Iranian Journal of Economic Studies, 10(1) 2021, 7-29

Shiraz University

Iranian Journal of Economic Studies

Journal homepage: ijes.shirazu.ac.ir

Estimating Domestic Value Added in Gross Exports and Its Relation to Vertical Specialization: The Case Study of Iran

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Article History

Received date: 11 August 2020
Revised date: 20 March 2021
Accepted date: 29 May 2021
Available online: 16 August 2021

JEL Classification
F11
F02
F15
C67

Keyword
Trade-in-Goods
Trade-in-Tasks
Hypothetical Extraction Method
Vertical Specialization
Input-Output Table

Abstract

Traditional trade theories and/or "Trade-in-Goods" predict that exports can generate 100% value added, which has recently been debated by Trade-in-Tasks theories. The root of these debates is referred to the existing conventional macro-economic accounting, which is expressed that expenditure components of final goods, including gross exports (GE), equals total value is consumed in each country. It means that a country's gross domestic product (GDP) is the sum of its final domestic demand, including GE. Therefore, generating 100% value added in final domestic demand may hold true, but GE, due to double counting, may not generate 100% value added for the domestic economy. In addition to that the domestic value added (DVA) has a nice property with vertical specialization (VS) in such a way that the sum of their shares is equal to one and, therefore, can measure the degree of VS in trade. In this article, we take this issue as a starting point and, for the first time, try to analyze it with the following questions: What amount of DVA should be attributed to GE from Iran? What is the relationship between DVA and VS? We apply two methods of Hypothetical Extraction (HEM) and VS with the latest Input-Output Tables (IOTs) of 2011 and 2001 in Iran. The overall findings are as follows: One- the share of DVA in GE in 2001 is 95.02%, downs to 93.33% in 2011, and the shares of residual as an overestimation of GE are 4.98% and 6.67% for each year, respectively. Second, there is an inverse relationship between DVA and VS shares for both years. Third, the considerable large shares of DVA followed by small shares of VS suggest that the Iranian economy is at the beginning of production chains with a non-symmetric trade pattern.

Highlights

- Trade-in-Tasks theory highlights the importance of trade in intermediate goods.
- A higher share of DVA is associated with a lower share of VS.
- The Iranian economy is at the beginning of the production chain with an asymmetric trade pattern.

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DOI: 10.22099/ijes.2021.38122.1694

1. Introduction

Right from the verge of the 21st Century, the available literature reveals that there has been a sea change in the international trade theories: traditional trade theories known as "Trade-in-Goods" have been substituting by the new international trade theory, focusing on "Trade in Tasks." The former emphasizes the factors of production to final goods, ignoring the role of trade in intermediate goods, while the latter highlights the importance of trade in intermediate goods between the countries. Taking into account the role of trade in intermediate goods has at least four main advantages: 1) can bridge between factors of production to final goods. 2) can reveal the stage of the production process generally known as "fragmentation of production process," "slicing of the production process," and so on (Timmer et al., 2012; Miroudot & Ye, 2017, 2020, 2021). 3) value added is generated at each stage. 4. it can reveal the ex-post rationalization of VS, which means that direct and indirect intermediate imported goods needed to satisfy gross exports (GE) (Hummels et al., 2001).

Considering the above advantages, the basic issue is to decompose value added in GE. The main reason behind this issue is that the traditional trade theories predict that exports can generate 100% value added. However, this prediction has been seriously debated by the proponents of new international trade theories (Koopman et al., 2014; Johnson, 2014). One of these debates is related to the existing conventional system of national accounting. The macroeconomic accounting equation derived from it shows that the domestic expenditure components such as private final consumption, government final consumption expenditure, fixed capital formation, and exports equal the amount of value added is consumed in each country. But this equation does not tell us where the value added comes from (Johnson, 2014). On the other hand, the accounting nature of the GDP equation suggests that a country's GDP is the sum of its domestic value added plus its value added in GE. But value added in GE generates double counting, which causes overestimation of the respective GE and GDP.

To quantify this debate, the existing conventional international trade statistics could not be used for the two possible reasons: First, it refers to the concept of "exports," i.e., trade-in-intermediates and trade-in-final goods are clubbed together without providing trade directions of origins and destinations (Los et al., 2016; Koopman et al., 2014). Second, applications of these kinds of trade statistics fail to reveal the issue of multiple borders crossing of goods and the possibility of generating value added, which brings about double counting and henceforth causes overestimation of the existing conventional GDP of countries (Miroudot & Ye, 2021, 2020, 2017).

To solve the above drawbacks, a comprehensive database is called. As an alternative to the existing traditional international trade statistics, the World Input-Output Database (WIOD) construction was introduced in 2004 and

revised several times. It covers 43 countries and shares around 90% of the world's GDP. The remaining countries are treated like the rest of the world[1].

In this article, we take the issue of decomposition GE into domestic value added (DVA) and residual to estimate the overestimation of GE as a starting point and show that even in the absence of WIOD, it is possible to use a national input-output table to decompose value added in GE. The objective is analyzed by following two main questions: 1. what amount of DVA should be attributed to GE in Iran? 2. what is the relationships between DVA and VS in Iran?

Concerning the posed questions, we apply two methods, namely HEM and VS. For analytical purposes, the latest available official Input-Output Tables for the years 2001 and 2011 in the constant price of 2011 are used for the first time to decompose GE into DVA due to GE and the remaining value added as residual. In addition to that, the relationships between the shares of DVA and VS to GE are also analyzed.

For this purpose, the contents of the article are organized into four sections. A summary of the Input-Output approach vis-a-viz interaction trade theory is presented in the first section. In the second section, we discuss the two methods of HEM and VS. The statistical bases followed by empirical analysis are allocated in the third section. The final section will end up with conclusions and some suggestions for further investigations.

2. Input-Output Approach vis-a-viz International Trade Theory

Available literature reveals that during the past seven decades, the Input-Output approach has at least two times entered into the arena of international trade theory. The first was in 1953, which was dominated by the traditional trade theories. Leontief with his newly invented input-output table of the U.S. tried to test the Hecksher-Ohlin model, which was considered one of the main streams in the arena of traditional international trade theories. This theory assumes that trade occurs because countries have different resources such as labor and capital. It contrasts with the Ricardian model, which assumed that trade occurs because countries use their comparative technological advantage to specialize in producing different goods (Feenstra & Taylor, 2017). Considering the availability of resources like labor and capital in the United States, Hecksher-Ohline theory predicts that the United States could have a comparative advantage to export capital intensive goods and import labor intensive goods.

Leontief used the 1947 Input-Output Table of the U.S. to test the Hecksher-Ohlin prediction. For this purpose, he measured the amount of labor and capital used in all sectors required to produce $1 million of U.S. final good exports and to produce $1 million of imports into the U.S. economy (Leontief, 1953, 1956).

Leontief's empirical test contrasted with Hecksher-Ohlin's prediction, and he reached a surprising conclusion that the United States imports capital-

[1] The construction of WIOD was in fact an ambitious project carried out with the collaboration of 12 countries. More information is given in Tukker and Dietzenbacher (2013), Dietzenbacher et al., (2013) and Timmer et al., (2015).

intensive goods and exports labor-intensive goods. These contrasting finding of Leontief is known as the "Leontief paradox" (Feenstra & Taylor, 2017; Trefler & Zhu, 2010).

Leontief paradox triggered a wide range of further research and explanation among the trade theory analysts for reconfirming or rejecting during the decades of 80, 90, and even in the 21st Century.[2] Concerning the above condensed literature, it seems that right from the pioneering work of Leontief and then the subsequent studies aim at analyzing the basic tenets of the existing traditional trade theory, which focuses on the factors of production to final exports, and therefore ignores the role of trade in intermediate goods as a bridge between factors of production and final exports of goods. This observation raises an important question. Whether Leontief who used national input-output information, was aware of the role of trade in intermediate goods? The answer for two reasons is no. The first reason is that Leontief used direct and indirect physical amounts of labor and capital needed to produce one million worth of final goods exports from the export side. Turning to the import side of calculation, Leontief faced a problem; he could not measure the corresponding amount of physical labor and capital stock used to produce imports. This is because he did not have data on foreign technology. To get rid of this trap, he, first of all, assumes all the U.S. imports are competitive in nature and fully substitutable with domestic counterparts. The logical explanation of this assumption is that the United States, instead of importing, what amount of labor and capital needed to produce them at home. Leontief implicitly assumes that export can generate 100% value added to maintain the basic tenet of the traditional trade theory.

The second reason is that Leontief has never used the concept of GE, but his assumption of competitive imports paved the way for analysts to work on direct and indirect requirements of intermediate imports to satisfy GE, which is known as the VS in the 21st Century. We shall outline this issue in the next section.

The emergence of the "Trade- in -Tasks" theory, generally known as the new international trade theory in the 21st Century, emphasizes trade in intermediate goods. Baldwin and Robert-Nicoud lucidly narrate such emergence with the following: "A growing list of economists argues that the nature of international trade is changing in important ways. Instead of simply creating more trade in goods, global integration is increasingly marked by trade in intermediate goods and services, also known as "fragmentation," "offshoring," or "Trade in Tasks." The importance of this trade has been clarified with the new data sets that remove the double counting in customs statistics when intermediates cross borders on their own. Then they are embodied in further processed goods. The new trade numbers are called "value added" trade to

[2] Some of these studies are as follows: Cases and Choi (1985), Brecher and Chouhri (1982), Leamer (1980), Trefler (1993), Lee et al., (1988), Trefler and Zhu (2010), Dietzenbacher and Markho padhyay (2007).

distinguish them from the "gross" trade flows that they are traditionally measured" (Baldwin & Robert-Nicoud, 2014).

The above passage reveals many aspects of the functioning of the new international trade theory. The first is that the "Trade-in-Tasks" terminology was for the first time introduced by Grossman and Rossi-Rossi-Hansberg in 2008, where they proposed a theory of the global production process that focuses on tradable tasks (Grossman & Rossi-Hasnberg, 2008). The second is the terms of "offshoring" or "fragmentation." Offshoring is a type of intermediate trade that differs from the type of trade analyzed with Ricardian and Hecksher-Ohlin Models. As already pointed out, the goods traded in those models were final goods, but offshoring is trade in intermediate goods which can sometimes cross borders several times before being incorporated into a final good that can be sold domestically or abroad (Koopman et al., 2012; Foster-Mc Gregorand & Stehrer, 2013). Therefore, offshoring is a relatively new phenomenon in world trade. The third aspect is the need for the new data sets to remove the issue of double counting, which for the first time was proposed by Koopmans et al. (Koopman et al., 2014). Double counting arises due to multiple crossing of geographical borders of trade in intermediate goods and then embodied in further process goods. The process of production of such goods, in turn, generates value added which is counted in GDP and GE and causes overestimation of both of them. Therefore, the emergence of WIOD in the 21st Century was an alternative to the prevailing traditional trade statistics and solved the issue of double counting value added by decomposing value added in GE (Dietzenbacher et al., 2013).

3. Literature Review

In recent years, tracing value added in gross exports has been increasingly debated in papers while this issue has been neglected in Iran. Although several papers have used different data sources for assessing DVA and VS, similar facts can be extracted from their observations which we describe below.

Johnson and Noguera (2012a) combine input-output data and bilateral trade information to assess the value added in gross exports. Based on their estimation, the average ratio of value added in GE represents 73%. According to their interesting findings at the regional level, the highest ratios belongs to Iran (95%), Nigeria (94%), and Peru (93%), while Singapore (37%), Luxembourg (40%), and Belgium (48%) stand out with the lowest ratios.

In another article, Johnson and Noguera (2012b) find that the value added in GE has decreased over time in various regions. For example, the ratio of value added to GE in Europe, Asia, and North America was 70%, 77%, and 81% in 1975 fell to 59%, 61%, and 64% in 2005, respectively.

Koopman et al. (2014) estimate a complete accounting of each country's GE in 2004 using input-output tables. Their calculations reveal that the average world value added in the GE ratio is 74%, while it varies between 36.3% for Singapore and 89.1% for Russian. Another finding of the aforementioned paper

is the inverse relationship between the ratio of DVA to GE and VS to GE so that countries with a higher ratio of DVA to GE have Less VS.

Baldwin and Lopez-Gonzales (2013) see again that production is not very globalized, and only 20% of GE comprise a value added in a foreign nation. Using the world input-output database, they find a 50% difference in the ratio of VS to GE between countries, with Russia at the bottom with less than 10% and Luxembourg at the top with 60%.

Johnson (2014) presents five facts about how DVA compares to GE for the world, across countries, between sectors, and bilateral trade partners. These five stylized facts are:

- Declining the ratio of DVA to GE from 85% in the 1970s and 1980 down to 70-75% today.
- Based on sectoral level comparisons, the ratio of DVA to GE in manufacturing sectors is relatively smaller. In contrast, a completely different picture is obtained in the case of services.
- The ratio of DVA to GE ranges from 50% to 90% across countries.
- Existence of heterogeneous and large gap between bilateral value add and GE.
- Heterogeneity of the DVA to GE ratio changes across countries.

Various studies, including Hummels et al. (2001), Trefler and Zhu (2010), Costinot and Noguera (2013), Timmer et al. (2014), Puzzello (2012), De Backer and Miroudot (2013), have reported similar and consistent findings with Johnson (2014).

This article focuses on answering two questions for the first time: What amount of DVA should be attributed to GE from Iran? Second, what is the relationship between DVA and VS?

4. Methodology

This section introduces two simple but powerful mathematical techniques: HEM and VS. The former can decompose the domestic value added in GE. This decomposition helps us to evaluate the issue of the overestimation of GE. Whereas the latter measures the degree of participation of each country in the world trade based on imported input content of exports. As the shares of the two to GE are equal to one, they are inversely related. The main reason is that the sum of DVA and VS, weighted in GE, expressed as a share of GE, is a suitable measure of the degree of a country's participation in the world economy.

4.1 Decomposition of GE Based on Hypothetical Extraction with WIOD

HEM is, in fact, a method that has been extensively used to measure interindustry linkages, which was for the first time introduced by Paelinck et al., 1965[3]. HEM considers the hypothetical situation in which a certain industry is no longer operational. Using HEM, one can calculate the outputs in the entire

[3] For an excellent review of HEM see Miller and Lahr (2001).

economy, which are required for the original final demands. Thus, extracting a sector or deleting a sub-sector of the economy may adequately explain what happens to the production process in the following cases: Disruption under disaster situation (like flood and earthquakes), the energy needed and subsequent emission of pollutants (like CO_2), and finally, disruption, or nullification in trade among countries. The focus of this article is to analyze the case of nullification in trade[4].

The application of HEM needs three standard steps: Step one) before extraction, Step 2) after extraction, and Step 3) the difference between before and after extraction. Therefore, the starting point of the application of HEM is to use the standard balance quantitative Leontief's production equation:

$$x = A^d x + y \quad (1)$$

where x and y are gross output and final domestic demand, including household consumption, public consumption, gross capital formation, and gross exports. A^d indicates domestic input-output coefficients. Equation (1) can be partitioned into the country s and the rest of the world containing remaining countries in the world as follow:

$$\begin{bmatrix} x_s \\ x_r \end{bmatrix} = \begin{bmatrix} A_{ss} & A_{sr} \\ A_{rs} & A_{rr} \end{bmatrix} \begin{bmatrix} y_{ss} & y_{sr} \\ y_{rs} & y_{rr} \end{bmatrix} \quad (2)$$

where x_s and x_r indicate the gross outputs of the country s and the remaining countries. A_{ss} and A_{rr} indicate domestic input-output coefficients of the respective countries, A_{sr} and A_{rs} are intermediate trade coefficients between the two countries. y_{ss} and y_{rr} are final domestic demands which include household consumption, domestic public consumption, and gross fixed capital formation of the two countries, respectively. y_{sr} and y_{rs} indicate final goods exports of the country s to the country r and vice-versa. Now, if we estimate the direct value added coefficient and then substitute it into Equation (1), we get a new equation where equality of final demand and value added (GDP) is expressed as follows:

$$v = \frac{V}{x} \rightarrow V = vx \quad (3)$$

Where V and v are value added (GDP) and value added coefficients. Substituting (3) in (1), we get:

$$V(GDP) = v(I - A^d)^{-1} y \quad (4)$$

Equation (4) shows that final domestic consumption, including GE, equals the amount of value added (GDP) is consumed. Similar to Equations (1) and (2), Equation (4) can be partitioned into the country s and the remaining countries of the world r:

$$\begin{bmatrix} V_s(GDP_s) \\ V_r(GDP_r) \end{bmatrix} =$$

$$[v_s \quad v_r] \begin{bmatrix} (I - A_{ss})^{-1} & (I - A_{ss})^{-1} A_{sr} (I - A_{rr})^{-1} \\ (I - A_{rr})^{-1} A_{rs} (I - A_{ss})^{-1} & (I - A_{rr})^{-1} \end{bmatrix} \begin{bmatrix} y_{ss} & y_{sr} \\ y_{rs} & y_{rr} \end{bmatrix}$$

[4] For the recent applications of HEM in all these cases, see: Dietzenbacher et al., (2019), Zhao et al., (2015), Los et al., (2016), Guerra and Sancho (2010), and Wang et al., (2013).

(5)

Now, if we assume that $v_r = 0$, the actual GDP of the country s equals:

$$GDP_s = \begin{bmatrix} v_s(I - A_{ss})^{-1} & (I - A_{ss})^{-1}A_{sr}(I - A_{rr})^{-1} \\ 0 & 0 \end{bmatrix} \begin{bmatrix} y_{ss} & y_{sr} \\ y_{rs} & y_{rr} \end{bmatrix} \quad (6)$$

Or

$$GDP_s = v_s(I - A)^{-1}y_i \quad (7)$$

where i is a column vector where all elements are unity, showing that it sums two elements of the rows of the matrix $y_i = \begin{bmatrix} y_{ss} & y_{sr} \\ y_{rs} & y_{rr} \end{bmatrix} \begin{bmatrix} 1 \\ 1 \end{bmatrix}$. Equation (7) indicates the first step of HEM, i.e., before extraction. Now, if we imagine a hypothetical world in which s does not export to r, then elements A_{sr} and y_{sr} are set to zero, which indicates the second step of HEM, means after extraction. Under this step, new matrices are as follows:

$$A^* = \begin{bmatrix} A_{ss} & 0 \\ A_{rs} & A_{rr} \end{bmatrix} \quad , \quad y^* = \begin{bmatrix} y_{ss} & 0 \\ y_{rs} & y_{rr} \end{bmatrix} \quad (8)$$

Hypothetical GDP* for the country s in the second step can be estimated as:

$$GDP_s^* = v_s(I - A^*)^{-1}y_i^* \quad (9)$$

where GDP_s^* indicates the total amount of value added consumed in the country s is due to the only household final consumption expenditure of the same country.

Now, if we take the difference between actual GDP_s in Equation (7) and hypothetical extracted GDP_s^* in Equation (9), DVA in GE from the country s can be obtained as:

$$DVA_s = GDP_s - GDP_s^* \quad (10)$$

Which is called domestic value added due to GE from the country s and absorbed in the country r. In WIOD, GE are classified into export of final goods y_{sr} and exports of intermediate goods $A_{sr}y_r$. Therefore, GE from the country s to the country r equals:

$$GE_s = A_{sr}x_r + y_{sr} \quad (11)$$

DVA_s in Equation (10) captures only the amount of domestic value added due to total GE expressed in Equation (11). DVA_s can be further decomposed into four following components: DVA in exports of final goods $[DVA(A, fin)]$, DVA in exports of intermediate goods $[DVA\,(A, Int)]$, DVA in exports of intermediate goods from the country s that is proceeding in the country r that is returned and absorbed in the country s $[DVA\,(R_s)]$, and the residual of value added in GE, RES_s. In order to decompose DVA, the first step is to nullify the final foreign demand (final demand of the country r). Thus, we set both y_{sr} and y_{rr} to zero such that $y^* = \begin{bmatrix} y_{ss} & 0 \\ y_{rs} & 0 \end{bmatrix}$.This means that hypothetically, there is no demand for final products in the country r. In other words, the country r consumes neither its domestically produced products nor the products purchases from the country s.

Concerning the above hypothetical assumption, the new DVA_s can be derived from the following equation:

$$DVA(A)_s = GDP - v_s(I - A)^{-1}y_i^{**} \quad (12)$$

$DVA(A)_s$ is the amount of domestic value added of the country s due to the induced foreign final demand. The important point is that $DVA(A)_s$ in Equation (12) is always smaller than DVA_s in Equation (10). The difference between the two is considered as the domestic value added in intermediate exports from the country s to the country r is processed in the country r and is returned and consumed in the country s. The difference defined residually is estimated as follows:

$$DVA(R)_s = DVA_s - DVA(A)_s \quad (13)$$

In addition to that $DVA(A)_s$ can be further decomposed into exports of final goods $[DVA(A, fin)_s]$ and exports of intermediate goods $[DVA\ (A, Int)_s]$. The interesting point of this decomposition is that the sum of decomposed value added in GE equals the total value of GE of the country s:

$$TGE_s = [DVA(A, fin)_s + DVA\ (A, Int)_s + DVA\ (R_s)] + RES_s \quad (14)$$

where RES_s is the residual value added recently been decomposed into "foreign value added" and "pure double counting" terms[5].

4.2 Decomposition of GE Based on Hypothetical Extraction Method with National Input-Output Information

We have already pointed out that WIOD captures 43 countries, and the remaining countries of the world are aggregated as the rest of the world. Therefore, the decomposition of DVA into different components is possible if one uses WIOD. In contrast to that, the national input-output information of the countries is more abundant. Compared to WIOD, national tables neither contain data on the origin of imports nor the destination of exports (Los et al., 2016). However, using this information, it is still possible to apply HEM for decomposing GE into two parts, DVA and RES. The sum of them equals the GE of country s.

In accordance with the general Equation (1), the balance quantitative production relation based on the national input-output table of the country s is expressed as:

$$x_s = (I - A_{ss})^{-1}y_s \quad (15)$$

where y_s contains the final domestic demands, including GE from the country s. In order to calculate GDP_s, before extraction. The direct value added coefficients have to be estimated as:

$$\bar{v}_s = \frac{\bar{V}}{x_s} \rightarrow \bar{V} = \bar{v}_s x_s \quad (16)$$

Substituting equation (16) into equation (15), the new equation is expressed as follows:

[5] Recently, Miroudot and Ye (2017, 2020, 2021) has taken the issue of $RESE_s$ as a starting point and worked out with the further decomposition using WIOD which was overlooked by Koopman, et al. (2014) and Los, et al. (2016).

$$\bar{V}_s(GDP) = \tilde{v}(I - A_{ss})^{-1} y_s \quad (17)$$

$\tilde{v}$ in Equation (16) indicates a row vector of direct sectoral value added coefficients for the country s. Equation (17) shows that the final domestic expenditure, including exports (y_s) equals to the amount GDP_s consumed in the country s. In other words, the amount of value added that is generated directly and indirectly in the country s to meet the final demand, including final domestic demand and exports. Equation (9) is used to estimate the amount of GDP_s^* due to only household final consumption expenditures, excluding or extracting GE from the country s. Because A^* is a partitioned matrix with hypothetically nullifying the elements of A_{sr} and y_{sr}. Therefore, the Leontief inverse $(I - A^*)^{-1}$ in terms of a partitioned matrix can be expressed as follows:

$$(I - A^*)^{-1} = \begin{bmatrix} (I - A_{ss})^{-1} & 0 \\ (I - A_{rr})^{-1} A_{rs} (I - A_{ss})^{-1} & (I - A_{rr})^{-1} \end{bmatrix} \quad (18)$$

Now, if we post-multiply y_i^* in Equation (9) and pre-multiply the value added coefficients, given in Equation (17), GDP_s^* can be obtained as follows:

$$GDP_s^* = [\bar{v}_s \quad 0] \begin{bmatrix} (I - A_{ss})^{-1} & 0 \\ (I - A_{rr})^{-1} A_{rs} (I - A_{ss})^{-1} & (I - A_{rr})^{-1} \end{bmatrix} \begin{bmatrix} y_{ss} & 0 \\ y_{rs} & y_{rr} \end{bmatrix} \begin{bmatrix} 1 \\ 1 \end{bmatrix}$$

$$= [\bar{v}_s \quad 0] \begin{bmatrix} (I - A_{ss})^{-1} y_{ss} & 0 \\ (I - A_{rr})^{-1} A_{rs} (I - A_{ss})^{-1} y_{ss} + (I - A_{rr})^{-1} y_{rs} & (I - A_{rr})^{-1} \end{bmatrix} \begin{bmatrix} 1 \\ 1 \end{bmatrix} \quad (19)$$

And

$$GDP_s^* = \bar{v}_s (I - A_{ss})^{-1} y_{ss}^{6} \quad (20)$$

Equation (20) indicates that GDP_s^* is generated due to only household final consumption expenditure of the country s. Then taking the differences between Equation (17) and Equation (20) gives the amount of DVA_s in GE as follows:

$$DVA_s = GDP_s - GDP_s^* \quad (21)$$

Since GDP_s reflects the direct and indirect value added generated in the country s to satisfy the final domestic expenditure and exports, and GDP_s^* represents the value added generated solely to meet the final domestic demand; the difference between the two terms is the value added generated directly and indirectly to meet GE. Now, if subtract total GE of the country s from DVA_s, we get residual of value added in GE from the country s:

$$RES_s = GE - DVA_s \quad (22)$$

4.3 Vertical Specialization (VS)

Hummels, Ishii, and Yi have initially introduced VS in 2001 (Hummel et al., 2001). It is a seminal article that has attracted many input-output practitioners and also international theory analysts[7]. It resembles the method of the factor contents introduced by Leontief more than seven decades ago. The

[6] See the Appendix for mathematical derivation.

[7] For example, see Koopman et al., (2012, 2014), Baldwin & Robert-Nicoud (2014), Bem, et. al. (2011), Dean et al., (2011).

key idea behind this is to conceptualize the terms of fragmentation, outsourcing, and/or slicing value-chains. The focus of this method is to trace countries increasingly link sequentially to produce goods caused by the imported intermediate goods. A country uses these goods to make goods or goods-in-process exported to another country (Hummels et al., 2001). Formally VS measures the imported intermediate goods content of GE of a country. For this purpose, Hummels et al. (2001) propose the following equation:

$$VS_s = iA_{rs}(I - A_{ss})^{-1}GE_s \quad (23)$$

where i is a 1×n vector of one, A_{rs} is the n×n imported coefficient matrix, and denote that how much intermediate inputs are required from the country r to produce one unit of gross output in the country s, GE_s is an n×1 vector of GE and $(I - A_{ss})^{-1}$ is the domestic multiplier matrix. Therefore, Equation (23) reflects the amount of imports directly and indirectly required to produce exported products. Equations (10) and (23) have a nice property so that their shares to total gross exports equal one, and therefore, there is an inverse relationship between the two. Now, if we divide both equations into total gross exports (TGE), we get the following equations:

$$\frac{VS_s}{TGE_s} = [i'A_{rs}(I - A_{ss})^{-1}\frac{GE_s}{TGE_s}] \times 100 \quad (24)$$

$$\frac{DVA_s}{TGE_s} + \frac{VS_s}{TGE_s} = 1 \quad (25)$$

and therefore,

$$\frac{DVA_s}{TGE_s} = 1 - \frac{VS_s}{TGE_s} \quad (26)$$

From Equation (26), we can discern two policy relevancies for the trading strategy in Iran. First, the equation can reveal the degree of participation in the country s in the world economy from both export and import sides.

Second, the World Bank has classified four groups of countries regarding their degree of participation in the global value chain. “Argentina, Ethiopia, and Indonesia are more engaged in simple manufacturing production chains, while the second group like Algeria, Chile, and Nigeria export commodity or raw material for further processing in other countries. Third, India and United States produce services that are being increasingly traded and embodied in manufacturing goods, and the fourth group mostly advanced countries and large emerging economies are producing innovative goods and services” (World Bank, 2020).

One of the distinctive features of the second group relative to other groups is that their shares of DVA to total gross exports ($\frac{DVA}{TGE}$) could considerably large with smaller shares of ($\frac{VS}{TGE}$), which suggests not only non-symmetric trade patterns of the resource-based economics, like Iran but also highlights that these economies are the beginning of the production chains.

5. Data Base and Empirical Analysis

The input-output tables in the constant price for 2001 and 2011, compiled by the Islamic Parliament Research Center of Iran, are used. Based on these tables, we first separate imports (including final and intermediate imports using the proportionality assumption (United Nations, 2018; Puzzello, 2012). Then aggregated them into 28 sectors, out of which 16 sectors are manufacturing sectors. Based on the above tables, we can decompose GE into two parts: DVA and RES for the years 2001 and 2011. Finally, the results at the macro level were given in Table 1.

Table 1. Decomposing of GE into DVA and VS and their Shares in 2001 and 2011

	2001		2011	
	Value (Billions of Iranian RLS) (1)	Share (%) (2)	Value(Billions of Iranian RLS) (3)	Share (%) (4)
GDP including GE	3,923,063	-	6,338,495	-
GE	1,362,449	34/73%(1)	1,814,561	28.63%(1)
DVA to GE	1,294,632	95.02%(2)	1,693,478	93.33%(2)
RES to GE	67,816	4.98%(2)	121,083	6.67%(2)

***Source**: The 2001 and 2011 IOTs of Iran and Authors Calculations*
***Notes**:*
(1) Share of GDP in each year
(2) Share of GE in each year

Table 1 consists of four columns. Columns (1) and (2) are the results of 2001, whereas the results of 2011 are presented in columns (3) and (4), respectively. From the table, the following observations can be made. First, we have already pointed out that the "Trade-in-Goods" theory predicts that GE can generate 100% value added, contrasted by the "Trade-in-Tasks" theory on account of double counting. For instance, from the figures, we observe that the share of actual GE to GDP for 2001 and 2011 are 34.73% and 28.63%, respectively. If we consider the shares of DVA, which are absorbed abroad to the actual GDP for 2001 and 2011, their corresponding shares are (1294632÷3923063=33.6%) for 2001 and (1693489÷6338495=26.73%) for 2011, which are less than the corresponding figures. Second, the size of GDP from 2001 to 2011 has almost doubled, which can be considered as the main factor for decreasing shares of GE to GDP, DVA to GE, and RES to GE in 2011 relative to 2001.

In the previous section (Equation 26), we observed that the share of DVA in TGE could reveal the functioning of the share of VS introduced by Hummels et al. (2001), which suggests that expressing both DVA and VS to TGE equals to one. Therefore, there is an inverse relationship between the two (Equation 26). Hence DVA in gross export could be considered as a good measure of the degree of a country's VS in trade pattern. Based on the calculated symmetric

input-output tables of 2001 and 2011, we have estimated the DVA and VS shares, and the results were given in Table 2.

Table 2. The Relationships between DVA and VS Shares in 2001 and 2011

	$\frac{DVA}{TGE}$	$\frac{VS}{TGE}$
2001	95.02%	4.98%
2011	93.33%	6.67%

***Source**: The 2001 and 2011 IOTs of Iran (25)*

Looking into the results of Table 2, we observe that there is an inverse relation between DVA share and VS share, which supports the theoretical observation of Los et al. (2016). Second, the shares of DVA to the total GE are 95.02% and 93.33% for 2001 and 2011. This means that for each one billion RLS of total GE, in 2001 and 2011, 0.95 and 0.93 billion RLS of DVA are absorbed foreign countries for further processing. These findings reveal the non-symmetric export pattern of the natural resource-based economy of Iran where upstream industries like crude oil and natural gas appear to a dominating sector. Third, based on an inverse relationship between the share of DVA and the share of VS, it is expected that high DVA shares lead to low VS shares. In this case, the results suggest that the VS shares for the concerned years are as low as 4.98% and 6.67%, respectively, which means that direct and indirect intermediate imported goods required to satisfy everyone's billion RLS of total GE are 0.0498 and 0.0667 billion RLS respectively. The above observations at least highlight one of the main features of the trade pattern of the resource-based economy of Iran with considerable high DVA shares follows by low VS shares. But the above analyses are at the macro level and therefore cannot capture the functioning at the sectoral level. In this article, we have calculated the DVA and VS shares for 28 sectors. The results were given in Table 3.

Table 3. The Sectoral Shares of GE, DVA, and VS in 2001 and 2011

	2001					2011				
	Share of GE/ TGE (1)	DVA		VS		Share of GE/ TGE (6)	DVA		VS	
		$\frac{DVA_i}{TGE}$ (2)	$\frac{DVA_i}{\sum_i DVA}$ (3)	$\frac{VS_i}{TGE}$ (4)	$\frac{VS_i}{\sum_i VS}$ (5)		$\frac{DVA_i}{TGE}$ (7)	$\frac{DVA_i}{\sum_i DVA}$ (8)	$\frac{VS_i}{TGE}$ (9)	$\frac{VS_i}{\sum_i VS}$ (10)
1. Farming and Gardening, Animal Husbandry, Raising Worms, Honey, Hunting, Forestry, Fishing	4.60%	3.96%	4.16%	0.24%	4.77%	3.66%	3.94%	4.22%	0.29%	4.37 %
2. Crude Oil and Natural Gas, Other Mining	67.29 %	69.15 %	72.78 %	0.27%	5.48%	56.31 %	55.00 %	58.94 %	0.07%	1.03 %
3. Manu. of Food Products and Beverages, Manu. of Tobacco Products	0.73%	0.24%	0.25%	0.20%	3.96%	2.53%	0.80%	0.85%	0.27%	4.02 %
4. Manu. of Textiles	2.93%	1.14%	1.20%	0.68%	13.75 %	1.22%	0.56%	0.60%	0.22%	3.24 %
5. Manu. of Wearing Apparel, Dressing, and Dyeing of Fur	0.21%	0.09%	0.10%	0.04%	0.88%	0.06%	0.03%	0.03%	0.02%	0.29 %
6. Tanning and Dressing of Leather, Luggage, Handbag, Saddles, Harness, and Foot Wear	0.42%	0.15%	0.15%	0.07%	1.33%	0.36%	0.15%	0.16%	0.04%	0.60 %
7. Manu. of Wood and Wood Products, Manu. of Paper and Paper Products, Publishing, Printing, and Reproduction of Recorded Media	0.05%	0.10%	0.10%	0.10%	2.07%	0.07%	0.11%	0.12%	0.21%	3.19 %
8. Manu. of Coke, Refined Petro. Products and Nuclear Fuel	6.40%	2.07%	2.17%	1%	20.12 %	5.21%	3.17%	3.40%	0.31%	4.72 %
9. Manu. of Chemical and Chemical Products	4.09%	2.52%	2.65%	1.41%	28.42 %	10.15 %	4.77%	5.12%	3.12%	46.74 %
10. Manu. of Rubber and Plastic Products	0.30%	0.23%	0.24%	0.12%	2.31%	0.84%	0.49%	0.53%	0.28%	4.25 %
11. Manu. of Other Non-Metallic Mineral Products	0.34%	0.24%	0.25%	0.02%	0.35%	1.56%	0.97%	1.04%	0.06%	0.83 %
12. Manu. of Basic Metals	1.38%	0.68%	0.72%	0.21%	4.31%	2.90%	1.39%	1.49%	0.79%	11.78 %
13. Manu. of Fabricated Metal Except Mach. and Equip.	0.35%	0.23%	0.24%	0.07%	1.33%	0.40%	0.30%	0.32%	0.06%	0.90 %

Table 3(Continued). The Sectoral Shares of GE, DVA, and VS in 2001 and 2011

	2001					2011				
	Share of GE/ TGE (1)	DVA		VS		Share of GE/ TGE (6)	DVA		VS	
		$\frac{DVA_i}{TGE}$ (2)	$\frac{DVA_i}{\sum_i DVA}$ (3)	$\frac{VS_i}{TGE}$ (4)	$\frac{VS_i}{\sum_i VS}$ (5)		$\frac{DVA_i}{TGE}$ (7)	$\frac{DVA_i}{\sum_i DVA}$ (8)	$\frac{VS_i}{TGE}$ (9)	$\frac{VS_i}{\sum_i VS}$ (10)
14. Manu. of Electrical Mach. Manu. of Office, Accounting and Computing Mach. And Operations, N.E.C.	0.09%	0.05%	0.05%	0.04%	0.78%	0.34%	0.16%	0.17%	0.09%	1.28 %
15. Manu. of Radio, Television and Communication Equip and Apparatus	0.04%	0.01%	0.01%	0.02%	0.43%	0.07%	0.05%	0.05%	0.05%	0.69 %
16. Manu. of Medical, Precision, and Optical Instruments, Watches and Clocks	0.02%	0.01%	0.01%	0.01%	0.22%	0.03%	0.02%	0.02%	0.02%	0.37 %
17. Manu. of Motor Vehicles, Trailer and Semi-Trailers, Manu. of Other Transport Equip	0.28%	0.12%	0.13%	0.11%	2.18%	0.37%	0.16%	0.18%	0.09%	1.39 %
18. Manu. of Furniture and Recycling	0.17%	0.11%	0.11%	0.14%	2.87%	1.62%	0.71%	0.77	0.21%	3.08 %
19. Electricity, Distribution of Gas, Water	0.47%	2.40%	2.53%	0.01%	0.11%	5.74%	7.61%	8.15%	0.00%	0.00 %
20. Construction	0%	0.09%	0.10%	0%	0.00%	0/00%	0.20%	0.21%	0.00%	0.00 %
21. Whole Sale, Retail Sale, Repairs of Motor Vehicles, Hotel, and Restaurants	4%	5.26%	5.53%	0.01%	0.26%	0.50%	3.69%	3.95%	0.13%	1.98 %
22. Transport, Storage and Communication	4.52%	3.98%	4.19%	0.18%	3.63%	3.18%	4.07%	4.36%	0.23%	3.38 %
23. Financial Inter Mediation	0.37%	0.92%	0.97%	0.01%	0.18%	0.18%	1.53%	1.64%	0.08%	1.13 %
24. Real Estate, Renting, and Business Services	0.35%	0.60%	0.63%	0.01%	0.13%	2.02%	2.56%	2.74%	0.03%	0.47 %
25. Public Sector, Defense, Social Security, and Urban Services	0.08%	0.12%	0.12%	0.00%	0.00%	0.23%	0.24%	0.26%	0.00%	0.04 %
26. Education	0.04%	0.06%	0.07%	0.00%	0.02%	0.19%	0.21%	0.23%	0.00%	0.04 %
27. Health and Social Work	0.01%	0.06%	0.06%	0.00%	0.00%	0.06%	0.11%	0.12%	0.00%	0.02 %
28. Other Services	0.49%	0.43%	0.46%	0.00%	0.09%	0.21%	0.30%	0.33%	0.00%	0.18 %

Table 3(Continued). The Sectoral Shares of GE, DVA, and VS in 2001 and 2011

	2001					2011				
	Share of GE/ TGE (1)	DVA		VS		Share of GE/ TGE (6)	DVA		VS	
		$\frac{DVA_i}{TGE}$ (2)	$\frac{DVA_i}{\sum_i DVA}$ (3)	$\frac{VS_i}{TGE}$ (4)	$\frac{VS_i}{\sum_i VS}$ (5)		$\frac{DVA_i}{TGE}$ (7)	$\frac{DVA_i}{\sum_i DVA}$ (8)	$\frac{VS_i}{TGE}$ (9)	$\frac{VS_i}{\sum_i VS}$ (10)
Sum	1	95.02 %	1	4.98%	1	1	93.33 %	1	6.67%	1

Table 3 contains ten columns. Columns 1 to 5 and columns 6 to 10 represent the sectoral shares of total GE, the sectoral shares of DVA to total GE, the sectoral shares of DVA to total DVA, the share of VS to total GE, and the share of sectoral shares to total VS for the years 2001 and 2011 respectively. From the results of Table 3, we can make the following observations:

One- The inverse relationships between DVA shares and VS shares hold true for 16 manufacturing sectors (sectors no.3 to 18 in Table 3), where the % shares of VS are larger than the corresponding figure of DVA for both the years under consideration. The manufacturing of Chemical and Chemical Products (sector 9) appears to have the largest differences. Its DVA and VS shares in 2001 are 2.65% and 28.42%, and the respective figures for 2011 decrease to 5.12% and 46.74%, which suggests that the sector is largely integrated with trade but generating less domestic value added in GE.

Second: The utility and service sectors show the opposite direction. Their shares of DVA in GE are larger than their shares of VS. One of the possible reasons is that the sectors are generally considered as national sectors and largely integrated with the domestic economy, and therefore, it is expected that they have larger shares of DVA than VS shares.

Third- The situation of Crude Oil, Natural Gas, and Other Mining (sector 2 in Table 4) is very interesting. This sector has more than 67% of total GE. Surprisingly, its share of DVA to gross export expressed is 69.15%, with a 5.48% VS share in 2001. The corresponding figures for 2011 are 56.3%, 55%, and roughly more than 1%, respectively. For this reason, we can present two possible reasons: One- in the development economy, this sector is known as the enclave sector, with very weak backward and forward linkage with the rest of the economy and therefore, one should expect that this sector should have relatively less share of DVA, but in fact, has the highest DVA share among the 28 sectors. The main reason is that this sector has the highest direct value added coefficients and the highest weight in total GE. Second, Los et al. (2016) observe that DVA in exports of intermediate (not DVA in GE) absorbed abroad could be considered a suitable measure for countries mainly operating in upstream parts of global production networks, such as natural resource exporters, the DVA in exports of intermediate goods will be large. This issue could be assessed more accurately if we could have used the WIOD.

6. Concluding Remarks

The article outlines two international trade theories; Traditional (Trade-in-Goods) and new theory (Trade-in-Tasks). The former emphasizes the factors of production to the final goods, ignoring the role of trade in intermediate goods. In contrast to that latter stresses the role of trade in intermediates focusing on the stage of the production process, which could be related to value added in exports. Trade-in-Goods predicts that exports can generate 100% value added, which is seriously debated by the new theories. One of these debates is referred to the existing conventional macro-economic accounting, which is expressed that expenditure components of final goods, including GE, equal to total value is consumed in each country. It means that a country's GDP is the sum of its final demand plus GE. Therefore, generating 100% value added in final domestic demand may hold true, but GE, due to accounts of double counting, may not generate 100% value added for the domestic economy due to the double counting. In this article, we take for the first time this issue as a starting point and try to decompose the GE of Iran into DVA in GE and residuals with the following two questions:

One: What amount of DVA should attribute to gross export in Iran?

Second: What is the relationship between DVA and VS? Concerning the above questions, we apply two methods: HEM and VS. Using the two input-output tables of Iran for the years 2001 and 2011 in the constant price of 2011, the overall findings suggest that:

One: GE has decomposed into DVA, and residual value added. The share of residual in gross export in 2001 is 4.98%, up to 6.67% in 2011, taken as gross double counting of value added in GE and hence an overestimation of GE of the country. This finding contrasts to the "Trade-in-Goods" theory which predicts that exports can generate 100% value and vindicates the "Trade-in-Tasks."

Second: there is an inverse relationship between DVA and VS shares for both years. This finding supports the theoretical observations made by Lost et al. (2016).

Third: At the sectoral level, the results show that the inverse relationship between DVA and VS shares holds true for 16 manufacturing sectors; the opposite trend is found for all service sectors.

Decreasing DVA share over time, down from about 95% in 2001 to around 93% in 2011, implies significant double counting in GE now than in the past. Indeed, the growing importance of the global supply chain leads to significant double counting. In addition, the ratio of DVA to GE is lower for manufacturing than services trade. Two reasons can be presented to illustrate this observation. First GE of manufacturing firms includes value added from the services sector because manufacturing companies purchase services as inputs. Second, manufacturing sectors have a higher degree of VS than services, which pushes down the share of DVA in GE relative to other sectors. These findings are exactly in line with the results of foreign studies and useful for designing appropriate trade policy. Trade policy is typically conducted using instruments

levied on gross trade, like tariffs, and studies such as the present paper can be useful to understand better how trade policy induces changes in value added trade and hence factor income and welfare.

From the above results, two potential suggestions can be made for further investigations: integration of input-output table of Iran with WIOD and more investigation of residual value added at sectoral level.

Author Contributions

Supervision: A.A.B. Conceptualization, methodology, validation, formal analysis, resources, writing—original draft preparation, writing—review and editing: all authors.

Funding

This research received no external funding.

Conflicts of Interest

The authors declare no conflict of interest.

Data Availability Statement

The data used in the study were taken from https://rc.majlis.ir/fa/report/show/1049215 (accessed on: 04 March 2018).

Acknowledgements

Not applicable.

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Appendix

The below equations prove that how DVA can be computed from the national input-output tables. However, first, Leontief's world balancing equation is expressed as follows:

$$x_w = (I - A_w)^{-1} y_w \quad (1)$$

where x_w, $(I - A_w)^{-1}, and\ y_w$ are gross world output, world production multiplier, and final world demand, respectively.

With the estimation of world direct value added coefficient $v_w = \frac{V_w}{x_w} \Longrightarrow V_w = v_w . x_w$ and then substituting in Equation (1), we can get the new equation:

$$V_w = v_w (I - A_w)^{-1} y_w \quad (2)$$

The matrix $v_w (I - A_w)^{-1}$ is known as the world value added multiplier, V_w and y_w indicate the world income (GDP_w) and world expenditure (GDP_w).

Considering only the two countries s and r, Equation (2) can be partitioned as follows:

$$[V_s \quad V_r] = [v_s \quad v_r] \begin{bmatrix} (I - A_{ss})^{-1} & (I - A_{ss})^{-1} A_{sr} (I - A_{rr})^{-1} \\ (I - A_{rr})^{-1} A_{rs} (I - A_{ss})^{-1} & (I - A_{rr})^{-1} \end{bmatrix} \begin{bmatrix} y_{ss} & y_{sr} \\ y_{rs} & y_{rr} \end{bmatrix} \quad (3)$$

Equation (3) can be used for the GDP estimation of the country s and the country r before extraction. If we assume that $v_s = 0$, then GDP for s can be derived as:

$$[V_s \quad V_r] = [v_s \quad 0] \begin{bmatrix} (I - A_{ss})^{-1} & (I - A_{ss})^{-1} A_{sr} (I - A_{rr})^{-1} \\ (I - A_{rr})^{-1} A_{rs} (I - A_{ss})^{-1} & (I - A_{rr})^{-1} \end{bmatrix} \begin{bmatrix} y_{ss} & y_{sr} \\ y_{rs} & y_{rr} \end{bmatrix}$$

$$[V_s \quad V_r] = [v_s (I - A_{ss})^{-1} + (0)(I - A_{rr})^{-1} A_{rs} (I - A_{ss})^{-1} \quad v_s (I - A_{ss})^{-1} A_{sr} (I - A_{rr})^{-1}] + (0)(I - A_{rr})^{-1}] \begin{bmatrix} y_{ss} & y_{sr} \\ y_{rs} & y_{rr} \end{bmatrix} \quad (4)$$

With further matrix multiplication of Equation (4), we can arrive at the following equation for the country s before extraction. Where GDP_s , $\tilde{v}_s$ and y_{ss} are the original GDP, sectoral value added coefficients, and final demand of countries:

$$GDP_s = \tilde{v}_s (I - A_{ss})^{-1} y_i \quad (5)$$

Now, if we nullify the gross exports comprising intermediate exports and final exports of the country s, new GDP^* of the country s is estimated as follows:

$$[V_s^* \quad V_r^*] = [\tilde{v}_s \quad 0] \begin{bmatrix} (I - A_{ss})^{-1} & 0 \\ (I - A_{rr})^{-1} A_{rs} (I - A_{ss})^{-1} & (I - A_{rr})^{-1} \end{bmatrix} \begin{bmatrix} y_{ss} & 0 \\ y_{rs} & y_{rr} \end{bmatrix} \quad (6)$$

Where $A^* = \begin{bmatrix} A_{ss} & 0 \\ A_{rs} & A_{rr} \end{bmatrix}, y_i^* = \begin{bmatrix} y_{ss} & 0 \\ y_{rs} & y_{rr} \end{bmatrix} \begin{bmatrix} 1 \\ 1 \end{bmatrix}$

With matrix multiplication of Equation (6), we get the new GDP^* of the country s after nullifying intermediate and final exports from the country s to the country r.

Now, if we take the difference between the real GDP_s and the new GDP_s^*, the DVA_s is obtained from the following equation:

$$DVA_s = GDP_s - GDP_s^* \quad (7)$$

Which is the same as Equation (21).