TRADE4SD

Fostering the positive linkages between trade and sustainable development

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Deliverable 1.4: Network analysis of global agri-food trade flows

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About TRADE4SD Project

Trade is a central factor in shaping not only global, but also regional and local development. Trade policy has an especially important part to play in achieving the UN Sustainable Development Goals (SDGs). The premise of the TRADE4SD project is that trade has the power to produce positive outcomes when the policies which define the rules of the game are framed and designed in a way to promote access to markets, fair prices and standards of living for farmers, as well as alleviating rural poverty and ensuring sustainable farming practices. Addressing the relation between trade and SDGs requires an integrated approach to policy-making and inclusive governance.

The main objective of the TRADE4SD project is to contribute to build new opportunities for fostering the positive sustainability impacts of trade supported by improved design and framing of trade policy at national, EU and global level, including WTO modernisation, increased policy coherence at different domains including agricultural, energy, climate, environmental and nutritional policies.

To meet this objective, the project will develop an integrated and systematic approach that combines quantitative models from different perspectives, and several qualitative methods recognising that SDGs and trade are highly context-related. On the one hand, a robust analysis of economic, social and environmental impacts is given by using diverse but integrated modelling techniques and qualitative case studies. On the other hand, a wide consultation process is implemented involving stakeholders both in the EU and in partner countries as well as those with a wide international scope of activity, providing opportunities for improved understanding, human capital building, knowledge transfer and dissemination of results. To this extent, the consortium involves, as co-producers of knowledge, a number of research and stakeholder participants with different backgrounds who will use their networks to facilitate the civil society dialogue and build consensus on the subject of gains from trade in view of sustainability.

Project Consortium

No.	Participant Organisation Name	Country
1	Corvinus University of Budapest (CORVINUS)	HU
2	University of Kent (UNIKENT)	UK
3	Consiglio per la Ricerca in Agricoltura e l'Analisi dell'Economia Agraria (CREA)	IT
4	Johann Heinrich von Thünen-Institut, Bundesforschungsinstitut für ländliche Räume, Wald und Fischerei (THUENEN)	DE
5	The University of Sussex (UOS)	UK
6	University of Ghana (UG)	GH
7	Luonnonvarakeskus (LUKE)	FI
8	Centrum Analiz Spoleczno-Ekonomicznych-Fundacja Naukowa (CASE)	PL
9	Food and Agriculture Organization of the United Nations (FAO)	IT
10	Institut national de recherche pour l'agriculture, l'alimentation et l'environnement (INRAE)	FR
11	Confederazione Generale Dell'Agricoltura Italiana (CONFAGRICOLTURA)	IT
12	Truong Dai Hoc Kinh Te Thanh Pho Ho Chi Minh (UEH)	VN
13	Luminaconsult Sprl (LUMINA)	BE

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1 Introduction

Over the past half a century, global value chains (GVCs) have emerged as the central model of production. Due to advanced and globalised information and transport technologies, production has been unbundled into different stages and tasks in different countries. The value added of trade in intermediate goods has doubled globally since the 1980s and the growth of world trade was expanding twice as fast as between 1995 and 2010 due to multinational enterprises (MNEs) functioning as networks and undertaking different stages of production. Participation in GVCs enables countries to focus on their comparative advantages, thereby maximising efficiency at all stages of production. All this has important macroeconomic implications, also for policymakers.

However, it appears that after 2008 and the consequent economic and financial crises, the world has entered into an era of "slowbalisation", implying the slowing down of globalisation, also affecting GVCs. GVCs recently have become more regional with shortened distances between different stages of production, thereby reacting to the consequences of the trade disputes, COVID-19 pandemic or the Russian-Ukraine war. GVCs seem to adapt to these recent shocks while trying to remain resilient.

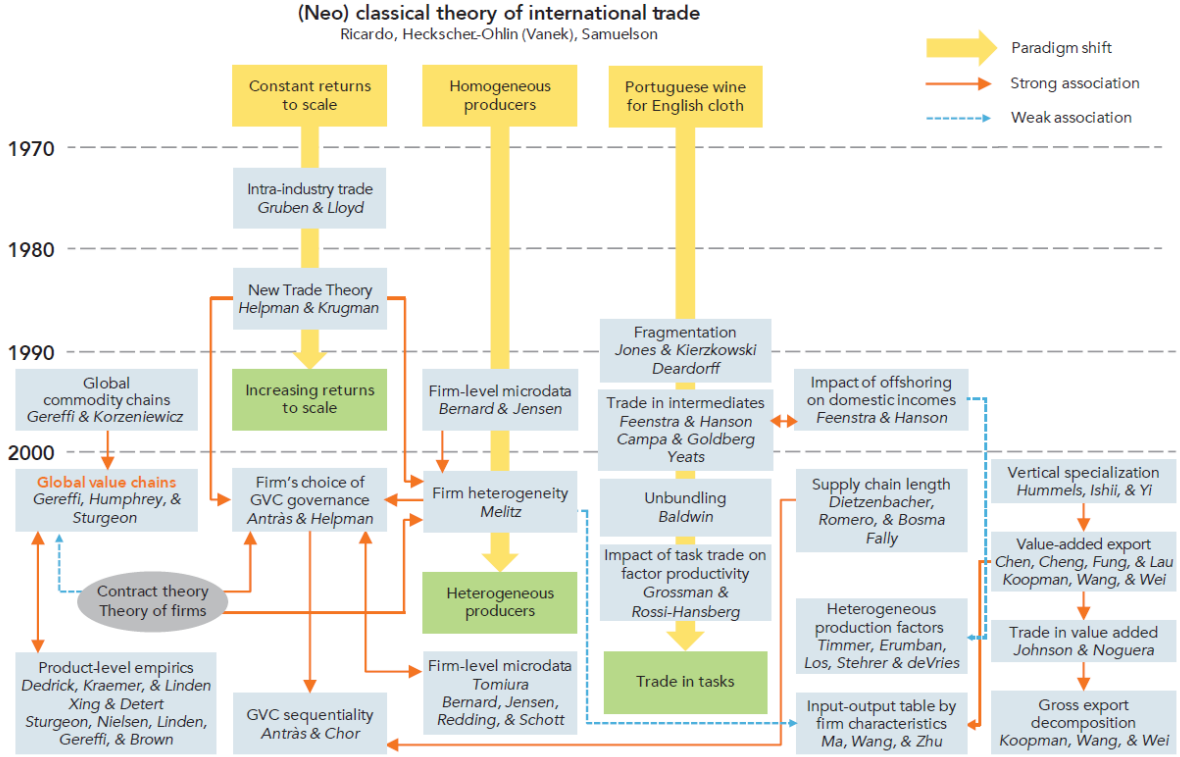
This deliverable aims to describe the complex nature of GVCs in line with the above with a special focus on agri-food value chains. It builds on previous research by applying the network analysis approach, using the inter-country input-output (ICIO) tables. Based on these grounds, after reviewing the theoretical background (Chapter 2), the economic literature (Chapter 3) as well as data and methods (Chapter 4), this deliverable describes recent trends in GVC participation (Chapter 5) and demonstrates the complex structure of agri-food GVCs (Chapter 6) and possible future (Chapter 7) of GVCs.

The deliverable serves as the basis of D1.5. providing a taxonomy of global agri-food value chains and a better understanding of the determinants of participation of developing countries in local and global agri-food value chains. Moreover, D1.4. also provides inputs to other WPs also working with and focusing on analysis of global trade patterns in various agri-food value chains.

2 Theoretical background

Since the seminal work of David Ricardo, the classical theory of international trade has evolved to a great extent over the last 40 years (Figure 2.1). From constant to increasing returns, from homogeneous to heterogenous products and from comparative advantages to trade in tasks, trade theories have been recently living their new renaissance with an increasing amount of literature dedicated to the new trade theories and their empirical investigations.

Figure 2.1. Genealogical map of analytical frameworks for global value chains



Source: World Bank (2017, p. 16.)

The latest wave of reconstructing the classic trade theory is now under way with the rise of trade theories related to global value chains (GVCs). With the advance of transport, communication and information technologies, production processes can be divided into several segments, often across national borders. The new focus of the emerging GVC literature is not on the movements of final products but also the cross-national transfer of tasks and the associated value added generation. Globalised production suggests that more and more firms choose to offshore product parts, components or services to producers in foreign countries and therefore it seems to be complicated to exactly tell where a certain product is "made".

As evident from Figure 2.1, fragmentation theory of Jones and Kierzkowski (1990) was followed by investigations of trade in intermediaries (Campa & Goldberg, 1997; Feenstra & Hanson, 1996; Yeats, 1998), developing key concepts like unbundling (Baldwin, 2006) and trade in tasks (Grossman & Rossi-Hansberg, 2008). In the meantime, methodological frameworks around GVCs have also been advanced (Gereffi et al., 2005). Antras and Helpman

(2004) were the first to integrate New Trade Theory (increasing returns to scale) and the New-New Trade Theory (firm heterogeneity) with the GVC approach, thereby creating the New-New-New Trade Theory (World Bank, 2017).

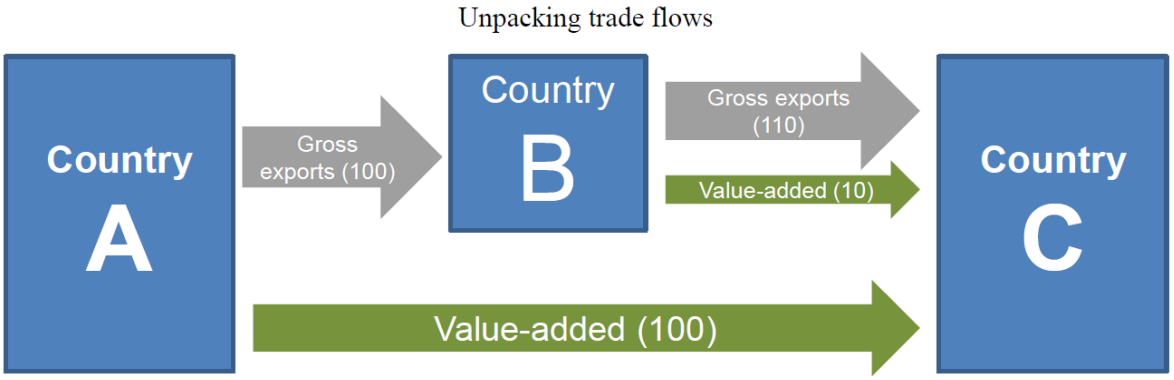
The value added of trade in intermediate goods has doubled globally since the 1980s and is currently giving around 50% of global trade. The growth of world trade is expanding twice as fast as between 1995 and 2010 due to multinational enterprises (MNEs) functioning as networks and undertaking different stages of production (Cigna et al., 2022). Furthermore, increasing vertical integration leads to growing interconnectedness between countries and higher specialisation through GVC participation.

The emergence of GVCS have also challenged the conventional use and interpretation of trade statistics and associated measurement methods. Traditional trade measures record trade flows of goods and services on a gross basis, suggesting that trade in intermediate inputs is calculated each and every time they cross the border for further processing, resulting in double-counting. This traditional way of thinking can lead to serious misinterpretation of the contribution of different countries to global trade flows. As a solution, the concept of trade in value added has been elaborated where gross exports are broken down according to the origin and destination of the value added by country and by industry, implying better tracking of global trade flows across borders.

According to Antràs (2020, p. 3), a GVC "consists of a series of stages involved in producing a product or service that is sold to consumers, with each stage adding value, and with at least two stages being produced in different countries. A firm participates in a GVC if it produces at least one stage in a GVC". Borin and Mancini (2015) develop this definition further and suggest that GVC trade is characterised by flows crossing at least two national borders (contrary to direct trade where a border is only crossed once).

The difference between traditional trade flows and trade in value added is shown in Figure 2.2. In this simple exercise, Country A exports $100 worth of goods which are fully domestically produced to Country B, which then further processes these goods before exporting them to Country C where they are consumed. In this example, Country B adds value of $10 so the value of its total exports is $110. In the conventional logic, total global exports and imports worth $210 instead of the $110 value generated. Conventional measures also show no trade between Country A and C as well as a trade deficit of Country C of $110 with Country B.

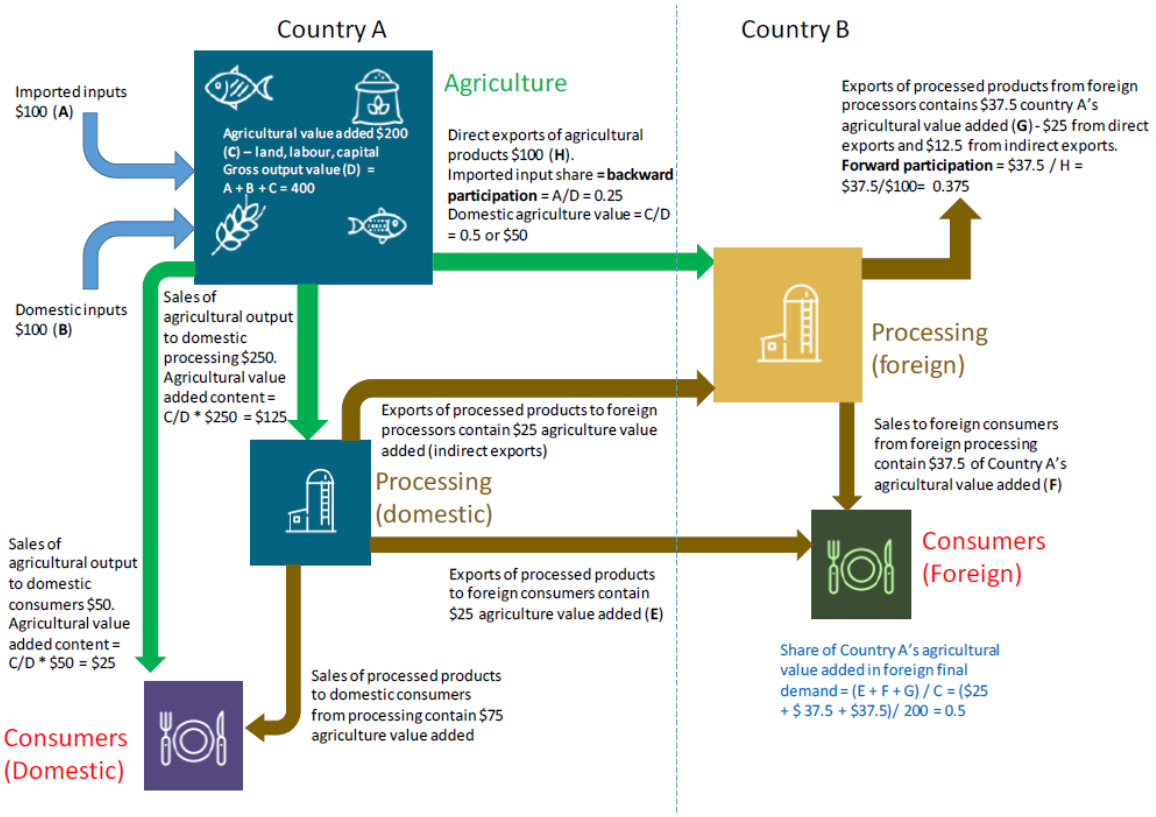
Figure 2.2. Measuring trade in value added



Source: OECD (2019, p. 15)

Figure 2.3 suggests another demonstrative example of how value added can be tracked through GVCs. Agricultural products generally undergo many different transformations before reaching the final consumers.

Figure 2.3. Tracking value added through GVCs

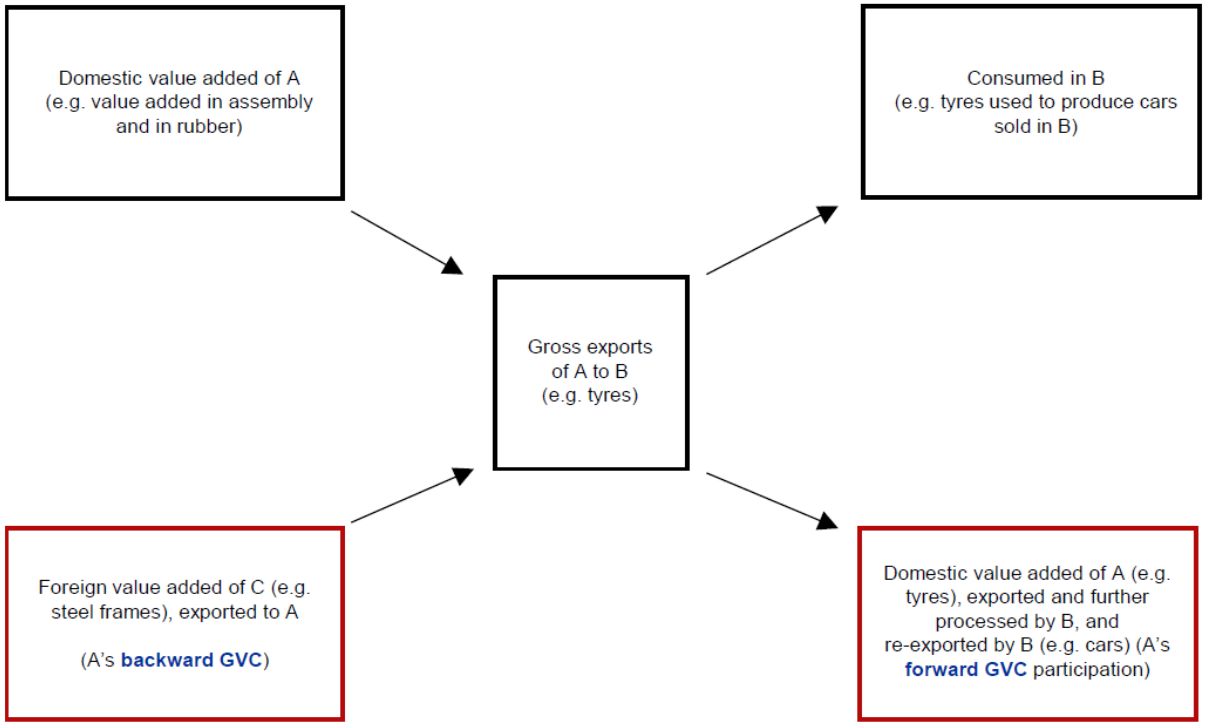


Source: OECD (2019, p. 16)

At the broadest level of disaggregation, countries participate in GVCs by engaging in backward and/or forward linkages. Backward (or upstream) participation refers to the share of foreign value added embedded in a country's total gross exports, while forward (or downstream) participation means the share of domestically produced value added embedded in a country's

exports which is further re-exported by the destination country. Figure 2.4 suggests an example created for tyre production.

Figure 2.4. Decomposition of country A's exports to country B. Origin and destination of value added



Source: Cigna et al. (2022, p. 8)

3 GVC participation: A Bibliometric Review of the Literature

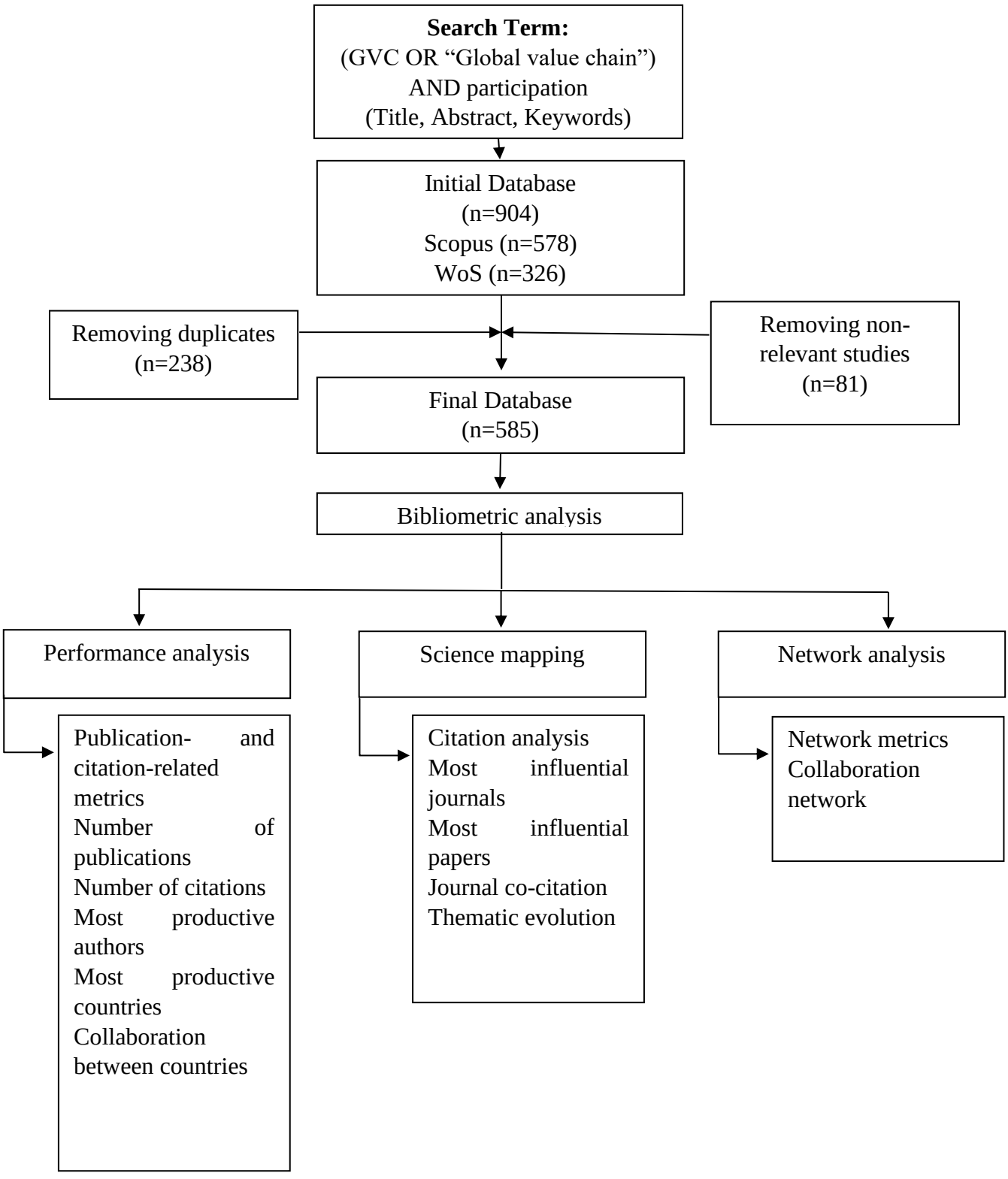
Bibliometric reviews are widely used for identifying trends in specific research domains. They involve applying statistical tools to a large number of publications (Paul & Criado, 2020). The methods (e.g. trend and network analysis) allow the researcher to measure the impact of research trends and analyze the structural characteristics of a specific research field (Zupic & Cater, 2015). The number of publications that have used this methodology in business, economics, and social sciences is growing (Donthu et al., 2021).

Therefore, to contribute to the existing literature, this section uses a bibliometric analysis to detect the most important research trends and to understand the research patterns related to participation in Global Value Chains.

Among the bibliometric reviews published recently, there is no consensus about which bibliometric database to use; however, in many cases, Google Scholar, Web of Science (WoS), and/or Scopus have been applied (Harzing & Alakangas, 2016). In our bibliometric analysis, priority was given to peer-reviewed publications in English; therefore, Google Scholar was not considered, as this platform includes the most unpublished materials and a large share of non-English publications (Martín-Martín et al., 2018). Recent bibliometric studies published in the field of business studies apply the WoS database (e.g., Alonso-Muñoz et al., 2022; Hernández-Perlines et al., 2022; Martín-Navarro et al., 2022) or Scopus (e.g., Gupta et al., 2021; Krishen et al., 2021; Luo et al., 2021; Misra & Mention, 2021); however, only a few studies can be identified that used both databases simultaneously (e.g., Verma & Gustafsson, 2020). For our study, both WoS and Scopus were included to help identify a wider range of high-quality and peer-reviewed publications (Verma & Gustafsson, 2020) after consideration of the advantages and disadvantages of this (Mongeon & Paul-Hus, 2016) and with a view to contributing to the literature with a more complex approach.

For this deliverable, the authors used several pieces of software and online platforms to build an accurate and reliable database and analyze it properly. First, to collect and maintain references, search items were imported into the software EndNote (Bramer et al., 2016). Next, the Covidence online platform was applied to identify duplicates and non-relevant studies (Babineau, 2014). Finally, the R programming language and a dedicated Bibliometrix package were used to undertake the bibliometric analysis (Aria & Cuccurullo, 2017; Gupta et al., 2021). Publications satisfying the search criterion of including *(GVC OR "Global value chain") AND participation* in the title, abstract, author keywords, or keywords plus (WoS) or title, abstract, or keywords (Scopus) were all considered. The search was run by the end of 2022, thus including hits available until this date. The initial database yielded over 904 hits, but after excluding duplicates and removing non-relevant studies, the final database for the bibliometric analysis consisted of 585 items (see Figure 3.1).

Figure 3.1. Research design for the literature review



Source: own composition.

Our search included both Scopus and WoS databases; therefore, a triple-stage process of duplicate removal was applied. First, the de-duplication tool of EndNote that focuses on Digital Object Identifiers (DOI numbers) was used (Bramer et al., 2016), then Covidence's duplicate

detection was applied (Harrison et al., 2020), which screens for matches between titles, publication years, volumes, and authors. Finally, the duplicated matching function in R was used to search for duplicates in the bibliometric database. The algorithm matches records as duplicates if the title, abstract, or identification number are the same. After removing duplicates, the authors manually screened the remaining database using the online Covidence platform. Only items published in English and peer-reviewed (research articles, review articles, books, and book chapters) were included. In addition, to identify non-relevant studies, the title and abstract screening method of Covidence was run to exclude studies that fit the mentioned criteria but focused on unrelated topics (e.g., farmers' market access or farmers' marketing schemes, etc.). Once the dataset was narrowed down to the final selection, we followed the guidelines of Paul et al. (2021) and applied the bibliometric techniques suggested by Donthu et al. (2021) and Mukherjee et al. (2022).

3.1 Basic descriptive indicators

Our sample covered 585 documents (hereinafter referred to as database) from 347 sources contributed by 1,163 authors from 2006 to 2022. The vast majority were research articles (520), although we have also collected 6 books (some of them with remarkable number of citations), 43 book chapters and 16 reviews. On average, 2-3 authors wrote a publication, while the rate of articles with foreign co-authors was only 14.36%. The average age of the articles in our database was 2.76 years, which means that the number of publications on this topic was increasing. The total number of references was 24,911, while the average number of citations per article was 7.59 and the average annual growth in the number of articles was 35.43%.

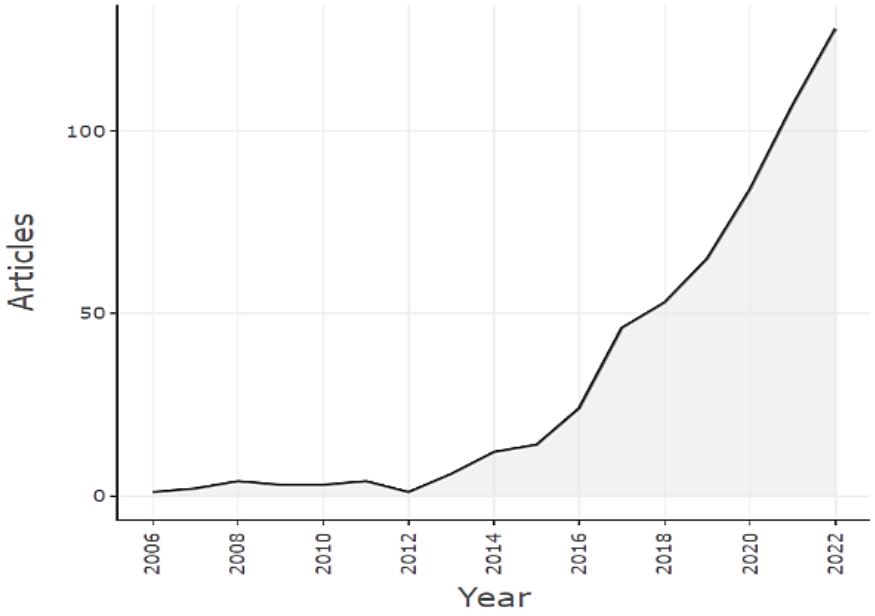
Table 3.1. Description of the database

Key Information about Data	
Documents	585
Time-Period	2006-2022
Average citations per doc	7.59
Annual Growth Rate %	35.43
Document Average Age	2.76
References	24,911
Authors	1163
Authors of single-authored docs	120
Single-authored docs	133
Co-Authors per Doc	2.52
International co-authorships %	14.36
DOCUMENT TYPES	
article	491
article: book chapter	1
article: early access	28
book	6
book chapter	43
review	16

Source: own composition.

There has been a significant increase in the number of GVC-connected scientific papers since the end of the 2000s in line with the growing shares of GVCs in global trade. The exponential increase in the number of published journal articles indicates the emerging scientific interest related to the field. Figure 3.2 shows the evolution of publications in the field by year.

Figure 3.2. Scientific papers published by year on GVC participation

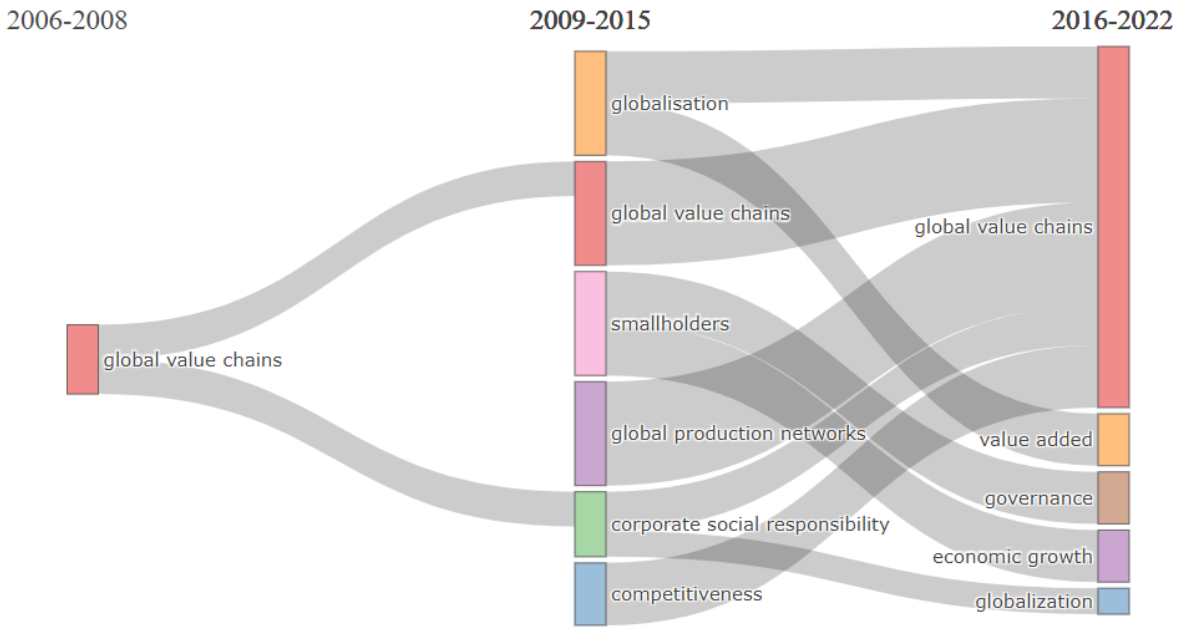


Note: the database was created on October 12, 2022, therefore, for 2022 not a full year is considered

Source: own composition.

Going more into detail, Figure 3.3 visualises the thematic evolution of GVC literature since 2006 based on the keywords. In the first period analysed (until 2009), the most frequently used keyword was global value chain, and this keyword – not surprisingly – dominated the research agenda. Between 2009 and 2015, new keywords like globalisation, smallholders, global production networks, corporate social responsibility and competitiveness also appeared, showing growing specialisation inside the main topic of GVCs. In the previous six years (2016-2022), topics like added value, economic growth, globalisation and governance were the most prominent ones for the researchers. As evident from Figure 3.3, many topics of the second period were redirected into partly different topics of the third period in line with the changes of research preferences.

Figure 3.3. Evolution of GVC topics in time



Source: own composition.

Among the papers identified, the average number of total citations has significantly fluctuated. The general citation structure shows that only 2 papers had more than 200 global citations (0.3% of the total), and only 2 publications had more than 100 citations (0.3). At the other end, 213 papers (36.4%) had no citations, and most papers were cited less than 50 times (61.4% of the total). The most cited document, according to the total citations (487 TC and 0 LC), published by Coe and Yeung (2015). This book is explains a new form of economic organization, termed global production networks (GPNs) and tries to answer the following question: 'how is development in different economies driven by their participation in value activities organized through global production networks?'. The most local cited article (212 TC and 22 LC) in the sample is written by Morrison et al. (2008). This is a critical review of the global value chain (GVC) literature in terms of technological capabilities approach to innovation in developing countries. In this list, the first classical empirical research (1 LC and 112 TC) written by Georgiadis (2016) investigates global output spillovers from US monetary policy. In addition, the range of topics of the articles is wide, from agriculture (Johns et al., 2013; Mancini, 2013) to the automotive industry (Wad & Chandran Govindaraju, 2011).

Table 3.2. General citation structure of the sample

Number of citations	Number of papers	% of paper
Over 200	2	0.3%
Between 100 and 200	2	0.3%
Between 50 and 100	9	1.5%
Less than 50	359	61.4%
0 citations	213	36.4%
Total	585	100%

Source: own composition.

3.2 Most productive authors & countries

Table 3.3 shows the top ten most cited and most published authors within the publications of the database. Pietrobelli, C. and Wang, S. were the most published authors, with 9 articles, followed by Nenci, S. (6), all the other authors had 5 or less publications. Rabelotti, R. was the most cited author with the total of 41 local citations, followed by Pietrobelli, C. (34), Sanfilippo, M. (25), Ruta, M. (24) and Morrison, A. (22). Among them, Pietrobelli (2008-) and Giovanetti (2015-) had the longest publication period. The most productive and cited authors were mainly located in Italy and China, and it was not uncommon for an author to publish with different affiliations. In other words, Table 3.4 shows the most important "working centres" of global GVC research.

Table 3.3. Top 10 most active and most cited authors

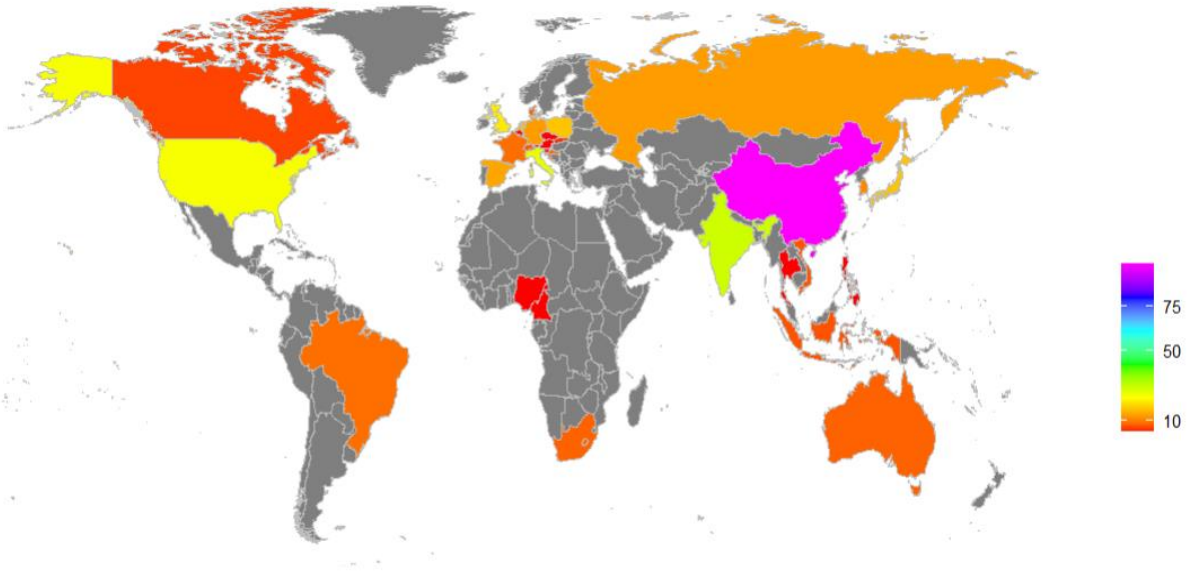
Author	Institution	Number of published articles	Author	Institution	Number of citations
Pietrobelli, C.	Roma Tre University, Italy; Georgetown University, USA; United Nations University, Netherlands	9	Rabelotti, R.	University of Eastern Piedmont, Italy	41
Wang, S.	Ocean University of China, China	9	Pietrobelli, C.	Roma Tre University, Italy; Georgetown University, USA; United Nations University, Netherlands	34
Nenci, S.	Roma Tre University, Italy	6	Sanfilippo, M.	University of Bari, Italy; University of Antwerp, Belgium	25
Wang, J.	Chongqing Technology and Business University, China	5	Ruta, M.	World Bank, USA	24
Giovannetti, G.	University of Florence, Italy	5	Morrison, A.	Utrecht University, Netherlands	22
Ha, L. T.	National Economics University, Vietnam	5	Mao, Z.	University of Johannesburg, South Africa	21

Author	Institution	Number of published articles	Author	Institution	Number of citations
Jangam, B. P.	Indian Institute of Technology Hyderabad, India Indian Institute of Management Bodh Gaya, India	5	Amendolagine, V.	University of Pavia, Italy	19
Kersan-Skabic, I.	Juraj Dobrila University of Pula, Croatia	5	Presbitero, A. F.	International Monetary Fund, USA	19
Lu, Y.	University of International Business and Economics, China	5	Giovannetti, G.	University of Florence, Italy	18
Marvasi, E.	Polytechnic University of Milan, Italy	5	Lu, Y.	University of International Business and Economics, China	18

Source: own composition.

Going more into details, research on participation in GVCs was spread over 59 countries in which some authors produced at least one article on this topic (Figure 3.4). In line with Table 3.4, taking the total number of publications by country, China had a leading role with 99 publications, while India was ranked the second place (29), followed by Italy (26), the USA (24), the United Kingdom (21), Japan (17) and Poland (17). China accounts for more than 20% of publications, which makes it stand out in terms number of publications.

Figure 3.4. The most productive countries in terms of total number of publications

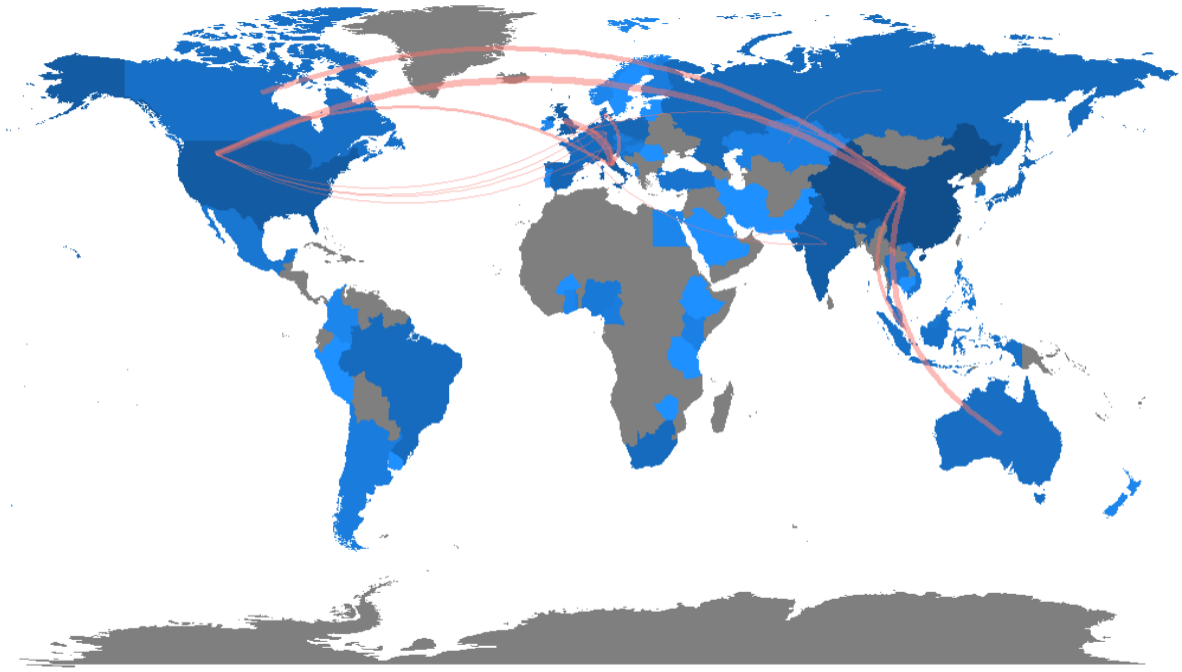


Source: own composition.

3.3 Network analysis of papers and citations

GVC seems to be global not just in trade flows but also in terms of research collaborations. The number of collaborations with authors from other countries was relatively the highest in Italian, American, and British publications, respectively, above 25%. The co-authorship of papers determines the network of cooperation between countries. Therefore, collaborative networks were analysed according to the origin of the publication's first authors. In line with the above, Chinese authors did not just publish papers alone but collaborated most often globally, mainly with USA (7), Australia (4), Canada (4) and Singapore (3). Italian authors collaborated mainly with British (6), Danish (3), Dutch (3) and American (3) authors (Figure 3.5). Interestingly, the topic of the GVC was not really investigated by the authors from the developing world.

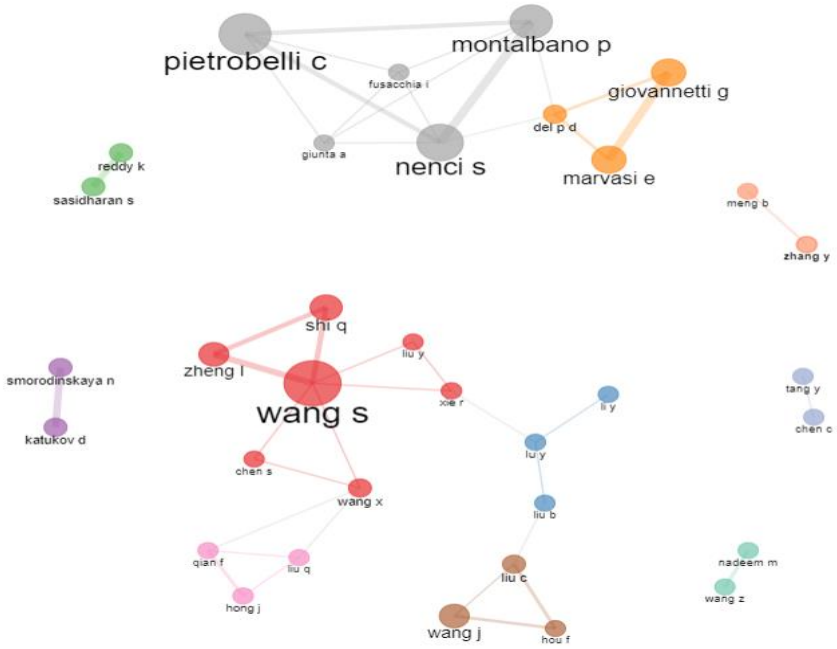
Figure 3.5. Collaboration among authors in publishing papers on GVC participation



Source: own composition.

Furthermore, with the help of network analysis, eleven (three main) collaborative groups of authors with a decisive research focus can be identified (Figure 3.6). One of the central authors is Wang, S., with 3 smaller sub-networks connected to his collaboration group (in red), mainly focusing on the environmental side of GVCs. The second cluster, indicated in grey, composed by Fusacchia, I., Giunta, A., Montalbano, P., Nenci, S. and Pietrobelli, C., mainly focuses on global value chains and productivity in Latin America as well as agricultural value chains. The third cluster (in yellow), including Del, P. D., Giovannetti, G. and Marvasi E., mainly deals with firm's heterogeneity and the African issues.

Figure 3.6. Author collaboration network in GVC research



Source: own composition.

As to citations, sources receiving the most citations were the book entitled Global Production Networks (487 citations), Oxford Development Studies (212), and the European Journal of Development Research (169). Articles with a Chinese corresponding author received 518 citations, followed by Italy (473 citations) and the USA (354 citations), as Table 3.5 suggests.

Table 3.4. Performance analysis and article citations of journals and countries

Rank	Journal/Book	Article citations	Country	Article citations
1	Global Production Networks	487	China	538
2	Oxford Development Studies	212	Italy	473
3	European Journal of Development Research	169	USA	354
4	World Development	158	Canada	240
5	World Economy	138	Denmark	240
6	Journal of International Money and Finance	122	Netherlands	155
7	Development Policy Review	111	United Kingdom	139
8	Journal of Cleaner Production	103	New Zealand	100
9	Journal of the Science of Food and Agriculture	83	South Korea	98
10	Environmental Science and Pollution Research	81	Germany	82

Source: own composition.

From the publishing side, as Table 3.6 suggests, The World Economy seemed to be the journal with the highest publication outlet on GVCs, with 20 articles published, followed by the European Journal of Development Research (9), International Economics (9) and Sustainability (9) (Table 3.6).

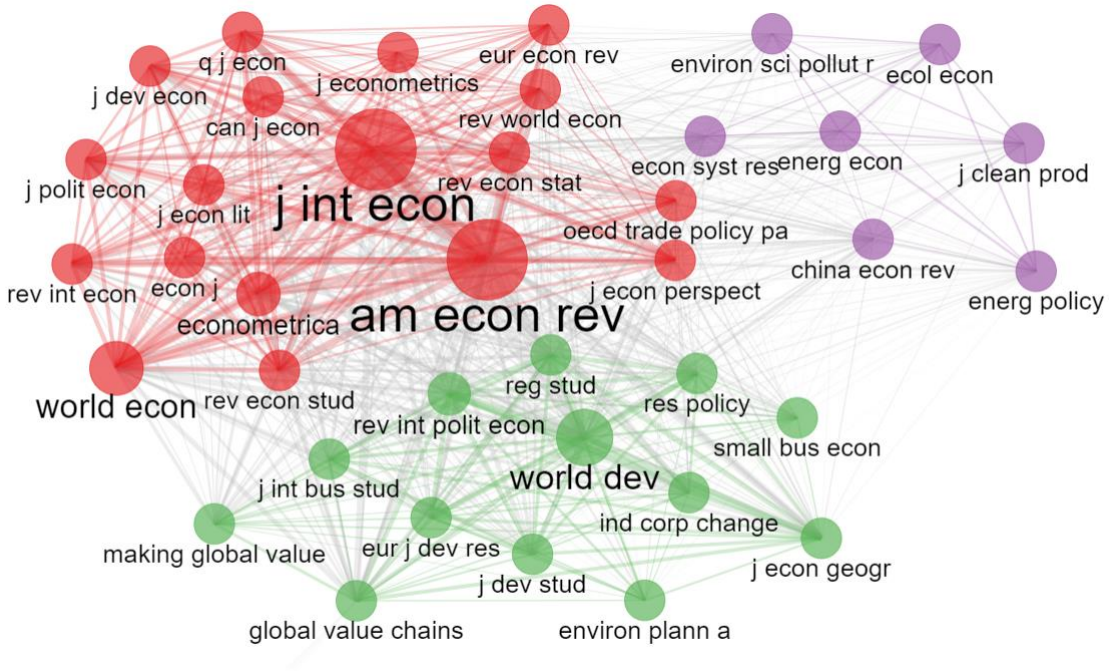
Table 3.5. Top 10 journals concerning relevance

Sources	Number of Articles (published)
World Economy	20
European Journal of Development Research	9
International Economics	9
Sustainability	9
Journal of Cleaner Production	8
World Development	8
Applied Economics Letters	7
Journal of Economic Integration	7
Journal of International Trade & Economic Development	7
Review of World Economics	7

Source: own composition.

Going further, network analysis is able to visualise which journals were citing each other, ending up in three significantly different clusters (Figure 3.7). The first cluster includes top journals in the field of international economics. These journals include Journal of International Economics, American Economic Review and the World Economy. These multidisciplinary journals work with diverse theoretical and empirical research in all areas of international economics such as trade, international policy and institutions, international finance as well as development. The second cluster includes journals that focus on policy and management issues like World Development, Review of International Political Economy, Journal of International Business Studies or Research Policy. These journals publish articles on international political economy, improvement of standards of living (e.g. poverty, unemployment), management practice areas of internationally operating firms and interactions between innovation, technology and research. Finally, the third cluster including seven journals (Energy Policy, Journal of Cleaner Production, China Economic Review, Energy Economics, Economic Systems Research, Ecological Economics, Environmental Science and Pollution Research), deal with wider aspects of environmental and ecological science. Therefore, the thematic distribution indicated by the journals' co-citation map also well illustrates the most relevant research avenues of GVCs.

Figure 3.7. Co-citation network of journals



Source: own composition.

4 Data and methods

4.1 GVC related databases

The new and diverse production arrangements organised by multinational enterprises through GVCs have increased the complexity of compiling economic statistics, as it is more difficult to break down production activities on a country-by-country basis.

Measurement challenges include (United Nations Statistical Division):

- the choice of the statistical unit,
- the classification of enterprises and products involved in GVCs,
- the implementation of the principle of economic control and ownership,
- and the recording of domestic and cross-border transactions and positions in national accounts and balance of payments statistics.

To analyse GVCs, several large scale databases and economic indicators are used provided by the World Bank, Asian Development Bank, OECD, CEPII (Centre d'Etudes Prospectives et d'Informations Internationales), the United Nations, University of Groningen, the Global Trade Analysis Project (GTAP) and EXIOBASE (Table 4.1).

Table 4.1. Main data sources and their characteristics

Data provider	Database	Period	Coverage	References
EXIOBASE consortium (legally represented by Netherlands Organization for Applied Scientific Research TNO)	EXIOBASE Multi-Regional Environmentally Extended Supply-Use Table (MR-SUT) Input-Output Table (MR-IOT) – version1-3 monetary and hybrid forms EXIOBASE1 (2000) EXIOBASE2 (2007) EXIOBASE3 monetary EXIOBASE3 hybrid	The monetary supply-use tables were available for the years 1995-2011 with nowcasts to extend the data to 2020 and beyond hybrid form the transactions in the supply-use tables are in mass or energy units	The monetary tables: 44 countries, 5 Rest of World regions 200 products, 163 industries 3 employment skill levels per gender 417 emission categories 662 material and resources categories The hybrid tables: 43 countries and 5 Rest of World regions 200 products,164 industries, 39 resources 5 land categories, 66 emissions supply and use of waste flows supply and use of packaging new accumulation of materials crop residues/grass accounts avoided emissions	Stadler et al. (2021), Merciai and Schmidt (2018), Wood et al. (2014), Donati et al. (2020), Wieland et al. (2018), Tukker et al. (2013), Wiebe et al. (2018)
Many institutions have contributed to the creation of the Eora MRIO tables University of Groningen	Eora supply chain database Eora26 (simplified model) Global Supply Chain Database - global multi-region input-output table (MRIO)	1990-2021	15,909 sectors 190 countries United Nations System of National Accounts (SNA)	Piccardi et al. (2022), Mancini et al. (2023), Raei et al. (2019), Montalbano and Nenci (2020), Kacani (2020),

				Kowalski et al. (2015)
Groningen Growth and Development Centre (GGDC)	World Input-Output Database (WIOD tables) Long-run WIOD	WIOD 2016 Release (2000-2014) WIOD 2013 Release (1995-2011) (1965-2000)	43 countries, 56 sectors (ISIC Rev. 4) 40 countries and the rest of the World, 35 sectors (ISIC Rev. 3). 25 countries, 23 sectors (ISIC Rev. 3)	Piccardi et al. (2022), Antràs (2020), Cigna et al. (2022), Kowalski et al. (2015)
Asian Development Bank	Augmented World Input-Output Tables	ADB MRIO database (2007-2019)	63 countries, 56 sectors	Mancini et al. (2023)
CEPII (Centre d'Etudes Prospectives et d'Informations Internationales)	International Trade Database at the Product-Level	BACI (1994-2007)	bilateral trade flows for 200 countries, 5000 products Harmonized System 6-digit code	Kowalski et al. (2015)
CEPII (Centre d'Etudes Prospectives et d'Informations Internationales)	PROduct level Trade Estimated Elasticity - ProTEE dataset	2001, 2004, 2007, 2010, 2013 and 2016	5,000 different product categories, 152 importing countries, HS6 product category, revision 2007	Fusacchia et al. (2022)
OECD	Trade in Value Added (TiVA) indicators - TiVA OECD dataset	1995-2018	66 countries, 45 sectors (ISIC Rev. 4)	Mancini et al. (2023) Antràs (2020) Kowalski et al. (2015) Tinta (2017) Urata and Baek (2020) Xing et al. (2021)

OECD	Structural Analysis (STAN) Databases STAN Input-Output Tables (IOTs)	2000-2021	66 countries, 45 sectors (ISIC Rev. 4)	Jaax et al. (2023) OECD Trade and Agriculture Directorate, OECD (2020), Cigna et al. (2022), Kowalski et al. (2015)
OECD	OECD Inter-Country Input-Output (ICIO) Tables - OECD ICIO	1995-2018	66 countries, 45 sectors (ISIC Rev. 4)	Jaax et al. (2023) Fusacchia et al. (2022) Montalbano and Nenci (2020) Kacani (2020), OECD (2020), Tinta (2017)
OECD	Activity of Multinational Enterprises AMNE Database	2008	31 OECD countries, 17 variables, ISIC Rev. 4 v	Xing et al. (2021)
Global Trade Analysis Project, a global network of researchers and policy makers	GTAP Data Base	2004, 2007, 2011, 2017	121 countries, 65 sectors, 50 I-O tables	Fusacchia et al. (2022) Montalbano and Nenci (2020) Montalbano and Nenci (2020) Kowalski et al. (2015)
Global Trade Analysis Project	GTAP-VA: An Integrated Tool for Global Value Chain Analysis	2018	3 regions (the United States, the European Union and the Rest of the World) and 3 sectors (Manufactures, Agrifood and Services) where a free trade area between the European	Fusacchia et al. (2022) Montalbano and Nenci (2020), OECD (2020),

			Union and the United States is simulated. The new version of the model (GTAP-VA) makes a useful contribution to trade policy analysis.	Kowalski et al. (2015)
World Bank	World Development Indicators (WDI)	1960-2021	217 countries, more than 40 country groups	Antràs (2020) Tinta (2017)
World Bank United Nations Conference on Trade and Development (UNCTAD) World Trade Organization (WTO)	World Bank (WITS) World Integrated Trade Solutions	The UNSD Commodity Trade (UN Comtrade) (UN Comtrade) since 1962 The UNCTAD Trade Analysis Information System (TRAINS) tariffs and non-tariff measures The WTO's Integrated Data Base (IDB)	170 countries 160 countries Commodity Description and Coding System (HS)	Kacani (2020), Kowalski et al. (2015)
World Bank	World Bank's Enterprise Surveys	2009–2018	111 countries, 38 966 firms (SMEs)	Urata and Baek (2020)
United Nations, OECD	United Nations Industrial Development Organization (UNIDO) Investor Survey Dataset	2005-2018	highly disaggregated data on the manufacturing sector (ISIC Rev. 4)	United Nations (2023)

Source: own composition

4.2 Data sources

Of the 16 scientific articles and reports analysed, the Eora Global Supply Chain Database that includes the global multiregional input-output table (MRIO), the University of Groningen World Input-Output Tables (WIOT), the OECD Trade in Value Added (TiVA) dataset, as well as the World Bank World Development Indicators and Exiobase dataset were the most popular sources used for the GVC analysis.

The Eora (also referred as Eora26) Global Supply Chain Database consists of a multi-region input-output table (MRIO) that provides a time series of high-resolution Input-Output (IO) tables with matching environmental and social satellite accounts for 190 countries.

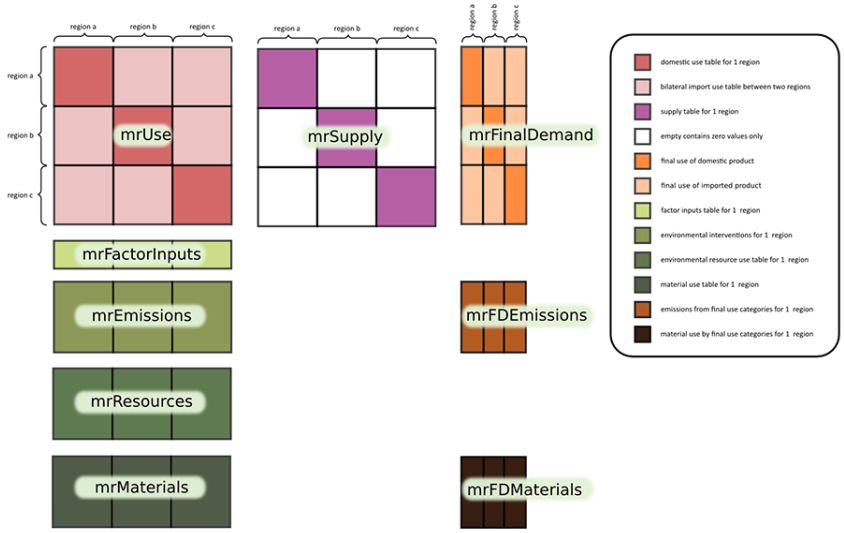
University of Groningen, Groningen Growth and Development Centre's World Input-Output Database (WIOD), and underlying data, covers 43 countries, and a model for the rest of the world for the period 2000-2014. Data for 56 sectors are classified according to the International Standard Industrial Classification revision 4 (ISIC Rev. 4). The tables adhere to the 2008 version of the SNA. In addition, the Long-run WIOD dataset also exists for 25 countries and 23 sectors for the period 1965-2000.

OECD provides Trade in Value Added (TiVA) dataset covering 66 countries and 45 sectors for the period 1995-2018 and OECD Inter-Country Input-Output (ICIO) tables which cover 65 economies, 45 industries for 1995-2018.

Moreover, the Asian Development Bank provided two main data sources: the ADB MRIO Augmented World Input-Output Tables (ADB MRIO database) which includes 63 countries and 56 sectors for the period 2007-2019 and Economic Insights from Input-Output Tables for Asia and the Pacific 2020.
Furthermore, the World Bank also has many large-scale economic indicators, such as World Development Indicators (WDI), and World Integrated Trade Solutions (WITS). Finally, the World Bank Enterprise Surveys including 111 countries and 38,966 firms with a focus on small and medium-sized enterprises (SMEs) for the period of 2009–2018.

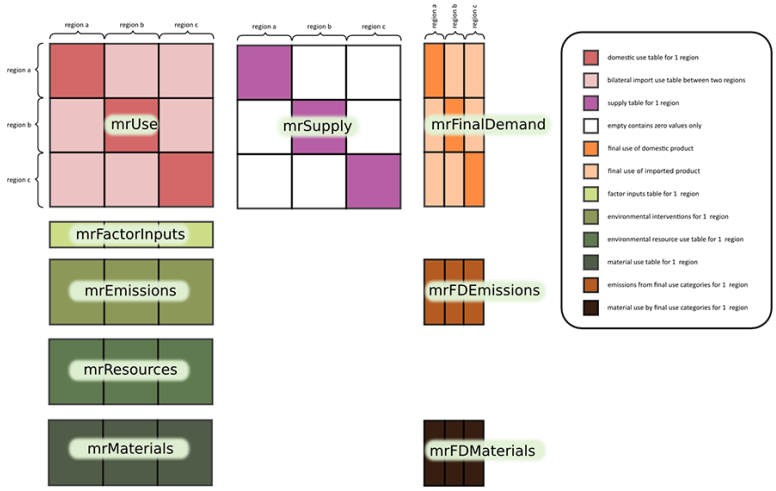
In addition to the abovementioned databases, Exiobase also exist, that consists of Multi-Regional Environmentally Extended Supply-Use Table (MRSUT) and Input-Output Table (MRIOT). This includes detailed tables for supply side, covering several nations and estimated emissions as well as used resources at sectoral level. This database is elaborated by research institutes funded by the European Research Framework Programmes. In particular, different types of tables are accessible from Exiobase such as monetary and hybrid. First, the monetary tables of Exiobase cover 44 countries, 163 industries, 200 products, and 417 categories of emissions, plus 662 categories of materials and resources. It is available from 1995 to 2011, and with projection to 2020. Second, the hybrid Exiobase tables cover 43 countries, 200 products, and 164 industries, and also 39 resources and 66 emissions. The dataset also comprises supply and waste flows, supply and packaging, accumulation of materials, crop residues, and avoided emissions (EXIOBASE, 2023). The tables are expressed in current prices, million EUR (Merciai, 2021; Merciai & Schmidt, 2018). The following Figures present the composition of the Exiobase Multi-Regional Input-Output Tables (Figures 4.1 and 4.2).

Figure 4.1. EXIOBASE2 Multi-Regional Input-Output Table (MR-IOT)



Source: EXIOBASE (2023).

Figure 4.2. EXIOBASE2 Multi-Regional Supply and Use table



Source: EXIOBASE (2023).

4.3 Modelling approach of GVC analysis

Macroeconomic theories and the applied econometric methods for analysing GVC are (see Table 4.2)

- Global computable General Equilibrium Models (GEM)
- Partial Equilibrium Models (PEM) estimating trade costs in help with gravity equation, gravity model with panel using fixed effects (FE)

The results are mostly visualised by different type of graphs and in help with network analysis.

Table 4.2. Applied theories, econometric methods, sources, and classification for GVC analysis

Macroeconomic theory	**Measurement**	**Econometric methods**	**Data**	**Classification**	**Visualisation**
Global computable General Equilibrium Models (GEM)[1]	GVC value added structure of international trade	Simulation	GTAP standard static	Harmonized Commodity System, at six-digit level (HS-6)	Various Graphs
	global upstream and downstream linkages regional trade liberalisation	Value-added decomposition of trade	GTAP model with perfect competition and constant returns to scale	Broad Economic Categories (BEC)	
	production fragmentation and networks		OECD global Inter-Country Input–Output (IO) tables		
			Exiobase database	monetary and hybrid tables including 200 products, 163 industries, 3 employment skill levels per gender, 417 emission categories, 662 material and resources categories	

[1] consider potential interactions across markets

Macroeconomic theory	Measurement	Econometric methods	Data	Classification	Visualisation
Partial[2] Equilibrium Models (PEM)	trade costs	Utility function, Constant Elasticity of Substitution (CES) functions	French Center for Research and Expertise on the World Economy. (CEPII)	Harmonized Commodity System (HS-6)	Network analysis
		Cobb-Douglas production function	World Bank World Development Indicators (WDI)		
		Trade cost functions (captured by a standard or structural bilateral panel gravity model/equation)	World Bank World Integrated Trade Solution (WITS)		

Source: own composition

In framework of the General Equilibrium Models, different versions of GTAP models were applied the most in the literature. The GTAP is a so-called Global Trade Analysis Project that captures bilateral trade characteristics, production, consumption, along with intermediate use of commodities and services. It illustrates the world economy and considered as an important input for applied general equilibrium (GEM) analysis (GTAP).

The GTAP database represents the world economy for a reference year. Regarding the database, there are several sources, including national input-output (I-O) tables, trade, macroeconomic, energy, and protection data. The underlying input-output tables are heterogeneous in sources, methodology, base years, and sectoral detail. Thus, for achieving consistency, substantial efforts are made to make the disparate sources comparable. For these reasons, the objective of the GTAP Data Base is not to provide I-O tables, but to facilitate the operation of economic simulation models ensuring users a consistent set of economic facts. Some users interested in particular Social Accounting Matrices (SAMs) use utilities written by researchers in the network to extract them. Users built I-O tables based on this information under their own risk

[2] consider only one market at a time ignoring potential interactions across markets

and are assumed to understand the limitations imposed by the construction process of the database.

The GTAP is not a relational database of economic variables. Users interested in economic data only for comparative purposes are better served by sources such as the World Bank Development Indicators (WDI), the International Monetary Fund (IMF) financial statistics, or the Food and Agriculture Organization (FAO) statistics. The data in the GTAP depicts the magnitudes of economic variables, but they are presented in terms of the aggregates that serve Computable General Equilibrium (CGE) modelling (GTAP).

The GTAP Data Base version 10 describes the world economy for four reference years (2004, 2007, 2011, and 2014) and distinguishes 65 sectors, up from 57 in the previous versions, in each of the 141 countries/regions. The 121 countries in the data set accounts for 98% of global GDP and 92% of world population. For each country or region, it reports production, intermediate and final uses, international trade, transport margins, and taxes or subsidies. This data mainly applied for the calculation of global general equilibrium models (Aguiar et al. 2019).

4.4 Measurement of GVCs and indicators applied

Regarding the measurement of GVCs, number of economic indicators and variables are available in the world biggest databases. The studies applied country-related and firm-related variables to capture for trade, economic development and export performance. Among others, GDP per capita, share of trade in GDP, openness to trade, foreign direct investment (FDI) flows or inflows, trade in value added (TiVA), trade in factor income (TiFI) were the most popular indicators. Trade policy variables often measured by import tariffs and taxes, as Free Trade Agreements (FTA), and Regional Trade Agreements (RTA).

Partial equilibrium is modelled by calculating the bilateral trade costs of trading countries, estimated by panel gravity models. Behind the standard panel gravity variables (GDP, distance, location, population, area, market size, cultural and colonial links, industrial structure, exporter and importer fixed effects, country pair fixed effects and time fixed effects), capital intensity, GNI per capita (PPP), bilateral FDI volumes were also employed. Furthermore, the studies also used agriculture-related indicators such as agriculture value added per worker, land intensity, and fertilizer use.

In addition, many GVC-specific variables are used as GVC participation index, measurement of GVC networks, GVC Trade (percent of nominal world GDP), percentage of domestic value added / domestic income (DVA), foreign value added (FVA) embedded in gross exports, Labour Productivity, Upstreamness (U) index, Downstreamness (D) index, backward and forward GVC participation (share of gross exports), survival of trade relationships (Table 4.3).

This deliverable builds on previous research and applies the network analysis approach for selected value chains available in the OECD (TIVA) and Exiobase inter-country input-output database. Chapter 5 builds on the comprehensive OECD dataset for describing general trends in all industries, while Chapter 6 uses Exiobase for agri-food value chains as this database has the highest, most disaggregated and most recent data available among the ones listed above.

Table 4.3. Measurement, variables, and indicators of GVCs

Country-related variables for trade performance	Variables of Economic development and export performance	Trade policy variables	Firm-related factors/ variables
• economic development (GDP per capita), income per capita • degree of industrialisation of the economy (the share of manufacturing value added in GDP) • share of final trade in GDP • intermediate trade in GDP • openness to trade • foreign direct investment (FDI) flows and inflows • import intensity of production • factor endowments • flows of credit and intellectual property • institutional quality • income elasticity of trade • world transport costs • digitalisation • technological advancements (R&D) • Revealed Comparative Advantage (RCA) • Intensive and extensive margins for intermediate export growth to the world • trade in factor income (TiFI)	• Gross and value-added exports • Economic development (Income per Capita) • foreign value-added (FVA) embedded in gross exports	• Tariffs • Import tariffs • Import taxes • Free Trade Agreements (FTA): NAFTA, MERCOSUR, ASEAN, EFTA etc • Regional Trade Agreements (RTAs)	• labour productivity • firm size • foreign ownership • technological capability • intra-firm trade

• trade in value added (TiVA) • Logistics performance, trade facilitation, intellectual property protection			
Measurement of bilateral trade costs (gravity models) variables • trade flows from country i to country j and from industry s to industry r, • domestic flows in country j from industry s to industry r, • Capital intensity • GNI per capita • bilateral FDI volumes • location • population • area • market size • Industrial structure • exporter fixed effects, • importer fixed effects, • country pair fixed effects • time fixed effects	Agriculture-specific variables • agriculture value added per worker • land intensity • use of fertilizers		GVC-specific variables • GVC participation index • GVC networks (OECD) • GVC Trade (Percent of nominal world GDP) • percentage of domestic value added / domestic income (DVA) • foreign value added (FVA) embedded in gross exports • Labour Productivity • Upstreamness (U) index • Downstreamness (D) index • Backward and forward participation index • Backward and forward GVC participation (share of gross exports) • Global upstream and downstream linkages • Survival of trade relationships

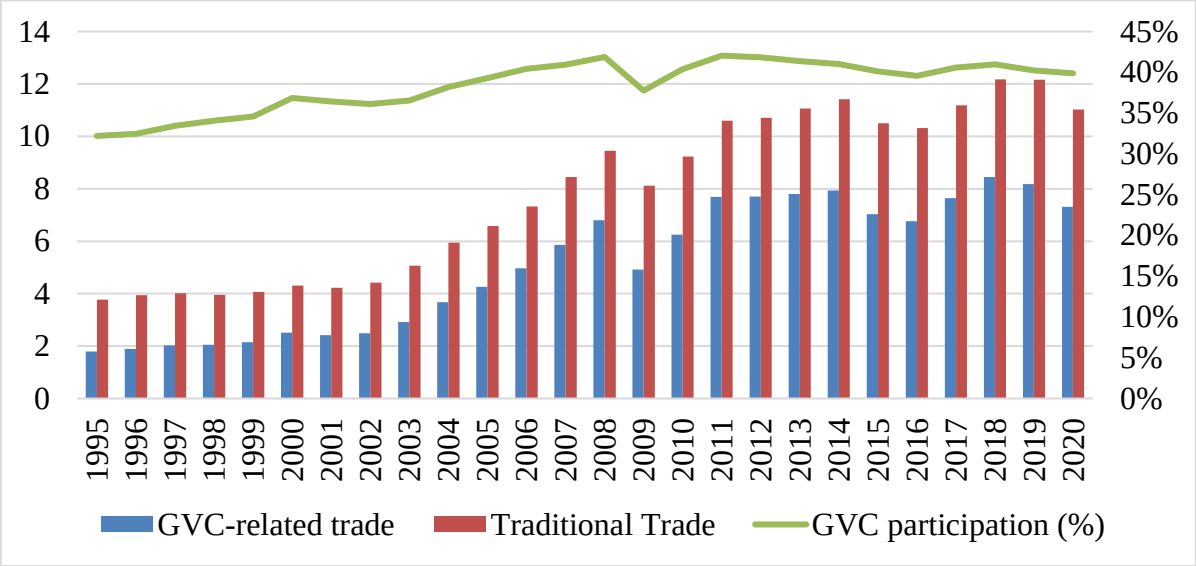
Source: own composition

5 Recent trends in GVCs

The last years have posed many challenges to globalisation. Since World War II, global trade grew many times faster than global GDP, but since 2008, this trend has started to change (WB, 2017). The financial crisis of 2008-2009, the trade conflict between US and China, the border closures because of COVID-19, the emerging food and energy price inflation dure to the Russia-Ukraine war have all contributed to the slowdown of globalisation called "slowbalisation" (WTO, 2021).

Figure 5.1. clearly shows the change from hyperglobalisation to slowbalisation, indicated by the GVC participation rate, measured as a share of indirect trading in gross exports. Although global trade in nominal terms more than tripled and GVC-related trade quadrupled from 1995 to 2019, global GVC participation shares stopped increasing after 2008 and started to stagnate at around 40%. The reasons behind are numerous. First, several shocks have hit the global economy and associated trade since 2008. Second, a reduction in cross-country production sharing in complex GVCs have become more existent. Third, again unlike in the hyperglobalisation era, recent economic recovery has been mainly driven by traditional trade (WB, 2017).

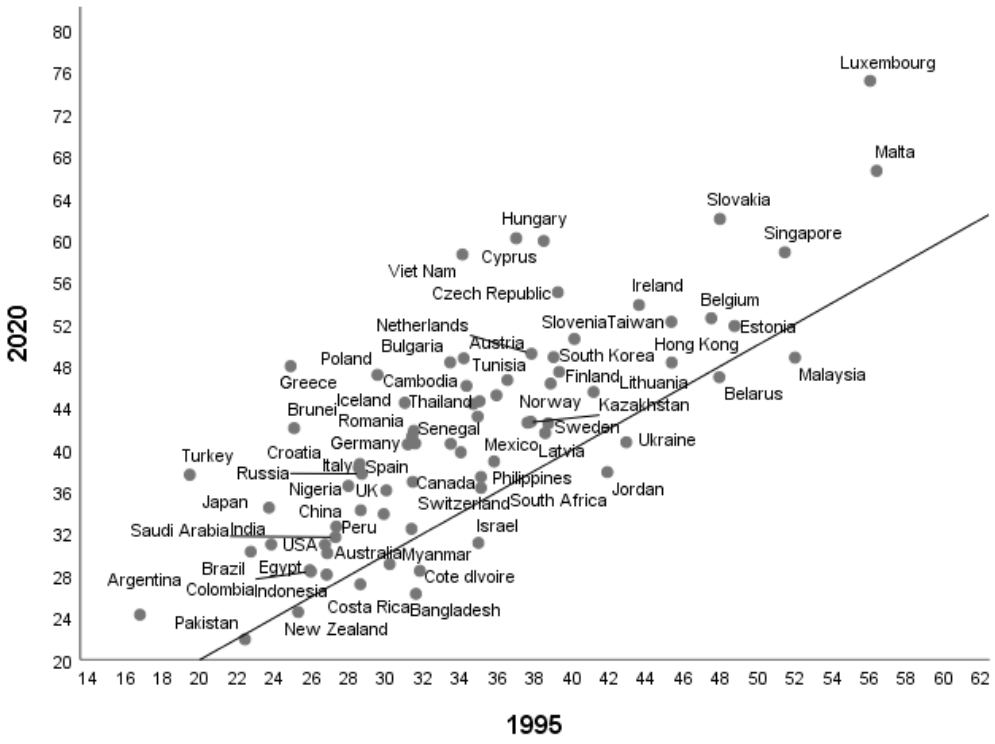
Figure 5.1. GVC trade and participation, 1995-2020, trillion USD and %



Source: Own composition from WITS (2023) data (based on TIVA).

The deceleration of GVC participation, however, highly differed across countries and sectors. As evident from Figure 5.2, the decline after 2008 was higher for developing economies, and lesser to developed economies. On the contrary, most advanced economies have maintained a steady engagement in global supply chains. In other words, most developed countries have maintained a continuous engagement in GVCs.

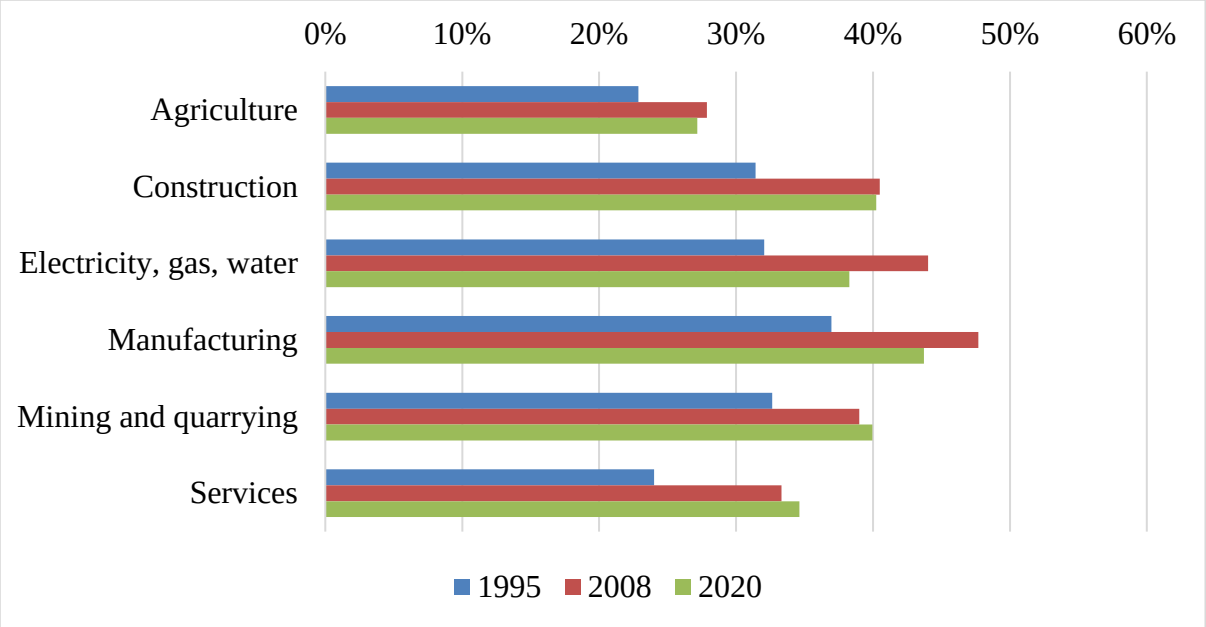
Figure 5.2. Global GVC participation rates for all sectors, 1995 and 2020, percentage



Source: WITS (2023) data visualisation (based on TIVA).

As to a sectoral breakdown, stagnation in GVC participation after 2008 is evident for all sectors (Figure 5.3.). Agriculture had the lowest GVC participation rates in 1995-2020, but this sector seems to have remained the most resilient after several economic shocks. Manufacturing and the electricity, gas and water sectors were most involved in cross-country value added trade in the period analysed, however, backdrops are the highest here as well. Services, mining and construction sectors appear to have been the most resilient ones. As one can imagine, these "slowbalisation" trends have just increased after 2020 (ECB, 2022).

Figure 5.3. Global GVC participation rates, 1995 and 2020, percentage

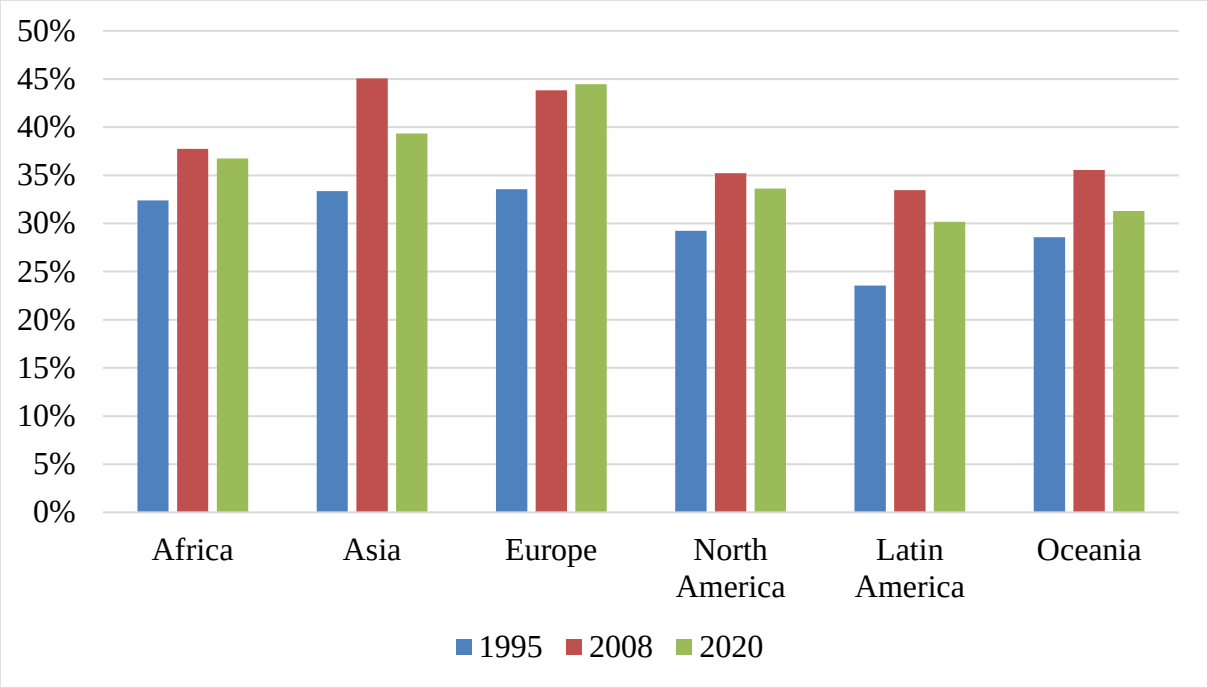


Source: WITS (2023) data visualisation (based on TIVA).

In line with the above trend, GVC production length (the average number of production stages between primary inputs and final products) has also shortened, indicating decreasing number of border crossings. This is fully in line with the rise of protectionism, the substitution of domestically produced intermediate inputs for imported ones in major emerging economies like China, together with the upgrading of their industries, and the deepening domestic division of labour in developed economies like the United States (WB, 2017).

Supply chains have retained a strong regional component over time (Figure 5.4). GVC participation was the highest in Asia and Europe in all years analysed, while it was the lowest in the Americas. Although there was a continuous rise from 1995 to 2008 (and then a fall from 2008 to 2020) in GVC participation in all regions analysed, the driving forces of such changes have been different. For Europe and Asia, GVC participation has changed mainly due to stronger links within the region itself, while extra-regional linkages were predominant for most developing countries. Although regional results also vary by country and sector, it is evident from our background calculations that 8 out of the top 10 highest GVC participation rates globally pertained to European countries in 2020.

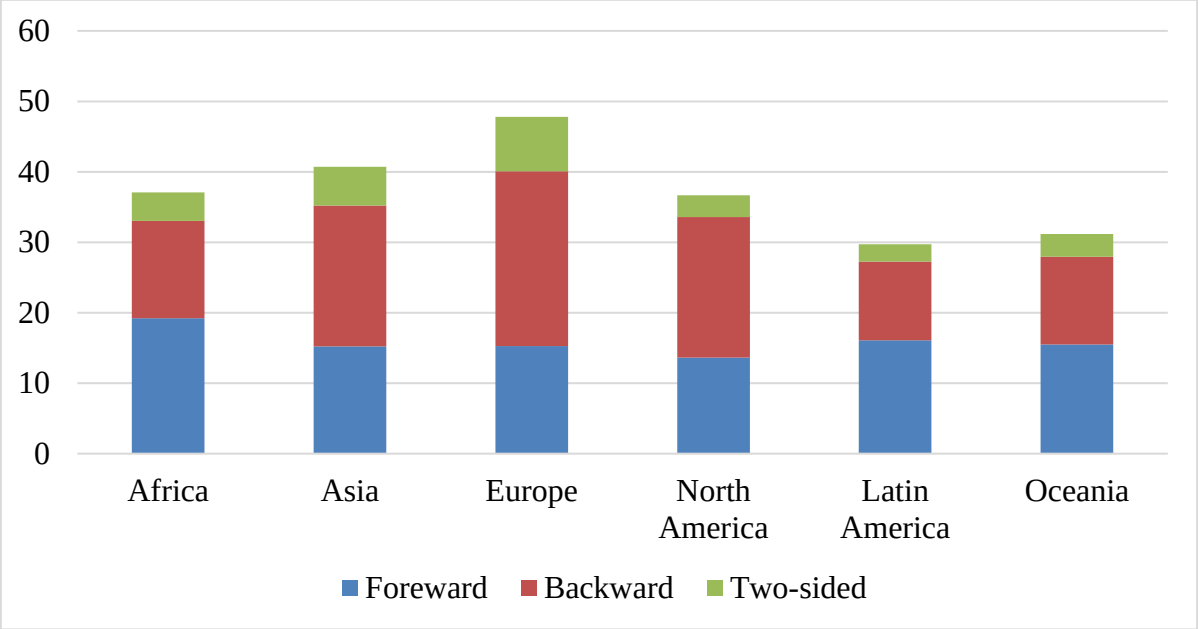
Figure 5.4. GVC participation by region, 1995-2020, (%)



Source: WITS (2023) data visualisation (based on TIVA).

The extent of engagement in GVCs significantly differs across countries. Figure 5.5. shows the backward (upstream) and forward (downstream) linkages of regions analysed in 2020. On the one hand, forward participation seems to dominate Africa, Latin America and Oceania, suggesting higher domestically produced value added. On the other hand, Asia, Europe and North America, backward participation dominated GVC trade, implying higher shares of foreign value added in gross exports. All this seems to be in line with experiences written so far (ECB, 2022; OECD, 2019).

Figure 5.5. Forward and backward participation by region, 2020, %



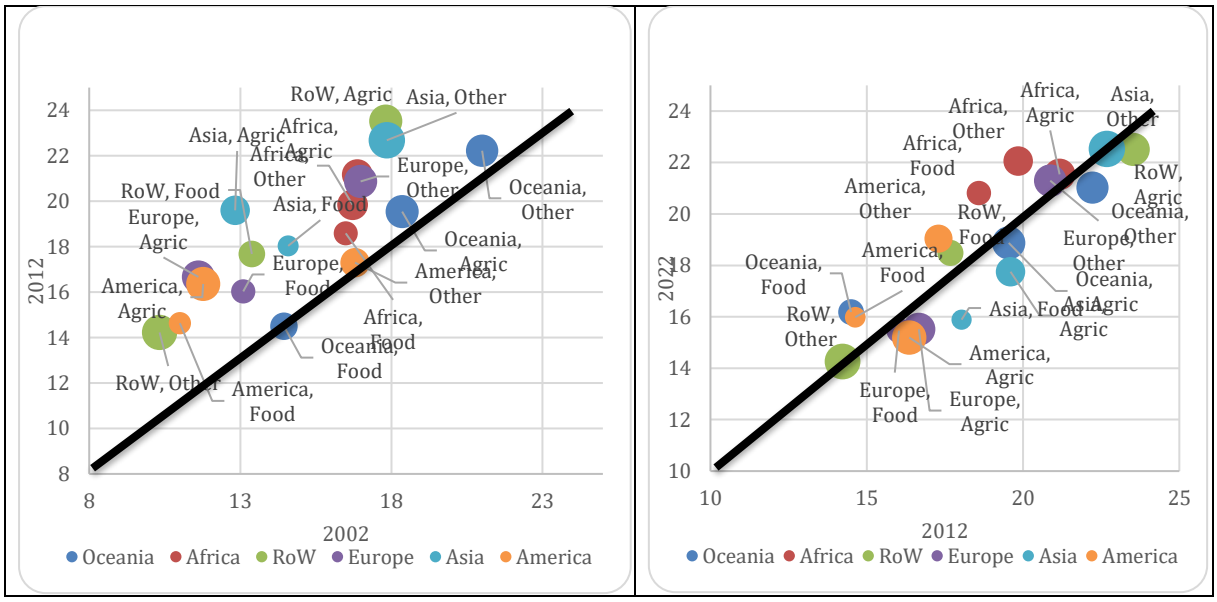
Source: WITS (2023) data visualisation (based on TIVA).

6 The complex structure of agri-food GVCs

After giving an overview of the recent trend in GVC, Chapter 6 goes further and deeper and identifies the complex structure of agri-food GVCs at the regional/country and product group levels. Compared to the previous chapter, here we just concentrate on agri-food value chains. In doing so, building on the Exiobase dataset, we have identified regional and three industry groups: Africa, America, Asia, Europe, Oceania and Rest of the World as well as agriculture, food and other products.

Figure 6.1. echoes Figure 5.2. and shows the change from hyperglobalisation to slowbalisation, indicated by the GVC participation rate, by regions and sectors, simultaneously. From 2002 to 2012, Figure 6.1. indicates that GVC participation increased from 2002 to 2012 in all industries of all regions. In 2002, GVC participation was the largest in Oceania's other industry (21.0%), followed by the agricultural sector of Oceania (18,4%) and the other industry of Asia (17.8%). The smallest GVC participation was measured in the agricultural industry of the EU (11.6%), the food sector of America (11.0%) and the other industry of the Rest of the World (10.3%). As for the value added (size of the circles), the other industry of the Rest of the World (64,0%), the other sector of Asia (61.5%) and the agricultural industry of America (56.7%) had the highest values. The smallest added values (between 26.7% and 36.0%) occurred in the food sector for all regions. In 2012, GVC participation was the highest in RoW's agricultural industry (23.5%,), followed by the other industry of Asia (22.7%) and Oceania (22.6%). The smallest GVC participation was measured in the food sector of America (14.6%) and Oceania (14.5%) and the other industry of RoW (14.2%).

Figure 6.1. Global GVC participation rates by region and industry pairs, 2002-2022, percentage



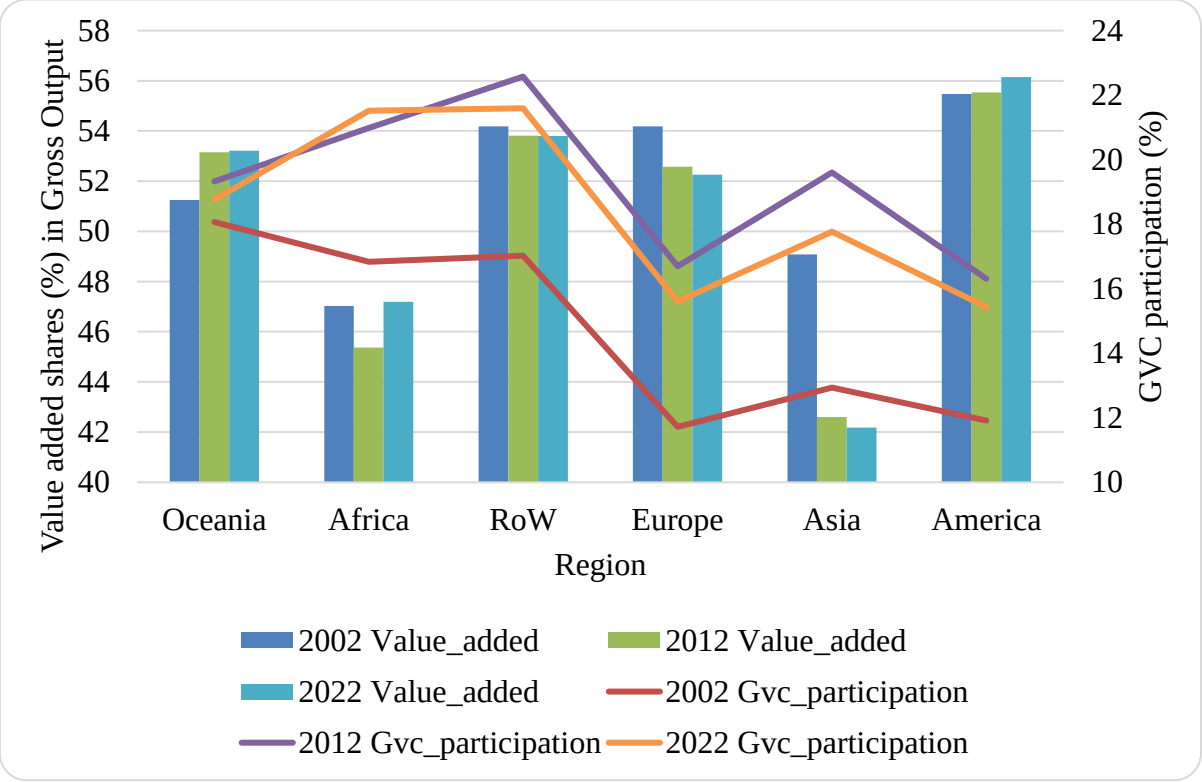
Source: own composition based on Stadler et al. (2022).

In 2022, GVC participation was the largest in the other industry of Asia (22.5%) and Africa (22.1%), and in the agricultural sector of RoW (22.5%). The smallest GVC participation was

measured in the industries of Ameria and Europe. Compared to 2012, on average, GVC participation decreased, except for Africa. As for the added value, similar to 2012, the other industry of Asia (64,6%) and RoW (62.4%) and the agricultural industry of America (57.8%) had the highest added value, the latter also slightly increased. In 2022, similar to 2002 and 2012, the smallest added values (between 15.9% and 18.5%) occurred in the food sector for all regions, values dropped significantly, often by more than 50%.

Supply chains have retained a strong regional component over time (Figure 6.2.). Agri-food GVC participation was the highest in 2022 in Africa and the Rest of the World, while it was the lowest in Europe and America. Although there was a continuous rise from 2002 to 2012 (and then a fall from 2012 to 2022) in GVC participation in all regions analysed, the driving forces of such changes have been different. For Europe and America, agri-food GVC participation has changed mainly due to stronger links within the region itself, while extra-regional linkages were predominant for most developing countries. Moreover, in terms of value added shares, the restructuring of global value chains in Asia is clearly observable.

Figure 6.2. Trends in production activities as a share of value added, by type of value added creation activity and region, 2002-2022

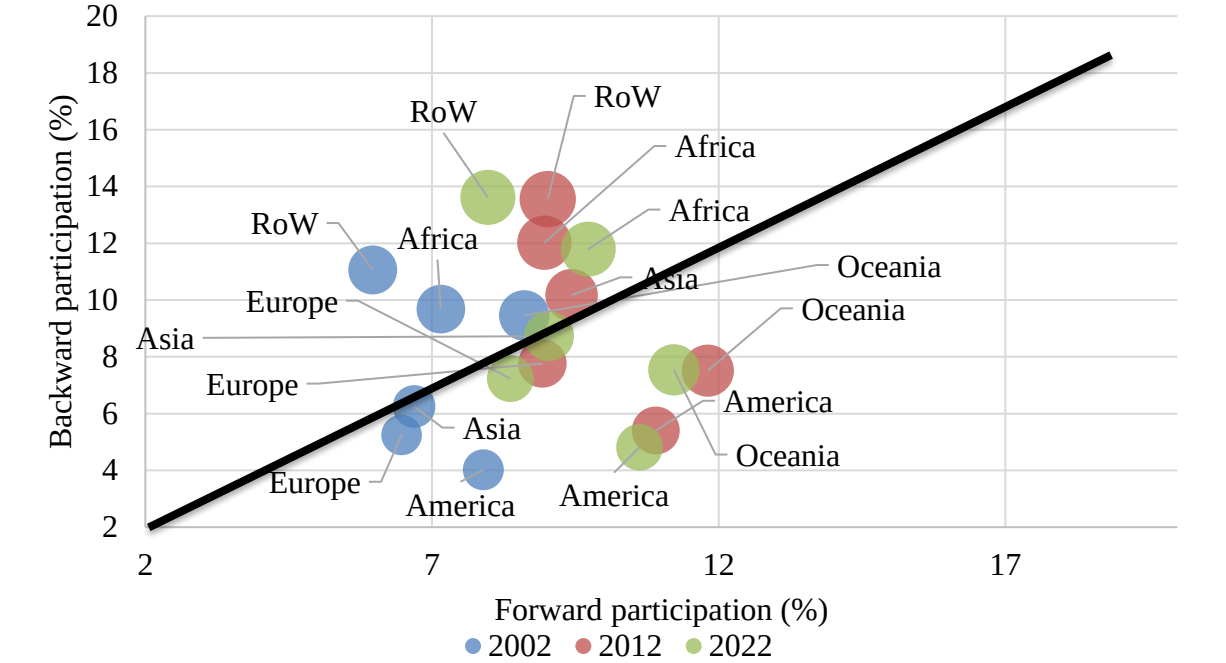


Source: own composition based on Stadler et al. (2022).

The extent of engagement in agri-food GVCs significantly differs across countries. Figure 6.3. shows the backward (upstream) and forward (downstream) linkages of regions analysed in 2002-2022. On the one hand, there has been a sharp increase in forward participation for Europe, America and Oceania, suggesting that their domestically produced agri-food value added was increased. On the other hand, Africa and the Rest of the World have experienced an increase in backward participation during the last two decades, implying growing shares of

foreign value added in gross exports. All this seems to be in line with the "slowbalisation" trends described above. The role of Asia in this regard seems to have remained constant.

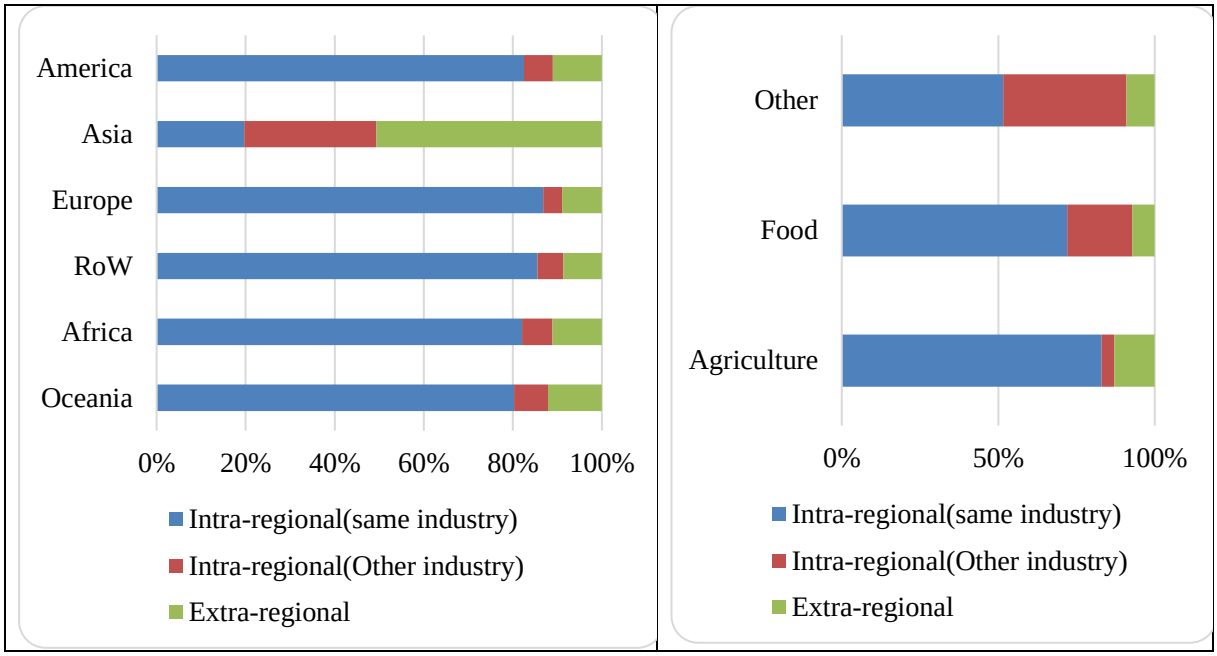
Figure 6.3. Forward and backward participation by region, 2002-2022



Source: own composition based on Stadler et al. (2022).

Figure 6.4 goes more into detail and shows the decomposition of agri-food value added as a share of gross exports by region and product. All regions except Asia seems to have had their highest value added exported to intra-regional markets, while Asia mainly added value through trade in external markets in 2022. At the product level, agriculture sectors seem to have had the highest intra-regional content of value added in gross exports, while other products had the lowest. Combining the two, our background calculations for the Asian case reveal that intra-regional trade was the highest in food and other industries, while the lowest in agriculture.

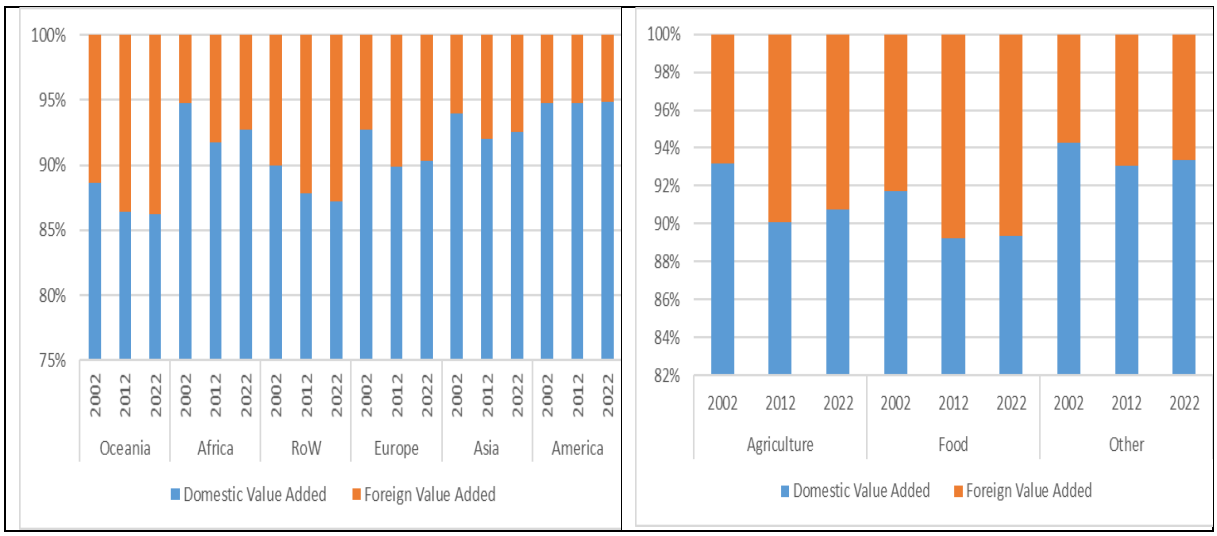
Figure 6.4. Decomposition of agri-food value added shares of gross exports by region any product, 2022



Source: own composition based on Stadler et al. (2022).

Figure 6.5. shows another evidence for changes in the composition of gross agri-food exports. Following Koopman et al. (2011), gross exports can be decomposed to two main value added components based on the location of value added creation and its purpose: foreign value added embedded in gross exports (backward linkages) and domestic value added in exports. The latter part can further be decomposed into exports that are further used as intermediate inputs (forward linkages). Domestic value added seems to have decreased for all regions and industries analysed.

Figure 6.5. Further decomposition of agri-food value added shares of gross exports by region any product, 2002-2022

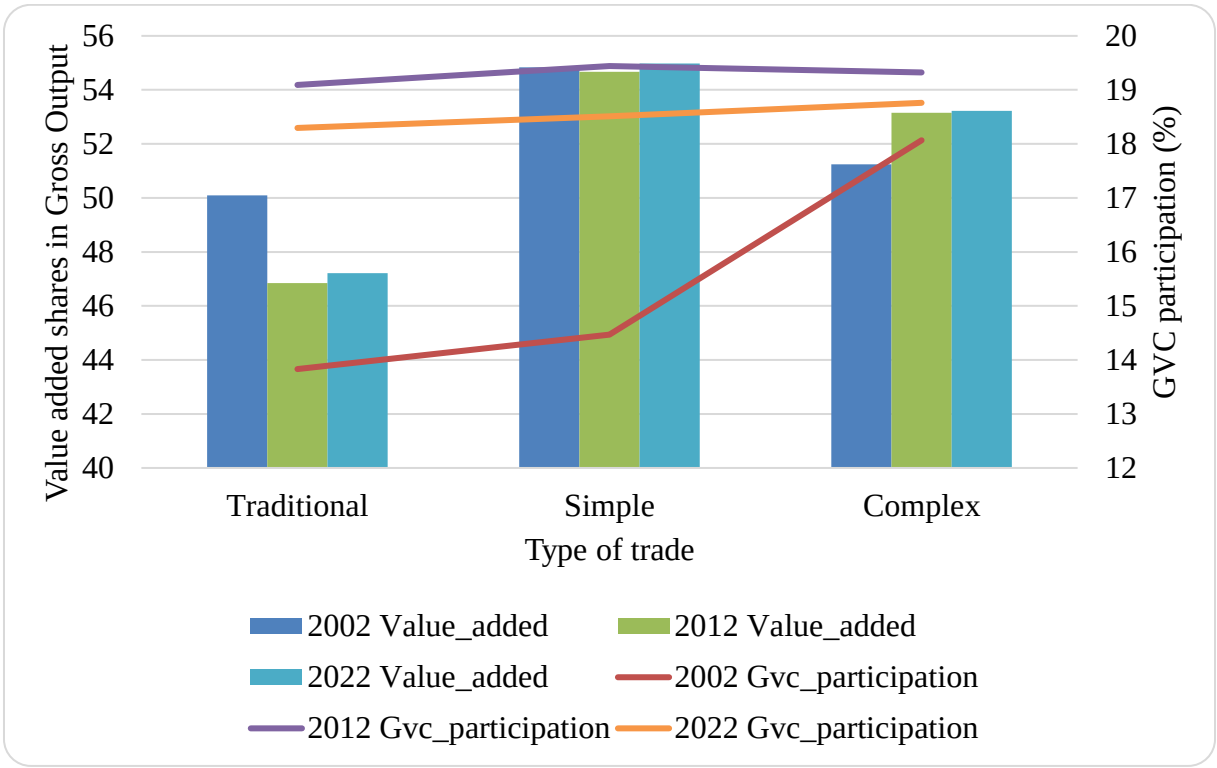


Source: own composition based on Stadler et al. (2022).

Going more into details, the Word Bank (2017) suggests that a country's GDP by industry can be decomposed into four types based on cross-border production sharing activities: pure domestic production, classic trade, simple GVCs and complex GVCs. On the one hand, pure domestic production and tradition trade categories contain no cross-country production sharing, classified as pure domestic production. On the other hand, simple GVCs contain simple cross-border production sharing activities but with only one border crossing, while complex GVCs contain at least two border crossings.

Globally, the share of both types of cross-border production sharing GVC activities stagnated, while the shares of traditional value added creation activities have decreased in value added creation (Figure 6.6). As for GVC participation, an increase can be seen in the case of the simple (13.8% and 18.1%) and traditional (18.3% and 18.8%) case from 2002 to 2022, while a slight decrease (19.4% and 19.3%) can be seen in the case of complex GVCs from 2012 to 2022. All GVC participation rates decreased in all cases from 2012 to 2022.

Figure 6.6. Trends in agri-food production activities as a share of value added, by type of value added creation activity, 2002-2022

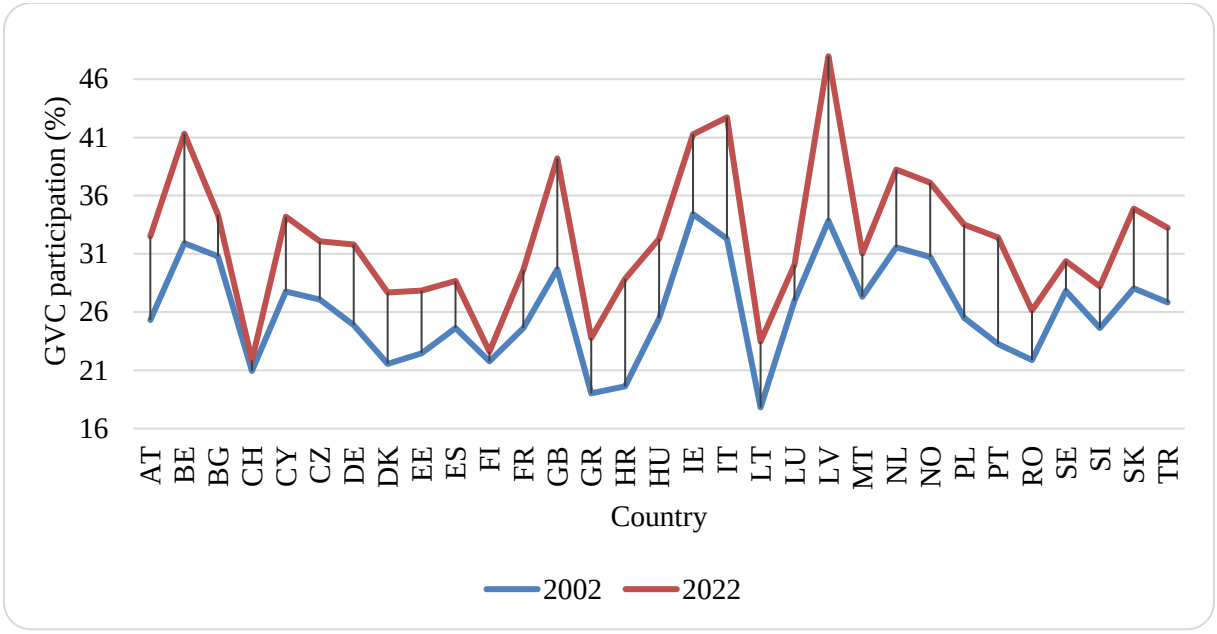


Source: own composition based on Stadler et al. (2022).

Country level differences in agri-food GVC participation shades the overall picture further (Figure 6.7 and Figure 6.8). For Europe, Ireland and Italy (34%) as well as Latvia (32%) had the highest GVC participation rates in 2002, while Lithuania (18%), Greece (19%) and Croatia (20%) had the lowest. The biggest increase in GVC participation from 2002 to 2022 is observable for Latvia (50%), while Switzerland could not increase its GVC participation in the period analysed.

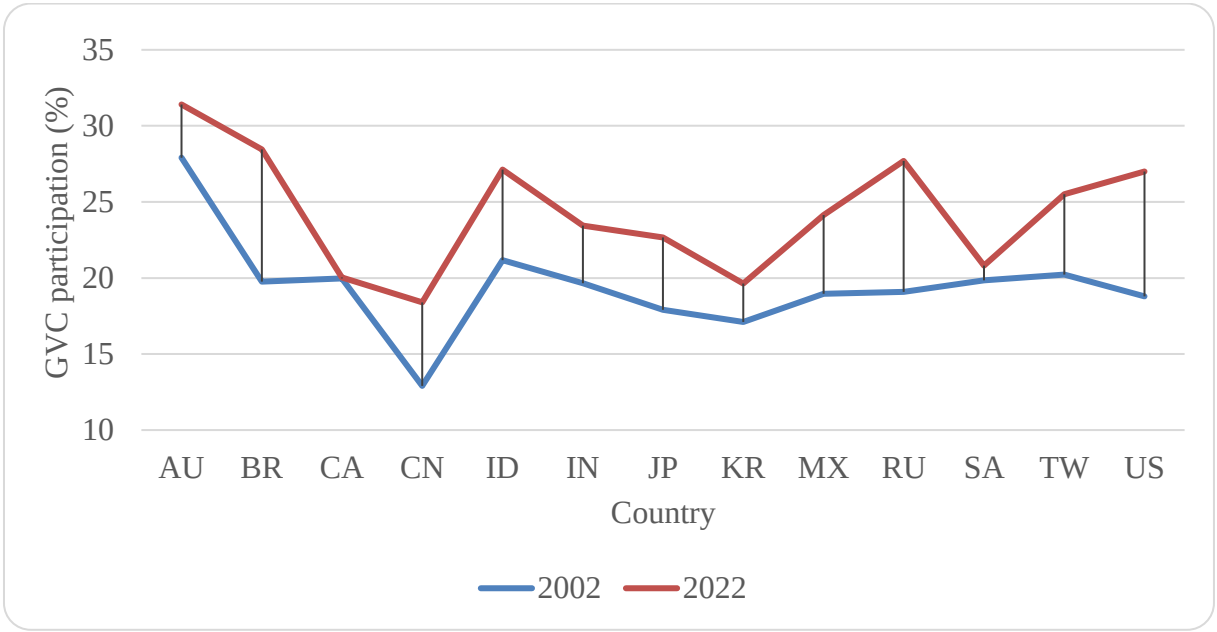
Non-European countries appear to have generally lower but more stable agri-food GVC participation rates in the period analysed (Figure 6.8.). Australia had the highest rate in both years, while China the lowest, with slight increases over the two decades.

Figure 6.7. Changes in agri-food GVC participation by country in Europe, 2002-2022, (%)



Source: own composition based on Stadler et al. (2022).

Figure 6.8. Changes in agri-food GVC participation by country outside Europe, 2002-2022, (%)



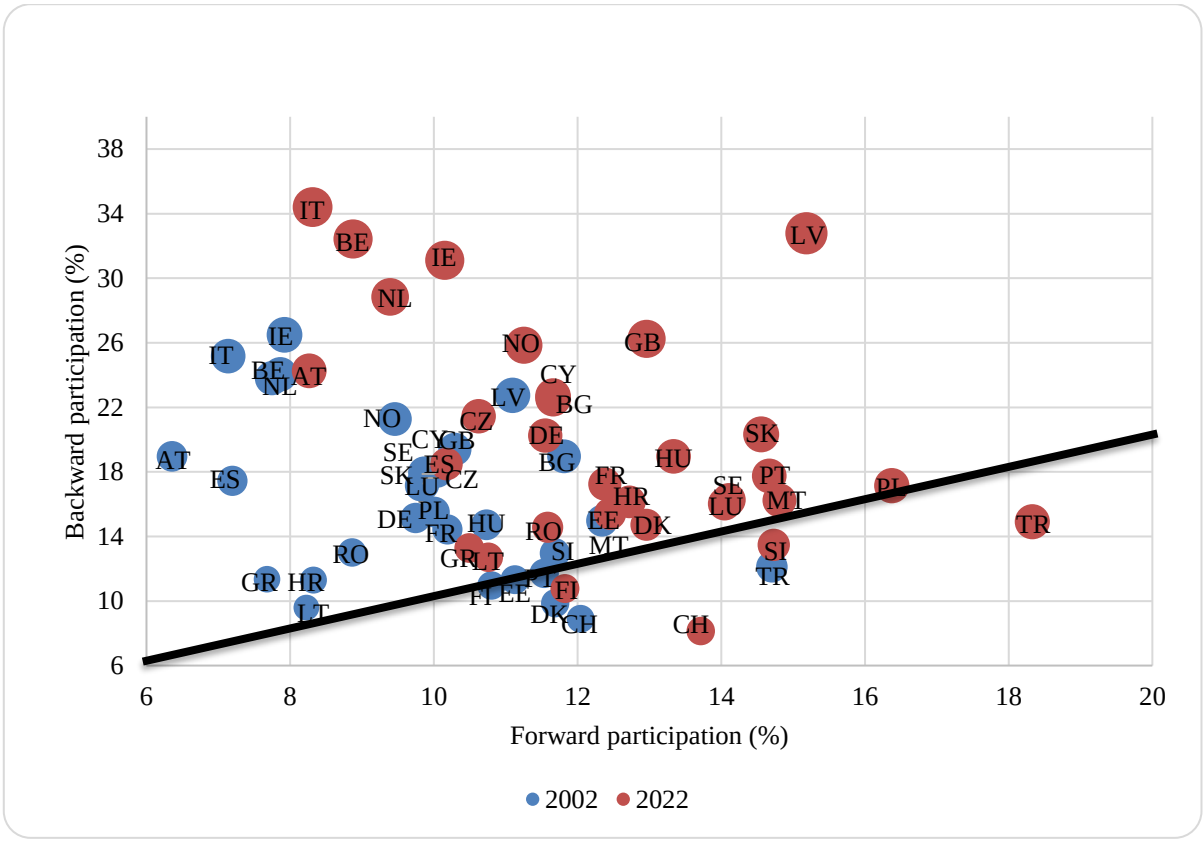
Source: own composition based on Stadler et al. (2022).

Going more into detail, Figure 6.9. and Figure 6.10. shows forward and backward participation changes for agriculture by country inside and outside Europe. Forward participation increased

from 2002 to 2022 just in a few cases among which Turkey experienced the highest growth, while backward participation grew the most for Latvia. According to our background calculations, Latvia's increase in backward participation was mainly driven by crop and animal processing, while Turkey's forward participation growth was mainly driven by animal production.

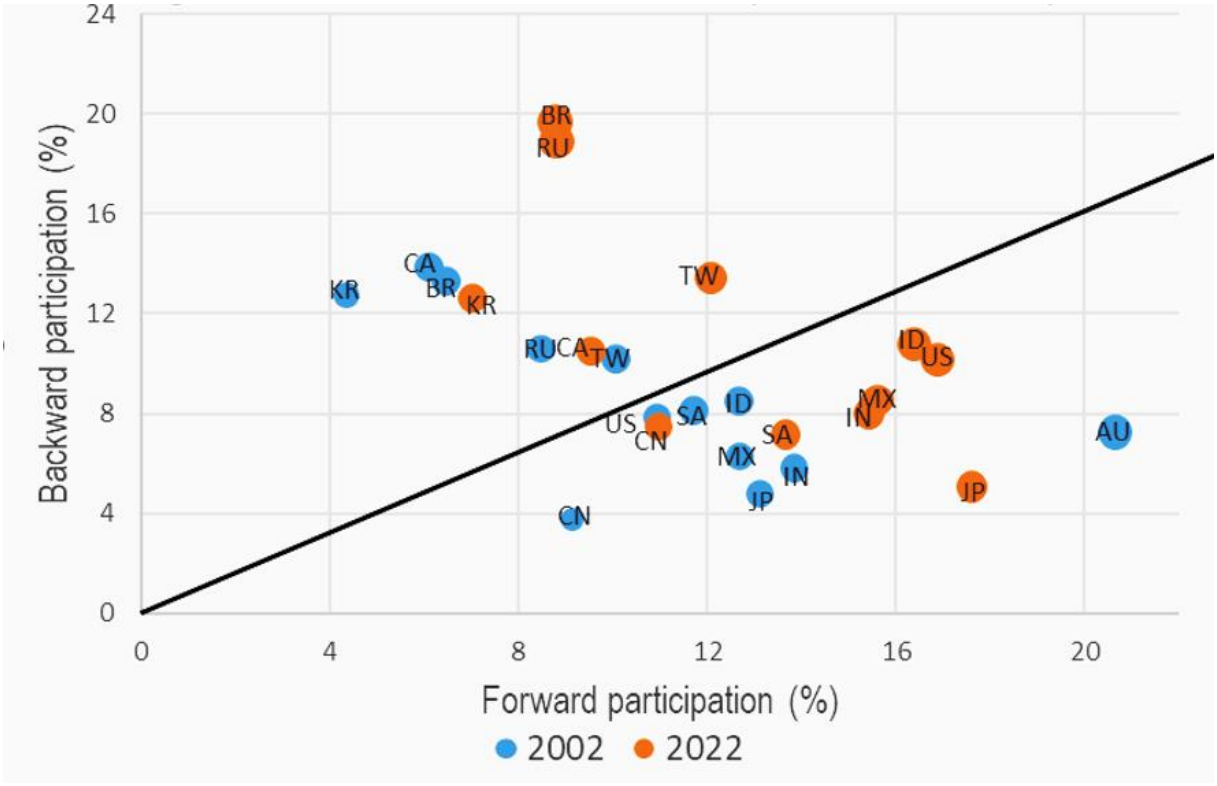
In non-European countries, Russia experienced the highest increase in backward participation, driven by processing, while China in forward participation, driven by raw material production, in their agriculture sectors.

Figure 6.9. Forward and backward participation in European agriculture by country, 2002-2022 (%)



Source: own composition based on Stadler et al. (2022).

Figure 6.10. Forward and backward participation in agriculture outside Europe by country, 2002-2022, (%)

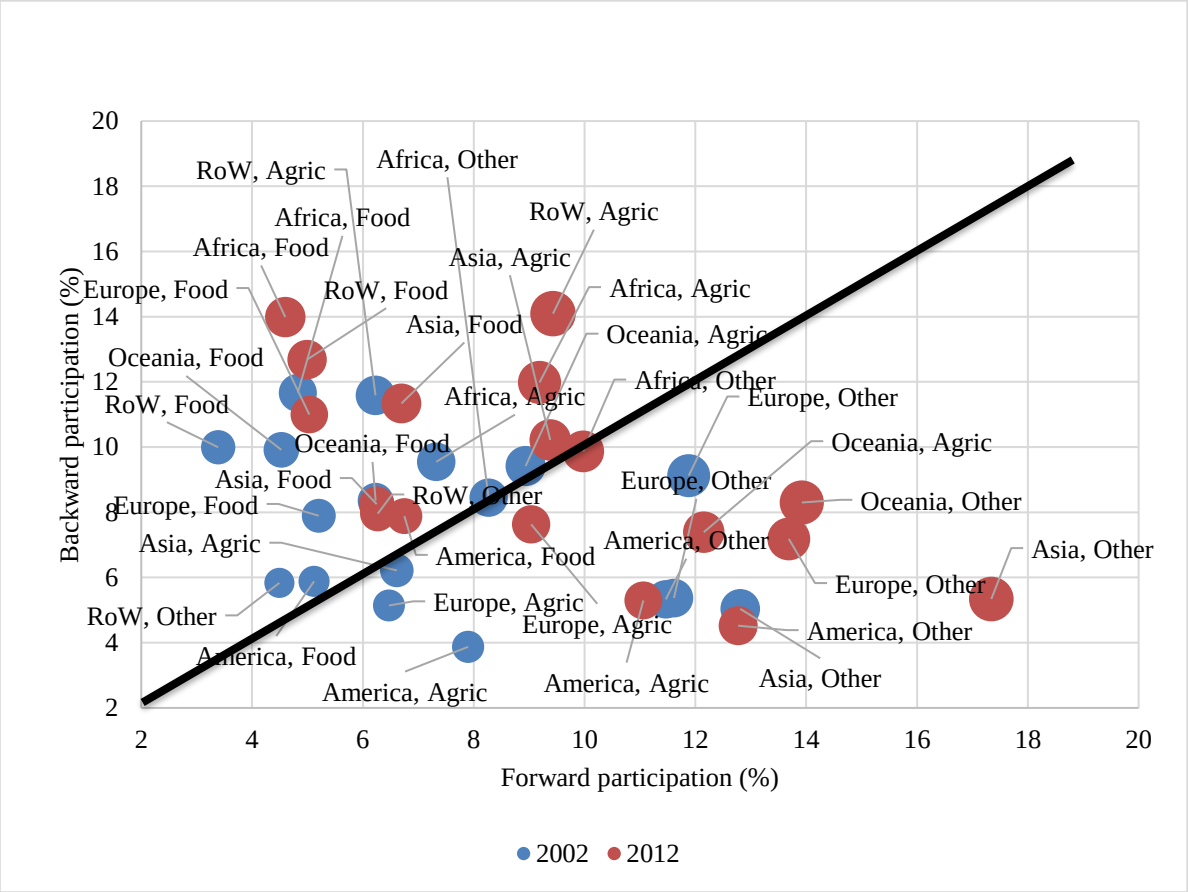


Source: own composition based on Stadler et al. (2022).

The extent of engagement in GVCs also significantly differs across countries and industries. Figure 6.11. shows the backward (upstream) and forward (downstream) linkages of region-industry pairs analysed in 2002-2012, while Figure 6.12. shows the same for 2012-2022.

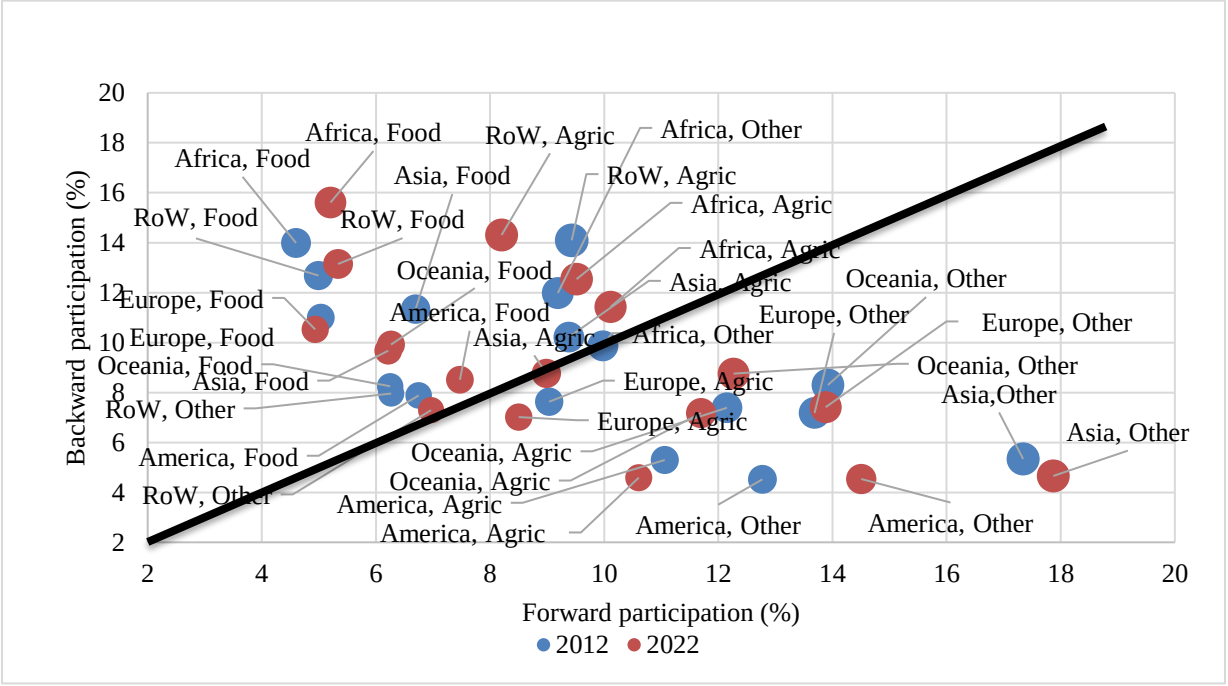
In line with Figure 5.5, there has been a sharp increase from 2002 to 2012 in forward participation of agriculture and food industries in Europe, America, Asia and Oceania, suggesting that their domestically produced value added was increased. On the other hand, Oceanian agriculture, African food, European food, Asian agriculture and food, as well as RoW food and other industries increased their backward participations, implying growing shares of foreign value added in gross exports. From 2012 to 2022, forward participation trends seem to have continued expect for some agriculture and food industries where backward participation increased. All this seems to strengthen the "slowbalisation" arguments described above.

Figure 6.11. Forward and backward agri-food participation by region and industry pairs, 2002-2012



Source: own composition based on Stadler et al. (2022).

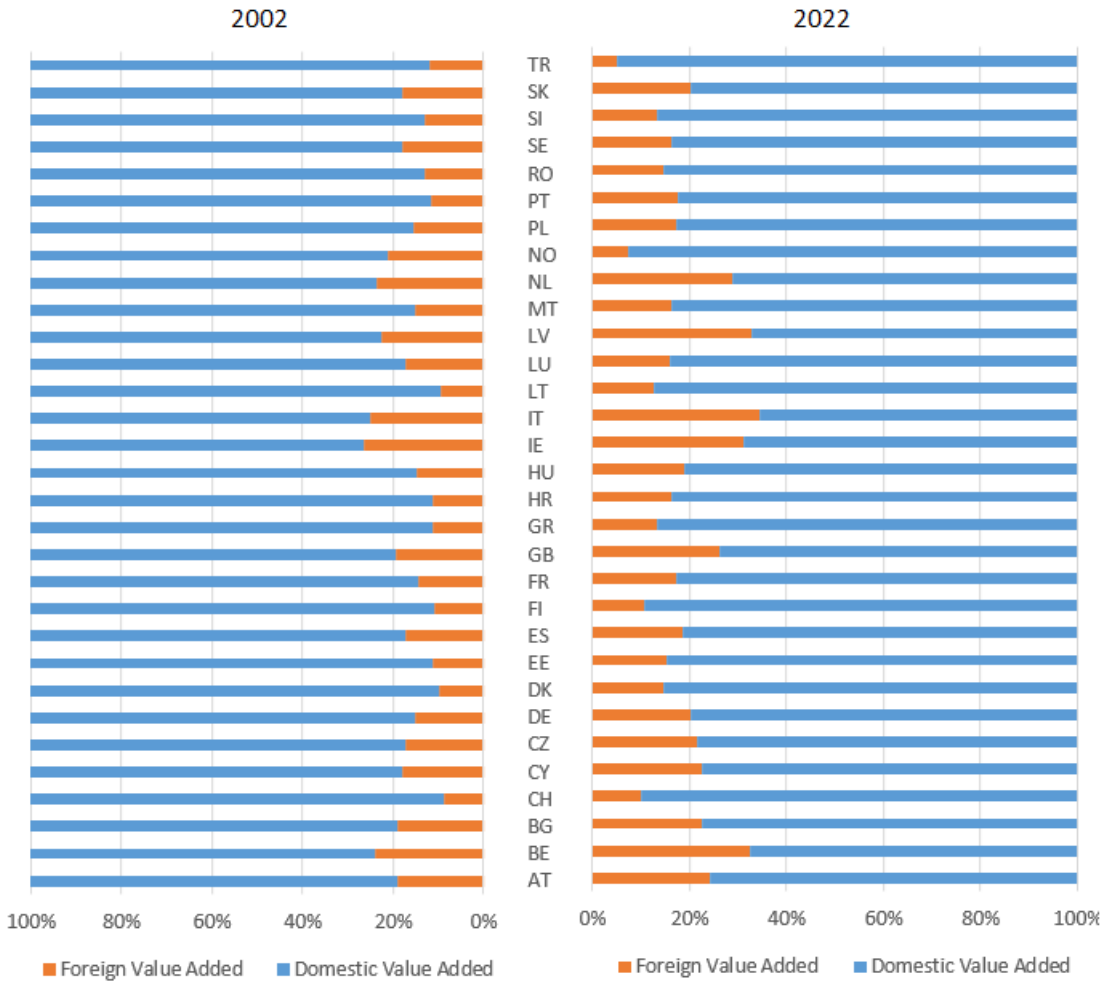
Figure 6.12. Forward and backward agri-food participation by region and industry pairs, 2012-2022



Source: own composition based on Stadler et al. (2022).

Figure 6.13. shows further evidence for changes in the composition of gross exports, Most European countries rely on domestic value added (shares were above 60% in 2002), indicating that they may have more control over their production processes and are less vulnerable to external factors. These patterns have not changed significantly by 2022, except in Italy, Latvia, Belgium, the Netherlands, and Austria, where foreign value added increased, in line with their changes in GVC participation as indicated above. As to DVA/FVA changes outside Europe, only Taiwan and China had more than 20% of FVA in 2022, starting from 10% and 4% in 2002, respectively.

Figure 6.13. Further decomposition of agri-food value added shares of gross exports by European countries, 2002-2022

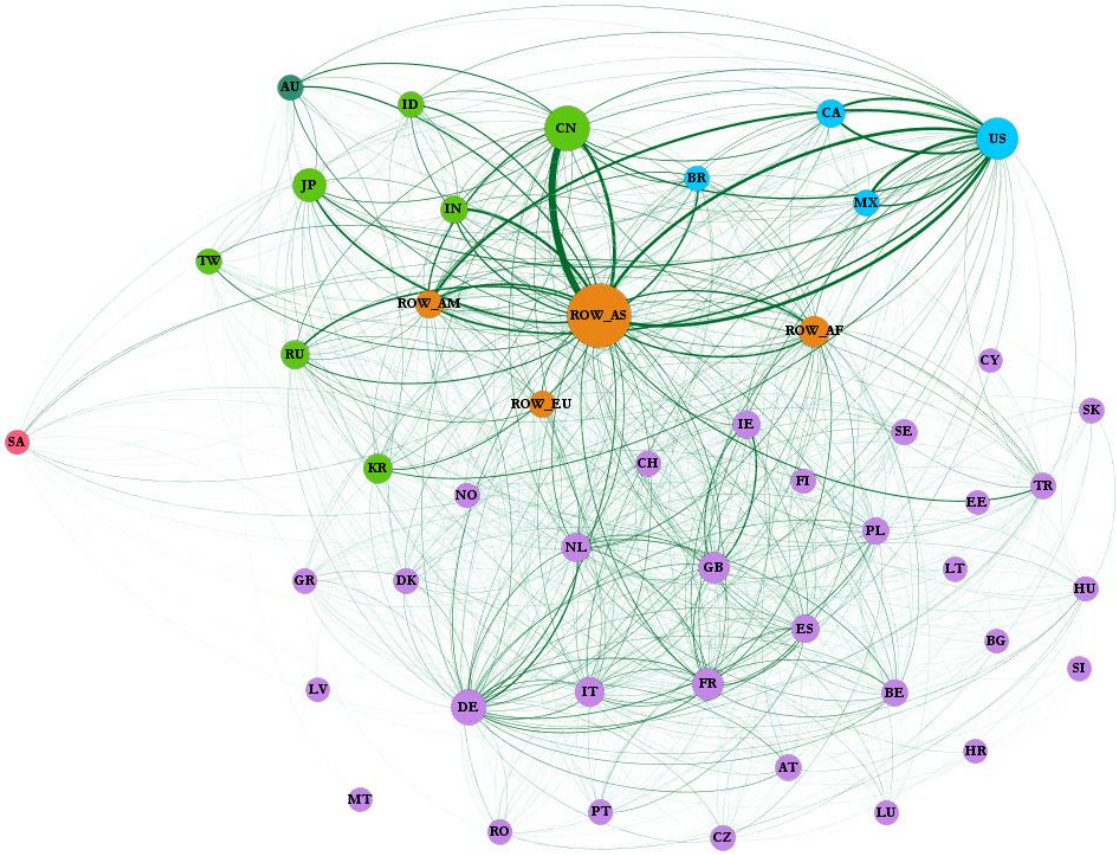


Source: own composition based on Stadler et al. (2022).

As a last step, network analysis tools were applied to the major value chains to better understand the dynamics of agri-food trade behind. Bubble charts below allow to see the centrality of countries in different value chains. All bubbles stand for a country/region, while arrows show a specific trade relationship. The thickness of bubbles depends on the magnitude of trade relationships (with PageRank method), while thickness of arrows depends on the magnitude of exports. If a country trades with a central player, its importance will also increase.

As evident from Figure 6.14, the most important agri-food market players are Asian economies, China, USA, Germany and the UK. On the one hand, these countries are major producers of agricultural products and export them, and on the other hand, these countries process many agricultural products directed towards them. In bilateral terms, relationships are the strongest between USA, Mexico and Canada, showing the power of their free trade agreements.

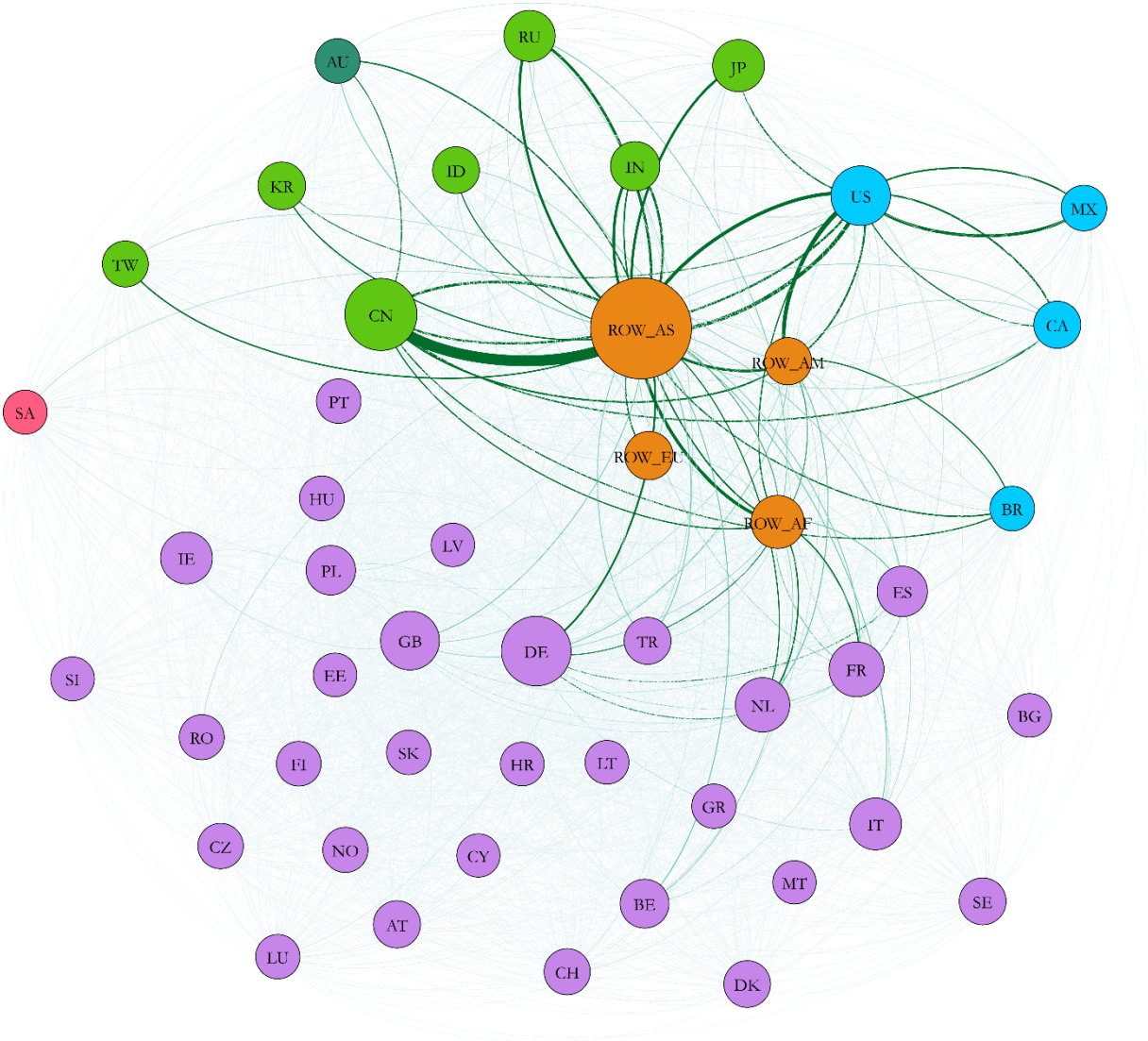
Figure 6.14. Network of gross export flows for agriculture as a whole



Source: own composition based on Stadler et al. (2022).

Figure 6.15. shows a similar network for gross exports in crop products. China takes the central role here with trading the most with other East Asian countries. The relationship between USA, Canada and Mexico is also strong here together with strong ties to China as well. In Europe, Germany, France and the Netherland seem to take a major role. Our results are in line with OECD (2019) arguments showing that cereals trade seem to be more global with lots of actors, where external shocks might not have such strong impacts. One reason behind is the characteristics of cereals as commodities easy to store, transport and trade. The 5 most significant importers with respect to just countries are Germany, Italy, UK, France, China. The 5 biggest exporters are Germany, Netherland, France, Italy and Estonia so we can see that the biggest importers and exporters are from Europe. With respect to regions, Rest of Asia and Africa are the two most significant importers and exporters as well. Regarding both export and import relationships and also the amount of trade, the United States, China and Germany play the most important part in the trade of agricultural products. When investigating the betweenness of the countries we can observe that the rest of EU and Africa always appear on the shortest path between two trades, so the trades generally flow through these regions.

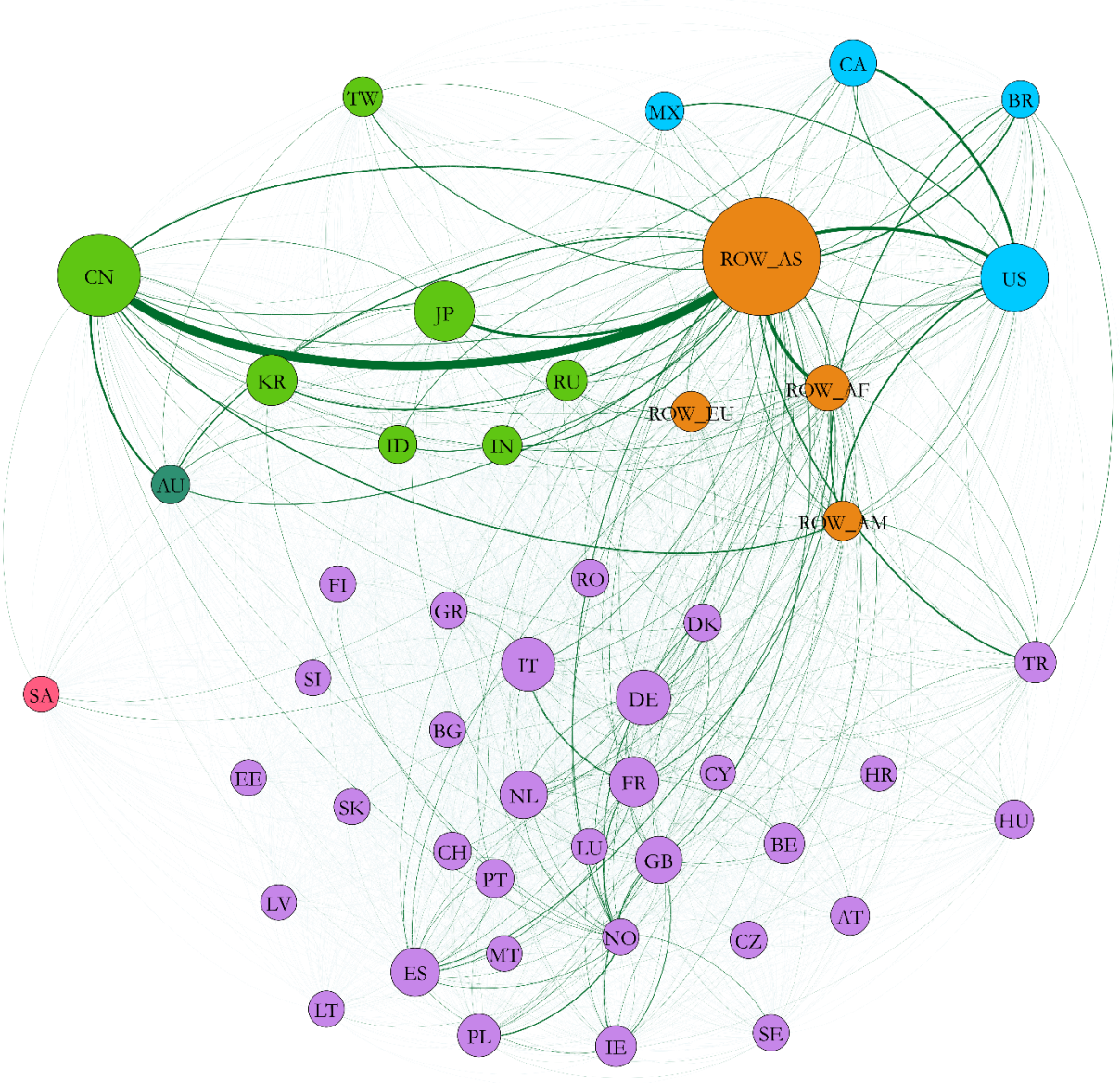
Figure 6.15. Network of gross export flows for crop products



Source: own composition based on Stadler et al. (2022).

Figure 6.16. depicts trade flows for animal products, retaining the Asian dominance with China, Japan and other Asian countries trading with North America and Europe mainly. Brazil appears to have an important role here, most probably via its increasing soya trade, as well as Turkey. The 5 most significant importers with respect to just countries are the United States, China, Germany, Japan, India. The 5 biggest exporters are the United States, Russia, France, Brazil and Canada so we can see that the greatest importers and exporters are from all over the world. With respect to regions, Rest of Asia and America are the two most significant importers and exporters as well. Regarding both export and import relationships and also the amount of trade, the United States, China and Germany play the most important part in the trade of crop products. When investigating the betweenness of the countries we can observe an interesting phenomenon. Some EU countries like Ireland, Luxembourg and Malta always appear on the shortest path between two trades, so these are the most important transit countries connecting different areas of the world.

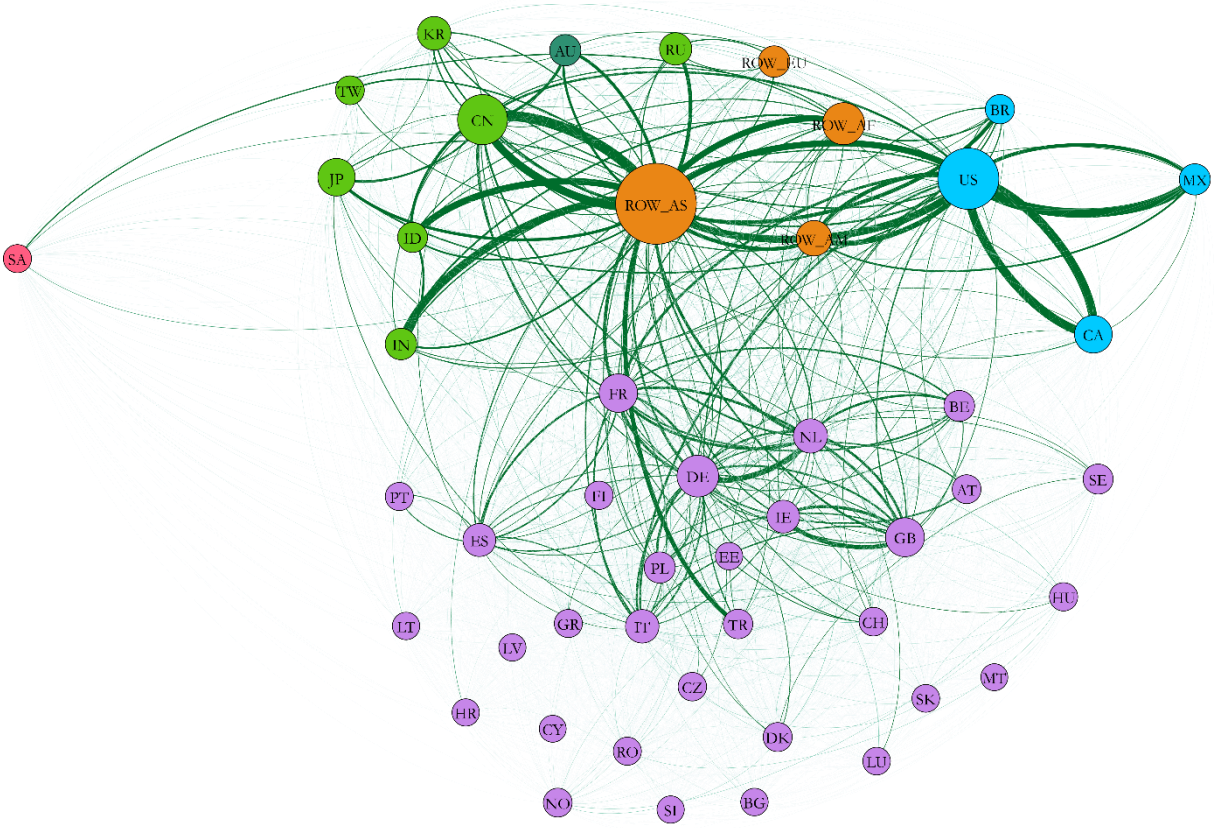
Figure 6.16. Network of gross export flows for animal products



Source: own composition based on Stadler et al. (2022).

The overall picture changes for plant (Figure 6.17) and animal processing (Figure 6.18) compared to crop and animal products with respect to the magnitude of the trade flows. Several differences can be observed and there are more and stronger relationships between countries. USA takes the central role from China in plant processing with strong ties to Asian economies and North America. European countries, especially Denmark, Netherland, France play a more important role in plant-based processing trade. Turkey also has strong ties with the rest of Asia. The 5 most significant importers are China, the United States, Japan, Italy, France. The 5 biggest exporters are Norway, Australia, Canada, Brazil, France. With respect to regions, Rest of Asia and Africa are the two most significant importers and exporters as well. Regarding both export and import relationships and also the amount of trade, China is the first, the United States is the second and Norway is the third most important county in the trade of animal products. When investigating the betweenness of the countries we can observe that some EU countries like Ireland, Malta and Norway play the most important role as transit countries.

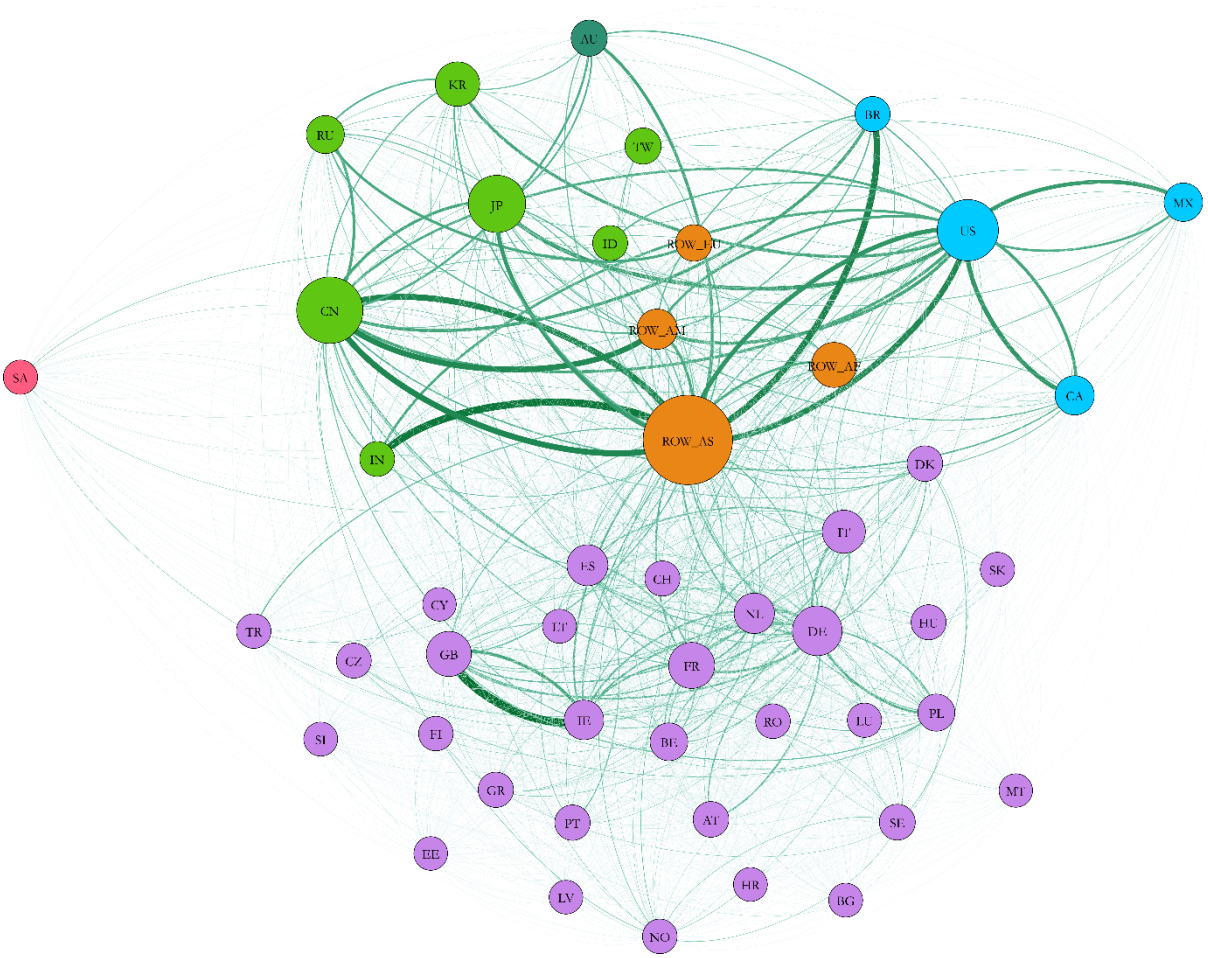
Figure 6.17. Network of gross export flows for plant processing



Source: own composition based on Stadler et al. (2022).

The overall picture remains the same for plant processing (Figure 6.17) and animal processing (Figure 6.18), though the magnitude to trade flows differs by country. For animal processing, we see the remaining role of China, Asia and the US with also important roles for Brazil. The UK and Ireland has stronger relationships in animal processing while the most of Europe has weaker ties to other parts of the world. The 5 most significant importers are China, the United States, Germany, UK and France. The 5 biggest exporters are the United States, Netherland, Germany, France and China, hence Europe plays an important role in exporting processed plant products throughout these 3 major countries. With respect to regions, Rest of Asia and America are the two most dominant importers and exporters as well. Regarding both export and import relationships and also the magnitude of trade, US is the first, Germany is the second and China is the third most important county in the trade of plant based processing. When investigating the betweenness of the countries we can also observe (just like in case of crop products) that Ireland, Luxembourg and Malta are the most dominant transit countries in Europe.

Figure 6.18. Network of gross export flows for animal processing



Source: own composition based on Stadler et al. (2022).

The overall picture of the network of animal processing shows a very active trade between all parts of the world with a greater magnitude. The 5 most significant importers are China, the United States, Japan, Germany, UK. The 5 biggest exporters are the United States, Germany, Ireland, China and Netherland. Apart from Germany, Europe is represented by two new countries, Ireland and Netherland. Regarding both export and import relationships and also the magnitude of trade, US is the first, China is the second and Germany is the third most important county in the trade of plant-based processing, but we have to mention Ireland as the fourth most important player. When investigating the betweenness of the countries, we can also observe (just like in case of plant processing) that Ireland, Luxembourg and Malta are the most dominant transit countries in Europe.

7 The future of GVCs

As evident from the above, GVCs are undergoing a fast transformation. After many decades of continuous growth, GVC participation has started to decline. Although their composition changes, GVCs remain highly complex and retain a strong regional dimension.

Reasons behind slowdown of GVC participation are numerous. Transportation costs are currently on the rise, making it more costly for companies to offshore production across the globe. COVID-19 and the associated border closures neither have helped this process. Moreover, what seems also be evident that several Asian economies have started to turn inward, especially due to global trade policy changes, COVID-19 related supply chain disruptions and the Russia-Ukraine war, reducing their reliance on imports. These trends seem to stay with us in the coming years, reshaping the future of GVCs globally.

After COVID-19, it has become evident that global supply chains are highly vulnerable to global risks, showing some spillovers magnifying the decline of global agri-food trade growth. Agri-food supply chains have proved to be highly resilient even in crisis years with their relatively complex and geographically sparse nature, though changes in the composition of global agri-food trade is still evident.

The evergreen debate around domestic food self-sufficiency has started to emerge due to processes described above. On the one hand, nationalistic governments claim that more localised production would provide greater security and lower uncertainty and dependency, calling for reshoring of GVCs. On the other hand, trade liberalists argue exactly the opposite, stating that reshoring exactly means greater reliance on own production, limiting the possibility to manage local/regional shocks. The low diversity of suppliers and buyers can also magnify the effects of such shocks, they say.

Recent trends of globally rising food and energy prices combined with serious effects of climate change on productivity calls for the need of more adaptation than ever. Digital technologies will surely play an important role in shaping the future of GVCs. It appears that the era of globalised GVCs is over and more regional and more complex GVCs will emerge in the upcoming years together with the reorganisation of global agri-food trade flows.

8 Conclusions

This deliverable provided a network analysis of global agri-food trade flows and reached a number of different conclusions.

- Based on the bibliometric review chapter, it seems that the importance of GVC participation is increasing with more authors, papers and citations dealing with the topic. Chinese, Italian and US authors are the most active with increasing number of collaborations among the continents.
- From the recent trend analysis, it turned out that due to consequent economic and financial crises, the world has entered into the era of "slowbalisation", suggesting that the pace of GVC participation growth has started to decline. This decline was higher for developing and lower for developed countries.
- It seems also evident from our analysis that GVCs have become more regional with shortened distances between different stages of production. Supply chains retain a strong regional component and GVC participation was the highest in Asia and Europe in all years analysed, while it was the lowest in the Americas. Agri-food GVC participation was the highest in 2022 in Africa and the Rest of the World, while it was the lowest in Europe and America.
- On the one hand, forward participation seems to dominate Africa, Latin America and Oceania, suggesting higher domestically produced value added. On the other hand, Asia, Europe and North America, backward participation dominated GVC trade, implying higher shares of foreign value added in gross exports.
- Agri-food sectors are among the most resilient ones to economic shocks and agriculture (raw materials) seems to have experienced the biggest GVC participation growth.
- GVC participation patterns appear to be highly country and product specific, also evident by backward and forward participation. Our network analysis echoes this complexity.

The deliverable serves as the basis for D1.5. providing a taxonomy of global agri-food value chains and a better understanding of the determinants of participation of developing countries in local and global agri-food value chains. Moreover, D1.4. also provides inputs to other WPs also working with and focusing on analysis of global trade patterns in various agri-food value chains.

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