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Research article

EU trade: deviations in multi-country input-output tables and their implications for trade policy

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Abstract: Over the past two decades, research institutions around the world have undertaken numerous projects to develop global multi-country input-output (MCIO) databases. This effort has resulted in the creation of several notable databases, including WIOD, Exiobase, GTAP-MRIO, OECD-ICIO, FIGARO, and Eora. These databases have allowed international organizations and countries to conduct comprehensive assessments of socioeconomic, environmental, and trade impacts. The trade-in-value -added indicators, in particular, have been widely used and have undergone detailed evaluations to compare the results across different databases. However, there has been limited examination of the compilation processes and underlying data that contribute to variations in indicators and trade values, and their implications for policy decisions. In this paper, we explored the significant discrepancies in trade policy-relevant indicators depending on the MCIO used, and delved into the reasons behind these deviations.

Keywords: multi-country input-output; trade in value added; global value chain indicators; trade policy

JEL Codes: F13, F14, F17, C67

1. Introduction

Over the past two decades, globalization has increased socio-economic and environmental interdependence worldwide. For instance, in the EU, the share of jobs supported by foreign demand has risen by 58% from 1995 to 2020, now accounting for nearly 15% of total employment in the region[1]. Similarly, in terms of CO_2 emissions, the share of EU consumption-related emissions occurring in other regions has increased by 7.6 percentage points during the same period, representing nearly 30% of the

[1] Data extracted from the OECD's trade in employment (TiM) 2023 edition database (Horvát et al., 2020).

EU's carbon footprint today[2]. As a result, in the EU, we are now more dependent than ever on other extra-EU players to maintain our economies and protect the environment. This might be expected, considering that EU exports to the rest of the world represent 11% of its total output, and imports represent nearly 12% of it[3]. However, insights from this type of indicators would not have been possible without the efforts of international organizations and academia, which have funded projects to compile global multi-country input-output (MCIO) databases[4]. MCIO tables depict the interconnectedness of upstream and downstream industries across countries and production factors and allow the assessment of a wide range of socioeconomic, environmental, and international trade impacts. International organizations have successfully used the MCIO tables for evidence-based policy-making since 2010, and now produce MCIO tables on a regular basis. Much of this has focused on the measurement of global value chains (GVC), carbon footprints, and employment content of gross exports.

The compilation of the first MCIO tables was experimental, in that the compilers purposely made different assumptions and methods. Moreover, many of the initial underlying datasets such as supply and use tables relied on projections for the lack of real data. Hence, subsequent research that explored the databases regarding key variables and indicators found in many cases significant deviations among MCIO and tried to detect the drivers behind such deviations[5]. None of these studies, however, addressed the role of the construction and compilation methods in explaining or rationalizing the apparent deviations nor provided a discussion on the (trade) policy implications of such differences. For example, these comparative analyses fail to discuss how different trade values across the MCIOs might not only reflect different sources of underlying data but also different estimation methods for re-exports, intermediate use, and the treatment of trade asymmetries, among other important topics.

In this regard, the research that follows provides a core contribution to the literature by offering a comprehensive comparative analysis of trade discrepancies in international trade with particular focus on EU trade. This contribution is developed through two interconnected components: i) a qualitative and quantitative analysis that identifies the underlying drivers of account differences and highlights the relevance of different compilation methods in explaining the discrepancies across databases; ii) a discussion of the policy implications of the revealed differences, with a particular emphasis on the employment content of international trade. It is, however, challenging to determine consistent data sets across organizations that compile MCIO databases for benchmark and non-benchmark years, as national supply and use tables and GDP figures are updated, published, and revised annually by national statistical offices. Consequently, the national data used by the MCIO databases compilers may differ, as these datasets are compiled at different times using varying data vintages.

[2]Data extracted from the OECD's greenhouse gas footprint indicators database (Yamano et al., 2020). Greenhouse gas footprints (GHGFP): Origin of emissions embodied in final demand.

[3]Output (P1) was extracted from Eurostat's gross value added and income by detailed industry (NACE Rev. 2) database (naio_10_fgte), and extra-EU imports and exports were obtained from the Eurostat's macroeconomic globalisation database (naio_10_fgti and naio_10_fgte) for the year 2023.

[4]This process produced the World Input-Output Database (WIOD) (Timmer et al., 2015), Exiobase (Stadler et al., 2018), GTAP-MRIO (Carrico et al., 2020), and Eora (Lenzen et al., 2013). Additionally, the OECD-ICIO (Yamano et al., 2022; OECD, 2021) turned out to be another pioneer in this emerging field in the early 2010s. More recently, other MCIO tables have started to be compiled and published, such as the EMERGING tables (Huo et al., 2022) and the GLORIA tables (Lenzen et al., 2017, 2022).

[5]As it is key to understanding the reasons for such (sometimes large) discrepancies, numerous studies such as Jones et al. (2014), Owen et al. (2014), Arto et al. (2014), Tarne et al. (2018), Fusacchia and Salvatici (2022), and Abd Rahman et al. (2023) have investigated the factors affecting these deviations and/or evaluated the dissimilarities.

2. Literature review

The comparison of trade in value added indicators and carbon footprint calculations using different MCIO tables has been a topic of increasing interest over the past decade. This section provides an overview of the existing literature on this topic.

Several studies have compared the trade in value added indicators estimated using different MCIO tables. For example, Jones et al. (2014) compared the GTAP, WIOD, and OECD-ICIO tables and found that the GTAP and OECD-ICIO estimates of the ratio of domestic value added to gross exports were higher than WIOD for most countries. However, the discrepancies between the estimates varied from one year to another. Similarly, Fusacchia and Salvatici (2022) compared the OECD-ICIO and GTAP MCIO tables and found that, unlike at aggregate level, trade data shows the largest discrepancies between OECD-ICIO and GTAP, with GTAP trade data exhibiting higher values in terms of both exports and imports, as well as trade in intermediate products. The authors believe that this is because OECD-ICIO excludes re-exports and transit trade, which can lead to underestimation of trade volumes.

In addition, several studies have also examined the carbon footprint calculations using different MCIO tables. For example, Owen et al. (2014) used structural decomposition analysis to compare the Eora, GTAP, and WIOD MCIO tables and found that the differences between the estimates could be attributed to differences in the components of the input-output table (e.g., final demand) and derived matrices (e.g., Leontief inverse), but also due to the emissions data. The drivers of these differences depend on the pair of MCIO tables under comparison. Similarly, Arto et al. (2014) compared the GTAP and WIOD MCIO tables and found that the estimates of the global carbon footprint were similar, but the differences in the estimates of the carbon footprint of individual countries were significant.

Several studies have examined the consistency and similarity of MCIO tables in terms of supply chain analysis. For example, Tarne et al. (2018) compared the Eora, Exiobase, GTAP, and WIOD MCIO tables and found that the estimates of the transaction volumes and intermediate consumption were similar, but the estimates of the supply chain analysis were found to deliver consistent results to a much lesser extent. Similarly, Abd Rahman et al. (2023) used a cross-entropy-based indicator to compare the Eora, Exiobase, GTAP, OECD-ICIO, and WIOD MCIO tables and found that the differences between the estimates were significant, at the industry and component level.

In conclusion, the discrepancies between the estimates can be attributed to various factors, including differences in the underlying data, methodologies, and assumptions used in the construction of the MCIO tables. As it was often observed, the relative importance of the deviations increases with geographical and industrial granularity. To shed light on the impact of these discrepancies, the next sections of this paper provide insights into the compilation processes of a number of global MCIO tables, with a focus on EU trade flows, and highlight how such discrepancies affect the estimation of the employment content of exports and value added.

3. Compilation factors affecting observed discrepancies among MCIO tables

Methodological differences between international merchandise trade statistics[6] and national accounts trade statistics exist. Indeed, trade economists, who are much more familiar with merchandise

[6]The term “international merchandise trade statistics” is defined here as the official statistics concerned with the provision of data on the movements of goods between countries and areas (United Nations, 2011).

trade concepts for trade policy analysis, are often perplexed by these differences and their potential impact on trade policy analyses. Moreover, global MCIO tables also have different trade values, reflecting not only different sources of underlying data but also different estimation methods. However, in practice, and in part because not all countries are able to fully align with the ownership principle[7], these differences are not generally significant at the aggregated level (e.g., a country's total exports of goods). Where larger differences occur, these often relate to the allocation of goods purchased by non-residents and residents abroad to exports and imports of goods, respectively, in supply and use tables.

Challenges can be more significant when considering particular products, trading partners, and/or allocations of trade to intermediate or final domestic use categories. Some of the key areas where these challenges arise include:

- Exports of goods and services for intermediate and final uses;
- Domestic exports and re-exports;
- Exports to intra-EU versus extra-EU countries;
- Direct purchases abroad (imports) and purchases of non-residents (exports).

These conceptual differences between international merchandise trade statistics and national accounts have become more apparent with the creation of global MCIO tables, which, as derived from national supply and use tables, also follow the ownership principle of national accounts (United Nations, 2018).

Existing literature well documents the reasons why trade values from international merchandise trade statistics differ from those of national accounts (UNECE, 2015). For instance, goods crossing the border to be processed without changing ownership are not recorded as trade in national accounts (United Nations, 2018; UNECE, 2015). Moreover, the same principles of changes in ownership that underpin the 2008 SNA also create complications for other global production arrangements, in particular, merchanting[8] (United Nations, 2018; UNECE, 2015). The difference in merchandise trade totals and national accounts totals for goods in supply and use tables may also differ if expenditures on goods by non-residents in the domestic economy and by residents abroad (which are captured in trade in services statistics and not in merchandise trade data) are allocated to specific products (United Nations, 2018).

Finally, there are other general challenges to the compilation of trade statistics that are beyond the scope of this paper. Despite their potential impact on current and future MCIO databases, these challenges will not be addressed here. However, for instance, the rise of digital trade poses enormous challenges for international trade in services statistics, driven by the factors highlighted in IMF et al. (2023): i) Digitalization has increased the involvement of small firms and households in global trade, but they are often not captured by traditional data sources. ii) The growth of digital commerce has also led to an increase in low-value trade, which may not be captured by conventional methods because it often falls below the threshold for reporting. iii) The involvement of digital intermediation platforms, such as online marketplaces and payment processors, adds complexity to transactions, making it harder to track and record international trade accurately. Another significant challenge is the inclusion of

[7] As defined in the System of National Accounts (2008 SNA) (European Commission et al., 2009).

[8] Merchanting is a type of international trade where a resident of one country buys goods from a non-resident and then resells those same goods to another non-resident, all without the goods physically entering or leaving the merchant's home country. The difference in the purchase and resale value of the goods is recorded as merchanting services in the Balance of Payments (BOP).

economic activity from economies with poor, less reliable, or non-existent data. For example, many MCIO tables often include one or more "rest of the world" regions, which encompass economies not individually represented in the database. The estimation of the economic structures of these unobserved economies can substantially impact the results, particularly in cases where impacts occur at specific points in the supply chain (Stadler et al., 2014). Furthermore, methodological decisions, such as how to convert different data sources using correspondence tables and imputation techniques (e.g., for non-allocated trade or trade in services), as well as statistical methods employed to handle many-to-many correspondences or different levels of data aggregation when transforming data from one classification system to another, are also crucial. However, these aspects involve a deeper understanding of the statistical methods used in every step of the compilation of the MCIO tables that falls beyond the scope of this paper.

In the following, the current paper discusses in more detail the compilation factors affecting observed discrepancies among MCIO tables.

3.1. Exports of goods and services for intermediate and for final uses

Given national supply and use tables, the allocation of goods to either an intermediate or final uses is generally relatively simple. Yet, significant challenges arise in aligning these flows to the underlying ownership principles used in constructing global MCIO tables, in particular, for countries with significant processing and merchanting activities, but also for products that may have dual uses (e.g., as final demand or intermediate), and where the respective shares are country-specific. To make this distinction, global MCIO tables[9] use the United Nations classification of Broad Economic Categories (BEC)[10], where trade flows are broken down into economic and end-use dimensions. For goods, they are also broken down between gross capital formation and final consumption.

To complement these estimates, therefore, and overcome some of the challenges, compilers of global MCIO tables also often use national import use tables. National import use tables show how much imports are used for intermediate (also by industry) and final uses (also by gross capital formation and final consumption). Leaving aside the different valuation concepts of exports (fob) and imports (cif) in national accounts, import use tables provide valuable information about the breakdown of imports between intermediates (by industry) and final uses (by category of final use) [11]. As long as import use tables are available, these better reflect trade flows following the national accounts ownership principle, as well as national specificities in modes of production and consumption, compared to the BEC classification, which is used to disentangle intermediate and end-use categories at the level of detailed merchandise trade statistics (especially for dual-use products). Indeed, it would be useful for MCIO tables to provide the basis for informing country-specific BEC estimations.

As a concluding remark, the estimation of intermediate and final exports can lead to differences in

[9] Such as the WIOD (Timmer et al., 2015, 2016), the GTAP-MRIO (Carrico et al., 2020), and the OECD-ICIO (Yamano et al., 2022).

[10] The BEC classification includes eight categories: Agriculture, forestry, fishing, food, beverages, tobacco; Mining, quarrying, refinery, fuels, chemicals, electricity, water, waste treatment; Construction, wood, glass, stone, basic metals, housing, electrical appliances, furniture; Textile, apparel, shoes, jewellery, leather; Transport equipment and services, travel, postal services; ICT, media, computers, business and financial services; Health, pharmaceuticals, education, cultural, sport; Government, military, and other. The United Nations Statistics Division (UNSD) uses its website to provide further information on the rationale and possible applications of BEC and makes the correspondence tables of BEC with HS, CPC, EBOPS, and ISIC available (United Nations, 2016).

[11] For instance, Eurostat's FIGARO tables are compiled using national import use tables (converted to fob), which, by extension, provide a basis to determine the corresponding share of exports in one product (or industry) category to intermediate and final users (at the classification level of the FIGARO table, NACE/CPA).

trade values due to compilation factors, such as the availability of import use tables and/or the use of the BEC classification for such purposes. However, it is difficult to quantify how much of the differences encountered between the results across MCIO databases can be allocated to the use of one or another source of data. Qualitatively speaking, the use of import use tables seems to be preferable whenever they are available[12].

3.2. Domestic exports and re-exports

Another important compilation factor that can drive discrepancies regarding export values is the breakdown of total exports into domestic exports and re-exports. Domestic exports refer to what is normally understood as "exports", namely exported goods and services that are domestically produced in the exporting country. In contrast, re-exports refer to goods that are imported and then exported to another country without significant transformation from their original imported state. As they are not domestically produced, re-exported goods have a weaker link to the economy of the exporting country compared to other exports (European Commission et al., 2009). It is essential to account for domestic exports alone in the estimation of employment supported by exports, since they generate income and jobs in the exporting industry, while re-exports only generate trade margins that are allocated to trade activities, typically supporting far fewer jobs per given unit of export than those exports that derive from a transformation process. It is particularly relevant for economies, such as Belgium and the Netherlands in Europe, that serve as significant trans-shipment hubs and host a large number of wholesalers, which tend to have substantial re-export values (European Commission et al., 2009).

Detailed information about the country of origin (producer), country of consignment (re-exporter), and traded product is limited in merchandise trade statistics (UN Comtrade), except for the European Union (Comext). Hence, for EU trade, once trade asymmetries are sorted out (see details in Martins-Ferreira (2018)), the balanced Comext database provides information about the country of origin and the country of consignment (first country entering the EU) per product traded at the level of HS 6 digits. Eurostat uses this information to reallocate trade flows from the countries of consignment to the countries of origin by using the so-called QDR approach (Martins-Ferreira, 2018; Remond-Tiedrez and Rueda-Cantuche, 2019). The results are benchmarked to the available import use tables for re-exports and domestic exports by CPA/CPC product. Therefore, Eurostat's FIGARO tables are able to provide a more realistic and empirically grounded picture of the geographical distribution of global trade flows by combining UN Comtrade and EU Comext databases, and in particular for EU countries. Eurostat is currently collaborating with other international institutions to improve the information on re-exports for non-EU countries. Other global MCIO initiatives use UN Comtrade and the limited information therein about re-exports for their compilation processes.

All in all, extra-EU exports based on the FIGARO tables tend to be estimated with enriched trade data of better quality and a specific treatment for re-exports. The unique combination of UN Comtrade and Comext[13] allows for a more realistic geographical breakdown of bilateral (domestic) exports between EU countries and non-EU countries.

[12] Yet, one caveat would be the assumption of the same import allocation across all countries of origin. However, these will be adjusted in the final balancing process of the MCIO tables anyway.

[13] The information on country of origin, country of consignment, and country of destination by product is not publicly available on Eurostat's website.

3.3. Trade asymmetries

A third factor that can influence EU trade values is the way each global MCIO table solves the so-called trade asymmetries (United Nations, 2018) and, therefore, the way it determines the geographical distribution of total (domestic) exports from the EU to the rest of the world.

Trade asymmetries are well-known facts with extensive literature and reports about their causes (Eurostat, 2018). Asymmetries occur when the declaration of the importer in country A (mirror exports) is not consistent with the declaration of the exporter in country B (reported exports). Asymmetries arise either from reporting errors or from differences in concepts and definitions applied by the partner countries. Some of the asymmetries could be removed by further harmonizing national practices, but others will continue as they are linked to basic principles for compiling trade statistics (Eurostat, 2018), which are unlikely to change (e.g., cif/fob valuation). The most common causes of methodological asymmetries (Eurostat, 2018) are:

- Cif/fob valuation: exports are valued in fob, and mirror exports (imports) in cif;
- Simplified product reporting, not applied by all countries;
- Different approaches to estimate or compile specific products, such as gas, electricity, vessels, or aircraft, which are not covered by customs or statistical declarations;
- Confidentiality, although this should not impact total trade values;
- Different time recording;
- Different estimation methods for missing trade;
- Currency conversion;
- Other causes: revisions, trade systems, definitions, thresholds, etc.

National statistical offices and Eurostat have been working for several years to mitigate trade asymmetries through workshops and quality reports (Eurostat, 2018). Notwithstanding the progress that has been made so far, balancing methods are always needed to come up with sound single (gross) trade flows between two countries (Martins-Ferreira, 2018; Miao and Fortanier, 2017; Remond-Tiedrez and Rueda-Cantuche, 2019; Timmer et al., 2016; Carrico et al., 2020; UN-ECLAC, 2016). Currently, the OECD and Eurostat use the same balancing method (Remond-Tiedrez and Rueda-Cantuche, 2019; OECD, 2025), which weighs the reported and mirror (gross) exports with a relative asymmetry index in a way that more reliable countries get higher weights (see details in (Martins-Ferreira, 2018)).

As a conclusion, the way trade asymmetries are balanced may affect the eventual geographical allocation of domestic exports of EU countries to other EU and non-EU countries.

3.4. Direct purchases abroad (imports) and purchases of non-residents (exports)

Direct purchases abroad by residents cover all purchases of goods and services made by residents while traveling abroad for business (intermediate use) or personal purposes (household consumption). The mirror concept to direct purchases abroad is the expenditure by non-resident tourists and business travelers, covering also purchases by non-residents on health and education services; this includes the provision of these services on the domestic territory as well as abroad (Eurostat, 2013).

National input-output tables are valued under the domestic concept, which includes household expenditure by residents and purchases of non-residents in the domestic territory (e.g., tourist expenditures), excluding direct purchases abroad by residents. In contrast, the national concept includes household expenditure by residents both in the domestic territory and abroad, but excluding purchases of non-residents in the domestic territory (Remond-Tiedrez and Rueda-Cantuche, 2019).

However, the greatest difficulty arises with the estimation of direct purchases abroad by product or service, country of purchase, and country of residence of the purchaser. International merchandise trade statistics cover a very limited number of these transactions[14]. These will have to be estimated using the information available in the countries' balance of payments datasets and other sources, such as tourism satellite accounts, short-term business statistics, transport statistics, structural business statistics, and labor force surveys (for cross-border workers), among others.

The range and variety of data sources and methods used by the different global MCIO initiatives (Remond-Tiedrez and Rueda-Cantuche, 2019; Timmer et al., 2015, 2016; Yamano et al., 2022; Carrico et al., 2020; UN-ECLAC, 2016) are large and far from consistent. This obviously leads to different estimates of EU exports of goods and services. This is particularly important for EU countries where non-resident purchases make up a large share of total exports [15]. However, direct purchases abroad are a different type of trade (of less relevance to conventional trade policy analysts).

3.5. Recommendations: to balance exports or not to balance exports

One distinctive feature of Eurostat's FIGARO tables is the fact that they have become official statistics and, therefore, respect the (gross) domestic export levels (in fob and basic prices) portrayed by national (domestic) use tables, by product. Domestic exports are part of the production processes of countries (and their output) and therefore better reflect the value added generated and jobs supported at the product level, as opposed to an alternative estimation where imports by product (from the supply table) would constitute one of the balancing targets, together with the total imports by industry from the use table.

In other global MCIO initiatives (Yamano et al., 2022; Carrico et al., 2020; Timmer et al., 2015; UN-ECLAC, 2016), imports by product are converted from cif to fob and subsequently broken down by country of origin with proportional assumptions, i.e., same product shares across countries of origin but different by industry/user. Overall, a limited number of import use tables were used to split those imports by product by user category due to their lack of availability. Otherwise, bi-proportional adjustment methods (e.g., 2D-GRAS[16]) are used to balance the fully-fledged import use tables with total imports by industry, previously estimated in fob. Only in some cases were detailed trade statistics and/or specific surveys conducted to get more information.

As a result, in all other global MCIO initiatives, (gross) domestic exports by exporter countries and product are endogenously determined to match the desired import target totals by product but do not necessarily match those of the national domestic use tables, although they would match at an aggregated level, as done also by Eurostat for the FIGARO tables (Remond-Tiedrez and Rueda-Cantuche, 2019).

Based on Remond-Tiedrez and Rueda-Cantuche (2019), the FIGARO tables would assume instead the same user's shares of exports across countries of origin (from their use tables of imports in fob), but different by product. Analogously, in FIGARO, imports by industry would differ from national import

[14] It is also relevant that international merchandise trade data misses trade flows below certain specific thresholds – i.e., de minimis trade, which may have increased with digitalization.

[15] Based on 2023 FIGARO data, five EU countries have a ratio of purchases of non-residents to total exports exceeding 10%. These countries are: Croatia (80%), Greece (28%), Portugal (25%), Spain (16%), and Cyprus (14%).

[16] As in Junius and Oosterhaven (2003) and Valderas-Jaramillo and Rueda-Cantuche (2021).

use tables but not at an aggregated level (cif and fob).

To conclude this section, this paper goes beyond the well-known reasons why trade flows' values from merchandise trade statistics differ from those of national accounts. It provides, for the first time, a deep dive into the compilation methods for the construction of global MCIO tables to identify other possible factors driving the differences encountered in the estimation of extra-EU exports, as is the focus of this paper. Based on the discussion, Eurostat's FIGARO tables seem to be the most accurate MCIO database regarding the value and composition of EU trade due to the wide availability of import use tables for all EU countries, the specific treatment of re-exports and trade asymmetries, as well as the use of detailed information on tourism statistics and other related databases for the estimation of direct purchases abroad by EU residents.

The next two sections also discuss quantitatively the corresponding differences across various global MCIO tables, making a link to the newly identified compilation factors wherever possible. These factors can also serve as a roadmap to the different global MCIO initiatives to increase consistency in the compilation methods and input data used for their work.

4. Methods and data

This section starts by enumerating the MCIO databases used, the necessary adjustments made to harmonize them, the currency exchange rate, the reference year, and the indicator used to measure differences in the comparative analyses.

Extra-EU trade in the FIGARO release 2022, OECD-ICIO release 2021, WIOD release 2016, and GTAP-MRIO version 10.1 databases are compared. This is complemented with a comparison of two additional datasets compiled by Eurostat during the compilation process of the FIGARO tables, namely:

- the (unbalanced) international trade in goods and services statistics – ITGS, valued in fob, and
- the (balanced) international trade in goods and services statistics – bITGS (*aka* balanced view of trade), which is the harmonized and reconciled version of the previous one, with bilateral export flows matching bilateral import flows (i.e., without trade asymmetries).

In addition, since the OECD-ICIO considers domestic purchases by non-residents as gross exports, and analogously, domestic purchases of nationals abroad as gross imports (*aka* national concept vs. domestic concept), the OECD-ICIO trade figures were adjusted to reflect the domestic concept, for the sake of comparison with the other MCIO databases.

Furthermore, the year 2014 was chosen because it was the most recent year available in all databases. Trade data were converted to euros by using the 2014 annual exchange rate of 1.329 $/€, wherever necessary. The weighted average percentage error (WAPE) is the indicator used to measure differences across databases, as often used in the existing literature. The WAPE measures require that one database be considered as a reference in comparison to others for estimating their deviations (Arto et al., 2014). Given the fact that the paper is focused on EU trade, Eurostat's FIGARO database is used as a reference, as it is the first official EU-specific MCIO table. When comparing the other databases, we used the OECD-ICIO as a reference compared to WIOD and GTAP, and WIOD as a reference compared to GTAP.

In terms of industry and regional classification, we created *ad hoc* concordance tables to generate a common industry and country classification[17]. It is worth noting that these concordance tables refer to the minimum pairwise common classification rather than the minimum common classification for all databases.

To further understand the implications of deviations in trade flows in MCIO databases, we use a simple decomposition method to break down intermediate and final gross exports. This method does not exclude double-counted terms (Arto et al., 2019) or taxes less subsidies on products (Piñero et al., 2024), allowing for a full decomposition of gross exports. Specifically, the sum of foreign and domestic components, plus taxes less subsidies on products, equals the total. This approach is consistent with the methodology used in the OECD TiVA database (OECD, 2023). The decomposition between the foreign and domestic fractions is split by intermediate and final products. However, deviations for the total foreign value in exports, also known as GVC backward participation, is also analyzed, since it is a popular indicator of participation in world supply chains. In addition, we calculate consistently employment supported by EU exports, based on Eurostat's methodology for "domestic employment in exports" (Piñero et al., 2024). For all estimations, we use the same EU employment data to avoid discrepancies across MCIO tables due to statistical differences in the number of persons employed. The EU employment figures were extracted from Eurostat's national accounts employment data by industry (Eurostat, 2023). There are few confidential cells, which were estimated using compensation of employees available in the FIGARO database, and assuming the same employment/compensation ratio in comparison to another (similar) industry. This employment data refers to 64 industries, which, for the case of WIOD, only need to be aggregated to the corresponding 56 industries. However, for OECD and GTAP-MRIO, employment data has to be disaggregated and allocated to more granular industries, which was performed by using data on value-added components (GTAP) and employment (OECD).

5. Results

The results presented in this section begin with a comparison among the actual trade flow differences in MCIO tables, followed by an assessment of the differences in the domestic value added content of gross exports for intermediate and for final uses, both separately. Next, a comparative analysis was carried out on the total foreign value added content of gross exports (aka GVC backward participation). These results report on the deviations between the MCIO databases, and, whenever possible, identify the factors that might potentially explain the observed differences[18].

5.1. Trade flows divergences across MCIO tables

Table 1 depicts the total EU exports and total EU imports, split by intra- and extra-region components, across databases in 2014. The biggest difference in total trade flows across the MCIO tables stands at €909 billion, which is between the GTAP-MRIO and the FIGARO databases. This difference increases to €2.2 trillion if the FIGARO MCIO is compared to the FIGARO's balanced view of merchandise trade (bITGS), mainly due to the different accounting schemes, i.e., ownership (national

[17] Available upon request.

[18] Given the fact that this paper is the first one reporting possible compilation factors explaining the differences in MCIO databases, the authors were cautious in assuming that the observed deviations could be allocated separately and indistinctly to the factors identified. To do that, we would have needed first to assume that the compilation methods are comparable and, most importantly, separable in the same different number of compilation stages for all MCIO initiatives.

accounts) versus cross-border (trade statistics) principles. For total EU exports, the biggest difference is €532 billion between the WIOD and the OECD-ICIO tables. For total EU imports, the biggest difference is between GTAP-MRIO and FIGARO, with €597 billion, while for the EU trade balance, the largest surplus, of €585 billion, is observed in WIOD, well above the GTAP-MRIO estimate, which is slightly below 1% of the total trade.

Regarding export versus import shares in total trade, percentages vary little, with total EU exports ranging between 50% and 53%, and total EU imports between 47% and 50%. However, when looking at intra- versus extra-EU trade for each flow, slightly more pronounced differences are noticeable. Regarding total EU exports, WIOD shows higher extra-EU export shares (51%), while the reverse situation occurs notably in FIGARO, with 52% intra-EU export shares of total trade.

Table 2 shows the weighted absolute percentage errors (WAPEs) at different levels of resolution, from total aggregated flows to a full disaggregation level, i.e., considering cell-wise deviations for each exporting country, exporting industry, importing country, and importing user (i.e., industry importer of intermediate products and final users).

First, and as expected, there are higher deviations at more disaggregated levels. Second, it is observed that extra-EU imports deviate more significantly than the other two flows at the total level (and at full resolution), except for WIOD vs. either the OECD-ICIO or the FIGARO tables. This can be related to the way the MCIO tables are compiled, with limited data availability and, therefore, limited use of official import use tables. However, there is an exception when looking at the FIGARO and OECD-ICIO tables compared to WIOD, which is mainly due to the fact that the allocation of EU exports to non-EU countries in WIOD has been significantly different, probably as a result of its compilation process. In contrast, intra-EU trade generally shows the lowest differences, which may reflect better quality and more harmonized data coming from European trade statistics (i.e., Comext).

Table 1. EU exports and EU imports across databases in 2014 (billion euros).

Flow	FIGARO		ITGS		bITGS		OECD		WIOD		GTAP	
Extra EU exports	2,102	48%	2,088	40%	2,267	43%	2,304	50%	2,485	51%	2,260	49%
Intra EU exports	2,241	52%	3,078	60%	3,056	57%	2,296	50%	2,385	49%	2,394	51%
Total EU exports	**4,342**	**52%**	**5,166**	**52%**	**5,323**	**51%**	**4,601**	**52%**	**4,870**	**53%**	**4,654**	**50%**
Extra EU imports	1,728	44%	1,878	39%	2,094	41%	2,010	47%	1,901	44%	2,171	48%
Intra EU imports	2,241	56%	2,941	61%	3,056	59%	2,296	53%	2,385	56%	2,394	52%
Total EU imports	**3,969**	**48%**	**4,818**	**48%**	**5,150**	**49%**	**4,306**	**48%**	**4,285**	**47%**	**4,566**	**50%**
EU trade balance	**373**	**4%**	**348**	**3%**	**173**	**2%**	**295**	**3%**	**585**	**6%**	**88**	**1%**
Total	**8,311**		**9,985**		**10,473**		**8,907**		**9,156**		**9,220**	

Note: In bold, % over total trade.

Table 2. WAPEs at different aggregation levels for EU trade flows in 2014.

Deviations level	Flow	Figaro vs. OECD	Figaro vs. WIOD	Figaro vs. GTAP	OECD vs. WIOD	OECD vs. GTAP	WIOD vs. GTAP	Mean
Deviations at total level	Extra EU exports	3%	18%	7%	15%	4%	9%	9%
	Extra EU imports	12%	10%	25%	1%	12%	14%	13%
	Intra EU trade	3%	6%	7%	10%	10%	0%	6%
Deviations at member state level	Extra EU exports	6%	18%	11%	15%	9%	11%	12%
	Extra EU imports	16%	23%	29%	17%	15%	18%	20%
	Intra EU trade	6%	12%	8%	15%	13%	8%	10%
Deviations at member state and industry levels	Extra EU exports	23%	32%	46%	31%	44%	41%	36%
	Extra EU imports	48%	63%	69%	49%	54%	55%	56%
	Intra EU trade	27%	27%	44%	40%	60%	39%	40%
Deviations at member state, industry, and partner levels	Extra EU exports	49%	71%	66%	59%	60%	61%	61%
	Extra EU imports	65%	79%	87%	65%	71%	70%	73%
	Intra EU trade	40%	44%	54%	49%	67%	49%	51%
Deviations at full resolution	Extra EU exports	74%	132%	100%	119%	93%	112%	105%
	Extra EU imports	90%	124%	116%	105%	102%	120%	110%
	Intra EU trade	65%	101%	85%	99%	94%	103%	91%

Regarding deviations at full resolution, these are often around 100%, meaning that one value of a MCIO table often doubles the other, which should be an issue of concern for policymakers and scientists and should also call for a greater harmonization.

5.2. Deviations by EU country, trading partner, and intermediate and final user

Figures 1 to 3 focus on extra-EU exports and extra-EU imports, and deviations refer to aggregated values. Figure 1 reports deviations by member state, Figure 2 by trading partner, and Figure 3 by exporting/importer and industry/user.

Figure 1 shows that in certain cases, large economies explain significant amount of the overall differences, while in others the values are quite similar. For example, for the German (DE) exports to non-EU countries, OECD-ICIO and FIGARO provide figures closer to each other while the WIOD and the GTAP-MRIO tables also provide similar figures. However, these are substantially different. This is particular relevant for the employment content of EU exports to non-EU countries, as will be shown in the next section. Intuitively, the apparent overestimation of extra-EU exports in the GTAP-MRIO tables might well be assumed by the difference in the accounting principles between trade statistics (cross-border principle) and the national accounts principle (ownership principle). Regarding the WIOD tables, it might be that the lack of official national supply and use tables by the time of compilation might have led to an overestimation of the share of EU exports produced for final uses. The same applies to countries such as Croatia (HR) in relative terms, with WAPEs almost 100%.

Regarding extra-EU imports, it is observed that Belgium (BE) explains a noticeable amount of the deviations between the GTAP-MRIO and the rest of MCIO tables, which might be related to the Antwerp effect and the cross-border principle that prevails in the GTAP-MRIO tables over the ownership principle. Netherlands (NL) stands out when explaining the differences between the WIOD and the rest of the MCIO tables, probably due to the Rotterdam[19] effect as well as an overestimation of the

[19] As stated by Eurostat (2024), "Dutch trade flows are over-estimated because of the so-called 'Rotterdam effect' (or quasi-transit trade): that is goods bound for other EU countries arrive in Dutch ports and, according to EU rules, are recorded as extra-EU imports by the Netherlands (the country where goods are released for free circulation) [. . .]. To a lesser extent, Belgian figures are similarly

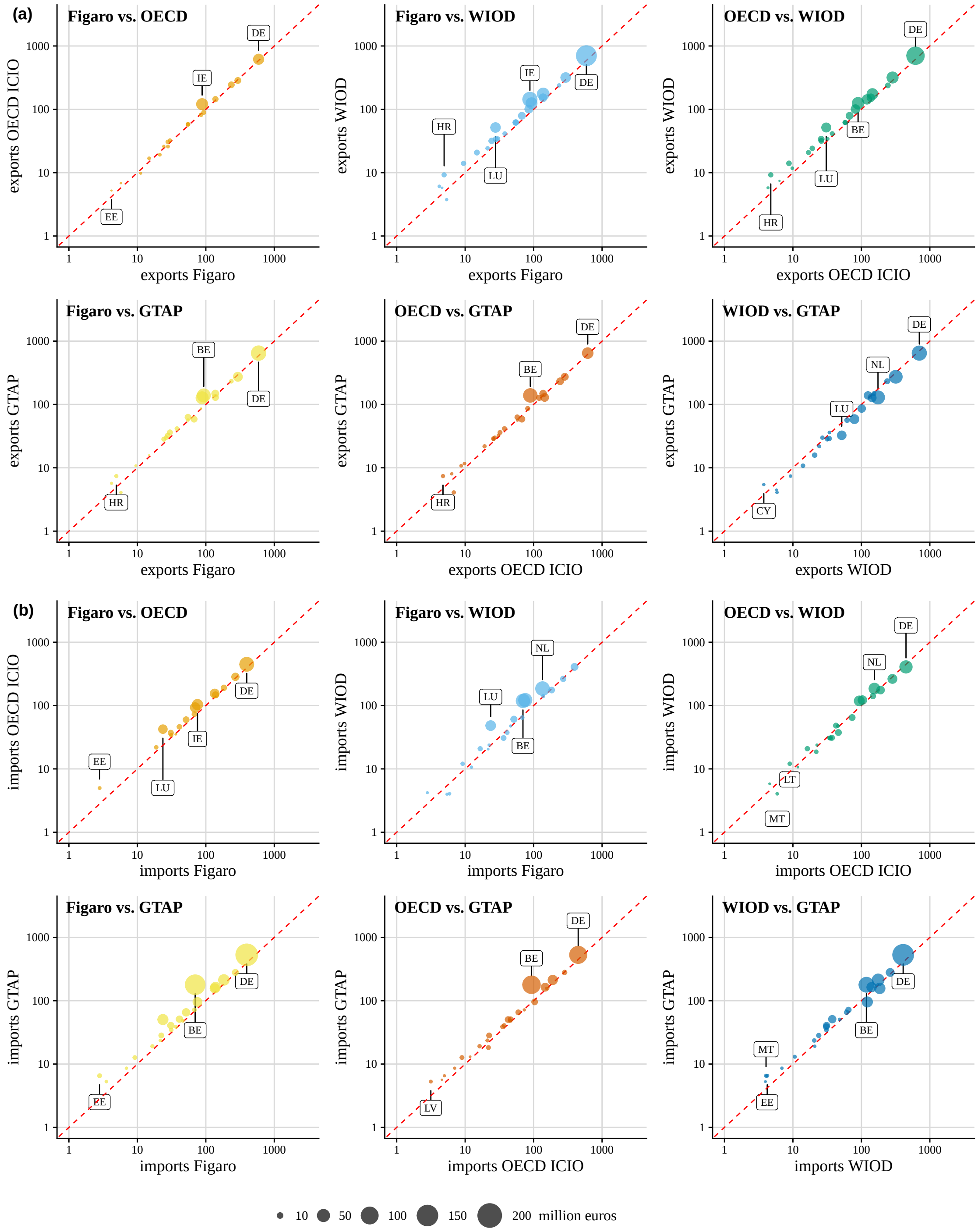

Figure 1. Deviations in extra-EU exports (a) and extra-EU imports (b) by country.

EU exports to non-EU countries, as mentioned earlier.

It is also noteworthy mentioning Ireland and Luxembourg when comparing the FIGARO and OECD-ICIO tables (also with WIOD), which are two of the largest differences between these databases. Given the fact that both MCIO tables use national supply and use tables directly sourced from the national statistical offices, the differences found in Ireland and Luxembourg are probably due to the way confidentiality is treated in both initiatives.

Figure 2 describes deviations by trading partner, showing the relevance of the "rest of the world" (ROW) region, notably for extra-EU exports and in the WIOD tables.

Notably, the WIOD tables tend to overestimate extra-EU bilateral exports when compared with all other MCIO tables, which is very relevant to the estimation of the value added and employment content in EU exports by trading partner. This might also lead to indirect biases in the results of value added and employment content of EU exports to other trading partners (e.g., Canada, United States), provided that the share of EU exports to non-EU countries does not differ significantly between each MCIO table. Other countries, such as Russia (RU), China (CN), the United Kingdom (GB), and India (IN), reported large differences, as shown in Figure 2.

Figure 3 focuses on deviations by exporting industry in extra-EU exports and by importing industry/final user in extra-EU imports. For extra-EU exports, for example, the GTAP-MRIO reports lower values in trade services (D45T47/G45_47) in all cases. This might be due to the different valuation of trade flows in the corresponding MCIO tables, i.e., basic prices (in WIOD, OECD-ICIO, and FIGARO) versus free on board (f.o.b.) prices in the GTAP-MRIO tables. The differences are due to domestic trade services that remain allocated to the products imported, which are valued in f.o.b., instead of being reallocated to domestic trade activities. This is equivalent to reporting bigger export values from the perspective of the exporter country.

As shown in Figure 3, the GTAP-MRIO table also reports lower extra-EU exports than all other MCIO tables in postal services and information and telecommunication services (H53_J63/D53T63). In this respect, this might be due to the assumptions made in the allocation of EU trade flows to non-EU countries in the absence of EU-specific trade in services data (e.g., trade asymmetries). Accordingly, the FIGARO and OECD-ICIO tables do not have such large differences in those service activities.

For extra-EU imports, government final consumption (P3_S13) seems to be overestimated in the WIOD tables compared to the FIGARO and OECD-ICIO tables, most probably due to the balancing of trade asymmetries and the subsequent reallocation of trade flows to non-EU countries. Given that the P3_S13 import totals are clearly provided by national supply and use tables, with a distinction between domestic and import uses, an alternative justification for the large differences would be the lack of official national supply and use tables at the time of the compilation process. We also argue that the same can be said for the large difference in gross fixed capital formation (GFCF) between the WIOD database and the GTAP-MRIO table.

Regarding the final consumption of households (HFCE/P31_S14) of imported products from non-EU countries, it is noteworthy that there is a large difference between the GTAP-MRIO database and the WIOD tables, most likely due to the fact that the use of the cross-border concept in the GTAP-MRIO tables can lead to bigger export values, which, in turn, means bigger import values as well for the importing country. Moreover, mathematically, this difference actually serves to compensate for the other large difference in terms of GFCF, in order to keep a similar EU GDP in the two MCIO tables.

overestimated."

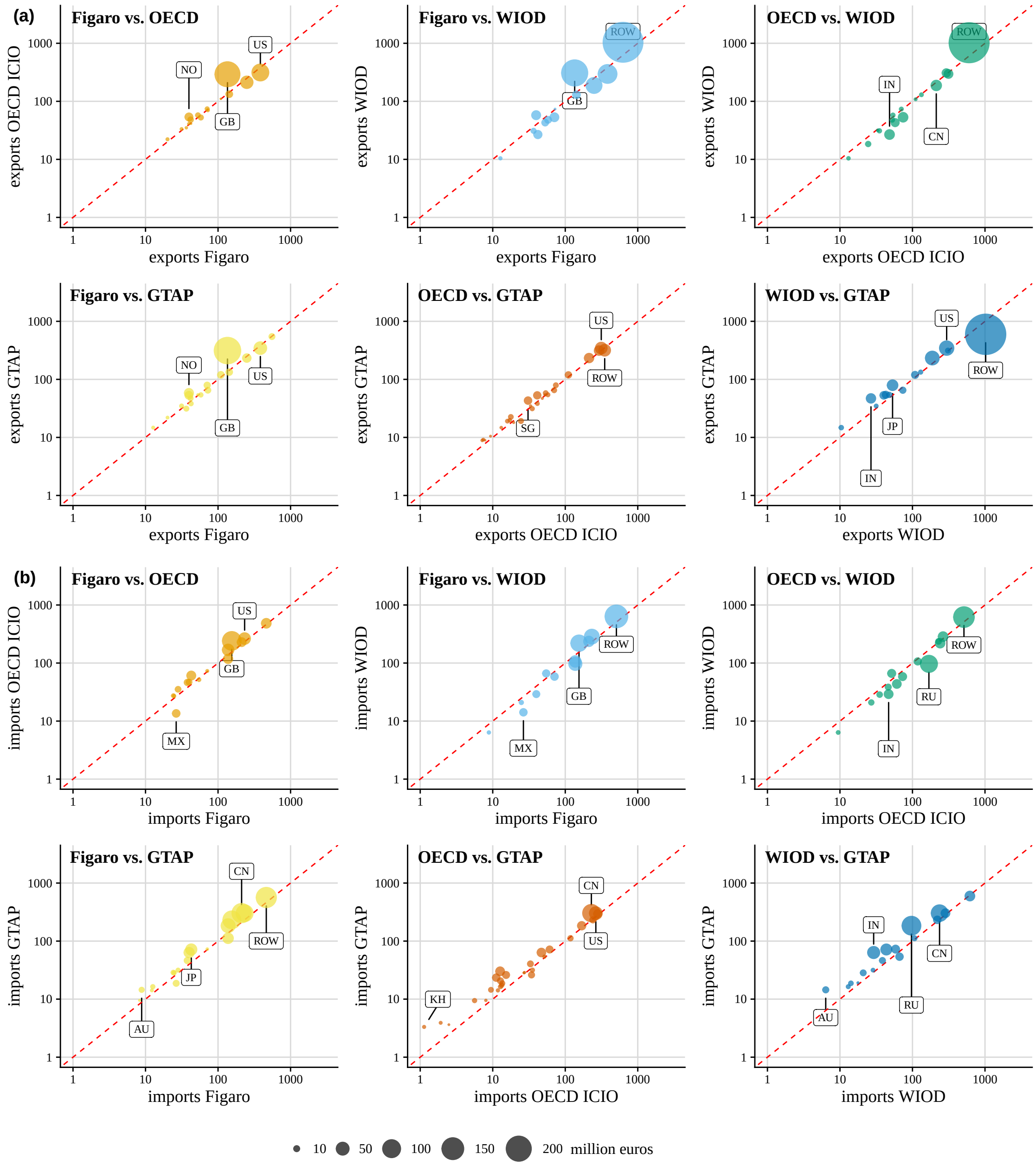

Figure 2. Deviations in extra-EU exports (a) and extra-EU imports (b) by trade partner.

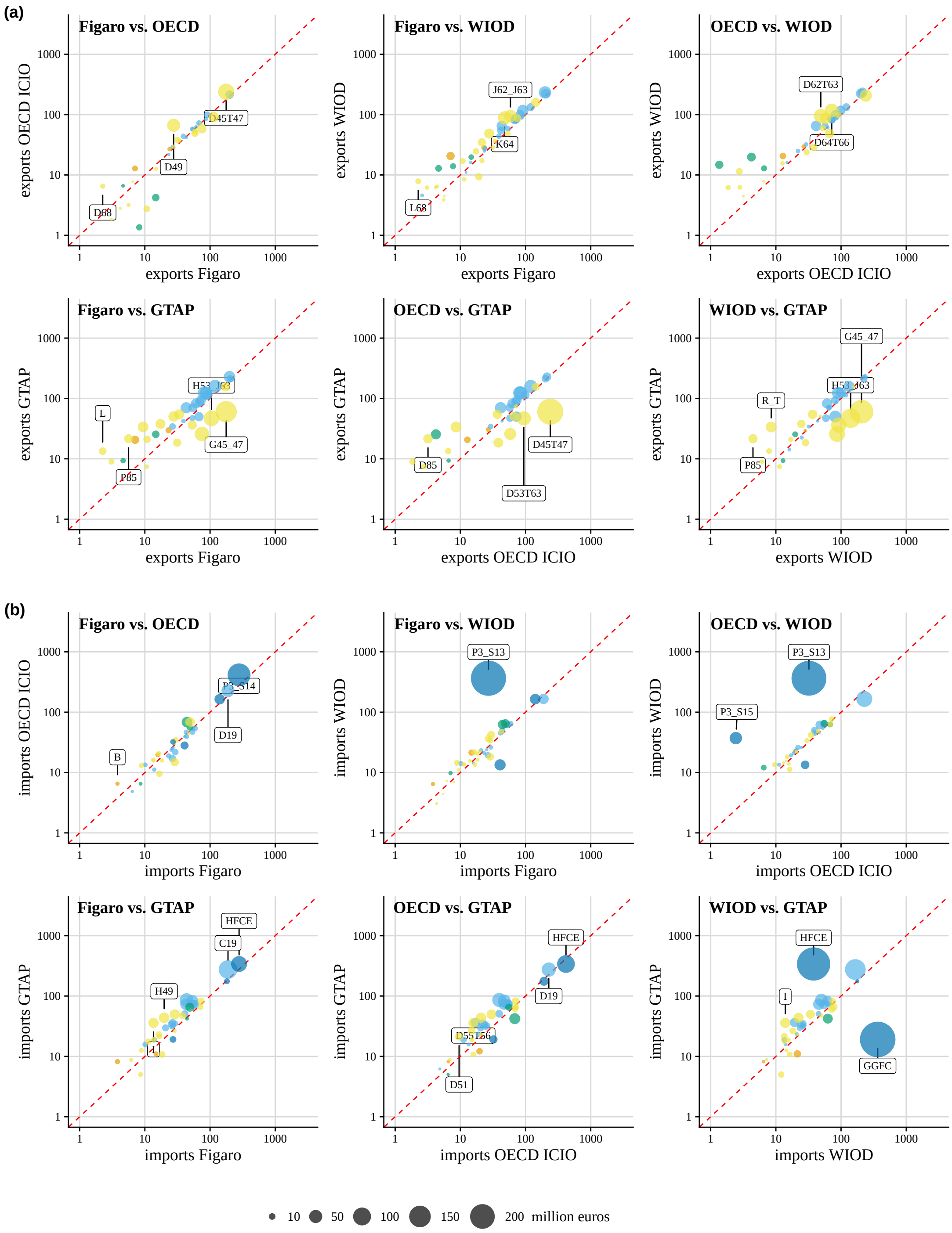

Figure 3. Deviations in extra-EU exports (a) and extra-EU imports (b) by industry/user.

In conclusion, the analysis of deviations in extra-EU exports and imports across different databases reveals notable patterns. Small economies exhibit higher relative deviations, highlighting the importance of accurate data representation for these countries, along with the data from economies with significant transit trade which also show high differences. The ROW region also plays a significant role in explaining discrepancies. Furthermore, trade in services emerges as a key area of difference, likely due to variations in valuation and allocation methods and/or underreporting. Moreover, the components of the final use matrix show significant discrepancies across databases, underscoring the need for greater harmonization and transparency in the allocation methods between intermediate and final users.

5.3. Deviations in the domestic and foreign value added content in EU gross exports for intermediate and final uses

This section analyzes the differences across MCIO tables in terms of the domestic and foreign value-added content of EU gross exports for intermediate and final uses, separately, as a share of gross exports (Table 3). The FIGARO tables are used as a benchmark for comparison with the other MCIO tables, using the absolute values of deviations, in both absolute (€ billion) and relative terms (%). Comparing aggregate EU data, the smallest differences always occur between the FIGARO and OECD-ICIO tables, followed by the FIGARO and WIOD tables. The largest differences occur between the FIGARO tables and the GTAP-MRIO database, clearly indicating the different methodological principles used in the compilation of both MCIO tables (cross-border principle versus ownership principle).

The use of official national supply and use tables, with a distinction between domestic and import uses, is crucial in assessing the differences in relation to the domestic value-added content of gross exports, either for intermediate or final uses. In this regard, it is not surprising to find that the FIGARO tables and the OECD-ICIO tables report the lowest differences, actually obtaining identical results at the EU level for the domestic content in gross exports for final uses. The lack of official national supply and use tables for EU countries at the time of compilation of the WIOD tables mostly explains the differences with respect to FIGARO. Regarding the biggest differences with GTAP-MRIO, it is noteworthy that the domestic content in gross exports does not deviate much, since the source of the EU national supply and use tables was Eurostat in both cases (Rueda-Cantuche et al., 2020). However, further adjustments made in the compilation process to gross exports values in the national use tables to reflect the cross-border principle have surely led to a bigger deviation in final exports (11%) with respect to FIGARO, as shown in Table 3.

However, with respect to the foreign components of gross exports, it is crucial to use the national supply and use tables of non-EU countries, as well as their value-added and output figures by industry. Typically, the OECD may be in a better position to use them, particularly for OECD non-EU countries and other non-OECD countries as well. The different sources of information used by the FIGARO and OECD-ICIO tables for non-EU countries might surely explain most of the differences found in the results shown in Table 3.

Interestingly, the use of the BEC classification versus national import use tables to break down gross exports into intermediate uses and final uses might justify the fact that the FIGARO results are closer to those of WIOD (based on national import use tables, too) rather than to the OECD-ICIO tables (based on the BEC classification). Overall, the deviations of the foreign value-added content in gross exports are 11% and 8% with respect to OECD-ICIO and WIOD, respectively, but with a significant difference

Table 3. Relative decomposition of the gross exports of EU member states in value added terms, by origin.

	FIGARO				OECD				FIGARO vs. OECD				WIOD				FIGARO vs. WIOD				GTAP				FIGARO vs. GTAP			
	Intermediate		Final		Intermediate		Final		Intermediate		Final		Intermediate		Final		Intermediate		Final		Intermediate		Final		Intermediate		Final	
	Dom.	Foreign	Dom.	Foreign	Dom.	Foreign	Dom.	Foreign	Dom.	Foreign	Dom.	Foreign	Dom.	Foreign	Dom.	Foreign	Dom.	Foreign	Dom.	Foreign	Dom.	Foreign	Dom.	Foreign	Dom.	Foreign	Dom.	Foreign
AT	47%	8%	39%	6%	51%	7%	37%	5%	9%	9%	6%	21%	52%	7%	36%	4%	12%	6%	8%	29%	49%	11%	33%	7%	4%	38%	15%	14%
BE	51%	12%	30%	6%	50%	11%	32%	7%	2%	9%	5%	9%	49%	16%	28%	8%	4%	25%	8%	18%	45%	22%	23%	10%	12%	79%	25%	56%
BG	44%	17%	31%	8%	44%	19%	29%	8%	0%	9%	6%	1%	57%	16%	22%	5%	30%	7%	28%	41%	46%	19%	26%	9%	4%	13%	15%	10%
CY	47%	19%	24%	10%	51%	14%	27%	8%	8%	24%	10%	16%	52%	9%	33%	5%	11%	51%	35%	43%	41%	14%	35%	10%	14%	23%	43%	5%
CZ	41%	10%	39%	10%	42%	9%	39%	9%	4%	8%	1%	11%	45%	9%	37%	9%	10%	10%	5%	12%	43%	13%	34%	10%	6%	24%	14%	3%
DE	44%	8%	42%	6%	47%	8%	40%	6%	5%	0%	4%	8%	45%	7%	41%	6%	2%	7%	1%	0%	44%	10%	37%	9%	2%	37%	10%	36%
DK	42%	18%	31%	9%	47%	11%	36%	7%	11%	40%	13%	19%	42%	13%	35%	10%	0%	26%	11%	12%	49%	10%	34%	7%	16%	45%	7%	15%
EE	55%	10%	29%	6%	52%	12%	27%	8%	5%	24%	6%	38%	56%	11%	26%	7%	2%	13%	11%	12%	42%	16%	30%	11%	23%	67%	1%	96%
ES	46%	10%	37%	7%	45%	10%	38%	7%	3%	0%	3%	2%	44%	11%	38%	7%	4%	15%	2%	4%	45%	12%	35%	8%	2%	18%	5%	17%
FI	50%	12%	31%	7%	52%	11%	31%	6%	4%	8%	0%	13%	53%	12%	29%	6%	7%	3%	7%	12%	53%	13%	27%	6%	7%	13%	14%	6%
FR	47%	8%	38%	7%	47%	8%	39%	7%	0%	7%	4%	9%	47%	8%	38%	7%	0%	6%	1%	2%	43%	10%	38%	9%	9%	18%	2%	26%
GR	45%	22%	24%	9%	45%	21%	26%	8%	0%	2%	5%	11%	51%	17%	25%	7%	14%	21%	4%	29%	35%	26%	25%	14%	21%	21%	2%	49%
HR	51%	8%	36%	5%	47%	6%	42%	5%	7%	29%	18%	3%	52%	9%	35%	4%	2%	10%	2%	21%	46%	8%	39%	6%	9%	4%	9%	27%
HU	41%	11%	37%	10%	43%	10%	38%	9%	3%	8%	2%	13%	42%	10%	37%	11%	1%	8%	1%	7%	40%	13%	35%	12%	4%	21%	6%	19%
IE	35%	13%	37%	15%	37%	15%	34%	15%	5%	18%	9%	4%	37%	22%	25%	17%	4%	74%	34%	10%	48%	20%	22%	10%	36%	55%	40%	33%
IT	41%	9%	43%	8%	42%	7%	45%	6%	2%	18%	5%	18%	42%	7%	44%	6%	3%	17%	4%	18%	43%	10%	39%	8%	5%	18%	9%	2%
LT	50%	15%	27%	8%	45%	12%	35%	8%	11%	19%	27%	9%	45%	16%	32%	7%	9%	5%	16%	7%	37%	21%	31%	11%	25%	42%	13%	38%
LU	42%	17%	29%	12%	40%	27%	20%	14%	4%	56%	32%	10%	33%	34%	16%	17%	21%	99%	45%	40%	29%	42%	14%	15%	29%	146%	53%	20%
LV	59%	9%	27%	5%	54%	7%	35%	4%	8%	24%	27%	9%	57%	10%	27%	5%	2%	11%	1%	2%	50%	14%	28%	8%	14%	46%	4%	62%
MT	27%	18%	33%	23%	28%	17%	37%	19%	6%	7%	12%	19%	28%	18%	36%	18%	7%	1%	10%	21%	36%	25%	25%	15%	34%	39%	25%	34%
NL	47%	14%	31%	9%	49%	11%	31%	8%	6%	15%	1%	13%	52%	14%	26%	8%	11%	5%	17%	7%	46%	16%	28%	9%	1%	22%	9%	6%
PL	47%	8%	39%	7%	47%	9%	38%	7%	0%	9%	2%	2%	49%	8%	37%	6%	5%	0%	4%	8%	46%	11%	35%	8%	1%	41%	10%	16%
PT	46%	11%	36%	8%	44%	8%	42%	7%	5%	30%	17%	8%	54%	9%	32%	5%	19%	18%	12%	36%	46%	10%	37%	8%	1%	12%	3%	1%
RO	52%	6%	38%	4%	48%	5%	43%	5%	8%	10%	12%	8%	59%	9%	28%	4%	15%	51%	28%	6%	54%	9%	32%	5%	4%	51%	15%	15%
SE	48%	8%	39%	6%	51%	8%	36%	6%	6%	3%	8%	1%	51%	9%	34%	5%	8%	20%	13%	5%	52%	11%	31%	6%	9%	45%	21%	4%
SI	46%	9%	37%	8%	49%	9%	36%	6%	5%	6%	2%	15%	53%	8%	34%	5%	14%	13%	8%	32%	46%	11%	34%	9%	0%	18%	7%	14%
SK	37%	10%	41%	12%	39%	11%	38%	11%	6%	14%	7%	6%	39%	6%	43%	12%	5%	32%	4%	4%	30%	8%	47%	15%	18%	14%	13%	22%
EU	**45%**	**10%**	**38%**	**8%**	**46%**	**9%**	**38%**	**7%**	**2%**	**5%**	**0%**	**6%**	**46%**	**11%**	**36%**	**8%**	**3%**	**8%**	**5%**	**0%**	**44%**	**13%**	**34%**	**9%**	**1%**	**32%**	**11%**	**16%**

Table 4. Absolute decomposition of the gross exports of EU member states in value added terms, by origin (€ bn.).

	FIGARO				OECD				FIGARO vs. OECD				WIOD				FIGARO vs. WIOD				GTAP				FIGARO vs. GTAP			
	Intermediate		Final		Intermediate		Final		Intermediate		Final		Intermediate		Final		Intermediate		Final		Intermediate		Final		Intermediate		Final	
	Dom.	Foreign	Dom.	Foreign	Dom.	Foreign	Dom.	Foreign	Dom.	Foreign	Dom.	Foreign	Dom.	Foreign	Dom.	Foreign	Dom.	Foreign	Dom.	Foreign	Dom.	Foreign	Dom.	Foreign	Dom.	Foreign	Dom.	Foreign
AT	26	4	21	3	29	4	21	3	4	0	0	1	32	5	22	3	7	0	1	1	31	7	21	5	5	3	1	1
BE	48	12	28	6	45	10	28	6	3	1	0	0	61	19	34	9	14	8	6	3	63	31	31	14	15	19	3	8
BG	5	2	3	1	4	2	3	1	1	0	1	0	7	2	3	1	2	0	1	0	5	2	3	1	0	0	0	0
CY	3	1	1	1	2	1	1	0	0	0	0	0	2	0	1	0	1	1	0	0	2	1	2	1	0	0	1	0
CZ	12	3	12	3	14	3	13	3	2	0	1	0	15	3	13	3	3	0	1	0	16	5	12	4	4	2	1	1
DE	262	44	247	37	288	46	247	36	26	2	0	1	317	49	291	44	56	5	44	7	283	67	243	55	21	22	4	18
DK	28	12	21	6	31	7	24	5	3	5	3	1	33	10	28	8	5	2	6	2	29	6	20	4	1	6	1	1
EE	2	0	1	0	3	1	1	0	0	0	0	0	3	1	2	0	1	0	0	0	2	1	2	1	0	1	0	0
ES	63	14	51	9	62	14	52	10	2	0	2	0	67	18	57	10	4	4	7	1	67	18	52	12	4	4	2	3
FI	19	5	12	3	19	4	12	2	1	0	0	0	22	5	12	2	3	0	0	0	22	6	11	3	3	1	1	0
FR	137	24	111	21	133	22	112	19	4	2	1	2	149	25	121	22	12	1	10	1	117	26	105	25	20	2	6	4
GR	13	6	7	3	12	6	7	2	1	1	0	0	17	6	8	2	5	0	2	0	10	8	7	4	2	2	0	1
HR	3	0	2	0	2	0	2	0	0	0	0	0	5	1	3	0	2	0	1	0	3	1	3	0	1	0	1	0
HU	11	3	10	3	12	3	10	2	1	0	1	0	11	3	10	3	0	0	0	0	12	4	11	4	1	1	1	1
IE	31	11	33	13	44	18	40	17	13	7	8	4	52	32	35	24	21	21	3	11	61	25	28	13	30	14	4	0
IT	96	21	100	19	101	18	109	16	5	3	9	3	100	18	106	15	4	3	5	3	99	24	90	19	3	3	10	0
LT	5	1	3	1	4	1	3	1	1	0	0	0	6	2	4	1	2	1	2	0	4	2	3	1	1	1	1	0
LU	12	5	8	3	12	8	6	4	1	3	2	1	17	18	8	9	5	13	0	5	10	14	5	5	2	9	3	2
LV	3	0	1	0	2	0	1	0	0	0	0	0	3	1	2	0	1	0	0	0	2	1	1	0	0	0	0	0
MT	2	1	2	1	2	1	3	1	0	0	1	0	2	1	2	1	0	0	0	0	1	1	1	1	0	0	1	1
NL	65	19	43	12	72	17	46	11	7	2	3	1	91	25	45	14	26	6	2	2	60	21	37	12	5	3	6	0
PL	26	4	21	4	27	5	22	4	2	1	1	0	30	5	23	4	5	1	2	0	26	6	20	4	1	2	1	1
PT	11	3	9	2	11	2	11	2	0	1	2	0	17	3	10	2	6	0	1	0	13	3	10	2	2	0	2	0
RO	11	1	8	1	9	1	8	1	2	0	0	0	14	2	7	1	3	1	1	0	12	2	7	1	1	1	1	0
SE	41	7	33	5	42	7	29	5	1	0	4	0	52	9	34	5	11	3	1	1	45	10	27	5	4	3	6	0
SI	3	1	3	1	3	1	2	0	0	0	0	0	4	1	3	0	1	0	0	0	4	1	3	1	0	0	0	0
SK	5	1	6	2	7	2	6	2	1	0	0	0	8	1	9	2	3	0	3	1	5	1	7	2	1	0	1	1
EU	**940**	**206**	**796**	**159**	**993**	**202**	**821**	**154**	**53**	**4**	**25**	**5**	**1141**	**263**	**893**	**188**	**200**	**57**	**97**	**29**	**1006**	**293**	**763**	**198**	**65**	**87**	**33**	**39**

in terms of trade allocation to intermediate or final uses. Finally, with respect to FIGARO and GTAP-MRIO, the overall absolute deviation in the foreign component of gross exports for intermediate use is 32%, and for final use is 16%, at the EU level.

Table 3 shows that deviations in relative terms are bigger in smaller countries, such as Luxembourg, Cyprus, Ireland, Estonia, or Lithuania, while lesser in big countries, such as France, Spain, Poland, and Germany. In absolute terms (see Table 4), deviations are greater in large countries, such as Germany and France, but, interestingly, also in Ireland (in our view, mostly due to confidentiality reasons), Belgium, and the Netherlands (both related to re-exports and trade asymmetries). Latvia and Slovenia reported the smallest deviations.

Table 5. GVC backward participation (in € bn.) and absolute values of deviations.

	Figaro	OECD	WIOD	GTAP	Figaro vs. OECD		Figaro vs. WIOD		Figaro vs. GTAP	
	€ bn.	€ bn.	€ bn.	€ bn.	%	€ bn.	%	€ bn.	%	€ bn.
AT	8	7	7	11	10%	0.77	6%	0.44	46%	3.62
BE	18	16	29	45	7%	1.21	64%	11.31	156%	27.42
BG	3	3	2	3	7%	0.19	14%	0.39	17%	0.47
CY	2	1	1	1	31%	0.47	64%	0.98	12%	0.19
CZ	6	6	6	8	2%	0.12	2%	0.14	38%	2.28
DE	82	82	93	122	1%	0.63	14%	11.81	50%	40.45
DK	18	12	18	10	33%	5.95	1%	0.26	43%	7.70
EE	1	1	1	2	60%	0.40	63%	0.42	142%	0.94
ES	23	24	28	30	2%	0.39	19%	4.39	28%	6.43
FI	7	6	7	8	10%	0.74	2%	0.16	16%	1.14
FR	45	41	47	51	10%	4.75	4%	1.68	13%	6.02
GR	9	8	8	12	12%	1.02	7%	0.62	34%	2.93
HR	1	1	1	1	22%	0.14	83%	0.54	69%	0.45
HU	6	5	6	8	8%	0.43	2%	0.12	37%	2.03
IE	25	36	56	38	46%	11.19	127%	31.08	56%	13.76
IT	39	33	33	43	15%	6.08	16%	6.46	9%	3.61
LT	2	2	3	3	16%	0.35	50%	1.07	60%	1.29
LU	8	12	26	19	51%	4.15	224%	18.27	135%	11.01
LV	1	0	1	1	24%	0.16	33%	0.22	48%	0.32
MT	2	2	2	2	3%	0.06	11%	0.25	30%	0.71
NL	31	28	39	33	10%	3.12	27%	8.26	8%	2.53
PL	8	9	9	11	10%	0.81	9%	0.70	34%	2.74
PT	5	4	4	5	16%	0.71	2%	0.10	8%	0.37
RO	2	2	3	3	12%	0.25	45%	0.96	40%	0.87
SE	11	11	15	15	2%	0.26	30%	3.38	29%	3.35
SI	1	1	1	2	19%	0.23	18%	0.22	31%	0.37
SK	3	4	4	4	17%	0.54	17%	0.55	13%	0.43
EU	**365**	**356**	**451**	**491**	**2%**	**8.80**	**24%**	**85.83**	**35%**	**126.22**

5.4. GVC backward participation in EU exports to the world

Table 5 shows the foreign value-added content of EU gross exports (for all intermediate and final uses) by member state, for each MCIO table, in absolute terms (in € billion) and in relative terms (%) with respect to FIGARO, used as a reference. This indicator is known as a good measure of GVC backward participation (Piñero et al., 2024).

As shown in previous sections for trade flows, the FIGARO and OECD-ICIO tables are well aligned in the measurement of GVC backward participation, whereas the other MCIO tables, such as WIOD and GTAP-MRIO, show substantially different results with respect to the FIGARO database, i.e., 24% and 35%, respectively. In absolute terms, WIOD reported almost ten times the difference of the OECD-ICIO with respect to FIGARO, while for GTAP-MRIO, it is more than fourteen times.

At the country level, the GVC backward participation values of Luxembourg and Ireland seem to be the most problematic, with high deviations in both relative and absolute terms. In both cases, the large differences might be due to the difficulty of dealing with confidentiality. A different case is Belgium, which has high deviations across all the different MCIO tables (vs. FIGARO), both in absolute and relative terms. However, those deviations might be more related to the treatment of re-exports and trade asymmetries rather than to confidential data. Estonia and Croatia report large deviations, but only in relative terms, not large enough when comparing differences in billion euros. Furthermore, France, Italy, and Germany report large differences in absolute values but not significantly high in relative terms.

6. Policy implications of MCIO trade discrepancies: the employment content of gross exports

In the formulation of trade policies, for example, when assessing the feasibility of signing a free trade agreement, it is crucial to understand the extent to which employment, both direct and indirect, is supported by exports. Table 6 presents the total employment in terms of the number of jobs, utilizing all the databases analyzed. Overall, the discrepancies are relatively low, with the absolute numbers ranging from 27.4 to 31.5 million workers, which accounts for approximately 15% of the total EU employment in 2014. In contrast to the previous example, the deviations between FIGARO and the OECD/GTAP-MRIO are quite similar in this case, whereas WIOD exhibits higher deviations of up to more than 4 million jobs in total.

At the country level, unsurprisingly, Ireland stands out with the largest deviations with respect to FIGARO, both in absolute and relative values and across all databases, followed by the Netherlands, in particular regarding OECD and WIOD comparisons. Whereas the Irish case is mainly related to confidentiality, the Dutch case is revealing in that the underestimation of bilateral re-exports by the OECD and WIOD databases might have overestimated the Dutch domestic exports (to non-EU countries) reported by the FIGARO tables. Germany is the country with the largest difference with respect to FIGARO in all other databases, rising up to 1 million jobs for WIOD. This might be related in part to the overestimation of domestic exports, as explained for the Netherlands, due to the lack of information on bilateral re-exports. The same can be said for Italy and France. Other smaller countries, such as Estonia, Cyprus, and Croatia, stand out with high relative deviations but are not substantially large in absolute terms.

As mentioned in previous sections, the use of official national supply and use tables with a distinction between domestic and import uses is crucial for reducing the deviations across the different MCIO tables. In the absence of an import use table, it is difficult to estimate accurately benchmark values for re-exports by product level. Moreover, the breakdown of total national production into intermediate use and final use (including exports) is of utmost importance. Otherwise, an overestimation of the number of jobs in extra-EU exports can be easily explained due to a possible underestimation of re-exports and/or an overestimation of the share of domestic production allocated to final uses (e.g., exports). In both cases, the result is an overestimation of domestic exports, resulting in a subsequent overestimation of the number of jobs supported by extra-EU exports, or even supported by total EU exports.

Table 6. Employment supported by EU exports by country in thousand jobs, and absolute values of deviations.

	Figaro	**OECD**	**WIOD**	**GTAP**	**Figaro vs. OECD**		**Figaro vs. WIOD**		**Figaro vs. GTAP**	
	th. jobs	th. jobs	th. jobs	th. jobs	%	th. jobs	%	th. jobs	%	th. jobs
AT	560	625	659	643	12%	65	16%	99	13%	83
BE	762	774	984	860	2%	13	29%	222	10%	98
BG	710	630	738	677	11%	80	5%	28	4%	32
CY	61	56	68	91	8%	5	13%	8	45%	30
CZ	835	864	940	970	3%	29	12%	104	14%	134
DE	6732	7153	7804	7113	6%	422	15%	1072	5%	381
DK	402	450	491	468	12%	48	20%	89	13%	65
EE	91	107	138	116	18%	17	44%	47	18%	25
ES	2140	2107	2000	2133	2%	33	7%	140	0%	7
FI	350	366	403	416	5%	16	15%	53	16%	66
FR	3080	3093	3306	2752	0%	13	7%	226	10%	328
GR	434	435	571	427	0%	2	32%	137	1%	7
HR	193	165	329	263	15%	28	82%	135	21%	70
HU	631	706	719	776	12%	75	12%	88	20%	145
IE	440	599	691	645	36%	159	42%	251	30%	205
IT	2920	3179	3218	3098	9%	259	9%	298	6%	178
LT	253	236	342	247	6%	16	38%	89	2%	6
LU	106	92	141	95	13%	14	37%	34	8%	11
LV	158	150	185	142	5%	8	18%	26	9%	16
MT	42	52	52	48	25%	11	20%	10	13%	7
NL	1317	1606	1862	1239	22%	288	34%	544	4%	78
PL	2103	2059	2327	2162	2%	44	11%	224	3%	59
PT	550	604	668	630	10%	54	20%	118	12%	80
RO	1271	1225	1411	1388	4%	46	11%	140	8%	116
SE	727	708	871	740	3%	19	20%	144	2%	13
SI	157	142	170	169	9%	15	10%	14	7%	12
SK	342	356	417	348	4%	14	21%	74	1%	6
EU	**27,367**	**28,540**	**31,503**	**28,656**	**4%**	**1,173**	**14%**	**4,136**	**4%**	**1,289**

7. Conclusions and recommendations

Over the last two decades, academic research institutions and international organizations across the world have conducted projects to compile global multicountry input-output (MCIO) databases. Several of these databases, such as WIOD, Exiobase, GTAP-MRIO, OECD-ICIO, FIGARO, and Eora, were the outcome of this process.

All of these MCIO tables depict the interconnectedness of upstream and downstream industries across countries and production factors, allowing for the assessment of a wide range of socio-economic, environmental, and international trade impacts.

However, as the compilation of these MCIO tables was experimental, following different assumptions and methodological approaches, (sometimes large) deviations regarding key variables and indicators among those databases were frequent and noticeable. In this respect, little attention has been paid to examining closely the compilation process and underlying trade data of each database as explanatory factors of the differences in the results and their subsequent effects on policy-relevant indicators. This paper provides insights into this subject and identifies key drivers in the compilation of the MCIO databases that deserve further scrutiny when comparing differences in indicators, in particular, in the estimation of the domestic and foreign value-added and employment content of gross exports. These key elements are:

- the breakdown of exports between intermediate and final uses;
- the breakdown between domestic exports and re-exports;
- the way trade asymmetries are balanced, for both goods and services, and the prioritization of global consistency versus regional or national accuracy;
- the way confidential values are replaced by guess-estimates; and
- the way the breakdown of products and their geographical allocation is handled when linking the domestic and national concepts in the supply and use tables (e.g., direct purchases abroad) and the ownership and cross-border principles between national accounts and trade statistics (e.g., processing services and merchanting).

As shown by the results for EU trade, the main conclusion is that the lack of official national supply and (domestic and imported) use tables can lead to substantial discrepancies among several MCIO databases regarding the calculation of employment supported by EU exports. The largest differences are observed when comparing the FIGARO database with WIOD, whereas OECD and GTAP deliver similar results. In respect to single EU member states, Belgium, the Netherlands, Ireland, and Luxembourg depict the largest deviations across the different MCIO databases, which can be linked to the different methods used in the estimation of (domestic) exports for intermediate and final uses, re-exports, confidentiality, among others.

We hope this paper can serve as a guideline for international organizations to pursue further the institutionalization (Rueda-Cantuche et al., 2018) of a global MCIO database, jointly produced with common classifications, agreed methodologies, and common use of input data entering the compilation process. It seems that the first steps have already been taken by seven international organizations[20]

[20] Asian Development Bank (ADB), the European Commission (EC) represented by Eurostat and the Joint Research Centre (JRC), the Organisation for Economic Co-operation and Development (OECD), the International Monetary Fund (IMF), the United Nations Economic Commission for Africa (UN-ECA), the United Nations Economic Commission for Latin America and the Caribbean (UN-ECLAC), and the World Trade Organisation (WTO).

under the GIANT (Global Input-Output Accounts) initiative (Rueda-Cantuche and Durán, 2023), an inter-agency network[21] that aims to converge on a common global benchmark for the input data used by the partner organizations to produce global multicountry supply, use, and input-output tables.

Use of AI tools declaration

The authors declare that Artificial Intelligence (AI) tools were used exclusively for improving the readability of the manuscript. No AI-generated content was incorporated into the body of the work, and all data analysis, interpretation, and scientific conclusions were drawn by the authors without the influence of AI tools.

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Disclaimer

The opinions expressed in this paper are the authors' own and do not necessarily reflect the views and opinions of the European Commission.

Conflict of interest

All authors declare no conflicts of interest in this paper.

References

Abd Rahman MD, Los B, Owen A, et al. (2023) Multi-level comparisons of input–output tables using cross-entropy indicators. *Econ Syst Res* 35: 75–94. https://doi.org/10.1080/09535314.2021.1990869

Arto I, Rueda-Cantuche JM, Peters GP (2014) Comparing the GTAP-MRIO and WIOD databases for carbon footprint analysis. *Econ Syst Res* 26: 262–283. https://doi.org/10.1080/09535314.2014.939949

Arto I, Dietzenbacher E, Rueda-Cantuche JM (2019) Measuring bilateral trade in terms of value added. Luxembourg: Publications Office of the European Union. Available from: https://op.europa.eu/en/publication-detail/-/publication/bbd49b67-8283-11e9-9f05-01aa75ed71a1/language-en.

[21] Created under the umbrella of the OECD informal group of Regional-Global Trade in Value Added Initiatives (2017–2024).

Carrico C, Corong E, van der Mensbrugghe D (2020) The GTAP 10A Multi-Region Input Output (MRIO) Data Base. Research Memorandum No. 34, April. Available from: https://www.gtap.agecon.purdue.edu/resources/download/10043.pdf.

European Commission, International Monetary Fund, Organisation for Economic United Nations Co-operation, et al. (2009) System of National Accounts – SNA 2008. Available from: https://unstats.un.org/unsd/nationalaccount/docs/SNA2008.pdf.

Eurostat (2013) European System of Accounts – ESA2010. Luxembourg: Publications Office of the European Union. Available from: https://ec.europa.eu/eurostat/documents/3859598/5925693/KS-02-13-269-EN.PDF/.

Eurostat (2018) International trade statistics – background. Luxembourg: Publications Office of the European Union. Available from: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=International_trade_statistics_-_background#Asymmetries.

Eurostat (2023) Employment by detailed industry (NACE Rev.2) - national accounts. Available from: https://ec.europa.eu/eurostat/databrowser/view/nama_10_a64_e/default/table?lang=en&category=na10.nama10.nama_10_dbr.

Eurostat (2024) International trade statistics - background. Explained Article. Available from: https://ec.europa.eu/eurostat/statistics-explained/SEPDF/cache/37447.pdf.

Fusacchia I, Salvatici L (2022) GTAP and TiVA: Differences Between the two Databases and their Implications for Trade in Value-Added Indicators. Collana Centro Rossi-Doria Papers, 5. Università degli Studi Roma Tre. Centro Rossi-Doria. Available from: https://romatrepress.uniroma3.it/wp-content/uploads/2022/08/RDP-5-22.pdf.

Huo J, Chen P, Hubacek K, et al. (2022) Full-scale, near real-time multi-regional input-output table for the global emerging economies (EMERGING). *J Ind Ecol* 26: 1218–1232. https://doi.org/10.1111/jiec.13264

Horvát P, Webb C, Yamano N (2020) Measuring employment in global value chains. OECD Science, Technology and Industry Working Papers, No. 2020/01. OECD Publishing, Paris. https://doi.org/10.1787/00f7d7db-en

International Monetary Fund (IMF), the Organisation for Economic Co-operation and Development (OECD), the United Nations Conference on Trade and Development (UNCTAD), et al. (2023) Handbook on Measuring Digital Trade. Second edition. Available from: https://www.oecd.org/content/dam/oecd/en/publications/reports/2023/07/handbook-on-measuring-digital-trade-second-edition_099afd2f/ac99e6d3-en.pdf.

Jones L, Wang Z, Xin L, et al. (2014) The Similarities and Differences among Three Major inter-Country input-output Databases and their implications for Trade in value-added estimates. Office of Economics Working Papers, no. 2014-12b, USITC. Available from: https://www.wto.org/english/res_e/statis_e/miwi_e/usitcwkpper.pdf.

Junius T, Oosterhaven J (2003) The Solution of Updating or Regionalizing a Matrix with Both Positive and Negative Elements. *Econ Syst Res* 15: 87–96. https://doi.org/10.1080/0953531032000056954

Lenzen M, Moran D, Kanemoto K, et al. (2013) Building Eora: A Global Multi-regional Input-Output Database at High Country and Sector Resolution. *Econ Syst Res* 25: 20-49. https://doi.org/10.1080/09535314.2013.769938

Lenzen M, Geschke A, Abd Rahman MD, et al. (2017) The Global MRIO Lab – charting the world economy. *Econ Syst Res* 29: 158–186. https://doi.org/10.1080/09535314.2017.1301887

Lenzen M, Geschke A, West J, et al. (2022) Implementing the material footprint to measure progress towards Sustainable Development Goals 8 and 12. *Nat Sustain* 5: 157–166. https://doi.org/10.1038/s41893-021-00811-6

Martins-Ferreira P (2018) QDR methodology: understanding trade flows in the EU. Eurostat Review on National Accounts and Macroeconomic Indicators (EURONA), 2/2018. Available from: https://cros-legacy.ec.europa.eu/system/files/euronaissue2-2018-article3.pdf.

Miao G, Fortanier F (2017) Estimating Transport and Insurance Costs of International Trade. OECD Statistics Working Papers, 2017/04. Available from: https://www.oecd-ilibrary.org/economics/estimating-transport-and-insurance-costs-of-international-trade_8267bb0f-en.

OECD (2021) OECD Inter-Country Input-Output Database. Available from: http://oecd/icio.

OECD, Directorate for Science, Technology, et al. (2023) Guide to OECD Trade in Value Added (TiVA) Indicators, 2023 edition. Available from: https://www.oecd.org/content/dam/oecd/en/topics/policy-sub-issues/trade-in-value-added/tiva-indicators-guide-2023.pdf.

OECD (2025) The OECD Balanced International Merchandise Trade Dataset (BIMTS). OECD Publishing, Paris. https://doi.org/10.1787/07518168-en

Owen A, Steen-Olsen K, Barrett J, et al. (2014) A Structural Decomposition Approach to Comparing MRIO Databases. *Econ Syst Res* 26: 262–283. https://doi.org/10.1080/09535314.2014.935299

Piñero P, Banacloche S, Rueda-Cantuche JM, et al. (2018) Macroeconomic globalisation indicators based on FIGARO. Insights into the measurement of value added and employment in the EU – 2024 edition. Eurostat Statistical Working Papers. Available from: https://ec.europa.eu/eurostat/documents/3888793/20487140/KS-01-24-017-EN-N.pdf/121d6f41-b669-22b2-cf9c-c1ef%c8731e9c?version=5.0&t=1747746278627.

Remond-Tiedrez I, Rueda-Cantuche JM (2019) EU inter-country supply, use and input-output tables — Full international and global accounts for research in input-output analysis (FIGARO). Eurostat 2019 edition. Available from: https://ec.europa.eu/eurostat/web/products-statistical-working-papers/-/ks-tc-19-002.

Rueda-Cantuche JM, Remond-Tiedrez I, Bouwmeester MC (2018) Institutionalization of Inter-Country Input-Output Tables: Working Towards Harmonization and Standardization. *J Ind Ecol* 22: 485–486. https://doi.org/10.1111/jiec.12761

Rueda-Cantuche JM, Revesz T, Amores AF, et al. (2020) Improving the European input–output database for global trade analysis. *J Econ Struct* 9: 33. https://doi.org/10.1186/s40008-020-00208-2

Rueda-Cantuche JM, Durán JE (2023) Global Input-Output Accounts (GIANT): a collective initiative to harmonise input data entering ICIO tables published by international organisations. 30th International Input-Output Conference, Santiago (Chile). Available from: `https://www.iioa.org/conferences/30th/papers/files/5209.pdf`.

Stadler K, Steen-Olsen K, Wood R (2014) The 'Rest of the World' - Estimating the economic structure of missing regions in global multi-regional input-output tables. *Econ Syst Res* 26: 303–326. https://doi.org/10.1080/09535314.2014.936831

Stadler K, Wood R, Bulavskaya T, et al. (2018). EXIOBASE 3: Developing a Time Series of Detailed Environmentally Extended Multi-Regional Input-Output Tables. *J Ind Ecol* 22: 502–515. https://doi.org/10.1111/jiec.12715

Tarne P, Lehmann A, Finkbeiner M (2018) A comparison of Multi-Regional Input-Output databases regarding transaction structure and supply chain analysis. *J Clean Prod* 196: 1486–1500. https://doi.org/10.1016/j.jclepro.2018.06.082

Timmer MP, Dietzenbacher E, Los B, et al. (2015) An Illustrated User Guide to the World Input–Output Database: the Case of Global Automotive Production. *Rev Int Econ* 23: 575–605. https://doi.org/10.1111/roie.12178

Timmer MP, Los B, Stehrer R, et al. (2016) GGDC research memorandum number 162. University of Groningen. Available from: `https://www.rug.nl/ggdc/html_publications/memorandum/gd162.pdf`.

UNECE (2015) Guide to Measuring Global Production. United Nations Economic Commission for Europe, Geneva. Available from: `https://unece.org/DAM/stats/publications/2015/Guide_to_Measuring_Global_Production__2015_.pdf`.

UN-ECLAC (2016) La matriz de insumo-producto de América del Sur. Principales supuestos y consideraciones metodológicas. Comisión Económica para América Latina y el Caribe (CEPAL), Santiago de Chile. Available from: `https://repositorio.cepal.org/bitstream/handle/11362/40271/1/S1600691_es.pdf`.

United Nations (2011) International Merchandise Trade Statistics: Concepts and Definitions 2010. Department of Economic and Social Affairs. Statistics Division. Statistical Papers, Series M, No. 52. United Nations, New York. Available from:
`https://unstats.un.org/unsd/trade/eg-imts/IMTS%202010%20(English).pdf`.

United Nations (2016) Classification by Broad Economic Categories Rev.5. Statistical Papers, Series M, No. 53, Rev. 5. United Nations, New York. Available from:

https://unstats.un.org/unsd/trade/classifications/SeriesM_53_Rev.5_17-01722-E-Classification-by-Broad-Economic-Categories_PRINT.pdf.

United Nations (2018) Handbook on Supply and Use Tables and Input Output-Tables with Extensions and Applications. United Nations, New York. Available from: https://unstats.un.org/unsd/nationalaccount/docs/SUT_IOT_HB_Final_Cover.pdf.

Valderas-Jaramillo JM, Rueda-Cantuche JM (2021) The multidimensional nD-GRAS method: Applications for the projection of multiregional input–output frameworks and valuation matrices. *Pap Reg Sci* 100: 1599–1624. https://doi.org/10.1111/pirs.12625

Yamano N, Guilhoto J, Alsamawi A, et al. (2022) Development of the OECD Inter-country Input-Output Database: Sources and Methods. WorldKlems Conf. Available from: https://www.worldklems.net/conferences/worldklems2022/paper_Webb.pdf.

Yamano N, Guilhoto J (2020) CO_2 emissions embodied in international trade and domestic final demand: Methodology and results using the OECD Inter-Country Input-Output Database. OECD Science, Technology and Industry Working Papers, No. 2020/11. OECD Publishing, Paris. https://doi.org/10.1787/8f2963b8-en