Journal of Money and Economy
Vol. 18, No. 3, Summer 2023
pp. 307-329
DOI: 10.61186/jme.18.60.307

Original Research Article

Upstreamness and Downstreamness Economic Activities of Iran in the Global Value Chain

Esfandiar Jahangard*

Received: 04 Feb 2024 Approved: 04 Aug 2024

This paper focuses on the fragmentation of the production stages in a related production process. Comparing alternative technologies that produce similar goods, one with fewer production stages and the other with a greater number requires a holistic perspective for the entire production sequence. What matters is not only the strength of production links but also the length of the links, determined by the number of production stages. In this study, we use the 2016 Inter-Country Input-Output (ICIO) table with a focus on the Iranian economy, covering 42 activities and 68 countries and Rest of the World. To achieve this, we concentrate on the global output supply chain and input demand chains, specifically considering Iran. We use the output upstreamness (OU) measure and input downstreamness (ID) measure to quantitatively determine the relative positions of Iran's economic activities along the global output supply chain and input demand chain, respectively. This study provides insights into countries with the highest and lowest (OU) and (ID) indicators, relating them respectively to industrial and agricultural activities. These indicators illustrate that Iran's role as a major supplier of natural resources, particularly in activities such as oil and natural gas extraction, is well explained.

Keywords: Upstreamness Measure, Downstreamness Measure, Global Value Chain, Iran
JEL Classification: F14, D57

1 Introduction

Quoting from Ricardo's famous example, *"countries no longer exchange clothes for wine"*. Instead, global production is now structured within global value chains (GVCs), where companies source components, parts, or services from producers in multiple countries and, in turn, sell their products to companies and consumers worldwide.

* Faculty of Economics, Allameh Tabataba'i University, Tehran, Iran;
Email:Jahangard@atu.ac.ir (Corresponding Author)

[DOI: 10.61186/jme.18.60.307]

With the significant transformation of the international production organization, the emergence of GVCs has placed the specialization of countries in GVCs at the center of attention. Hence, questions arise, such as: Where do different countries specialize in GVCs? What are the determinants of a country's position in GVCs? Although definitive answers to these questions are still lacking, recent works in international trade, with the development of metrics related to the positions of countries and activities in GVCs, have contributed to our understanding. This progress, coupled with the use of input-output techniques by trade economists, has increased the interest in global inter-industry linkages. In fact, a significant facilitator in the proliferation of literature on GVC positioning has been the construction and availability of extensive global input-output tables, providing an accurate depiction of interactivity between activities within and between countries.

With this description, this paper contributes to the literature on GVCs in Iran in four ways. First, we provide a brief overview of various developments in the literature to depict upstream or downstream positions of activities and countries in GVCs. Second, we utilize data from the Inter-Country Input-Output database with Iran's inclusion in 2016, prepared by Jahangard et al. (2023a) and supported by Iran Chamber of Commerce Research Center, to document the empirical evolution of these metrics. Third, we build on a theoretical framework based on Caliendo and Parro (2015), Fally (2012), and Antra`s and Chor (2018), providing a structural interpretation of all elements of the ICIO for a specific year in Iran.

We initially consider a measure of the upstream of a production activity from national demand, independently developed by Fally (2012) and Antra`s and Chor (2013), later integrated by Antra`s et al. (2012). This measure (denoted as U or OU) collects information about the extent to which the production of goods from a specific activity in a particular country is directly sold to domestic consumers or disproportionately sold to other activities that, in turn, sell relatively less to final consumers. The second relevant measure, initially proposed by Fally (2012), represents the downstream of a specific activity from the primary factors of production in the economy (or value-added resources). According to this measure (denoted as D or ID), an activity in a specific country seems downstream when its production process uses less value-added compared to intermediate inputs, especially when it acquires intermediate inputs from activities that heavily use intermediate inputs themselves.

Furthermore, we discuss simpler versions of these two GVC positioning measures: the first measure, as measured by Antra`s et al. (2012), simply

[DOI: 10.61186/jme.18.60.307]

reduces the country-activity share of production directly sold to final consumers, while the second measure, as measured by Fally (2012), reduces the distance from value-added share to the country-activity share, which relates to payments to country-activities that come with payments to primary factors.

With this framework, the article is structured as follows: first, a review of the relevant literature; next, an overview of the research methodology and model; then, a discussion of the data and information utilized; followed by the model implementation and empirical results; and finally, a summary and conclusion.

2 Literature

Notably, production has experienced increased dispersion across countries in recent years, accompanied by a substantial surge in the trade of intermediate goods. However, there is a lack of comprehensive quantitative information regarding the fragmentation of production at the level of domestic factories. This raises several questions, including the average length of production chains and whether production is more dispersed than in previous decades.

The stages of production and the number of consecutively involved factories in production chains, referred to as vertical fragmentation, play a crucial role in various trade and economic phenomena. Reduced transaction costs enhance trade benefits when production is fragmented, leading to lower prices for imported goods for consumers and cost reduction for producers importing intermediate inputs at lower prices. Vertical linkages and the potential for fragmented production also contribute significantly to profits from agglomeration, as argued by Marshall. Economic development traditionally emphasizes the role of vertical linkages, as discussed in the O-ring theory by Kremer (1993).

The conventional input-output approach to analyzing production networks typically focuses on cohesion or the strength of connections between related activities. The concept of the "length" of production linkages, introduced by the input-output model calculating the average length of propagation, has been applied by Dietzenbacher et al., (2005). This model indicates the average number of production stages, measuring the fragmentation of an activity. Dietzenbacher and Romero (2007) applied this model to analyze inter-country linkages in the economies of large European countries using multi-country input-output tables in 1985.

Fally (2012) developed a model for measuring fragmentation based on a philosophy similar to the average length of propagation model, focusing on

[DOI: 10.61186/jme.18.60.307]

the average number of production stages leading to final consumption. De Backer and Miroudot (2012) later applied the Fally model to inter-country input-output tables of the OECD, covering 56 countries for the years 1995, 2000, and 2005.

The "length" model in GVCs is utilized to identify the relative positions of countries or activities in the global production system. If a country's production chains involve products with longer final product chains compared to those representing primary products, the country operates in a relatively upstream position. Conversely, shorter final product chains indicate a relatively downstream position. The average length of propagation can be measured in both the forward (cost-push) and backward (demand-pull) directions, helping identify a country's relative position in global production networks.

Fally's (2012) findings indicate a decline in the number of production steps over time, but the bulk of this decline occurred before the explosion in GVC activity. Ongoing reviews suggest an increase in the number of production steps over a more recent period, consistent with findings from other studies. The primary measure of dispersion, representing the weighted average of value added, may find potential explanations for changes in this measure through shifts in the relative prices of intermediate goods compared to final goods. Notably, fluctuations in oil prices might elucidate short-term variations in fragmentation by accentuating the weight applied in the early stages. However, in the long run, it suggests that alterations in the relative prices of goods and intermediate goods do not account for the overall observed decline.

In recent decades, intermediary trade has gained significance as countries worldwide have become more open, introducing new questions and opportunities to elucidate economic phenomena. Jones (2011) demonstrates that incorporating interfirm linkages through intermediate goods in standard neoclassical growth models significantly enhances our understanding of the substantial income differences observed across countries. The literature on trade in intermediate goods has expanded rapidly, addressing theoretical and empirical importance.

Several crucial issues underscore the theoretical and/or empirical importance of this concept. For instance, Alfaro and Charlton (2009) find that multinational companies decide to have close production stages. Antra`s and Chor develop a property rights model, where a firm decides whether to outsource inputs or produce them internally within its scope, confirming their theory empirically. This model recognizes that the position of a company is determined in the production line. The business cycle literature also explores

[DOI: 10.61186/jme.18.60.307]

the transmission of shocks through production chains, emphasizing the quantification of the position of the production line of activities, considering activities selling their outputs to other activities and final consumers.

3 Methodology and Model

In the realm of international trade literature, several criteria have been devised to position countries and activities within GVCs. With the aid of global input-output tables, it is now feasible to calculate the upstream or downstream linkages of activities and specific countries. This approach examines the extent to which a country-activity pairs sells its final product for global consumption or, conversely, sells intermediate inputs to other production activities worldwide. Notably, an activity that predominantly sells directly to final consumers is considered downstream in the value chains, whereas an activity with relatively low sales to final consumers is likely to be upstream in the value chains.

This paper aims to compute four GVC positioning criteria for the Iranian economy, leveraging widely recognized indicators from the literature, along with simplified versions recently proposed by Antra`s and Chor (2018). The first two criteria are well-established, while the other two are simplified adaptations.

The first indicator assesses the distance or upstream position of an output activity from final demand, as developed by Fally (2012), Antràs et al. (2012), and Antràs and Chor (2013). The Fally model, along with variations by Antràs et al. (2012), visualizes the average number of production stages by anchoring the endpoint of the sequence at final consumption. This effectively measures the distance to final demand along the production path. Referred to as criterion U in Antràs and Chor (2018), it collects information about the extent to which "an activity in a specific country produces goods directly sold to final consumers or sold to other activities that, in turn, disproportionately sell to final consumers." Thus, a relatively upstream activity is one that sells a small share of its production to final consumers and, instead, sells proportionally to other activities that themselves have relatively low sales to final consumers.

These steps enable the identification of the relative position of countries (or activities) in the global production system. If a country's value chains lean towards longer final product sequences compared to those producing raw materials, the country is relatively upstream (and vice versa). The second criterion, originally proposed by Fally (2012), assesses the distance or downstream position of a specific production activity from primary factors of production (or value-added). Labeled as criterion D, it designates an activity

[DOI: 10.61186/jme.18.60.307]

as downstream if its production process involves a greater use of intermediate inputs.

Fally (2012) demonstrated the calculation of the length of production chains from input-output tables. Importantly, this measure calculates the length of linear chains and is not applicable to spider web-like chains. It gauges the average number of consecutive production stages and is not suitable for parallel production stages. According to Fally's definition, the average number of stages embedded in a product depends on the number of stages embedded in each intermediate good. If no intermediate good is used in production, the chain length becomes one; otherwise, it depends on the relative importance of intermediate goods in each production stage. This indicator is constructed based on the weighted average importance (value-added share) of production stages.

Conversely, using primary factors of production, if an activity is disproportionately dependent on the value-added of primary factors, it is considered relatively upstream. Additionally, simpler versions of these two GVC positioning criteria are also calculated. The first case, labeled as F/GO, measures the share of a country's activity in production that is directly sold to final consumers. A lower value of this ratio corresponds to a higher upstream. The second case ($\frac{VA}{GO}$) reduces Fally's (2012) measurement of distance from value-added to the share of payments by a country-activity calculated using payments to primary factors. Large values of this measure are associated with less downstream or more upstream.

In this regard, Miller and Temurshoev (2015) argue that it is not only the supply chain that matters but also the demand chain of input firms, providing a complete picture of the entire production process. They emphasize the importance of distinguishing between supply and demand chains, stating that at the activity level, these two chains are not equivalent. For a producer (activity), the structure of the supply chain is generally different from the structure of input purchases. There is substantial literature on activity clusters. For example, Porter (1990) and Ellison and Glaeser (1997) state that related activities tend to agglomerate and focus on the " agglomeration economies," analyzing mechanisms that drive companies and employees to locate geographically. One of them is the mechanism of sharing input, which is particularly important.

This research considers the overall perspective of the value chain, including indirect input demand linkages and the role of households,

[DOI: 10.61186/jme.18.60.307]

governments, and investors (HGI) in the Iranian economy. The production line position of an activity is ultimately considered with respect to HGI.

The ID criterion presented here is mathematically precisely the same as Fally (2012) concerning the "average number of production stages in each product" or the "average weight of factories sequentially involved in producing a specific commodity." It is worth noting that the foundation presented by Fally (2012) for both criteria, OU and ID, is entirely distinct from the formula/interpretation of the OU index proposed by Antra`s et al. (2012) and the ID criterion presented. Specifically, Fally (2012) employs recursive formulas that will be discussed further.

In Table 1, according to Miller and Temurshoev (2015), we have outlined the main reasons why an activity has large or small values of the OU/ID metrics. For example, an activity with a large OU should: (a) have a large share of intermediate production in its gross output, and (b) have numerous strong and continuous linkages in the supply chain of intermediate inputs with similar activities. The second reason explains why the direct share of intermediate value in gross output cannot be used to determine the OU quantity of activity i; instead, according to recent literature, calculating the OU index fully captures the complexity and overall size of the entire supply network of activity i.

Table 1
Interpretation of the OU and ID Measures

	Output upstreamness (OU) measure, ui	**Input downstreamness (ID) measure, di**
Large	(a) Large (small) share of intermediate output (final demand) in gross output and (b) complex [direct, indirect] and strong intermediate output supply links with similar sectors	(a) Large (small) share of intermediate input (value added) in gross input and (b) complex [direct, indirect] and strong intermediate input demand links with similar sectors
Small	(a) Small (large) share of intermediate output (final demand) in gross output and (b) simple and weak intermediate output supply links with similar sectors	(a) Small (large) share of intermediate input (value added) in gross input and (b) simple and weak intermediate input demand links with similar sectors

Source: Miller and Temurshoev (2015)

Extracting OU and ID in the ICIO table between countries elucidates the position of activities/countries along the global supply chain and global input

[DOI: 10.61186/jme.18.60.307]

demand chain, both representing global production characteristics. Using a summary measure of OU and a summary measure of ID can be useful for observing the average relative position development of activities (or countries) over time with respect to HGI, the weighted averages of which are calculated for countries in this article.

In this study, we initially consider a traditional International Input-Output framework with s=1, 2..., G countries, r=1,2, 3…, G partner countries, and i=1, 2…. N sectors. In this framework, Z represents the matrix of intermediate inputs with dimensions ($GN * GN$), FD is the matrix of final demand ($NG * G$), VA is the value-added matrix ($1 * NG$), and Y is the output matrix ($NG * 1$).

According to Antra`s et al. (2012) and Antra`s and Chor (2018), we calculate our GVC indicators. As mentioned, to measure the upstream activity, we adopt two methods. The first one is measuring $\frac{F}{GO}$: ${FD_i^r}/{Y_i^r}$, which simply represents the share of gross output (GO)in activity *r* in country *i* that is sold to final consumers (FD). The other one is the index U_i^r introduced by Antra`s and Chor (2013), which is used as the second indicator.

$$Y_i^r = \sum_{s=1}^{S}\sum_{j=1}^{J} Z_{ij}^{rs} + \sum_{j=1}^{J} FD_{ij}^{r} = \sum_{s=1}^{S}\sum_{j=1}^{J} a_{ij}^{rs}\, Y_j^s + FD_i^r$$

that

$$a_{ij}^{rs} = z_{ij}^{rs}/Y_j^s$$

The value of the production of activity *r* from country *i* required to produce one dollar of the production of activity *S* in country *j*.

$$Y_i^r = FD_i^r + \sum_{s=1}^{S}\sum_{j=1}^{J} a_{ij}^{rs}\, FD_j^s + \sum_{s=1}^{J}\sum_{j=1}^{J}\sum_{t=1}^{S}\sum_{k=1}^{J} a_{ij}^{rs}\, a_{jk}^{st}\, FD_k^t + \cdots$$

Therefore, the index U_i^r can be obtained as follows:

$$U_i^r = 1 * \frac{FD_i^r}{Y_i^r} + 2 * \frac{\sum_{s=1}^{S}\sum_{j=1}^{J} FD_j^r}{Y_i^r} + 3 * \frac{\sum_{s=1}^{J}\sum_{j=1}^{J}\sum_{t=1}^{S}\sum_{k=1}^{J} a_{ij}^{rs} a_{jk}^{st} FD_k^t}{Y_i^r} + \cdots$$

Calculating a series of infinite powers is unnecessary, as to calculate the vector J·S with the upper-level value of 1, it is sufficient:

[DOI: 10.61186/jme.18.60.307]

$$U = [I - A]^{-2} FD_i^r \oslash [I - A]^{-1} FD_i^r$$

Where A is a matrix formed by a_{ij}^{rs} and $\oslash$ refers to an element-wise division. Two criteria have also been used for downstream activities. The first one measures VA/GO, calculated as VA_j^s / Y_j^s, as it represents the share of value added (VA) over the total inputs (GO). The second one, D_j^s, is calculated as:

$$Y_i^r = \sum_{r=1}^{S} \sum_{i=1}^{J} Z_{ij}^{rs} + VA_j^s = \sum_{r=1}^{S} \sum_{i=1}^{J} b_{ij}^{rs} Y_i^r + VA_j^s$$

that

$$b_{ij}^{rs} = z_{ij}^{rs} / Y_i^r$$

The share of output of activity r in country i that is used in activity S in country j can be represented as:

$$Y_j^s = VA_j^s + \sum_{r=1}^{S} \sum_{i=1}^{J} b_{ij}^{rs} VA_i^r + \sum_{r=1}^{J} \sum_{i=1}^{J} \sum_{t=1}^{S} \sum_{k=1}^{J} b_{ij}^{rs} b_{ki}^{tr} VA_k^t + \cdots$$

$$D_j^s = 1 * \frac{VA_j^s}{Y_j^s} + 2 * \frac{\sum_{r=1}^{S} \sum_{i=1}^{J} VA_i^s}{Y_j^s} + 3 * \frac{\sum_{r=1}^{J} \sum_{i=1}^{J} \sum_{t=1}^{S} \sum_{k=1}^{J} b_{ki}^{rt} b_{ij}^{rs} VA_k^t}{Y_j^s} + \cdots$$

Calculating a series of infinite powers is unnecessary, as to calculate the vector J·S with the upper-level value of 1, it is sufficient:

$$D = [I - B]^{-2} VA_j^s \oslash [I - B]^{-1} VA_j^s$$

Where B is a matrix formed by b_{ij}^{rs} and $\oslash$ refers to an element-wise division.

4 Data

In this paper, to operationalize this topic in Iran, Jahangard et al. (2023b), with the support of the Research Center of the Chamber of Commerce, Industries, Agriculture and Mines of Iran, added the national IO table for the year 2016 compiled by the Central Bank of Iran to the ICIO table. They incorporated the national IO table for the year 2016, compiled by the Central Bank of Iran, into the ICIO table. This comprehensive approach involved a dataset featuring 42 activities and 68 countries (see Appendix Table A1 and A2), measured in million dollars. In the ICIO table for 2016, Iran's economy is categorized among the rest of the world countries, with the study integrating data for the year 2016 according to the Iranian Central Bank. Therefore, the ICIO table

[DOI: 10.61186/jme.18.60.307]

represents a global economy with 67 countries (J), including a category named "Rest of the World," and 42 activities (S).

The final demand in this context includes household consumption, non-profit institutions serving households, government consumption, gross fixed capital formation, and changes in inventories. The Value-Added matrix illustrates the value added for primary factors employed in the production of activities in each country. Iran has been seamlessly integrated into an extensive database of international production and consumption, capturing all value-added flows. This ICIO table surpasses the scope of national IO tables, providing a detailed account of the origin and destination of all exchange flows based on activity, along with each intermediate or final use for these flows.

According to the ICIO table, Iran's economy in 2016 showcased approximately $460.5 billion in gross value added, $752.4 billion in output, $97.3 billion in gross exports (comprising $13.1 billion as final exports and $84.2 billion as intermediate exports), and $86.1 billion in imports (with $42.5 billion as final imports and $43.5 billion as intermediate imports). The data are presented at base prices and assumes a fixed structure for selling the produced products.

5 Empirical Results and Discussion

The empirical results based on the data set between countries in 2016, including Iran and following the methodology mentioned earlier, indicate that Cambodia, Morocco, Greece, Costa Rica, Mexico, Tunisia, Croatia, the United States, Argentina, and Peru, alongside Iran, have the highest values of F/GO globally. In other words, Iran, along with these countries, has a higher ratio of final demand to gross output compared to other countries. F/GO, according to Antra`s et al. (2012), represents the share of a country's production that is directly sold to final consumers. A lower value of this ratio is associated with a higher upstream use. This indicates that Iran is among the countries globally where a significant portion of its products reaches final demand. Additionally, in terms of the VA/GO index, Iran, alongside Saudi Arabia, Kazakhstan, Peru, Costa Rica, and Morocco, falls into the category of countries with a high VA/GO index (Table 2).

[DOI: 10.61186/jme.18.60.307]

Table 2
Final Demand and Value Added to Output by Country in 2016

Code	F/GO	VA/GO	Code	F/GO	VA/GO
AUS	۰/۴۸۸	۰/۴۹۹	CHE	۰/۴۹۸	۰/۴۹۴
AUT	۰/۵۰۵	۰/۴۹۲	TUR	۰/۵۲۴	۰/۴۶۸
BEL	۰/۴۷۰	۰/۴۴۲	GBR	۰/۵۵۶	۰/۵۲۷
CAN	۰/۵۴۶	۰/۵۳۲	USA	۰/۵۷۳	۰/۵۶۱
CHL	۰/۴۹۶	۰/۵۳۲	ARG	۰/۵۶۷	۰/۵۲۹
COL	۰/۵۳۵	۰/۵۰۹	BRA	۰/۵۵۳	۰/۵۱۴
CRI	۰/۵۹۸	۰/۵۶۷	BRN	۰/۴۱۷	۰/۵۳۸
CZE	۰/۴۴۰	۰/۳۹۵	BGR	۰/۴۷۴	۰/۴۳۱
DNK	۰/۵۴۵	۰/۵۰۵	KHM	۰/۶۳۰	۰/۵۳۸
EST	۰/۴۸۱	۰/۴۴۰	CHN	۰/۳۷۸	۰/۳۵۰
FIN	۰/۵۱۳	۰/۴۷۴	BGR	۰/۵۸۴	۰/۴۸۶
FRA	۰/۵۵۰	۰/۵۱۳	KHM	۰/۴۹۹	۰/۴۶۲
DEU	۰/۵۰۵	۰/۵۰۳	CHN	۰/۵۴۷	۰/۴۹۸
GRC	۰/۶۰۷	۰/۵۶۰	IDN	۰/۵۲۹	۰/۵۲۴
HUN	۰/۵۰۴	۰/۴۲۵	HKG	۰/۴۹۴	۰/۴۸۷
ISL	۰/۵۳۸	۰/۴۹۵	KAZ	۰/۴۹۳	۰/۵۹۳
IRL	۰/۴۷۳	۰/۴۴۷	LAO	۰/۴۵۶	۰/۴۳۰
ISR	۰/۵۹۸	۰/۵۷۰	MYS	۰/۴۰۸	۰/۴۰۰
ITA	۰/۵۱۱	۰/۴۸۲	MLT	۰/۴۷۰	۰/۳۱۵
JPN	۰/۵۵۴	۰/۵۳۶	MAR	۰/۶۲۹	۰/۵۶۳
KOR	۰/۴۳۹	۰/۴۱۸	MMR	۰/۴۵۲	۰/۴۲۵
LVA	۰/۴۸۵	۰/۴۷۶	PER	۰/۵۶۵	۰/۵۸۴
LTU	۰/۵۴۶	۰/۵۲۶	PHL	۰/۵۱۸	۰/۴۹۲
LUX	۰/۳۱۳	۰/۲۵۳	ROU	۰/۵۰۵	۰/۴۶۹
MEX	۰/۵۹۳	۰/۵۶۰	RUS	۰/۴۷۹	۰/۵۰۲
NLD	۰/۴۸۶	۰/۴۶۶	SAU	۰/۵۵۷	۰/۶۷۰
NZL	۰/۵۰۰	۰/۴۷۹	SGP	۰/۳۹۲	۰/۳۸۰
NOR	۰/۵۱۳	۰/۵۲۸	ZAF	۰/۴۷۸	۰/۴۵۷
POL	۰/۴۷۵	۰/۴۴۲	TWN	۰/۴۴۵	۰/۴۶۷
PRT	۰/۵۵۱	۰/۴۹۸	THA	۰/۴۶۲	۰/۴۰۸
SVK	۰/۴۵۰	۰/۳۹۱	TUN	۰/۵۹۱	۰/۵۳۵
SVN	۰/۴۸۸	۰/۴۶۵	VNM	۰/۳۷۶	۰/۲۸۰
ESP	۰/۵۴۵	۰/۵۱۷	IRN	۰/۵۵۸	۰/۶۱۰
SWE	0.532	0.513	ROW	0.551	0.559

Source: Calculations based on the ICIO table for the year 2016, with added Iran

Based on the provided information, it can be summarized for Iran as follows: F/GO values are highest in sectors such as Water transport, Accommodation and food service activities, Motor vehicles, trailers and semi-trailers, Air transport, Fishing, aquaculture, Real estate, Construction, Public administration and defense, compulsory social security, Education Human health and social work activities.

[DOI: 10.61186/jme.18.60.307]

VA/GO values peak in activities related to the Mining and quarrying, non-energy producing products and Mining support service activities, Postal and courier services, Warehousing, support activities for transportation, Real estate, and Mining and quarrying, energy producing products.

OU values are particularly high (around 3) for activities like the Mining and quarrying, energy producing products, Paper products and printing, Coke and refined petroleum products, Chemical and chemical products, Basic metals, Computer, electronic and optical equipment, Electricity, gas, steam and air conditioning supply, financial services and insurance activities, Administrative, and support services.

This analysis underscores the diversity of Iran's economic activities, with oil and mining sectors playing pivotal roles in shaping the $\frac{F}{GO}$ and VA/GO indices.

Our analysis indicates that approximately twelve activities out of the 42 specified activities in the provided table have the lowest (OU) in Iran's economy. These activities include Agriculture, hunting, forestry, Fishing and aquaculture, Machinery and equipment, nec[1], Production of motor vehicles, trailers, and semi-trailers, Motor vehicles, trailers and semi-trailers, Construction, Accommodation and food service activities, Air transport, Real estate activities, public administration and defense; compulsory social security, Education and Human health and social work activities. In other words, these activities have a smaller (or larger) share of the final demand in gross value added in the global value chain, and they also have simple and weak linkages in the supply chain with similar global economic activities (Table 3).

Table 3

Average Economic Activity Results for Iran Based on OU and ID.

OU/ID	NO	Activities
OU≅3	10	Mining and quarrying, energy producing products
		Mining and quarrying, non-energy producing products and Mining support service activities
		Paper products and printing
		Coke and refined petroleum products
		Chemical and chemical products
		Basic metals
		Computer, electronic and optical equipment
		Electricity, gas, steam and air conditioning supply

[1] not elsewhere classified

[DOI: 10.61186/jme.18.60.307]

		Financial and insurance activities Administrative and support services.
OU≅2	20	Food products, beverages and tobacco Textiles, textile products, leather and footwear Wood and products of wood and cork Pharmaceuticals, medicinal chemical and botanical products Rubber and plastics products Other non-metallic mineral products Fabricated metal products Electrical equipment Other transport equipment Water supply; sewerage, waste management and remediation activities Wholesale and retail trade; repair of motor vehicles Land transport and transport via pipelines Water transport Warehousing and support activities for transportation Postal and courier activities Publishing, audiovisual and broadcasting activities and IT and other information services Telecommunications Professional, scientific, and technical activities Arts, entertainment, and recreation Other service activities and Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use
OU≅1	12	Agriculture, hunting, forestry Fishing and aquaculture Machinery and equipment, nec Production of motor vehicles, trailers, and semi-trailers Motor vehicles, trailers and semi-trailers Construction Accommodation and food service activities Air transport Real estate activities Public administration and defense; compulsory social security Education Human health and social work activities
ID≅3	3	Rubber and plastics products Electrical equipment Motor vehicles, trailers and semi-trailers
ID≅2	29	Agriculture, hunting, forestry Fishing and aquaculture Food products, beverages and tobacco Textiles, textile products, leather and footwear Wood and products of wood and cork Paper products and printing Coke and refined petroleum products

[DOI: 10.61186/jme.18.60.307]

		Chemical and chemical products Pharmaceutical and medicinal product manufacturing Other non-metallic mineral products Basic metal Fabricated metal products Computer, electronic and optical equipment Machinery and equipment, nec Other transport equipment Manufacturing nec; repair and installation of machinery and equipment Electricity, gas, steam and air conditioning supply Water supply; sewerage, waste management and remediation activities Construction Land transport and transport via pipelines Water transport Air transport Accommodation and food service activities Publishing, audiovisual and broadcasting activities and IT and other information services Telecommunications Financial services and insurance activities Administrative and support services Arts, entertainment, and recreation Public administration and defense; compulsory social security Other service activities and Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use
ID≅1	9	Mining and quarrying, energy producing products Mining and quarrying, non-energy producing products and Mining support service activities Wholesale and retail trade; repair of motor vehicles Warehousing and support activities for transportation Postal and courier activities Professional, scientific, and technical activities Education Human health and social work activities Real estate activities

Source: Calculations based on the ICIO table for the year 2016, with added Iran.

From the perspective of the position in the global value chain of ID, three economic activities in Iran, namely the Rubber and plastic products, the Electrical equipment, and Motor vehicles, trailers, and semi-trailers, have an ID close to 3, indicating the highest score in this index. This implies that these activities have a significant (or smaller) intermediate input share (value added) in the gross value added and complex linkages (both direct and indirect) with the strong demand for intermediate inputs in similar activities globally. Following this, about nine economic activities in Iran also have the lowest ID,

[DOI: 10.61186/jme.18.60.307]

including the Mining and quarrying, energy producing products, Mining and quarrying, non-energy producing products and Mining support service activities, Wholesale and retail trade; repair of motor vehicles, Warehousing and support activities for transportation, Postal and courier activities, Professional, scientific, and technical activities, Education, Human health and social work activities, Real estate activities. These mentioned activities in the Iranian economy have a small (or large) share of intermediate inputs (value added) in gross value added and simple and weak linkages with the demand for intermediate inputs in similar activities in the global value chain. (See Figure 1).

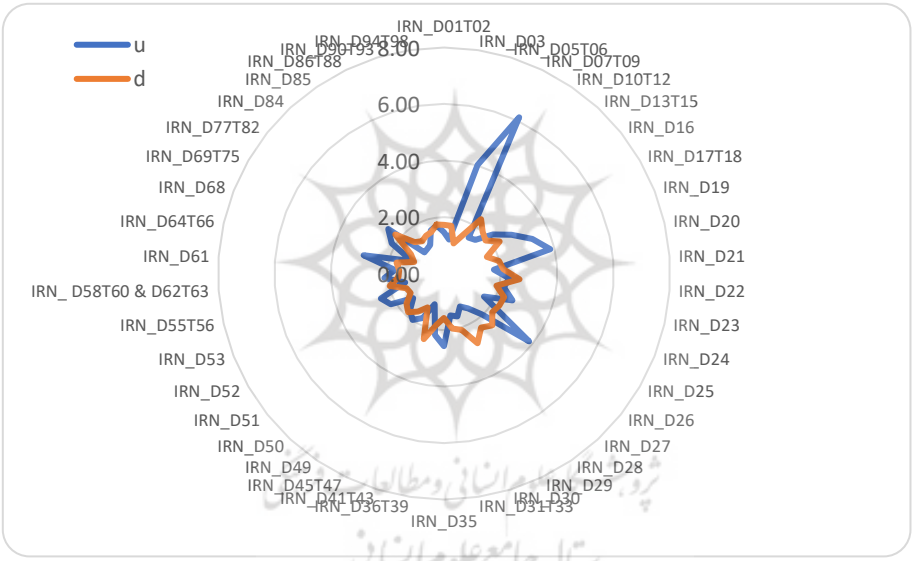

Figure 1. OU and ID measures for economic activities in Iran.
Source: Calculations based on the ICIO table for the year 2016, with added Iran.

Fig. 2 shows the relationship between the OU and the Index of ID for 42 activities in 68 countries, with 2856 observations for each criterion in 2016. The chart reveals a positive correlation of 0.35 between OU and ID. The crucial question raised is how it is possible for an upper-level criterion OU to be positively related to a lower-level criterion ID, while their partial labels indicate otherwise. Here, two different chains are considered: Uc represents the upper-level positions of activities in country c along the global supply chain. IDc represents the lower-level positions of activities in country c along

[DOI: 10.61186/jme.18.60.307]

the global input chain. Since both relative positions ultimately consider the HGI, the observed positive correlation indicates that an activity that is close to HGI as the final downstream consumer is, on average, also close to HGI as the primary input providers.

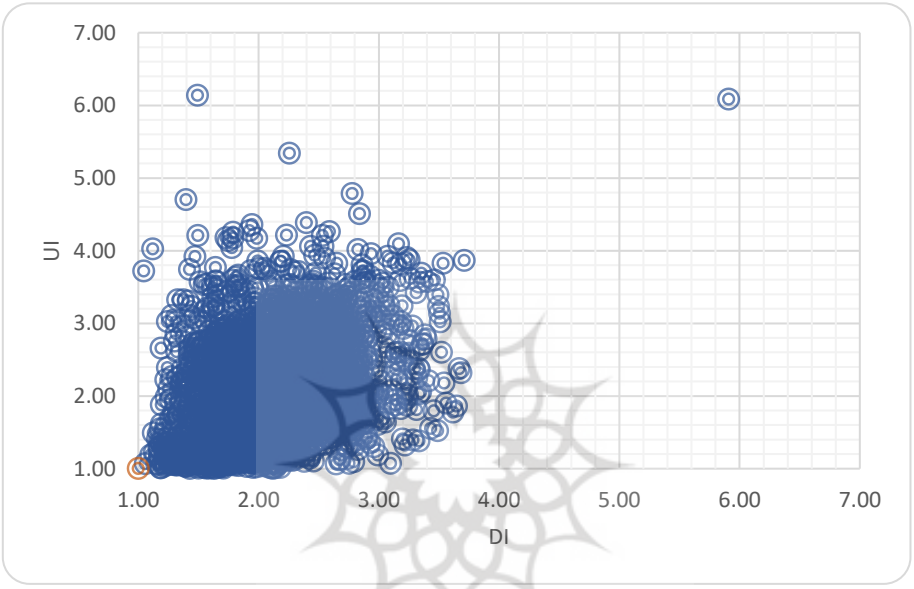

Figure 2. Dispersion of standardized upstreamness (OU) and downstreamness (ID) measures for global economic activities.
Source: Calculations based on the ICIO table for the year 2016, with added Iran.

The results demonstrate that the correlation between these two criteria is positive in South Korea, Malaysia, Vietnam, and Turkey, but negative in Iran and Saudi Arabia. In other words, in Iran, no positive relationship between upper-level and lower-level positions of activities is observed, while in most other countries, this relationship is positive. This suggests that an activity close to HGI as the final downstream consumer is, on average, not close to HGI as the primary input providers in Iran. (Fig. 3)

[DOI: 10.61186/jme.18.60.307]

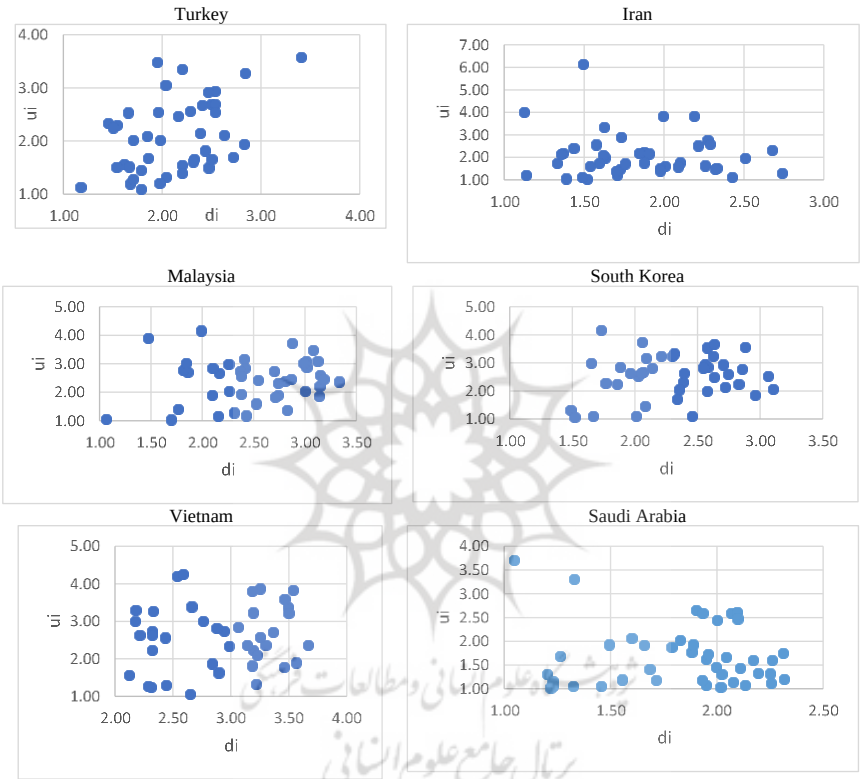

Figure 3. Dispersion of upstreamness (OU) and downstreamness (ID) measures for economic activities in Iran and some world countries
Source: Calculations based on the ICIO table for the year 2016, with added Iran.

At the global level, the average weighted values of OU and ID for activities or countries can be considered in terms of gross activities or world countries. The theoretical discussions presented do not differ based on whether the approach of "average distance from final consumers" or "average distance from primary input providers" is used. Economically, it may be intuitive that although each activity usually has different supply and demand chains at an

[DOI: 10.61186/jme.18.60.307]

individual level, for the average activity or country representing the entire system, these two chains must be mirror images of each other.

With this description, based on calculations, the global average for both OU and ID is approximately 2.1. However, for comparing Iran's position, the average weights of OU and ID are calculated for each specific country based on global results. It is found that Iran ranks fourth in the region with an average ID and OU of approximately 2. In these calculations, China, Vietnam, and almost Malaysia, are at the farthest distance from HGI along the global supply chain, while the closest countries to HGI along the downstream demand chain are Cambodia, Saudi Arabia, Morocco, Mexico, and Costa Rica. In the global downstream demand chain, Vietnam, China, South Korea, and almost Malaysia have the largest IDs with 2.77, 2.56, 2.55, and 2.49, respectively. On the other hand, Kazakhstan, Peru, Saudi Arabia, Iran, Costa Rica, Greece, and Morocco have the smallest IDs, respectively, and most other countries have an average ID value around two, indicating the average position of countries globally.

Recalling the interpretation of the OU criterion presented in Table 1, countries with the highest average OUs, such as China, Vietnam, and to some extent Malaysia, have a significant share of intermediate downstream activities (or a small share of final demand) in their gross activities. They also have extensive direct/indirect supply links with countries with similar characteristics. In contrast, countries with the lowest average OUs, such as Cambodia, Saudi Arabia, Morocco, Mexico, and Costa Rica, should have a relatively larger share of final production, and their intermediate downstream supply links are weaker and less correlated with each other at the global level. Therefore, with these calculations, it can be said that economies with the highest OUs are primarily specialized in the production and sale of industrial goods (China, Vietnam, Taiwan, Malaysia, South Korea, Laos), and to some extent in agriculture (China, New Zealand, Australia, Malaysia, and Chile) with high OUs. Meanwhile, those with the lowest OUs are more involved in-service activities (Hong Kong, Morocco, Iran, Tunisia, Saudi Arabia, Indonesia, Cyprus, and Mexico), having the lowest OUs, indicating less specialization in the services sector.

Similarly, activities with IDs listed in Table 4 should have a relatively large share of intermediate downstreamness inputs in the gross activities of countries with the largest IDs, such as Vietnam, China, South Korea, and almost Malaysia. Again, considering the interpretation of the ID criterion in Table 1, economies with large IDs should have a significant share of intermediate inputs (or a small share of value-added) in their gross activities

[DOI: 10.61186/jme.18.60.307]

and strong and complex downstream demand links with countries with similar characteristics. From Table 4, we observe that the countries with the largest OU and ID are related to China and Vietnam. South Korea has an OU of almost 3, but its ID is less than 3. Hong Kong has an ID of 3, but its OU is less than 3.

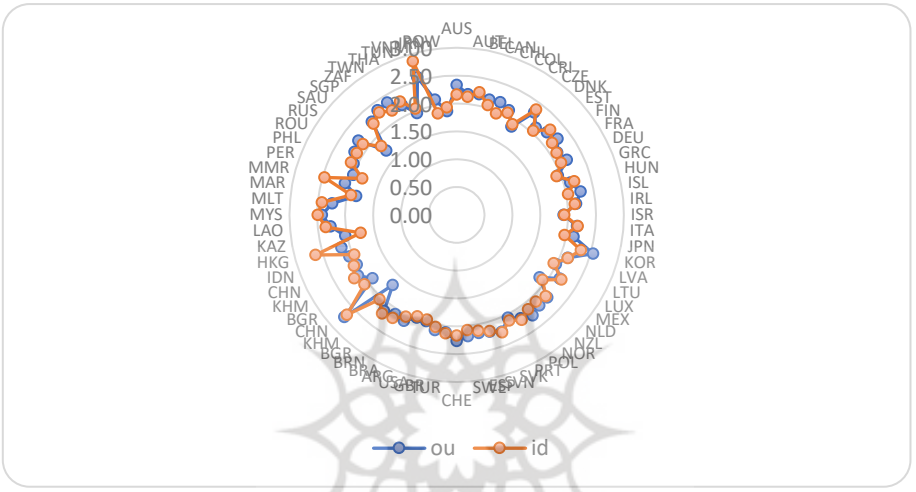

Figure 4. The level of OU/ID for countries.
Source: Calculations based on the ICIO table for the year 2016, with added Iran.

Table 4
Classification of countries based on OU/ID criteria of activities.

	OU≧3	**OU≧2**
ID≧3	China Vietnam	-Hong Kong
ID≧2	South Korea	Iran, Turkey, Saudi Arabia, India, Russia, Germany, France, Taiwan, Canada, Brazil, Indonesia, Malaysia, Kazakhstan, and other countries not mentioned in the table.

Source: Calculations based on the ICIO table for the year 2016, with added Iran.

Among these, Iran ranks less than 3 for both indices and is in the fourth quadrant region. Regarding ID, it falls among the lowest in the world. This can be explained by the fact that Iran is one of the main suppliers of natural resources to its trading partners, at least in activities such as Mining and quarrying, energy producing products and Mining and quarrying, non-energy

[DOI: 10.61186/jme.18.60.307]

producing products and Mining support service activities. Therefore, it occupies this position.

Countries with the lowest IDs are mostly due to lower IDs in agricultural activities (Peru, Indonesia, India, Saudi Arabia, and Tunisia), but Iran, Mexico, and Peru have the lowest IDs in services and differ from the rest. The countries with the highest IDs in the world include Vietnam, China, Hong Kong, Malaysia, Luxembourg, Slovakia, Thailand, South Korea, Singapore, Taiwan, and Turkey, resulting from the industrial activities' IDs in their global input chains.

6 Conclusion

The paper employs ICIO table for 2016 with added Iran to calculate various criteria for positioning countries and activities in GVCs. Four GVC positioning criteria for the Iranian economy are calculated, focusing on upstream and downstream linkages. The study introduces the concepts of "input demand chain" and "value chain" at the firm/activity level, emphasizing the importance of distinguishing between supply and demand chains. The results highlight the diversity of Iran's economic activities, with oil and mining sectors playing pivotal roles in shaping GVC indices. The analysis indicates that Iran has a higher ratio of final demand to gross output, emphasizing significant portions of its products reaching final demand. The value-added over total inputs index also places Iran among countries with high values.

The study identifies economic activities with high and low values of OU and ID in Iran. It reveals that oil and mining-related activities contribute significantly to the high OU values, while services and agricultural activities have lower OU values. The correlation between OU and ID is explored, showing a positive correlation globally but a negative correlation in Iran and Saudi Arabia. Iran’s average position in the global supply chain is calculated, indicating that Iran ranks fourth in the region with an average ID and OU of approximately 2. The discussion emphasizes the specialization of economies with high OUs in industrial and agricultural goods, while those with lower OUs are more involved in-service activities. Furthermore, the study provides insights into countries with the highest and lowest IDs globally, attributing them to industrial and agricultural activities, respectively. Iran's lower ID is explained by its role as a main supplier of natural resources, particularly in activities like oil and natural gas extraction.

In conclusion, the paper provides an in-depth analysis of Iran's role in global value chains from both upstream and downstream perspectives,

[DOI: 10.61186/jme.18.60.307]

enhancing our understanding of Iran's economic dynamics and specialization in global trade.

References

Alfaro, L., and A. Charlton (2009). ‘‘Intra-industry Foreign Direct Investment.’’ American Economic Review 99:2096–119. DOI: 10.1257/aer.99.5.2096

Antràs, P., and D. Chor (2013). ‘‘Organizing the Global Value Chain.’’ Econometrica 81: 2127–204. DOI: 10.3982/ECTA10813

Antràs, P., D. Chor, T. Fally, and R. Hillberry (2012). ‘‘Measuring the Upstreamness of Production and Trade Flows.’’ American Economic Review: Papers and Proceedings 102: 412–16. DOI: 10.1257/aer.102.3.412

Antràs, P. & Chor, D (2018). "On the Measurement of Upstreamness and Downstreamness in Global Value Chains", NBER Working Papers, No. w24185, National Bureau of Economic Research, published in World trade Evolution. Growth, Productivity and Employment, ch. 5, edited by L.Yan Ing and M. Yu, Routledge, NY, 2019.

Caliendo and Parro (2015). “Estimates of the Trade and Welfare Effects of NAFTA, The Review of Economic Studies, Volume 82, Issue 1, January 2015, Pages 1–44.

De Backer, K., and S. Miroudot (2012). “Mapping Global Value Chains”. Working Paper Series No. 1677, European Central Bank, Frankfurt.

Dietzenbacher, E., and I. Romero (2007). “Production Chains in an Interregional Framework: Identification by Means of Average Propagation Lengths.” International Regional Science Review 30 (4): 362–83. https://doi.org/10.1177/01600176073053

Dietzenbacher, E., I. Romero, and N. S. Bosma (2005). “Using Average Propagation Lengths to Identify Production Chains in the Andalusian Economy.” Estudios de Economia Aplicada 23 (2): 405–22.

Ellison, G., and E. L. Glaeser (1997). ‘‘Geographic Concentration in U.S. Manufacturing Industries: A Dartboard Approach.’’ Journal of Political Economy 105:889–927.

Fally, T (2012). Production Staging: Measurement and Facts. Mimeo. University of Colorado Boulder.

Jahangard, Esfandiar, Ali Faridzad, Jamal Kakaie, Najmeh Sajedianfard, Elaheh Shokri (2023a). Inserting Iran's input-output table in the inter-country input-output (ICIO) table”. Journal of Econometric Modelling. Volume7.No4. pp65-92. (in Persian). https://doi.org/10.22075/jem.2023.29619.1804

Jahangard, Esfandiar, Ali Faridzad, Najmeh Sajadianfard, Jamal Kakaie, and Elahe Shokri (2023b). Inserting of Iran in the ICIO Table.Chamber of Commerce, Industries, Mines, and Agriculture of Iran, Tehran. (in Persian).

[DOI: 10.61186/jme.18.60.307]

Jones, Charles (2011). Intermediate Goods and Weak Links in the Theory of Economic Development", American Economic Journal:Macroeconomics.VOL. 3, NO. 2:1-28. DOI: 10.1257/mac.3.2.1

Kremer, M. (1993). The O-Ring Theory of Economic Development," Quarterly Journal of Economics, 108:3: 551-576.

Miller, R., E. & Temurshoev, U (2015). Output Upstreamness and Input Downstreamness of Industries/Countries in World Production," International Regional Science Review 40(5): 443-475. DOI: 10.1177/0160017615608095

Porter, M. E (1990). The Competitive Advantage of Nations. New York: Free Press.

Appendix A

Table A1
List of country in ICIO 2016 with added Iran

Row	Country	Code	Row	Country	Code	Row	Country	Code
1	Australia	AUS	25	Mexico	MEX	49	Hong Kong	HKG
2	Austria	AUT	26	Netherlands	NLD	50	Kazakhstan	KAZ
3	Belgium	BEL	27	New Zealand	NZL	51	Laos	LAO
4	Canada	CAN	28	Norway	NOR	52	Malaysia	MYS
5	Chile	CHL	29	Poland	POL	53	Malta	MLT
6	Colombia	COL	30	Portugal	PRT	54	Morocco	MAR
7	Costa Rica	CRI	31	Slovakia	SVK	55	Myanmar	MMR
8	Czech Republic	CZE	32	Slovenia	SVN	56	Peru	PER
9	Denmark	DNK	33	Spain	ESP	57	Philippines	PHL
10	Estonia	EST	34	Sweden	SWE	58	Romania	ROU
11	Finland	FIN	35	Switzerland	CHE	59	Russia	RUS
12	France	FRA	36	Turkey	TUR	60	Saudi Arabia	SAU
13	Germany	DEU	37	United Kingdom	GBR	61	Singapore	SGP
14	Greece	GRC	38	United States of America	USA	62	South Africa	ZAF
15	Hungary	HUN	39	Argentina	ARG	63	Taiwan	TWN
16	Iceland	ISL	40	Brazil	BRA	64	Thailand	THA
17	Ireland	IRL	41	Brunei	BRN	65	Tunisia	TUN
18	Israel	ISR	42	Bulgaria	BGR	66	Vietnam	VNM
19	Italy	ITA	43	Cambodia	KHM	67	Iran	IRN
20	Japan	JPN	44	China	CHN	68	Rest of the World	ROW
21	South Korea	KOR	45	Croatia	HRV	69	Mexico 1	
22	Latvia	LVA	46	Cyprus	CYP	70	Mexico 2	
23	Lithuania	LTU	47	India	IND	71	China 1	
24	Luxembourg	LUX	48	Indonesia	IDN	72	China 2	

Source: OECD, Inter-Country Input-Output (ICIO) Tables, 2021 edition adjusted with Iran

[DOI: 10.61186/jme.18.60.307]

Table A2
List of Activities in ICIO 2016 with added Iran

Row	code	activities
1	D01T02	Agriculture, hunting, forestry
2	D03	Fishing and aquaculture
3	D05T06	Mining and quarrying, energy producing products
5	D07T09	Mining and quarrying, non-energy producing products and Mining support service activities
5	D10T12	Food products, beverages and tobacco
6	D13T15	Textiles, textile products, leather and footwear
7	D16	Wood and products of wood and cork
8	D17T18	Paper products and printing
9	D19	Coke and refined petroleum products
10	D20	Chemical and chemical products
11	D21	Pharmaceuticals, medicinal chemical and botanical products
12	D22	Rubber and plastics products
13	D23	Other non-metallic mineral products
14	D24	Basic metals
15	D25	Fabricated metal products
16	D26	Computer, electronic and optical equipment
17	D27	Electrical equipment
18	D28	Machinery and equipment, nec
19	D29	Motor vehicles, trailers and semi-trailers
20	D30	Other transport equipment
21	D31T33	Manufacturing nec; repair and installation of machinery and equipment
22	D35	Electricity, gas, steam and air conditioning supply
23	D36T39	Water supply; sewerage, waste management and remediation activities
24	D41T43	Construction
25	D45T47	Wholesale and retail trade; repair of motor vehicles
26	D49	Land transport and transport via pipelines
27	D50	Water transport
28	D51	Air transport
29	D52	Warehousing and support activities for transportation
30	D53	Postal and courier activities
31	D55T56	Accommodation and food service activities
32	D58T60 & 62 T63	Publishing, audiovisual and broadcasting activities and IT and other information services
33	D61	Telecommunications
34	D64T66	Financial and insurance activities
35	D68	Real estate activities
36	D69T75	Professional, scientific and technical activities
37	D77T82	Administrative and support services
38	D84	Public administration and defence; compulsory social security
39	D85	Education
40	D86T88	Human health and social work activities
41	D90T93	Arts, entertainment and recreation
42	D94T98	Other service activities and Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use

Source: OECD, Inter-Country Input-Output (ICIO) Tables, 2021 edition adjusted with Iran.

[DOI: 10.61186/jme.18.60.307]