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Offshoring, reshoring, and the location of production:

What can we measure in a cross-country industry-level setting?

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What can we measure in a cross-country industry-level setting?

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Abstract

Geopolitical tensions, security concerns, and the COVID-19 supply chain disruptions have prompted countries to reconsider their reliance on the origin of the inputs they use in production. Consequently, policy makers and researchers are increasingly interested in understanding shoring strategies and patterns of production relocation. While the interest in shoring has surged, the literature offers ample measures for (off-, re-, near-, friend-) shoring, ranging from intuitively appealing, simple indicators to more sophisticated, complex metrics based on input-output techniques. Those measures come with specific trade-offs and assumptions. Without a proper understanding of these measures, empirical analyses – and the policies based on them – risk being misinformed. Against this background, this paper compares five different measures – so-called domestic participation indicators (DPIs) – that aim to measure shoring and production locations. In particular, we examine how they behave under different forms of shoring. We use global multiregional input-output (GMRIO) tables from the OECD, covering 45 industries in 76 countries, to track the development of the five DPIs through the stages of (de-)globalisation between 1995 and 2022. We find that the direct DPIs explain the trends in globalisation well.

Keywords: Offshoring, reshoring, domestic participation indexes, global value chains, input-output tables

JEL classification: F15, F14, F62, L60

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1. Introduction

Geopolitical tensions, security concerns, and disruptions, such as the COVID-19 pandemic, have put global supply chains under severe stress (Alfaro & Chor, 2023). These events highlighted that countries face substantial risk when relying heavily on foreign inputs for production (Baldwin et al., 2023). In response, firms and governments are increasingly exploring options to 'bring back' production processes that were previously offshored to decrease reliance on foreign inputs. For instance, in February 2025, US President Donald Trump proposed raising tariffs on imports under the guise of protecting domestic producers and national security (The White House, 2025). At the same time, European policy makers aim to reduce Europe's dependence on foreign countries in the context of 'strategic autonomy', which is defined as 'the capacity to act autonomously – that is, without being dependent on other countries – in strategically important areas' (Damen, 2022). Empirical evidence suggests that this is not merely political rhetoric, as supply chains are already fragmenting along geopolitical lines (Gopinath et al., 2025).

Parallel to the geopolitical discourse, another strand of literature has examined concentration and diversification from the viewpoint of resilience and growth. The urgent need to find alternative suppliers following natural disasters (e.g. the Fukushima tsunami, tropical storms, and flooding) has demonstrated that diversification of imports is crucial for absorbing such shocks (Brakman et al., 2015; Christopherson et al., 2010; Groot et al., 2011; Martin et al., 2016). At the same time, diversification of exports has been shown to positively affect growth (Saviotti & Frenken, 2008; Drucker, 2011; Lei & Zhang, 2014; Freire, 2017). Consequently, comprehending the complex dynamics that are reshaping the global economy – amid rising volatility and geopolitical tension – is critical for policy makers and firms seeking to foster economic resilience.

At the same time, empirically quantifying exactly how global supply chains are being reconfigured and what shoring activities take place remains a non-trivial challenge. While the interest in shoring has surged, the literature offers a wide array of measurement approaches, ranging from intuitively appealing, simple indicators to more sophisticated, complex metrics (see Lavorati & Tredicine, 2026, for a review). Those measures come with specific trade-offs and assumptions. Without a proper comparison and understanding of these metrics, empirical analyses – and the policies based on them – risk being misinformed.

In this paper, we address this measurement challenge by providing a systematic overview and comparison of shoring measures. We use inter-country input-output (ICIO) tables to facilitate this comparison, but these tables are not necessary to calculate each measure. Unlike case studies or survey data at the micro or firm level (Kinkel & Maloca, 2009; Di Mauro et al., 2018; Piatanesi & Aurauzo-Carod, 2019), the use of ICIO tables facilitates a comparison of developments across countries and a more comprehensive global perspective essential for macro- or industry-level analysis (Feenstra & Hanson, 1996, 1999; Krenz & Strulik, 2021). Our empirical analysis adopts the latter perspective. Ultimately, this paper serves as a methodological guide. By dissecting the pros and cons of these measurements, we provide the necessary foundation for researchers and policy makers to accurately assess supply chain reconfigurations and, by extension, economic resilience.

In this paper, we describe various concepts of shoring as well as a set of measures. While some of these measures have been taken from the literature and slightly adapted, one has been newly developed. We refer to those measures as ‘domestic participation indexes’ (DPIs), which fall into two groups. The first group of DPIs looks at domestic participation in production (i.e. the actual making of goods or provision of services) through intermediate inputs and value-added items (i.e. payments for primary factors, such as labour, capital, and entrepreneurship). The second group contains DPIs that express the ultimate domestic participation in the production of goods for final use. Because each final good is ultimately made up of pieces of (domestic and foreign) value added, the domestic participation reflects how much domestic value added is embodied in the goods supplied to final users. For each of the measures, we analyse how it responds to each of the shoring types.

In our empirical application, we find that the trends in the DPIs align well with common wisdom about key stages of (de-)globalisation. Specifically, the DPIs steadily decline from the 1990s onwards, which is consistent with the increase in international fragmentation during this period (Hummels et al., 2001). The DPIs reach a peak in 2008, followed by a sharp but temporary reversal during the global financial crisis (GFC) of 2009, while the DPIs remain stagnant during the era of so-called ‘slowbalisation’ in the 2010s. Finally, and perhaps counterintuitively, domestic participation decreased during the COVID-19 pandemic.

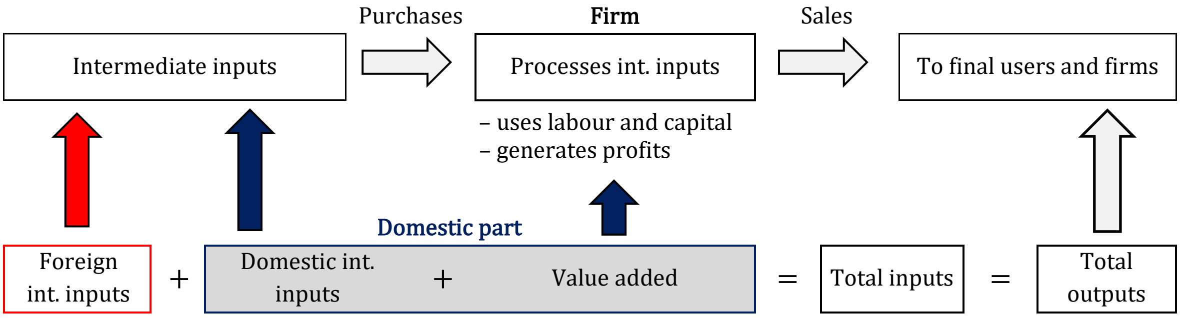
The remainder of this paper is structured as follows. In Section 2, we introduce a conceptual framework to illustrate the mechanics of shoring. In Section 3, we formally introduce the five DPIs. In Section 4, we discuss the advantages and disadvantages of these DPIs. In Section 5, we provide some key descriptives for the DPIs. In Section 6, we conclude.

2. Conceptual framework: The mechanisms of shoring

At its core, the production of goods and services involves processing inputs into final output. As highlighted in Figure 1, this process requires a mix of intermediate inputs (i.e. purchases from other firms, whether domestic or foreign) and value added. Value added represents the internal creation of value within a firm, capturing payments to primary factors of production (e.g. labour and capital) required for in-house activities.

Changes in the production process often reflect strategic sourcing decisions. To sketch the differences in shoring types, consider two distinct examples involving US automobile firms. The first shoring type replaces domestic with foreign intermediate inputs. For instance, if US automobile firms initially purchase parts from other US suppliers but then replace these domestic inputs with parts imported from Chinese firms, offshoring has occurred via the substitution of intermediate inputs. The second shoring type replaces in-house inputs with foreign intermediate inputs. Consider the same US automobile firms, but suppose they initially produced certain parts in-house. If these activities are outsourced and replaced by Chinese parts, domestic value added – comprising the costs of labour, capital, and profits – is replaced by foreign intermediate inputs. It is crucial to distinguish between these shoring types because measures that cover the first type of shoring do not always cover the second.

Figure 1 / A stylised production process



The conceptual view of production in Figure 1 is represented directly in the data structure of ICIO tables. These tables record the sales and purchases between industries across countries, effectively capturing the inputs required by every industry in the global economy. We illustrate how these types of shoring can show up in macro-level data using the illustrative ICIO table in Table 1. In this table, there are two countries (country A and country B), each of which has two industries (industry 1 and industry 2). Some of the cells in this ICIO table are left empty for expositional purposes.

Table 1 / An illustrative ICIO table

Sales of intermediate inputs (or final products) by industries		Use of inputs by industries				To final users		Total outputs
		in cnt A		in cnt B		in cnt A	in cnt B	
		ind 1	ind 2	ind 1	ind 2			
in cnt A	ind 1	6			z_{ij}^{RS}		f_i^{RS}	
	ind 2	4						
in cnt B	ind1	3						
	ind 2	1						x_j^S
Value added		6		v_i^S				
Total inputs		20	x_j^R					

Note: The abbreviations ‘ind’ and ‘cnt’ refer to industries and countries, respectively.

The column highlighted in Table 1 represents the inputs that industry 1 in country A requires to produce its outputs. Just as baking a cake requires (for most of us) a cooking recipe listing the necessary ingredients, this column serves as the industry’s ‘production recipe’. This recipe includes both intermediate inputs (i.e. purchases from other firms) and value added, which includes payments to primary factors of production (e.g. labour and capital). Strategic sourcing decisions lead to changes in this recipe, reflecting how the industry uses domestic and foreign inputs.

To illustrate, suppose the highlighted column gives the production recipe for the car manufacturing industry (industry 1) in the US (country A). One form of offshoring occurs when firms in this industry move in-house assembly to assembly firms in, say, China (country B) to capitalise on cheaper labour. In this case, the US firms import more Chinese intermediate inputs while their requirements for domestic labour and capital – and, thus, their value added – decrease. Alternatively, offshoring can occur when firms replace production stages previously completed by other domestic suppliers (i.e. a production stage that was already outsourced) with imported products, thereby replacing domestic intermediate inputs with foreign ones.

Reshoring represents the inverse movement. Consider the case of rising productivity of industrial robots. This can reduce the relative cost of in-house production of high-wage countries (Antràs et al., 2017; Krenz et al., 2021). If US car manufacturers bring previously offshored assembly back home, they import fewer intermediate inputs from Chinese firms while adding more value in-house to cover the installation and maintenance of industrial robots.

By understanding that shoring leads to a fundamental change in an industry’s production recipe, we can develop quantitative indicators to track these shifts. In the following section, we introduce a set of DPIs. These measures, ranging from simple direct ratios to more complex global value chain (GVC) metrics, are designed to capture the varying degrees of domestic (and foreign) participation in production.

3. Domestic participation indexes

3.1. DIRECT DPIS

In this section, we introduce the so-called direct domestic participation indexes (DPIs). These DPIs have the advantages of being easy to compute (because no input-output techniques are needed) and of being computable for an individual firm, as the computation does not require an input-output (IO) table. We use IO tables to facilitate a comparison to the GVC-based DPIs, which we will introduce in Section 3.2. For further calculations, it is useful to define the content of an inter-country IO (ICIO) table with n industries and N countries, as is done in Table 2.

Table 2 / An ICIO table with n industries and N countries

Sales to from	ind 1 in cnt 1	$\cdots$	ind j in cnt S	$\cdots$	to ind n in cnt N	fu in cnt 1	$\cdots$	fu in cnt S	$\cdots$	fu in cnt N	Total outputs
ind 1 in cnt 1	z_{11}^{11}	$\cdots$	z_{1j}^{1S}	$\cdots$	z_{1n}^{1N}	f_1^{11}	$\cdots$	f_1^{1S}	$\cdots$	f_1^{1N}	x_1^1
$\vdots$	$\vdots$	$\ddots$	$\vdots$	$⋰$	$\vdots$	$\vdots$	$\ddots$	$\vdots$	$⋰$	$\vdots$	$\vdots$
ind i in cnt R	z_{i1}^{R1}	$\cdots$	z_{ij}^{RS}	$\cdots$	z_{in}^{RN}	f_i^{R1}	$\cdots$	f_i^{RS}	$\cdots$	f_i^{RN}	x_i^R
$\vdots$	$\vdots$	$⋰$	$\vdots$	$\ddots$	$\vdots$	$\vdots$	$⋰$	$\vdots$	$\ddots$	$\vdots$	$\vdots$
ind n in cnt N	z_{n1}^{N1}	$\cdots$	z_{nj}^{NS}	$\cdots$	z_{nn}^{NN}	f_n^{N1}	$\cdots$	f_n^{NS}	$\cdots$	f_n^{NN}	x_n^N
Value added	v_1^1	$\cdots$	v_j^S	$\cdots$	v_n^N						
Total inputs	x_1^1	$\cdots$	x_j^S	$\cdots$	x_n^N						

Note: The abbreviations 'ind', 'cnt', and 'fu' refer to industries, countries, and final users, respectively. Values in ICIO tables are recorded in millions of US dollars.

Suppose we have N countries, each with n industries. In our empirical application, we will work with $n = 45$ industries in $N = 76$ countries. The ICIO tables provide industries' intermediate deliveries (z_{ij}^{RS}), final use (f_i^{RS}), value added (v_i^R), output (x_i^R) in USD millions. Take, for example, the sales from the Chinese steel manufacturers to US car manufacturers. Final use (f_i^{RS}) gives the deliveries from industry i in country R for final use in country S. Final use includes household consumption, private investment, government expenditures (for consumption and investments), and changes in stocks and inventories (e.g. the sales from US car manufacturers to Canadian households). Note that elements f_i^{RS} are absorbed (in consumption or investment), while elements z_{ij}^{RS} are transmitted to the next production stage. x_i^R gives the output (or the production volume in USD millions) of industry i in country R, and v_i^R gives the value added of industry i in country R. Value added includes the payments for labour (wages and salaries, including employers' contributions), capital (depreciation), entrepreneurial activities (profits), and taxes minus subsidies. These value-added items are also denoted as primary inputs.

In any IO table, an industry's total amount of inputs is, by definition, equal to the same industry's total output. For industry i in country R, we have the total amount of inputs from the corresponding column in the IO table: $x_i^R = \sum_S \sum_j z_{ji}^{SR} + v_i^R$ (i.e. the sum of purchased intermediate inputs plus the primary inputs). The corresponding column in the IO table gives the total amount of outputs: $x_i^R = \sum_S \sum_j z_{ij}^{RS} + \sum_S f_i^{RS}$. The output of an industry is sold as intermediate deliveries to industries and as final products to final users.

As a first DPI of an industry, we propose to measure the use of all domestic inputs (intermediate and primary) as a share of the total inputs:

$$DPI(1)DDW_j^S = (\underbrace{\textstyle\sum_i z_{ij}^{SS}}_{\substack{dom.\ int.\\ inputs}} + \underbrace{v_j^S}_{\substack{value\\ added}})/ \underbrace{x_j^S}_{\substack{total\\ inputs}} \tag{1}$$

We use the first letter of the authors' surnames as an abbreviation to indicate the origin of each DPI (e.g. the '*DDW'* part if the equation above stands for 'Dijkstra, Dietzenbacher and Wacker'). This DPI is simple to interpret because it is the complement of imported intermediate inputs as a share of the total inputs. Specifically, $1 - DPI(1)DDW_j^S = \sum_{R \neq S} \sum_i z_{ij}^{RS} \,/\, x_j^S$ is a proxy for an industry's reliance on imported intermediate inputs. A downside that arises from this simplicity is the fact that the index only takes the current stage of production into account, while GVCs are usually more complex and imported (domestic) intermediate inputs may include domestic (foreign) value added in prior production stages.

Next, we will turn to indexes that have been used in the literature to measure shoring while also focusing on the current production stage. Feenstra & Hanson (1996, 1999) proposed an industry's imports of intermediate inputs as a share of the industry's total use of intermediate inputs ($\sum_{R \neq S} \sum_i z_{ij}^{RS} \,/\, \sum_R \sum_i z_{ij}^{RS}$) as a measure for offshoring.[1] Its complement is a proxy for domestic participation and is defined as domestic intermediate inputs as a share of total intermediate inputs:

$$DPI(2)FH_j^S = \underbrace{\textstyle\sum_i z_{ij}^{SS}}_{\substack{dom.\ int.\\ inputs}} / \underbrace{\textstyle\sum_R \sum_i z_{ij}^{RS}}_{\substack{total\ int.\\ inputs}} \tag{2}$$

The key difference to our newly proposed $DPI(1)DDW$ is that $DPI(2)FH$ does not take an industry's domestic value added (v_j^S) into account either in the numerator or the denominator. Given that an industry's value added is a key factor in production, ignoring it paints a highly incomplete picture of what happens to sourcing decisions and production locations. At the same time, valued added is also impacted by several aspects that are not necessarily related to decisions about sourcing and production locations. This highlights that there are trade-offs between these approaches

Finally, Krenz & Strulik (2021) proposed a measure of shoring that captures an industry's use of domestic intermediate inputs relative to its use of imported intermediate inputs:

$$DPI(3)KS_j^S = \underbrace{\textstyle\sum_i z_{ij}^{SS}}_{\substack{dom.\ int.\\ inputs}} / \underbrace{\textstyle\sum_{R \neq S} \sum_i z_{ij}^{RS}}_{\substack{for.\ int.\\ inputs}} \tag{3}$$

Note that the key difference of $DPI(3)KS$ compared to $DPI(2)FH$ is the fact that the denominator ignores domestic intermediate inputs (i.e. those from country *S*). A disadvantage of $DPI(3)KS$ is that the DPI has the foreign intermediate inputs in its denominator. The practical consequence of this is that the DPI is substantially inflated if a firm uses relatively few foreign intermediate inputs. In those cases, relatively small changes in the use of foreign intermediate inputs can lead to relatively large changes in this DPI. The other two DPIs are, by definition, bound between zero and one.

1 The authors also proposed an industry's imports of intermediate inputs from the same 2-digit industries as a share of the industry's total use of intermediate inputs from the same 2-digit industries ($\sum_{R \neq S} \sum_{i=j} z_{ij}^{RS} \,/\, \sum_R \sum_{i=j} z_{ij}^{RS}$) as a 'narrow' measure for offshoring. We only examine the 'broad' measure because this is consistent with the other DPIs that do not have a 'narrow' measure.

3.2. GVC-BASED DPIS

The measures above only consider the inputs (domestic intermediate, foreign intermediate, and primary) that go directly into production by an industry at a given first-tier production stage. It is also possible to consider the sum of inputs that is embodied in, for example, certain investments or exports to foreign households. The embodied inputs are supplied in tiers. We consider that intermediate inputs are produced by first-tier suppliers, which requires further intermediate inputs from second-tier suppliers. These are the inputs that go into the production of the inputs. Next, we have third-tier suppliers of the inputs that go into the inputs that go into the inputs, and so forth. Final products are made in GVCs, and suppliers in each tier add a bit of value. We calculate the embodied inputs by taking all tiers into account while following the global chain of values added, which is why we refer to it as the 'GVC approach'.

Accordingly, we ask the question: how much total output is needed (on average) from industry i in country R to produce a unit of (final) output δ in industry j in country S? We first note that this unit of (final) output δ by industry j in country S is part of this total output needed (on average) from industry j in country S. To produce this unit of (final) output δ by industry j in country S, some intermediate inputs are needed from industry i in country R. These first-tier intermediate inputs are given by the average input coefficient $a_{ij}^{RS} = z_{ij}^{RS}/x_j^S$. To produce these first-tier intermediate inputs, industry i in country R also needs some intermediate inputs from industry u in country U. These second-tier intermediate inputs are given by $a_{ui}^{UR}a_{ij}^{RS}$. Similarly, to produce these third-tier intermediate inputs, industry u in country U also needs some intermediate inputs from industry v in country V. These third-tier intermediate inputs are given by $a_{vu}^{VU}a_{ui}^{UR}a_{ij}^{RS}$. We sum over all tiers of intermediate inputs and include the unit of (final) output, which yields:

$$l_{ij}^{RS} = \underbrace{\delta}_{\substack{final\\unit}} + \underbrace{a_{ij}^{RS}}_{\substack{first\\tier}} + \underbrace{\sum_U \sum_u a_{iu}^{RU} a_{uj}^{US}}_{\substack{second\\tier}} + \underbrace{\sum_U \sum_V \sum_u \sum_v a_{iu}^{RU} a_{uv}^{UV} a_{vj}^{VS}}_{\substack{third\\tier}} + \underbrace{\cdots\cdots\cdots\cdots}_{\substack{all\ other\\tiers}} \qquad (4)$$

where the unit of (final) output δ is included by setting $\delta = 1$ if $i = j$ and $R = S$, and $\delta = 0$ otherwise. The element l_{ij}^{RS} is an element of the so-called Leontief inverse and gives the outputs (or inputs) from industry i in country R that are required – directly and indirectly – to produce a unit of (final) output by industry j in country S. The formula includes $a_{iu}^{RU}a_{uj}^{US}$ rather than $a_{ui}^{UR}a_{ij}^{RS}$ because we are interested in the intermediate inputs needed from industry i in country R. The intermediate inputs $a_{ui}^{UR}a_{ij}^{RS}$ are included as a part of l_{uj}^{US}. The same applies for all higher tiers of intermediate inputs. We derive l_{ij}^{RS} using standard IO techniques, of which the appendix provides a matrix statement.

The value added by industry i in country R (on average) per unit of output is given by the average value-added coefficient $w_i^R = v_i^R/x_i^R$. This value-added coefficient (w_i^R) is used to transform outputs x_i^R into value-added terms. That is:

$$b_{ij}^{RS} = w_i^R l_{ij}^{RS} \qquad (5)$$

where b_{ij}^{RS} gives the value added by industry i in country R that is directly and indirectly necessary for or embodied in a dollar of final output by industry j in country S. These value-added shares sum to unity, $\sum_R \sum_i b_{ij}^{RS} = 1$, as the value of a unit of final output is entirely made up of pieces of value added in each tier of the production chain. These pieces are added either at home or abroad, thus containing domestic and foreign value added, respectively.

In our first GVC-based measure for domestic participation, we look at the 'country of completion' (Los et al., 2015). For example, we calculate how much German value added is embodied in the final output produced by the German car manufacturing industry. Specifically, the final output of industry j in country S is $\sum_T f_j^{ST}$ (in this case, it does not matter to whom these final products are sold, and hence, we sum over T). The value added that is contributed by industry i in country R to produce this final output equals $g_{ij}^{RS} = \sum_T b_{ij}^{RS} f_j^{ST}$. All domestic value added embodied in the final output of industry j in country S is $\sum_i g_{ij}^{SS}$. The total (domestic and foreign) value added in the final output of industry j in country S is given by $\sum_R \sum_i g_{ij}^{RS}$, which equals the value $\sum_T f_j^{TS}$ of the final output of industry j in country S.[2] This yields the following index:

$$DPI(4)LTV_j^S = \underbrace{\sum_i g_{ij}^{SS}}_{\substack{dom.\ value\ in \\ final\ output\ j\ in\ S}} \Big/ \underbrace{\sum_T f_j^{ST}}_{\substack{total\ value\ of\ final \\ output\ by\ j\ in\ S}} \quad (6)$$

All the measures considered so far implicitly assume that the location in which the final production stage takes place (i.e. the 'country of completion') is 'home' and determines what is seen as domestic. However, in practice, sourcing decisions may also include the location in which the final stage of production takes place. To consider this, we can alternatively define the 'home' country as the country in which final goods are ultimately used (i.e., the 'country of final use'), which builds on Johnson and Noguera (2012). For example, we calculate how much German value added is embodied in the final output produced by car manufacturing industries anywhere across the world but used in Germany. We consider the value added by industry i in country R that is embodied in the final products j (i.e. irrespective of the country of completion) that are ultimately used in country S. Specifically, the final output of industry j in country S is $\sum_T f_j^{TS}$ (in this case, it only matters to whom these final products are sold, and hence, we sum over T). The value added that is contributed by industry i in country R to produce this final output equals $h_{ij}^{RS} = \sum_T b_{ij}^{RS} f_j^{TS}$. All domestic value added embodied in the final products j that are ultimately used as final products in country S is then given by $\sum_i h_{ij}^{SS}$. The total (domestic and foreign) value added embodied in the final products j that are ultimately used in country S is given by $\sum_R \sum_i h_{ij}^{RS}$, which equals the value of all final products j used in country S, or $\sum_T f_j^{ST}$.[3] This yields the following index:

$$DPI(5)JN_j^S = \underbrace{\sum_i h_{ij}^{SS}}_{\substack{dom.\ value\ in\ final \\ output\ by\ j\ used\ by\ S}} \Big/ \underbrace{\sum_T f_j^{TS}}_{\substack{total\ value\ of\ final \\ output\ by\ j\ used\ in\ S}} \quad (7)$$

3.3. SHORING AND DPIS

In Section 2, we presented a conceptual framework that highlighted how firms' sourcing decisions could lead to changes in ICIO tables. To track these changes, we developed a set of DPIs in the previous two subsections. This yields three direct DPIs and two GVC-based DPIs, for a total of five DPIs. Table 3 provides an overview of all the DPIs referred to in this paper.

2 $\sum_R \sum_i g_{ij}^{RS} = \sum_R \sum_i \sum_T b_{ij}^{RS} f_j^{ST} = \sum_T (\sum_R \sum_i b_{ij}^{RS}) f_j^{ST} = \sum_T f_j^{ST}$ because $\sum_R \sum_i b_{ij}^{RS} = 1$

3 $\sum_R \sum_i h_{ij}^{RS} = \sum_R \sum_i \sum_T b_{ij}^{RT} f_j^{TS} = \sum_T (\sum_R \sum_i b_{ij}^{RT}) f_j^{TS} = \sum_T f_j^{TS}$ because $\sum_R \sum_i b_{ij}^{RT} = 1$.

Table 3 / Overview of the direct and GVC-based DPIs

DPI	Based on	Category	Definition of 'home' country
$DPI(1)DDW$	Dijkstra, Dietzenbacher & Wacker (2026)*	Direct	Current production stage
$DPI(2)FH$	Feenstra & Hanson (1996, 1999)	Direct	Current production stage
$DPI(3)KS$	Krenz & Strulik (2021)	Direct	Current production stage
$DPI(4)LTV$	Los, Timmer & de Vries (2015)	GVC-based	Country of completion
$DPI(5)JN$	Johnson & Noguera (2012)	GVC-based	Country of final use

Note: * This work is the same as this paper.

In the exposition that follows, we examine how sourcing decisions affect the DPIs using the different types of shoring discussed above. Panel A in Table 4 provides a summary of the changes in the ICIO table, while Panel B provides a summary of the changes in the DPIs.

Starting with the first column of Table 4, assume that a certain firm in industry j in country S performs certain production stages in-house (e.g. assembly). Suppose this firm decides to outsource these production stages to a firm in industry i in the same country S. In such a case, the costs of domestic intermediate inputs (i.e. assembled products) by industry j in country S from industry i in the same country S ($\sum_i z_{ij}^{SS}$) increase. Given that the firm no longer completes assembly in-house, the costs of labour and capital inputs (δ_j^S) decreases. The firm outsources if it expects that this increases its profits. This implies that the decrease in the costs of in-house assembly (δ_j^S) must be larger than the increase in the costs of domestic intermediate inputs ($\sum_i z_{ij}^{SS}$). This leads to a decrease in value added (v_j^S) at a given level of output (x_j^S).

Table 4 / Changes in ICIO tables of sourcing strategies by industry j in country S

Panel A		Out.	Off. (i)	Off. (ii)	Re. (i)	Re. (ii)
Domestic intermediate inputs (DII)	$\sum_i z_{ij}^{SS}$	↑	–	↓↓	–	↑
Foreign intermediate inputs (FII)	$\sum_{R\neq S}\sum_i z_{ij}^{RS}$	–	↑	↑	↓↓	↓↓
Total intermediate inputs (TII)	$\sum_R\sum_i z_{ij}^{RS}$	↑	↑	↓	↓↓	↓
Labour and capital costs	δ_j^S	↓↓	↓↓	–	↑	–
Total costs (TC)	$\sum_R\sum_i z_{ij}^{RS}+\delta_j^S$	↓	↓	↓	↓	↓
Profits	π_j^S	↑	↑	↑	↑	↑
Value added (VA)	$v_j^S=\delta_j^S+\pi_j^S$	↓	↓	↑	↑	↑
Panel B						
Direct: $(VA+DII)/(VA+TII)$	$DPI(1)DDW_j^S$	–	↓	↓	↑	↑
Direct: $DII\ /\ TII$	$DPI(2)FH_j^S$	↑	↓	↓	↑	↑
Direct: $DII\ /\ FII$	$DPI(3)KS_j^S$	↑	↓	↓	↑	↑

Note: The abbreviations 'Out.', 'Off.', and 'Re.' refer to outsourcing, offshoring, and reshoring, respectively. Upward (downward) arrows indicate an increase (decrease), and a dash denotes no change. Double arrows are used for relatively large changes. The implicit assumption is that the output (x_j^S) and, particularly, associated prices remain constant.

Offshoring can occur in two forms: when the same firm decides to outsource (i) production stages that were previously completed in-house (in column 2 of Table 4) or (ii) production stages that were completed by other domestic firms to a firm in industry i in a different country R (in column 3 of Table 4). In both cases, the costs of foreign intermediate inputs (i.e. assembled products) by industry j in country S from industry i in country R ($\sum_{R\neq S}\sum_i z_{ij}^{RS}$) increase. The firm offshores if it expects that this will increase its profits. This implies that the decrease (i) in the costs of in-house assembly (δ_j^S), in the former case, and (ii) in the costs of domestic intermediate inputs ($\sum_i z_{ij}^{SS}$), in the latter case, is larger than the increase in the costs of foreign intermediate inputs ($\sum_{R\neq S}\sum_i z_{ij}^{RS}$). While the firm substitutes value added with foreign intermediate inputs in the former case, the firm substitutes domestic intermediate inputs with foreign intermediate inputs in the latter case.

Reshoring occurs when the same firm in industry j in country S, after this firm has offshored certain production stages, decides to relocate production back to country S either by (i) completing production stages in-house or (ii) outsourcing these production stages to other domestic firms. In both cases, precisely the opposite happens compared to the case of offshoring (see the last two columns of Table 4). Specifically, the purchases of foreign intermediate inputs (i.e. assembled products) by industry j in country S from industry i in country R ($\sum_{R\neq S}\sum_i z_{ij}^{RS}$) decrease. The firm reshores if – and only if – in-house production or domestic outsourcing is once again cheaper than offshoring (e.g. due to an increase in the productivity of industrial robots). This implies that (i) the costs of the labour and capital inputs required for in-house assembly (δ_j^S) increase in the former case, and that (ii) the costs of domestic intermediate inputs ($\sum_i z_{ij}^{SS}$) increase in the latter case. In both cases, the increases in costs are smaller than the decrease in cost of offshoring, with the result that the firms' profits (π_j^S) increase. Thus, the firms' value added ($v_j^S = \delta_j^S + \pi_j^S$) increases at a given level of output (x_j^S).

Panel B in Table 4 indicates how the different shoring types affect the DPIs. These different shoring types (except for outsourcing) lead to similar changes in the direct DPIs. This raises the question: what is the difference between these DPIs? The answer lies not in the direction in which the DPIs change, but in the magnitude of these changes. For example, $DPI(1)DDW$ is much more responsive compared to $DPI(2)FH$ and $DPI(3)KS$ in the case where firms offshore production stages that were previously completed in-house because value added is included in its numerator. Vice versa, the latter DPIs are more responsive compared to $DPI(1)DDW$ in the case where firms replace domestic intermediate inputs with foreign ones.

The GVC-based DPIs are deliberately excluded from Panel B in Table 4 because it is not possible to systematically indicate how changes in value added, domestic intermediate inputs, and foreign intermediate inputs used by industry j in country S affects these DPIs. This is because these DPIs also depend on the domestic and foreign intermediate inputs used by industry i in country R through supply chain linkages. The effect of the different shoring types on the GVC-based DPIs depends on the magnitude of every single link in the supply chain (i.e. it depends on every input coefficient a_{ij}^{RS}). Despite this, we can indicate that the different shoring types considered generally lead to changes in the same direction in the GVC-based DPIs compared to the direct DPIs. The reason for this is that, in most cases, the direct effects dominate the indirect effects.

Table 5 summarises the main differences between the DPIs, while we discuss the advantages and disadvantages of the different DPIs in Section 4. Table 5 indicates that the GVC-based DPIs are sensitive to changes at previous production stages, while the direct DPIs are not. This is because the direct DPIs only consider the current production stage, while the GVC-based DPIs consider multiple production stages. $DPI(5)JN$ is the only DPI that is sensitive to changes in the location of the final production stage. This is because all other DPIs consider the location of the final production stage as exogenous. In other words, changes in final output (f_j^{RS}) do not lead to changes in the input coefficient (a_{ij}^{RS}) and in the value-added coefficient (v_j^S). This is not the case for $DPI(5)JN$, as it is essentially a weighted average of $DPI(4)LTV$ using the final use in country S delivered by industry j in country T (f_j^{TS})

as a share of the total final use in country S delivered by industry j ($\sum_T f_j^{TS}$) as weights. Given that a change in the location of final production leads to a change in these weights, it also affects the DPI.

Table 5 / Differences between the direct and GVC-based DPIs

	DPI				
Sensitive to changes	(1)DDW	(2)FH	(3)KS	(4)LTV	(5)JN
in value added	Yes	No	No	Yes	Yes
at previous production stages	No	No	No	Yes	Yes
in the location of the final production stage	No	No	No	No	Yes

4. Discussion

In this section, we discuss the advantages and disadvantages of the different DPIs. We start by comparing the direct to the GVC-based DPIs. An important advantage of the direct DPIs is that their calculation does not require an IO table, as information about a firm's value added and use of foreign and domestic intermediate inputs is sufficient for the calculation of the direct DPIs. Conversely, GVC-based DPIs do require an IO table and, hence, they can only be calculated at the industry level and not for an individual firm.

Direct DPIs also have an advantage because they help policy makers to identify which industries to target. This contrasts with the GVC-based DPIs, which can hardly be used for industry-specific targeting. For example, suppose that US automobile firms import Japanese tires (i.e. from first-tier suppliers), which are produced using Chinese rubber (i.e. from second-tier suppliers). If the goal is to change the sourcing patterns of US firms, direct DPIs provide a clear advantage as a measurement tool: the US government can effectively regulate the direct import of Japanese tires, whereas it is substantially harder to influence Japanese firms' imports of Chinese rubber.

GVC-based DPIs have a substantial advantage when researchers need to account for the complete value chain. This is necessary when indirect effects are important. For example, traditional gross export statistics often fail to capture how domestic services are indirectly embodied in manufactured exports, thereby understating the importance of the service sector in international trade (Drake-Brockman & Stephenson, 2012; Johnson, 2014; Bohn et al., 2018). By considering these indirect effects, GVC-based DPIs offer a more complete picture of international trade. Furthermore, considering the complete value chain is required to determine the economic nationality of goods, which is calculated based on the share of value added within the country of origin. GVC-based measures are therefore necessary when so-called 'rules of origin' are applied to ensure compliance with trade agreements or trade policies.

Although GVC-based DPIs are designed to capture sourcing decisions across multiple production stages, researchers cannot use them to trace single product chains because IO tables aggregate commodities at the industry level. GVC-based DPIs can instead be used to analyse interconnected 'production chains' rather than isolated individual 'product chains' (Dietzenbacher & Romero, 2007). Production chains are interconnected because industries simultaneously operate as suppliers across multiple chains. Consequently, these production chains are interdependent and cannot be studied independently: a shift in an industry's sourcing pattern affects the production chains of other industries.

Next, we compare the direct DPIs. The main advantage of $DPI(1)DDW$ compared to the other direct DPIs is that it explicitly accounts for changes in value added, which is important for one of the shoring types (i.e. replacing value added with foreign intermediate inputs). This also implies that $DPI(1)DDW$ remains constant when firms outsource production stages that were previously completed in-house, whereas the other direct DPIs would change. A change in the latter DPIs could lead researchers to incorrectly attribute domestic outsourcing to shoring.

Table 6 / Comparing shoring types: A numerical example of outsourcing

		Start (USD)	Outsourcing (USD)	
Domestic intermediate inputs	$\sum_i z_{ij}^{SS}$	2	3	+1
Foreign intermediate inputs	$\sum_{R\neq S}\sum_i z_{ij}^{RS}$	2	2	
Total intermediate inputs	$\sum_R\sum_i z_{ij}^{RS}$	4	5	+1
Value added	v_j^S	2	1	−1
Total outputs	$x_j^S = v_j^S + \sum_R\sum_i z_{ij}^{RS}$	6	6	
$DPI(1)DDW_j^S$	$(\sum_i z_{ij}^{SS} + v_j^S)/\,x_j^S$	4/6	4/6	+0%
$DPI(2)FH_j^S$	$\sum_i z_{ij}^{SS}\,/\sum_R\sum_i z_{ij}^{RS}$	2/4	3/5	+20%
$DPI(3)KS_j^S$	$\sum_i z_{ij}^{SS}\,/\sum_{R\neq S}\sum_i z_{ij}^{RS}$	2/2	3/2	+50%

To illustrate this, suppose that a firm uses USD 2 of domestic and foreign intermediate inputs and adds USD 2 of value. In that case, $DPI(1)DDW = USD\ 4/6$ while $DPI(2)FH = USD\ 2/4$ and $DPI(3)KS = USD\ 2/2$. Suppose that this firm outsources production stages that were previously completed in-house by substituting USD 1 of value added with USD 1 of domestic intermediate inputs. Then we still have $DPI(1)DDW = USD\ 4/6$, while $DPI(2)FH = USD\ 3/5$ and $DPI(3)KS = USD\ 3/2$. In this case, the former DPI remains constant while the latter DPIs increase by 20% and 50%, respectively, which could incorrectly be attributed to reshoring, as domestic participation has seemingly increased. Table 6 provides an overview.

Another disadvantage of $DPI(3)KS$ is that the DPI has foreign intermediate inputs in its denominator. The practical consequence of this is that the DPI is substantially inflated if a firm uses relatively few foreign intermediate inputs. In those cases, relatively small changes in the use of foreign intermediate inputs can lead to relatively large changes in this DPI. The other two indices are, by definition, bound between zero and one.

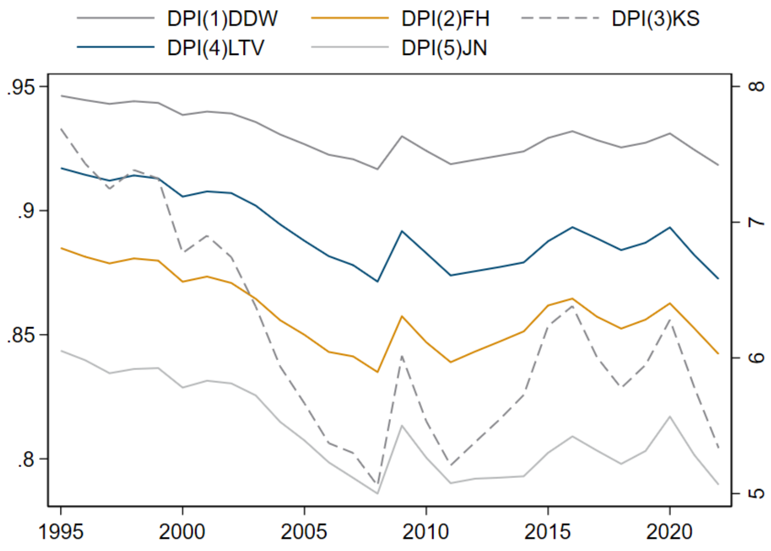
5. Application with IO tables and descriptive trends

In this section, we first confirm that the trends in the DPIs align well with common wisdom about key stages of (de-)globalisation. Second, we look at the distributional properties and pairwise correlations of these DPIs. Third, we provide a country- and industry-specific example by examining the German automotive industry. Our application uses the annual ICIO tables from the Organization for Economic Co-operation and Development (OECD, 2026), which cover 45 industries in 76 countries from 1995 to 2022. Because the 'rest of the world' is included as an additional country, the ICIO tables cover the entire world economy.

5.1. TRACKING THE STAGES OF GLOBALISATION

Figure 2 provides the global trends in the DPIs between 1995 and 2022. These figures are weighted by the value of the denominator for each DPI. We start by discussing the results for $DPI(1)DDW$. We find that the average industry sourced 93% of inputs domestically in 1995 and more than 90% between 1995 and 2022. Despite the emergence of GVCs, industries predominantly rely on domestic inputs. The trend of this DPI also illustrates that – although production was predominantly domestic – it became more global between 1995 and 2008, as it decreased by nearly 3 percentage points, which is in line with the increase in the international fragmentation of production after the 1990s, famously branded as the 'second unbundling' of globalisation by Baldwin (2006).

Figure 2 / Tracking the stages of globalisation: All industries, 1995-2022



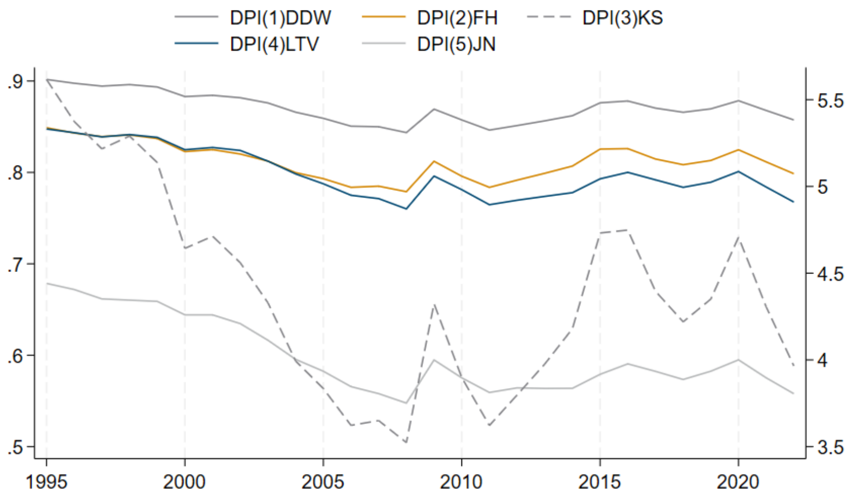
Note: While the RHS axis applies to $DPI(3)KS$, the LHS axis applies to the other DPIs.
Source: Authors' calculations based on the ICIO tables (OECD, 2026).

The trend of this DPI reversed in 2009, as it suddenly increased during the global financial crisis (GFC). Bems et al. (2011) argue that this sudden reversal was due to demand uncertainty, which caused firms to use their remaining stock of intermediate inputs instead of importing the usual amount of intermediate inputs. This sudden reversal was short-lived, however, and the DPI quickly rebounded to its pre-GFC level. We also observe no further decreases of this DPI in the 2010s, which is consistent with the findings of Miroudot & Nordström (2020), who concluded that the pace of globalisation slowed remarkably in the 2010s.

Figure 2 also demonstrates that the average industry entered an era of 'slowbalisation' in the 2010s. In other words, we do not observe a further decrease in this DPI during this period. Los et al. (2015) argue that structural changes in international fragmentation may be due to an increase in transport costs (notably fuel prices) or to an increase in Chinese wages. Alternatively, protectionist government policies and firms' reshoring strategies may have been driving this trend. Finally, we note that the DPI decreases substantially between 2020 and 2022 (i.e. during the COVID-19 era). This implies that, during this period, domestic participation decreased, which is somewhat counterintuitive given that the pandemic caused an unprecedented and rapid disruption to global trade in 2020 (WTO, 2026).

The trends for other DPIs are similar. In Section 5.2, we confirm that these measures are strongly correlated. Given that $DPI(1)DDW$ captures nearly the same variation as the more complex $DPI(4)LTV$ and $DPI(5)JN$, we consider it preferable for most applied purposes due to its simplicity.

Figure 3 / Tracking the stages of globalisation, 1995-2022: Manufacturing



Note: While the RHS axis applies to $DPI(3)KS$, the LHS axis applies to the other DPIs.
Source: Authors' calculations based on the ICIO tables (OECD, 2026).

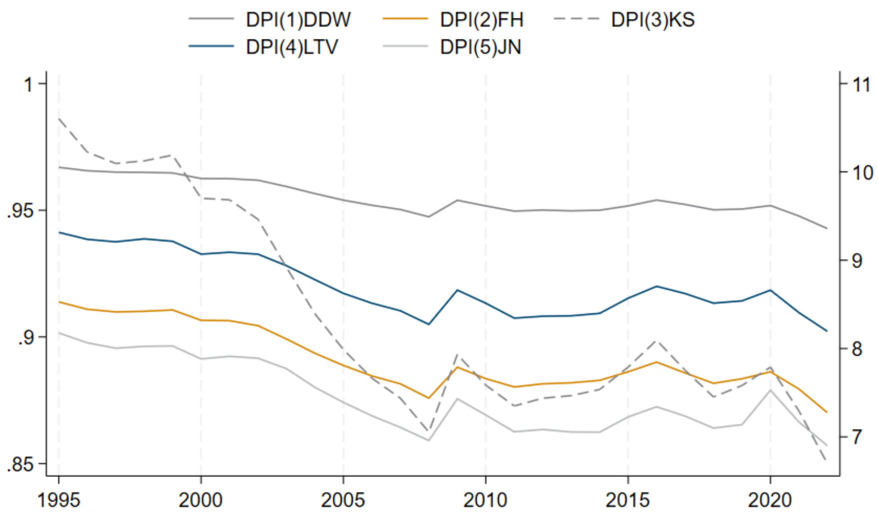
Despite their high correlation, the levels of these measures differ considerably. The reason why the direct DPIs differ from each other can be inferred from equations (1), (2), and (3). Specifically, since $DPI(1)DDW$ counts an industry's value added as a domestic contribution, it always has a higher value than $DPI(2)FH$.[4] $DPI(3)KS$ is plotted using the RHS vertical axis because it tends to have substantially

4 Since $DPI(1)DDW_j^S = \left(\sum_i z_{ij}^{SS} + v_j^S\right)/\left(\sum_R \sum_i z_{ij}^{RS} + v_j^S\right)$ and $DPI(2)FH_j^S = \sum_i z_{ij}^{SS} / \sum_R \sum_i z_{ij}^{RS}$, we have that $DPI(1)DDW_j^S >$ $DPI(2)FH_j^S$ when $v_j^S > 0$ because $\sum_i z_{ij}^{SS} \leq \sum_R \sum_i z_{ij}^{RS}$.

higher values than the other DPIs. The reason for this is that this DPI is not bound between zero and one. Additionally, since industries on average use substantially more domestic intermediate inputs than foreign ones, this implies that $DPI(3)KS$ usually exceeds one.

To understand why $DPI(4)LTV$ is generally higher than $DPI(5)JN$, it is useful to recall how these DPIs are constructed. $DPI(4)LTV$ captures the domestic value added embodied in an industry's final output produced in a specific country, regardless of where it is ultimately used. In contrast, $DPI(5)JN$ captures the domestic value added embodied in an industry's final output used in a specific country, regardless of where it was produced. $DPI(4)LTV$ tends to be higher because many final products are imported. While these products predominantly contain domestic value added from the perspective of the country where the final production stage takes place, that same value added is counted as foreign from the perspective of the importing country.

Figure 4 / Tracking stages of globalisation, 1995-2022: Services



Note: While the RHS axis applies to $DPI(3)KS$, the LHS axis applies to the other DPIs.
Source: Authors' calculations based on the ICIO tables (OECD, 2026).

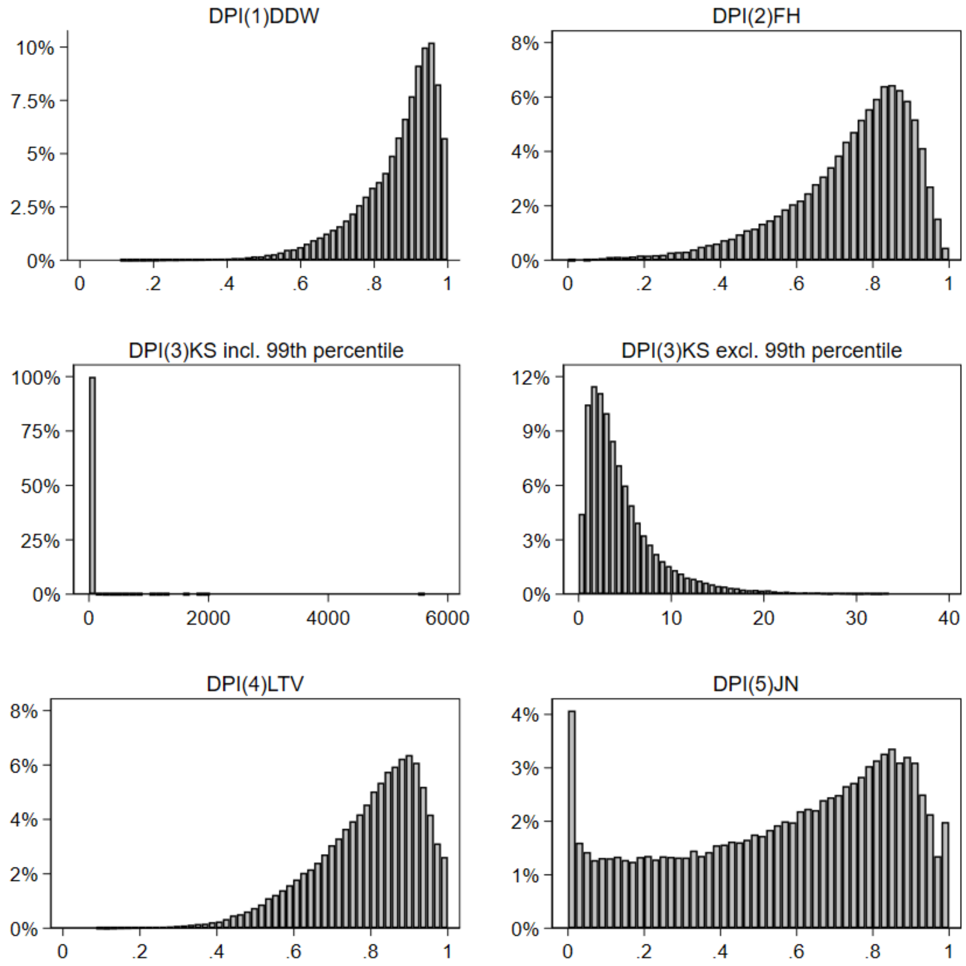
To illustrate this point, consider a car whose final production stage takes place in Germany. The German value added embodied in this car is captured in the German $DPI(4)LTV$ as domestic value added because the final production stage takes place in Germany. However, if the car is exported for final use in Italy, the German value added embodied in this car will be counted as foreign value added in the Italian $DPI(5)JN$. This implies that the value added generated in Germany is no longer 'domestic'. Instead, this value is counted as foreign from the perspective of Italy as the final user. Because Italy relies on many final products (e.g. German cars) for which the final production stage takes place abroad, $DPI(4)LTV$ is on average higher than $DPI(5)JN$.

Figures 3 and 4 present the trends in the DPIs for the average manufacturing and services industries, respectively. Once again, we find that the trends in the DPIs are similar, including across different industries. Similarly, we again observe that, despite their high correlation, these measures differ considerably in levels. The most striking difference between the average manufacturing and services industries is that the former is significantly more global than the latter. Specifically, the average manufacturing industry relies far more on foreign intermediate inputs and value added than the average services industry.

5.2. DISTRIBUTIONAL PROPERTIES AND PAIRWISE CORRELATIONS

Figure 5 displays the distribution of the measures in our dataset for each country-industry-year combination. The value of the DPIs is plotted on the x-axis, while the share of the number of observations with a particular value is plotted on the y-axis. We start by commenting on the distribution of the direct DPIs. $DPI(1)DDW$ and $DPI(2)FH$ range between zero and one and are skewed to the left. In contrast, $DPI(3)KS$ usually exceeds one and is skewed to the right. Despite the fragmentation of production into GVCs – and, hence, the remarkable increase in trade in intermediate inputs since the 1990s (Hummels et al., 2001) – these DPIs indicate that industries predominantly source direct inputs domestically.

Figure 5 / Distribution of the DPIs for each country-industry pair using histograms



Note: While the percentage of the total number of observations is given on the vertical axis, the value of each DPI is given on the horizontal axis.

The distribution of $DPI(3)KS$ is not particularly well-behaved compared to the other direct DPIs, although it is a ratio as well. Recall that it is defined as an industry's purchases of domestic intermediate inputs relative to its purchases of foreign intermediate inputs. The measure uses an industry's purchases of foreign intermediate inputs in the denominator, which distorts the distribution: some industries import very few intermediate inputs, which causes $DPI(3)KS$ to take extremely high values in some cases. This distortion is not immediately apparent in Figure 5, as the bars representing these high values are so small that they are barely visible, making it difficult to observe this aspect directly. Hence, we have plotted $DPI(3)KS$ both including and excluding the 99th percentile. The high sensitivity to such extreme observations makes $DPI(3)KS$ possibly prone to influential outliers in empirical studies.

We continue by comparing $DPI(1)DDW$ to the GVC-based DPIs. The GVC-based DPIs are also clearly skewed to the left. The distributions of $DPI(1)DDW$ and $DPI(4)LTV$ are extremely similar, which illustrates that there may be little to gain from using a more complex measure based on the GVC approach. Although these DPIs have an extremely similar distribution, we only find a correlation of 0.783 in Table 7.

Nevertheless, it is worth highlighting that, compared to $DPI(1)DDW,$ substantially more observations for $DPI(4)LTV$ lie between 0.4 and 0.6. This reflects that foreign intermediate inputs imported by industries may contain both domestic and foreign value added. Even if an industry only imports intermediate inputs, these foreign intermediate inputs may still contain some domestic value added. Suppose that (i) US automobile firms import tires from China and that (ii) the Chinese firms import synthetic US rubber to produce these tires. In this case, the tires used by the US automobile firms contain both US and Chinese value added. The fact that foreign intermediate inputs may contain domestic value added explains why $DPI(1)DDW$ is skewed more than $DPI(4)LTV$.

$DPI(5)JN$ is also left-skewed, but with a lower kurtosis (2.2) – or degree of tailedness – than $DPI(1)DDW$ (7.0) and $DPI(4)LTV$ (4.2). Recall that $DPI(5)JN$ measures the share of domestic value added in a country's use of an industry's final outputs, although irrespective of the country in which this industry is located. A substantial number of observations for $DPI(5)JN$ lie between 0 and 0.6. This reflects that most countries do not only produce final outputs but also import them. Nearly 4% of the observations for $DPI(5)JN$ contain (almost) no domestic value added. This implies that a substantial number of final products are (almost) fully produced abroad and subsequently imported.

$DPI(4)LTV$ illustrates that, on average, and despite the emergence of GVCs, most of the value of an industry's final outputs consists of domestic value added. This domestic value added is foreign value added from the perspective of the country that imports these final outputs. For example, if US consumers purchase both US and Chinese cars, then the US cars contain on average more US value added compared to the Chinese cars. The Chinese cars contain, for example, mostly Chinese value added, which is foreign value added from the perspective of the US. The result is that, in most cases, $DPI(5)JN$ contains substantially more foreign value added than $DPI(4)LTV$. Again, $DPI(5)JN$ is essentially a weighted average of $DPI(4)LTV$ using the final use in country S delivered by industry j in country T as a share of the total final use in country S delivered by industry j ($\sum_T f_j^{TS}$) as weights.

Table 7 provides the pairwise correlations of the DPIs. Consistent with the distributions of the measures in Figure 5, we find that the correlations between $DPI(1)DDW$ and, in particular, $DPI(2)FH$ and $DPI(4)LTV$ are relatively high. The correlation between $DPI(1)DDW$ and the $DPI(5)JN$ is slightly lower, and the correlation with $DPI(3)KS$ is rather weak. We view this as evidence that the direct DPIs provide qualitatively similar information compared to the GVC-based DPIs.

Table 7 / Correlation table

Variables	(1)	(2)	(3)	(4)	(5)
(1) DPI_1	1.000				
(2) DPI_2	0.886***	1.000			
(3) DPI_3	0.157***	0.188***	1.000		
(4) DPI_4	0.955***	0.783***	0.160***	1.000	
(5) DPI_5	0.732***	0.667***	0.132***	0.728***	1.000

*** p<0.01, ** p<0.05, * p<0.1

The fact that the correlation between $DPI(1)DDW$ and $DPI(2)FH$ is high raises the question: what is the advantage of considering not only substitution between domestic and foreign intermediate inputs (as in $DPI(2)FH$), but also substitution between domestic value added and foreign intermediate inputs (as in $DPI(1)DDW$). We point out that these correlations are averages, and that substantial heterogeneity exists for different industry-country-year combinations. This is illustrated in Figure 6.

Figure 6 / Scatterplots and linear fits of the DPIs for each country-industry pair

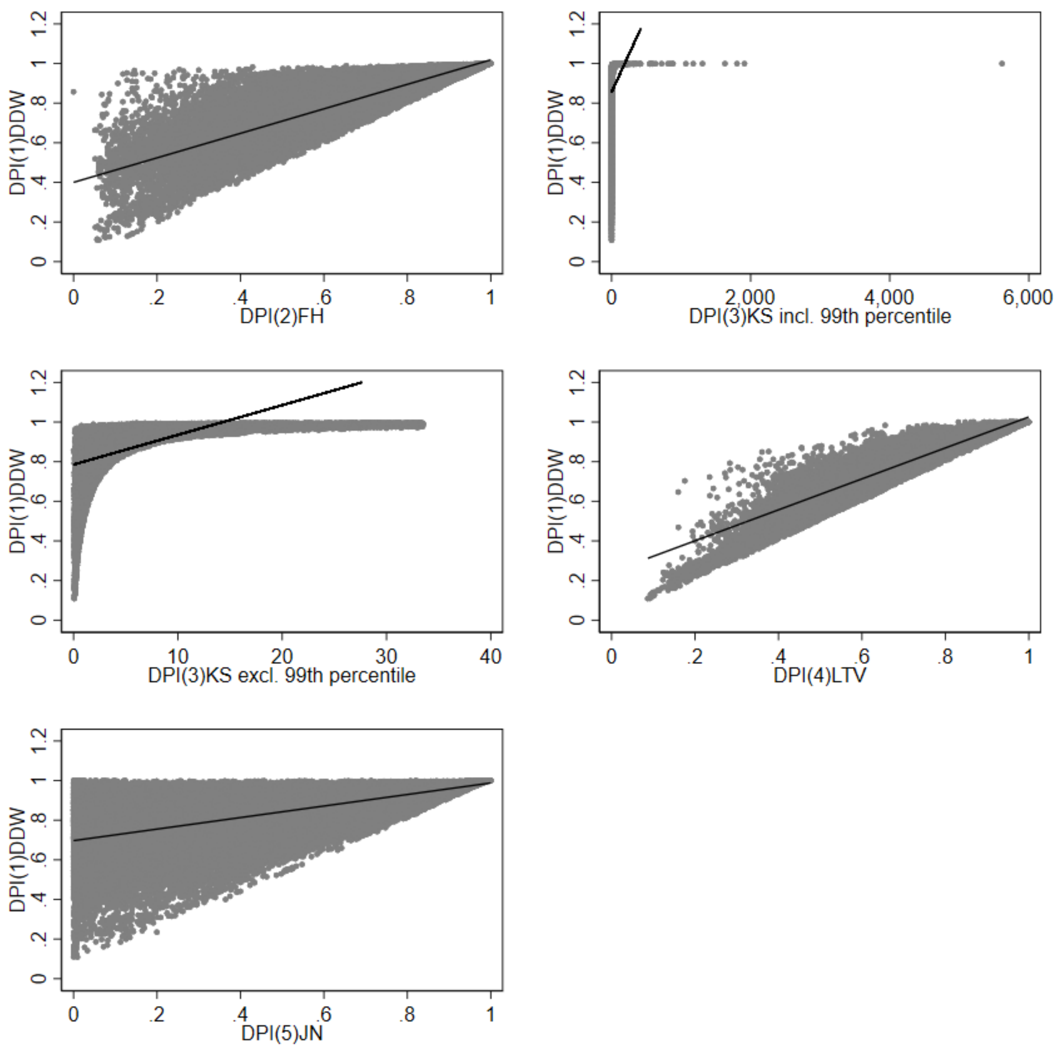
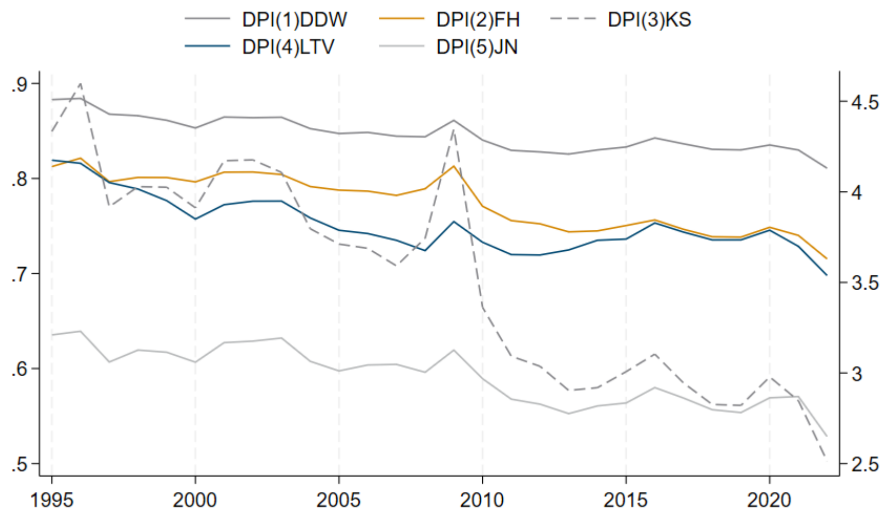


Figure 6 illustrates that there is substantial heterogeneity between the different DPIs. For example, consider the observations for which $DPI(1)DDW$ is approximately equal to 0.8. $DPI(2)FH$ ranges from approximately 0.2 to around 0.8 at this level of $DPI(2)DDW$, which indicates substantial variation. This variation becomes larger at low levels of $DPI(2)FH$. The reason is that when $DPI(2)FH$ is equal to one, $DPI(1)DDW$ is also equal to one because, in that case, industries do not import any intermediate inputs. Substantial variation in value added – which can be driven by shoring – explains the difference between these DPIs when they are not equal to one.

We observe similar patterns when comparing $DPI(1)DDW$ to the GVC-based DPIs. If the GVC-based DPIs are equal to one, then $DPI(1)DDW$ is also equal to one. If the GVC-based DPIs equal one, this implies that final products used in a country are fully produced domestically. The dispersion between $DPI(1)DDW$ and the GVC-based DPIs becomes larger at lower values of the GVC-based DPIs, in particular for $DPI(5)JN$. This again indicates that there is substantial heterogeneity among the different DPIs.

5.3. COUNTRY-SPECIFIC EXAMPLE: GERMAN AUTOMOTIVE INDUSTRY

Figure 7 / A country-specific example: The German automotive industry



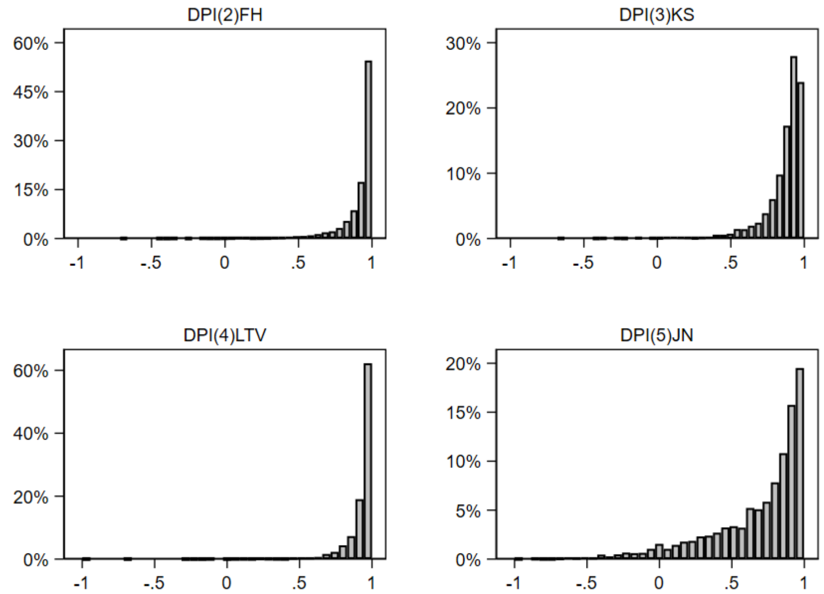
Note: While the RHS axis applies to $DPI(3)KS$, the LHS axis applies to the other DPIs.
Source: Authors' calculations based on the ICIO tables (OECD, 2026).

In this subsection, we highlight that the DPIs strongly correlate even for a specific industry in a specific country. Figure 7 uses the example of the German automotive industry, which has been used as an example several times in the literature (see Timmer et al., 2015; Los et al., 2015). We find that the trend in the DPIs also closely aligns in the German automotive industry. We again find that, despite their strong correlation, these measures exhibit notable differences in levels. Again, since $DPI(1)DDW$ counts an industry's value added as a domestic contribution, it always has a higher value than $DPI(2)FH$. Again, $DPI(4)LTV$ exceeds $DPI(5)JN$ for reasons that we explained at the end of Section 5.1.

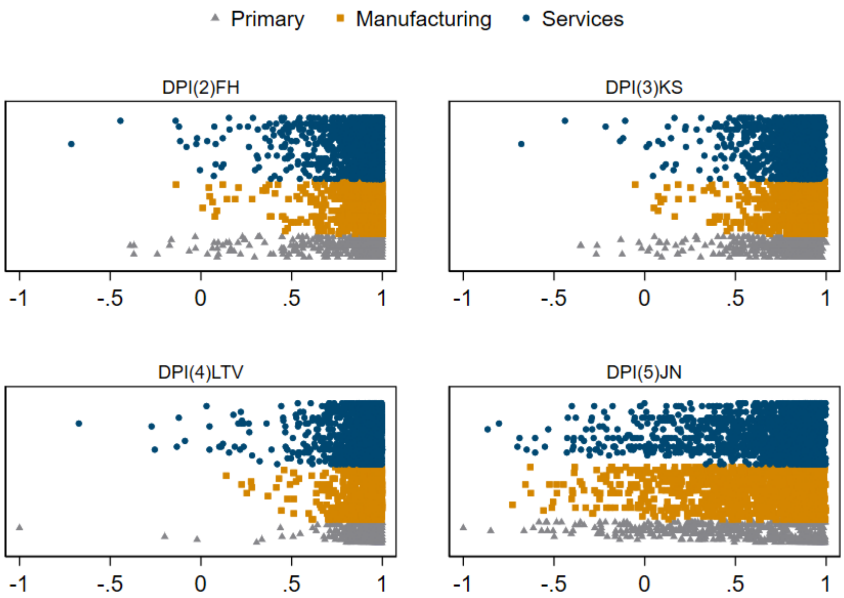
These high correlations are further illustrated by Figure 8, which includes a histogram (in panel A) and as a scatterplot (in panel B) depicting the correlation between $DPI(1)DDW$ and every other DPI for every country-industry pair. Even though the DPIs are highly correlated with $DPI(1)DDW$ for most country-industry pairs, there is still a substantial number of correlations that are substantially weaker. While we find some heterogeneity in specific cases, we generally find that the correlation between these measures is exceptionally high for most industries in most countries.

Figure 8 / Correlation between DPI(1)DDW and other DPIs

Panel A / Histograms for every country-industry pair



Panel B / Scatterplots for every country-industry pair



Source: Authors' calculations based on the ICIO tables (OECD, 2026).

6. Conclusion

This paper provides a systematic overview and comparison of five domestic participation indexes (DPIs) designed to quantify production locations in the global economy. Three DPIs only consider the current production stage, while two DPIs consider the complete value chain. It is important to emphasise that these DPIs do not directly measure shoring activities. Instead, shoring strategies lead to changes in sourcing patterns, which are reflected as shifts in the DPIs.

Our findings confirm that the trends captured by these DPIs align well with common wisdom regarding the key stages of (de-)globalisation between 1995 and 2022. We observe a steady decline in domestic participation between 1995 and 2008, reflecting the 'second unbundling' of international fragmentation and the rise of global value chains (GVCs). This trend was interrupted by a sharp, temporary reversal during the global financial crisis (GFC) of 2009, followed by a period of 'slowbalisation' in the 2010s and a notable decrease in domestic participation during the COVID-19 pandemic.

A central finding of this study is the high degree of similarity between direct and GVC-based measures. Trends in direct DPIs, which focus on the current production stage, are highly similar to those of GVC-based DPIs that trace the value chain upstream. This indicates that the simpler direct measures capture much of the same variation as the more complex GVC-based metrics, although they differ substantially in their absolute levels. Despite these broad similarities, substantial heterogeneity exists among the different DPIs across different country-industry-year combinations.

The choice between these indicators depends on the researcher's specific objectives, as both groups offer distinct advantages. Direct DPIs are advantageous for their simplicity and accessibility, as they do not require input-output (IO) tables and can be calculated for individual firms. Furthermore, they are useful for policy makers seeking to target specific industries, as direct import regulations are easier to implement than those affecting indirect tiers of a supply chain. In contrast, GVC-based DPIs are essential when the research goal is to account for the complete value chain and indirect effects. They are particularly useful for capturing how domestic services are embodied in manufactured exports as well as for determining the 'economic nationality' of goods – a requirement to enforce so-called 'rules of origin' in trade agreements. Ultimately, this paper serves as a methodological guide providing the foundation for researchers and policy makers to accurately assess supply chain reconfigurations and economic resilience.

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Appendix - Empirical approach

Suppose we have N countries, each with n industries.[5] In our empirical application we will work with $n = 45$ industries in $N = 76$ countries. The global multiregional input-output (GMRIO) tables provide the $Nn \times Nn$ matrix $\mathbf{Z}$ of intermediate deliveries, the $Nn \times N$ matrix $\mathbf{F}$ of final use, the Nn-element vector with value added, and the Nn-element output vector $\mathbf{x}$, which are given (in partitioned form) by:

$$\mathbf{Z} = \begin{bmatrix} \mathbf{Z}^{11} & \cdots & \mathbf{Z}^{1R} & \cdots & \mathbf{Z}^{1N} \\ \vdots & \ddots & \vdots & ⋰ & \vdots \\ \mathbf{Z}^{R1} & \cdots & \mathbf{Z}^{RR} & \cdots & \mathbf{Z}^{RN} \\ \vdots & ⋰ & \vdots & \ddots & \vdots \\ \mathbf{Z}^{N1} & \cdots & \mathbf{Z}^{NR} & \cdots & \mathbf{Z}^{NN} \end{bmatrix}, \mathbf{F} = \begin{bmatrix} \mathbf{f}^{11} & \cdots & \mathbf{f}^{1R} & \cdots & \mathbf{f}^{1N} \\ \vdots & \ddots & \vdots & ⋰ & \vdots \\ \mathbf{f}^{R1} & \cdots & \mathbf{f}^{RR} & \cdots & \mathbf{f}^{RN} \\ \vdots & ⋰ & \vdots & \ddots & \vdots \\ \mathbf{f}^{N1} & \cdots & \mathbf{f}^{NR} & \cdots & \mathbf{f}^{NN} \end{bmatrix}, \mathbf{x} = \begin{pmatrix} \mathbf{x}^{1} \\ \vdots \\ \mathbf{x}^{R} \\ \vdots \\ \mathbf{x}^{N} \end{pmatrix}$$

Element z_{ij}^{RS} of the $n \times n$ matrix $\mathbf{Z}^{RS}$ gives the monetary value (in USD millions) of intermediate deliveries from industry i in country R to industry j in country S (e.g. of the sales from the Chinese steel manufacturers to US car manufacturers). Element f_i^{RS} of the n-element vector $\mathbf{f}^{RS}$ gives the deliveries from industry i in country R for final use in country S. Final use includes household consumption, private investment, government expenditures (for consumption and investments), and changes in stocks and inventories (e.g. the sales from US car manufacturers to Canadian households). Note that elements f_i^{RS} are absorbed (in consumption or investment), while elements z_{ij}^{RS} are transmitted to the next production stage. Element x_i^R of the n-element vector $\mathbf{x}^R$ gives the output (or the production volume in USD millions) of industry i in country R, and v_i^R of the n-element vector $\mathbf{v}^R$ gives the value added of industry i in country R. Value added includes the payments for labour (wages and salaries, including employers' contributions), capital (depreciation), entrepreneurial activities (profits), and taxes minus subsidies. These value-added items are also denoted as primary inputs.

In what follows, we use standard input-output techniques (Miller & Blair, 2009). Recall the accounting equation $x_i^R = \sum_S \sum_j z_{ij}^{RS} + \sum_S f_i^{RS}$ for industry i in country R. The Nn accounting equations for all industries are given by:

$$\mathbf{x} = \mathbf{Z}\mathbf{i}_{Nn} + \mathbf{F}\mathbf{i}_{N} \quad \text{(A1)}$$

where $\mathbf{i}_{Nn}$ and $\mathbf{i}_N$ are Nn- and N-element summation vectors consisting of ones.

The columns in matrix $\mathbf{Z}$ express what – on average – the production process of specific industry in a country looks like. The $Nn \times Nn$ matrix $\mathbf{A} = \mathbf{Z}\hat{\mathbf{x}}^{-1}$ gives the average input coefficients (i.e. $\mathbf{A}^{RS} = \mathbf{Z}^{RS}(\hat{\mathbf{x}}^S)^{-1}$ or $a_{ij}^{RS} = z_{ij}^{RS}/x_j^S$), which indicates the intermediate inputs from industry i in country R that are used (on average) per US dollar of output in industry j in country S. Substituting $\mathbf{Z}\mathbf{i}_{Nn} = \mathbf{A}\mathbf{x}$ into the accounting identities (4) yields:

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5 Matrices are in bold capital letters (e.g. $\mathbf{Z}$ or $\mathbf{Z}^{RS}$), vectors are in bold lower case letters (e.g. $\mathbf{x}$ or $\mathbf{x}^R$), and scalars are in italicized letters (e.g. n, x_i^R, or z_{ij}^{RS}). A circumflex (or 'hat') is used to indicate a diagonal matrix (e.g. $\hat{\mathbf{x}}$ or $\hat{\mathbf{x}}^R$), and an apostrophe is used for transposition (e.g. $\mathbf{x}'$ or $(\mathbf{x}^R)'$).

$$\mathbf{x} = \mathbf{A}\mathbf{x} + \mathbf{F}\mathbf{i}_N \tag{A2}$$

which can be rewritten as $(\mathbf{I} - \mathbf{A})\mathbf{x} = \mathbf{F}\mathbf{i}_N$ or

$$\mathbf{x} = (\mathbf{I} - \mathbf{A})^{-1}\mathbf{F}\mathbf{i}_N = \mathbf{L}\mathbf{F}\mathbf{i}_N \tag{A3}$$

where the $Nn \times Nn$ matrix $\mathbf{L} \equiv (\mathbf{I} - \mathbf{A})^{-1}$ is the Leontief inverse, which – in its partitioned form − is given by:

$$\mathbf{L} = \begin{bmatrix} \mathbf{L}^{11} & \cdots & \mathbf{L}^{1R} & \cdots & \mathbf{L}^{1N} \\ \vdots & \ddots & \vdots & ⋰ & \vdots \\ \mathbf{L}^{R1} & \cdots & \mathbf{L}^{RR} & \cdots & \mathbf{L}^{RN} \\ \vdots & ⋰ & \vdots & \ddots & \vdots \\ \mathbf{L}^{N1} & \cdots & \mathbf{L}^{NR} & \cdots & \mathbf{L}^{NN} \end{bmatrix}$$

Element l_{ij}^{RS} of the $n \times n$ matrix $\mathbf{L}^{RS}$ gives the value of deliveries from industry i in country R that are required – directly and indirectly – to produce a US dollar of final output by industry j in country S. Each column of the Leontief inverse $\mathbf{L}$ can be interpreted as a complete overview of the output required by each industry in every country to produce a US dollar of final output by a specific industry in a country.

The Nn-vector $\mathbf{w} = \hat{\mathbf{x}}^{-1}\mathbf{v}$ gives the average value-added coefficients. Specifically, this is $\mathbf{w}^S = (\hat{\mathbf{x}}^S)^{-1}\mathbf{v}^S$ or $w_j^S = v_j^S / x_j^S$, which indicates the value added by industry j in country S (on average) per US dollar of its output. These value-added coefficients ($\mathbf{w}$) are used to transform outputs ($\mathbf{x}$) into value-added terms. That is:

$$\mathbf{B} \equiv \hat{\mathbf{w}}\mathbf{L} \tag{A4}$$

where element $b_{ij}^{RS} = w_i^R l_{ij}^{RS}$ of the $Nn \times Nn$ value-added shares matrix $\mathbf{B}$ gives the value added by industry i in country R that are directly and indirectly necessary (i.e. embodied in) for a US dollar of final output by industry j in country S. The columns of the value-added shares matrix $\mathbf{B}$ sum to unity (i.e. $\mathbf{i}'_{Nn}\mathbf{B} = \mathbf{i}'_{Nn}$) because the value of the final output is entirely made up of pieces of value added in each tier of the production chain. The formal proof is straightforward and comes from the definition of the value-added coefficients. The value added of a sector is equal to its outputs minus all intermediate inputs it uses (i.e. $\mathbf{v}' = \mathbf{x}' - \mathbf{i}'_{Nn}\mathbf{Z}$ or $\mathbf{w}' = \mathbf{i}'_{Nn} - \mathbf{i}'_{Nn}\mathbf{A}$). This yields:

$$\mathbf{i}'_{Nn}\mathbf{B} = \mathbf{i}'_{Nn}\hat{\mathbf{w}}\mathbf{L} = \mathbf{w}'\mathbf{L} = (\mathbf{i}'_{Nn} - \mathbf{i}'_{Nn}\mathbf{A})\mathbf{L} = \mathbf{i}'_{Nn}(\mathbf{I} - \mathbf{A})(\mathbf{I} - \mathbf{A})^{-1} = \mathbf{i}'_{Nn} \tag{A5}$$

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