Iranian Journal of Economic Studies, 9(2) 2020, 413-436

Shiraz University

Iranian Journal of Economic Studies

Journal homepage: ijes.shirazu.ac.ir

Virtual Water Trade between Iran and the European Union (EU28) – A Sectoral-Country Analysis Using the Input-Output Model

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Article History

Received date: 02 October 2020
Revised date: 07 April 2021
Accepted date: 08 May 2021
Available online: 19 June 2021

JEL Classification

C67
Q25

Keyword

Input-output analysis
Virtual water trade
Iran
European Union
Economic sectors

Abstract

The article is grounded on the rapid demand growth and supply constraints, which have imposed unprecedented pressure on water resources in Iran. Virtual water import has been recently discussed as a policy to tackle water scarcity and so the study calculates (with input-output technique) virtual water flows between Iran and European Union (EU 28) in 2011. The results show that Iran has been a net importer of virtual water in trade with the EU28, with net imports of about 667 million m3. The largest Virtual Water Export from Iran to the EU28 are respectively to Germany, Spain and Italy, which accounted for more than 74% of the total virtual water exports. By contrast, the Netherlands, Germany and Austria have been the largest virtual water exporters to Iran, with a total share of over 68.8% of the total. In any case, while Iran's virtual water import from the EU28 is about 2 times as much as virtual water exports, the value of Iran's imports from the EU28 is more than 7.6 times of its exports. An indicator developed shows that Iran's exports to the EU are high water-intensive but Iran's imports from the European Union are low water intensive.

Highlights

- Net virtual water imports from the EU28 to Iran are positive and is about 667 million m3.
- Iran's exports to the EU relatively are high water-intensive but Iran's imports from the EU are low water-intensive.
- In order to examine the theory of comparative advantage for water resources, it should not only consider positive or negative net virtual water imports, but it is also necessary to evaluate this criterion in comparison with the values of exports and imports.

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DOI: 10.22099/ijes.2021.38632.1714

1. Introduction

According to Ricardo's comparative advantage theory, trade between countries increases consumption and welfare in all trading countries. The idea behind this theory is based on the difference between the opportunity cost of resources used to produce goods and services. Riccardo believes that if the opportunity cost of producing two products varies between countries A and B, the existence of trade between the two countries, each of which produces low-cost goods, will increase welfare in both countries (Widodo, 2009). Although, the traditional model of comparative advantage theory only emphasized the opportunity cost of the capital and labor (as factors of production), over time and with sharp decline in natural resources such as water, these factors have also become important in the production of various products and are important in assessing the comparative advantage of different products in countries.

In recent years, the sharp increase in demand for water resource and the scarcity of global water resources have led many researchers to consider the water used to produce of different products as an important factor in measurement of opportunity cost of those products. This is done with the help of a concept called "virtual water". This concept was first introduced by Allan in the early 1990s (Allan, 1994) and refers to the volume of the water used in various steps of produce a commodity or service (Hoekstra & Chapagain, 2007; Zhao et al., 2009). According to Allan idea, water-scarce regions such as Middle Eastern countries can save their water resources by importing water intensive commodities instead of producing them internally. Although, Alan is not an economist, his idea of virtual water trade has extensively been discussed and criticized among economists. Many economists have tried to comment on their idea in the framework of comparative advantage theory and Heckscher-Ohlin model.

Over the past few years, there has been a growing interest among economists and water experts in examining virtual water trade between different countries (Hoekstra, 2010). Accordingly, many researchers have calculated the virtual water trades between countries and regions around the world based on Allen's idea. These studies have evaluated the virtual water trade from the perspective of normative economy and have provided policy recommendations. For example Chapagain and Hoekstra (2004) calculated the water footprint of 181 countries during the 1997-2001. Feng et al. (2012) examined the virtual water flows and water footprints in the Yellow River Basin. Cazcarro et al. (2013) evaluated the virtual water flows and water footprints in different regions of Spain as well as the impact of trade in these regions (with each other and with the outside world) on domestic water resources. Lenzen et al. (2013) assessments the global flows of virtual water due to the concept of scarce water. Mubako et al. (2013) examine the direct and indirect water consumption and virtual water trade in California and Illinois. Huang et al. (2016) calculated virtual water trade between 30 provinces of China. Lutter et al. (2016) examined the water footprint and the virtual water trade in the European Union. Serrano et al. (2016) assessment the virtual water flows in the European Union. Chen et al. (2017) estimates the water footprint and

virtual water transfer between provinces of China. Liu et al. (2019) traced virtual water trade between different regions of China. Zhang et al. (2021) calculated the virtual water trade between the Yellow River Delta and other provinces of China. The joint recommendation of all these studies is that trade-in products between different regions of the world should be in a way that virtual water flows from water-rich to water-poor regions.

On the opposite side in some studies, this issue has been examined in the form of a comparative advantage theory from the standpoint of positive economics. These studies have examined the comparative advantage of water resources and have evaluated whether virtual water has been flowing from water-abundant regions to water- scarce countries. For example, Sayan (2003) tested the Heckscher–Ohlin theory within the context of trade patterns of 11 relatively water-abundant and relatively water-scarce countries. Reimer (2012) tried to place the concept of virtual water on an economic framework. Dang et al. (2016) developed a theoretical model to considere four tradeoffs involving water-use decision-making. Afkhami et al. (2018) examine the comparative advantage theory in virtual water trade with respect to the relative abundance of capital. Zhao et al. (2019) given the theory of comparative advantage tries to explain why trade patterns often does not support the virtual water hypothesis.

Statistical evidence suggests that virtual water used in international trade is almost equivalent to one quarter to one-third of the total volume of global water withdrawals (Hassan et al., 2017; Mekonnen & Hoekstra, 2011; Lenzen et al., 2013). This shows that international trade has a very high potential for the world's redistribution of water resources. The present study deals with the review of the trade between Iran and the EU28 in 2011[1] in the context of the normative economics. However, the results refer to comparative advantage theory; these results have been examined from the positive economics point of view. In fact, the current paper investigates whether the pattern of trade between Iran and the European Union is to protect Iran's scarce water resources, or this pattern has increased the pressure on these resources. For this purpose, the output- input model has used. In this article, for the first time, Iran's virtual water trade with a group of countries is examined by country-sector. Furthermore, a new index is to measure the relative water-intensity of Iran's exports and imports.

The article is organized as follows: The second section describes the some economic and climatic characteristics of Iran and the EU28. The third section presents the research methods and data. The fourth section provides the findings and fifth sections describes the research limitations. Finally it concludes in section six.

2. Some Economic and Climatic Variables of Iran and the EU28 in 2011

In 2011, Iran has a population of 75.5 million, accounting for about 1.1% of the world's population, the eighteenth largest country in the world (World Bank,

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[1] The study period in this paper is year of 1390 in the Iranian calendar, and this year is not perfect match with 2011. Therefore, the data provided in this article may not be fully compatible with the data in the EU28 statistical sources.

2015). According to the World Bank data, the value of Iran's GDP in this year is about $ 592 billion (current US $), which accounts for less than 0.82% of global production. The EU has 28 countries in 2011, while its population comprised only about 7.1% of the world's total population (about 505 million) in this year, but with a GDP of about $ 18336 billion, nearly a quarter produced the entire global product. In other words, the European population is about 6.6 times more than Iran, while its production is about 30 times. This has led to significant difference in the per capita GDP of these two regions.

Iran is located in dry and semi-arid region, with 65% of the country is considered to be arid and 20% is semi-arid (Madani, 2014). The average annual precipitation in Iran is about 250 mm; almost one-third of the global average, while average annual evaporation rates in Iran are about three times the global average (zakeri & momeni, 2015). The disparity between spatial and temporal rainfall is another factor that has hit the country with adverse climatic conditions. About 75% of the country's annual precipitation is belongs to only 25% its area, and much of this rainfall occurs outside the agricultural season (zakeri & momeni, 2015; Madani, 2014). Iran's per capita renewable freshwater in 2012 was estimated to be 1639 m^3 (less than one-third of the world average) and Iran's renewable freshwater withdrawals in 2007 was over 72% of internal resources.

Despite the fact that water resources are under pressure in many European countries (Serrano et al., 2016), the per capita renewable water resources in this union is about 1.8 times of Iran (2979 m^3). The EU's share of the world's total water resources is only about 4%, which is 40% less than its share of the total population (Serrano et al., 2016). However, in 2014, the fresh water withdrawals in the European Union was only about 15% of the total internal resources. Table 1 shows some of the economic and climatic indicators of Iran and EU28 in 2011.

Table 1. Some economic and climatic indicators of Iran and EU28 in 2011

	Population		gross domestic product		Renewable Water Resources per capita (cubic meter)	Annual freshwater withdrawals (% of domestic)
	Total Population (Million people)	percentage of the total world	Total (current US b$)	% of the total world		
Iran	75.5	1.1	592	.81	1639	72
European Union	504.4	7.1	18336.4	25.1	2979	15.2
The world	7015	100	72923.7	100	6064	---

***Source**: https://data.worldbank.org/*

According to the evidence shown in table 1, from the perspective of normative economics, in order to reduce the pressure on scarce water resources in Iran and to increase the productivity of global water use, the pattern of trade between Iran and the European Union should be such that virtual water flows from the EU to Iran. From the perspective of positive economics, if we consider water

resources as an input, by measuring the opportunity cost of using these resources, it can be expected that Iran as a water-poor country, in its trade with the EU, must import high water-intensive products and export low water-intensive products.

3. Methods and Data

3.1 Methodology

Input-output model was used to calculate the virtual water embodied in the products traded between Iran and the EU, because this model can, in addition to direct water use, also calculate the amount of indirect water used to produce products in each economic sector. Generally, in previous studies, to calculating the virtual water embodied in different products, two approaches have been used; bottom-up and top-down approaches (Feng et al., 2011). In the bottom-up approaches, to calculate the virtual water of a sector (or product), the whole supply chain is not taken into account and there is a so-called truncation error. On the other hand, there are top-down approaches refers to input-output analysis, which consider all supply chain loops of a product for the calculation of virtual water and avoids the truncation errors (Feng et al., 2011, 2012). In fact, each economic sector uses a combination of different inputs to produce its products, each of which, in turn, requires the use of a set of inputs. On the other hand, the production of each input requires the use of water at different stages of the production process. These interdependencies between different economic sectors, lead to that increase in production in each sector indirectly affect water resources, through changes in production of other sectors. The input-output model is capable of tracing and calculating all the indirect water use from the origin to the final destination (Duarte & Yang, 2011).

3.1.1 Input-Output Analysis Framework

Input-output is an analytical framework for modelling the inter-sectoral transactions in an economic in specific geographic region (nation, state, county, etc.) practices, developed by Wassily Leontief in the late 1930s (Miller & Blair, 2009). The basic idea of this model is that the output of each economic sector is distributed among other sectors of the economy (intermediate demand) and final consumers (final demand). This idea is described in form of linear equation system (1):

$$\begin{aligned} x_1 &= x_{11} + x_{12} + \cdots + x_{1n} + y_1 \\ x_2 &= x_{21} + x_{22} + \cdots + x_{2n} + y_2 \\ &\vdots \\ x_n &= x_{n1} + x_{n2} + \cdots + x_{nn} + y_n \end{aligned} \tag{1}$$

$$x_i = \sum_{j=1}^{n} x_{ij} + y_i \tag{2}$$

Where n denotes the number of economic sectors, x_i represents the total gross

output of the i-th sector, x_{ij} is the inputs from sector i to sector j, and y_i also denote the final demand of sector i. The matrix form of the equations 1 and 2 and its solved form are shown in the form of equations (3) and (4):

$$X = AX + Y \tag{3}$$

$$X = (I - A)^{-1} Y \tag{4}$$

$$A = [a_{ij}] \qquad a_{ij} = x_{ij} / x_j \tag{5}$$

Where X denotes the gross output vector, $[A]_{a_{ij}}$ is the matrix of the technical coefficients, and Y is the final demand vector. The element a_{ij} of the matrix A represents the amount of input from sector i, which is required to increase one unit output in sector j. Moreover, $[I]_{n\times n}$ is the identity matrix and $(I - A)^{-1}$ called the Leontief inverse matrix. The l_{ij} element of the inverse Leontief inverse matrix represents the total (direct and indirect) output of sector i, which is required to increase one unit of monetary final demand in sector j. in other words, elements of Leontief inverse matrix representing the total production every sector must generate to satisfy the final demand of the economy (Velazquez, 2006).

3.1.2 The Extended Water Input-Output Model

One way of extending input-output model for environmental analysis is to add a vector of pollution output (or natural resource use) to the input-output table (see Miller & Blair, 2009). Based on this method, the first stage of the present study is to calculate the direct water-intensity of different sectors. This is done using equation (6), whose matrix form is in the form of equation (7):

$$w_j^d = w_j / x_j \tag{6}$$

$$W^d = W(\hat{X})^{-1} \tag{7}$$

Where x_j and w_j represent the total output and total water consumption in the sector j, respectively. The w_j^d is also direct water intensity of the sector j, and determines how much water sector j consumes (in direct form) to produce one unit of its output. Total direct water intensity (direct and indirect) in each sector can be shown by Eq. (8) (Wang et al., 2009):

$$w_j^t = w_j^d + \sum_{i=1}^{n} w_i^t . a_{ij} \tag{8}$$

The first part of the right side of the equation 8 shows direct water intensity while the second part shows indirect water intensity (indirect consumption of water per unit of production) of sector j. By solving the equation 8, equation (9) obtained:

$$W^t = W^d .(I - A)^{-1} \tag{9}$$

Where, W^d and W^t refer to direct and indirect vectors of water intensity of economic sectors, respectively. Equation (9) calculates a vector, each element of which indicates that if the final demand of a particular sector is increased one unit,

how much water will be used directly and indirectly in the whole economy. In order to show the total amount of water needed to satisfy the final demand of each sector, equation 9 multiplies the final demand vector. Therefore, by multiplication of the final demand changes (ΔY) in the equation 9, the change in water consumption of each sector (ΔW) is obtained:

$$W = W^{d}(I - A)^{-1}Y \tag{10}$$

$$\Delta W = W^{d}(I - A)^{-1}\Delta Y \tag{11}$$

Since exports are part of the final demand, by replacing Y with the export vector (E), the vector of virtual water exports (the amount of virtual water embodied in exports) is obtained:

$$VWE = W^{d}(I - A)^{-1}E \tag{12}$$

Where *E* and *VWE*, represent the value of exports and virtual water Export, respectively. It can be expected that some of Iran's exports to EU countries (especially agricultural products) will be re-exported from these countries without being used. For example, a large volume of Iranian exports of saffron to Spain, after packaging, will be exported again from Spain. But this does not harm the results of the research. The focus of this study is on the export and import of virtual water from Iran, and its results show the amount of water exported to EU without paying attention to the issue whether it is consumed there or re-exported.

Calculation of virtual water imports is more complicated than exports, because imported Iranian products come from different countries with different technologies, and formulating it as a single-regional input-output model is not possible. To solve this problem, it is assumed that the technology of production of imported products are similar to those of domestic products. This assumption, given the research objectives and considering Renault's (2003) definition of virtual water, does not detract the results of the study. Renault (2003) says that virtual water embedded in the import of a country is not the actual amount of water used to produce it, but the amount of water used by the country if these products were produced inside it. This definition will make it clear exactly how much water is saved by importing products instead of producing them inside (Zhao et al., 2009). Nevertheless, when the scale of analysis has expanded to all countries in the world, and the target is the global water, this method cannot be applied, and the technological differences of various countries should to be considered (Chen et al., 2018).

When a country (region) imports goods, it saves the amount of water needed to produce it domestically, and the water saved is equal to the water consumption needed to produce the goods in the importing country. Therefore, the amount of water saved due to imports, is only related to the level of productiontechnology. Although, this is an unrealistic assumption and the virtual water content in this method is not the actual water consumption, but this method can better reflect the influence of the import on the water resources in the country (Chen et al., 2018; Cegar, 2020). For example, agricultural technology in the Netherlands is much

more efficient than that of Iran, and the production of each unit of agricultural production in this country needs much less water than its production in Iran. Importing virtual water embodied in Dutch products does not mean how much water has been used in the Netherlands to produce it, but it means that if these products were produced in Iran rather than the Netherlands, how much water was consumed in Iran. Some researchers do not accept the same technology assumption and to overcome this problem, they use the multi-regional input-output model (for example see Feng et. Al, 2012). In this paper, in accordance with Renault's definition of virtual water imports, the assumption of the same technology is applied

Considering the economic structure of Iran, it can be assumed that the re-export of imported products in Iran is zero (see Banouei, 2012). Thus, with the assumption of competitive imports, Iran's virtual water imports calculated in line with its export using Equation (13):

$$VWI = W^{d}(I - A)^{-1} IM \tag{13}$$

Where *IM* is import values and *VWI* represents the amount of virtual water import. Clearly, the net import of virtual water (NVWI) equals with virtual water imports minus virtual water exports:

$$NVWI = IM_{vw} - EX_{vw} \tag{14}$$

3.1.3 Measure the Relative Water-Intensity

In this study, a new index is defined to measure the relative water-intensity of Iran's exports and imports from the European Union and its member countries. This index can show the relative water-intensity of import (export) to a country (region) compared to other countries (regions). This index difined as equations (15) and (16):

$$U_{ex}^{i} = \frac{VWE^{i}/VWE}{ex^{i}/ex} \tag{15}$$

$$U_{im}^{i} = \frac{VWI^{i}/VWI}{im^{i}/im} \tag{16}$$

Where u_{ex}^{i} and u_{im}^{i} are the relative water intensity of Iran's exports to and imports from region *i*. If these indicators are used to compare the relative water intensity of the Iran’s imports and exports from (to) an EU-country, compared with the rest of the EU, the index *i* refers to that country, and the non-index variables represent the whole of Europe. But if the mentioned indicators are used to compare EU with the whole of the world, then the variables with the index *i* represent the European Union and the non-index variables represent the whole

world. If the value of this indicator for a region is greater than one, this means water intensity of Iran's exports (or imports) to (from) the region is higher than the other regions (EU28 or the whole world), and if this index is smaller than one, it means that these products have relatively low water intensive.

3.2 Data

The data used in this study consists of three distinct sections as follows. First, inter-sectoral relationships data (input-output table). The office of Statistical Center of Iran, with a ten-year rotation, provides the input-output table of Iran. The latest is for 2011, which includes 99 sectors. In this study, considering the limitation of water data, these sectors were aggregated in 27 sectors.

The second data category concerns with water consumption data in different sectors. These data was collected from various organizations. Water consumption data in agricultural and mining sectors were extracted from Water Resources Management Co and Statistical Center of Iran, respectively. According to the report of Iran Water Resources Management CO, the total drinking water consumption in Iran in 2011 was about 8826 million m^3. But according to the report of the National Water and Wastewater Eng. Co, in 2011, about 3793 million m^3 water was consumed in the household sector. Therefore, it can be said that other drinking water consumptions (5033 million m^3) has been consumed in the service sector. Water consumption data in manufacturing sectors (sectors 3 to 23 in table 2) is collected from the reports of the Statistical Center of Iran. This data includes two sections: industrial units with 10 or more workers and industrial units with less than 10 workers. According to the reports of the Water Resources Management Co, the total water consumption in the Iran's industrial sectors has been about 2470 million m^3. This includes water consumption in all sectors of the economy except agriculture and services.Therefore, in the present study, according to the study of Zakeri and Momeni (2015), the difference between the this and the total water consumption in manufacturing and mining industries, is divided between the "construction" and "electricity, gas and water supply " in proportion to their share of demand from water input, in the input-output table.

Finally, the third data category is concerned with Iran's exports to and imports from EU28 Countries. The Iranian Customs Agency publishes every year's these statistics, but the classification of products is based on HS codes, while, the classification of economic sectors in Iran's input-output table is based on ISIC codes. To solve this problem, using the United Nations Statistics Division (UNSD) guides and with Excel formulation, these codes were converted to ISIC. It is also noteworthy that, given the nature of the crude petroleum and natural gas sector, this sector is not included in the calculations because the products of this sector are typically sold to multinational corporations rather than to a particular country. In addition, in the sectors of "water, electricity, gas" and "construction", Iran did not have trade with Eu28. As a result, these sectors are not included in the analysis of the results.

4. Results

Table 2 shows the direct consumption of water, direct water intensity, total water intensity and the value of Iran's exports to and imports from the European Union, divided to different sectors. This table reveals that agricultural sector, with a consumption of about 80.2 billion m^3, accounts for over 91.4% of the total water consumption in the Iranian economic system. These results confirm that, considering the indirect use of water, there is a very different picture of water intensity of the economic sectors. For example, although the direct consumption of water in agriculture sector relative to other sectors is much higher, but taking into account indirect consumption, water use in sectors of "Food, beverage and tobacco", "Tanning and dressing of leather" and "Manufacture of textiles" are also significant. In many sectors, indirect water consumption is considerably higher than direct consumption. For example, the indirect consumption of water used to produce one unit of product in the sectors of "food, beverage and tobacco" and "Manufacture of textiles" is respectively 43.5 and 36.2 times higher than direct consumption.

Table 2. Some indexes of Iran's economic sectors

Sector	Section	x_j 10^{12} Rials	w_j 10^6 m^3	w_j^d $m^3/10^6$ Rial	w_j^t $m^3/10^6$ Rial	EU_{ex} 10^9 Rials	EU_{im} 10^9 Rials
1	Agriculture,	866.8	80165.9	92.49	113.62	3736.6	3137.7
2	Mining Expect crude petroleum and natural gas	67.0	99.8	1.49	3.78	44.7	867.4
3	Food products, beverages and tobacco	479.7	669.8	1.40	62.18	1879.1	9969.7
4	Manufacture of textiles	63.3	26.0	0.41	15.31	2487.2	290.3
5	Manufacture of wearing apparel	7.8	5.2	0.66	4.15	1.9	61.0
6	Tanning and dressing of leather	8.6	5.2	0.60	15.81	725.6	23.4
7	Wood and products of wood	16.9	7.6	0.45	8.93	10.8	442.7
8	Paper and paper products	15.8	53.2	3.36	10.39	0.7	2635.4
9	Publishing, printing and reproduction of recorded media	8.9	10.7	1.20	2.97	12.7	278.5
10	Manufacture of coke, refined petroleum products and Nuclear fuel	556.2	50.2	0.09	1.36	779.7	936.5

Table 2 (Continued). Some indexes of Iran's economic sectors

Sector	Section	x_j 10^{12} Rials	w_j 10^6 m^3	w_j^d m^3/10^6 Rial	w_j^t m^3/10^6 Rial	EU_{ex} 10^9 Rials	EU_{im} 10^9 Rials
11	Manufacture of chemicals and chemical products	396.8	386.4	0.97	3.36	5331.0	23342.3
12	Rubber and plastics products	65.5	28.4	0.43	4.94	60.9	1789.3
13	Manufacture of other non-metallic mineral products	153.2	115.7	0.76	2.28	82.5	1933.0
14	Basic metals	330.2	125.4	0.38	2.09	1917.7	10578.9
15	Fabricated metal products, except Machinery and equipment	103.0	55.3	0.54	1.98	88.5	1566.9
16	Manufacture of machinery and equipment n.e.c.	97.1	76.6	0.79	2.01	272.6	51131.3
17	Manufacture of office, accounting and computing machinery	6.4	1.7	0.27	1.40	0.0	858.2
18	Manufacture of electrical machinery and apparatus n.e.c.	61.4	14.0	0.23	1.59	79.2	4490.6
19	Manufacture of radio, television and communication Equipment and apparatus	7.8	3.5	0.44	0.96	46.6	1862.0
20	Manufacture of medical, precision and optical instruments, Watches and clocks	12.7	9.5	0.75	2.06	27.6	7043.2
21	Manufacture of motor vehicles, trailers and semi-trailers	360.2	31.7	0.09	1.74	184.5	9709.0
22	Manufacture of other transport equipment	18.3	6.2	0.34	1.74	12.4	1323.3

Table 2 (Continued). Some indexes of Iran's economic sectors

Sector	Section	x_j 10^{12} Rials	w_j 10^6 m^3	w_j^d m^3/10^6 Rial	w_j^t m^3/10^6 Rial	EU_{ex} 10^9 Rials	EU_{im} 10^9 Rials
23	Manufacture of furniture; manufacturing n.e.c.	74.5	81.0	1.09	3.00	1.2	384.2
24	Electricity, gas and water supply	497.9	462.4	0.93	1.11	0.0	0.0
25	Construction	821.2	114.9	0.14	1.39	0.0	0.0
26	Services	3959.9	5032.9	1.27	2.33	3.0	3.1
27	Extraction of crude petroleum and natural gas	1026.1	29.3	0.03	0.20	---	----
	Total	10083.2	87668.4			17786.9	134658.1

In 2011, the value of Iran's exports to the EU28 was about 17786.9 billion Rials (approximately $ 1.6 billion). While, the value of Iran's imports from this union is more than 7.5 times its exports, almost 134658.1 billion Rials (approximately $ 12.4 billion). In other words, Iran's exports to the EU only account for 4.8% of its total non-oil exports. While Iran's imported products from the EU account for about 21.5% of total imports. In this year, Latvia is the only country in EU28 that did not have trade with Iran.

Tables A to C in appendix 1, present the Iran's exports, imports and net imports of virtual water to (from) the EU28 in terms of country-sector. In the last column of tables A and B, also the U_{ex} and U_{im} index for each country (and the whole EU) are presented. These results show that the total volume of Iran's virtual water exports to the EU28 in 2011 was about 616 million m^3. In other words, on average, per million Rials of Iranian exports to the EU28, there were about 34.6 m^3 of hidden water (water intensity for export products). At the same time, in the aggregate of all countries, the water intensity of Iran's exports is about 18 m^3 per a million Rials, which is about 52% of the water intensity of products for export to EU. While the EU28 share of Iran's export value is only about 4.8%, Iran's virtual water exports to the Union totaled 9.2% of total virtual water exports. Therefore, the EU's U_{ex} index is about 1.9, which indicates that Iran's exports to this union have a high level of water intensity compared to other parts of the world. These results are shown in fig. 1. In this figure, the left and right hand side axis show the "value" and "cumulative percentage" of Iran's VWE to EU countries respectively.

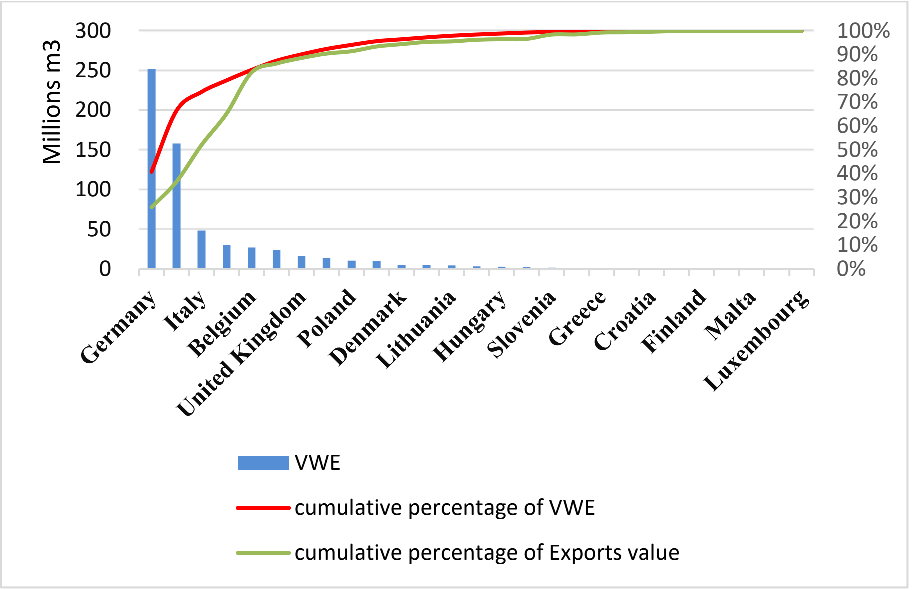

Figure 1. Iran's Virtual Water Exports to EU members- million m³

Fig.1 reveals that Germany has the largest share of Iran's VWE to the European Union, amounting to about 251.3 million m^3 (more than 40% of the total). The red bar shows the cumulative percentage of Iran's VWE to EU countries. As it can be seen from the figure, three countries, Germany, Spain and Italy, accounted for more than 74% of the total virtual water exported from Iran to the EU28. By comparing this bar with the green bar representing the aggregate percentage of Iran's exports value to the EU, each country's share of export value and its share of VWE can be inferred. This can determine the countries with the most water intensive imports from Iran. For example, Iran's exports to Germany and Spain have a high level of water intensity, this leading the gap between the two curves above the Spanish column to be at its maximum level. However, with the arrival of Italy, the distance between these two curves has declined, so it is clear that Italy's share of Iran's VWE to the EU is less than its share of export value, and it can be said that Iran's VWE to Italy are low water-intensive than other EU28 countries (U_{ex} is less than one). Iran's exported products to Lithuania and Slovakia have high water-intensity, with U_{ex} being 2.98 and 2.87, respectively. This ratio reaches 0.13 for Greece.

Fig .2 shows the import of Iranian virtual water from the EU28 countries.

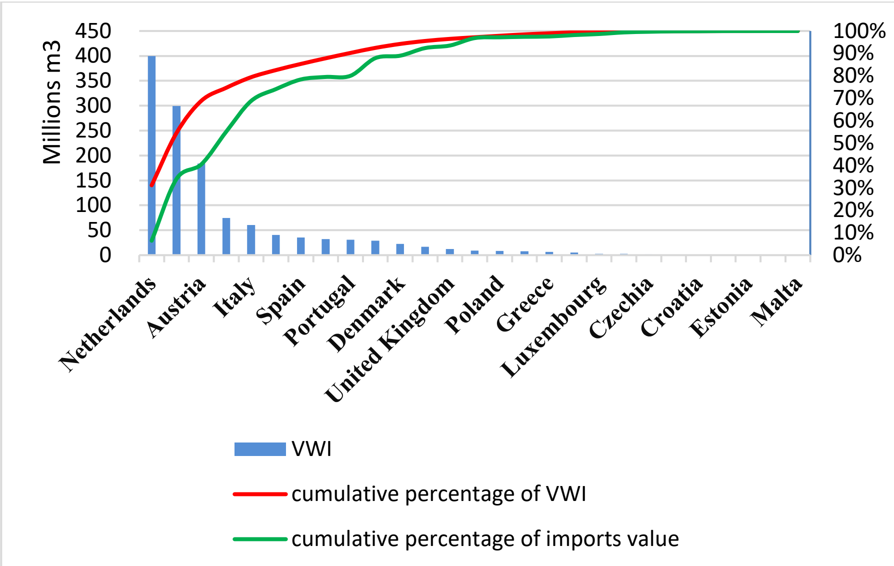

Figure 2. Iran's Virtual Water Imports from the EU members- million m^3

The total amount of virtual water imported from the EU28 to Iran is about 1,283 million m^3, which is almost twice Iran's VWE to the EU. Therefore, NVWI from the EU28 are positive and is about 667 million m^3. Accordingly, if the net virtual water import are taken into account, it seems that the theory of comparative advantage in water resources is confirmed, because virtual water flows from water- abundant region to water- scarce country. However, by comparing the level of water intensity of imports with exports, quite different result will be obtained. On average, virtual water embodied in Iran's imports is about 9.5 m^3 per million Rials, which is about one quarter of the water intensity of exports. The U_{im} index for Iran's import from the EU is about .57, which is less than one. Therefore, unlike exports, Iran's imports from this union have relatively low water intensity. In other words, while the value of Iran's imports from the EU is greater than 7.6 times of its exports, the volume of Iran's VWI from this union is only about two times that of VWE. With this approach, it is clear that trade between Iran and the European Union does not support Ricardo's comparative advantage theory, and contrary to the recommendations of virtual water policy, the pattern of trade has been towards the withdrawal of water from the water-scarce region (Iran) to the water-abundant region (the European Union). *Therefore, this finding suggests that in order to examine the theory of comparative advantage for water resources, it should not only consider positive or negative net virtual water imports, but it is also necessary to evaluate this criterion in comparison with the trade balance of countries.*

Three countries have been the largest exporters of virtual water to Iran, namely the Netherlands, Germany and Austria, with a total contribution of 68.8%

. Iran's imports from the Netherlands are the most water intensive imports compared to other EU28 countries, so that the ratio of *U* reaches 4.8. This ratio reaches 0.2 for Romania, which is less than other European Union countries. Of the 28 members of EU, 18 countries are net virtual water exporters to Iran (positive NVWI for Iran) and 10 countries are net virtual water importers (negative NVWI for Iran). The largest Iran's NVWI were from the Netherlands with a volume of 370 millionm^3. By contrast, Iran has the largest net virtual water exports to Spain, 123 million m^3. Fig.3 and fig.4 shows these values. The fig.3 depicts these results in numerical form and fig.4 represents them schematically. In fig.4, the amount of NVWI from the EU countries are in accordance with the colors of the countries (See the guide at the top of the figure).

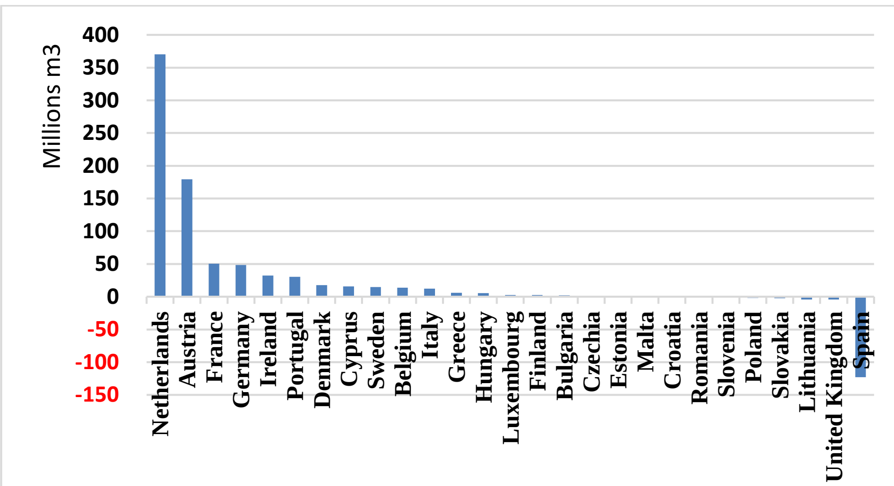

Figure 3. Net imports of Iran from the EU-million cubic meters

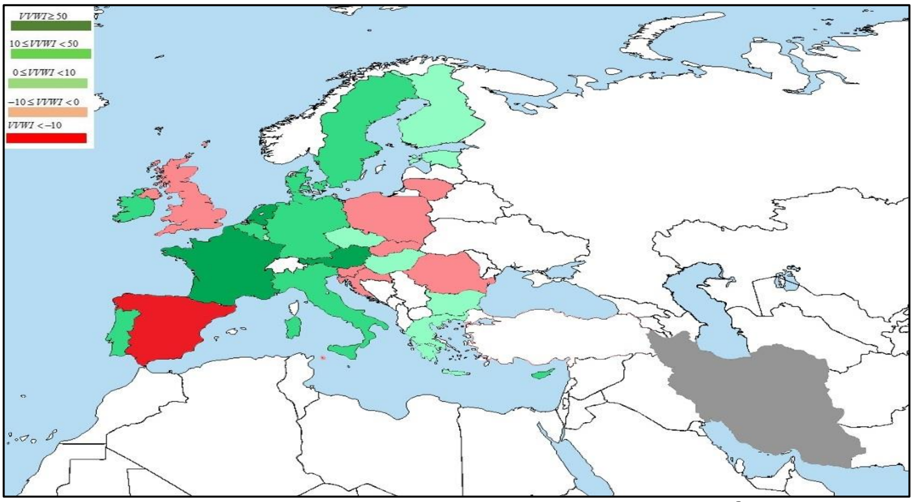

Figure 4. Iran's NVWI from EU Countries (million m^3)

Table c in the appendix shows in detail the net results of virtual water imports by sector-country .Based on these results, Iran is a net importer of virtual water in trade with the European Union. Iran's total import of virtual water from the European Union in 2011 was about 667 million m^3. To imagine the magnitude of this amount, it is enough to pay attention to the fact that this amount was more than 13 times the water consumption of households in Yazd province in 2011 (the total drinking water consumption of households in Yazd province in 2011 was about 49 million m^3). Also, this amount was more than 17% of the total drinking water consumption of Iranian households in 2011.

In fig.5, import and export of virtual water are shown for each economic sector, the sectors number are according to table 2. Iran's largest exports to the European Union are related to the agricultural sector, amounting to about 424.6 million m^3, which is about 68.9% of the total. This sector, along with food and textiles, accounted for more than 94% of the total VWE to the European Union. It can be concluded that any to water save policy through trade with the European Union should be focused on these sectors. However, the largest virtual water import from the European Union comes from the food sector, which is about 619.9 million m^3, accounting for about 48.3% of total imports. This sector, along with "agriculture", "Manufacture of machinery and equipment n.e.c." and "Manufacture of chemicals and chemical products ", account for more than 90% of Iran's VWI from the European Union. The largest NVWI were from "food, beverages and tobacco", "Manufacture of machinery and equipment n.e.c", and "Manufacture of chemicals and chemical products" (503.1, 102.3 and 60.1 m^3 respectively), while the highest net virtual water exports is related to "agriculture", "Manufacture of textiles" and "Tanning and dressing of leather" (68, 33/6 and 11/1, respectively).

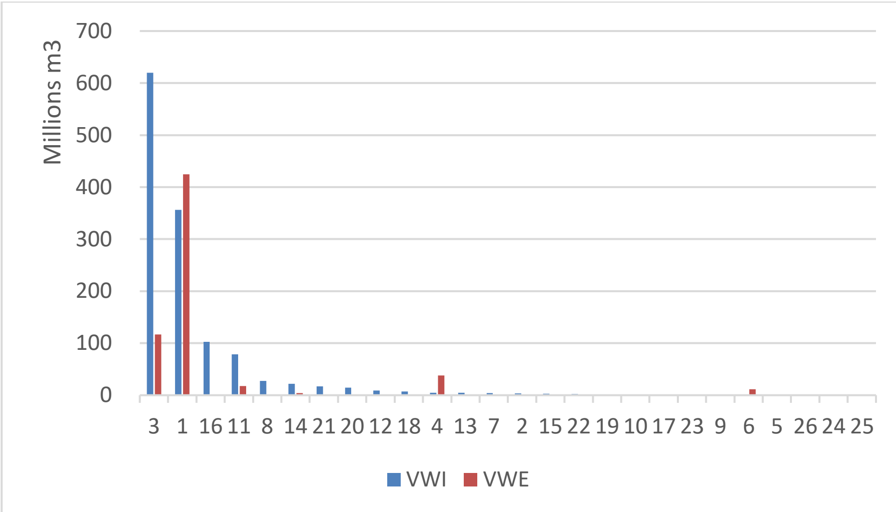

Figure 5. Iran's virtual water Export and import to (from) the EU (28) - million m^3

5. Limitations

This research was faced with a limitation that should be taken into account in using its results. The classification of economic sectors in Iran's input-output table is based on ISIC codes, but water consumption data is not provided by any organization in Iran with this details. Of course, this has been the limitation noted in many similar studies, even in developed countries (for example see Mubako et al., 2013). However, as indicated above, the data required for this research was collected with maximum accuracy from all possible statistical sources and in some sectors, data was estimated with some assumptions taken into account.

6. Concluding Remarks

The economical, social and demographic changes during the past decades have led to a sharp increase in the demand for global water resources, and these vital resources are under unprecedented pressure. In arid and semi-arid regions such as Iran, rising demand for water has been accompanied by limitation of supply of these resources and it is expected that due to climate change, this supply limitation will become even more severe in the future. All of these, in addition to the dispersion of precipitation, have encountered the Iran's with even more sophisticated water crisis, and therefore the proper management of water resources is vital.

Nowadays, virtual water import strategy is suggested as a promising political direction to get rid of water crisis, according to which countries can protect their domestic water resources by importing virtual water. Accordingly, the study of flows of virtual water imports and exports in a deeply water-scarce regions country, such as Iran, can be a valuable help for policymakers in order to adopt an optimal pattern of trade with other countries. The present study deals with the

evaluation of virtual water trade between Iran and the European Union, broken down by different sectors of the economy in 2011.

The results of this study show that Iran is a net importer of virtual water in trade with the EU in 2011, so that its imports (about 1283 m^3) is twice of its exports (about 616 m^3). Consequently, it may seem that the pattern of trade between Iran and the EU is in the interest of Iran, and that comparative advantage theory is confirmed in this regard. However to judge correctly about the virtual water trade pattern between these two regions, these values should be compared with the value of exports and imports between them. This was done in the present study with the index called *U*. This indicator shows that Iran's exports to the EU are high water-intensive but Iran's imports from the EU are low water-intensive. Therefore, contrary to what seems initially, the pattern of trade between Iran and the EU, contrary to the policy recommendations of relevant research, is in favor of the water-abundant regions (EU), and this result does not confirm comparative advantage theory.

The largest VWE from Iran to the EU28 are respectively to Germany, Spain and Italy, which accounted for more than 74% of the total virtual water exports. By contrast, the Netherlands, Germany and Austria have been the largest virtual water exporters to Iran, with a total share of over 68.8% of the total. The most water intensive exports to the European Union are exported to Lithuania and Slovakia, with U_{ex} being 2.98 and 2.87, respectively. This is the lowest for the Greek and is about 0.13. The most water intensive imported products are from the Netherlands, with a *U* ratio of about 4.8. This ratio for Romania is about 0.2, which is lower than other union countries. NVWI from the 18 EU countries were positive, the largest of which is the Netherlands with a volume of 370 million m^3. On the other side, there were 10 countries that Iran’s NVWI from them were negative, the largest of which was Spain with 123 million m^3.

Among the economic sectors, Iran's largest VWE to the European Union are related to the agricultural sector, with a volume of 424.6 m^3, which is about 68.9% of the total. This sector, along with "food, beverages and tobacco" and "textiles", accounted for more than 94% of the total. The largest VWI from the EU comes from the sector of "food, beverages and tobacco", which is about 619.9 million m^3.

The results show that the pattern of trade between Iran and the EU28 is not in favor of Iran's domestic water resources, but this pattern will lead to the flow of scarce water resources from Iran to the water-abundant regions of European Union. Therefore, it is suggested that in the Iranian trade policy, this pattern should be changed and high water-intensive products must be imported instead of the producing them in Iran. In fact, the virtual water import can be considered as a suitable strategy to overcome the problem of water scarse in Iran. Obviously, this proposal should be considered with regard to other economic, social and political variables, such as employment, food security and value added.

Acknowledgements

We would like to thank the Directors of the Iran Water Resources Management Company for providing the data of water use. We also acknowledge the Ms. Zahra Zakeri in Parliament Research Center of the Iran for her helps to provide some data.

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Appendix

Tables A to B of appendix show the export, import, and net imports of Iran's virtual water to (from) the EU28 countries in each of the economic sectors. The rows of these tables refer to countries, and the columns represent sectors of the economy. Column number is placed according to table 2. For example, in the second row of the third column of the table A, show the Iran's virtual water exports to Spain through exports of "food products, beverages and tobacco". The last column of tables A and B show the U_{ex} and U_{im} index for each country (and the whole EU).

Table A. Iran's virtual water exports to the EU28 by sectoral-country-division-m³

U_{ex}	Total VWE	26	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	Sector / Country
0.86	4,914,992	75	105	0	550	57	0	0	0	7,539	5,441	780	921	3	552	0	35	0	0	109	0	1,702,901	2,372,700	578	822,647	Austria
2.38	27,082,697	21	0	0	21	0	0	26	0	3,805	368	1,045,541	1,800	3,594	7,165,086	360,536	178	0	0	0	0	75,704	893,537	2,633	17,529,846	Belgium
1.80	3,111,838	0	0	0	0	0	0	0	0	0	0	0	11,103	1,032	238,397	9,918	0	5,335	0	0	0	34	1,788,466	0	1,057,553	Bulgaria
2.87	390,826	0	0	0	0	75	0	0	0	0	21	0	0	0	0	44,497	15,138	0	0	0	0	988	211,800	0	118,306	Croatia
0.13	618,677	74	0	0	0	0	0	0	0	243	13,263	19,805	9,022	0	54,863	118,182	0	0	0	0	0	139,013	260,389	3,824	0	Cyprus
1.14	559,778	0	0	0	0	358	0	0	0	1,199	95	0	56	0	9,878	0	11,436	0	0	0	0	57,510	423,682	0	55,564	Czechia
0.51	5,003,076	0	3	0	0	0	0	0	0	667	307	0	213	0	25,582	0	92	18	0	0	0	2,185,320	136,387	1,173	2,653,314	Denmark
0.58	39,112	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	39,112	0	0	Estonia
1.58	147,382	0	134	0	0	0	0	4	0	0	0	0	1	730	0	0	73	0	0	0	0	112,955	68	267	33,149	Finland
0.25	23,824,314	133	96	7,621	71,635	16,373	0	45,577	0	172,491	38,182	340,168	5,363	3,422	20,464	1	85	0	4,371	111,085	2,004	1,524,156	1,920,241	2,431	19,538,415	France
0.74	251,331,559	5,459	313	0	49,144	17,751	4,869	3,614	5	62,854	18,381	441,811	17,080	40,064	1,377,243	54,188	1,915	412	72,904	212,195	1,113	19,785,057	69,320,341	3,800	159,841,046	Germany
0.20	819,518	0	0	0	0	0	0	0	0	2,491	0	0	1,737	0	7	0	0	580	0	0	0	20,572	512,364	0	281,767	Greece
0.86	2,599,503	0	401	0	9	0	0	360	0	0	0	0	0	0	0	0	0	0	0	0	0	28,306	2,337,268	0	233,159	Hungary
0.82	141,871	0	0	0	0	290	0	0	0	13	0	0	0	20,261	710	0	4,454	0	0	0	0	785	0	28	115,329	Ireland
0.78	48,361,469	91	1,589	0	140,677	20,621	516	567	0	249,157	43,909	617,757	55,224	34,690	2,384,056	88,071	103	1,052	11,844	11,111,813	4,245	5,799,334	4,353,573	148,903	23,293,676	Italy
1.23	4,308,959	0	0	0	38	0	0	0	0	0	0	1,721	0	0	0	0	0	0	0	0	0	0	401,327	378	3,905,494	Lithuania
1.03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Luxembourg
0.53	80,039	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	83	30,034	0	49,922	Malta
1.68	29,826,468	0	50	0	114	1,197	1	3,440	0	12,347	21,026	876,808	33,723	76,022	5,314,708	37,084	8	0	2,706	0	0	111,690	6,959,489	898	16,375,156	Netherlands
0.27	10,498,996	0	0	0	10,742	0	0	0	0	0	0	10,836	3,841	151	1,213	345	0	0	157	0	0	15,040	9,547,395	0	909,277	Poland
____	374,816	0	0	0	0	0	0	64,053	0	0	0	11,037	939	647	18,203	0	0	0	0	0	0	8,979	106,034	0	164,923	Portugal
1.72	9,496,253	0	379	13,809	10,291	144	2,252	4,421	0	23,082	2,569	597	7,816	81,217	4,386	240,091	177	97	291	19,871	0	29,337	5,187,279	129	3,868,019	Romania
2.98	2,495,770	0	0	0	0	0	0	0	0	5	0	0	7	0	0	0	0	0	0	0	0	0	426,604	0	2,069,154	Slovakia
2.49	1,448,920	0	0	0	0	0	0	2,525	0	0	442	0	0	786	1,050,958	0	1,545	0	0	0	0	4,763	253,235	0	134,665	Slovenia
1.79	158,182,896	45	47	0	37,711	0	0	12	21	1,781	21,478	625,185	7,713	25,431	249,747	85,209	1	0	4,432	17,864	0	502,699	3,805,471	3,943	152,794,107	Spain
0.37	14,035,490	75	61	4	0	81	37,004	156	0	681	1,216	115	1,050	163	1,427	0	1,146	12	1	3	2	2,765,764	1,068,839	0	10,157,693	Sweden
0.13	16,374,915	977	295	189	93	10	0	970	0	10,173	8,512	21,912	30,432	12,649	7,462	23,121	1,341	18	1	900	433	3,204,780	4,480,023	198	8,570,426	United Kingdom
1.90	616,070,135	6,949	3,475	21,623	321,025	56,955	44,641	125,725	26	548,526	175,209	4,014,074	188,040	300,864	17,924,943	1,061,243	37,727	7,525	96,706	11,473,839	7,797	38,075,772	116,835,658	169,187	424,572,608	total

Table B. Iran's virtual water imports from the EU28 by sectoral-country-division-m³

U_{im}	Total VWI	26	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	Sector / Country
2.20	184,053,938	0	17,705	168,608	31,979	219,916	2,476	242,028	486	2,950,204	129,141	3,836,146	889,702	240,754	4,844,084	9,258	5,064	13,020,080	322,158	14,103	960	311,320	61,639,528	11,953	95,146,286	Austria
0.64	40,735,509	0	4,259	458	95,155	4,597,709	1,038	113,665	887	3,010,694	53,996	323,268	120,664	559,058	8,419,954	19,234	10,236	56,029	252,536	19,845	1,840	923,499	17,696,392	60,633	4,394,460	Belgium
0.47	5,161,245	0	1,182	14,659	2,273	3,582	7	10,784	0	132,641	2,480	1,033	3,209	18,039	2,408,930	0	0	6,582	213,490	0	49	23,319	783,312	7,032	1,528,641	Bulgaria
0.28	337,878	0	0	0	0	2,786	13	776	0	36,294	0	0	0	1,192	92,921	0	0	0	0	0	0	0	203,897	0	0	Croatia
0.33	6,380,626	0	0	0	0	222	21	6,812	0	23,748	9,002	13,858	83,160	15,711	95,263	536	0	0	4,865	0	0	9,848	6,028,666	298	88,617	Cyprus
0.83	1,178,497	0	2,083	38,008	2,413	11,247	1,381	16,282	3,478	221,817	60,367	9,234	128,788	39,099	238,154	0	0	58,266	1,384	0	0	32,144	135,316	179,036	0	Czechia
0.35	22,717,820	0	575	0	2,893	134,637	3,614	32,894	125,269	563,746	25,282	4,946	29,622	27,889	2,221,031	0	1,934	100,623	89,905	0	96	26,653	15,636,228	2,828	3,687,154	Denmark
2.25	92,181	0	662	0	1,502	1,022	297	616	0	9,688	8,707	0	0	211	10,432	0	0	48,850	6,210	0	0	0	1,398	2,586	0	Estonia
0.85	2,470,010	0	2,295	12,463	2,639	109,005	333,355	68,254	0	598,469	5,205	8,346	9,520	23,745	49,386	0	302,188	817,762	93,299	0	0	0	31,895	2,183	0	Finland
0.60	74,386,637	0	73,398	49,164	3,185,745	902,657	77,189	1,130,108	77,484	24,533,452	569,972	489,211	342,547	1,109,825	9,478,616	27,599	20,614	488,613	4,015	34,904	12,375	153,743	17,448,392	117,458	14,059,556	France
0.63	299,711,556	7,120	804,272	1,112,697	2,861,460	3,950,138	290,179	2,541,055	930,374	26,189,556	705,218	5,831,149	1,219,382	4,089,928	27,162,377	282,029	79,791	5,982,028	1,167,175	38,699	18,079	1,729,389	191,612,757	679,187	20,427,517	Germany
4.66	16,779,156	0	756	0	0	2,687	5	5,380	86	18,902	454	7,784,998	232	2,266	177,109	845,931	1,379	681,838	0	0	0	5,974	2,414,946	67,553	4,768,661	Greece
0.32	7,943,630	0	13,534	0	22,874	132,473	225	18,269	18	59,240	4,584	2,780	28,661	174,471	175,401	3,277	0	0	8,903	0	0	3,953	115,390	24	7,179,555	Hungary
1.63	32,346,574	0	1,193	1,874	56,706	139,060	772	10,976	634	196,488	24,657	747	382,831	7,222	1,798,527	484	120,886	719,162	19,273	204	508	2,670	28,754,449	27,135	80,117	Ireland
0.21	60,536,200	38	135,260	89,295	1,435,721	1,144,627	63,673	779,213	12,910	22,759,334	952,442	1,918,669	546,427	1,602,333	7,203,335	15,143	107,304	1,194,828	303,409	207,154	192,681	696,214	7,239,086	1,680,005	10,257,098	Italy
0.28	84,368	0	0	0	0	5,568	604	0	0	49	0	0	449	408	9,031	0	0	112	0	0	0	0	68,146	0	0	Lithuania
0.40	2,526,781	0	0	0	0	1,018	38	825	0	96,400	1,776	11,310	0	28,221	1,846,080	0	0	0	1,672	0	0	0	535,119	4,323	0	Luxembourg
0.27	30,515	0	0	0	0	0	0	0	0	0	0	0	0	25,950	1,498	0	0	0	0	0	0	0	0	0	3,067	Malta
0.39	399,911,087	0	27,268	14,113	432,766	2,147,532	25,090	359,959	19,742	1,121,689	117,906	42,131	26,310	45,667	4,639,468	1,935	1,189	182,835	67,191	1,119	12	73,602	216,079,251	6,284	174,478,027	Netherlands
0.69	8,583,895	0	18,615	0	142,227	47,332	261	3,913	304	146,312	9,182	197,393	26,081	32,972	102,616	3,253	80	2,073	10,899	0	37	35,788	7,702,170	0	102,386	Poland
0.43	30,747,427	0	1,500	0	17,718	836	108	129,089	0	41,948	9,580	19,561	8,126	99,340	44,846	0	0	161,834	239,973	0	0	20,939	29,945,440	6,588	0	Portugal
1.94	9,117,261	0	502	76,546	403,341	104,371	0	1,817	0	8,194,030	8,277	78,948	1,175	93,958	12,857	0	0	0	21,543	0	0	3,815	16,098	0	99,982	Romania
1.19	293,973	0	14,893	550	153	134	0	704	0	76,846	9,157	2,426	72,900	3,044	9,997	0	0	20,333	0	0	0	0	0	82,837	0	Slovakia
0.56	799,269	0	353	0	2,788	8,904	2,051	57,991	0	76,946	741	20,714	156,624	15,355	243,343	0	249	25,835	6,024	0	0	181,099	0	251	0	Slovenia
2.82	35,150,411	0	20,829	2,586	430,660	262,333	5,868	1,433,529	17,096	3,586,465	294,973	1,289,988	174,526	360,337	3,727,683	20,760	40,497	1,554,479	1,113,009	51,752	26,237	189,215	12,796,003	340,609	7,410,976	Spain
4.85	28,810,484	0	9,361	707,105	7,756,568	106,940	969,677	96,887	10,282	7,303,110	75,635	133,499	147,794	42,848	1,463,973	45,127	131,120	2,257,688	5,283	330	230	13,850	1,839,400	799	5,692,978	Sweden
3.44	12,150,207	0	1,404	10,167	4,810	486,590	4,003	63,955	1,433	931,646	22,349	122,859	5,280	174,304	2,009,717	194	3,912	8,566	0	2,329	36	7,715	1,168,613	9	7,120,317	United Kingdom
0.57	1,283,037,133	7,158	1,151,900	2,298,292	16,892,391	14,523,329	1,781,945	7,125,778	1,200,484	102,879,717	3,101,081	22,143,215	4,404,009	8,834,145	78,486,630	1,274,760	826,443	27,388,415	3,952,216	370,440	253,141	4,444,748	619,891,892	3,279,610	356,525,393	total

Table C. Iran's Net virtual water import from EU27 by country-division-m^3

Total	26	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	Sector Country
179,138,946	-75	17,600	168,608	31,428	219,860	2,476	242,028	486	2,942,665	123,700	3,835,366	888,781	240,751	4,843,532	9,258	5,030	13,020,080	322,158	13,995	960	-1,391,581	59,266,828	11,375	94,323,638	Austria
13,652,812	-21	4,259	458	95,134	4,597,709	1,038	113,638	887	3,006,890	53,627	-722,273	118,864	555,463	1,254,868	-341,302	10,059	56,029	252,536	19,845	1,840	847,794	16,802,855	58,000	-13,135,386	Belgium
2,049,407	0	1,182	14,659	2,273	3,582	7	10,784	0	132,641	2,480	1,033	-7,894	17,007	2,170,534	-9,918	0	1,247	213,490	0	49	23,285	-1,005,154	7,032	471,088	Bulgaria
-52,948	0	0	0	0	2,711	13	775	0	36,294	-21	0	0	1,192	92,921	-44,497	-15,138	0	0	0	0	-988	-7,903	0	-118,306	Croatia
5,761,948	-74	0	0	0	222	21	6,812	0	23,506	-4,260	-5,947	74,138	15,711	40,400	-117,645	0	0	4,865	0	0	-129,165	5,768,276	-3,526	88,617	Cyprus
618,719	0	2,083	38,008	2,413	10,889	1,381	16,282	3,478	220,618	60,272	9,234	128,732	39,099	228,275	0	-11,436	58,266	1,384	0	0	-25,366	-288,365	179,036	-55,564	Czechia
17,714,744	0	572	0	2,893	134,637	3,614	32,894	125,269	563,080	24,975	4,946	29,409	27,889	2,195,448	0	1,841	100,605	89,905	0	96	-2,158,667	15,499,841	1,655	1,033,840	Denmark
53,068	0	662	0	1,502	1,022	297	616	0	9,688	8,707	0	0	211	10,432	0	0	48,850	6,210	0	0	0	-37,714	2,586	0	Estonia
2,322,627	0	2,161	12,463	2,639	109,005	333,355	68,250	0	598,469	5,205	8,346	9,519	23,015	49,386	0	302,115	817,762	93,299	0	0	-112,955	31,826	1,915	-33,149	Finland
50,562,323	-133	73,302	41,543	3,114,110	886,285	77,189	1,084,531	77,484	24,360,961	531,790	149,043	337,184	1,106,403	9,458,153	27,598	20,529	488,613	-356	-76,181	10,372	-1,370,413	15,528,151	115,027	-5,478,860	France
48,379,997	1,661	803,959	1,112,697	2,812,316	3,932,387	285,310	2,537,441	930,369	26,126,702	686,838	5,389,338	1,202,302	4,049,864	25,785,133	227,840	77,876	5,981,616	1,094,272	-173,496	16,966	-18,055,668	122,292,416	675,387	-139,413,529	Germany
15,959,638	0	756	0	0	2,687	5	5,380	86	16,411	454	7,784,998	-1,505	2,266	177,102	845,931	1,379	681,258	0	0	0	-14,598	1,902,582	67,553	4,486,894	Greece
5,344,127	0	13,132	0	22,865	132,473	225	17,909	18	59,240	4,584	2,780	28,661	174,471	175,401	3,277	0	0	8,903	0	0	-24,354	-2,221,878	24	6,946,396	Hungary
32,204,704	0	1,193	1,874	56,706	138,770	772	10,976	634	196,475	24,657	747	382,831	-13,040	1,797,817	484	116,432	719,162	19,273	204	508	1,885	28,754,449	27,107	-35,212	Ireland
12,174,731	-53	133,670	89,295	1,295,045	1,124,006	63,158	778,646	12,910	22,510,177	908,534	1,300,912	491,203	1,567,642	4,819,278	-72,928	107,201	1,193,776	291,566	-10,904,659	188,436	-5,103,119	2,885,513	1,531,101	-13,036,578	Italy
-4,224,591	0	0	0	-38	5,568	604	0	0	49	0	-1,721	449	408	9,031	0	0	112	0	0	0	0	-333,181	-378	-3,905,494	Lithuania
2,526,781	0	0	0	0	1,018	38	825	0	96,400	1,776	11,310	0	28,221	1,846,080	0	0	0	1,672	0	0	0	535,119	4,323	0	Luxembourg
-49,524	0	0	0	0	0	0	0	0	0	0	0	0	25,950	1,498	0	0	0	0	0	0	-83	-30,034	0	-46,856	Malta
370,084,619	0	27,218	14,113	432,653	2,146,335	25,089	356,519	19,742	1,109,342	96,880	-834,677	-7,412	-30,355	-675,240	-35,149	1,180	182,835	64,486	1,119	12	-38,088	209,119,763	5,386	158,102,871	Netherlands
-1,915,102	0	18,615	0	131,485	47,332	261	3,913	304	146,312	9,182	186,557	22,240	32,821	101,404	2,908	80	2,073	10,742	0	37	20,747	-1,845,225	0	-806,891	Poland
30,372,611	0	1,500	0	17,718	836	108	65,036	0	41,948	9,580	8,523	7,187	98,692	26,643	0	0	161,834	239,973	0	0	11,959	29,839,406	6,588	-164,923	Portugal
-378,992	0	124	62,737	393,050	104,228	-2,252	-2,603	0	8,170,949	5,708	78,351	-6,640	12,741	8,471	-240,091	-177	-97	21,252	-19,871	0	-25,522	-5,171,181	-129	-3,768,037	Romania
-2,201,797	0	14,893	550	153	134	0	704	0	76,841	9,157	2,426	72,893	3,044	9,997	0	0	20,333	0	0	0	0	-426,604	82,837	-2,069,154	Slovakia
-649,651	0	353	0	2,788	8,904	2,051	55,467	0	76,946	299	20,714	156,624	14,569	-807,615	0	-1,296	25,835	6,024	0	0	176,336	-253,235	251	-134,665	Slovenia
-123,032,486	-45	20,782	2,586	392,950	262,333	5,868	1,433,517	17,075	3,584,684	273,494	664,803	166,814	334,906	3,477,936	-64,448	40,496	1,554,479	1,108,577	33,888	26,237	-313,484	8,990,532	336,666	-145,383,132	Spain
14,774,994	-75	9,300	707,101	7,756,568	106,860	932,674	96,732	10,282	7,302,429	74,419	133,384	146,743	42,686	1,462,547	45,127	129,973	2,257,676	5,282	327	228	-2,751,914	770,561	799	-4,464,715	Sweden
-4,224,708	-977	1,109	9,977	4,717	486,581	4,003	62,984	1,433	921,473	13,837	100,947	-25,153	161,655	2,002,254	-22,927	2,571	8,548	-1	1,429	-397	-3,197,065	-3,311,410	-190	-1,450,109	United Kingdom
666,966,998	209	1,148,425	2,276,669	16,571,366	14,466,373	1,737,305	7,000,053	1,200,458	102,331,191	2,925,873	18,129,141	4,215,969	8,533,281	60,561,687	213,517	788,716	27,380,891	3,855,510	-11,103,399	245,344	-33,631,024	503,056,234	3,110,423	-68,047,215	total