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Can we increase the granularity in understanding global value chains? An integration of academic and practice perspectives to enhance future developments

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Abstract

Value chains are increasingly fragmented globally, and companies and governments struggle with understanding where value is added. Both scholars and practitioners developed models, but recent challenges are calling for original approaches to develop instruments to map and evaluate global value chains (GVCs) footprint.

We carried out a Structured Literature Review (SLR) to summarize the existing academic knowledge about GVCs mapping and also examined the related practitioners' materials. We then investigated what data sources are currently available to collect data about global trade flows, and involved practitioners in the discussion to collect insights that could improve the current understanding.

We aim at offering guidance in this process, highlighting what future directions should be pursued to increase the models' descriptive and explanatory power. For example, customs data is largely available. Original models could be developed, and GVCs could be studied leveraging rich and granular customs data rather than traditional macro-economic data.

Keywords: global value chain; structured literature review; customs; value chain mapping

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1. Introduction

Global operations have changed significantly in recent decades (Ferdows, 2018) and the rise of global value chains (GVCs) has revolutionized the way goods and services are exchanged worldwide (Gereffi and Lee, 2012; Cohen and Lee, 2020). Raw materials are supplied in some countries, while components are produced in others and later stages such assembly and distribution to final customers often overcome national borders (Amador and Cabral, 2014; Wieland et al., 2020). The fragmentation of production is not an unknown phenomenon (Gereffi, 1994), but the gradual liberalization and deregulation of international trade and investment, coupled with the rapid development and spread of IT technologies, have been increasing the GVCs geographical dispersion (Mudambi, 2007; Kano et al., 2020).

Policymakers around the world are thus looking for stronger policy evidence to examine the position of countries within international production networks (Johnson, 2018), as they are needed to define regulations in different areas (De Backer and Miroudot, 2014). The academic literature offers many contributions concerning the study of GVCs (e.g., Gereffi and Lee, 2012; Kano et al., 2020). However, one of the biggest challenges about GVCs is properly mapping their footprint to identify where (and how much) value is added (Escaith, 2014; Nielsen, 2018), because of the heterogeneity about statistical units, ownership structures, and business mechanisms to be considered (Gibbon et al., 2008; Gereffi and Lee, 2012). Existing frameworks allow for tracing the patterns of global production and linking geographically dispersed activities (e.g., Johnson and Noguera, 2012; Ferrarini, 2013; Los et al., 2015). They mostly focus on the sequence of the value-adding operations, offering high-level overviews of the macro-economic scenarios that characterize global trade (Miroudot and Nordstrom, 2020). But, companies and policymakers increasingly require more sophisticated instruments to answer questions about the changed global-local trade dynamics (Gereffi et al., 2005; Amador and Cabral, 2014).

Related academic reviews can be traced back to 2014 (Amador and Cabral, 2014), and this research aims at offering an updated overview of the available contributions to summarize the current state-of-the-art on the topic of GVCs mapping and measurement. The following Research Question (RQ) was developed: "*How to investigate trade across countries to formalize GVCs footprint?"*

To address this RQ, we adopted a two-step multi-method approach. First, we conducted a Structured Literature Review (SLR) to develop a robust overview of the related academic studies (Durach et al., 2017). We also reviewed the wide range of contributions that are published by consultancy firms, governmental agencies, and trade organizations. Then, meetings and interviews were arranged with global trade managers and a customs officer. Lastly, the main publicly accessible databases with data that could suit the research purpose were identified and classified. The rationale behind this approach

was to critically review the available academic peer-review contributions along with research reports and other documents made available by a wide set of institutions worldwide to increase the practical relevance of the study (Stentoft and Rajkumar, 2018). Our approach allowed for systematically collecting previous knowledge, and identifying directions for future developments taking into account the rapidly evolving market scenarios and the increasing data availability (and fragmentation).

This work can contribute to both scientific and managerial knowledge. On the one hand, it provides an updated SLR about GVCs mapping, highlighting that customs data could help increase granularity and precision. On the other hand, it shows practitioners what tools might be currently available, and what data sources could be leveraged to empower decision-making processes. This could be relevant for companies, to understand how their GVCs have evolved over time and where value-added is created (Los et al., 2015; Amador et al., 2018), as well as for policymakers, to provide them with more efficient tools to design and implement policies (De Backer and Miroudot, 2014).

The paper is organized as follows. The adopted methodology is first described, followed by the illustration of the SLR findings and the existing databases characteristics. Implications are then discussed, and conclusions are drawn along with research avenues proposals.

2. Methodology

To address the identified RQ a two-step multi-method approach was adopted (Figure 1). A preliminary exploration phase included a seminal literature review to contextualize the identified RQ by familiarizing with GVCs and the methodologies for their measurement. Along with academic sources, grey literature (including reports, discussion papers, briefings, reviews and data sets produced by government, academic centers, NGOs, consultancy firms, and trade organizations) was also examined (Lawrence et al., 2014). They both contributed to increase awareness about the relevance of the topic (Sodhi and Tang, 2014) and provide substantive justification for the ongoing study (Mentzer and Kahn, 1995), thus leading to designing and framing the following research conduction phase. This second phase encompassed first a Structured Literature Review, followed by conversations with practitioners and experts about global trade and by an analysis and classification of the main databases available.

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2.1 Structured Literature Review

SLRs bolster knowledge advancement by leveraging previous studies to foster the development of original contributions (Tranfield et al., 2003; Seuring et al., 2020). More importantly, they "provide

the opportunity to critically reflect, compare and discuss prior study findings, allowing for more objectivity through triangulating through the different perspectives and contexts" (Durach et al., 2017, p. 17). Equal to other research techniques, SLRs are based on the rigorous application of defined rules and procedures ensuring the validity and reliability of the method (Seuring et al., 2020). The SLR was conducted to identify all contributions in the literature that may be relevant for further research, following the six-step approach offered by Durach et al. (2017).

The seminal literature review allowed for contextualizing the RQ in focus and identifying a sub-set of contributions that could be particularly significant for the study's purpose. A couple of studies summarized the previous literature about the main methods to measure GVCs, i.e., international trade statistics on parts and components, customs statistics on processing trade, and international trade data combined with Input–Output (I–O) tables (Amador and Cabral, 2014; 2017). For example, Ferrarini et al. (2013) used trade data based on customs codes to investigate global vertical trade concerning assembled products including several parts and components.

The primary characteristics of the study to be included in this review were then identified by defining opportune inclusion/exclusion criteria. The search was conducted for contributions published after 1994, the year in which the concept of the "global commodity chain" (i.e., the precursor of modern GVCs) was first introduced by Gereffi (1994). Moreover, the seminal review highlighted that many contributions were published by governments, trade organizations, and other non-academic institutions. Therefore, we decided to avoid any a priori limitation about the publication source. The material investigated included international peer-reviewed scientific journal papers, conference proceedings, working papers and books, all published in English and available on Elsevier Scopus database. To collect a baseline sample of the potentially relevant literature, appropriate keywords ("global value chain", "trade", "mapping", "model", "fragmentation production", "value added", "network analysis") were defined and applied in combination with Boolean operators (OR and AND). The following research string was applied in Scopus: (TITLE-ABS-KEY (global AND value AND chain) AND ((TITLE-ABS-KEY (trade) AND TITLE-ABS-KEY (mapping)) OR (TITLE-ABS-KEY (trade) AND TITLE-ABS-KEY (customs)) OR (TITLE-ABS-KEY (mapping)) OR (TITLE-ABSKEY (fragmentation AND production)) OR (TITLE-ABS-KEY (value AND added) AND TITLE-ABS-KEY (trade)) OR (TITLE-ABS-KEY (trade) AND TITLEABS-KEY (network AND analysis)))) AND PUBYEAR > 1993 AND (LIMIT-TO (LANGUAGE, "English")).

810 contributions were retrieved, and the authors proceeded with filtering them first by title and then by reading the abstract. Each author conducted this process autonomously and, in case of divergence, discussions took place to jointly determine the inclusion/exclusion of a given paper. From the 810 articles initially identified, only 65 were selected after reading the title and 49 after reading the

abstract. The authors carefully read the full-text of each remaining publication, and 43 studies were selected. Backward and forward cross-referencing was then applied, and 16 more are identified to be added to the previous ones, bringing the total number of articles considered in this SLR to 59.
The selected publications mainly focused on approaches to model and map GVCs leveraging a wide range of data sources. Such contributions were examined through coding data from each study, to synthetize and integrate the findings into descriptive and thematic analyses (Tranfield et al., 2003).
The coding task consists of creating a sample that contains all the data related to an item and it can be associated with the so-called data-extraction form, which contributes to reduce human bias (Denyer and Tranfield, 2009). The last step involved the reporting of the SLR results, combining insights from different methodological approaches and research settings (Durach et al., 2017).

2.2 Conversations with practitioners and experts

Literature reviews can have limited impact over the current practice, thus we involved industry experts to validate our understandings and capture further insights so as to further increase the practical relevance of the study (Stentoft and Rajkumar, 2018). Meetings with consultants, supply chain managers, and customs officers took place to capture real-world based dynamics related to approaching GVCs from a practical perspective. A full list is provided in Table 1. These meetings contributed to better acknowledge data sources and classification methods to be used, as well as the possible practical limitations. In addition, they created opportunities not only to get input from the people the study intends to help but also to educate them about the benefits of ongoing scientific research (Wickert et al., 2021).

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Such conversations led to collect rich insights and recommendations about GVCs mapping. Many interviewees highlighted opportunities related to using customs trade data. This data is based on the Harmonized System (HS) nomenclature. HS is an internationally standardized system of labels and numbers used to classify traded products, established and maintained by the World Customs Organization (WCO). 6-digits HS customs codes are widely used worldwide, but further details can be provided by using 10-digits codes. As 10-digits codes might increase complexity, a possible compromise between accuracy and complexity can be represented by the 8-digits codes.

2.3 Database exploration and classification

The literature and interviews with managers brought to surface a considerable amount of potential data sources that can be used to pursue the research objective. Consequently, 15 different data sources were analyzed and categorized according to the types of data they contain. After reviewing datasets characteristics, a few were further explored. After having outlined the data classifications contained in the various databases, HS nomenclature was deepened with specific emphasis on the Eurostat Comext and United Nations Comtrade databases. Both subdivide data according to HS customs codes, which offer good granularity. There are however two substantial differences between the two databases. Comext collects trade data where at least one of the two nations is European (EU27), while Comtrade collects trade data between all possible pairs of nations worldwide. The second difference is the resolution of the data: Comext allows tracking detailed 8-digit level customs codes, while Comtrade only 6-digits ones.

3. Findings

3.1 Methodological approaches

The academic and empirical trade literature suggested a range of methodological approaches which collect methods and data sources to map and measure GVCs.

3.1.1 Use of international trade statistics on parts and components

The first approach leverages international trade statistics to measure fragmentation by comparing trade in goods classified as parts and components with trade in final products (Amador and Cabral, 2014). The aggregate parts and components can be obtained from the Standard International Trade Classification (SITC), including products belonging to SITC 7 (Machinery and transport equipment) which encompass more than 50% of world trade in all manufactures (Yeats, 1999). The main advantage of this approach is the high coverage and low degree of complexity of data and its comparability across countries. However, a possible drawback is the low accuracy of the measure, as it heavily relies on aggregate product classification (Amador and Cabral, 2014).

In the literature, there are several applications of this measurement approach. For example, Athukorala (2011) used trade data on parts and components to study the international product fragmentation and its implications for global and regional trade patterns in East Asia. Sturgeon and Memedovic (2011) examined patterns of final and intermediate goods trade at the country level and find a growing involvement of developing countries in GVCs.

3.1.2 Use of customs statistics on processing trade

The second methodological approach concerns the analysis of customs statistics on processing trade. This approach offers good measurement accuracy and the information contained in the datasets is relatively easy to be analyzed. But, outward processing trade is considered a narrow measure of fragmentation because it captures only the cases where components or materials are exported for processing abroad and then reimported (Amador and Cabral, 2014). Without the transit through customs (outward or inward), it is not possible to trace the trade flows between countries. Besides, they do not contain information about how exports are used abroad, and they do not tell anything about how imported goods are produced (Johnson, 2018).

To differentiate between intermediate and final goods, some scholars recommended the integration of the Broad Economic Categories (BEC) classification, which splits the SITC or the HS of merchandise into their final use (intermediate, capital, or consumer goods) (Escaith, 2014). Crossing BEC with SITC data allows for classifying each good by production stage and industry (OECD, 2005). HS classification can further improve granularity, as its 6-digit level structure distinguishes more than 5,000 different categories of goods. Consequently, mapping activities can be more precise and provide information on the specialization of each country within regional or international productive clusters (Escaith, 2014).

If the focus is on single products or components the use of HS classification can be recommended, while SITC is more appropriate for studies about specific industries. However, the HS classification can be critical when coming to the correct allocation of parts among industries (Ferrarini, 2013). For example, in the case of processing trade within the automotive industry, parts and components are spread across a wide range of HS categories, which complicates the task of matching intermediate and final goods. Conversely, for the electrical/electronic industries, where both parts and final exports are mostly spread over a single HS category, components matching is easier.

3.1.3 Use of input-output based measures

Many authors considered the production fragmentation worldwide by focusing on the imported input shares of gross output, total inputs or total exports, thus leveraging information from classical input-output (I–O) tables (Amador and Cabral, 2014). I–O tables allow for developing cross-industry and time analyses, but are affected by some potential drawbacks.

First, they are available only for some countries on a comparable basis and are not always updated regularly (Amador and Cabral, 2014). Moreover, the accuracy of the measurement of fragmentation depends on the considered product classification and the related depth. A very detailed product classification assures that the characteristics of the production chain are identified and tracked

properly. However, such data is typically unavailable, making accurate cross-country and time-series analysis very difficult to be developed by both academics and policymakers (Johnson, 2018). For example, the widely used World Input-Output Database (WIOD) considers only 19 manufacturing industries. To put this into perspective, this means that trillions of dollars of US manufacturing output are divided into only 19 categories (De Gortari, 2019). Consequently, the identification of countries with important fragmentation activities and the assessment of their main trends have usually been carried out at aggregate product detail.

Another problem that concerns the use of I–O tables is that they normally track how raw materials are used as inputs by individual industries, but they cannot distinguish between input use patterns for domestically produced and imported goods and services. This implies that assumptions (or data imputation techniques) have to be introduced to decompose input use across sources. Tables of imported input use are usually built through assumptions of proportionality according to which imported inputs are distributed across sectors in the same proportion as domestic goods. Furthermore, the proportionality assumption is naturally applied to total imports, so inputs from all bilateral trade partners are treated in the same way (Johnson, 2018).

A further issue related to I-O tables is that imported inputs are assumed to be used with the same intensity in industry-wide production for domestic and export markets. When the intensity of imported inputs differs between firms within an industry, using the average input intensity reported in I-O tables can lead to large distortions in measuring the trade value-added content (Johnson, 2018).

Academicians considered I-O tables to develop two main measures for GVCs mapping (Hijzen, 2005). The first type of I–O based measure focuses on the foreign content of domestic production by considering the share of imported intermediate inputs in production (Feenstra and Hanson, 1996). This measure captures the intensity of international outsourcing, i.e., the firm decision to substitute domestic value-added by foreign production (Hijzen, 2005). The second type of I–O based measure instead focuses on the foreign content of exports (Hummels et al., 1998). This measure captures the extent to which the production of a good involves at least two countries and that the good-in-process crosses at least two borders (importing and re-exporting) (Hijzen, 2005). Therefore, it contributes to define vertical specialization as “the value of imported intermediates embodied in a country’s exports” (Hummels et al., 2001). Additionally, some scholars used I–O data to measure the average position of an industry in the production line (Antràs et al., 2012). For example, Fally (2012) considered the average distance from the final consumption of goods as “upstreamness”, analyzing the number of production stages embodied in a given industry’s output.

3.1.4 Integration of macro-level data with firm-level data

To improve granularity and include the performance of individual companies some scholars proposed to integrate the previously described approaches with the collection of firm-level data (Amador and Cabral, 2014). There are several databases based on questionnaires, generally organized according to countries, geographical areas, and industries and whose data is normally collected via open-ended interviews rather than through formal surveys (Frederick, 2014).

However, cross-country firm-level data covering several years is very rare because of the national regulations on statistics confidentiality, as well as the different criteria for collecting and recording information (Amador and Cabral, 2014). The complexity of the data required, considering several companies at a time, can be very high, but the accuracy of the measurement of GVCs linkages can improve significantly (Blyde, 2014). When adopting a firm-level approach, data on imports of intermediate products can be used to obtain a quantification of the importance of imported inputs in the production process for each enterprise (Amador and Cabral, 2014).

A key strength of firm-level data is that transactions between firms and their foreign partners become the object of analysis, rather than inferring them by combining industry-level information with trade data (Johnson, 2018). In addition, firm-level sources can capture heterogeneity in GVC linkages between firms, which is instead obscured by aggregated industry-level data (Bems and Kikkawa, 2021). Macro-level and micro-level data could thus be jointly leveraged, as the firm-level data could improve the accuracy of I-O tables while macro-level data could strengthen the generalization of outcomes emerging from individual firms.

3.2 Subject areas

Given the RQ addressed in this study, it was also possible to identify similarities and differences about the subject areas of the retrieved sample of studies. Six research clusters were identified, as illustrated in Table 2.

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3.2.1 Value-added measurement

Many studies have been conducted to develop indicators or models to track and measure value-added (Amador et al., 2018). The basic concept is that domestic value-added combines with foreign value-added to produce exports, which may be later embodied in other products or consumed as final goods and services (Amador and Cabral, 2014). Thus, imports of intermediate products to be incorporated into exports are an important part of the production process, making the gross value of exports much larger than their domestic value-added component (Johnson and Noguera, 2012; Amador et al., 2015).

Consequently, the analysis of gross trade flows has to be complemented with the analysis of trade in value-added, tracing the country of origin of value-added (Miroudot and Nordstrom, 2020).

When introducing value-added measurement, a very important concept is "vertical specialization" (VS), which basically encompasses that countries are linked sequentially to produce final goods (Hummels et al., 2001). In more detail, VS occurs when i) goods are produced in two or more sequential stages; ii) two or more countries contribute with value-added operations; and iii) at least one country uses imported inputs in its stage of the production process, and some of the resulting output is exported. VS can be computed as the contribution of imported inputs into gross production multiplied by the amount that is exported (Hummels et al., 2001). It provides a value for the imported input content of exports, assuming that trade takes place between two countries at a time and there are two stages of production (Daudin et al., 2011). To empirically determine VS, data on the production processes and trade flows of each individual stage of each good that is traded should be used. However, this data is scarcely available, and scholars often have to consider I-O tables (Amador and Cabral, 2009) or bilateral trade data (Johnson and Noguera, 2012).

Amador and Cabral (2009) argued that, given a country, a high share of simultaneous exports of a specific product and a high share of imports of some intermediate product used in its production, compared to the world average, provides indirect evidence of VS. By quantifying this "excess" of intermediate imports it is thus possible to obtain a proxy of trade related to VS activities (Amador and Cabral, 2009). Alternatively, Johnson and Noguera (2012) aimed at elaborate Hummels et al. (2001) by developing a new indicator called the ratio of value-added to gross export (VAX). The VAX ratio has two components: the first captures the value-added associated with the gross output needed to produce exports as a fraction of total exports (in line with Hummels et al., 2001), while the second component considers that part of the exports could be dedicated to producing goods that are ultimately consumed in the country in focus.

Other authors specifically focused on processing trade, proposing methods to compute domestic and foreign contents share in a country's exports when processing trade is prevalent (Koopman et al., 2012; Koopman et al., 2014). In the presence of significant processing exports the key assumption by Hummels et al. (2001) that the intensity in the use of imported inputs is the same between production for exports and production for domestic sales could be violated. Therefore, the model developed by Koopman et al. (2012) allows for potential differences in the use of imported inputs between normal and processing exports. Processing exports are characterized by imports for exports with favorable tariff treatment and this led to a significant difference in the intensity of imported intermediate inputs in the production of processing exports and that in other demand sources (for domestic final sales and normal exports).

3.2.2 Value-added measurement with respect to specific countries

Some scholars offer contributions aimed at analyzing and measuring value-added, but focusing on specific countries. They have been divided into two sets: (i) those that consider data from trade databases and (ii) those that also use firm-level data. This section brings together articles that use models already described in the literature and apply them to specific countries using trade or value-added databases.

Kersan-Škabic (2017) sought to determine the characteristics and importance of GVCs within the EU new member states (EU NMS), relying on two indicators developed by Koopman et al. (2010): i) domestic value-added embedded in gross export (DVA), that refers to the value-added generated by the domestic economy in the production of goods and services; and ii) foreign value-added embodied in gross exports (FVA), that refers to the value-added of foreign goods and services that are used as intermediates to produce goods and services for export. Their combination leads to determine a further indicator named GVC position index, which indicates if a country specializes in the first or the last steps of production. Conversely, Wen (2018) measured the ratio of domestic value-added content in China's exports to the world and its major trading partners at the aggregate and sector level starting from the models developed by Hummels et al. (2001) and Johnson and Noguera (2012). Lastly, Solaz (2018) focused on Spain, analysing the production and trade specialisation pattern from the perspective of trade in the value-added and vertical specialization. It combined the models developed by Johnson and Noguera (2012) and Koopman et al. (2014) with the approach of Timmer et al. (2014) to compute the entire set of indicators related to value-added measurement and VS.

3.2.3 Value-added measurement with respect to specific products

Some studies coped with value-added measurement but specifically focused on a limited sample of products, mostly in the electronic industry (Dedrick et al., 2010; Ali-Yrkkö et al., 2011; Xing, 2016; Xing, 2020). Electronic products allow for easily determine the bill of materials, leading to reconstructing the value chain and identifying the various parts of value that contribute to the final product. Dedrick et al. (2010) studied the different stages of the value chain where each producer buys an input to which it adds value, which then transforms into a cost in the next production step. The sum of the value-added by everyone in the chain equals the final product price. They considered a wide range of stakeholders, including components suppliers, software contents providers, third-party services providers, distributors, branded vendors, and retailers to identify who takes advantage of innovation in GVCs. Similarly, Ali-Yrkkö et al. (2011) studied the value chain of the Nokia N95 mobile phone to break down where the value was captured (and by whom), starting from the list of

mobile phone components and their value. More recently, Xing (2020) took Apple as a case study where to investigate the value-added of intellectual property in products that are not taken into account in US export statistics.

3.2.4 Value-added measurement including firm-level data

Some studies leveraged firm-level data, instead of trade databases, to measure value-added (Blyde, 2014; Kee and Tang, 2016). This approach embraces firm heterogeneity and hence can reduces aggregation bias, but is normally limited to individual countries. Blyde (2014) calculated the share of domestic value-added as a portion of the firms' exports in the Mexican economy, while Kee and Tang (2016) and Ma et al. (2015) used firm and customs transaction-level data merged with firm survey data to study China's rising domestic content in exports.

Ito et al. (2020) used plant-level data to elaborate data related to individual industries in the OECD-ICIO table for Japan. They found the DVA computed from the extended ICIO table was lower in most industries (and overall) than the DVA computed from the original ICIO table. The lower level of domestic value-added means that foreign value-added is higher than in the original ICIO table, implying that Japanese export production is more based on foreign value-added than estimates that do not take into account plant heterogeneity.

Lastly, a recent study by Bems and Kikkawa (2021) aimed to clarify the bias that arises when GVCs and value-added trade are measured using I–O tables, suggesting how firm-level data could improve measures with a focus on Belgium.

3.2.5 Value-added mapping

A group of studies investigated value-added processes to map them from a geographical viewpoint. Previously discussed articles aimed at identifying value-added components in different countries or geographical areas examined, or at framing the value chain of a finished product. Some already mentioned the importance to geographically map value-added (e.g. Dedrick et al., 2010), but they mostly overlooked the links between different countries at a geographical level in order to understand how many and which flows exist among different areas.

Import shares for intermediate inputs can be calculated on the basis of national I-O tables, as an increase in these shares can reflect international fragmentation under the assumption that all imports value is added outside the country (Feenstra and Hanson, 1999). However, modern supply chains often have multiple and intertwined production stages, and imports can likely embody value that the importing country added itself in previous stages (Mahutga, 2012). Los et al. (2015) addressed the issue of whether fragmentation of product value chains was mainly within or across regional blocs,

extending the work by Feenstra and Hanson (1999) to decompose the value of a final product value-added contributions using a multi-country setting. GVCs could thus be represented as weighted networks of foreign-value added in exports, to identify the role of specific countries and quantity their impact over time (Amador et al., 2018). Ferrarini (2013) introduced a new indicator, called Network Trade Index (NTI), computed on the basis of international trade statistics as "a supplier country's share in parts imports by a processing industry in the hosting country, weighted by that industry's share of total final goods exports". NTI quantifies vertical trade among countries, allowing for identifying the closest trade links. Once value-adding activities are identified and geographically located, foreign value-added can be split into value-added within and outside the region to analyze (Los et al., 2015; Xiao et al., 2018). To define the interactions between countries, Amador et al. (2015; 2018) chose to use the bilateral foreign value-added content of gross exports (FVAiX). They then proposed to represent interactions among countries by developing a network where the nodes were represented by the countries and the weight by the FVAiX.

3.2.6 Network analysis

Graph theory can be a significant approach to study international trade, as networks are powerful tools for the geographical representation of GVCs, and specifically to represent trade or GVCs flows (Escaith, 2014; Cingolani et al., 2018). Any network requires the identification of a set of nodes and a criterion for the interactions between them, which defines the edges and the respective weights (Amador et al., 2018).

Different techniques can be used to visualize, calculate, and represent network trade data (De Benedictis and Tajoli, 2011; De Benedictis et al., 2014). GVCs are normally represented through tree schemes (with nodes and branches), but alternative configurations (e.g. chains or stars, as well as "snakes" or "spiders") can be identified (Timmer et al., 2014; Zhu et al., 2015). Despite their visual impact and simplicity, graphs and networks can encompass complex mathematical models, providing important insights on the way the nodes interact and emphasizing connectivity (Escaith, 2014).

Feenstra and Taylor (2008) offered a tool based on the use of a cartogram and some lines connecting different nations or geographical areas. They proposed to represent each country with a node, whose size is proportional to the number of incoming arcs. A large circle indicates that a country is among the main partner for a large number of exporting countries, but the geographical representation of international trade does not allow to describe the effect of interdependence on individual countries (De Benedictis and Tajoli, 2011). Instead, to examine the countries' interactions and determine their relative position in the whole trading system, the constraints imposed by a geographical representation of international trade can be overcome by moving from physical space to topological

space (De Benedictis et al., 2014). This could be based on an algorithm that minimizes the energy in the system: countries that are connected tend to be placed close together, while countries that are not connected tend to be placed far apart. However, the position of each country should depend not only on its bilateral ties but also on the indirect effect of others: its trading partners' trading partners help determine the country's position in the network (De Benedictis et al., 2014).

4. Database summary

In this section, databases available for academicians and practitioners to analyze trade flows are listed and described. They are then schematized to classify them according to their peculiarities, offering first the databases more focused on the industrial sector, then others using data from flows through customs, input-output tables and finally datasets based on questionnaires or data from companies. Before listing them, some preliminary information is offered to contextualize.

The discussed databases include trade-related data among different countries or geographical areas, and adopt heterogeneous classifications to identify industries and/or goods. Figure 2 summarizes the links between these classification methods:

- ISIC: is the United Nations' International Standard Industrial Classification of all Economic Activities.
- CPC: is the United Nations' Central Product Classification.
- HS: is the Harmonized Commodity Description and Coding System, managed by the World Customs Organisation.
- SITC: is the aggregated classification of transportable goods for international trade statistics for comparison purposes.
- NACE: is the European standard classification of productive economic activities.
- CPA: is the European Classification of Products by Activity.
- PRODCOM: is the classification of goods used for statistics on industrial production
- in the EU.
- CN: stands for the Combined Nomenclature, a European classification of goods used for foreign trade statistics.

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The basis of the classification of the different industrial sectors is based on the International Standard Industrial Classification of All Economic Activities (ISIC), a United Nations industry classification

system. The ISIC is an alpha-numeric classification with varying degrees of detail: the letters indicate the macro-sector of economic activity, while the numbers (ranging from two to six digits) represent, with varying degrees of detail, the articulations, and breakdowns of the sectors themselves. The various economic activities are grouped, from general to, into sections (coding: 1 letter; there are 21 sections, from A to U), divisions (2 digits), groups (3 digits) and classes.

From ISIC the Statistical Classification of Economic Activities in the European Community (NACE) is derived. ISIC and NACE have exactly the same items at the highest levels, where NACE is more detailed at lower levels (Eurostat, 2008). Then, NACE is further developed with the Classification of Products by Activity (CPA). The CPA is the classification of products (goods as well as services) at the level of the EU. CPA product categories are related to activities as defined by the NACE. Each CPA product is assigned to one single NACE activity. This linkage to NACE activities gives the CPA a structure parallel to that of NACE at all levels (Eurostat, 2020c).

When focusing on goods rather economic activities, the Harmonized System (HS) is widely adopted. It is in use in more than 200 countries and economic regions and more than 98% of all trans-border trade is statistically and economically classified using HS nomenclature (Weerth, 2008). The HS comprises approximately 5,300 article/product descriptions that appear as headings and subheadings, organized in 99 chapters grouped in 21 sections (UN Trade Statistics, 2017).

The HS nomenclature has undergone numerous changes over time, as some entries have been deleted and others have been added. The most recent nomenclature is the one released in 2017, replacing the previous one from 2012. The first 6-digits can be broken down into three parts. The first two digits (HS-2) identify the chapter the goods are classified in, the next two digits (HS-4) identify groupings within that chapter and the next two digits (HS-6) are even more specific.

Up to the HS-6-digit level, all countries classify products in the same way (a few exceptions can exist where some countries apply old versions of the HS). 6-digit level can be exceeded, parties usually set their customs duties at the 8-digit “tariff code” level. Indeed, with the 8-digit level it is possible to go into more detail about what a good is. Statistical suffixes are often added to the 8-digit tariff code for a total of 10-digits. If the number of digits is more than eight, additional digits are called as the national subheading. HS codes can be determined by a variety of factors including the composition of a product, its form and function. Any product for which there is no explicit description may be classified in a “residual” heading or subheading. Residual codes are normally found last in numerical order under their relative headings and subheadings. Table 3 offers a short description for each database and summarizes the related main characteristics.

-Insert_Table_3-

4.1 Databases classification

Depending on the classification system used, the various datasets were analyzed and schematized in Table 4. The first important distinction to be made is whether they are based on questionnaires or trade data, and according to the typology of classification methodology.

-Insert_Table_4-

Only one dataset among those analyzed, the EW-MFA, collects specific data on the exchange of raw materials and materials for industrial use. On the other hand, there are several datasets analyzing industrial sectors, broken down by different classifications, and others analyzing products and goods. In order to proceed with the mapping of GVC, it is necessary to go into as much detail as possible to try to break down the final product into as many sub-components as possible. Therefore, databases based on product classifications are deepened.

The datasets based on the analysis of products and goods trade are then analyzed in Table 5 by investigating which classification methodologies they use. Among these classification methods, the CPA is used at European level, so it is not sufficient if one wants to reconstruct the value chain at global level: the ideal would be to use codifications adopted at international level.

-Insert_Table_5-

The classification based on BEC can be critical, as this method analyses statistics at a very aggregated level. Conversely, HS classification is the most frequently used at company level when coping with flows of goods through customs. The datasets based on the HS classification are shown in Table 6.

-Insert_Table_6-

They were analyzed on the basis of the level of detail of the customs code, i.e. the number of digits, and the number of countries covered. Some of these databases, notably Eurostat Comext and Global Transport Cost, are not symmetrical considering the number of countries analyzed. Eurostat Comext allows data to be identified by considering a EU country as the reporting country (country declaring commercial transactions), while there is no limit on the partner country (trade partner of the reporter). This means that there are no limitations in data analysis where the country of origin or destination of

the goods is a member country of the EU. On the other hand, it is not possible to study flows between two countries outside the EU, such as goods flows between China and Australia.

These databases differ according to the number of HS code digits considered. To undertake as accurate an analysis as possible of the sub-components of a product, it is necessary to have access to as many digits of the HS code as possible. For example, Eurostat Comext could be a good choice, but has the limitations outlined above on data retrieval between non-European countries. Therefore, a feasible approach could be using data from Eurostat Comext when at least one European country is considered, otherwise UN Comtrade should be used. This procedure overcomes the main limitation of Eurostat Comext and at the same time ensures a high level of detail, in terms of customs code digits, for trade flows involving the departure or arrival of a European country.

5. Discussion

In recent years characterized by increasing supply chains globalization and fragmentation many scholars developed models and frameworks to track GVCs (Hummels et al., 2001; Amador and Cabral, 2009; Ferrarini, 2013). Globalization has become pervasive, leading to more complex supply chain networks where suppliers are playing more important roles in many industries (Cohen and Lee, 2020). However, almost all existing studies were based on macroeconomic analyses, individual industries, or particular market niches. As a matter of fact, using firm-level data for value-added measurement can be very complicated. Providing a detailed mapping of a GVC company by company presents huge challenges due to time-consumption, data homogeneity, and achievable level of detail and completeness (Amador and Cabral, 2014). For example, Dedrick et al. (2010) and Ali-Yrkkö et al. (2011) reconstructed GVCs for electronics products. They first mapped the suppliers producing the components, the assembly factories, the distribution centers and the points of sale. This kind of approach required huge efforts, since tier-2 and tier-3 suppliers' lists may not be known. Although these articles succeeded in reconstructing the value chain of the products analyzed, they still lacked a generalizable model. Other contributions attempted to track industry-level value-added flows across countries (Amador and Cabral, 2017; Amador et al., 2018). A possible future direction is to further develop the foreign value-added content in a country's gross exports (FVAiX) indicator defined in Amador and Cabral (2017), e.g., by mapping all the contributions of a given country, not only the value-added on exports. Also, in line with De Benedictis and Tajoli (2014), network analysis emerged as a powerful option to explore GVCs, allowing for developing geographical or mathematical networks to represent value chains.

Moreover, the type of data to be leveraged is another important element to be considered. A wide range of databases have been examined to improve current knowledge about data sources that could

be leveraged to study GVCs and analyze not only broad industries, but also specific products' value chains. So far, codes describing industrial categories have been generally preferred by academics. However, network analyses (De Benedictis et al., 2014) could be done through using customs firm-level data (collected e.g. through Eurostat Comext and United Nations Comtrade), which are barely considered in the literature due to the difficulty of collecting data itself (Amador and Cabral, 2014). Nevertheless, this could allow for obtaining much greater accuracy of the result than with I-O databases which limit their scope to industrial sectors (Ferrarini, 2013).

5.1 Leveraging customs data to improve GVCs mapping

The global economy is in the midst of major upheavals that affect global supply chain strategy in every industry, and there are unknowns concerning government policies that affect both cross-border trade and local processes. As supply chain executives have to design their product structure to determine what part should be built in each country, implications for customs duties can be huge (Cohen and Lee, 2020). Some countries have redefined what constitutes the country of origin of a given part or finished product, and this implies that supply chain design is increasingly complex. This also complicates global value chains understanding and mapping, but customs data could enable managers to track the GVCs footprint with much more detail than I-O tables (Escaith, 2014). It offers sufficient granularity to identify the contribution of different countries, also allowing for considering not only finished goods but also the related raw materials and components (Ferrarini, 2013). The conversations we had with practitioners and experts in the field widely highlighted that through HS data it is possible to trace the evolution of imports and exports and to understand in which geographical areas value-adding activities are concentrated.

However, input data might be required like the customs codes of the parts composing a given assembled product. Moreover, when investigating the mapping of the components that make up a finished product, "tracking of the components can be critical as it is often difficult to assess the customs code (HS code) with certainty" (EX1). Sometimes the code depends on the type of machining that has been used in production, thus scholars are recommended to integrate data from companies knowing the exact customs codes of the components used in the industry in focus.

To achieve an acceptable balance between complexity yield and efforts, a possible option could be asking managers for the customs codes of the main components that mostly contribute to the overall value of the finished product. However, EX4 highlighted that "a company which imports components and then assembles the finished product may not be interested in deepening where the raw materials or sub-components could come from". The analysis and mapping of GVC starting from the finished

product alone could thus be concluded at the first level of supply, but this clearly limits the possible implications that could be drawn.

In fact, companies and supply chains could not only study the movements of finished products, components, and raw materials, but also investigate the countries where they could be cheaper. This might be possible thanks to statistical data that generally report trade in terms of weight, and for certain types of product code also per unit. However, "one point of attention should be the presence of some countries that act as bridges for trade" (EX5). Examples might be Hong Kong or Singapore for shipping goods from China to Europe, or Turkey as a link between the EMEA region and the European Union, but also Switzerland and the Netherlands. Also, "some peaks in imports from these countries should not always be interpreted as evidence for high component production" (EX2). They could be more simply links between the origin and final destination of the goods. This kind of considerations illustrate how the study of the mapping of GVCs could also be very interesting from the perspective of policymakers to drawn up dumping policies, e.g., when an increase in customs duties generates a shift of production lines to other countries.

6. Concluding remarks

GVCs are increasingly fragmented, and companies and government often struggle with determining where value is added worldwide. Many models have been proposed, but current GVCs challenges have been calling for new approaches that take into account the rising complexity of modern supply chains. We carried out a SLR to summarize the existing academic knowledge about GVCs mapping, and also examined the related practitioners' materials. We then examined what data sources are currently available to collect data about global trade flows, and involved practitioners in the discussion to collect insights that improved the study's practical relevance.

Overall, this study highlights the lack of approaches or models to calculate the contribution of individual countries for GVCs of finished products that also take into account raw materials and components. Also, it offers an overview of the characteristics of relevant practitioner-oriented databases. It emerged that a wide amount of data might be available, but the best way to leverage it to improve current understanding is far from being clear. We aim at offering guidance in this process, highlighting what previous scholars contributed but more importantly what future directions should be pursued to increase models' descriptive and explanatory power.

From an academic perspective, the study offers avenues to address the identified gap in the academic literature by proposing to leverage customs data. It could improve granularity and accuracy of GVCs mapping to: i) analyze GVCs for different industries and finished products, made up of components that come from outside the national borders of the country of assembly; ii) allow for enhancing

understanding of GVCs changes over time which could lead to macroeconomic considerations; iii) enable for output elaboration through graphical tools, diagrams, and networks, elaborating the insights that could emerge from pure numerical results and strengthening understanding. Thanks to the use of databases based on customs flows, GVCs could be studied with much more detailed and rich data than macro-economic data, and original models and tools might be developed. This could also bolster further studies that focus on the GVCs of assembled products, such as cars, workstations, but also drugs as the COVID-19 vaccine.

The study also has managerial implications, which might concern those involved in optimizing supply chains within companies. It shows practitioners what tools might be currently available, and what data sources could be leveraged to empower decision-making processes. Today, firms have to restructure, redesign, and rethink where and how products are produced, inputs are sourced, and customer demand is fulfilled. At the same time, companies strive to optimize their particular global value chains, which operate in multiple jurisdictions and generate extensive cross-border flows of goods, money, and information. They also have to deal with the uncertainties of customs duties and taxes, government incentives, and trade agreements.

Companies thus need to understand how their GVCs have evolved over time and where value-added is produced. For example, they might re-design their sourcing processes to align main sourcing countries with the main destination markets. Given a final destination, companies could examine the customs duties in place and identify more cost-efficient supply corridors.

Lastly, sourcing importance is rising along with the relevance of research and development activities. Many multinational corporations are increasingly offshoring these crucial activities in countries like China and India. Although these activities can hardly be identified and mapped via customs codes, future studies could include them into the equations to further improve the understanding of global value chains. Moreover, future studies should investigate the value-adding processes for each country against the adoption of certain trade policies. For example, the EU promoted policies aimed at slowing down the growth of supply chains outside Europe, trying to keep the production of parts and sub-components in EU countries. Measuring trade data with a value-added perspective could bring a new perspective and is likely to impact policy choices (Rifflart and Schweisguth, 2013). Accurate value-added trade data could improve exchange rate assessments. Real effective exchange rates based on value-added trade weights could reveal more accurate measures of competitiveness of a country than those based on gross trade weights. Also, they could improve the assessment of potential macro-economic shocks, whose enhanced understanding could help policymakers to forecast their impact and develop adequate policy responses.

References

Aguiar, A., Chepeliev, M., Corong, E., McDougall, R., and van der Mensbrugghe, D. (2019). The GTAP data base: Version 10. Journal of Global Economic Analysis, 4(1):1–27.

Aichele, R. and Heiland, I. (2018). Where is the value added? Trade liberalization and production networks. Journal of International Economics, 115:130–144.

Ali-Yrkkö, J., Rouvinen, P., Seppälä, T., and Ylä-Anttila, P. (2011). Who captures value in global supply chains? Case Nokia N95 Smartphone. Journal of Industry, Competition and Trade, 11(3):263–278.

Amador, J. and Cabral, S. (2009). Vertical specialization across the world: A relative measure. The North American Journal of Economics and Finance, 20(3):267–280.

Amador, J. and Cabral, S. (2017). Networks of value-added trade. The World Economy, 40(7):1291–1313.

Amador, J., Cabral, S., Mastrandrea, R., and Ruzzenenti, F. (2018). Who's who in global value chains? a weighted network approach. Open Economies Review, 29(5):1039–1059.

Amador, J., Cappariello, R., and Stehrer, R. (2015). Global Value Chains: A View from the Euro Area. Asian Economic Journal, 29(2):99–120.

Amador, J.L. and Cabral, S. (2014). Global value chains: surveying drivers and measures. European Central Bank Research Paper Series.

Antràs, P., Chor, D., Fally, T., and Hillberry, R. (2012). Measuring the upstreamness of production and trade flows. American Economic Review, 102(3):412–16.

Athukorala, P. (2011). Production networks and trade patterns in East Asia: Regionalization or globalization? Asian Economic Papers, 10(1):65–95.

Bems, R. and Kikkawa, A. K. (2021). Measuring trade in value added with Firm-Level Data. Journal of International Economics, 129:103434.

Blyde, J.S. (2014). The participation of Mexico in global supply chains: The challenge of adding Mexican value. Applied Economics Letters, 21(7):501–504.

Cerina, F., Zhu, Z., Chessa, A., and Riccaboni, M. (2015). World input-output network. PloS one, 10(7):e0134025.

Cingolani, I., Iapadre, L., and Tajoli, L. (2018). International production networks and the world trade structure. International Economics, 153:11–33.

Cohen, M.A., and Lee, H.L. (2020). Designing the right global supply chain network. Manufacturing & Service Operations Management, 22(1):15-24.

De Backer, K. and Miroudot, S. (2014). Mapping global value chains. Global value chains and world trade: Prospects and challenges for Latin America. Santiago: ECLAC, 2014. LC/G. 2617: 43-78.

De Benedictis, L., Nenci, S., Santoni, G., Tajoli, L., and Vicarelli, C. (2014). Network analysis of world trade using the BACI-CEPII dataset. Global Economy Journal, 14(3-4):287–343.

De Benedictis, L. and Tajoli, L. (2011). The world trade network. The World Economy, 34(8):1417–1454.

De Gortari, A. (2019). Disentangling global value chains. Technical report, National Bureau of Economic Research.

Dedrick, J., Kraemer, K.L., and Linden, G. (2010). Who profits from innovation in global value chains?: a study of the iPod and notebook PCs. Industrial and Corporate Change, 19(1):81–116.

Dietzenbacher, E., Los, B., Stehrer, R., Timmer, M., and De Vries, G. (2013). The construction of world input–output tables in the WIOD project. Economic Systems Research, 25(1):71–98.

Durach, C.F., Kembro, J., and Wieland, A. (2017). A new paradigm for systematic literature reviews in supply chain management. Journal of Supply Chain Management, 53(4):67–85.

Escaith, H. (2014). Mapping global value chains and measuring trade in tasks. In Asia and Global Production Networks. Edward Elgar Publishing.

Eurostat (2008). NACE Rev.2 Statistical classification of economic activities in the European Community. Eurostat Methodologies and Working papers.

Eurostat (2018). Economy-wide material flow accounts HANDBOOK. In World Trade Report 2008 - Trade in a Globalizing World. European Union.

Eurostat (2020a). Focus on Comext, available at: https://ec.europa.eu/eurostat/web/international-trade-in-goods/data/focus-on-comext (accessed: 10/03/2021).

Eurostat (2020b). Full International and Global Accounts for Research in Input- Output Analysis (FIGARO), available at: https://ec.europa.eu/eurostat/web/experimental-statistics/figaro (accessed: 10/03/2021).

Eurostat (2020c). Glossary: Statistical classification of products by activity (CPA), available at: https://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:Statistical_classification_of_products_by_activity_(CPA) (accessed: 10/03/2021).

Eurostat (2020d). Prodcom - an overview, available at: https://ec.europa.eu/eurostat/web/prodcom (accessed: 10/03/2021).

Fally, T. (2012). Production staging: measurement and facts. Boulder, Colorado, University of Colorado Boulder, May, pages 155–168.

Fan, Z., Zhang, Y., and Liao, C. (2019). Global or Regional Value Chains? Evidence from China. International Regional Science Review, 42(5-6):459–494.

Feenstra, R. and Taylor, A. (2008). International Trade. Palgrave Macmillan Limited.

Feenstra, R. C. and Hanson, G.H. (1996). Globalization, outsourcing, and wage inequality. Technical report, National Bureau of Economic Research.

Feenstra, R. C. and Hanson, G.H. (1999). The impact of outsourcing and high-technology capital on wages: estimates for the United States, 1979–1990. The Quarterly Journal of Economics, 114(3):907–940.

Ferrarini, B. (2011). Mapping vertical trade. Asian Development Bank Economics Working Paper Series, (263).

Ferrarini, B. (2013). Vertical trade maps. Asian Economic Journal, 27(2):105–123. Foster-McGregor, N. and Stehrer, R. (2013). Value added content of trade: A comprehensive approach. Economics Letters, 120(2):354–357.

Franssen, L. (2020). Capturing value in south–south and south–north value chains: Evidence from East Africa. The European Journal of Development Research, 32(4):939–975.

Frederick, S. (2014). Combining the Global Value Chain and global IO approaches. In Center on Globalization, Governance & International Conference on the Measurement of International Trade and Economic Globalization Aguascalientes, Mexico.

Gaulier, G. and Zignago, S. (2010). BACI: international trade database at the product-level (the 1994-2007 version).

Gereffi, G. (1994). The organization of buyer-driven global commodity chains: How U.S. retailers shape overseas production networks. Contributions in Economics and Economic History.

Gereffi, G., Humphrey, J., and Sturgeon, T. (2005). The governance of global value chains. Review of international political economy, 12(1):78–104.

Gereffi, G. and Lee, J. (2012). Why the world suddenly cares about global supply chains. Journal of supply chain management, 48(3):24–32.

Gibbon, P., Bair, J., and Ponte, S. (2008). Governing global value chains: an introduction. Economy and society, 37(3):315–338.

Hanson, G. H., Mataloni Jr, R.J., and Slaughter, M. J. (2005). Vertical production networks in multinational firms. Review of Economics and statistics, 87(4):664–678.

Hijzen, A. (2005). A bird's eye view of international outsourcing: data, measurement and labour demand effects. Economie internationale, (4):45–63.

Hummels, D.L., Ishii, J., and Yi, K.-M. (2001). The nature and growth of vertical specialization in world trade. Journal of international Economics, 54(1):75–96.

Hummels, D.L., Rapoport, D., and Yi, K.-M. (1998). Vertical specialization and the changing nature of world trade. Economic Policy Review, 4(2):79-99.

IMSS (2020). The International Manufacturing Strategy Survey, available at: http://www.manufacturingstrategy.net/ (accessed: 10/03/2021).

International Trade Centre (2020). Trade map, available at: https://www.trademap.org/Index.aspx

(accessed: 10/03/2021).

Ito, K., Deseatnicov, I., and Fukao, K. (2020). Japan's participation in global value chains: splitting the IO table into production for export and domestic sale. Economic Systems Research, 32(2):173–191.

Johnson, R.C. (2018). Measuring global value chains. Annual Review of Economics, 10:207–236.

Johnson, R.C. and Noguera, G. (2012). Accounting for intermediates: Production sharing and trade in value added. Journal of international Economics, 86(2):224–236.

Kano, L., Tsang, E.W., and Yeung, H.W.-c. (2020). Global value chains: A review of the multi-disciplinary literature. Journal of International Business Studies, 51: 577–622.

Kee, H.L. and Tang, H. (2016). Domestic value added in exports: Theory and firm evidence from China. The World Bank.

Kersan-Škabic, I. (2017). Trade in value added (TiVA) in EU new member states (EU NMS). Croatian Economic Survey, 19(2):105–133.

Koopman, R., Powers, W., Wang, Z., and Wei, S.-J. (2010). Give credit where credit is due: Tracing value added in global production chains. Technical report, National Bureau of Economic Research.

Koopman, R., Wang, Z., and Wei, S.-J. (2012). Estimating domestic content in exports when processing trade is pervasive. Journal of Development Economics, 99(1):178–189.

Koopman, R., Wang, Z., and Wei, S.-J. (2014). Tracing value-added and double counting in gross exports. American Economic Review, 104(2):459–94.

Kuboniwa, M. (2015). Russia's global value chain using modified world input-output data. Eastern European Economics, 53(4):277–308.

Kwon, T. and Ryou, J.-W. (2015). Global Value Chains of East Asia: Trade in Value Added and Vertical Specialization. Asian Economic Journal, 29(2):121–143.

Lawrence, A., Houghton, J., Thomas, J., & Weldon, P. (2014). Where Is the Evidence? Realising the Value of Grey Literature for Public Policy & Practice, A Discussion Paper.

Lenzen, M., Kanemoto, K., Moran, D., and Geschke, A. (2012). Mapping the structure of the world economy. Environmental science & technology, 46(15):8374–8381.

Liu, G. and Müller, D.B. (2013). Mapping the global journey of anthropogenic aluminum: a trade-linked multilevel material flow analysis. Environmental science & technology, 47(20):11873–11881.

Los, B., Timmer, M.P., and de Vries, G.J. (2015). How global are global value chains? a new approach to measure international fragmentation. Journal of regional science, 55(1):66–92.

Luck, P. (2019). Global supply chains, firm scope and vertical integration: evidence from China. Journal of Economic Geography, 19(1):173–198.

Ma, H., Wang, Z., and Zhu, K. (2015). Domestic content in China's exports and its distribution by firm ownership. Journal of Comparative Economics, 43(1):3–18.

Mahutga, M.C. (2012). When do value chains go global? a theory of the spatialization of global value chains. Global Networks, 12(1):1–21.

Meng, B., Ye, M., and Wei, S.-J. (2020). Measuring Smile Curves in Global Value Chains. Oxford Bulletin of Economics and Statistics, 82(5):988–1016.

Miroudot, S. and Nordström, H. (2020). Made in the World? Global Value Chains in the Midst of Rising Protectionism. Review of Industrial Organization, 57(2):195–222.

Mudambi, R. (2007). Offshoring: economic geography and the multinational firm. Journal of International Business Studies, 38(1):206.

Nielsen, P.B. (2018). The puzzle of measuring global value chains – the business statistics perspective. International economics, 153:69–79.

OECD (2005). Handbook of Economic Globalization Indicators.

OECD (2020a). OECD, TiVA, available at: https://www.oecd.org/sti/ind/measuring-trade-in-value-added.htm (accessed: 10/03/2021).

OECD (2020b). Trade by enterprise characteristics data, available at: http://www.oecd.org/sdd/its/trade-by-enterprise-characteristics.htm (accessed: 10/03/2021).

Rifflart, C. and Schweisguth, G. (2013). Report on new measures of international trade. European Framework for Measuring Progress, e-Frame.

Seuring, S., Yawar, S. A., Land, A., Khalid, R.U., and Sauer, P.C. (2020). The application of theory in literature reviews – illustrated with examples from supply chain management. International Journal of Operations & Production Management, 41(1):1-20.

Shen, B., Zhang, J., Li, Y., Zheng, Q., and Li, X. (2015). International trade modelling using open flow networks: a flow-distance based analysis. PloS one, 10(11):e0142936.

Solaz, M. (2018). Value added and participation in global value chains: The case of Spain. The World Economy, 41(10):2804–2827.

Sturgeon, T.J. (2008). Mapping integrative trade: conceptualising and measuring global value chains. International journal of technological learning, innovation and development, 1(3):237–257.

Sturgeon, T.J. and Memedovic, O. (2011). Mapping global value chains: Intermediate goods trade and structural change in the world economy. United Nations Industrial Development Organization.

Timmer, M.P., Erumban, A.A., Los, B., Stehrer, R., and De Vries, G.J. (2014). Slicing up global value chains. Journal of economic perspectives, 28(2):99–118.

Tranfield, D., Denyer, D., and Smart, P. (2003). Towards a methodology for developing evidence-informed management knowledge by means of systematic review. British journal of management, 14(3):207–222.

Tsekeris, T. (2017). Global value chains: Building blocks and network dynamics. Physica A: Statistical Mechanics and its Applications, 488:187–204.

UN Trade Statistics (2017). Harmonized Commodity Description and Coding Systems (HS), available at: https://unstats.un.org/unsd/tradekb/Knowledgebase/Harmonized-Commodity-Description-and-Coding-Systems-HS (accessed: 14/03/2021).

United Nations (2020). What is UN Comtrade?, available at: https://unstats.un.org/unsd/tradekb/knowledgebase/50075/what-is-un-comtrade (accessed: 10/03/2021).

United Nations Conference on Trade and Development (2020). Global Transport cost for International Trade, available at: https://unctadstat.unctad.org/EN/TransportCost.html (accessed: 10/03/2021).

Weerth, C. (2008). Harmonized system in developing countries. Global Trade and Customs Journal, 3(11/12).

Wen, D. (2018). Domestic value added in China's exports to the world and its partners. The Chinese Economy, 51(1):45–68.

Wickert, C., Post, C., Doh, J.P., Prescott, J.E., and Prencipe, A. (2021). Management research that makes a difference: Broadening the meaning of impact.

Wieland, A., Bals, L., Mol, M.J., & Handfield, R.B. (2020). Overcoming blind spots in global sourcing research: Exploiting the cross-sections between supply chain management and international business. Journal of International Management, 26(1), 100709.

Xiao, H., Meng, B., Ye, J., and Li, S. (2020). Are global value chains truly global? Economic Systems Research, 32(4):540–564.

Xiao, H., Sun, T., Meng, B., and Cheng, L. (2018). Complex network analysis for characterizing global value chains in equipment manufacturing. PloS one, 12(1):e0169549.

Xing, Y. (2016). Global Value Chains and China's Exports to High-income Countries. International Economic Journal, 30(2):191–203.

Xing, Y. (2020). Global value chains and the "missing exports" of the United States. China Economic Review, 61:101429.

Yeats, A. J. (1999). Just how big is global production sharing? The World Bank.

Zhu, X., Liu, B., and Wei, Q. (2019). Does participation in global value chains extend export duration? Review of Development Economics, 23(3):1282–1308.

Zhu, Z., Morrison, G., Puliga, M., Chessa, A., and Riccaboni, M. (2018). The similarity of global value chains: a network-based measure. Network Science, 6(4):607–632.

Zhu, Z., Puliga, M., Cerina, F., Chessa, A., and Riccaboni, M. (2015). Global value trees. PloS one, 10(5): 0126699.

Expert No.	Type of expert	Company	Country	Company description
EX1	Consultant	Company A	Italy/UK	Consultancy for developing export strategies
EX2	Customs officer	-	Italy	Italian customs authority
EX3	Supply chain manager	Company B	Italy/USA	Household appliances manufacturer
EX4	Customs clearance and import manager	Company B	Italy/USA	Household appliances manufacturer
EX5	Consultant	Company C	Italy/China	Consultancy for developing export strategies
EX6	Supply chain manager	Company D	UK	Distributor of spare parts for motorcycles
EX7	Consultant	Company E	UK	Consultancy in operations strategy
EX8	Supply chain manager	Company F	USA	Cosmetics manufacturer and distributor

Table 1 – List of practitioners and experts involved in the study

Research cluster	Definition	Main references
Value-added measurement	Introducing original models for measuring value-added, or implementing existing ones	Hummels et al. (2001) Sturgeon (2008) Amador and Cabral (2009) Daudin et al. (2011) Johnson and Noguera (2012) Koopman et al. (2012) Amador and Cabral (2014) Koopman et al. (2014) Amador et al. (2015) Aichele and Heiland (2018) Miroudot and Nordstrom (2020)
Value-added measurement with respect to specific countries	Using existing models to investigate value-added with respect to specific countries	Kersan-Škabić (2017) Wen (2018) Solaz (2018)
Value-added measurement with respect to specific products	Investigating the entire value chain of specific products	Dedrick et al. (2010) Ali-Yrkkö et al. (2011) Xing (2016) Xing (2020)
Value-added measurement integrating firm-level data	Combining trade data or I-O tables with company and firm-level data	Blyde (2014) Kee and Tang (2016) Ito et al. (2020) Ma et al. (2015) Bemas and Kikkawa (2021)
Value-added mapping	Investigating value-added processes to map them from a geographical point of view.	Mahutga (2012) Ferrarini (2013) Ming et al. (2015) Los et al. (2015) Amador et al. (2018) Xiao et al. (2018) Escaith (2014)
Network analysis	Developing original instruments to visualize, calculate, and represent trade networks.	De Benedectis and Tajoli (2011) De Benedectis et al. (2014) Timmer et al. (2014) Zhu et al. (2015) Cingolani et al. (2018)

Table 2 – SLR research clusters according to subject areas

	Database name	Description	Main characteristics
1	Trade by Enterprise Characteristics (TEC)	The Trade by Enterprise Characteristics (TEC) database contains international annual trade in goods data broken down by different categories of enterprises. The data provides a solid basis for policy analyses that explore which types of firms are responsible for international trade in goods. It answers questions like who are the firms that are engaged in foreign markets, and what are their characteristics.	The dataset explores export and import values and the number of exporting and importing enterprises are available for 26 Organization for Economic Co-operation and Development (OECD) and 6 non-OECD countries: including 27 EU member states plus United Kingdom, Canada, Norway, Israel, Turkey and the United States (OECD, 2020b).
2	Economy-wide Material flow accounts (EW-MFA)	Economy-wide material flow accounts (EW-MFA) are a statistical accounting framework recording, in thousand tons per year, material flows into and out of an economy.	They cover solid, gaseous, and liquid materials, except for bulk flows of water and air. The general purpose is to describe the physical interaction of the national economy with the natural environment and the rest of the world economy in terms of flows of materials (Eurostat, 2018).
3	Sold production, exports and imports by PRODCOM List	PRODCOM provides statistics on the production of manufactured goods carried out by enterprises on the national territory of the reporting countries.	The database comprises about 4000 headings relating to industrial products and some industrial services. These products are detailed at an eight-digit level. The first four digits refer to the equivalent class within the Statistical classification of economic activities in the European Community (NACE), and the next two digits refer to subcategories within the Classification of Products by Activity (CPA). Most PRODCOM headings correspond to one or more Combined Nomenclature (CN) codes (Eurostat, 2020d).
4	United Nations Comtrade	The United Nations (UN) International Trade Statistics Database Comtrade includes data over 170 reporter countries with their annual and monthly international trade statistics detailed by commodities and services categories and partner countries.	All commodity values are converted from the national currency into US dollars using exchange rates provided by the countries or derived from monthly market rates. Quantities are converted into metric units when provided with data from the reporting country and when possible (United Nations, 2020). Commodities are classified according to different standards: SITC, BEC and the HS.
5	Eurostat Comext and Access2Market	Comext is Eurostat's reference database for detailed statistics on international trade in goods. It provides access not only to both recent and historical data of the European Union and its individual	This database is divided into several sections, where data can be accessed according to different types of classification codes: SITC, BEC, HS (eight-digit level) and CPA are available.

		Member States but also to statistics of a significant number of non-EU countries.	In October 2020, the European Commission released an interactive portal (DG Trade) allowing easy viewing and documentation of trade data.
6	Trade Map (International Trade Centre)	Trade Map provides, in the form of tables, graphs and maps, indicators on import and export performance, international demand, alternative markets and competitive markets.	It covers 220 countries and territories and 5300 products of the HS. The monthly, quarterly, and yearly trade flows are available from the most aggregated level to the tariff line level.
7	Global Transport cost for International Trade	To support evidence-based policymaking and research in the transport sector, the United Nations Conference on Trade and Development (UNCTAD) and the World Bank have developed a Global Transport Costs dataset for International Trade (United Nations Conference on Trade and Development, 2020).	The dataset provides the transportation cost, the transport cost to Free on Board (FOB) value, transport cost per unit, transport cost per unit per 10000 km, between two or more countries subdivided into HS code products. The FOB export unit values are a proxy for the trade prices at the factory gate, relying on exporters' declarations. They do not include trade costs.
8	Base pour l'Analyse du Commerce International (BACI)	Base pour l'Analyse du Commerce International (BACI) database, developed by the Centre d'Études Prospectives et d'Informations Internationales (CEPII) provides disaggregated data on bilateral trade flows for more than 5000 products and 200 countries (Ferrarini, 2011).	The database is built from data directly reported by each country to the United Nations Comtrade and products are defined as items from the Harmonized System nomenclature, at the six-digit level. The CEPII developed a procedure that reconciles the declarations of the exporter and the importer, that may be different in the original data. In general, import values are reported CIF and exports are reported FOB. To allow the comparison between mirror data, CIF rates must be estimated and removed from imports values. It uses a gravity-type equation to estimate them (Gaulier and Zignago, 2010).
9	OECD Inter-Country Input-Output (ICIO)	The Inter-Country Input-Output (ICIO) model links internationally input-output tables from 58 countries (one of these countries being the "rest of the world") and accounts more than 95% of world output.	The OECD ICIO model allows the analysis of GVCs from a global perspective detailing all transactions between industries and countries for 37 industries (De Backer and Miroudot, 2014). The basis of the classification of the different industrial sectors is based on the ISIC, a United Nations industry classification system.
10	Trade in Value Added (TiVA)	The Trade in Value Added (TiVA) database, based on ICIO tables, consists of a set of measures that aim to provide better insights into global production networks and supply chains than is possible with conventional trade statistics.	It allows for analyzing the values of flows through different industrial sectors in different countries, but above all also to study the flows of goods between different industrial sectors in the same country. The 2018 version of TiVA covers 64 economies and 36 industrial sectors from 2005 to 2015 (OECD, 2020a).

11	World Input-Output Database (WIOD)	World Input-Output Database combines detailed information on national production activities and international trade data.	This type of information is available in the WIOD database for 43 countries (all EU27 countries and major other countries), plus estimates a model for the rest of the world for the period 2000-2014 (Dietzenbacher et al., 2013). The data are subdivided into 56 sectors, classified according to the ISIC.
12	Global Trade Analysis Project (GTAP) database	The Global Trade Analysis Project (GTAP) database describes the world economy for four reference years (2004, 2007, 2011, and 2014) and distinguishes 65 sectors in 121 countries/regions.	The GTAP reports production, intermediate and final uses, international trade and transport margins, and taxes/subsidies. In terms of sector coverage, GTAP 10 considers 65 products and services and the data sources also refer to datasets from other organisations, such as the United Nations, OECD and World Trade Organization (WTO) (Aguiar et al., 2019).
13	Eora Global Supply Chain Database	The Eora Global Supply Chain Database consists of a Multi-Region Input-Output (MRIO) model that provides a time series of high-resolution input-output tables with matching environmental and social accounts for 190 countries.	The full version of the dataset consists in a balanced global MRIO table documenting the inter-sectoral transfers amongst 15909 sectors, but there is also an EORA26 version, with the more common 26-sector classification. The classification of sectors is defined directly in the dataset (Lenzen et al., 2012).
14	Full International and Global Accounts for Research in Input-Output Analysis (FIGARO)	The Full International and Global Accounts for Research in Input-Output Analysis (FIGARO) tables are a new tool for analyzing the socio-economic and environmental effects of globalization in EU through studies on competitiveness, growth, productivity, employment, environmental footprint and international trade (Eurostat, 2020b).	The structure of this database is in the input-output format and can be based both on trade in product by product categories between European nations but also based on industry by industry. The classification of products is based on CPA.
15	International Manufacturing Strategy Survey (IMSS)	The International Manufacturing Strategy Survey (IMSS) is a research network of business schools and manufacturing assembly companies, which designs a common database and collects data for the study of manufacturing management strategies and practices on both a global and national scale.	The data in this database relate to management strategies: production process, technology, innovation, accountability, supply chain management and globalization.

Table 3 – Database summary

#	Dataset name	Survey based	Trade based	Raw material based	Industry based	Product based
1	TEC	✘	✔	✘	✔	✘
2	EW-MFA	✘	✔	✔	✘	✘
3	PRODCOM List	✘	✔	✘	✘	✔
4	UN Comtrade	✘	✔	✘	✘	✔
5	Comext	✘	✔	✘	✘	✔
6	Trade Map	✘	✔	✘	✘	✔
7	Global Transport Cost	✘	✔	✘	✘	✔
8	BACI	✘	✔	✘	✘	✔
9	ICIO	✘	✔	✘	✔	✘
10	TiVA	✘	✔	✘	✔	✘
11	WIOD	✘	✔	✘	✔	✘
12	GTAP	✘	✔	✘	✘	✔
13	Eora	✘	✔	✘	✔	✘
14	FIGARO	✘	✔	✘	✔	✔
15	IMSS	✔	✘	✘	✘	✘

Table 4. Dataset characteristics

Dataset name	HS based	SITC based	BEC based	CPA based	Other based
PRODCOM List	✘	✔	✘	✘	✘
UN Comtrade	✔	✔	✔	✘	✘
Comext	✔	✔	✔	✔	✘
Trade Map	✔	✘	✘	✘	✘
Global Transport Cost	✔	✘	✘	✘	✘
BACI	✔	✘	✘	✘	✘
GTAP	✘	✘	✘	✘	✔
FIGARO	✘	✘	✘	✔	✘

Table 5. Product-based dataset comparison

Database name	Digit Level	Countries/Areas
UN Comtrade	6-digit	170 countries
Comext	8-digit	reporter: 27 partner: 240
Trade Map	6-digit	220 countries
Global Transport Cost	6-digit	reporter: 105 partner: 200
BACI	6-digit	150 countries

Table 6. HS-based dataset comparison

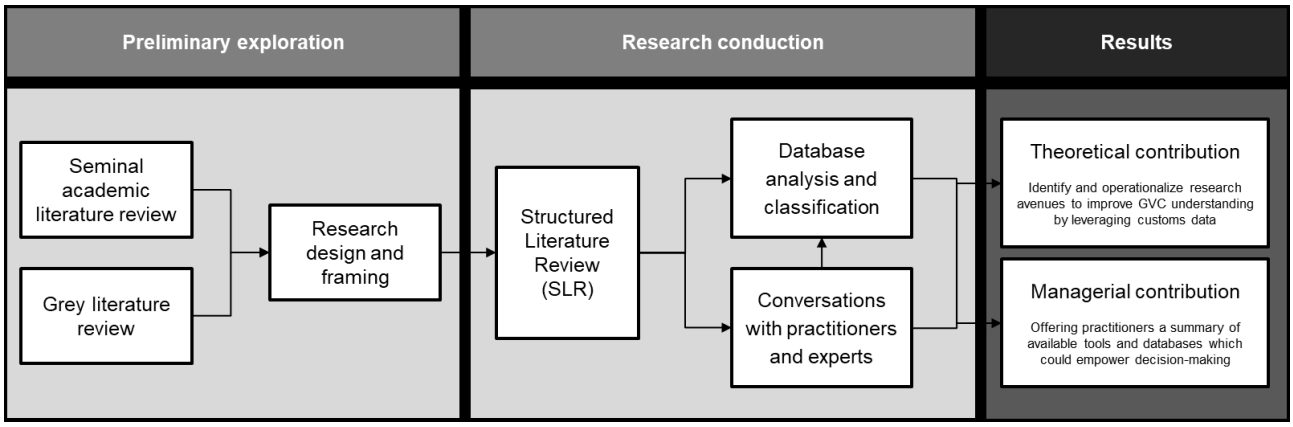

Figure 1 – Research methodology overview

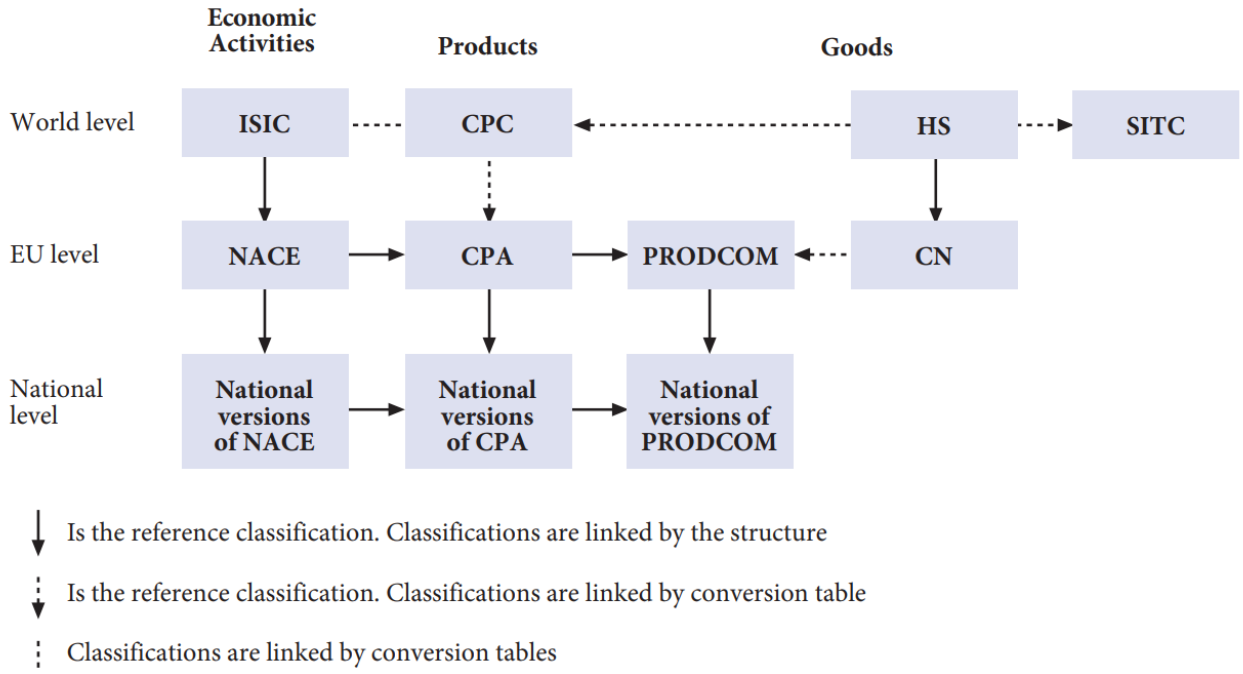

Figure 2. Classification systems representation (*Source: Eurostat, NACE Rev. 2*).