

Performing supply chain analysis using different sources: differences between TiVA and GTAP trade in value added indicators

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1. INTRODUCTION

Production processes are becoming increasingly fragmented and dispersed among many different locations in various countries. More than 50% of trade in goods takes place in intermediate products, implying that traditional trade statistics based on gross flows do not provide information on the actual patterns of production behind world trade. From one side, the value added exported by a country does not coincide with the value of that country's exports because exports contain value added from other countries; from the other side, imports have a domestic content given by the contribution of domestic firms exporting intermediate inputs, which are processed abroad and then imported back. In other terms, gross recording of trade flows does not account for backward/forward trade, i.e., trade in value added between two countries occurring via a third country.

There is widespread recognition that fragmentation of global production requires measurement of trade in Value Added (VA), which accounts for the way slices of value embedded in goods or services are added at each step of increasingly international manufacturing processes within global supply chains (GVCs). The current standard for GVC analysis at the macro level relies on the global Inter-Country Input-Output (ICIO) accounting. An ICIO table harmonizes national input-output (IO) tables for multiple regions and links trade flows directly from producers in each region to importing firms and consumers in all other regions. The use of statistics based on an ICIO accounting has become more routine for analyzing key areas of international economics and governance (e.g., international trade and governance, the link between the environment and the economy, the impact of globalization on labour markets) (Tukker and Dietzenbacher, 2013).

Since the early 2000s, various research initiatives have undertaken the development of different ICIO databases in response to policy needs and scientific aims. Among the most well-known there are the Trade in Value Added (TiVA)¹ that features global production and value-added trade and provides data on social, economic and environmental indicators at the industry level and the Global Trade Analysis Project (GTAP) Data Base, which considers trade policy measures and impacts.²

We provide a comparison between indicators estimated using two of the main global databases used for macroeconomic analysis of GVCs and trade in VA patterns, namely, the GTAP Data Base (Aguiar et al., 2019) in its MRIO version (Carrico et al., 2020) and

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¹ <http://www.oecd.org/sti/ind/measuringtradeinvalue-addedanoecd-wtojointinitiative.htm>

² Other widely used global databases include the World Input-Output Database (WIOD) and the UNCTAD-Eora GVC database. Major regional initiatives include the Asian Multi-Region Input-Output Database from the Asian Development Bank (ADB) and the South-American Input-Output Table from the Economic Commission for Latin America and the Caribbean (ECLAC).

the OECD-WTO TiVA database (OECD-WTO, 2012), and discuss the reasons for the deviation in the estimates of GVC-related trade based on the two databases.³ This work is related to the analysis by Jones et al. (2014) comparing main global ICIO databases with official macro-economic statistics, and also among themselves to evaluate their accuracy.

The use of statistics based on an ICIO accounting has become more routine for analyzing key areas of international economics and governance (e.g., international trade and governance, the link between the environment and the economy, the impact of globalization on labour markets) (Tukker and Dietzenbacher, 2013). But there is not harmonization among different global databases nor a systematic evaluation of the differences among them (Jones et al., 2014). The construction of a global ICIO requires a huge amount of data, often suffering from time lag, and above all a high level of harmonization, consolidation and adaptation of different data sources.

The latest versions available of both the databases are considered: Version 10 of GTAP and Edition 2018 for TiVA.⁴ In section 2 we analyze the differences between the two databases - harmonized into the same country and sector classification - in structural economic variables, including production, value added, exports and imports, as well as traded intermediate inputs. In section 3, major TiVA indicators are estimated based on the two databases and discrepancies among them are discussed. Concluding remarks are contained in section 4.

2. STRUCTURE VARIABLES AND INDICATORS IN THE GTAP AND TiVA DATABASES

This Section provides an evaluation of the differences in the structural variables and the main trade in VA indicators based on the GTAP and the OECD's ICIO databases. Comparing different ICIO tables requires a preliminary harmonization procedure as they are based on different country coverage and sector classifications. To enable the juxtaposition, the sectors in GTAP and TiVA databases are first mapped to the ISIC (<https://unstats.un.org/unsd/classifications/Econ/isic>), the reference point for sectoral classification in most input-output statistics. This means that both GTAP sectors (GSC3)⁵ and TiVA industry codes (Ed. 2018) are defined by reference to the ISIC Rev. 4 codes. Tables 1A and 2A in the Appendix provide the mapping of GTAP and TiVA sectors to the ISIC Rev.4, respectively. Next, the databases are aggregated at the highest possible detail, depending on the common ISIC codes. The result of the mapping procedure is represented in Table 1.

Table 1 Mapping between GTAP and TiVA sectors (based on ISIC Rev. 4 codes)

GSC3_No.	New sector code*	New sector description
1 to 14	D01T03	Agriculture, forestry and fishing
15 to 18	D05T09	Mining and quarrying
From 19 to 26	D10T12	Food products, beverages and tobacco

³ Our contribution is motivated by the inclusion of TiVA-like indicators within the module introducing the VA decomposition of gross trade flows within a general equilibrium model, namely the GTAP-VA model (Antimiani et al., 2018).

⁴ At the moment of writing this paper, the 2021 edition of TiVA - including two new countries, Lao PDR and Myanmar, and extending to 45 the number of unique industries covered - has been launched but data are not still available to perform the analysis.

⁵ This is available for GSC3 sectors No. 14 to 18 and 27 to 64. Instead, GTAP agricultural and food processing sectors (No. 1 to 13 and 19 to 26) are defined by reference to the Central Product Classification (CPC - <https://unstats.un.org/unsd/classifications/Econ/cpc>), as the ISIC does not provide the detail included in the GTAP Data Base

27, 28, 29	D13T15	Textiles, wearing apparel, leather and related products
30	D16	Wood and products of wood and cork
30, 31	D17T18	Paper products and printing
32	D19	Coke and refined petroleum products
33, 34	D20T21	Chemicals and pharmaceutical products
35	D22	Rubber and plastic products
36	D23	Other non-metallic mineral products
37, 38	D24	Basic metals
39	D25	Fabricated metal products
40	D26	Computer, electronic and optical products
41	D27	Electrical equipment
42	D28	Machinery and equipment, nec
43	D29	Motor vehicles, trailers and semi-trailers
44	D30	Other transport equipment
45	D31T33	Other manufacturing; repair and installation of machinery and equipment
46, 47, 48	D35T39	Electricity, gas, water supply, sewerage, waste and remediation services
49	D41T43	Construction
50	D45T47	Wholesale and retail trade; repair of motor vehicles
52 to 56	D49T53 / D58T63	Transportation and storage / Information and communication
51	D55T56	Accommodation and food services
57, 58	D64T66	Financial and insurance activities
59	D68	Real estate activities
60	D69T82	Other business sector services
63	D85	Education
64	D86T88	Human health and social work
61	D90T98	Other social and personal services
62,65	D84etal	D84 and other

* Based on TiVA nomenclature.

Source: Author's aggregation based on GTAP10A Data Base and TiVA (Ed. 2018) database.

In terms of geographical coverage, the correspondence tables discussed here include all European Union countries plus the major players in the trading world system, namely, the United Kingdom, China, Japan, and the United States. The Rest of the World aggregate includes all the other countries in the databases. The regional aggregation is synthesized in Table 2.

Table 2 Geographical coverage

Number	Country code	Country description
1	AUT	Austria
2	BEL	Belgium
3	CZE	Czech Republic
4	DNK	Denmark
5	EST	Estonia
6	FIN	Finland
7	FRA	France
8	DEU	Germany
9	GRC	Greece
10	HUN	Hungary
11	IRL	Ireland
12	ITA	Italy
13	LVA	Latvia
14	LTU	Lithuania
15	LUX	Luxembourg
16	NLD	Netherlands
17	POL	Poland
18	PRT	Portugal

19	SVK	Slovakia
20	SVN	Slovenia
21	ESP	Spain
22	SWE	Sweden
23	BGR	Bulgaria
24	HRV	Croatia
25	CYP	Cyprus
26	MLT	Malta
27	ROU	Romania
28	GBR	United Kingdom
29	CHN	China
30	JPN	Japan
31	USA	United States of America
32	ROW	Rest of the World

Source: Author's aggregation based on GTAP10A Data Base and TiVA (Ed. 2018) database.

The analysis is performed for 2014, the only year which is available for all the databases under examination.

3. COMPARISON OF INDICATORS

In a first step we analyze the differences in the **structural indicators**, directly derived from the values in the underlying ICIO tables. Figure 3 shows differences between TiVA statistics and GTAP data⁶ in production (a), value added (b), value added shares of gross output (c), exports (d), imports (e) and intermediate total trade (f). All differences are expressed as percentage changes of the GTAP data with respect to TiVA values. Trade data include both goods and services.

GTAP and TiVA databases are based on distinct sources and harmonization choices to reproduce cost structures for each economic agent (see Section 1). In addition, the GTAP database is benchmarked to adjusted trade statistics instead of national accounts statistics as is preferred in TiVA. This is reflected in the results for the major economic variables presented here. For all the structural variables under consideration, the major discrepancies between the two databases are found for Belgium, Malta, Latvia and Lithuania.

Except for a few exceptions (namely, Malta, Ireland, Romania, Luxemburg and Denmark), GTAP figures for production (**a**) in European countries are higher than those derived from TiVA, with Belgium and Malta showing the highest discrepancies between the two databases (+19.1% and -18.7% in GTAP with respect to TiVA data). Conversely, the value added indicator (**b**) in GTAP tends to be lower than TiVA in almost all the countries under examination, up to -13% for Malta. The only exception is represented by Romania (+1.8%).

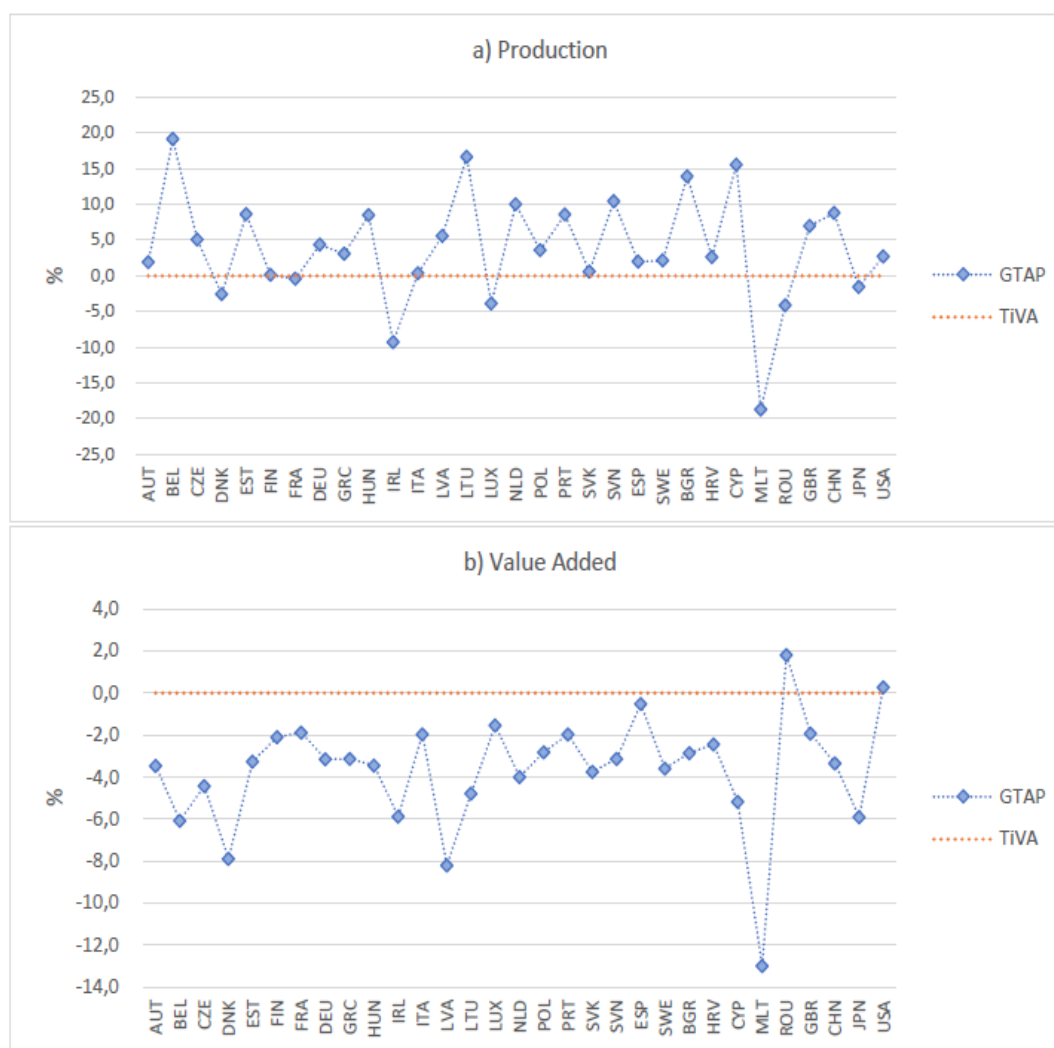
These differences impact the results for the value added as a share of gross output figures (**c**), the crucial variable in the estimation of trade in value added metrics and a major determinant of countries shares of value added embodied in trade and final demand. For most of the countries under examination, GTAP data provide lower value added to output

⁶ As for GTAP data, all the results in this section are computed on the MRIO version. For the ease of readability, we omit in the figures the estimates based on the standard GTAP (adapted through a proportional attribution of bilateral import by agent) as the differences between the two versions of GTAP are too small with respect to the discrepancies registered with TiVA

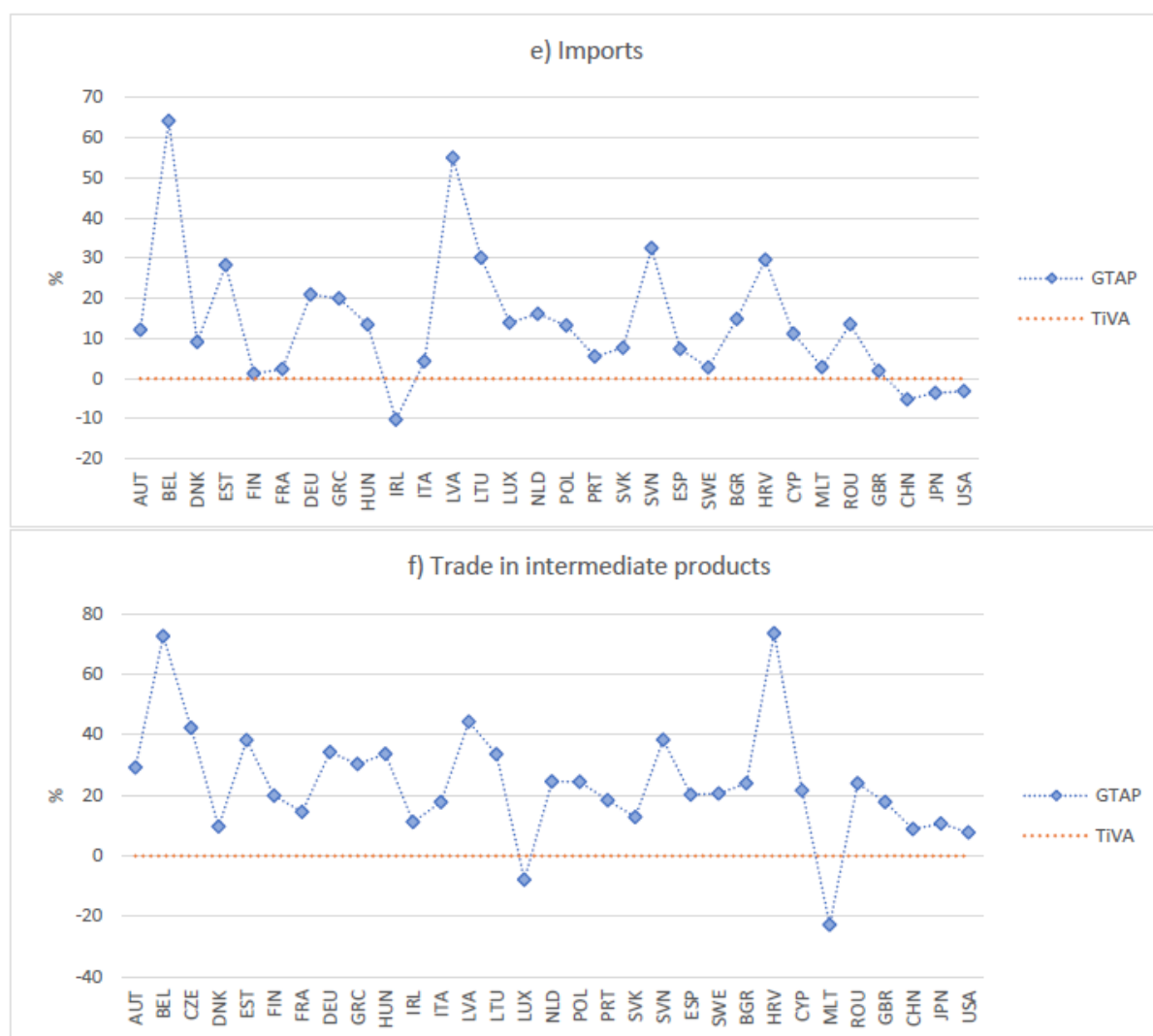
ratio than TiVA, up to -10% for Belgium, Lithuania and Cyprus. For these three countries, this reflects the high and opposite discrepancies of output and value added. In the case of Malta, as both production and value added indicators are lower using the GTAP data, the distortion between the databases is lower for the value added share. Romania, Malta, Ireland and Luxemburg are the only countries for which value added shares are higher in GTAP than in TiVA

Trade data show larger differences from one database to the other. The OECD trade data are generally lower. The biggest deviations mainly concern EU member countries; a plausible explanation is that the OECD table excludes the re-exports and transit trade taking place within the EU. More generally, the potential reasons lie in the different harmonization choices and evaluation adjustments (see section 1) regarding trade values. Overall, we observe higher values for both exports (**d**) and imports (**e**) in the GTAP than in TiVA data, with only a few exceptions. GTAP values are around 60% higher for imports of Belgium and Latvia, and up to 36% higher for Belgium exports. The opposite is true in the case of exports from Malta (-39%) and Luxemburg (-25%).

Figure 1 Differences between GTAP and TiVA databases, structural indicators (% , 2014)







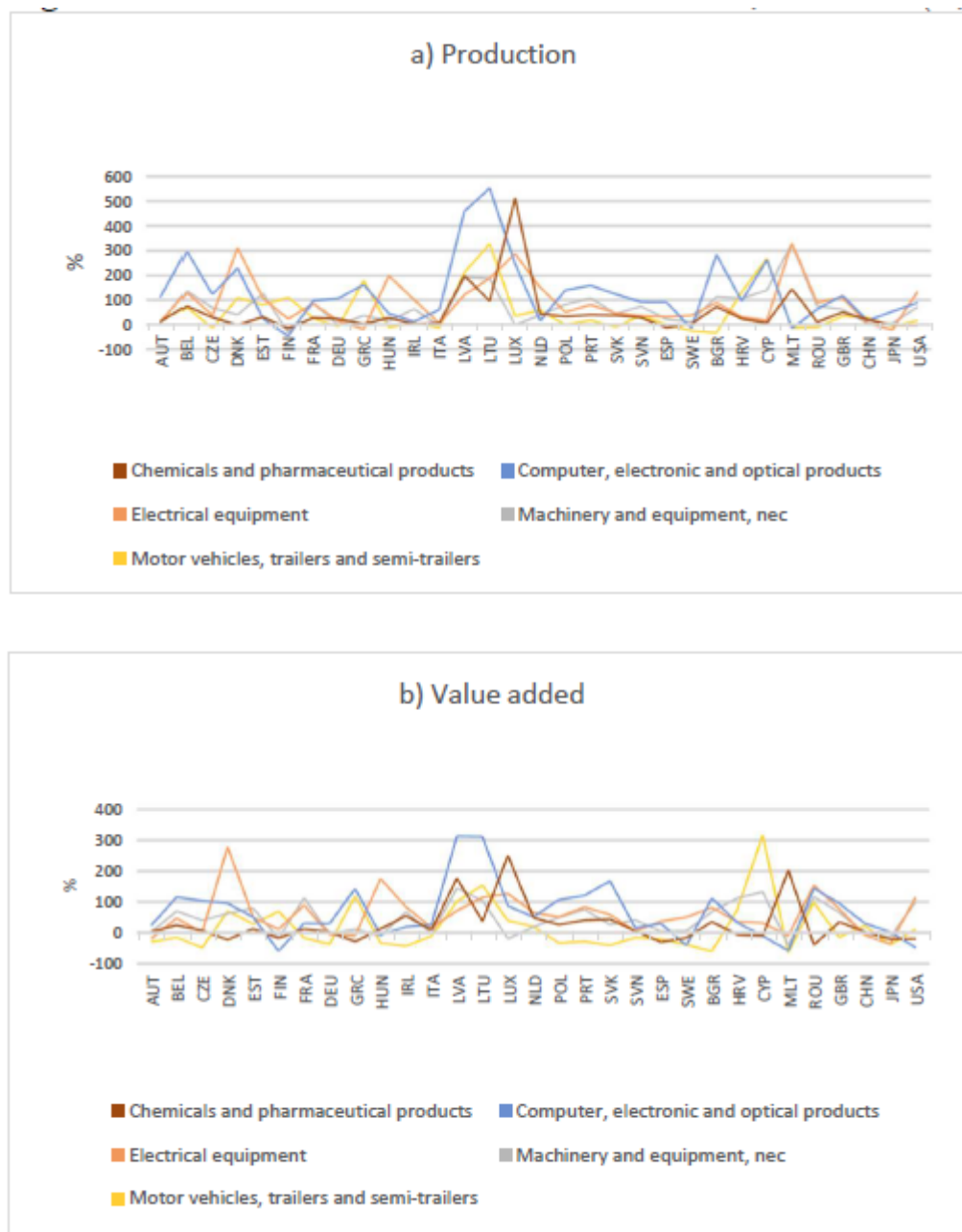
Source: Authors' elaborations based on TiVA and GTAP databases.

In figure 1 f) we look at exports plus imports in intermediate products, where we notice higher figures from the GTAP database than from TiVA for all the countries but Malta and Luxemburg. This is consistent with the trade and value added data suggesting a relatively more intense use of intermediate inputs (including imported intermediates) in the production structure in GTAP than TiVA. The higher range of variation in this indicator reflects differences in the reattribution of bilateral flows accordingly to the final or intermediate usage between the two databases.

Figure 2 shows percentage differences in the same indicators for selected manufacturing sectors. GTAP and TiVA data describe figures completely different suggesting that the two databases are indeed hardly comparable at the sector level.

We find upward peaks in the GTAP data with respect to TiVA in the production of Computer, electronic and optical products for Lithuania and chemicals and pharmaceutical products for Luxemburg. The value added in Electrical equipment is very much higher in the GTAP Data Base for Denmark, similarly for Computer, electronic and optical products in Latvia and Lithuania and motor vehicles for Hungary. Computer, electronic and optical products show the highest difference between the databases, both for exports (for Latvia, Lithuania and Belgium) and imports (for Cyprus).

Figure 2. Differences between GTAP/TiVA databases, sector level (% , 2014)





Source: Authors' elaborations based on TiVA and GTAP databases.

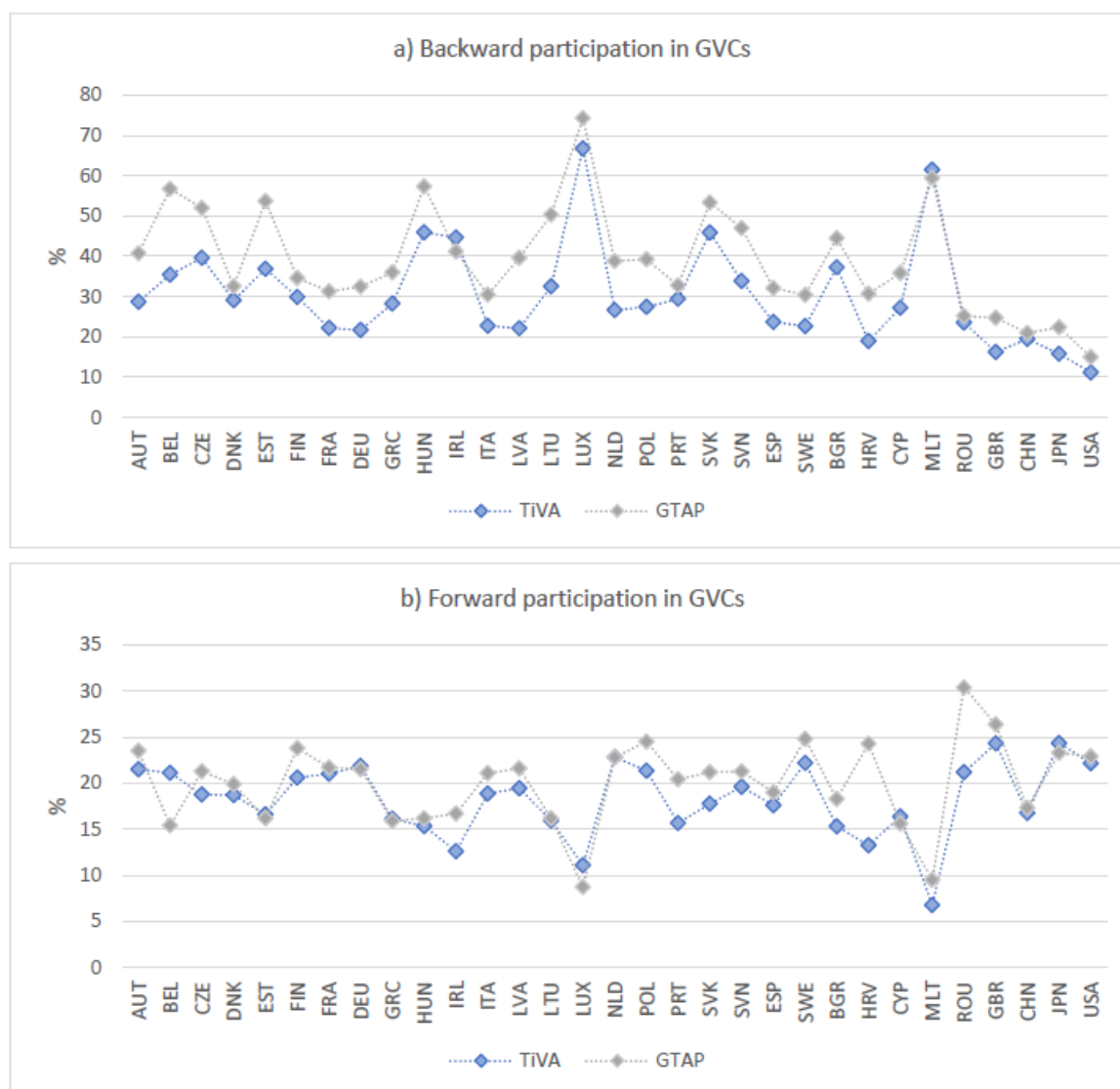
Next, we look at the computation of the **GVC participation index** based on the two databases. Consistently with the literature, we characterize countries participation in global production networks from two perspectives: one looks at the use of foreign inputs in the production of a country's exports (backward linkages), the other follows a country's value added which is exported by the importer (forward linkages). Both the value of foreign inputs and the forwarded domestic value are expressed as shares of a country's gross exports and provide, respectively, the backward and forward participation indexes shown in Figure 3. Specifically, the backward participation index is the share of the foreign value added on gross exports, and the forward participation index is computed as the share of the domestic value added used in third countries' exports on gross exports.

Backward participation is generally higher when using GTAP data than TiVA, except for Ireland and Malta. Overall, we find a very much similar ranking characterizing backward linkages for the countries analyzed for the two databases. The highest discrepancies are

found for Belgium (slightly more than 20% points more with GTAP than TiVA) and Baltic states (around 17% points more with GTAP than TiVA).

For forward participation indexes TiVA and GTAP figures compare less homogeneously. Although for most countries, forward linkages have a bigger incidence with GTAP data than TiVA, forward indicators estimated with TiVA present a higher level of forward participation in several cases, including Belgium, Luxemburg and, outside the EU, Japan.

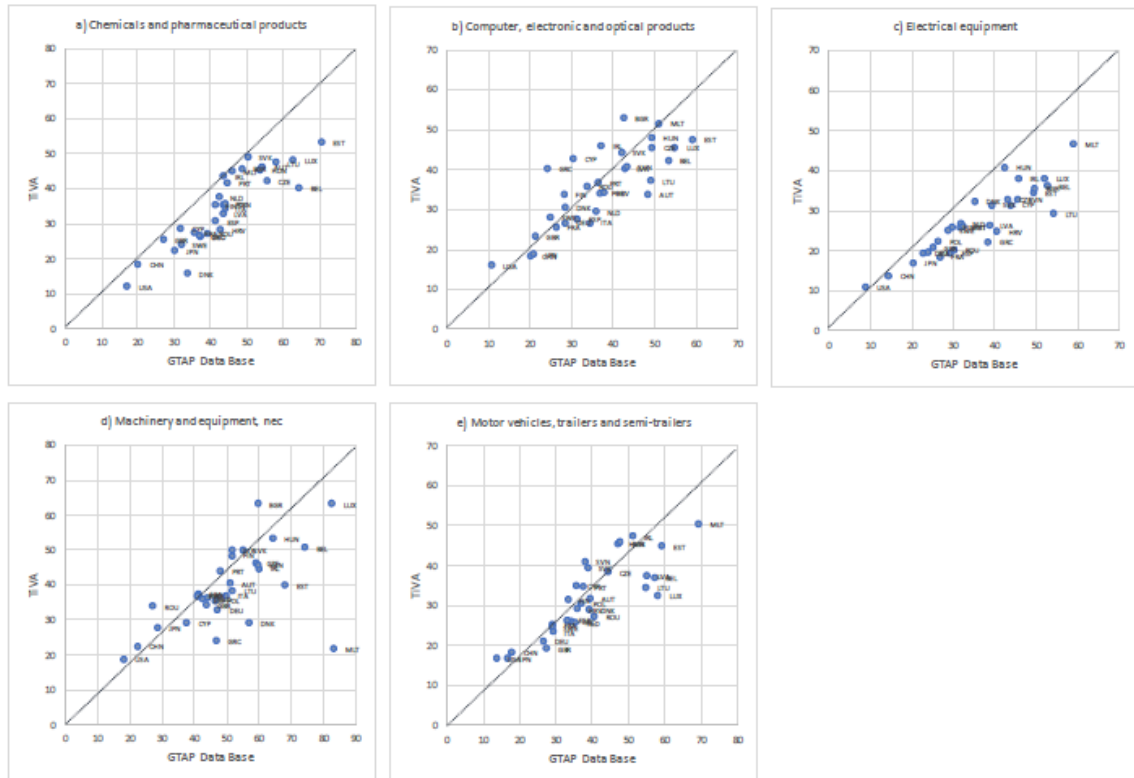
Figure 3 GVC participation indexes based on GTAP and TiVA databases (% , 2014)



Source: Authors' elaborations based on TiVA and GTAP databases

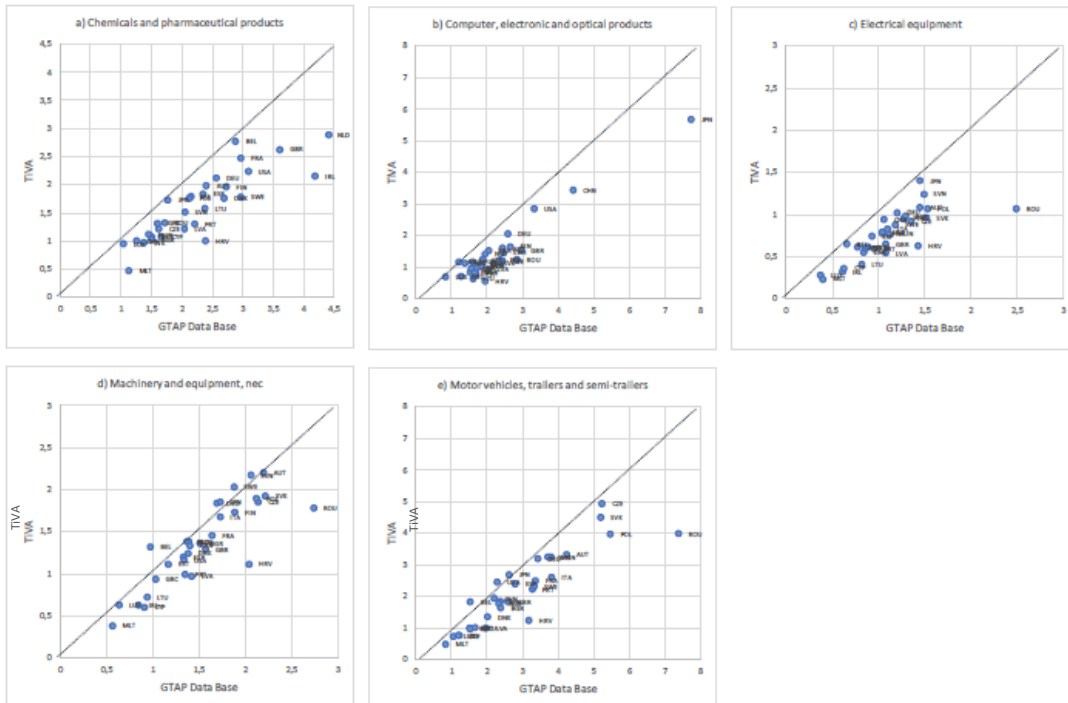
In **Figure 4** the backward linkages for selected sectors are shown, while in **Figure 5** forward linkages for the same manufacturing sectors are represented. The horizontal axes of the diagrams display the value for the indexes based on the GTAP data; on the vertical axes, TiVA indicators are displayed. Then, the countries above the bisector are those that show higher integration for TiVA, while the countries more integrated according to the GTAP data are below the bisector.

Figure 4 GVC backward participation indexes based on GTAP and TiVA databases, selected sectors (% , 2014)



Source: Authors' elaborations based on TiVA and GTAP databases

Figure 5 GVC forward participation indexes based on GTAP and TiVA databases, selected sectors (% , 2014)



Source: Authors' elaborations based on TiVA and GTAP databases

Chemicals and pharmaceutical products and Electrical equipment are more integrated, both backward and forward, when GTAP data are used, reflecting a more intensive intermediate exchange (recall Figure 2). Results are less homogeneous among countries

for the other three sectors, namely Computer, electronic and optical products, Machinery and equipment, and Motor vehicles. As in the analyzed manufacturing sectors both GTAP and TiVA has a direct correspondence with ISIC Rev.4, the aggregation is directly comparable between them. The deviations here are partially due to differences in the underlying base data, also depending on the different HS to end-use concordance to allocate aggregate bilateral trade flows to intermediate and final goods used by two sources.

4. CONCLUDING REMARKS

The aim of this work is to compare estimations of trade in value added using two different sources and to explain such discrepancies. Specific policy needs and scientific aims underlying the global ICIOs, data sources, the country coverage, the period of the data available, the level of detail for industries and products, the methodological choices in the compilation process (UN, 2018), all are ingredients that have led to the development of different ICIO systems, constructed by various approaches. Observed discrepancies mainly arise from differences in the underlying data sources and the methodological choices in the compilation process. We find that these differences are large, both at the country and sector level.

The resulting discrepancies in the estimation of trade in VA are significant and not fully explained. But there have been attempts to compare estimates deriving from different databases, mainly in the field of environmental economics and emission accounting (see, for example, Inomata and Owen, 2014; Owen et al., 2014; Giljum et al., 2019; Tukker et al., 2020).

We know that the construction of ICIO tables is complex and usually requires the application of specific compilation methods and assumptions to reconcile data from different sources and cope with data availability or reliability issues (Fusacchia and Salvatici, 2022). Therefore, the concepts applied to build the tables can justify the differences observed with official statistics. For example, GTAP is mainly benchmarked to trade statistics, not to sector level supply and demand data for individual countries; this may lead to the observed differences between production or trade data. Additionally, the way goods and services are broken down by end use category in the ICIO table necessarily affects the results obtained for TiVA indicators and explains some of the discrepancies between the two sources.

Building on the above observations, we concur with Antras and Chor (2021) that anticipate and welcome more efforts to bring to bear more detailed micro data, to directly inform and refine the construction of the proportionality weights. Such work is likely to benefit as empirical researchers gain more access to administrative data on firm operations that can be merged with customs data on the international trade patterns of these firms. However, there remain significant hurdles to linking such micro datasets across countries – not least of which is how to preserve the confidentiality of firm identities when merging data across countries. Although these improvements are unlikely to be feasible at the world level, they may eventually become feasible for individual countries and be limited in geographic coverage.

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