2.12E+10
Manufacture of office, accounting, and computer machines	1.61E+07	4.65E+07	Governmental higher education	6.43	9.75
Manufacturing home appliances	1.71E+08	5.08E+08	Private higher education	-5496.35	-8424.91
Manufacturing electronic machines and unclassified devices elsewhere	-1.77E+09	-5.25E+09	Governmental adult & other education	-1.50E+09	-1.22E+10

Manufacturing motor vehicles and other transport equipment, parts, and accessories	2.69E+07	7.98E+07	Private adult & other education	-1574	-18048
Manufacture of furniture	-261222	-773308	Private hospital activities	-0.02250	-0.06492
Manufacture of optical instrument & photographic equipment & watches & clock	1.97E+06	1.05E+07	Private medical & dental practice activities	34.23	278.78
Production, collection and distribution of electricity	203427	602606	Other governmental health & treatment activities	0.00008	0.00126
Manufacture & distribution of gas	22501	66384	Other public health services	0.00008	0.00126
Collection, purification & distribution of water	256458	755807	Social work activities	-511.59	-4166.86
Manufacturing n. e. c. & recycling	150394	445097	Religious and political services	-1249.25	-10257.20
Dwelling constructions	343397	1.01E+06	Library, museum, and other cultural activities	7.24E+06	5.90E+07
Other constructions	-6.53E+08	-1.94E+09	Sporting & other recreational activities	7.41E+06	6.04E+07
Repairing motor vehicles, motorcycle, personal and household goods	8.66E+06	2.57E+07	Other service activities	-4.99	-52.28
Wholesalers and retailers	-2.31E+08	-5.61E+08	Reimport	1.22E+06	3.56E+06

Resource: research findings

As mentioned previously, the left side of equation (15) shows that predicted factor content of trade and its right side measured factor content of trade. Table (2) reports predicted factor content of trade. The value of factor services and the differences between Iran's factor price and its trade partners are considered to estimate the measured factor content (right side of equation (10)). Then, two tests, sign and rank tests, were used to assess the prediction power of the model. The results are depicted in Table (3). The sign test indicates that the prediction power of the model is 66.67%. The rank test comprises two comparative pairs of all country factors. This test shows that the prediction power of the model is 46.67%. These results are in line with that of the Jošić (2017), who used the data of Croatia and noticed that the sign test have shown that the factor proportions model holds only in 46.8% cases for the merchandise trade between Croatia and the world and in 62.5% of cases for the merchandise trade between Croatia and the EU.

Table 3: The Results of Sign and Rank Tests

Test type	Prediction power of model
Sign test	66.67 %
Rank test	46.67 %

Resource: research findings

5. Conclusions and Suggestions

In the present study, we attempted to estimate the factor content of Iranian trade in 2015 by using the Heckscher-Ohlin-Vanek model and the World Bank input-output tables by analyzing the economic structure of exported or imported goods and services. Results indicate that net trade of industries is positive for 7 sections of extraction of crude oil and natural gas, manufacture and distribution of gas, breeding bee and silkworm, manufacture of basic copper, water transport, short-stay accommodation, and public management. Consequently, in these sections, the trade balance of the country is positive in terms of exporting goods and services. Net trade for the services of self-owned dwelling activities and governmental hospital activities is zero. Net trade is negative for other industries that

account for 91% of economic activities and 78.01% of domestic production. This fact shows the high import volume for Iran's activity. One of the main reasons can be addressed as Iran's sanction. In addition, the export composition is indicative of the dominance of oil and gas section and even in agriculture sections, the country has been a net importer during the recent years. Sanction, political relationship, water crisis, no high quality goods and products, no innovation and weak competitive power of Iran export are the main reasons that the country has negative net trade in most industries.

By evaluating the export of goods and services, we reached the net export of production factors. Factor content of trade was positive for 50 industries, negative for 48 industries, and zero for two sections of self-owned dwelling activities and governmental hospital activities. This means that Iran enjoys a relative abundance of factors in 50 economic sections and is considered as an exporter. In contrast, in 48 industries, we imported the factors. Hence, in these activities, the commercial partners, compared with Iran, enjoy the relative abundance of factors and export those factors to the country. In general, the factor content of trade has been positive in the raw materials and minerals, electricity, gas, and water industries. While the factor content of trade for manufacturing machinery and instrument and in general for those sections that require to use intermediate and investment goods and advanced technology was negative.

In agriculture, the factor content of trade was positive only in three sections, and in other five industries, we observed a negative factor content of trade. Some experts claim that political tensions worsen agricultural export to neighbors. Thus, the country has no longer the relative advantage in this area and we lose our priority. In mine extraction industries, factor content of trade has been often positive and we have a relative abundance of factors. In contrast to the prior studies, the factor content of trade in extraction of crude oil and natural gas is negative and the country is considered as a relative importer of capital and labor factors in this area.

In the manufacturing industry, the factor content of trade is mainly negative, such that for 12 industries, it was positive and in 16 other industries it was negative. In infrastructure, electricity and gas distribution and water refinement and distribution, factor content of trade is positive and the country enjoys a relative abundance of labor and capital in these sections. In transportation, the country has a positive factor content of trade except in railways, land transport of passengers and air transport, and by exporting goods and services in these sections, labor and capital services were exported. Moreover, in other Iranian industries, we have an overall positive factor content of trade. In these sections, the country has some advantages in especial cases. But increasing price of production, as a result of increasing energy prices, decreases our competitive power.

Next, in order to assess the prediction power of the model, the measured factor content of trade is calculated by using the value of factor services in the production processes and the factor price differences. Then, two sign and rank tests were used. The sign test indicates that the prediction power of the model is 66.67%. The rank test comprises two comparative pairs from all country factors. This test also reveals that the prediction power of the model is 46.67%.

The productivity improvement of production factors, especially in areas that have the potential to increase production and employment, can aid to the development of these activities and can be the political and applicable recommendations of this paper. In addition, in most areas, by considerable amount of export and extensive import of intermediate goods, the factor content of trade is negative. Hence, the production chain development of a certain product is required to supply the raw materials and intermediate goods for each section. Moreover, since the exported products of the country have no competitive advantage in the world markets, in order to enhance export, the quality of products should be improved, the costs of research and development should increase, scientific and research institutions should be strengthen, the packaging industry should be enhanced, and finally the innovations and inventions should be supported. Furthermore, one of main reasons that biases our results is Iran's Sanctions. Comparing factor content of trade before and after Iran's imposed Sanctions

will show this effect.

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