Ilaria Fusacchia, Luca Salvatici

GTAP and TiVA

Differences Between the two Databases and their Implications for Trade in Value-Added Indicators

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GTAP and TiVA: Differences Between the two Databases and their Implications for Trade in Value-Added Indicators

by

Ilaria Fusacchia and Luca Salvatici
Dipartimento di Economia and Centro Rossi-Doria
Università degli Studi Roma Tre, Italia

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Table of contents

Introduction

With the growth and spread of international linkages, the production processes are 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.

Accordingly, 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 Value 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. 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: <http://www.oecd.org/sti/ind/measuringtradeinvalue-addedanoecd-wtojointinitiative.htm>) database – which features global production and value-added trade and provides data on social, economic and environmental indicators at the industry level that can be used for a wide range of applications – and the Global Trade Analysis Project (GTAP) Data Base – which considers trade policy measures and impacts.[1]

[1] 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-

Although the use of statistics based on an ICIO accounting has become more routine for analysing key areas of global 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), 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. 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.

Indeed, the resulting discrepancies in the estimation of trade in VA are significant and not fully explained. 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).

Our contribution is an attempt to systematize the potential sources of the differences between databases and to show how estimations of trade in VA are impacted. It is motivated by the inclusion of TiVA-like indicators (TiVA 2018 ed) within the module introducing the VA decomposition of gross trade flows in a general equilibrium model, namely the GTAP-VA model (Antimiani et al., 2018),[2] and the consequent need to properly understand what differentiates the two sources, once the analytical framework for the definition of the indicators is harmonized.

This work provides a comparison between 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), and the GTAP-MRIO version (Carrico et al., 2020), as well as the OECD-WTO TiVA database

American Input-Output Table from the Economic Commission for Latin America and the Caribbean (ECLAC).

[2] The GTAP-VA suit allows to provide descriptive statistics related to GVCs and trade in VA harmonized with an alternative and widely used data source like the TiVA, and, simultaneously, to directly perform ex-ante policy analysis on GVC-related linkages.

(OECD-WTO, 2012), and provides a discussion of the reasons for the deviation in the estimates of GVC-related trade based on the two databases. In this regard, it 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.

In the first Section, a description of the databases and the underlying construction methodologies is provided. For this purpose, the latest versions available of both the databases are considered: Version 10 of GTAP and Edition 2018 for TiVA.[3] In the second Section, 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 are presented. Finally, major TiVA indicators are estimated based upon the different databases and discrepancies among them are discussed.

Our findings outlines large differences in the figures depicted by the two databases, both at the country and sector level. This suggests that more efforts would be required in the direction of a commonly agreed methodology to meet the statistical challenges in measuring the GVC-related trade. In this vein, efforts to provide a micro-foundation in the construction of global ICIO (e.g., by using firm level data to directly inform and refine the construction of the proportionality weights) would be likely to benefit researchers in this field. Although these improvements are unlikely to be feasible at the world level as there remain significant obstacles to linking micro data across countries, they may eventually become feasible for individual countries and be limited in geographic coverage.

[3] At the moment of writing this article, 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.

1
Main Databases in Macro Analyses of GVC: TiVA and GTAP-based ICIOs

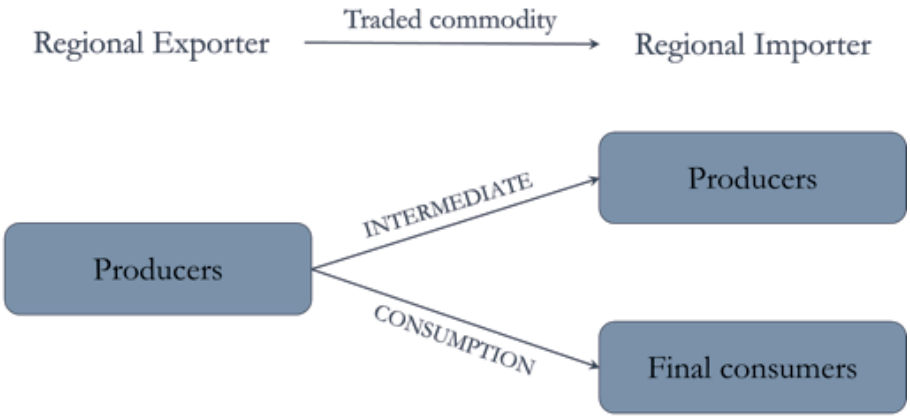
Luca Salvatici

1.1 Description of the databases

Macroeconomic analyses of GVCs are anchored in an input-output framework and require information on the cross-border input-output relationships with world coverage. Global Inter- ICIO tables are the main source of data. The construction of an ICIO requires data on transactions of intermediate and final goods both within and between each country at a sector level, direct value added in the production of every sector in all countries, and the gross output of every sector in all countries (Koopman et al., 2010).

As bilateral trade flows at the industry level are not worldwide collected systematically, work on trade in VA relies on datasets constructed outside of the official statistical systems. The existing global databases involve choices about how to distinguish sectoral level bilateral trade flows into different uses (essentially, intermediate use or final consumption, see **Figure 1.1**), and, within intermediate flows, how to allocate them from a certain source country to individual purchasing sectors in all destination countries (Koopman et al., 2014).

Figure 1.1. The ICIO Framework



Source: Adapted from Figure 1 in Carrico et al., 2020.

The **proportionality method** is an approximation built on the twofold assumption that within each sector the overall break down of imports by use (final or intermediate) in the destination country is applied proportionally to the split by use of imports from each source country, and that the destination sectors of intermediate imports are derived as a proportion of the total imported intermediate use in those destinations. This assumption is used in the first GTAP-based ICIO developed by Trefler and Zhu (2010), Daudin et al. (2011), Johnson and Noguera (2012), and in the GTAP-VA module developed by Antimiani et al. (2018).

Another approach relies on the United Nations Broad Economic Categories (BEC) classification and end use categories to distinguish imports. Within each use category allocation is based on proportionality assumption, so that country of origin import shares might differ across use categories, but not within these categories.[4] The BEC classification concordance method provides an improved split by source and is used in TiVA, WIOD, and the GTAP-ICIO developed by Koopman et al. (2010), and the recently constructed GTAP-MRIO.

[4] Accordingly, import shares by country might differ across use categories (e.g., final and intermediate), but it is equal within these categories.

In this work, we focus on two global ICIO databases that are widely used in trade in VA analysis, namely: GTAP, including the GTAP-MRIO, and TiVA. Table 1.1 provides a summary of the databases.

Table 1.1. Overview of the main features of the databases

	Geographical coverage	*Sector breakdown*	*Time span*	*Methodological reference*
GTAP Data Base Ver. 10A *https://www.gtap.agecon.purdue.edu/databases/v10/index.aspx*	121 countries and 20 regions	65 sectors	2004, 2007, 2011, and 2014	Aguiar A., Chepeliev M., Corong E., McDougall R., van der Mensbrugghe D. (2019) "The GTAP Data Base: Version 10", *Journal of Global Economic Analysis*, 4(1): 1-27.
GTAP-MRIO Ver. 10A *https://www.gtap.agecon.purdue.edu/databases/Utilities/v10.aspx*	121 countries and 20 regions	65 sectors	2014	Carrico C., Erwin C. and van der Mensbrugghe D. (2020) "The GTAP version 10A Multi-Region Input Output (MRIO) Data Base", Research Memorandum, 34.
OECD/WTO TiVA Database [Ed. 2018] *https://www.oecd.org/sti/ind/measuring-trade-in-value-added.htm*	64 countries	36 sectors	2005 to 2015 (preliminary projections to 2016 for some indicators)	OECD-WTO (2012) "Trade in Value Added: Concepts, Methodologies and Challenges", Joint OECD-WTO concept note.

Source: Authors' elaborations.

GTAP The GTAP Data Base was developed by the Center of Global Trade Analysis at Purdue University and underlies the majority, if not all, of global general equilibrium models that are used to examine environmental and economic issues at the global level. GTAP 10A provides a time series of snapshots of the global economy for each of four reference years: 2004, 2007, 2011, and 2014. It describes global bilateral trade patterns, international transport margins and protection matrices that link individual countries/regions. For each of the 141 countries/regions, the Data Base presents values of production and intermediate and final consumption of commodities and services. In terms of sectoral coverage, GTAP 10 considers 65 products and services (Aguiar et al., 2019). GTAP10 relies on country-based input output tables, however, it is not readily applicable to GVC analysis. A key aspect related to the construction of a

full ICIO table is that import sources can be attributed to intermediate and final demand and individual source countries and sectors. The standard GTAP database aggregates these flows at the border level. Sourcing information at the bilateral level can be obtained by assuming proportional sourcing of imports for all agents (e.g., proportionality assumption).

In GTAP, national IO tables are combined with macro, trade and protection data are contributed based on international sources and are considered more reliable than the individual country data because they have gone through standardization and reconciliation process. Accordingly, national IO tables only provide the structure (shares) and the other data provide the values. An entropy procedure is then used to ensure that the data in the IO tables match the macro, trade and protection data.[5]

GTAP-MRIO The GTAP version 10A Multi-Region Input Output (GTAP-MRIO) Data Base extends the standard GTAP Data Base by additionally distinguishing bilateral trade and tariff flows by agents or so-called end-users, namely: firms, private households, government and investors. GTAP-MRIO is constructed by first incorporating United Nations Statistics Division (UNSD)'s Harmonized System (HS) to BEC to the basic end-use classes in the System of National Accounts (SNA) and the GTAP Center's HS to GTAP concordances into MAcMap. Then, the trade and tariff data by end-users in MAcMap are aggregated over GTAP commodities. This information is consequently used to disaggregate their associated flows in the standard GTAP Data Base. Finally, constrained optimization procedures are employed to ensure that the GTAP-MRIO

[5] Specifically, Minimum Cross-Entropy (MCE) methods are employed to adjust the regional IO tables to meet international data on imports. As part of the MCE process, the input-output structure is divided into two levels. The first level includes the commodity shares (the share of individual commodities in each use category as a proportion of total expenditure on that commodity or the share of a primary factor in total expenditure on primary factors), and the second level includes the source shares (the share of domestic products or imports in total expenditure for each commodity in each use category). These two levels of shares are allowed to vary to meet the disaggregated import targets. As minimum cross entropy is employed, the difference between the original shares and the new shares is minimised. The objective function is formulated so that the commodity shares are altered only if altering the domestic/import shares cannot produce a solution that satisfies the constraints with a reasonable adjustment. See Harslett (2013) for details.

trade and tariff flows, when summed over end-users, aggregate back to the standard GTAP Data Base (Carrico et al., 2020).

TiVA The 2018 edition of the TiVA database provides indicators for 64 economies including all OECD, EU28 and G20 countries, most East and South-east Asian economies and a selection of South American countries. 36 unique industrial sectors are represented within a hierarchy, including aggregates for total manufactures and total services. This edition covers the period 2005 to 2015, with preliminary projections to 2016 for some indicators. The underlying ICIO tables are based on statistics compiled according to the SNA 2008 from national, regional and international sources and use an industry list based on the International Standard Industrial Classification (ISIC) Revision 4.[6] To distinguish bilateral trade by the main end-use categories (intermediate consumption, final consumption, gross capital formation), it uses the OECD-adjusted version of the official UN HS-BEC concordance table (OECD Bilateral Trade Database by Industry and End-use, BTDIxE). In contrast to GTAP, the TiVA reconciliation procedure gives priority to national IO tables, and exports and imports are benchmarked on national accounts.

1.2 GTAP-based and OECD's ICIO tables: source data and compilation choices

Although the use of statistics based on an ICIO accounting has become more routine for analysing key areas of global 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), there is neither 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, and a high level of harmonization, consolidation and adaptation of different data sources. Table 1.2 summarizes the underlying data sources and the methodological choices in the compilation process considering GTAP-based ICIOs and OECD's ICIO database.

[6] Previous editions of TiVA indicators were based on SNA 1993 and an ISIC Rev. 3 industry list. Use of the more recent international standards has inevitably resulted in revisions to the TiVA indicators.

Table 1.2. Main differences in the data sources and methodologies underlying GTAP-MRIO and TiVA

BASE DATA		
Variable	Data source	Methodological choices / Estimation techniques
Output, value added	– TiVA (2018 edition): OECD STAN Database (2008 SNA/ISIC Rev.4), OECD annual National Accounts database, SUTs, IO tables, and structural business statistics (UNIDO's INDSTAT) – GTAP: IO tables provided by GTAP network members, WB mainly from the World Development Indicators (WDI) by the World Bank.	Adjusted to achieve consistency with other macroeconomic data.
Trade	United Nations International Trade Statistics Database (UN Comtrade)	Re-exports: – In GTAP, trade data for more than 50 countries that re-export are re-estimated by deriving domestic exports and by converting total imports into retained imports. – In the construction of OECD's ICIO, for partner shares of trade in goods, reported imports are prioritized as initial values. Evaluation adjustments: – The OECD's ICIOs are based on the available data and therefore reflect the use table at basic prices when disseminated or estimated from existing information. – GTAP constructs the data with the use of information on multi-country margins and taxes.
ESTIMATIONS AND HARMONIZATION		
Intermediate trade	– TiVA: The Bilateral Trade Database by Industry and End-use category (BTDIxE) Estimated Bilateral Trade in Services by Industry (EBTSI) – GTAP-MRIO: UNSD 6-digit HS 2012, BEC concordances rev. 4, SNA	
Reconciliation of IO tables and trade data		– TiVA starts from the SUTs or IO tables and then benchmark them to national accounts statistics using trade data. – GTAP and GTAP-MRIO use trade data as a benchmark for adjusting the IO tables.

Source: Authors' elaborations.

For most OECD countries, TiVA draws gross output and value added from the 2008 SNA/ISIC Rev.4 version of the OECD STAN Database, or OECD's annual National Accounts database adapted to the industry classification of the ICIO system. Where necessary, industry estimates of gross output are calculated by drawing on other sources such as national Supply and Use tables (SUTs), IO tables and structural business statistics such as UNIDO's INDSTAT database. The implementation of SNA 2008 in the latest release of TiVA (2018 edition), the one considered in this study, results in upwards revisions in value added to output ratio (OECD, 2018). The TiVA database coverage is heavily influenced by the quality of IO tables.

Conversely, the GTAP Data Base uses IO tables to reproduce cost structures for each economic agent which are provided by GTAP network members and not limited to official statistics. These are supplemented by international data to reflect economic activities for each country/region in the reference years. The advantage of this process is that the database has a wide coverage and is very detailed, but the drawback is that national tables that are put together are heterogeneous in sources, methodology, base years, and sectoral detail and require substantial manipulation to achieve consistency with other macroeconomic data, mainly from the World Development Indicators (WDI) by the World Bank.

The main point of distance between the two databases concerns the reconciliation of IO tables and trade data. GTAP and GTAP-MRIO use trade data as a benchmark for adjusting the IOTs, while TiVA starts from the SUTs or IO tables and then benchmark them to national accounts statistics using trade data.

Other choices influencing the estimations based on ICIO accounting include the evaluation adjustments, the method used to reconcile and attribute trade data, and the treatment of re-exports.

Inter-country SUTs and IO tables are generally expressed at basic prices (that is, net of taxes and transport margins). Many national use tables are compiled and disseminated at purchasers' prices. Adjustments are therefore needed to compile the use table at basic prices when the data are not available from the country in question. In this respect, the OECD's ICIOs are based on the available data – and therefore reflect the use table at basic prices when disseminated – or estimated from existing information.

GTAP-MRIO, in contrast, constructs the data with the use of information on multi-country margins and taxes (UN, 2018; Corong and McDougall, 2020).

In general, the United Nations International Trade Statistics Database, namely, the UN Comtrade, is used for trade statistics. However, some manipulations are required to retrieve the four-dimensional information needed to compile an ICIO, that is the sector-to-sector trade. As we have mentioned, while in the standard GTAP database this can be obtained by assuming proportional sourcing of imports for all agents, a more refined method is used in the MRIO version of the GTAP database which applies BEC-informed shares to bilateral trade (and tariffs) to differentiate the sourcing at the agent level. To better align trade data with National Accounts, the OECD developed an alternative correspondence table to link HS codes with end-use categories. The BTDIxE is used in the OECD's ICIO tables underlying the TiVA database (Zhu et al., 2011). BTDIxE is derived from the OECD's International Trade by Commodities Statistics (ITCS) and the UNSD's Comtrade and gathers bilateral trade flows of goods by industries and end-use categories.

Another challenge in reconciling bilateral trade data is the increasing presence of re-exports. Re-exports occur when products enter a customs territory from one country and are shipped to another country without undergoing any transformation. In GTAP, trade data for more than 50 countries that re-export are re-computed by deriving domestic exports and by converting total imports into retained imports. In the construction of OECD's ICIO, for partner shares of trade in goods, reported imports are prioritized as initial values (country of origin principle).[7]

[7] For details on the method to reconcile merchandise trade asymmetries used by the OECD, see Fortanier (2016).

2
Differences between GTAP and TiVA databases and the Implications for Trade in Value-Added Indicators

Ilaria Fusacchia

2.1 Mapping of 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/classifica tions/Econ/isic>, the reference point for sectoral classification in most input-output statistics. This means that both GTAP sectors (GSC3)[8] 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 2.1**.

In terms of geographical coverage, the correspondence tables which are discussed in this work 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 2.2**.

[8] 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.

Table 2.1. 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
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

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

In terms of geographical coverage, the correspondence tables which are discussed in this work 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 2.2**.

Table 2.2. 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.

2.2 Structural Indicators

We start by analyzing differences in the structural indicators, directly derived from the values in the underlying ICIO tables. **Figure 2.1** graphs the differences between the TiVA statistics and GTAP data[9] 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 Lituania.

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 ratio than TiVA, up to -10% for Belgium, Lituania and Cyprus. For these three countries, this reflects the high and opposite discrepancies of output and

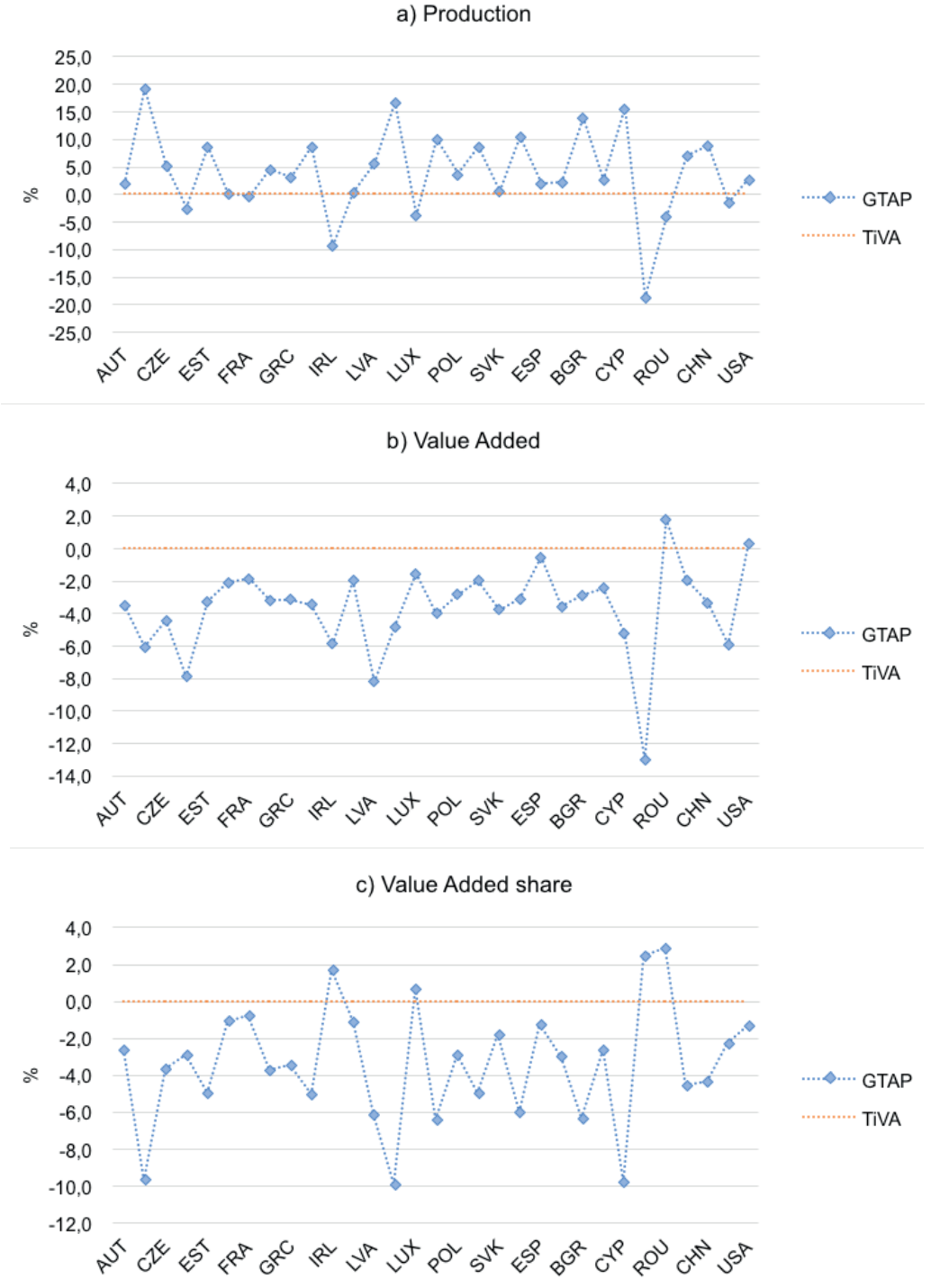
[9] As for GTAP data, all the results in this section are computed on the MRIO version. For the ease of readability, we omit in the figures the estimates based on the standard GTAP (adapted through a proportional attribution of bilateral import by agent) as the differences between the two versions of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

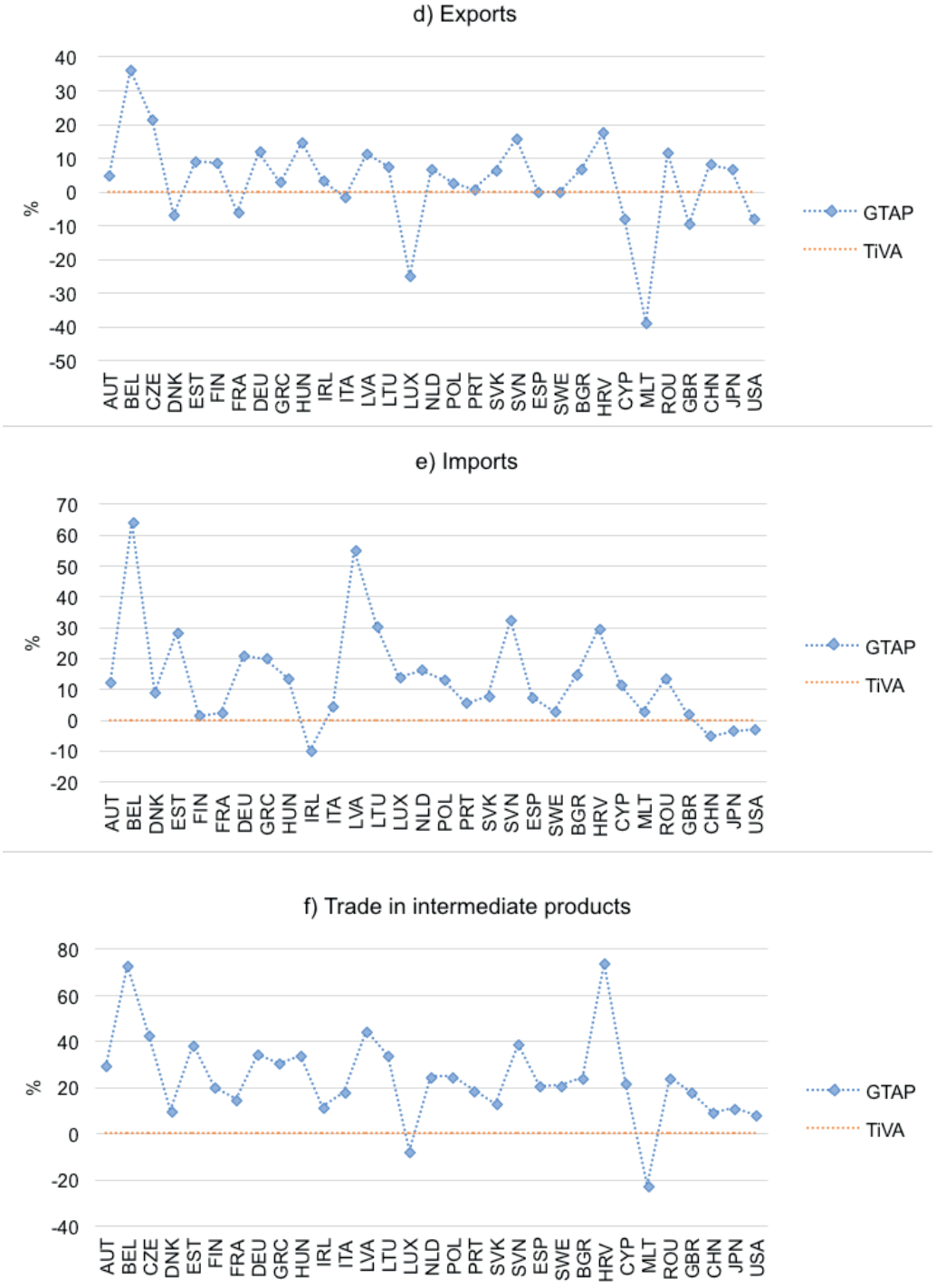
value added. In the case of Malta, as both production and value added indicators are lower using the GTAP data, the distortion between the databases is lower for the value added share. Romania, Malta, Ireland and Luxemburg are the only countries for which value added shares are higher in GTAP than in 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%).

Finally, we look at exports plus imports in intermediate products (**f**) and we register 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 2.1. Differences between GTAP and TiVA databases, structural indicators (%, 2014)

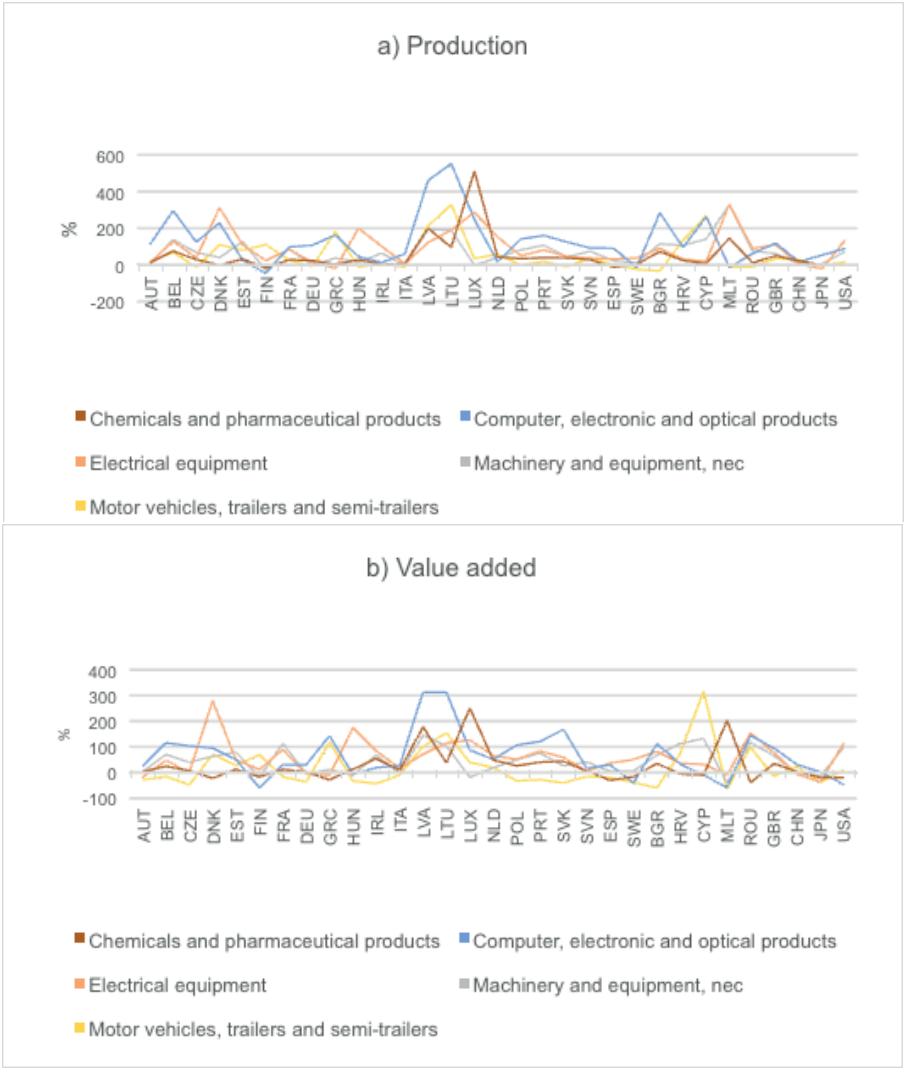




Source: Authors' elaborations based on TiVA and GTAP databases.

Figure 2.2 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.

Figure 2.2. Differences between GTAP/TiVA databases, sector level (%, 2014)



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

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).

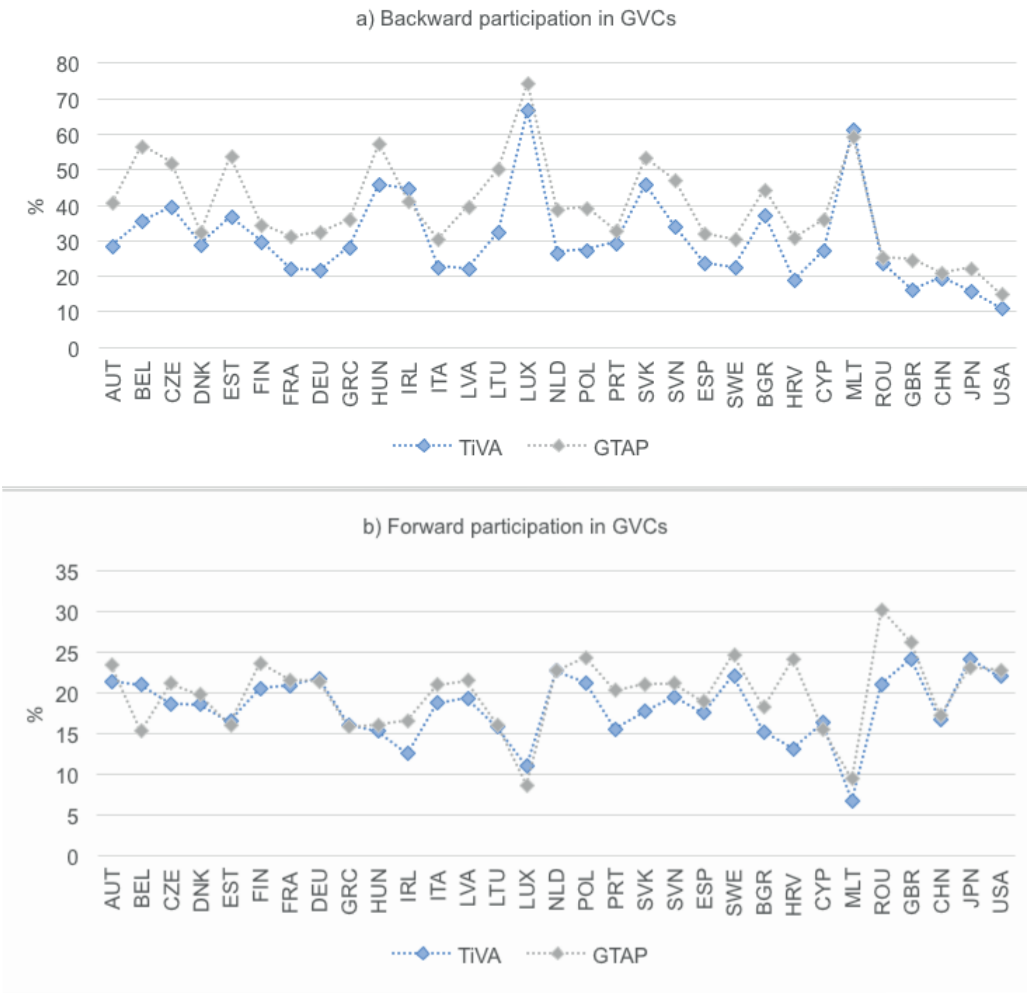
2.3 GVC-participation Indicators

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 2.3**. 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).

The relation between TiVA and GTAP figures is less homogeneous for the forward participation indexes. Although for the majority of countries, forward linkages have a bigger incidence with GTAP data than TiVA, TiVA data present a higher level of forward participation in several cases, including Belgium, Luxemburg and, outside the EU, Japan.

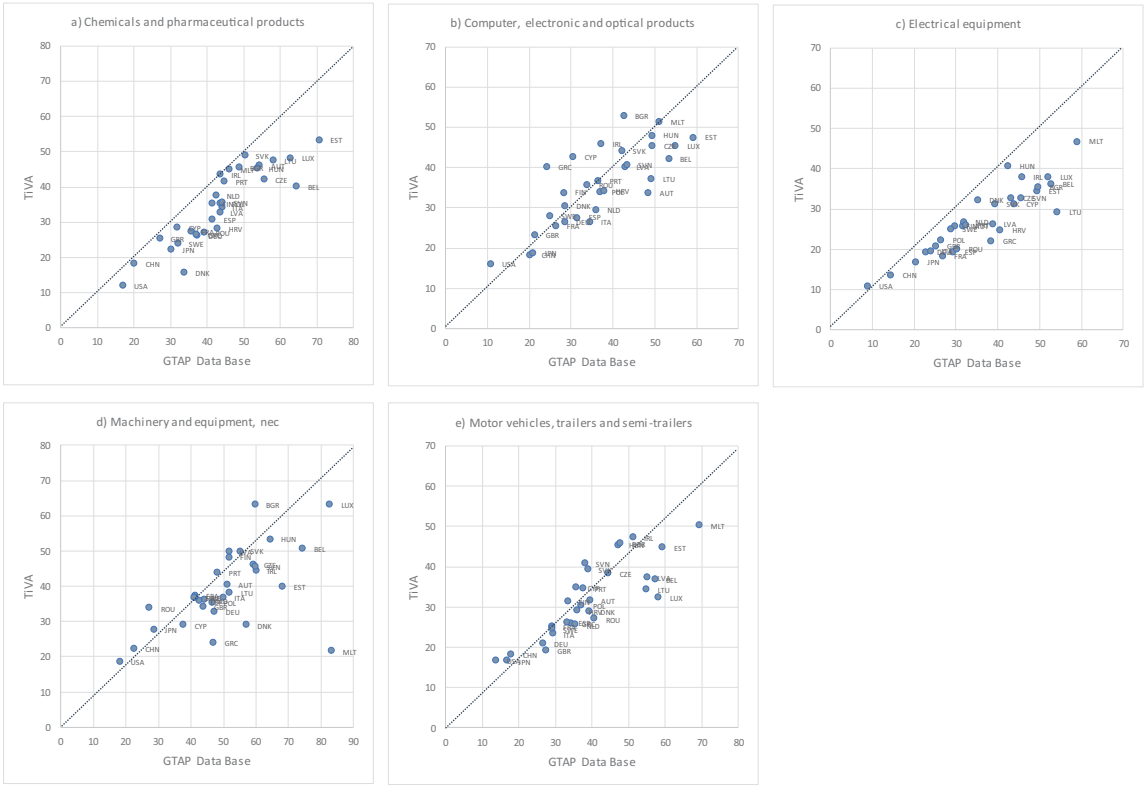
Figure 2.3. GVC participation indexes based on GTAP and TiVA databases (%, 2014)



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

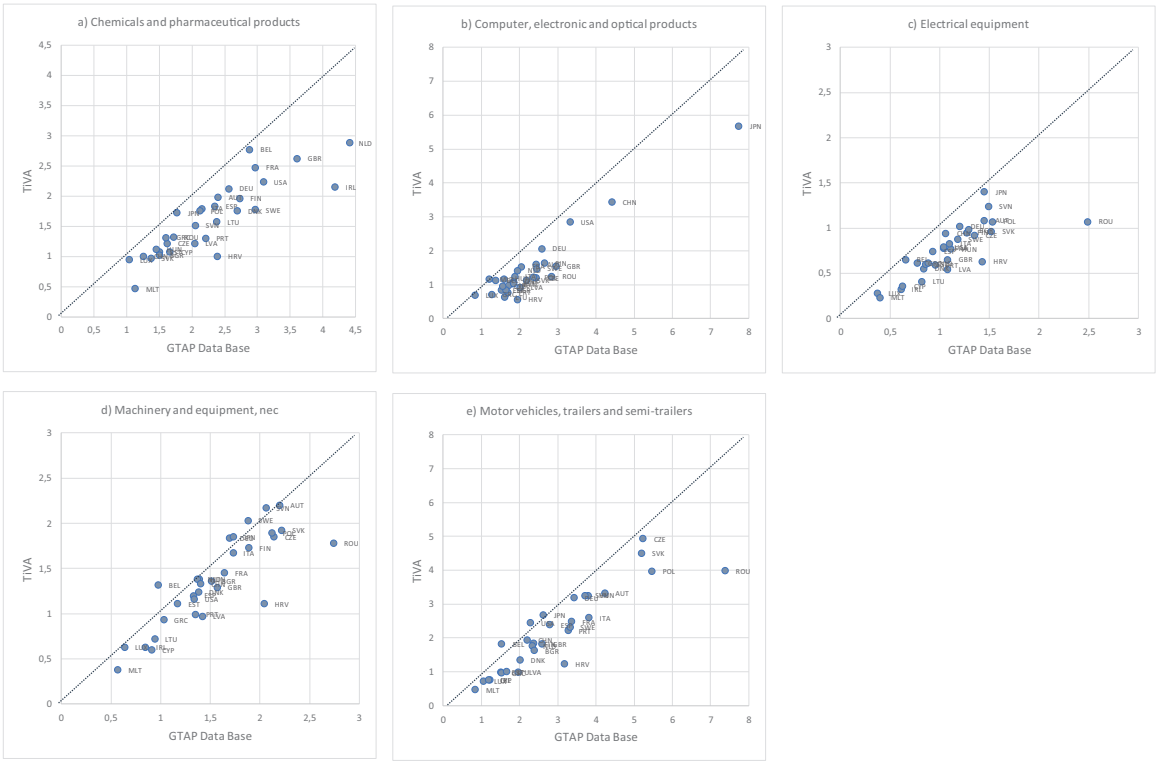
In **Figure 2.4** the backward linkages for selected sectors are shown, while in **Figure 2.5** forward linkages for the same manufacturing sectors are represented. The horizontal axes of the diagrams display the value for the indexes based on the GTAP data; on the vertical axes, TiVA indicators are 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 2.4. GVC backward participation indexes based on GTAP and TiVA databases, selected sectors (%, 2014)



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

Figure 2.5. 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.

Conclusions

The quality of indicators measuring trade in value added finally depends on the quality of the underlying global ICIO which, in turn, depends on the quality and availability of underlying national statistics and the balancing and estimation techniques used in the harmonization procedure.

Although the use of statistics based on an ICIO accounting has become more routine in economic research, there is neither harmonization among different global databases nor a standard in the construction of data on which trade in value added is estimated.

This work is an attempt to systematize the potential sources of the differences between databases and to show how estimations of trade in value added are impacted. Indeed, the observed discrepancies mainly arise from the differences in the underlying data sources and the methodological choices in the compilation process. As we have seen, these differences are large, both at the country and sector level.

In conclusion, 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. 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, which may lead to the differences noticed between production and/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 use 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 firms' 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. As a consequence, these improvements are likely to be feasible, though this may eventually become feasible in individual countries and be limited in geographic coverage.

List of Acronyms

VA	Value Added
GVCs	Global Value Chains
ICIO	Inter-Country Input-Output
IO	input-output
TiVA	Trade in Value Added
GTAP	Global Trade Analysis Project
WIOD	World Input-Output Database
ADB	Asian Development Bank
ECLAC	Economic Commission for Latin America and the Caribbean
BEC	Broad Economic Categories
MCE	Minimum Cross-Entropy
UNSD	United Nations Statistics Division
HS	Harmonized System
SNA	System of National Accounts
BTDIxE	Bilateral Trade Database by Industry and End-use
EBTSI	Estimated Bilateral Trade in Services by Industry
SUTs	Supply and Use tables
WDI	World Development Indicators
ITCS	International Trade by Commodities Statistics
CPC	Central Product Classification
GSC3	GTAP sectors

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APPENDIX
Mapping and harmonization of the databases

Table 1A. Concordance between GSC3 and ISIC Rev. 4

GSC3_No.	Code	ISIC Rev.4	Description
14	fsh	03	Fishing and aquaculture
		017	Hunting, trapping and related service activities
15	coa	05	Mining of coal and lignite
16	oil	061	Extraction of crude petroleum
		091(part)	Support activities for petroleum and natural gas extraction (petroleum part)
17	gas	062	Extraction of natural gas
		091(part)	Support activities for petroleum and natural gas extraction (natural gas part)
18	oxt	07	Mining of metal ores
		08	Other mining and quarrying
		099	Support activities for other mining and quarrying
27	tex	13	Manufacture of textiles
28	wap	14	Manufacture of wearing apparel
29	lea	15	Manufacture of leather and related products
30	lum	16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
31	ppp	17	Manufacture of paper and paper products
		18	Printing and reproduction of record media
32	p_c	19	Manufacture of coke and refined petroleum products
33	chm	20	Manufacture of chemicals and chemical products
34	bph	21	Manufacture of pharmaceuticals, medicinal chemical and botanical products
35	rpp	22	Manufacture of rubber and plastics products
36	nmm	23	Manufacture of other non-metallic mineral products
37	i_s	241	Manufacture of basic iron and steel
		2431	Casting of iron and steel
38	nfm	242	Manufacture of basic precious and other non-ferrous metals
		2432	Casting of non-ferrous metals
39	fmp	25	Manufacture of fabricated metal products, except machinery and equipment
40	ele	26	Manufacture of computer, electronic and optical products
41	eeq	27	Manufacture of electrical equipment
42	ome	28	Manufacture of machinery and equipment n.e.c.
43	mvh	29	Manufacture of motor vehicles, trailers and semi-trailers
44	otn	30	Manufacture of other transport equipment
45	omf	31	Manufacture of furniture
		32	Other manufacturing
		33	Repair and installation of machinery and equipment
46	ely	351	Production, collection and distribution of electricity
		353	Steam and hot water supply
47	gdt	352	Manufacture of gas; distribution of gaseous fuels through mains
48	wtr	36	Collection, purification and distribution of water, water collection, treatment and supply
		37	Sewerage
		38	Waste collection, treatment and disposal activities; materials recovery
		39	Remediation activities and other waste management services

49	cns	41	Construction of buildings
		42	Civil engineering
		43	Specialized construction activities
50	trd	45	Wholesale and retail trade and repair of motor vehicles and motorcycles
		46	Wholesale trade, except of motor vehicles and motorcycles
		47	Retail trade, except of motor vehicles and motorcycles
51	afs	55	Accommodation
		56	Food and beverage service activities
52	otp	49	Land transport and transport via pipelines
53	wtp	50	Water transport
54	atp	51	Air transport
55	whs	52	Warehousing and support activities for transportation
56	cmn	53	Postal and courier activities
		58	Publishing activities
		59	Motion picture, video and television programme production, sound recording and music publishing activities
		60	Programming and broadcasting activities
		61	Telecommunications
		62	Computer programming, consultancy and related activities
		63	Information service activities
57	ofi	64	Financial service activities, except insurance and pension funding
		661	Activities auxiliary to financial service activities, except insurance and pension funding
		663	Fund management activities
58	ins	65	Insurance, reinsurance and pension funding, except compulsory social security
		662	Activities auxiliary to insurance and pension funding
59	rsa	68	Real estate activities
60	obs	M (69 to 75)	Professional, scientific and technical activities and Administrative and support service activities
		N (77 to 82)	
61	ros	R (90 to 93)	Arts, entertainment and recreation; Other service activities; Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use
		S (94 to 96)	
		T (97,98)	
62	osg	84	Public administration and defence; compulsory social security
		99	Activities of extraterritorial organizations and bodies
63	edu	85	Education
64	hht	Q (86 to 88)	Human health and social work activities
65	dwe	n.a.	n.a.

Source: Authors' elaborations based on the concordance table from the GTAP website: <https://www.gtap.agecon.purdue.edu/databases/contribute/concordinfo.asp>

Table 2A. Concordance between TiVA sectors (Ed. 2018) and ISIC Rev. 4

TiVA_industry_code	*ISIC Rev.4*	*Description*
D01T03	01 to 03	**Agriculture, forestry and fishing**
D05T09	05 to 09	**Mining and quarrying**
D05T06	05,06	Mining and extraction of energy producing products
D07T08	07,08	Mining and quarrying of non-energy producing products
D09	09	Mining support service activities
D10T33	10 to 33	**Manufacturing**
D10T12	10,11,12	Food products, beverages and tobacco
D13T15	13,14,15	Textiles, wearing apparel, leather and related products
D16T18	16 to 18	Wood and paper products; printing
D16	16	Wood and products of wood and cork
D17T18	17,18	Paper products and printing
D19T23	19 to 23	Chemicals and non-metallic mineral products
D19	19	Coke and refined petroleum products
D20T21	20,21	Chemicals and pharmaceutical products
D22	22	Rubber and plastic products
D23	23	Other non-metallic mineral products
D24T25	24,25	Basic metals and fabricated metal products
D24	24	Basic metals
D25	25	Fabricated metal products
D26T27	26,27	Computers, electronic and electrical equipment
D26	26	Computer, electronic and optical products
D27	27	Electrical equipment
D28	28	Machinery and equipment, nec
D29T30	29,30	Transport equipment
D29	29	Motor vehicles, trailers and semi-trailers
D30	30	Other transport equipment
D31T33	31,32,33	Other manufacturing; repair and installation of machinery and equipment
D35T39	35,36,37,38,39	**Electricity, gas, water supply, sewerage, waste and remediation services**
D41T43	41,42,43	**Construction**
D45T82	45 to 82	**Total business sector services**
D45T56	45 to 56	Distributive trade, transport, accommodation and food services
D45T47	45,46,47	Wholesale and retail trade; repair of motor vehicles
D49T53	49,50,51,52,53	Transportation and storage
D55T56	55,56	Accommodation and food services
D58T63	58 to 63	Information and communication
D58T60	58,59,60	Publishing, audiovisual and broadcasting activities
D61	61	Telecommunications
D62T63	62,63	IT and other information services
D64T66	64,65,66	Financial and insurance activities
D68	68	Real estate activities
D69T82	69 to 82	Other business sector services
D84T98	84 to 98	**Public admin, education and health; social and personal services**
D84T88	84 to 88	Public admin, defence; education and health
D84	84	Public admin. and defence; compulsory social security
D85	85	Education
D86T88	86,87,88	Human health and social work
D90T98	90 to 98	Other social and personal services
D90T96	90 to 96	Arts, entertainment, recreation and other service activities
D97T98	97,98	Private households with employed persons

D05T39	**From 05 to 39**	**Industry (mining, manufactures and utilities)**
D45T98	From 45 to 98	**Total services**
D58T82	From 58 to 82	**Information, finance, real estate and other business services**
D41T98	From 41 to 98	**Total services (incl. construction)**
DINFO	26, from 58 to 60,61,62,63	**Information industries**

Source: ATiVA, List of industries (2018):
<https://www.oecd.org/sti/ind/measuring-trade-in-value-added.htm>

Ilaria Fusacchia is post-doc researcher at the Department of Economics and Manlio Rossi-Doria Centre, Roma Tre University, Italy.

Luca Salvatici is Full Professor at the Department of Economics and a member of the Board of Directors of the Manlio Rossi-Doria Centre, Roma Tre University, Italy.

Fragmentation of global production requires measurement of trade in value added, 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. The quality of indicators measuring trade in value added finally depends on the quality of the underlying global Inter-Country Input-Output tables which, in turn, depend on the quality and availability of underlying national statistics and the balancing and estimation techniques used in the harmonization procedure. Although the use of statistics based on these tables has become more routine in economic research, there is neither harmonization among different global databases nor a standard in the construction of data on which trade in value added is estimated. This contribution is an attempt to systematize the potential sources of the differences between databases and to show how estimations of trade in value added are impacted. Specifically, it provides a comparison between two of the main global databases used for macroeconomic analysis of global value chains and trade in value added patterns, namely, the GTAP Data Base and the OECD-WTO TiVA database, and provides a discussion of the reasons for the deviation in the estimates of global value chains-related trade. In the first part, a description of the databases and the underlying construction methodologies is provided. In the second part, the differences between the two databases in structural economic variables are presented. Finally, major TiVA indicators are estimated based on the different databases and discrepancies among them are discussed.

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