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Macroeconomic globalisation indicators based on FIGARO

Insights into the measurement of value added and employment in the EU

2024 edition

STATISTICAL WORKING PAPERS

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Abstract

This statistical working paper provides a comprehensive guide to the newly developed macroeconomic globalisation indicators, which were generated through a collaborative effort between the European Commission's Joint Research Centre and Eurostat. These indicators are essential for assessing the European Union's (EU) economic exposure and dependence on global value chains (GVCs), and for informing EU trade and industrial policymakers in an increasingly interconnected global economy.

This paper introduces a novel set of 12 macroeconomic globalisation indicators, derived from the EU inter-country supply, use, and input-output tables, commonly referred to as FIGARO tables. These indicators encompass exports, imports, various forms of value added in exports and value added in final use, GVC participation, total exposure, and employment metrics. They are designed to capture the direct and indirect economic effects across both industries and countries (spillovers), providing a nuanced understanding of the EU's economic interdependencies and vulnerabilities.

A distinctive feature of this paper is its dual perspective analysis, differentiating between the EU as a whole and the EU countries on an individual basis for the intra-EU trade. This approach allows for a granular assessment of broader economic implications of trade activities between the EU and its main trade partners, and within the single market. Additionally, the paper introduces the total exposure indicator, a comprehensive measure of the EU's total exposure to disruptions in trade with specific partners, also via third countries, which is often neglected.

For the sake of transparency, quality assurance procedures are outlined to verify the correctness of the calculations, ensuring that they provide a reliable statistical foundation for policy analysis. By offering these new macroeconomic globalisation indicators, with their associated methodologies and examples in boxes, this paper equips EU policymakers with valuable tools to navigate the complex landscape of international trade and to formulate strategies for a competitive and strategically less dependent European economy.

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Contents

1 Introduction

1.1. Background

Global value chains (GVCs) have reshaped the world we live in the last decades, redefining how international trade functions today. Against the backdrop of rising trade frictions, military conflicts, and a recovery from the COVID-19 pandemic, that caused severe disruption to supply chains, it is important to understand how GVCs affect economies. This topic has become of utmost importance for the European Union (EU). The EU's Political Guidelines for 2024-2029 presented by the European Commission's President, Ursula von der Leyen[1], stressed three central planks for economic foreign policy: economic security, trade and investment in partnerships. Furthermore, the Draghi's Report[2] also emphasised the need to strengthen supply chains and increase economic security. To achieve these goals, whilst also ensuring momentum on the European twin green and digital transition, understanding how GVCs work at macroeconomic level is needed. In response to supply chain vulnerabilities and disruptions, there is nowadays a pressing need to create policies for resilient supply chains and addressing strategic dependencies.

The European Commission has expressed interest in such topics. To mention four examples:

a) the Resilience Dashboards present a broad set of indicators in an interactive way, and aim to help EU countries identify their existing and emerging challenges for further analysis and potential policy actions; the dashboards feature a selection of GVC-related indicators;

b) the European Economy Institutional Papers are important reports analysing the economic situation and economic developments prepared by the European Commission's Directorate-General for Economic and Financial Affairs (DG ECFIN), which serve to underpin economic policy-making by the European Commission, the Council of the European Union and the European Parliament; as an example, the European Economic Forecast 2022 (Spring edition) used GVC indicators to measure vulnerability in trade and value chains;

(1) von der Leyen, U. (2024). Europe's choice. Political guidelines for the next European Commission 2024−2029. European Commission.
(2) Draghi, M. (2024). The future of European competitiveness. European Commission.

c) the EU Industrial R&D Investment Scoreboard 2023 chapter on the automotive business model transformation directly tackles the global value chain phenomena;

d) the Eurostat's Report on Sustainable development in the European Union uses GVC-type indicators to measure spillover effects on EU consumption.

From a macroeconomic perspective, GVCs are usually measured using (multi-country) input-output analysis. One of the advantages of this approach is its ability to provide a comprehensive view of supply chains (direct and indirect effects) across countries and industries. In this report, direct effects are those affecting the reference industry while indirect effects are those affecting other upstream industries. Moreover, there can also be effects among countries/regions, which are denoted as domestic and spillover effects to avoid confusion[3].

Spillover effects may reflect those effects occurring in a given EU country that are supported by the exports of other EU countries or the final use of others. For example, they comprise the effects in a EU country engaged in the production of intermediate inputs to be used in other EU countries' exports to non-EU countries. These effects can include changes in production, employment, income, and overall economic activity in upstream and downstream industries. Very often, spillover effects are being considered relevant when assessing the broader economic implications of changes in demand, investment, or policy decisions within a specific industry. Understanding these indirect (industry) and spillover (country) effects is important for policymakers and analysts to evaluate the potential consequences of EU trade and industrial policies.

The new set of macroeconomic globalisation indicators presented in this report aims to become a statistical reference to facilitate EU policymakers to make informed decisions towards a more competitive, strategically less dependent and more decarbonised European economy. In this context, these indicators can assist policymakers and businesses in understanding the changes in the global trade landscape, such as the growing significance of services, the emergence of regional value chains, and the potential vulnerabilities to trade disruption. Eurostat will annually produce and disseminate this set of **macroeconomic globalisation indicators** for the EU and its main trade partners, estimated using the Eurostat's EU inter-country supply, use and input-output tables, *aka* 'FIGARO' tables.

The new Eurostat's database of macroeconomic globalisation indicators includes 12 indicators, which are:

- **Trade**
    1. Exports – sum of exports for intermediate and final uses.
    2. Imports – sum of imports for intermediate and final uses.
- **Value added in trade**
    3. Domestic value added in exports – gross value added generated in the economy due to its exports.

([3]) As an example, direct domestic effects will refer to the changes in the reference industry of a reference EU country, and indirect domestic effects will refer to the subsequent effects in the upstream industries of the same reference EU country.

4. Foreign value added in exports – gross value added generated elsewhere due to the exports of an economy.

- **Value added in final use**
  5. Domestic value added in foreign final use – gross value added generated in the economy due to the final use of other countries.
  6. Foreign value added in domestic final use – gross value added generated elsewhere due to the domestic final use of the economy.
- **GVC participation**[4]
  7. Forward participation – domestic gross value added in foreign exports as percentage of total exports.
  8. Backward participation – foreign gross value added in exports as percentage of total exports.
  9. Overall participation – sum of forward and backward participation.
- **Exposure**
  10. Total exposure – domestic gross value added generated by the exports of the economy to a trade partner directly and indirectly through third countries.
- **Employment**
  11. Domestic employment in exports – employment supported in the economy due to its exports.
  12. Domestic employment in foreign final use – employment in the economy supported by the final use of other countries.

1.2. EU inter-country supply, use and input-output tables (FIGARO)

The FIGARO tables break down, by industry and product, the main macroeconomic aggregates of the national GDP of countries, also providing explicitly the bilateral trade flows among countries and industries, using international trade in goods and services statistics, among other data sources. The FIGARO[5] tables provide a consistent picture of the world GDP, the world trade and the world economy broken down into the 27 EU countries and their EU-wide 18 main trading partners, in addition to a 'rest of the world' region (Remond-Tiedrez and Rueda-Cantuche, 2019). In the 2024 edition, the FIGARO tables include detailed information about 64 industries and 64 products for the

([4]) It is important to note the limited capacity of these indicators to measure the GVC participation of industries with a high share of processing services, where the goods to be processed does not change ownership and therefore, they are not included in the exports values of national accounts and input-output tables.
([5]) See Remond-Tiedrez and Rueda-Cantuche (2019) for a full description of the methodology to compile the FIGARO tables.

period 2010-2022. Since 2021, the FIGARO tables have been recognised as official statistics, and are produced on a yearly basis by Eurostat.

1.3. Overview of existing similar initiatives

We provide below a (non-exhaustive) list of other existing initiatives from academia, national statistical institutes and international organisations:

- **OECD Trade in Value Added (TiVA) database (2023 edition)**[6]: this collection of GVC indicators contains a selection of the principal indicators that track the origins of value added in exports, imports and final use. The latest edition covers 76 economies (including all OECD, EU, G20 and ASEAN countries) as well as region aggregates. Indicators are available for 45 industries within a hierarchy based on ISIC Rev. 4, for the years 1995-2020.
- **Global Value Chains WITS Database**[7]: produced as part of the World Development Report 2020 exercise and subsequent refinements by the World Bank. Data has been provisioned from multiple data sources, including EORA26 (1990-2015), WIOD 2013 version (1995-2011), WIOD 2016 version (2000-2014), WIOD Long Run (1965-2000), OECD TiVA (1995-2020), and ADB MRIO 2023 version (2000; 2007-2022). They follow the methodology from Borin, Mancini and Taglioni (2021)[8].
- **The UIBE GVC Database**[9]**:** constructed and maintained by Research Institute for Global Value Chains of the University of International Business and Economics (UIBE). This database uses multi-country input-output data from the ADB, WIOD and OECD.
- **UNCTAD-Eora Global Value Chain Database**[10] offers a global coverage (189 countries and a 'rest of the world' region) and a time series from 1990 to 2018 of the key GVC indicators: domestic and foreign value added embodied in exports, and GVC participation indexes.
- **ADB MRIO**[11] **Global Value Chain indicators Database**, at different levels of disaggregation (72 and 62 economies) and also in constant prices. They follow Borin and Mancini's (2019) methodology[12] to decompose exports. They also have real effective exchange rate on the basis of Bems and Johnson (2017) and Patel, Wang and Wei (2019).

(6) https://oe.cd/tiva
(7) https://wits.worldbank.org/gvc/global-value-chains.html
(8) Borin, A., Mancini, M. and Taglione, D. (2021) "Economic Consequences of Trade and Global Value Chain Integration. A Measurement Perspective", World Bank Policy Research Working Paper no. 9785.
(9) RIGVC UIBE,2022, UIBE GVC Database, http://gvcdb.uibe.edu.cn
(10) https://worldmrio.com/unctadgvc/
(11) Asian Development Bank Multiregional Input-Output (ADB-MRIO) Tables. https://kidb.adb.org/globalization (accessed date) & https://www.adb.org/sites/default/files/publication/720461/part3-gvcs.pdf
(12) Borin, A. and Mancini, M. (2019). "Measuring What Matters in Global Value Chains and Value-Added Trade", World Bank Policy Research Working Paper no. 8804.

- Countries such as Germany, the Netherlands and Finland currently produce national GVC indicators. Other countries are working on forthcoming publications, such as Spain. Outside the EU, the US Bureau of Economic Analysis also produces national GVC indicators.

1.4. What is new in this list of indicators?

The most important feature of this new set of macroeconomic globalisation indicators is that it covers **two different perspectives**: the country (national) perspective and the EU (multi-regional) perspective.

One of the EU's most critical considerations is the treatment of intra-EU spillover effects on value added and employment, specifically whether they are categorised as domestic or foreign. For instance, the value added and employment generated by a Czech company selling products to a German company, which then exports to a non-EU partner, could be recorded as Czech value added / employment in exports to Germany, or as Czech value added / employment in exports to a non-EU partner (indirectly via Germany).

This presents two possibilities:

i) a 'country perspective', where the value added/employment generated in a different EU country is considered foreign, and

ii) an 'EU perspective', where the value added/employment generated in a different EU country is considered domestic.

In brief, the need for these two approaches is justified by the own nature of the EU, where trade outside the EU is an exclusive responsibility of the EU, rather than the national governments of EU countries. The main difference between the two approaches lies in how intra-EU trade is treated, either as international trade (country perspective) or domestic trade (EU multi-regional perspective), both of which may respond to different policy questions.

There are **other methodological considerations** that have to be taken into account when comparing the results of this new database with respect to similar indicators published elsewhere.

- **Double counting components**[13]**:** In order to avoid double counting, we adopted the approach introduced by Arto, Dietzenbacher and Rueda-Cantuche (2019)[14], which can be categorised as a source approach with an exporting country perspective, according to the terminology proposed by Borin and Mancini (2023) and Miroudot and Ye (2020)[15].

([13]) Double counting components refer, for instance, to the value added (e.g. metal) incorporated into the export values of products (e.g. cars) when this (e.g. metal) was already accounted for in upstream activities (e.g. metallurgy) as an exported input for the production of intermediate imported inputs (e.g. engines) to produce the goods exported (e.g. cars).
([14]) Arto, I., Dietzenbacher, E., and Rueda-Cantuche, J. M. (2019). Measuring bilateral trade in terms of value added. Report JRC116694. EUR 29751 EN. Publications Office of the European Union, Luxembourg.
([15]) Miroudot, S. and Ye, M. (2020) Decomposing value added in gross exports. Economic Systems Research 33, 67-87.

This approach allows a full decomposition of exports into eight components[16] bilaterally, both country-to-country and from country-industry to country-industry pairs. The calculations were double checked with the European Commission's JRC Trade-Scan tool[17]. The estimated double-counting components were relatively small[18] though.

- **Taxes less subsidies on intermediate products:** By definition, gross value added is the difference between total production (at basic prices) and total intermediate consumption (at purchaser's prices). This is the way basic input-output models are frequently shown in textbooks. However, as intermediate consumption in an input-output system is expressed at basic prices, rather than market prices, this difference is made of two components: taxes less subsidies (TLS) on intermediate products by industry and, strictly speaking, gross value added (2008SNA) at basic prices. This is the reason why existing GVC indicators typically include taxes less subsidies on intermediate products as an additional component of the value added they are trying to measure. This leads to an overestimation in industries, such as refineries, insurance and air transportation services, where the TLS on intermediate products are high in relation to their total gross value added at market prices. In contrast, this new set of macroeconomic globalisation indicators provides for the first time GVC indicators based on gross value added (at basic prices), thus excluding TLS on intermediate products.
- **Direct purchases abroad:** The FIGARO tables currently include a supplementary matrix of direct purchases abroad (OP_RES) by residents and purchases by non-residents in the domestic territory (OP_NRES). These components are technically imports and exports, respectively, but not recorded by customs (mainly reflecting international tourism). These variables can be used to shift from the domestic (*aka* territorial) principle to the national (*aka* residence) principle, providing better estimations for environmental footprints and tourism impacts. However, the GVC indicators presented in this paper are based on the domestic[19] principle, thus, excluding direct purchases abroad by residents in imports and including purchases by non-residents in the domestic territory as domestic consumption instead of exports.

([16]) 1. Domestic value added in intermediate exports; 2. Domestic value added in exports for final uses; 3. Foreign value added in intermediate exports; 4. Foreign value added in exports for final uses; 5-8. Double counting components of each of the previous four components.
([17]) Román, M.V., Rueda-Cantuche, J.M., Amores, A.F. and Florencio, P., Trade-SCAN v2: A user-friendly tool for global value chains analysis, User Guide, Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-19177-3, doi:10.2760/673809, JRC120789
([18]) Provided that Eurostat is not publishing all eight components of the decomposition of gross exports in value added terms, the user may not be able to replicate the total value of gross exports by summing up domestic and foreign value added components. The same applies when separating taxes less subsidies on products.
([19]) To compute the indicators, presented in this paper, based on the territorial principle, the reader should use the FIGARO tables, the equations presented in this paper and the information on OP_RES and OP_NRES published by Eurostat next to the FIGARO tables..

1.5. How to read this manual?

1.5.1. Terminology and mathematical notation

The mathematical expressions of the 12 selected indicators are based on the methodology introduced by Arto, Dietzenbacher and Rueda-Cantuche (2019). This notation is complemented with other auxiliary notation from the theory of sets and logic symbols, whenever appropriate.

For illustrative purposes, there are two sets defined, $\mathbf{EU}$ and $\mathbf{RoW}$, which respectively denote the 27 EU countries and the 19 non-EU economies[20] available in FIGARO.

In formulae, economies can belong to one set or to both, for instance $\mathbf{r} \in \mathbf{EU}$ means that economy $\mathbf{r}$ belongs to the EU, while $\mathbf{r} \in \mathbf{RoW}$ implies that economy $\mathbf{r}$ belongs to the 'rest of the world' region. Similarly, $\mathbf{r} \in \mathbf{EU} \cup \mathbf{RoW}$ denotes that economy $\mathbf{r}$ belongs to any economy available in FIGARO, where $\cup$ indicates the union of sets $\mathbf{EU} \cup \mathbf{RoW}$. The symbol $\forall$ means 'all elements' in one set and $\wedge$ denotes 'and'.

1.5.2. Example boxes

Explanatory boxes with numerical examples are provided along the document to illustrate the calculation of each of the 12 GVC indicators with their components as well as the implemented measures of quality assurance (QA). Data used in the simplified numerical examples are presented for illustrative purposes, and do not necessarily replicate the actual data from the FIGARO tables.

In the boxes, the world economy is schematised into four economies: two sets of EU countries, MS1 and MS2, the United States (US), and one aggregated 'rest of the world' (RoW) region. MS1 includes countries having joined the EU before 2004[21] excluding the United Kingdom, while MS2 gathers countries having joined the EU after 2004[22]. In addition, the original 64 industries in FIGARO are aggregated to three broad industries: primary industry[23], manufacturing[24], and services[25]. Furthermore, the five final use categories[26] in FIGARO are merged into a single final use (FU) category, while gross value added categories[27] are combined into one gross value added (GVA) category. Finally, the TLS category remains as a single category for illustrative purposes.

([20]) Argentina, Australia, Brazil, Canada, China, India, Indonesia, Japan, Mexico, Norway, Russia, Saudi Arabia, South Africa, South Korea, Switzerland, Türkiye, the United Kingdom, the United States, and a 'rest of the world' region.
([21]) Austria, Belgium, Germany, Denmark, Spain, France, Greece, Ireland, Italy, Luxembourg, Malta, the Netherlands, and Portugal.
([22]) Bulgaria, Cyprus, Czechia, Estonia, Finland, Croatia, Hungary, Lithuania, Latvia, Poland, Romania, Sweden, Slovenia, and Slovakia.
([23]) NACE Rev. 2 sections A and B.
([24]) NACE Rev. 2 section C.
([25]) All NACE Rev. 2 sections except for A, B, and C.
([26]) Final consumption expenditure of general government (P3_S13), final consumption expenditure of households (P3_S14), final consumption expenditure of non-profit institutions serving households (P3_S15), gross fixed capital formation (P51G), and changes in inventories and acquisition less disposals of valuables (P5M).
([27]) Compensation of employees (D1), other net taxes on production (D29X39), and gross operating surplus (B2A3G).

As supplementary material, a Microsoft Excel file containing all the results presented in the explanatory boxes, as well as the simplified inter-country input-output table (ICIO) and all the steps required for the calculation of the 12 indicators, is available on the Eurostat website.

1.5.3. Infographics

Visuals are included along the document to illustrate the set of 12 macroeconomic globalisation indicators. These are all in line with the simplified global value chains shown in Figure 1, which presents a schematic view of direct and indirect trade relations between five world economies: the EU, the US, China, India, and the rest of the world (RoW). It is worth noting that, depending on the case, the RoW may include some of the other four world economies.

FIGURE 1

Streamlined global value chains

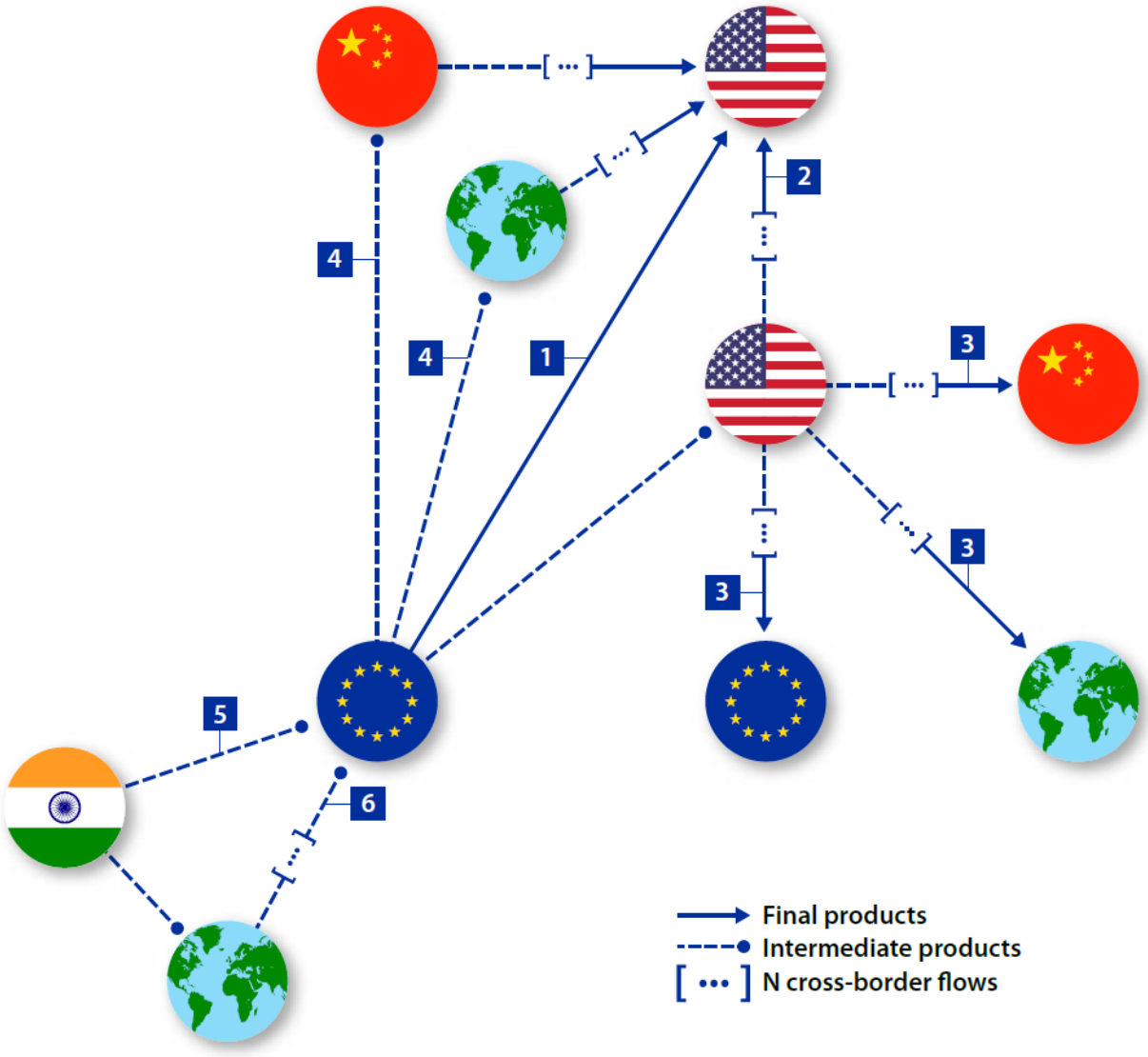


Figure 1 illustrates the streamlined GVCs, with the EU as the exporting region and the US as the partner economy. There are two types of exports depicted: final products (indicated by a solid line, labelled as flow number 1) and intermediate products (represented by a dashed line). Intermediate exports from the EU to the US may serve two purposes: they can be used in the manufacturing of US exports to other economies (denoted as flow number 3), or they can be integrated into products for final consumption within the US (marked as flow number 2). Furthermore, the EU has the capability to export intermediate products to third-party countries, such as China. These Chinese imports may then be processed into finished products that eventually find their way into the US market for final use (highlighted as flow number 4). Eventually, the production of EU exports may incorporate imports from countries such as India. These imports might arrive directly (identified as flow number 5) or indirectly, via third countries (flow number 6).

In the infographics, trade flows of goods and services for final uses are represented by solid lines while trade flows of goods and services for intermediate uses are represented by dashed lines. The three bracketed dots illustrate a number of finite (N) stages in the value chain before reaching the final user.

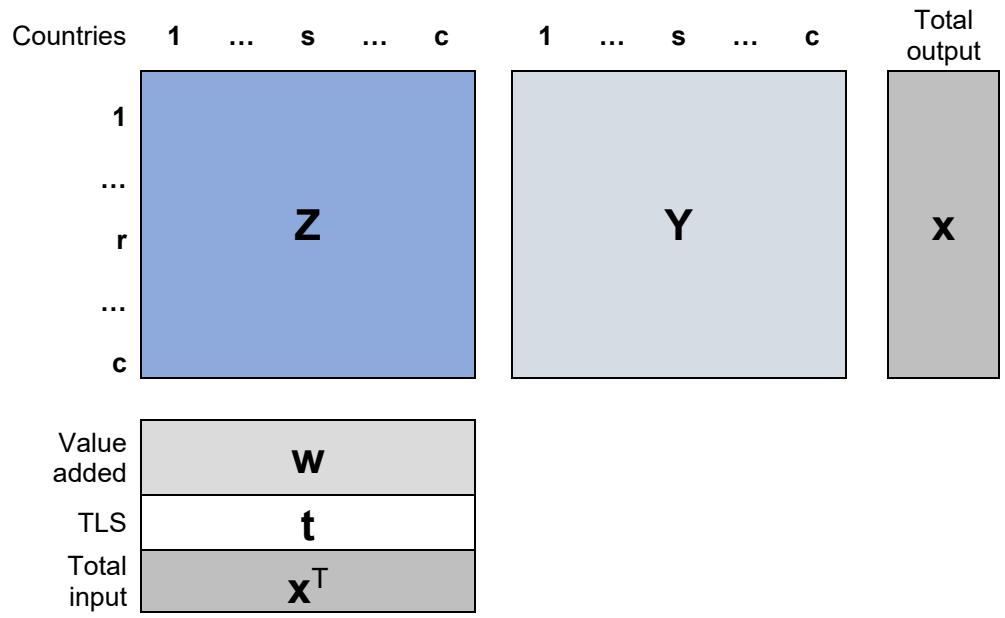
For instance, Figure 1 features among others the case of a EU export of goods A to China (flow 4) which are incorporated into the Chinese exports of goods B to Brazil, which in turn can be used to produce goods C that Brazil will export to India for the production of goods D that will eventually be exported to US as final products. In this particular case, the value chain has N=2 stages (Brazil and India) before reaching the final user (US).

2 Methods

2.1. General

The FIGARO industry-by-industry inter-country input-output (ICIO) tables are used to calculate the set of 12 macroeconomic globalisation indicators. By definition, for each economy, the total output should equal the total input. As illustrated in Table 1, the production of each economy can be used as intermediate inputs into other countries ($\mathbf{Z}$) or as products for final use ($\mathbf{Y}$) in other countries. This can be expressed mathematically as $\mathbf{x} = \mathbf{Zu} + \mathbf{Yn}$, where $\mathbf{u}$ and $\mathbf{n}$ are summation vectors with the appropriate dimensions. Similarly, the total production can be expressed[28] as $(\mathbf{x})^{\mathrm{T}} = (\mathbf{u})^{\mathrm{T}}\mathbf{Z} + \mathbf{t} + \mathbf{w}$, where $\mathbf{w}$ is the gross value added and $\mathbf{t}$ the taxes less subsidies on intermediate products.

Table 1. FIGARO industry by industry ICIO framework (simplified)



([28]) $^{\mathrm{T}}$ denotes transposition of a vector, uppercase indicates matrices and lowercase indicates vectors.

The technical (or input) coefficient matrix is defined[29] as $\mathbf{A^{rs}} = \mathbf{Z^{rs}}\langle \mathbf{x^s} \rangle^{-1}$, which describes input requirements from economy $\mathbf{r}$ per unit of industry output of economy $\mathbf{s}$. Here, $\langle \mathbf{x^s} \rangle$ denote diagonalisation of vector $\mathbf{x}$, and $\langle \mathbf{x} \rangle^{-1}$ is the inversion of matrix $\langle \mathbf{x} \rangle$. $\mathbf{I}$ is the identity matrix.

First, three types of matrices are computed in order to obtain the new set of indicators:

- the local Leontief inverses: $\mathbf{L^{rr}} = (\mathbf{I} - \mathbf{A^{rs}})^{-1} \ \forall \ \mathbf{r} = \mathbf{s} \in \mathbf{EU} \cup \mathbf{RoW} \ \wedge \ \mathbf{r} \neq \mathbf{s} \in \emptyset$,
- the global Leontief inverse: $\mathbf{B^{rs}} = (\mathbf{I} - \mathbf{A^{rs}})^{-1} \ \forall \ \mathbf{r}, \mathbf{s} \in \mathbf{EU} \cup \mathbf{RoW}$, and
- the EU multi-regional Leontief inverse: $\mathbf{R^{rs}} = (\mathbf{I} - \mathbf{A^{rs}})^{-1} \ \forall \ \mathbf{r}, \mathbf{s} \in \mathbf{EU}$.

For value added[30], $\mathbf{v^s} = \mathbf{w^s}\langle \mathbf{x^s} \rangle^{-1}$ stands for the gross value added per unit of industry output (*aka* GVA coefficient) of country $\mathbf{s}$. Similarly, employment in country $\mathbf{s}$ per unit of industry output is obtained following the equation[31] $\boldsymbol{\beta^s} = \boldsymbol{\alpha^s}\langle \mathbf{x^s} \rangle^{-1}$, where $\boldsymbol{\alpha^s}$ is total employment by industry in thousands of jobs for country $\mathbf{s}$.

Box 1. Input-output framework

Table 2 presents a simplified inter-country input-output table featuring four regions: two sets of EU countries (labelled MS1 and MS2), the United States (US), and one 'rest of the world' (RoW) region. The table encompasses three industries: the primary industry (denoted as P), manufacturing (M), and services (S), along with one category for final use (FU). Additionally, the table includes gross value added (GVA) and a row for taxes less subsidies (TLS) on intermediate products.

In an input-output framework, total output (TO) must equal total input (TI). The table visually differentiates domestic transactions with dark blue colour.

Table 2. Simplified input-output table for four regions, three industries, one final use, one gross value added category, and TLS

		MS1 P	MS1 M	MS1 S	MS2 P	MS2 M	MS2 S	US P	US M	US S	RoW P	RoW M	RoW S	MS1 FU	MS2 FU	US FU	RoW FU	TO
MS1	P	59	247	61	1	5	2	0	1	0	2	13	4	134	5	2	13	**550**
MS1	M	94	1,857	1,119	7	178	63	7	92	55	27	428	206	1,829	153	163	598	**6,876**
MS1	S	116	1,648	6,521	2	42	93	3	32	99	17	167	418	9,073	41	65	334	**18,673**
MS2	P	1	10	1	31	79	24	0	0	0	1	7	2	6	50	0	4	**217**
MS2	M	3	166	60	25	368	245	1	14	10	7	95	52	163	328	24	120	**1,681**
MS2	S	2	54	104	38	328	1,134	0	3	14	4	35	75	38	1,775	12	59	**3,676**
US	P	0	26	5	0	3	1	183	499	126	15	104	25	3	0	193	30	**1,214**
US	M	1	38	18	0	7	3	122	1,437	1,620	24	326	158	58	8	2,436	395	**6,651**
US	S	2	71	134	0	8	17	278	1,205	11,408	18	186	369	46	4	20,613	324	**34,683**
RoW	P	3	144	24	2	49	13	5	131	6	1,124	3,799	835	31	7	35	1,794	**8,002**
RoW	M	8	381	156	4	128	49	27	405	294	1,065	14,497	7,583	458	116	996	10,939	**37,107**
RoW	S	9	219	498	2	40	86	15	154	421	1,092	6,959	19,133	181	40	223	37,533	**66,603**
GVA		243	1,979	9,676	98	434	1,874	570	2,623	20,386	4,492	10,188	36,492					
TLS		9	37	296	5	10	74	2	54	245	115	302	1252					
TI		**550**	**6,876**	**18,673**	**217**	**1,681**	**3,676**	**1,214**	**6,651**	**34,683**	**8,002**	**37,107**	**66,603**					

([29]) $\mathbf{Z^{rs}}$ is a matrix (with n x n industries) of bilateral trade of intermediate products between country $\mathbf{r}$ and country $\mathbf{s}$; and $\mathbf{x^s}$ is the total output of economy $\mathbf{s}$ by industries.
([30]) $\mathbf{w^s}$ is the gross value added of economy $\mathbf{s}$ by industries.
([31]) Greek letters here emphasise different units of measurement (i.e. number of jobs).

Table 3 presents the technical coefficient matrix, which is derived from Table 2. This matrix provides insight into the inter-industry requirements for production. For instance, to generate one billion euro of output in the primary industry of MS2, it is necessary to use 0.03 billion euros (30 million euros) worth of inputs from the manufacturing industry of MS1. This result is calculated by dividing 7 billion euros worth of inputs sourced from MS1's manufacturing industry by the total primary industry output of MS2, which amounts to 217 billion euros.

Table 3. Technical coefficient matrix

		MS1 P	MS1 M	MS1 S	MS2 P	MS2 M	MS2 S	US P	US M	US S	RoW P	RoW M	RoW S
MS1	P	0.11	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MS1	M	0.17	0.27	0.06	**0.03**	0.11	0.02	0.01	0.01	0.00	0.00	0.01	0.00
MS1	S	0.21	0.24	0.35	0.01	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.01
MS2	P	0.00	0.00	0.00	0.14	0.05	0.01	0.00	0.00	0.00	0.00	0.00	0.00
MS2	M	0.01	0.02	0.00	0.12	0.22	0.07	0.00	0.00	0.00	0.00	0.00	0.00
MS2	S	0.00	0.01	0.01	0.18	0.20	0.31	0.00	0.00	0.00	0.00	0.00	0.00
US	P	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.08	0.00	0.00	0.00	0.00
US	M	0.00	0.01	0.00	0.00	0.00	0.00	0.10	0.22	0.05	0.00	0.01	0.00
US	S	0.00	0.01	0.01	0.00	0.00	0.00	0.23	0.18	0.33	0.00	0.01	0.01
RoW	P	0.01	0.02	0.00	0.01	0.03	0.00	0.00	0.02	0.00	0.14	0.10	0.01
RoW	M	0.02	0.06	0.01	0.02	0.08	0.01	0.02	0.06	0.01	0.13	0.39	0.11
RoW	S	0.02	0.03	0.03	0.01	0.02	0.02	0.01	0.02	0.01	0.14	0.19	0.29

Table 4 depicts the global Leontief inverse matrix, which measures the interdependencies between industries and regions within a global framework. The economic interpretation of the matrix is as follows: for every billion euro of MS1's final use of products produced in its manufacturing industry, an output of 0.15 billion euros (150 million euros) is required in the services industry of the RoW region. This figure represents the direct and indirect input requirements of the RoW services industry in the production of products for final use by the MS1's manufacturing industry.

Table 4. Global Leontief inverse matrix

		MS1 P	MS1 M	MS1 S	MS2 P	MS2 M	MS2 S	US P	US M	US S	RoW P	RoW M	RoW S
MS1	P	1.13	0.06	0.01	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MS1	M	0.31	1.44	0.14	0.10	0.23	0.07	0.02	0.03	0.01	0.01	0.04	0.01
MS1	S	0.49	0.56	1.59	0.09	0.16	0.09	0.02	0.03	0.01	0.02	0.03	0.02
MS2	P	0.00	0.01	0.00	1.18	0.08	0.02	0.00	0.00	0.00	0.00	0.00	0.00
MS2	M	0.02	0.05	0.01	0.21	1.34	0.13	0.00	0.01	0.00	0.00	0.01	0.00
MS2	S	0.02	0.04	0.02	0.36	0.40	1.49	0.00	0.00	0.00	0.00	0.01	0.00
US	P	0.00	0.01	0.00	0.00	0.01	0.00	1.20	0.12	0.01	0.00	0.01	0.00
US	M	0.01	0.02	0.01	0.01	0.02	0.01	0.18	1.32	0.09	0.01	0.03	0.01
US	S	0.02	0.04	0.02	0.01	0.03	0.02	0.46	0.40	1.52	0.01	0.03	0.02
RoW	P	0.03	0.06	0.01	0.04	0.09	0.02	0.02	0.05	0.01	1.21	0.22	0.06
RoW	M	0.09	0.19	0.06	0.11	0.25	0.08	0.09	0.18	0.04	0.33	1.80	0.30
RoW	S	0.09	**0.15**	0.09	0.08	0.16	0.09	0.06	0.11	0.04	0.32	0.52	1.49

Table 5 illustrates the local Leontief inverse matrix in a block matrix format, where the local Leontief inverse matrices for each country are positioned along the main diagonal and the off-diagonal elements are zero. This matrix indicates that for every billion euro of US final use of products produced by its manufacturing industry, there is an input requirement of 0.39 billion euros (390 million euros) from the US services industry. These figures include all the gross value added generated throughout the domestic supply chains, implying that the values will consistently be lower than those found in the global Leontief inverse matrix, which also accounts for international trade spillovers.

Table 5. Local Leontief inverse matrix

		MS1 P	MS1 M	MS1 S	MS2 P	MS2 M	MS2 S	US P	US M	US S	RoW P	RoW M	RoW S
MS1	P	1.13	0.06	0.01									
MS1	M	0.30	1.43	0.13									
MS1	S	0.48	0.55	1.59									
MS2	P				1.18	0.08	0.02						
MS2	M				0.21	1.33	0.13						
MS2	S				0.36	0.39	1.49						
US	P							1.20	0.12	0.01			
US	M							0.18	1.31	0.09			
US	S							0.46	0.39	1.52			
RoW	P										1.21	0.22	0.06
RoW	M										0.32	1.78	0.29
RoW	S										0.32	0.51	1.49

Table 6 displays the EU multi-regional Leontief inverse matrix. This matrix is computed by considering intra-EU trade as domestic trade flows. Consequently, the values are greater than those in the local Leontief inverse matrix, which focuses on individual country-wise domestic trade flows, but are lower than those of the global Leontief inverse matrix, which includes international linkages beyond the EU. For instance, for every billion euro of MS2's final use of products supplied by its services industry, there is an input requirement of 0.06 billion euros (60 million euros) from the manufacturing industry of MS1.

Table 6. EU multi-regional Leontief inverse matrix

		MS1 P	MS1 M	MS1 S	MS2 P	MS2 M	MS2 S
MS1	P	1.13	0.06	0.01	0.01	0.01	0.00
MS1	M	0.31	1.44	0.14	0.10	0.22	0.06
MS1	S	0.48	0.55	1.59	0.08	0.16	0.09
MS2	P	0.00	0.01	0.00	1.18	0.08	0.02
MS2	M	0.02	0.05	0.01	0.21	1.33	0.13
MS2	S	0.02	0.04	0.02	0.36	0.40	1.49

2.2. Trade

2.2.1. Exports

Exports ($\mathbf{e^{rs}}$) from country $\mathbf{r}$ to country $\mathbf{s}$, including both exports for intermediate and for final uses[32], are defined in equation 1 as:

$$\mathbf{e^{rs}} = \mathbf{Z^{rs}u} + \mathbf{y^{rs}} \qquad (1)$$
$$(\mathbf{r} \in \mathbf{EU}) \wedge (\mathbf{s} \in \mathbf{EU} \cup \mathbf{RoW}) \; \forall \; \mathbf{r} \neq \mathbf{s}$$

The EU perspective is a particular case when $\mathbf{s} \in \mathbf{RoW}$.

([32]) $\mathbf{y^{rs}}$ is a column vector (with n industries) of bilateral trade between country $\mathbf{r}$ and country $\mathbf{s}$, assuming one single category of final use.

2.2.2. Imports

Imports ($\mathbf{m^{rs}}$) of country $\mathbf{s}$ from country $\mathbf{r}$, including both imports for intermediate and for final uses, are defined in equation 2[33] as:

$$\mathbf{m^{rs}} = \mathbf{Z^{rs}u} + \mathbf{y^{rs}} \quad (2)$$
$$(\mathbf{r} \in \mathbf{EU} \cup \mathbf{RoW}) \wedge (\mathbf{s} \in \mathbf{EU}) \ \forall \mathbf{r} \neq \mathbf{s}$$

In this case, the EU perspective is a particular case when $\mathbf{r} \in \mathbf{RoW}$.

Box 2. Exports and imports

Table 7 describes how exports (EX) and imports (IM) are derived by summing certain elements of the rows and columns of the inter-country input-output table. Beforehand, the inter-country input-output table is simplified by summing up intermediate and final uses, by removing domestic transactions of countries in both intermediate and final uses, and by removing all trade flows among non-EU countries (i.e. US and RoW). These elements appear as empty cells in Table 7. Regarding other trade flows, the dark blue cells correspond to intra-EU trade, which is considered 'international' from the country perspective but domestic from the EU perspective. Other trade figures correspond to extra-EU trade.

Table 7. Exports and imports

		MS1	MS2	US	RoW	EX
MS1	P		13	3	32	**49**
MS1	M		401	317	1,259	**1,978**
MS1	S		179	**199**	936	**1,315**
MS2	P	18		1	14	**33**
MS2	M	393		49	272	**714**
MS2	S	198		30	173	**401**
US	P	34	4			**38**
US	M	114	18			**132**
US	S	252	30			**282**
RoW	P	202	71			**273**
RoW	M	1,003	298			**1,301**
RoW	S	907	168			**1,075**
IM		**3,122**	**1,182**	**599**	**2,687**	**7,590**

In 2022, the MS1's services industry exported 199 billion euros to the US, which results from the sum of intermediate exports (broken down as 3+32+99 billion euros) and the exports of services for final use (65 billion euros), as detailed in Table 2. It is important to note that Table 7 does not display the importing industry or final user.

([33]) Equations 1 and 2 have the same right hand side formulation since the exports of country **r** to country **s** are also imports of country **s** from country **r**.

2.3. Value added in exports

2.3.1. Domestic value added in exports

The domestic value added in exports is one of the most well-known GVC indicators. It reflects the value added generated in the reference economy, both directly and indirectly in other upstream activities of the same exporting economy. This enables a more accurate estimation of the value added contribution of trade as a share of GDP. However, this indicator does not reflect the foreign value added contribution that is not generated domestically (see next indicator). This indicator is often used to measure the GVC participation compared to other countries.

From the EU perspective, $\mathbf{D^{tr}}$ is the matrix of domestic value added generated in EU country $\mathbf{t}$ due to the exports of EU country $\mathbf{r}$ to any non-EU economy $\mathbf{s}$. Each element of the matrix is defined in equation 3 as:

$$\mathbf{D^{tr}} = \langle \mathbf{v^{t}} \rangle \mathbf{R^{tr}} \langle \mathbf{e^{rs}} \rangle \quad (\mathbf{t}, \mathbf{r} \in \mathbf{EU}) \wedge (\mathbf{s} \in \mathbf{RoW}) \tag{3}$$

From the country perspective, $\mathbf{D^{rr}}$ is the matrix of domestic value added generated in country $\mathbf{r}$ due to their exports to any importing economy $\mathbf{s}$. The matrix is defined in equation 4 as:

$$\mathbf{D^{rr}} = \langle \mathbf{v^{r}} \rangle \mathbf{L^{rr}} \langle \mathbf{e^{rs}} \rangle \quad (\mathbf{r} \in \mathbf{EU}) \wedge (\mathbf{s} \in \mathbf{EU} \cup \mathbf{RoW}) \; \forall \; \mathbf{r} \neq \mathbf{s} \tag{4}$$

The difference between equations 3 and 4 is twofold. First, while in equation 4 the value added is generated in the reference economy alone (although maybe in a different industry), equation 3 allows spillover effects across EU countries, being them considered domestic under the EU perspective. This also explains the use of $\mathbf{R^{tr}}$ and $\mathbf{L^{rr}}$. Second, exports include intra-EU trade in equation 4, differently from equation 3, where only extra-EU trade is considered.

Box 3. Domestic value added in exports

Equation 3 yields a double-entry matrix where the origin of value added is displayed in rows, indicating in which country the value added is generated. This is described in Table 8 for the exports to the US and in Table 9 for the exports to the RoW. The matrix also shows the exporting economy in columns.

Consequently, the row sum of Table 8 yields the amount of gross value added that is generated in a specific industry due to the exports of all EU countries, while the column sum is the domestic value added generated in all EU countries due to the total country exports of a specific industry. For instance, row-wise, the exports of the manufacturing industry of MS1 (131 billion euros) and MS2 (3 billion euros) and the exports of the services industry of MS1 (8 billion euros) and MS2 (1 million euro), both to US, generated a total of 143 billion euros of value added in the manufacturing industry of MS1.

Column-wise, as shown in Table 9, the exports of the manufacturing industry of MS1 to the RoW generated a total of 959 billion euros of value added, of which 915 billion euros (33+521+361) in

MS1 and 44 billion euros (3+17+24) in MS2. The latter is often defined as country spillovers because the value added is generated in a EU country different from the exporting country.

Table 8. EU valued added in exports to the US (EU perspective)

		MS1 P	MS1 M	MS1 S	MS2 P	MS2 M	MS2 S	GVA
MS1	P	2	8	1	0	0	0	11
MS1	M	0	131	8	0	3	1	143
MS1	S	1	91	164	0	4	1	261
MS2	P	0	1	0	0	2	0	3
MS2	M	0	4	1	0	17	1	23
MS2	S	0	6	2	0	10	23	41
GVA		3	241	176	1	36	26	482

Table 9. EU valued added in exports to the RoW (EU perspective)

		MS1 P	MS1 M	MS1 S	MS2 P	MS2 M	MS2 S	GVA
MS1	P	16	33	5	0	2	0	56
MS1	M	3	521	37	0	17	3	582
MS1	S	8	361	772	1	22	8	1,171
MS2	P	0	3	1	8	9	1	22
MS2	M	0	17	3	1	94	6	120
MS2	S	0	24	9	3	56	131	222
GVA		28	959	826	12	200	150	2,174

For equation 4, the off-diagonal blocks of Tables 10 and 11 are set to zero by definition since the local Leontief inverse matrix is used to calculate the domestic value added. Consequently, from the perspective of the country, the domestic value added content of the exports of the MS1's manufacturing industry amounts to 228 billion euros, which is the sum of the gross value added generated in the primary, manufacturing and services industry of MS1, calculated as 8+130+90 billion euros. The same applies to the MS1's exports of the manufacturing industry to the rest of the world, amounting to 907 billion euros.

Table 10. EU valued added in exports to the US (MS perspective)

		MS1 P	MS1 M	MS1 S	MS2 P	MS2 M	MS2 S	GVA
MS1	P	2	8	1				11
MS1	M	0	130	8				138
MS1	S	1	90	164				254
MS2	P				0	2	0	2
MS2	M				0	17	1	18
MS2	S				0	10	23	33
GVA		3	228	173	1	28	24	456

Table 11. EU valued added in exports to the RoW (MS perspective)

		MS1 P	MS1 M	MS1 S	MS2 P	MS2 M	MS2 S	GVA
MS1	P	16	33	5				54
MS1	M	3	518	36				556
MS1	S	8	356	771				1,135
MS2	P				8	9	1	18
MS2	M				1	93	6	100
MS2	S				3	55	131	188
GVA		27	907	812	11	157	138	2,052

Considering that intra-EU trade is treated as foreign trade from the country perspective, one can calculate the amount of value added generated in MS1 due to its exports to MS2, as shown in Table 12, as well as the value added generated in MS2 resulting from its exports to MS1, as shown in Table 13. For instance, the exports from the manufacturing industry of MS1 to MS2 generated a total of 289 billion euros of value added in MS1. This amount includes 165 billion euros of value added generated in the manufacturing industry itself, and indirectly an additional 11 billion euros and 113 billion euros in the primary and services industries, respectively.

Table 12. MS1 value added in exports to MS2

		MS1 P	MS1 M	MS1 S	GVA
MS1	P	7	11	1	18
MS1	M	1	165	7	173
MS1	S	3	113	148	264
GVA		11	289	155	455

Table 13. MS2 value added in exports to MS1

		MS2 P	MS2 M	MS2 S	GVA
MS2	P	10	13	2	25
MS2	M	1	135	7	142
MS2	S	3	79	150	232
GVA		14	227	158	399

FIGURE 2

Domestic value added in exports

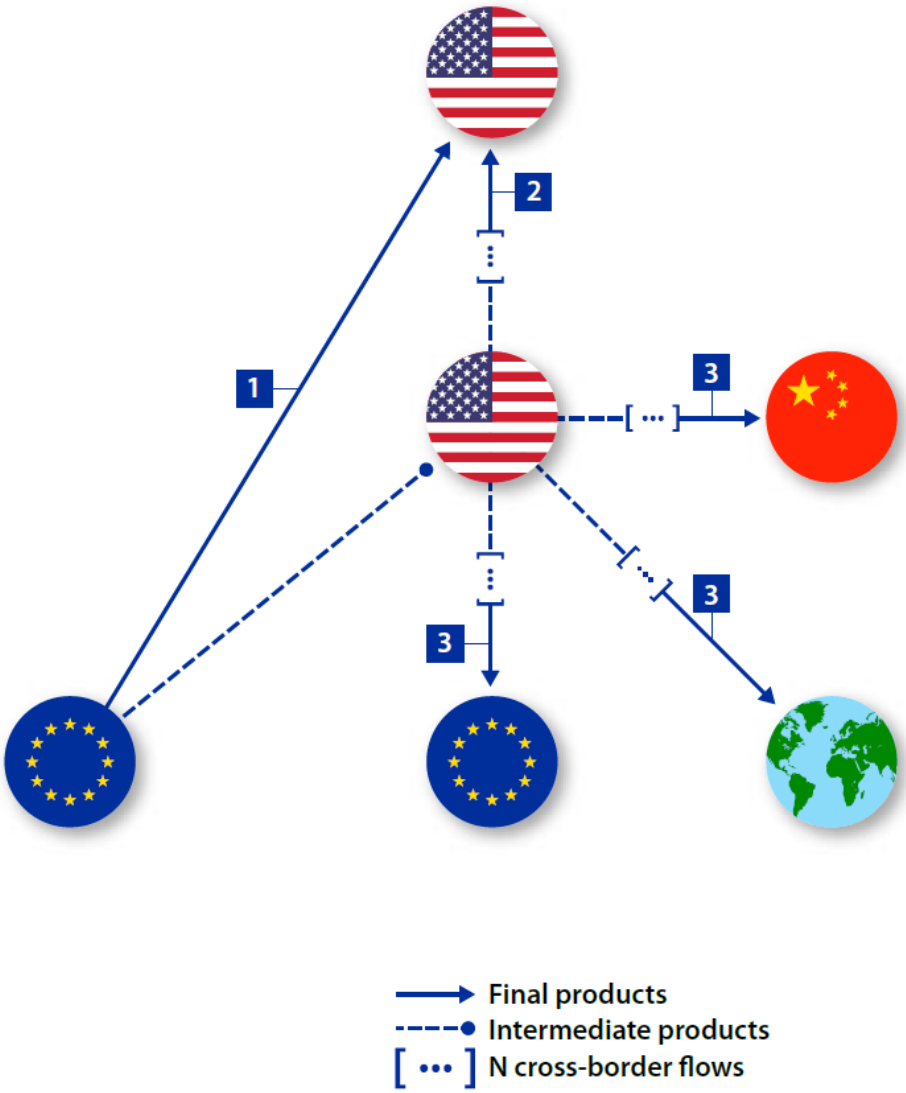


Figure 2 shows a diagram for domestic value added in exports. The value added in exports generated in the EU can be exported to the US following two channels: one as a product for final use, as represented by flow number 1, and second, as exports of products for intermediate uses, which is represented by flows 2 and 3. The intermediate exports can be employed in subsequent stages of production (e.g. foreign exports of the US to China or somewhere else including the EU) to produce a product for final use that is eventually consumed in the US, as represented by flow 2. Alternatively, the intermediate exports can also serve to produce products for final use along the GVC that is eventually consumed in other countries different from the US, such as China or any other country in the world, including the EU, as represented by flow 3. It is worth noting that Figure 2 is an illustrative diagram, and the new set of indicators will not provide, for instance, the final user countries for all the bilateral exports between the EU and the US. Instead, it will provide, for example, the total amount of value added generated in the EU due to its exports to the US, independently of where the traded goods and services will be eventually consumed, incorporated into a product for final use.

2.3.2. Foreign value added in exports

The foreign value added in exports is the value added generated elsewhere due to the imports of goods and services used by the reference economy to produce other goods and services that will be exported. The value added can be generated in any foreign upstream industry along the production value chain. This indicator provides a good measure of the degree of participation (see GVC backward participation) of economies in global value chains (except for manufacturing services) and it provides insights into the overall dependence of the reference economy on imports from other suppliers along the full GVC of the goods and services exported.

For the EU perspective, the matrix $\mathbf{F^{tr}}$ of foreign[34] value added generated in a non-EU economy $\mathbf{t}$ due to the exports of a EU country $\mathbf{r}$ to any non-EU destination $\mathbf{s}$, via third EU countries $\mathbf{p}$ and third non-EU economies $\mathbf{z}$, is defined in equation 5 as:

$$\mathbf{F^{tr}} = \langle \mathbf{v^t} \rangle \mathbf{C^{(pr)tz}} \mathbf{A^{zp}} \mathbf{R^{pr}} \langle \mathbf{e^{rs}} \rangle \quad (\mathbf{t}, \mathbf{z}, \mathbf{s} \in \mathbf{RoW}) \wedge (\mathbf{p}, \mathbf{r} \in \mathbf{EU}) \tag{5}$$

For the country perspective, the matrix $\mathbf{F^{tr}}$ of foreign value added generated in economy $\mathbf{t}$ due to the exports of a EU country $\mathbf{r}$ to any trading partner $\mathbf{s}$, via third countries $\mathbf{z}$, is defined in equation 6 as:

$$\mathbf{F^{tr}} = \langle \mathbf{v^t} \rangle \mathbf{C^{(r)tz}} \mathbf{A^{zr}} \mathbf{L^{rr}} \langle \mathbf{e^{rs}} \rangle \quad (\mathbf{t}, \mathbf{z}, \mathbf{s} \in \mathbf{EU} \cup \mathbf{RoW}) \wedge (\mathbf{r} \in \mathbf{EU}) \; \forall \; \mathbf{r} \neq \mathbf{s} \tag{6}$$

Box 4. Foreign value added in exports

Equation 5 yields a double-entry matrix identifying in rows the origin of the foreign value added due to the exports of an economy. Table 14 and Table 15 show the value added generated in the US and in the RoW due to the exports of MS1 and MS2 to the US and to the RoW, respectively. For example, the exports of the MS1's services industry to the US generated 17 billion euros of foreign value added in US (3 billion euros) and in the RoW (14 billion euros), as shown in Table 14. Analogously, the exports of MS1 and MS2 to the RoW generated a total of 49 billion euros in the services industry of US, most of it coming from the exports of the MS1's manufacturing industry (29 billion euros) to the RoW.

Equation 6 also yields a double-entry matrix but from the country perspective. Table 16, Table 17 and Table 18 show exporting industries displayed by column and the origin of the value added generated by the exports of MS1 to different destinations: to MS2 (Table 16), to the US (Table 17), and to the RoW (Table 18).

([34]) Following Arto, Dietzenbacher and Rueda-Cantuche (2019), the calculation of the foreign value added in exports requires a new matrix $\mathbf{C^{rs(r)}} = \left(\mathbf{I} - \mathbf{A^{rs(r)}}\right)^{-1}$, where $\mathbf{A^{rs(r)}}$ results from removing economy $\mathbf{r}$'s rows and economy $\mathbf{r}$'s columns in the technical coefficient matrix $\mathbf{A^{rs}}$. This is denoted by superscript $(\mathbf{r})$. This matrix $\mathbf{C^{(r)}}$ avoids double counting the value added contributions that had already been accounted for in upstream activities of the value chain in the exporting economy $\mathbf{r}$. The expression $\mathbf{C^{(r)tz}} \mathbf{A^{zr}} \mathbf{L^{rr}}$ is equivalent to the matrix $\mathbf{B_{ts}^{s}}$ in Borin and Mancini (2023).

Table 14. Foreign valued added in exports to the US (EU perspective)

		MS1 P	MS1 M	MS1 S	MS2 P	MS2 M	MS2 S	GVA
US	P	0	1	0	0	0	0	**2**
US	M	0	2	0	0	0	0	**3**
US	S	0	7	3	0	1	0	**11**
RoW	P	0	11	2	0	2	0	**16**
RoW	M	0	17	3	0	3	1	**24**
RoW	S	0	27	9	0	4	1	**42**
GVA		**0**	**66**	**17**	**0**	**11**	**3**	**97**

Table 15. Foreign valued added in exports to the RoW (EU perspective)

		MS1 P	MS1 M	MS1 S	MS2 P	MS2 M	MS2 S	GVA
US	P	0	5	1	0	1	0	**7**
US	M	0	9	2	0	2	0	**13**
US	S	0	29	12	0	4	2	**49**
RoW	P	1	45	8	0	13	2	**69**
RoW	M	1	67	15	0	19	4	**105**
RoW	S	2	106	44	1	24	8	**184**
GVA		**3**	**261**	**81**	**2**	**63**	**16**	**426**

As an example, the exports from the manufacturing industry of MS1 to MS2 generated 97 billion euros of foreign value added, of which 14 billion euros were generated in MS2, broken down as 1+5+8 billion euros across different industries; another 14 billion euros were sourced from the US, divided as 2+3+9 billion euros; and the remaining 69 billion euros of foreign value added were generated in the primary (14 billion), manufacturing (21 billion) and services industry (34 billion) of the RoW.

Table 16. Foreign valued added in exports to the MS2 (MS perspective)

		MS1 P	MS1 M	MS1 S	GVA
MS2	P	0	1	0	**1**
MS2	M	0	5	1	**6**
MS2	S	0	8	2	**10**
US	P	0	2	0	**2**
US	M	0	3	0	**3**
US	S	0	9	2	**12**
RoW	P	0	14	1	**16**
RoW	M	0	21	3	**24**
RoW	S	1	34	8	**43**
GVA		**2**	**97**	**18**	**116**

Table 17. Foreign valued added in exports to the US (MS perspective)

		MS1 P	MS1 M	MS1 S	GVA
MS2	P	0	1	0	**1**
MS2	M	0	4	1	**5**
MS2	S	0	6	2	**8**
US	P	0	1	0	**2**
US	M	0	2	0	**3**
US	S	0	7	3	**10**
RoW	P	0	11	2	**13**
RoW	M	0	17	3	**20**
RoW	S	0	26	9	36
GVA		**0**	**77**	**20**	**97**

Table 18. Foreign valued added in exports to the RoW (MS perspective)

		MS1 P	MS1 M	MS1 S	GVA
MS2	P	0	3	1	**4**
MS2	M	0	17	3	**20**
MS2	S	0	24	9	**33**
US	P	0	5	1	**6**
US	M	0	9	2	**11**
US	S	0	29	12	**42**
RoW	P	1	45	8	**53**
RoW	M	1	66	14	**81**
RoW	S	2	105	44	**150**
GVA		**4**	**304**	**93**	**401**

Based on the country perspective, Table 19, Table 20 and Table 21 provide analogous results to the preceding tables, but instead focused on the exports of MS2 to various destinations, i.e. to MS1 (Table 19), to the US (Table 20), and to the RoW (Table 21), respectively.

Table 19. Foreign valued added in exports to the US (MS perspective)

		MS2 P	MS2 M	MS2 S	GVA
MS1	P	0	3	0	**3**
MS1	M	1	26	4	**30**
MS1	S	1	33	9	**43**
US	P	0	1	0	**1**
US	M	0	2	0	**3**
US	S	0	6	2	**8**
RoW	P	0	19	3	**22**
RoW	M	1	27	4	**32**
RoW	S	1	34	9	**44**
GVA		**3**	**151**	**32**	**186**

Table 20. Foreign valued added in exports to the RoW (MS perspective)

		MS2 P	MS2 M	MS2 S	GVA
MS1	P	0	0	0	**0**
MS1	M	0	3	1	**4**
MS1	S	0	4	1	**5**
US	P	0	0	0	**0**
US	M	0	0	0	**0**
US	S	0	1	0	**1**
RoW	P	0	2	0	**3**
RoW	M	0	3	1	**4**
RoW	S	0	4	1	6
GVA		**0**	**19**	**5**	**24**

Table 21. Foreign valued added in exports to the MS1 (MS perspective)

		MS2 P	MS2 M	MS2 S	GVA
MS1	P	0	2	0	**2**
MS1	M	0	18	3	**21**
MS1	S	1	23	8	**31**
US	P	0	1	0	**1**
US	M	0	2	0	**2**
US	S	0	4	2	**6**
RoW	P	0	13	2	**16**
RoW	M	0	19	4	**23**
RoW	S	1	24	8	**32**
GVA		**3**	**105**	**28**	**135**

FIGURE 3

Foreign value added in exports

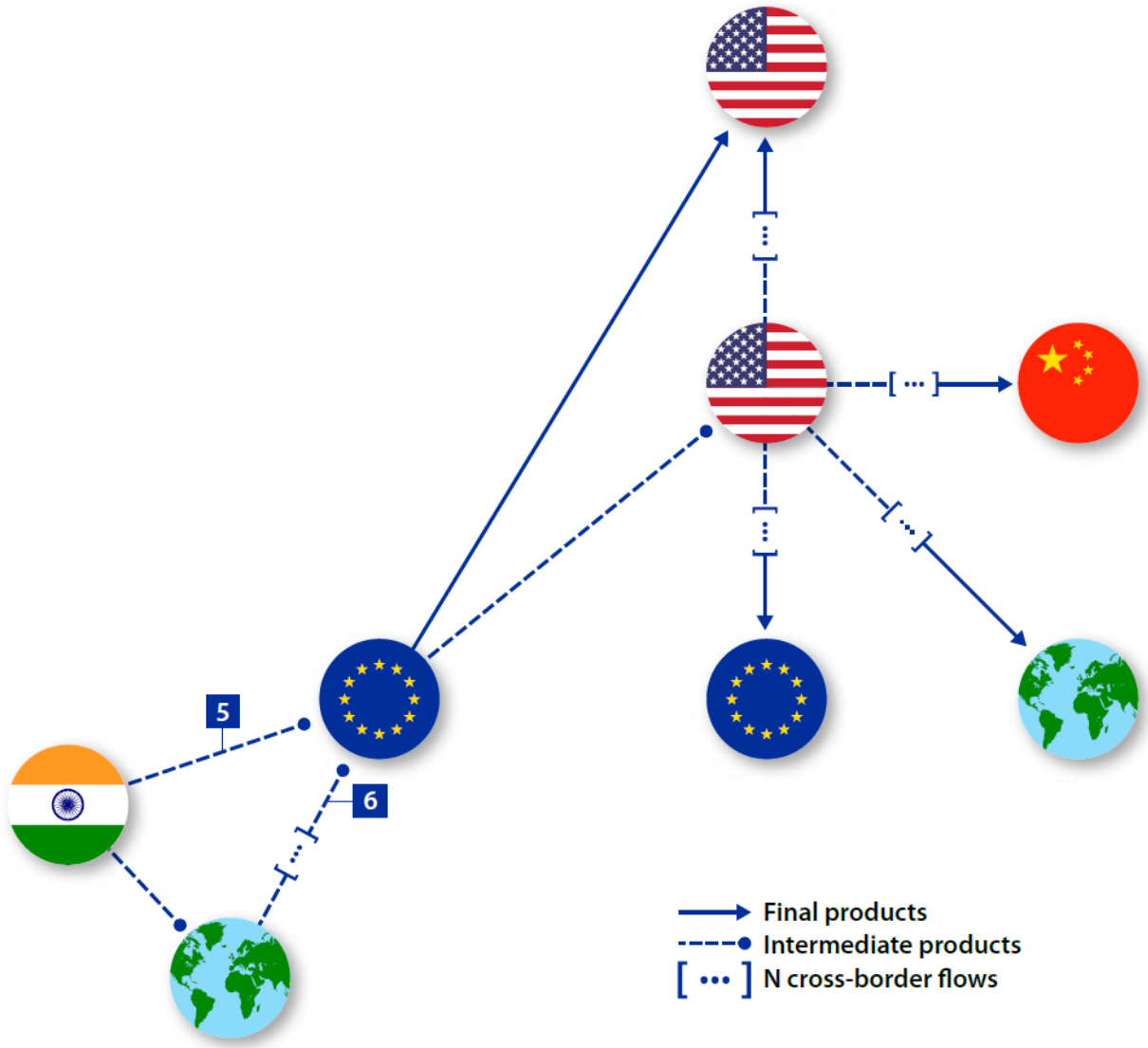


Figure 3 shows a diagram illustrating foreign value added in exports. For instance, flow 5 represents the value added generated in India that is further incorporated into the EU exports to somewhere else. However, the EU can also import intermediate products from anywhere in the world with value added previously incorporated by India upstream the supply chain (flow 6). Flows 5 and 6 are presented here for illustration purposes only, and they are not provided separated in the set of macroeconomic globalisation indicators.

2.4. Value added in final use

2.4.1. Domestic value added in foreign final use

Domestic value added in final use captures the value added generated in country $\mathbf{t}$ along the value chain of goods and services produced by country $\mathbf{r}$ for final uses that are consumed in country $\mathbf{r}$ or $\mathbf{s}$, including direct exports of final products from country $\mathbf{t}$ to country $\mathbf{s}$. When $\mathbf{t} \neq \mathbf{s}$, it is usually denoted as the domestic value added in foreign final use. This indicator provides a much better measure of dependencies between final destination markets and producers in country $\mathbf{t}$, including when those dependencies are also reliant on other countries in the value chain.

The matrix $\mathbf{P^{tr}}$ of domestic value added in foreign final use generated in the EU country $\mathbf{t}$ due to the country $\mathbf{s}$' consumption of products for final use produced in country $\mathbf{r}$, is defined in equation 7 as:

$$\mathbf{P^{tr}} = \langle \mathbf{v^t} \rangle \mathbf{B^{tr}} \langle \mathbf{y^{rs}} \rangle \qquad (7)$$
$$(\mathbf{t} \in \mathbf{EU}) \wedge (\mathbf{r}, \mathbf{s} \in \mathbf{EU} \cup \mathbf{RoW}) \;\; \forall \, \mathbf{t} \neq \mathbf{s}$$

In this case, there is no need to distinguish between the EU and country perspectives in the estimation. The EU perspective is set up when the subset $\mathbf{s} \in \mathbf{RoW}$.

Box 5. Domestic value added in foreign final use

Equation 7 yields a double-entry matrix where rows stand for the origin of the value added and columns represent the producer industries and countries that export goods and services for final use to somewhere else.

Table 22. EU value added in US final use

		MS1 P	MS1 M	MS1 S	MS2 P	MS2 M	MS2 S	US P	US M	US S	RoW P	RoW M	RoW S	GVA
MS1	P	1	4	0	0	0	0	0	2	4	0	1	0	**13**
MS1	M	0	68	3	0	2	0	1	24	43	0	11	1	**152**
MS1	S	0	47	54	0	2	1	2	36	118	0	17	3	**280**
MS2	P	0	0	0	0	1	0	0	1	1	0	0	0	**4**
MS2	M	0	2	0	0	8	0	0	4	8	0	2	0	**25**
MS2	S	0	3	1	0	5	9	0	5	18	0	4	0	**45**
GVA		**1**	**125**	**58**	**0**	**18**	**10**	**3**	**71**	**192**	**1**	**35**	**4**	**519**

Table 23. EU value added in RoW final use

		MS1 P	MS1 M	MS1 S	MS2 P	MS2 M	MS2 S	US P	US M	US S	RoW P	RoW M	RoW S	GVA
MS1	P	7	16	2	0	1	0	0	0	0	1	12	15	**53**
MS1	M	1	248	13	0	8	1	0	4	1	8	117	154	**554**
MS1	S	3	173	276	0	10	3	0	6	2	14	191	440	**1,118**
MS2	P	0	2	0	2	4	0	0	0	0	0	5	6	**21**
MS2	M	0	8	1	0	41	2	0	1	0	2	25	34	**114**
MS2	S	0	12	3	1	24	45	0	1	0	3	39	83	**211**
GVA		**11**	**458**	**295**	**4**	**89**	**52**	**0**	**12**	**3**	**28**	**388**	**732**	**2,072**

Table 22 and Table 23 display the EU value added generated due to the US final use, and due to the final use of the RoW, respectively. These tables illustrate that products for final use can be produced anywhere in the world.

For instance, to meet the US final use, the manufacturing industry in MS2 generated 25 billion euros of domestic value added. This amount does not only comprise MS2's manufacturing of final exports to the US (8 billion euros) but also value added contained in MS1 final exports to the US (2 billion euros), in the US production of final products consumed domestically in the US (8+4 billion euros), and in exports of final products from the RoW to the US (2 billion euros).

Looking at the columns (see Table 23), the exports of the MS1's services industry consumed by the final users in the RoW generated 295 billion euros of EU value added. This value added was generated in various industries and EU countries: 2 billion euros in the primary industry of MS1, 13 billion euros in the manufacturing industry of MS1, 276 billion euros in the services industry of MS1, 1 billion euro in the manufacturing industry of MS2, and 3 billion euro in the services industry of MS2.

Table 22 and Table 23 are constructed from the EU perspective, where intra-EU trade is not treated as foreign trade. Alternatively, Table 24 and Table 25 provides an analogous interpretation from a country perspective, which considers intra-EU trade as foreign. Table 24 shows MS2 as the domestic region and MS1 (and others) as foreign, thus indicating the value added generated in MS2 due to the final use of MS1. Table 25 takes the opposite approach, considering MS1 as the domestic region and MS2 as foreign, and as such, it illustrates the value added in MS1 that is generated due to the final use of MS2.

Table 24. EU value added in MS1 final use

		MS1 P	MS1 M	MS1 S	MS2 P	MS2 M	MS2 S	US P	US M	US S	RoW P	RoW M	RoW S	GVA
MS2	P	0	5	5	3	6	0	0	0	0	0	0	0	**20**
MS2	M	1	25	31	0	56	1	0	0	0	0	1	0	**115**
MS2	S	1	35	86	1	33	29	0	0	0	0	2	0	**189**
GVA		**2**	**65**	**122**	**5**	**95**	**30**	**0**	**0**	**0**	**0**	**3**	**1**	**324**

Table 25. EU value added in MS2 final use

		MS1 P	MS1 M	MS1 S	MS2 P	MS2 M	MS2 S	US P	US M	US S	RoW P	RoW M	RoW S	GVA
MS1	P	3	4	0	0	2	3	0	0	0	0	0	0	**13**
MS1	M	0	64	2	1	22	33	0	0	0	0	1	0	**124**
MS1	S	1	44	34	2	28	83	0	0	0	0	2	0	**196**
GVA		**4**	**112**	**36**	**4**	**51**	**120**	**0**	**0**	**0**	**0**	**3**	**1**	**332**

FIGURE 4

Domestic value added in foreign final use

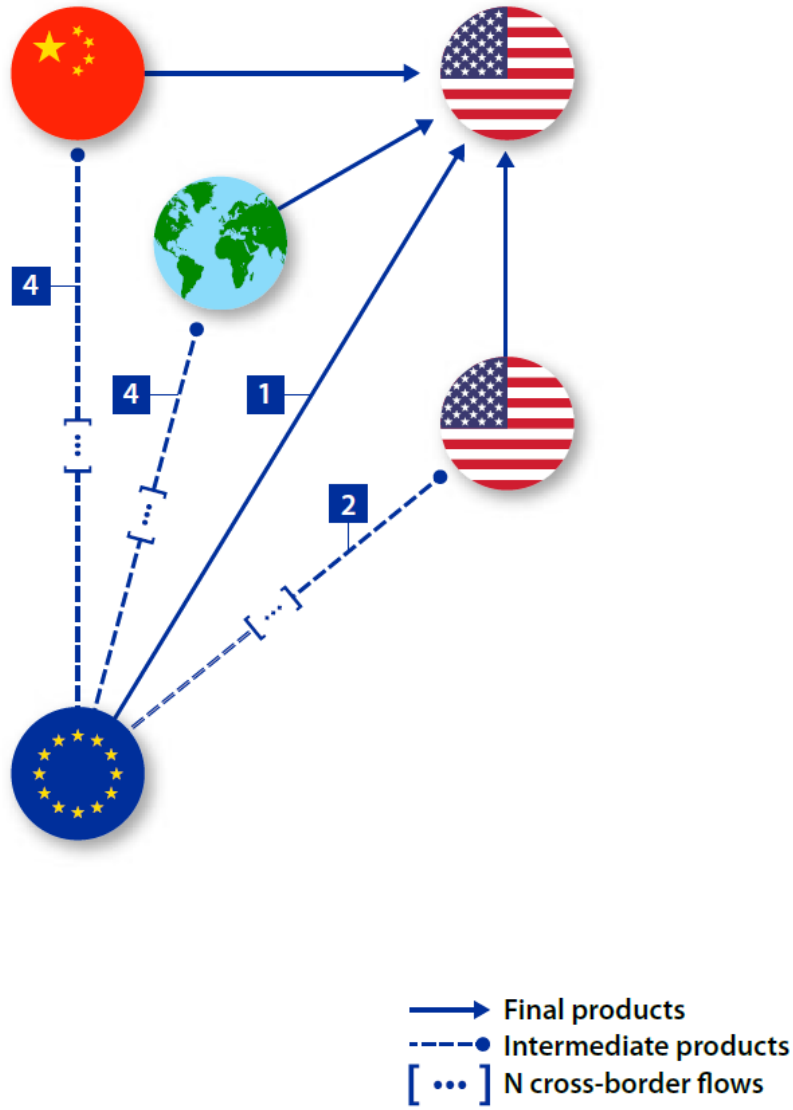


Figure 4 shows a diagram for the domestic value added in the EU (= **t**) generated due to the foreign (e.g. **s** = US) final use. US residents can import directly goods and services for final uses (flow 1) and therefore, generate value added in the EU. Alternatively, US residents can also import goods and services for final uses that were produced with US intermediate inputs containing other upstream value added contributions, including the EU (flow 2). Finally, US residents can directly import intermediate goods and services from China or other countries that may contain EU value added generated in upstream activities (flow 4) as well.

2.4.2. Foreign value added in domestic final use

The present indicator, like the previous one, looks at where the value added is generated and by whom it is driven. However, the foreign value added in domestic final use does it from a consumption perspective, which means that the value added is generated in a foreign country (foreign $\mathbf{t} \neq \mathbf{s}$) and the final users are domestic ($\mathbf{s}$).

This indicator reveals the amount of foreign value added incorporated in the domestic final use of products and can show how industries abroad are connected to EU final consumers. At the partner country and industry level, this measure can reveal trading relationships that are otherwise not evident when looking at bilateral trade statistics in gross terms.

The matrix $\mathbf{H^{tr}}$of foreign value added ($\mathbf{t} \neq \mathbf{s}$) generated in country $\mathbf{t}$ due to the EU country $\mathbf{s}$' domestic final use of products produced by country $\mathbf{r}$, is defined in equation 8 as:

$$\mathbf{H^{tr}} = \langle \mathbf{v^t} \rangle \mathbf{B^{tr}} \langle \mathbf{y^{rs}} \rangle \quad (8)$$
$$(\mathbf{t}, \mathbf{r} \in \mathbf{EU} \cup \mathbf{RoW}) \wedge (\mathbf{s} \in \mathbf{EU}) \; \forall \; \mathbf{t} \neq \mathbf{s}$$

In this case, the EU and country perspectives only differ by the fact that the EU perspective requires that $\mathbf{t} \in \mathbf{RoW}$.

Box 6. Foreign value added in domestic final use

Equation 8 generates a double-entry matrix that identifies three different foreign origins in rows and depicts the domestic final producer industry and country in columns. Table 26 presents the foreign value added that is associated with the final use of products by MS1. Similarly, Table 27 details the foreign value added that is related to the final use of products by MS2. These tables show the foreign value added contained in the final consumption of goods and services from specific domestic markets.

Table 26. Foreign value added in MS1 final use

		MS1 P	MS1 M	MS1 S	MS2 P	MS2 M	MS2 S	US P	US M	US S	RoW P	RoW M	RoW S	GVA
MS2	P	0	5	5	3	6	0	0	0	0	0	0	0	**20**
MS2	M	1	25	31	0	56	1	0	0	0	0	1	0	**115**
MS2	S	1	35	86	1	33	29	0	0	0	0	2	0	**189**
US	P	0	8	9	0	0	0	2	3	0	0	2	0	**25**
US	M	0	13	20	0	1	0	0	30	2	0	5	1	**72**
US	S	2	43	121	0	3	0	1	14	41	0	8	2	**234**
RoW	P	2	66	74	0	8	0	0	2	0	21	57	6	**237**
RoW	M	3	97	142	0	11	1	0	3	1	3	226	15	**501**
RoW	S	7	155	425	0	14	2	0	4	1	5	131	148	**891**
GVA		**17**	**447**	**912**	**5**	**133**	**34**	**3**	**55**	**45**	**30**	**431**	**172**	**2,284**

The results indicate that the MS1's final use of products produced by the manufacturing industry of MS2 generated 133 billion euros of foreign value added along the GVCs. This total is generated across several regions, with 95 billion euros in MS2, 4 billion euros in the US, and the remainder in the RoW. This result illustrates the interconnectivity and impact of MS1's final consumption on the value added of other economies along the GVC.

Table 27. Foreign value added in MS2 final use

		MS1 P	MS1 M	MS1 S	MS2 P	MS2 M	MS2 S	US P	US M	US S	RoW P	RoW M	RoW S	GVA
MS1	P	3	4	0	0	2	3	0	0	0	0	0	0	**13**
MS1	M	0	64	2	1	22	33	0	0	0	0	1	0	**124**
MS1	S	1	44	34	2	28	83	0	0	0	0	2	0	**196**
US	P	0	1	0	0	1	2	0	0	0	0	1	0	**4**
US	M	0	1	0	0	2	4	0	4	0	0	1	0	**12**
US	S	0	4	1	0	5	17	0	2	4	0	2	0	**36**
RoW	P	0	6	0	1	16	23	0	0	0	5	15	1	**67**
RoW	M	0	8	1	1	23	38	0	0	0	1	57	3	**133**
RoW	S	0	13	2	2	29	83	0	0	0	1	33	33	**197**
GVA		**5**	**144**	**39**	**9**	**127**	**288**	**0**	**7**	**4**	**7**	**112**	**39**	**782**

FIGURE 5

Foreign value added in domestic final use

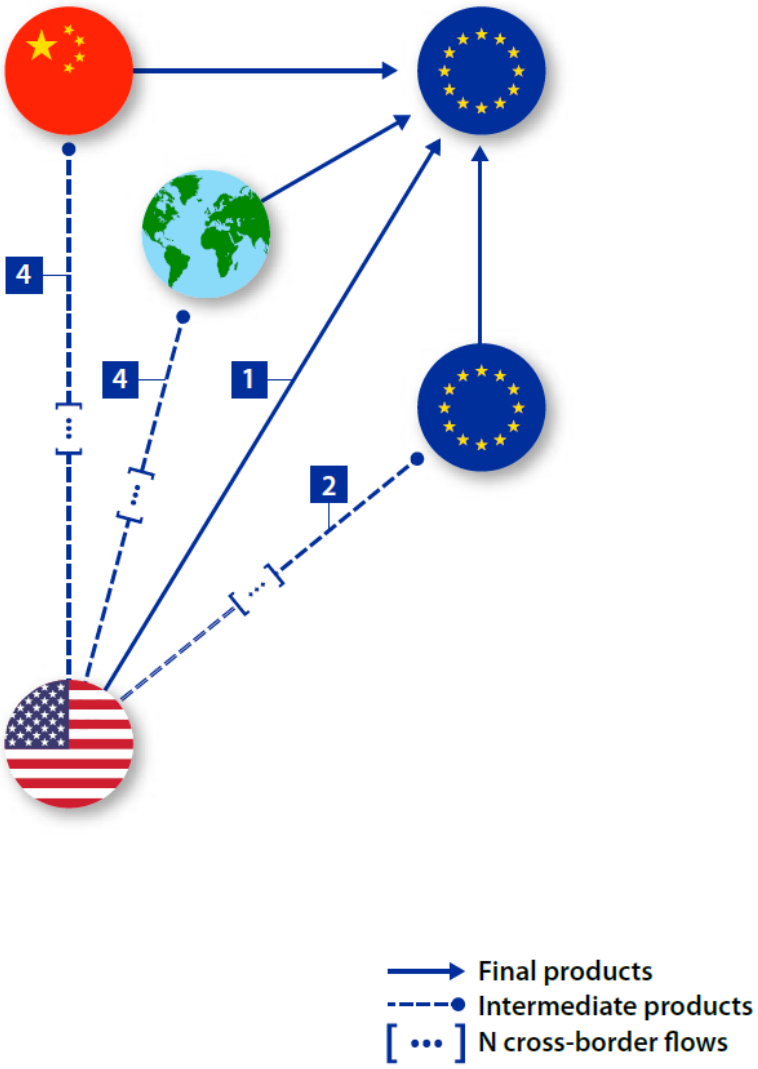


Figure 5 shows a diagram for the foreign value added in domestic final use, which has exactly the same configuration as Figure 4, but exchanging EU and US positions. The EU can generate value added in the US due to the imports of EU residents of products for final use produced in the US (flow 1). Alternatively, EU residents can buy EU manufactured products that contain part of value added generated in the US (flow 2). Moreover, EU residents can import goods and services from third countries different from the US (e.g. China) that may contain value added generated in the US, too (flow 4).

2.5. GVC participation

2.5.1. Forward participation

Forward participation[35] in GVCs refers to the value added generated in the reference economy that serve others to produce goods and services for export; it is the domestic value added generated due to foreign exports. This indicator provides an estimation of how much of the value added contained in the exports of a reference economy $\mathbf{t}$ is used by other countries to produce goods and services for export. The higher the value, the greater the country's participation in GVC and GDP (except for manufacturing services).

From the EU perspective, the forward participation $\mathbf{k^{ts}}$ of the EU country $\mathbf{t}$ in the exports of economy $\mathbf{s}$ to any economy $\mathbf{z}$, via a third EU country $\mathbf{r}$, is defined in equation 9 as:

$$\mathbf{k^{ts}} = \langle (\mathbf{v^t})^{\mathrm{T}} \mathbf{R^{tr}} \rangle \mathbf{A^{rs}} \mathbf{L^{ss}} \mathbf{e^{sz}} \quad (\mathbf{t}, \mathbf{r} \in \mathbf{EU}) \wedge (\mathbf{s} \in \mathbf{RoW}) \wedge (\mathbf{z} \in \mathbf{EU} \cup \mathbf{RoW}) \tag{9}$$

From the country perspective, the forward participation $\mathbf{k^{ts}}$ of the EU country $\mathbf{t}$ in the exports of economy $\mathbf{s}$ to any economy $\mathbf{z}$, is defined in equation 10 as:

$$\mathbf{k^{ts}} = \langle (\mathbf{v^t})^{\mathrm{T}} \mathbf{L^{tt}} \rangle \mathbf{A^{ts}} \mathbf{L^{ss}} \mathbf{e^{sz}} \quad (\mathbf{r} \in \mathbf{EU}) \wedge (\mathbf{s}, \mathbf{z} \in \mathbf{EU} \cup \mathbf{RoW}) \ \forall \mathbf{t} \neq \mathbf{s} \tag{10}$$

The GVC forward participation of country $\mathbf{t}$ is presented as a share of the exports of the EU country $\mathbf{t}$. This is expressed in equation 11 as:

$$\mathbf{k^t}(\%) = \mathbf{k^t}/\mathbf{e^t} \times \mathbf{100} \quad \mathbf{t} \in \mathbf{EU} \tag{11}$$

where $\mathbf{k^t} = \sum_{\mathbf{s},\mathbf{z}} \mathbf{k^{ts}}$ and $\mathbf{e^t} = \sum_{\mathbf{s}} \mathbf{e^{ts}}$.

([35]) This indicator is used in the EU Resilience Dashboard, and is included as input to Annex 5 of European Semester Country Reports. The forward participation indicator has also been used extensively during the COVID-19 crisis to estimate a country's exposure to demand and supply shocks and its resilience.

FIGURE 6

Forward participation

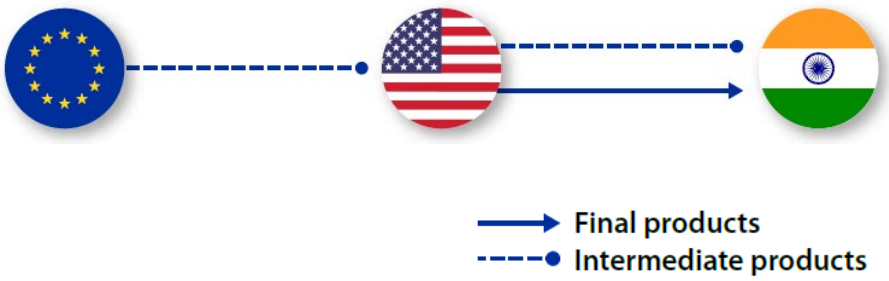


Figure 6 provides an illustration of the EU's forward participation in US exports to India. Within this framework, American exports to India may consist of both intermediate goods, which are used as inputs in further production processes, and final goods, which are ready for use by the final consumer. The figure shows the extent to which EU-produced inputs contribute to the value of the goods that the US subsequently exports to India.

2.5.2. Backward participation

Backward participation[36] in GVC refers to the value added generated elsewhere due to the exports of a reference country $\mathbf{r}$. It is precisely the foreign value added in exports presented earlier in this document. This value added generated in other foreign supplier economies is further incorporated in the exports of goods and services of the reference country $\mathbf{r}$. A higher share of backward participation in GVC reflects greater integration, higher connectedness, and high capacity of economies to harness the benefits of globalisation[37] (except for manufacturing services). However, this may increase the risk of supply chain disruptions and vulnerabilities.

The GVC backward participation $\mathbf{n^r}(\%)$ of country $\mathbf{r}$ is calculated as the share of the foreign value added in the EU country $\mathbf{r}$'s exports. This is defined in equation 12 as:

$$\mathbf{n^r}(\%) = \mathbf{f^r}/\mathbf{e^r} \times \mathbf{100} \quad \mathbf{r} \in \mathbf{EU} \tag{12}$$

where foreign value added in exports is expressed as a vector following $(\mathbf{f^r})^{\mathrm{T}} = (\mathbf{u})^{\mathrm{T}}\mathbf{F^{tr}}$.

(36) Similar to forward participation, the GVC backward participation is included in the EU Resilience Dashboard and used as input to Annex 5 of the European Semester Country Reports. This indicator has been used extensively during the COVID-19 crisis to detect country's exposure to demand and supply shocks and to assess resilience.

(37) Sometimes, a higher share of GVC backward participation is also associated with increased competitiveness if less expensive imported intermediate products are replacing more expensive domestically produced intermediate products.

FIGURE 7

Backward participation

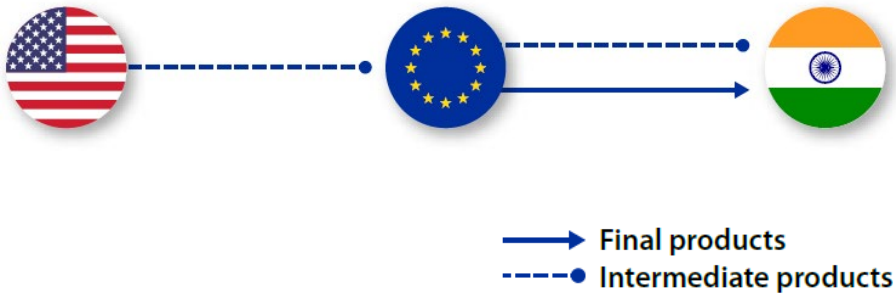


Figure 7 depicts the backward participation of US value added in EU exports to India. This participation refers to the inclusion of US-produced goods and services that are used as inputs in the production of other goods and services in the EU that are then exported to India. These inputs can be in the form of intermediate goods that are further processed or incorporated into other products, or final goods. The figure shows the contribution of US value added to the overall value of EU exports to the Indian market, underscoring the role of the US in the EU's export supply chain.

2.5.3. Overall participation

One of the most well-known indicators of a country's position in the value chains is the GVC participation index. This indicator measures the extent to which countries participate in GVCs. A higher value indicates a higher participation, i.e. higher value added associated to trade in intermediate products involving third countries' (crossing borders at least twice) exports. This phenomenon is increasingly prominent in global international trade due to the higher fragmentation of global production networks.

The GVC overall participation[38] index has recently become a standard in the literature together with the GVC forward and backward participation indicators. It is measured as the sum of the GVC backward and GVC forward participation indicators. This indicator is similar to the openness ratio[39] but in value added terms. The GVC overall participation index $\mathbf{p^r}(\%)$ of the EU country $\mathbf{r}$ is defined in equation 13 as:

$$\mathbf{p^r}(\%) = \mathbf{k^r}(\%) + \mathbf{n^r}(\%) \qquad \mathbf{r} \in \mathbf{EU} \tag{13}$$

([38]) As previously mentioned, the measurement of the GVC participation of industries with high shares of manufacturing services is limited since processing services where there is no change of ownership are not included as part of the trade values reported by national accounts and input-output tables.
([39]) Sum of exports and imports divided by GDP.

Box 7. Participation

With equations 9 and 10, one can calculate the domestic value added in foreign exports, also known as forward participation. Similarly, equations 5 and 6 serve to the foreign value added in exports, also known as backward participation. The sum of backward and forward participation yields the GVC overall participation index, which serves as an indicator of a region or country's participation into global production networks.

These three indicators are presented in Table 28 for the EU perspective, and in Table 29, for the country perspective. Table 28 captures the EU participation in GVCs as one single entity, while Table 29 refers to the individual participation of each EU country.

Table 28. GVC forward, backward and overall participation index for the EU perspective

	EX bn. €	k bn. €	k %	n bn. €	n %	p %
MS1	2,747	155	5.6%	429	15.6%	21.2%
MS2	539	31	5.7%	94	17.5%	23.2%
EU	**3,286**	**186**	**5.7%**	**524**	**15.9%**	**21.6%**

Table 29. GVC forward, backward and overall participation index for the country perspective

	EX bn. €	k bn. €	k %	n bn. €	n %	p %
MS1	3,341	285	8.5%	614	18.4%	26.9%
MS2	1,148	112	9.7%	345	30.1%	39.8%
EU	**4,489**	**397**	**8.8%**	**959**	**21.4%**	**30.2%**

From the EU perspective, 5.6% of the domestic value added in MS1's exports to non-EU economies correspond to intermediate exports that MS1's trading partners will use to produce other goods and services that will be exported elsewhere (forward participation). In absolute figures, that is equal to 155 billion euros out of the 2.75 trillion euros exported by MS1. From the country perspective, the forward participation rate rises to 8.5% due to the consideration of intra-EU trade.

On the upstream side (backward participation), MS1 imported 429 billion euros worth of intermediate inputs from its trading partners, which were then used in the production of exported goods by MS1. This accounts for 15.6% of the total value of MS1's exports. With the country perspective, the backward participation rate increases to 18.4% due to the consideration of intra-EU trade.

By integrating both upstream and downstream aspects, from an EU perspective, the GVC overall participation accounts for 21.2% of the value of MS1's exports. From a country perspective, the GVC overall participation increases to 26.9%, indicating the substantial role of both forward and backward GVC participation in the trade activities among EU countries, and when the single market is considered.

2.6. Exposure

2.6.1. Total exposure

Two widely used GVC indicators are the domestic value added in exports and the domestic value added in foreign final use, expressed in equations 3 and 5. Both have frequently been used to detect vulnerabilities and strategic dependences with respect to exports and foreign final users.

However, as shown in Figure 8, none of them separately can cover all possible sources of risks

and vulnerabilities. On the one hand, the domestic value added in exports covers flows 1, 2 and 3 (see also Figure 2) while it misses out the domestic value added in the exports to third countries (flow 4) that ends up in the foreign final use of a selected country (e.g. the US). On the other hand, the domestic value added in the foreign final use (e.g. of the US, see also Figure 4) covers flows 1, 2 and 4. That is, respectively, US imports of products for final use directly from the EU, US imports of products for final use from the US containing EU value added and US imports of products for final use from countries different from the US that also contain EU value added. Therefore, none of them covers the other foreign final users (different from US) that import US goods and services for final use with EU value added content, too.

For this reason, both have been combined into a total exposure indicator for analysing the potential risks in value added generation of a region affected by trade disruption or other similar shocks. This new indicator introduced here provides, in one single metric, the sum of the value added generated in a EU country $\mathbf{r}$ that is exposed to one selected trading partner, including those intermediate exports via third countries (i.e. sum of flows 1 to 4 in Figure 6).

The total exposure indicator $\mathbf{g^{rq}}$ measures the overall exposure of the EU country $\mathbf{r}$ to a non-EU economy $\mathbf{q}$, as defined in equation 14:

$$\mathbf{g^{rq}} = \langle \mathbf{v^r} \rangle \mathbf{R^{rs}}\, \mathbf{y^{sq}} + \langle \mathbf{v^r} \rangle \mathbf{R^{rs}} \mathbf{A^{sq}} \mathbf{B^{qz}} \mathbf{y^{zq}} + \langle \mathbf{v^r} \rangle \mathbf{R^{rs}} \mathbf{A^{sq}} \mathbf{B^{qz}} \mathbf{y^{zp}} + \langle \mathbf{v^r} \rangle \mathbf{R^{rs}} \mathbf{A^{sp}} \mathbf{B^{pz}} \mathbf{y^{zq}} \quad (14)$$

$$(\mathbf{r}, \mathbf{s} \in \mathbf{EU}) \wedge (\mathbf{q} \in \mathbf{RoW}) \wedge (\mathbf{z}, \mathbf{p} \in \mathbf{EU} \cup \mathbf{RoW}) \; \forall \; \mathbf{q} \neq \mathbf{p}$$

As observed, the total exposure indicator is calculated under the EU perspective by summing the following four elements[40]:

1. Direct exports of products for final uses to the selected trading partner $\mathbf{q}$: $\langle \mathbf{v^r} \rangle \mathbf{R^{rs}}\, \mathbf{y^{sq}}$ (flow 1 in Figure 6);
2. Intermediate exports to the selected trading partner $\mathbf{q}$ ending up in its final use: $\langle \mathbf{v^r} \rangle \mathbf{R^{rs}} \mathbf{A^{sq}} \mathbf{B^{qz}} \mathbf{y^{zq}}$ (flow 2 in Figure 6);
3. Intermediate exports to a selected trading partner $\mathbf{q}$ ending up in a third country's final use $\mathbf{p}$: $\langle \mathbf{v^r} \rangle \mathbf{R^{rs}} \mathbf{A^{sq}} \mathbf{B^{qz}} \mathbf{y^{zp}}$ (flow 3 in Figure 6);
4. intermediate exports to a third country $\mathbf{p}$ ending up in the selected trading partner $\mathbf{q}$'s final use: $\langle \mathbf{v^r} \rangle \mathbf{R^{rs}} \mathbf{A^{sp}} \mathbf{B^{pz}} \mathbf{y^{zq}}$ (flow 4 in Figure 6).

In equation 14, value added is generated by EU countries due to their trade with non-EU countries. Analogously, the total reverse exposure $\mathbf{g^{qr}}$ measures the total exposure of the non-EU economy $\mathbf{q}$ to the EU ($\mathbf{r}$), as defined in equation 15:

(40) The total exposure can also be expressed in shares (%), i.e. dividing it by the reference economy's total exports.

$$\mathbf{g^{qr}} = \langle \mathbf{v^{q}} \rangle \mathbf{L^{qq}}\, \mathbf{y^{qr}} + \langle \mathbf{v^{q}} \rangle \mathbf{L^{qq}} \mathbf{A^{qr}} \mathbf{B^{rz}} \mathbf{y^{zr}} + \langle \mathbf{v^{q}} \rangle \mathbf{L^{qq}} \mathbf{A^{qr}} \mathbf{B^{rz}} \mathbf{y^{zp}} + \langle \mathbf{v^{q}} \rangle \mathbf{L^{qq}} \mathbf{A^{qp}} \mathbf{B^{pz}} \mathbf{y^{zr}} \quad (15)$$

$$(\mathbf{q} \in \mathbf{RoW}) \wedge (\mathbf{r} \in \mathbf{EU}) \wedge (\mathbf{z}, \mathbf{p} \in \mathbf{EU} \cup \mathbf{RoW}) \; \forall \; \mathbf{r} \neq \mathbf{p}$$

Box 8. Exposure

By using equation 14, the total exposure of the EU to the US and the RoW is computed and presented in Table 30 and Table 31. The total exposure of the EU to the US and to the RoW amounts to 556 billion euros and 2,205 billion euros, respectively.

Following Figure 8, the trade dynamics between the EU and both the US and the RoW are primarily characterised by flows 1 (e.g. direct exports of products for final use in the US – 211 billion euros) and 2 (e.g. direct exports of intermediate products to the US ending up in the final consumption of the US – 234 billion euros).

In the context of EU-US trade, the total exposure measured through third countries (flow 4) is 74 billion euros while for the RoW is 31 billion euros. However, the EU exposure to the intermediate exports to the RoW that are used to produce other goods and services that are further exported to third countries for final use (flow 3) is 133 billion euros while for the US is 37 billion euros.

Typically, flows 1 to 3 are captured by indicators such as the domestic value added in exports presented in section 2.3.1. However, the total exposure indicator adds a fourth component (flow 4) to capture the indirect exposure via third countries, which sometimes might be relevant.

Table 30. Single exposure of the EU to the US

		flow 1	flow 2	flow 3	flow 4	Total
MS1	P	6	5	1	2	**13**
MS1	M	72	59	12	21	**164**
MS1	S	103	138	20	38	**299**
MS2	P	1	2	0	1	**4**
MS2	M	11	10	2	4	**27**
MS2	S	18	20	3	8	**48**
Total		**211**	**234**	**37**	**74**	**556**

Table 31. Single exposure of the EU to the RoW

		flow 1	flow 2	flow 3	flow 4	Total
MS1	P	25	28	4	1	**57**
MS1	M	270	274	37	10	**591**
MS1	S	463	639	69	16	**1,188**
MS2	P	9	12	2	0	**22**
MS2	M	53	60	8	2	**122**
MS2	S	85	124	14	2	**225**
Total		**904**	**1,137**	**133**	**31**	**2,205**

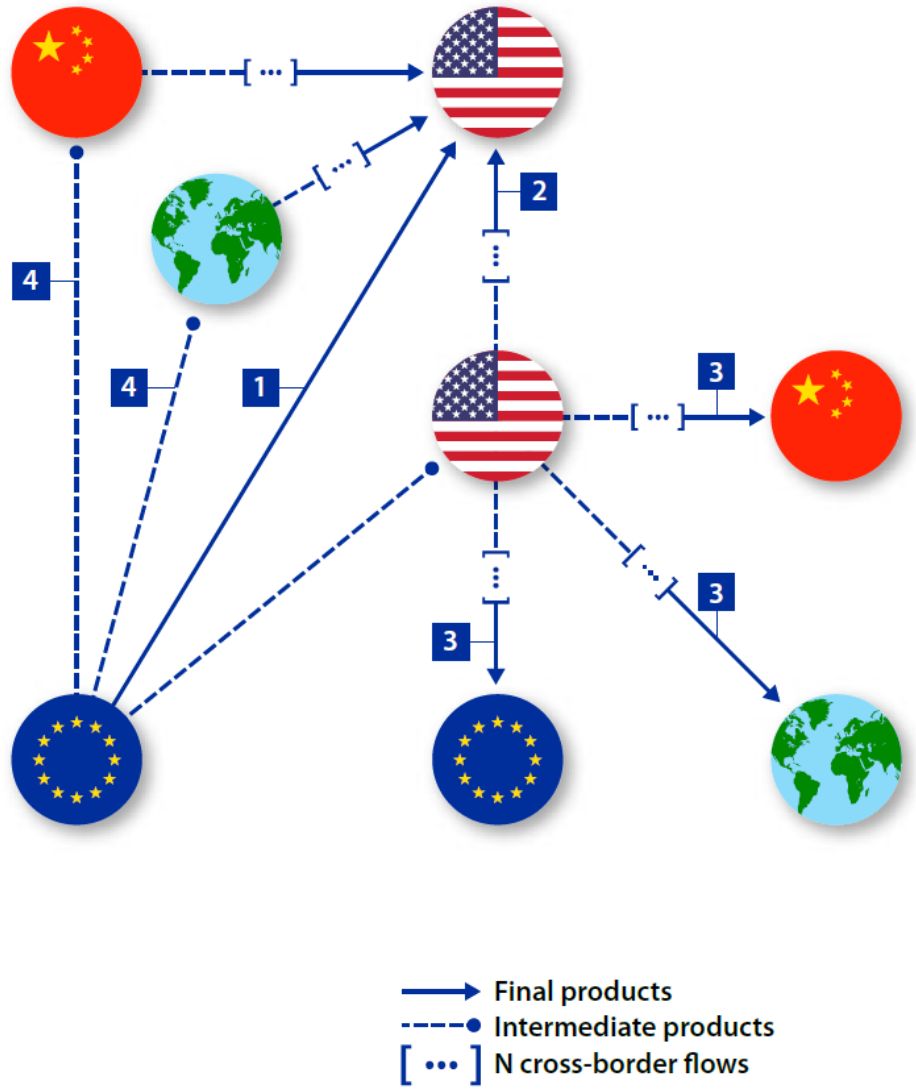
Likewise, the total exposure of the US and the RoW with respect to the EU can be calculated using equation 15. The results of this calculation are displayed in Table 32. It is noted that the exposure of the US to the EU is 456 billion euros (37+97+322), whereas the exposure of the RoW to the EU amounts to 2,449 billion euros (386+758+1305). These figures indicate the extent to which the economies of the US and the RoW can be potentially affected by changes in EU trade dynamics.

Table 32. Single exposure of the US and RoW to the EU

		flow 1	flow 2	flow 3	flow 4	Total
US	P	6	17	8	6	**37**
US	M	36	33	12	15	**97**
US	S	61	180	52	30	**322**
RoW	P	104	195	82	6	**386**
RoW	M	303	322	124	10	**758**
RoW	S	348	725	217	15	**1,305**
Total		**857**	**1,471**	**494**	**82**	**2,904**

FIGURE 8

Total exposure



2.7. Employment

2.7.1. Domestic employment in exports

The matrix of domestic employment in exports $\mathbf{\Pi^{tr}}$ is analogous to domestic value added in exports $\mathbf{D^{tr}}$, but operating with the employment intensity vectors $\boldsymbol{\beta}$ instead of $\mathbf{v}$. Therefore, under the EU perspective, the matrix $\mathbf{\Pi^{tr}}$ of domestic employment in the EU country $\mathbf{t}$ supported by the exports of other EU countries $\mathbf{r}$ to a non-EU economy $\mathbf{s}$ is defined in equation 16 as:

$$\mathbf{\Pi^{tr}} = \langle \boldsymbol{\beta}^{\mathbf{t}} \rangle \mathbf{R^{tr}} \langle \mathbf{e^{rs}} \rangle \qquad (\mathbf{t}, \mathbf{r} \in \mathbf{EU}) \wedge (\mathbf{s} \in \mathbf{RoW}) \tag{16}$$

Similarly for the country perspective, the matrix $\mathbf{\Pi^{rr}}$ of domestic employment in the EU country $\mathbf{r}$ due to its exports to any importing economy $\mathbf{s}$ is defined in equation 17 as:

$$\mathbf{\Pi^{rr}} = \langle \boldsymbol{\beta}^{\mathbf{r}} \rangle \mathbf{L^{rr}} \langle \mathbf{e^{rs}} \rangle \qquad (\mathbf{r} \in \mathbf{EU}) \wedge (\mathbf{s} \in \mathbf{EU} \cup \mathbf{RoW}) \; \forall \, \mathbf{r} \neq \mathbf{s} \tag{17}$$

Box 9. Domestic employment in exports

The input-output framework introduced in Box 1 can be extended with other auxiliary accounts, including information in different units, such as the case of employment (EMP), measured in thousand workers, and as shown in Table 33. This auxiliary account shows that the EU employment in 2022 was approximately 172 million jobs (this figure is used for illustrative purposes only).

Table 33. Employment by industry for MS1 and MS2

	MS1 P	MS1 M	MS1 S	MS2 P	MS2 M	MS2 S	EMP
EMP	3,633	16,001	107,371	4,094	8,172	33,088	**172,359**

Equation 16 yields a double entry matrix where the location of employment is displayed in rows, indicating in which EU country the employment is supporting exports, as shown in Table 34 for the US, and in Table 35 for the RoW. The matrix also shows the exporting EU country in columns. As a result, row sums yield the total employment supported in one specific country and industry due to the exports of all industries of MS1 and MS2, which are shown in columns. For example, the exports of MS1 and MS2 to the US support 1.155 million jobs in the manufacturing industry of MS1, of which 1.126 (1.061+0.063+0.002) come from MS1 itself and 29 thousand jobs (25+4) from MS2. For the column sums, the exports of the MS1 manufacturing industry support 2.41 million jobs in MS1 and MS2, of which 2.19 million (0.13+1.06+1) in MS1, and 22 thousand in MS2.

Table 34. EU employment in exports to the US (EU perspective)

		MS1 P	MS1 M	MS1 S	MS2 P	MS2 M	MS2 S	EMP
MS1	P	23	126	15	0	5	1	**170**
MS1	M	2	1,061	63	0	25	4	**1,155**
MS1	S	9	1,007	1,823	0	43	15	**2,897**
MS2	P	0	34	5	19	70	10	**137**
MS2	M	0	79	12	1	315	19	**426**
MS2	S	1	105	33	3	175	401	**717**
EMP		**35**	**2,412**	**1,950**	**23**	**633**	**451**	**5,504**

Table 35. EU employment in exports to the RoW (EU perspective)

		MS1 P	MS1 M	MS1 S	MS2 P	MS2 M	MS2 S	EMP
MS1	P	241	500	70	1	27	5	**844**
MS1	M	23	4,214	295	3	141	25	**4,702**
MS1	S	90	4,001	8,568	7	243	88	**12,997**
MS2	P	2	133	21	319	392	60	**928**
MS2	M	3	314	57	15	1,766	111	**2,266**
MS2	S	6	419	154	47	980	2,321	**3,927**
EMP		**365**	**9,581**	**9,166**	**391**	**3,549**	**2,611**	**25,663**

Alternatively, from a country perspective, equation 17 yields the domestic value added in exports only from the exporting country's view. Table 36 and Table 37 provide the results for the domestic value added in the exports of MS1 and MS2, respectively. As a result, the domestic employment of the exports of the manufacturing industry of MS1 supported 2.173 million jobs in MS1 and MS2, which is the sum of 0.125+1.054+0.994 million jobs.

Table 36. EU employment in exports to the US (country perspective)

		MS1 P	MS1 M	MS1 S	MS2 P	MS2 M	MS2 S	EMP
MS1	P	23	125	15				**162**
MS1	M	2	1,054	62				**1,118**
MS1	S	9	994	1,820				**2,823**
MS2	P				19	69	10	**98**
MS2	M				1	313	19	**333**
MS2	S				3	172	400	**575**
EMP		**34**	**2,173**	**1,896**	**22**	**554**	**430**	**5,109**

Table 37. EU employment in exports to the RoW (country perspective)

		MS1 P	MS1 M	MS1 S	MS2 P	MS2 M	MS2 S	EMP
MS1	P	241	495	69				**805**
MS1	M	23	4,187	290				**4,499**
MS1	S	89	3,950	8,556				**12,595**
MS2	P				318	387	59	**765**
MS2	M				14	1,755	109	**1,878**
MS2	S				46	965	2,317	**3,328**
EMP		**353**	**8,631**	**8,915**	**379**	**3,107**	**2,486**	**23,871**

Since intra-EU trade is considered as foreign trade under the country perspective, Table 38 displays how much employment is generated in MS1 due to its exports to MS2. Table 39 shows the employment in MS2 due to its exports to MS1. For example, the exports of the manufacturing industry of MS1 supports 1.33 million jobs in this industry itself, and 0.16 and 1.26 million jobs in the primary and services industries of MS1, respectively.

Table 38. MS1 employment in exports to MS2

		MS1 P	MS1 M	MS1 S	EMP
MS1	P	99	158	13	**270**
MS1	M	9	1,334	56	**1,399**
MS1	S	37	1,258	1,639	**2,934**
EMP		**146**	**2,750**	**1,708**	**4,603**

Table 39. MS2 employment in exports to MS1

		MS2 P	MS2 M	MS2 S	EMP
MS2	P	404	559	68	**1,031**
MS2	M	18	2,532	125	**2,675**
MS2	S	59	1,392	2,646	**4,097**
EMP		**481**	**4,484**	**2,838**	**7,803**

2.7.2. Domestic employment in foreign final use

The matrix $\mathbf{\Omega^{tr}}$ of domestic employment in the EU country $\mathbf{t}$ supported by the foreign final use of a non-EU economy $\mathbf{s}$ via a third economy $\mathbf{r}$ is defined in equation 18 as:

$$\mathbf{\Omega^{tr}} = \langle \boldsymbol{\beta}^{\mathbf{t}} \rangle \mathbf{B^{tr}} \langle \mathbf{y^{rs}} \rangle \qquad (18)$$
$$(\mathbf{t} \in \mathbf{EU}) \wedge (\mathbf{r}, \mathbf{s} \in \mathbf{EU} \cup \mathbf{RoW}) \;\; \forall \, \mathbf{t} \neq \mathbf{s}$$

This indicator is analogous to the domestic value added in foreign final use but operating with the employment intensity vector $\boldsymbol{\beta}$ instead of $\mathbf{v}$. Similarly, the EU perspective is calculated by setting up a subset $\mathbf{s} \in \mathbf{RoW}$.

Box 10. Domestic employment in foreign final use

Equation 18 yields a double entry matrix, where the location of domestic employment is displayed in rows, and final producer industries and country in columns. Table 40 and Table 41 show the EU employment supported by the US final use, and the RoW final use, respectively.

As can be seen, these products consumed by final users can be produced anywhere in the world. As an example, the US final use of products supports 477 thousand workers in the manufacturing industry of MS2.

Regarding columns, the exports of products for final use to US of the services industry of MS1 supported 639 thousand workers in MS1 and MS2.

Table 40. EU employment in US final use

		MS1 P	MS1 M	MS1 S	MS2 P	MS2 M	MS2 S	US P	US M	US S	RoW P	RoW M	RoW S	EMP
MS1	P	12	65	5	0	2	0	1	30	54	0	16	1	**188**
MS1	M	1	549	21	0	13	2	8	193	351	1	86	7	**1,232**
MS1	S	4	524	597	0	22	6	18	394	1,313	3	193	29	**3,104**
MS2	P	0	18	2	5	34	4	1	28	51	0	20	2	**164**
MS2	M	0	42	4	0	155	8	3	73	145	1	42	4	**477**
MS2	S	0	56	11	1	86	161	4	93	319	1	62	9	**803**
EMP		**18**	**1,254**	**639**	**6**	**312**	**182**	**36**	**810**	**2,233**	**6**	**419**	**52**	**5,968**

Table 41. EU employment in RoW final use

		MS1 P	MS1 M	MS1 S	MS2 P	MS2 M	MS2 S	US P	US M	US S	RoW P	RoW M	RoW S	EMP
MS1	P	99	239	25	0	12	2	0	5	1	14	179	223	**799**
MS1	M	10	2,007	107	1	64	9	1	31	6	61	944	1,241	**4,482**
MS1	S	37	1,918	3,064	2	111	31	3	64	21	160	2,116	4,885	**12,411**
MS2	P	1	65	8	100	173	21	0	4	1	17	216	263	**869**
MS2	M	1	152	21	5	777	38	0	12	2	31	465	640	**2,146**
MS2	S	3	205	56	15	432	798	1	15	5	52	682	1,462	**3,724**
EMP		**150**	**4,586**	**3,281**	**123**	**1,569**	**899**	**6**	**131**	**35**	**335**	**4,602**	**8,714**	**24,431**

Table 40 and Table 41 show the results from the EU perspective while Table 42 and Table 43 show the results from a country perspective, where intra EU trade is considered foreign trade. Table 42 shows the employment in MS2 supported by the final use of MS1 and analogously, Table 43 shows the employment in MS1 due to final use of MS2.

Table 42. EU employment in MS1 final use

		MS1 P	MS1 M	MS1 S	MS2 P	MS2 M	MS2 S	US P	US M	US S	RoW P	RoW M	RoW S	EMP
MS2	P	9	199	215	138	236	13	0	1	0	0	9	1	**821**
MS2	M	14	467	575	6	1,061	25	0	2	0	1	19	3	**2,172**
MS2	S	26	626	1,524	20	590	508	0	2	1	1	29	7	**3,335**
EMP		**49**	**1,292**	**2,314**	**165**	**1,887**	**546**	**0**	**5**	**1**	**2**	**57**	**11**	**6,328**

Table 43. EU employment in MS2 final use

		MS1 P	MS1 M	MS1 S	MS2 P	MS2 M	MS2 S	US P	US M	US S	RoW P	RoW M	RoW S	EMP
MS1	P	39	61	3	4	33	50	0	0	0	0	2	0	**193**
MS1	M	4	515	13	12	175	270	0	1	0	0	10	1	**1,001**
MS1	S	15	492	377	25	305	926	0	1	0	1	22	5	**2,169**
EMP		**58**	**1,068**	**394**	**41**	**514**	**1,246**	**0**	**2**	**0**	**1**	**34**	**7**	**3,364**

3

Quality assurance

This chapter describes a set of quality assurance methods (QA) that were developed to ensure that the results were correctly calculated.

3.1. Decomposition of exports

Following Arto, Dietzenbacher and Rueda-Cantuche (2019), the total exports $\mathbf{e^r} = \sum_s \mathbf{e^{rs}}$ of the EU country $\mathbf{r}$ can be broken down into five components:

a. domestic value added in exports,

b. foreign value added in exports,

c. double counting component of domestic value added in exports,

d. double counting component of foreign value added in exports,

e. Taxes less subsidies on intermediate products in exports.

Domestic value added in exports $\mathbf{d^r}$ of the EU country $\mathbf{r}$ can be obtained applying $(\mathbf{d^r})^{\mathrm{T}} = (\mathbf{u})^{\mathrm{T}}\mathbf{D^{tr}}$ from the EU perspective in equation 3, or analogously $(\mathbf{d^r})^{\mathrm{T}} = (\mathbf{u})^{\mathrm{T}}\mathbf{D^{rr}}$ from the country perspective in equation 4. Similarly, the foreign value added of the EU country $\mathbf{r}$'s exports $\mathbf{f^r}$ is obtained by $(\mathbf{f^r})^{\mathrm{T}} = (\mathbf{u})^{\mathrm{T}}\mathbf{F^{tr}}$ from equations 5 and 6.

Following the EU perspective, the double counting component of domestic value added in exports $\mathbf{dcd^r}$ of the EU country $\mathbf{r}$ is obtained following equation 19:

$$(\mathbf{dcd^r})^{\mathrm{T}} = (\mathbf{v^t})^{\mathrm{T}}(\mathbf{B^{tr}} - \mathbf{R^{tr}})\langle\mathbf{e^{rs}}\rangle \quad (\mathbf{t}, \mathbf{r} \in \mathbf{EU}) \wedge (\mathbf{s} \in \mathbf{RoW}) \tag{19}$$

Similarly, from the country perspective, equation 20 holds as:

$$(\mathbf{dcd^r})^{\mathrm{T}} = (\mathbf{v^t})^{\mathrm{T}}(\mathbf{B^{rr}} - \mathbf{L^{rr}})\langle\mathbf{e^{rs}}\rangle \tag{20}$$

$$(\mathbf{r} \in \mathbf{EU}) \wedge (\mathbf{s} \in \mathbf{EU} \cup \mathbf{RoW})\ \forall\ \mathbf{r} \neq \mathbf{s}$$

The double counting component of the foreign value added in exports $\mathbf{dcf^r}$ of the EU country $\mathbf{r}$, following the EU perspective, is obtained as shown in equation 21:

$$(\mathbf{dcf^r})^{\mathrm{T}} = (\mathbf{v^t})^{\mathrm{T}}(\mathbf{B^{tp}} - \mathbf{C^{(pr)tz}})\mathbf{A^{zp}}\mathbf{R^{pr}}\langle\mathbf{e^{rs}}\rangle \qquad (21)$$
$$(\mathbf{t}, \mathbf{z}, \mathbf{s} \in \mathbf{RoW}) \wedge (\mathbf{p}, \mathbf{r} \in \mathbf{EU})$$

Similarly, for the country perspective, equation 22 holds as:

$$(\mathbf{dcf^r})^{\mathrm{T}} = (\mathbf{v^t})^{\mathrm{T}}(\mathbf{B^{tt}} - \mathbf{C^{(r)tz}})\mathbf{A^{zr}}\mathbf{L^{rr}}\langle\mathbf{e^{rs}}\rangle \qquad (22)$$
$$(\mathbf{t}, \mathbf{z}, \mathbf{s} \in \mathbf{EU} \cup \mathbf{RoW}) \wedge (\mathbf{r} \in \mathbf{EU})\ \forall\ \mathbf{r} \neq \mathbf{t}$$

Taxes less subsidies on exporting intermediate products $\mathbf{tls^r}$ of the EU country $\mathbf{r}$ is obtained with equation 23:

$$(\mathbf{tls^r})^{\mathrm{T}} = (\mathbf{s^t})^{\mathrm{T}}\mathbf{B^{tr}}\langle\mathbf{e^{rs}}\rangle \qquad (23)$$
$$(\mathbf{t} \in \mathbf{EU} \cup \mathbf{RoW}) \wedge (\mathbf{r} \in \mathbf{EU}) \wedge (\mathbf{s} \in \mathbf{EU} \cup \mathbf{RoW})\ \forall\ \mathbf{t} \neq \mathbf{s}$$

where $(\mathbf{s^t})^{\mathrm{T}} = \mathbf{t^t}\langle\mathbf{x}\rangle^{-1}$, and $\mathbf{t^t}$ is the TLS value by industry in million euros of economy $\mathbf{t}$.

Please note that the double counting component associated to TLS is not broken down as the others. With all components of the decomposition defined, equation 24 describes QA1 for both perspectives:

$$\mathbf{e^r} = \mathbf{d^r} + \mathbf{f^r} + \mathbf{dcd^r} + \mathbf{dcf^r} + \mathbf{tls^r} \qquad (24)$$
$$\mathbf{r} \in \mathbf{EU}$$

Box 11. Decomposition of exports

Table 44 presents the outcome of applying equation 24, providing a breakdown of the different components that make up the total exports of economy $\mathbf{r}$ (see Table 7). For example, the exports from MS1's manufacturing industry to the RoW amounted to 1,259 billion euros. This total is made up of several components: i) 959 billion euros of EU value added, which encompasses contributions from both MS1 and MS2, ii) 262 billion euros of foreign value added, originating from the US and the RoW, iii) a total of 8 billion euros of double-counted terms, with 7 billion euros being domestic and 1 billion euros being foreign, and iv) 31 billion euros associated to TLS on intermediate products.

The sum of these components yields the aggregate export figure for MS1's manufacturing exports to the RoW as reported in Table 7. This detailed decomposition offers a clearer picture of the economic contributions from various sources to the total value of exports.

Table 44. Full decomposition of EU exports (EU perspective)

		US						RoW						
		d	f	dcd	dcf	tls	EX	d	f	dcd	dcf	tls	EX	EX
MS1	P	3	0	0	0	0	**3**	28	3	0	0	1	**32**	**35**
MS1	M	241	66	2	0	8	**317**	959	262	7	1	31	**1,259**	**1,576**
MS1	S	176	17	0	0	6	**199**	826	81	2	0	27	**936**	**1,135**
MS2	P	1	0	0	0	0	**1**	12	2	0	0	1	**14**	**15**
MS2	M	36	11	0	0	1	**49**	200	63	2	0	8	**272**	**321**
MS2	S	26	3	0	0	1	**30**	150	16	0	0	6	**173**	**203**
GVA		**482**	**98**	**3**	**0**	**16**	**599**	**2,174**	**427**	**11**	**1**	**74**	**2,687**	**3,286**

Table 45 and Table 46 detail the complete decomposition of exports of MS1 and MS2, from a country perspective, respectively. As expected, the exports from MS1's manufacturing industry to the RoW are also reported as 1,259 billion euros. However, the breakdown of this figure differs slightly: i) 907 billion euros of domestic value added generated in MS1, ii) 304 billion euros of foreign value added, which includes contributions from MS2, the US, and the RoW, iii) a total of 18 billion euros in double-counted terms, with 14 billion euros being domestic and 4 billion euros being foreign, and iv) 31 billion euros associated to TLS on intermediate products (same figure as in Table 44). Table 46 provides analogous results for MS2.

Table 45. Full decomposition of EU exports of MS1

		MS2						US						RoW						EX
		d	f	dcd	dcf	tls	EX	d	f	dcd	dcf	tls	EX	d	f	dcd	dcf	tls	EX	
MS1	P	11	2	0	0	0	**13**	3	0	0	0	0	**3**	27	4	0	0	1	**32**	**49**
MS1	M	289	97	4	1	10	**401**	228	77	4	1	8	**317**	907	304	14	4	31	**1,259**	**1,978**
MS1	S	155	18	1	0	5	**179**	173	20	1	0	6	**199**	812	93	3	1	27	**936**	**1,315**
GVA		**455**	**116**	**5**	**1**	**16**	**594**	**403**	**97**	**4**	**1**	**14**	**519**	**1,745**	**401**	**18**	**4**		**592,228**	**3,341**

Table 46. Full decomposition of EU exports of MS2

		MS1						US						RoW						EX
		d	f	dcd	dcf	tls	EX	d	f	dcd	dcf	tls	EX	d	f	dcd	dcf	tls	EX	
MS2	P	14	3	0	0	1	**18**	1	0	0	0	0	**1**	11	3	0	0	1	**14**	**33**
MS2	M	227	151	3	1	11	**393**	28	19	0	0	1	**49**	157	105	2	1	8	**272**	**714**
MS2	S	158	32	0	0	7	**198**	24	5	0	0	1	**30**	138	28	0	0	6	**173**	**401**
GVA		**399**	**186**	**3**	**2**	**19**	**609**	**53**	**24**	**0**	**0**	**2**	**79**	**307**	**135**	**2**	**1**	**14**	**460**	**1,148**

3.2. Decomposition of gross value added

Gross value added $\mathbf{w^t}$ can be decomposed into two components:

a. domestic value added in foreign final use,

b. domestic value added in domestic final use.

The domestic value added $\mathbf{p^t}$ generated in the EU country $\mathbf{t}$ due to foreign final use can be obtained applying $\mathbf{p^t} = \mathbf{P^{ts}u}$ from equation 7. The domestic value added generated in the EU country $\mathbf{t}$ due to its domestic final use $\mathbf{dfu^t}$ can be obtained following equation 25:

$$\mathbf{dfu^t} = \langle \mathbf{v^t} \rangle \mathbf{B^{tr}} \mathbf{y^{rs}} \tag{25}$$

In this case, there is no need to distinguish between the EU and country perspectives, the only difference is what concerns $\mathbf{s}$. The EU perspective refers to $(\mathbf{t}, \mathbf{s} \in \mathbf{EU}) \wedge (\mathbf{r} \in \mathbf{EU} \cup \mathbf{RoW})$, while the country perspective refers to $(\mathbf{t} \in \mathbf{EU}) \wedge (\mathbf{r} \in \mathbf{EU} \cup \mathbf{RoW})$ with $\mathbf{t} = \mathbf{s}$.

The decomposition of gross value added can be performed as expressed in equation 26:

$$\mathbf{w^t} = \mathbf{p^t} + \mathbf{dfu^t} \quad \mathbf{t} \in \mathbf{EU} \tag{26}$$

Box 12. Decomposition of gross value added

Table 47 and Table 48 present the decomposition of the gross value added (GVA) for MS1 and MS2, respectively. The tables show that when the two aforementioned components are summed, it yields the industry-specific GVA outlined in Table 2.

Taking MS1's primary industry as an example, its domestic GVA amounted to 243 billion euros. This figure can be broken down into two main components: i) 79 billion euros of domestic GVA generated due to foreign final use, which is further divided into contributions from different industries and regions (13+13+53 billion euros), and ii) 164 billion euros of domestic GVA associated to domestic final use.

Table 47. Decomposition of GVA of MS1

		MS2 p	US p	RoW p	MS1 dfu	GVA
MS1	P	13	13	53	164	243
MS1	M	124	152	554	1,149	1,979
MS1	S	196	280	1,118	8,082	9,676
GVA		332	445	1,726	9,395	11,898

Table 48. Decomposition of GVA of MS2

		MS1 p	US p	RoW p	MS2 dfu	GVA
MS2	P	20	4	21	54	98
MS2	M	115	25	114	180	434
MS2	S	189	45	211	1,428	1,874
GVA		324	75	346	1,662	2,406

3.3. Decomposition of final use

The total final use $\mathbf{y}^{\mathbf{r}}$ of the EU country $\mathbf{r}$ comprises three components:

a. foreign value added in domestic final use,

b. domestic value added in domestic final use, and

c. Taxes less subsidies (TLS) on intermediate products in domestic final use.

The foreign value added in the domestic final use of country $\mathbf{r}$ can be obtained applying $\mathbf{h}^{\mathbf{r}} = \mathbf{H}^{\mathbf{tr}}\mathbf{u}$ from equation 8. The domestic value added in domestic final use $\mathbf{dfu}^{\mathbf{r}}$ can be obtained following equation 25, and TLS $\mathbf{tls}^{\mathbf{r}}$ from equation 23. The decomposition of total final use can be performed as expressed in equation 27:

$$\mathbf{y}^{\mathbf{r}} = \mathbf{h}^{\mathbf{r}} + \mathbf{dfu}^{\mathbf{r}} + \mathbf{tls}^{\mathbf{r}} \quad \mathbf{r} \in \mathbf{EU} \tag{27}$$

Box 13. Decomposition of final use

Table 49 and Table 50 show the decomposition of final use (FU) for MS1 and MS2, respectively. By summing up the various components listed in the columns of these tables, we reproduce the total FU by industry, as shown in Table 2.

Focusing on MS2, the total final use amounted to 2,529 billion euros. This total can be broken down into the following components: i) 1,662 billion euros of domestic value added in domestic final use, ii) 782 billion euros of foreign value added in domestic final use, and iii) 85 billion euros of TLS on intermediate products in domestic final use.

Table 49. Decomposition of FU of MS1

		h	dfu	tls	FU
MS1	P	17	113	4	**134**
MS1	M	447	1,338	45	**1,829**
MS1	S	912	7,897	264	**9,073**
MS2	P	5	0	0	**6**
MS2	M	133	26	5	**163**
MS2	S	34	3	1	**38**
US	P	3	0	0	**3**
US	M	55	1	1	**58**
US	S	45	0	1	**46**
RoW	P	30	0	1	**31**
RoW	M	431	13	13	**458**
RoW	S	172	3	6	**181**
FU		**2,284**	**9,395**	**342**	**12,021**

Table 50. Decomposition of FU of MS2

		h	dfu	tls	FU
MS1	P	5	0	0	**5**
MS1	M	144	5	4	**153**
MS1	S	39	1	1	**41**
MS2	P	9	39	2	**50**
MS2	M	127	192	9	**328**
MS2	S	288	1,424	64	**1,775**
US	P	0	0	0	**0**
US	M	7	0	0	**8**
US	S	4	0	0	**4**
RoW	P	7	0	0	**7**
RoW	M	112	1	3	**116**
RoW	S	39	0	1	**40**
FU		**782**	**1,662**	**85**	**2,529**

3.4. Decomposition of domestic value added in exports

The domestic value added $\mathbf{d^r}$ generated by the exports of the EU country $\mathbf{r}$ can be broken down into three components:

a. domestic value added that serve other countries to produce goods and services for domestic consumption,

b. domestic value added that serve other countries to produce goods and services for export (forward participation), and

c. domestic value in exports of products for final uses.

The domestic value added that serve other countries to produce products for their own domestic consumption $\mathbf{cd^r}$ (following the EU perspective) can be obtained following equation 28:

$$\mathbf{cd^r} = \langle (\mathbf{v^t})^{\mathrm{T}} \mathbf{R^{tr}} \rangle \mathbf{A^{rs}} \mathbf{L^{ss}} \mathbf{y^s} \quad (\mathbf{t}, \mathbf{r} \in \mathbf{EU}) \wedge (\mathbf{s} \in \mathbf{RoW}) \tag{28}$$

Similarly, for the country perspective, equation 29 can be applied:

$$\mathbf{cd^r} = \langle (\mathbf{v^r})^{\mathrm{T}} \mathbf{L^{rr}} \rangle \mathbf{A^{rs}} \mathbf{L^{ss}} \mathbf{y^s} \quad (\mathbf{r} \in \mathbf{EU}) \wedge (\mathbf{s} \in \mathbf{EU} \cup \mathbf{RoW}) \; \forall \; \mathbf{r} \neq \mathbf{s} \tag{29}$$

The forward participation $\mathbf{k^r}$ is obtained following equations 9 and 10, whereas the domestic value added in exports for products for final uses $\mathbf{fn^r}$ is obtained following equation 30 (for the EU perspective):

$$\mathbf{fn^r} = (\mathbf{v^r})^{\mathrm{T}} \mathbf{R^{tr}} \langle \mathbf{y^{rs}} \rangle \quad (\mathbf{t}, \mathbf{r} \in \mathbf{EU}) \wedge (\mathbf{s} \in \mathbf{RoW}) \tag{30}$$

and equation 31 for the country perspective:

$$\mathbf{fn^r} = (\mathbf{v^r})^{\mathrm{T}}\mathbf{L^{rr}}\langle\mathbf{y^{rs}}\rangle \quad (\mathbf{r} \in \mathbf{EU}) \wedge (\mathbf{s} \in \mathbf{EU} \cup \mathbf{RoW})\ \forall\ \mathbf{r} \neq \mathbf{s} \tag{31}$$

Finally, equation 32 describes the decomposition QA4 for country $\mathbf{r}$:

$$\mathbf{d^r} = \mathbf{cd^r} + \mathbf{k^r} + \mathbf{fn^r} \quad \mathbf{r} \in \mathbf{EU} \tag{32}$$

Box 14. Decomposition of domestic value added in exports

Table 51 and Table 52 provide the decomposition of domestic value added in exports from two different viewpoints: the EU perspective is shown in Table 51, while the country perspective is detailed in Table 52. The figures in Table 51 coincide with the sum of those of Table 8 and 9 in Box 3, which is 2,656 billion euros.

For the country perspective, the summation of domestic value added as depicted in Tables 10 to 13 amounts to 3,362 billion euros, which is consistent with the total presented in Table 52. This aggregate can be further broken down into: i) 1,635 billion euros of domestic value added in exports that are used for the production of products consumed domestically, ii) 1,330 billion euros from the exports of final products, iii) and 397 billion euros associated to forward participation, which refers to the domestic value added in foreign exports.

This decomposition helps to clarify the various ways in which domestic value added contributes to the overall export figures, distinguishing between direct exports for own domestic consumption, exports of products for final use and the value added that supports the exports of other countries.

Table 51. Decomposition of d in the EU perspective

		cd	k	fn	d
MS1	P	15	3	13	**30**
MS1	M	533	88	579	**1,200**
MS1	S	584	65	352	**1,001**
MS2	P	8	1	4	**13**
MS2	M	112	18	105	**236**
MS2	S	103	11	62	**176**
GVA		**1,355**	**186**	**1,116**	**2,656**

Table 52. Decomposition of d in the MS perspective

		cd	k	fn	d
MS1	P	18	6	17	**41**
MS1	M	593	173	658	**1,424**
MS1	S	652	106	382	**1,140**
MS2	P	12	5	8	**26**
MS2	M	172	63	177	**412**
MS2	S	189	44	88	**320**
GVA		**1,635**	**397**	**1,330**	**3,362**

3.5. Decomposition of total exposure

The total exposure $\mathbf{g^{rq}}$ of the economy $\mathbf{r}$ to the economy $\mathbf{q}$ can be obtained from two alternative formulations[41]:

a. Domestic value added in exports (sum of flows 1 to 3) and flow 4 in Figure 6.

([41]) An analogous quality assessment can be applied for the reverse exposure $\mathbf{g^{qr}}$.

b. Domestic value added in foreign final use (sum of flows 1, 2 and 4) and flow 3 from Figure 6.

The total exposure is calculated as the domestic value added in exports plus flow 4, which is expressed in equation 33 as:

$$\mathbf{g^{rq}} = \mathbf{d^{rq}} + \langle \mathbf{v^r} \rangle \mathbf{R^{rs}} \mathbf{A^{sp}} \mathbf{B^{pz}} \mathbf{Y^{zq}} \mathbf{u} \quad (33)$$
$$(\mathbf{r}, \mathbf{s} \in \mathbf{EU}) \wedge (\mathbf{q} \in \mathbf{RoW}) \wedge (\mathbf{z}, \mathbf{p} \in \mathbf{EU} \cup \mathbf{RoW}) \forall \mathbf{q} \neq \mathbf{p}$$

Alternatively, the total exposure can be calculated as the domestic value added in foreign final use plus flow 3, which is expressed in equation 34 as:

$$\mathbf{g^{rq}} = \mathbf{p^{tq}} + \langle \mathbf{v^r} \rangle \mathbf{R^{rs}} \mathbf{A^{sq}} \mathbf{B^{qz}} \mathbf{Y^{zp}} \mathbf{u} \quad (34)$$
$$(\mathbf{r}, \mathbf{s} \in \mathbf{EU}) \wedge (\mathbf{q} \in \mathbf{RoW}) \wedge (\mathbf{z}, \mathbf{p} \in \mathbf{EU} \cup \mathbf{RoW}) \forall \mathbf{q} \neq \mathbf{p}$$

Box 15. Decomposition of total exposure

Table 53 and Table 54 show the decomposition of the total exposure of the EU to the US, based on equation 33 and equation 34, respectively. These equations break down the total exposure into different types of trade flows, offering two different perspectives. Therefore, the total exposure of the EU to the US, which amounts to 556 billion euros, can be broken down in two ways, either from the perspective of the EU as the value added is generated there due to its direct and indirect exports to the US (Table 53), or from the final user perspective – the US (Table 54), which demands products from the EU directly and indirectly.

From the exports side, the total exposure is the sum of 482 billion euros of domestic value added in exports to the US (flows 1 to 3 in Figure 8) and 74 billion euros associated to flow 4, as in Figure 8. Flow 4 represents the domestic value added in intermediate exports to third countries that are subsequently used throughout the whole global value chain to produce a product that will be consumed in the US for final use.

Alternatively, the total exposure can be considered from the final use perspective. Indeed, EU generates 519 billion euros of domestic value added due to the US final use (flows 1, 2 and 4), and 37 billion euros indirectly through the final use of other countries that requires intermediate inputs from the US that ultimately incorporate EU value added (flow 3).

Table 53. Total exposure between EU and US for domestic value added in exports and indirect exposure

		Flows 1, 2, 3	Flow 4	Exposure
MS1	P	11	2	**13**
MS1	M	143	21	**164**
MS1	S	261	38	**299**
MS2	P	3	1	**4**
MS2	M	23	4	**27**
MS2	S	41	8	**48**
GVA		**482**	**74**	**556**

Table 54. Total exposure between EU and US for domestic value added in foreign final use and indirect exposure

		Flows 1, 2, 4	Flow 3	Exposure
MS1	P	13	1	**13**
MS1	M	152	12	**164**
MS1	S	280	20	**299**
MS2	P	4	0	**4**
MS2	M	25	2	**27**
MS2	S	45	3	**48**
GVA		**519**	**37**	**556**

Table 55 and Table 56 also outline the decomposition of the total exposure according to equation 33 and equation 34, respectively, for the RoW instead of the US.

Table 55. Total exposure between EU and the RoW for domestic value added in exports and indirect exposure

		Flows 1, 2, 3	Flow 4	Exposure
MS1	P	56	1	**57**
MS1	M	582	10	**591**
MS1	S	1,171	16	**1,188**
MS2	P	22	0	**22**
MS2	M	120	2	**122**
MS2	S	222	2	**225**
GVA		**2,174**	**31**	**2,205**

Table 56. Total exposure between EU and the RoW for domestic value added in foreign final use and indirect exposure

		Flows 1, 2, 4	Flow 3	Exposure
MS1	P	53	3.8	**57**
MS1	M	554	36.9	**591**
MS1	S	1,118	69.1	**1,188**
MS2	P	21	1.6	**22**
MS2	M	114	7.9	**122**
MS2	S	211	13.8	**225**
GVA		**2,072**	**133**	**2,205**

3.6. Decomposition of domestic employment

The domestic employment $\boldsymbol{\alpha^t}$ can be broken down into two components:

a. domestic employment in exports,

b. domestic employment in domestic final use of domestically produced products.

The domestic employment in exports $\boldsymbol{\pi^\circ}$ of the EU country $\mathbf{r}$ can be obtained by applying $\left(\boldsymbol{\pi^\circ}\right)^{\mathrm{T}} = (\mathbf{u})^{\mathrm{T}}\boldsymbol{\Pi}^{\circ\mathbf{r}}$ for both perspectives in equations 16 and 17, where ° denotes $\mathbf{t}$ or $\mathbf{r}$, respectively.

The domestic employment in domestic final use $\mathbf{dfud^t}$ from the EU perspective can be obtained with equation 35:

$$\mathbf{dfud^t} = \langle\boldsymbol{\beta^t}\rangle\mathbf{R^{tr}y^{rs}} \qquad \mathbf{t, r, s} \in \mathbf{EU} \tag{35}$$

Further, domestic employment in domestic final use $\mathbf{dfud^t}$ from the country perspective can be obtained with equation 36:

$$\mathbf{dfud^t} = \langle\boldsymbol{\beta^t}\rangle\mathbf{L^{tt}y^{tt}} \qquad \mathbf{t} \in \mathbf{EU} \tag{36}$$

Then, the decomposition of domestic employment can be performed as expressed in equation 37:

$$\boldsymbol{\alpha^t} = \boldsymbol{\pi^\circ} + \mathbf{dfud^t} \qquad \mathbf{t} \in \mathbf{EU} \tag{37}$$

Alternatively, domestic employment $\boldsymbol{\alpha^t}$ can be broken down into the following two components:

a. domestic employment in foreign final use,

b. domestic employment in domestic final use (irrespective of where the products have been produced).

The domestic employment in foreign final use $\boldsymbol{\omega^t}$ of the EU country $\mathbf{t}$ can be obtained applying $(\boldsymbol{\omega^t})^{\mathrm{T}} = (\mathbf{u})'\boldsymbol{\Omega^{tr}}$ from equation 18.

The domestic employment in domestic final use of products (produced anywhere) $\mathbf{dfua^t}$ can be expressed as in equation 38 (or equation 18 for $\mathbf{t = s}$):

$$\mathbf{dfua^t} = \langle \boldsymbol{\beta}^{\mathbf{t}} \rangle \mathbf{B^{tr}} \mathbf{Y^{rt}} \mathbf{u} \qquad (\mathbf{t} \in \mathbf{EU}) \wedge (\mathbf{r} \in \mathbf{EU} \cup \mathbf{RoW}) \tag{38}$$

Then, the domestic employment in final use can be decomposed as expressed in equation 39:

$$\boldsymbol{\alpha}^{\mathbf{t}} = \boldsymbol{\omega}^{\mathbf{t}} + \mathbf{dfua^t} \qquad \mathbf{t} \in \mathbf{EU} \tag{39}$$

Box 16. Decomposition of employment

Table 57 describes the decomposition of employment from the EU perspective and using equation 37. In this sense, 172.4 million jobs in the EU are supported by its exports to the US (5.5 million jobs) and to the RoW (25.6 million jobs) as well as by the EU final use of domestically produced products (141.2 million jobs).

Table 57. Decomposition of employment (EU perspective) based on equation 37

	US	RoW	dfud	Total
MS1 P	170	844	2,619	**3,633**
MS1 M	1,155	4,702	10,144	**16,001**
MS1 S	2,897	12,997	91,476	**107,371**
MS2 P	137	928	3,029	**4,094**
MS2 M	426	2,266	5,480	**8,172**
MS2 S	717	3,927	28,444	**33,088**
EMP	**5,504**	**25,663**	**141,192**	**172,359**

Further, Table 58 and Table 59 describe the decomposition of employment for the country perspective based on equation 37, respectively, for MS1 and MS2. Here, the total employment of each EU country is broken down by the US, RoW and MS2, plus the MS1's final use of products produced by MS1. For example, 45.4 million jobs in MS2 are supported by the foreign final use (14.8 million jobs) and the MS2's final use of products produced by MS2 (30.6 million jobs).

Table 58. Decomposition of employment (MS perspective) – based on equation 37 for MS1

	US	RoW	MS2	dfud	Total
MS1 P	162	805	270	1,475	**2,713**
MS1 M	1,118	4,499	1,399	12,538	**19,553**
MS1 S	2,823	12,595	2,934	86,387	**104,739**
EMP	**4,103**	**17,899**	**4,603**	**100,400**	**127,005**

Table 59. Decomposition of employment (MS perspective) – based on equation 37 for MS2

	US	RoW	MS1	dfud	Total
MS2 P	98	765	1,031	1,337	**3,231**
MS2 M	333	1,878	2,675	3,745	**8,631**
MS2 S	575	3,328	4,097	25,492	**33,492**
EMP	**1,006**	**5,972**	**7,803**	**30,574**	**45,354**

Finally, Table 60 and Table 61 describe the decomposition of employment based on equation 39, respectively, for MS1 and MS2. In this case, the decomposition is slightly different, since, for instance, the total employment of MS2 is broken down by foreign final use (14.5 million jobs) and domestic final use of products (30.8 million jobs).

Table 60. Decomposition of employment – based on equation 39 for MS1

	US	RoW	MS2	dfua	Total
MS1 P	188	799	193	2,453	**3,633**
MS1 M	1,232	4,482	1,001	9,287	**16,001**
MS1 S	3,104	12,411	2,169	89,686	**107,371**
EMP	**4,523**	**17,692**	**3,364**	**101,426**	**127,005**

Table 61. Decomposition of employment – based on equation 39 for MS2

	US	RoW	MS1	dfua	Total
MS2 P	164	869	821	2,239	**4,094**
MS2 M	477	2,146	2,172	3,378	**8,172**
MS2 S	803	3,724	3,335	25,226	**33,088**
EMP	**1,444**	**6,739**	**6,328**	**30,843**	**45,354**

4

Conclusions

Macroeconomic globalisation indicators can help policymakers and businesses to understand changes in the global trade landscape, such as the increasing importance of services, the rise of regional value chains, key dependencies and potential vulnerabilities to trade disruption. For this reason, Eurostat will annually produce and disseminate macroeconomic globalisation indicators with the aim to facilitate the analysis of the EU trade and EU industrial policies.

This first release of the Eurostat's macroeconomic globalisation indicators comprises a set of 12 selected indicators, which provide different perspectives on the socio-economic impacts of trade in the EU economy. The set includes indicators that are already in use by the European Commission (e.g. backward and forward GVC participation in the Resilience Dashboards) but also introduces new indicators, such as the total exposure indicator.

This document presents the 12 indicators in a clear and accessible manner, offering illustrative and explanatory examples. It addresses the needs of assessment from both EU and national perspectives, meeting the requirements of the EU countries and the EU as a whole.

As a result, this document provides a comprehensive summary of the most important, well-established, and widely used macroeconomic globalisation indicators, enabling users to understand and adequately use the FIGARO tables and these macroeconomic globalisation indicators that will be yearly published on the Eurostat website.

Abbreviations

ADB	Asian Development Bank
ASEAN	Association of Southeast Asian Nations
B1G/GVA	Gross value added category in the European System of Accounts
D1	Compensation of employees
D21X31/TLS	Taxes less subsidies on products
D29X39	Other taxes less subsidies on production
EMP	Employment
EU	European Union
FIGARO	Full International and Global Accounts for Research in Input-output analysis
FU	Final Use
G20	Group of 20
GDP	Gross domestic product
GVC	Global value chain
ICIO	Inter-country input-output
JRC	European Commission – Joint Research Centre
M	Manufacturing industry
MEG	Macroeconomic globalisation indicators
MS1	First set of EU countries
MS2	Second set of EU countries
OECD	Organisation for Economic Co-operation and Development
OP_NRES	Purchases by non-residents in the domestic territory
OP_RES	Direct purchases abroad by residents
P	Primary industry
QA	Quality assurance
R&D	Research and Development
RoW	Rest of the World
S	Services
SEI	Single exposure indicator
SNA	System of National Accounts
TI	Total input
TiVA	Trade in Value Added
TO	Total output
UIBE	University of International Business and Economics
US	United States

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Macroeconomic globalisation indicators based on FIGARO

This working paper describes the set of macroeconomic globalisation indicators computed on the basis of the EU inter-country supply, use, and input-output tables, called the FIGARO tables, offering illustrative and explanatory examples.

These indicators are crucial for assessing the EU economic interdependencies, strengths and vulnerabilities. Indeed, they allow us to capture the direct and indirect economic effects along the global value chains across both industries and countries. They are also presented from the perspective of the EU and the 27 individual EU countries, considering the intra-EU trade as domestic or international trade respectively, in order to answer different needs related to the EU trade and the single market policies.

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