
1. Global value chain mapping

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1.1 INTRODUCTION: FROM THEORY TO APPLIED RESEARCH

Theoretical research frameworks are developed by academics as a means for researchers and scholars to describe and compare the trends and results they see based on their exploratory case-based research. Like basic research in the hard sciences, social scientists have the advantage of looking at many different factors that may explain why observed phenomena occur without an applied agenda and from an unbiased viewpoint. The objective is to provide a theory and framework to explain why things occur and why they vary under certain circumstances (such as by industry, geography, and time).

Global value chain (GVC) research has evolved from a theoretical framework to become an applied research approach over the last 20 years. As described in detail in other chapters of the *Handbook* and elsewhere, the GVC framework was developed based on case studies and qualitative firm-based research. As GVC analysis has increasingly gained the attention of policymakers, there has become a need to link theoretical concepts to a definable research approach. This shift from theory to application has also led to the use of more standardized data sources to enable comparability and repeatability over time. Applied research implies that actionable recommendations can be made based on the outcomes of using the framework. The objective is no longer just to explain how and why certain countries participate in an industry, but also to determine how successful a country has been in the industry and to provide recommendations on how this can be sustained or increased into the future. In today's data-driven world, to be useful for policymakers and government agencies, these comparisons and recommendations need to have at least estimated quantifiable metrics on key topics such as increases in exports, output, employment, wages or skill levels. This requires the use of industry-specific national and firm-level data.

While case studies and fieldwork remain key elements in GVC analysis as they provide critical insight on factors that are not explained by industrial statistics, there are several benefits to defining or mapping GVCs using international classification systems. For example, it enables repeatability and comparability over time and across countries and provides the ability to measure GVCs.¹ Once a GVC has been defined using classification systems, it is possible to develop metrics related to both current participation and upgrading over time (Frederick, 2014a). Furthermore, it enables policymakers to evaluate GVCs in a more quantifiable way and to see how GVC-specific developments impact macroeconomic indicators.

GVC mapping and measurement by international agencies and trade economists seeking to develop new metrics of global economic activity such as 'trade in value added' that integrate international trade statistics, national production data and input–output data at high levels of industrial aggregation should be viewed as complementary yet distinct from the approach outlined in this chapter (see Frederick, 2014a and Sturgeon, Chapter 3 this volume for a review and comparison of work by these groups; and Mattoo, Wang and Wei,

2013 for a compilation of key themes). The GVC work by the former seeks to give a more accurate depiction of where and how value is added at the country level to improve how countries are evaluated using indicators such as gross domestic product (GDP) and gross exports. The objective of the GVC approach described here is to categorize and group products, services, firms and countries in ways that provide explanations for why specific industries operate in different ways using a range of secondary and primary data sources. Value chain mapping seeks to describe an industry in a way that is analytically useful.

Section 1.2 introduces the key parts of the global value chain research approach. Section 1.3 defines global value chains and mapping and provides a template and taxonomy with which to describe key GVC concepts, followed by the types of data and classification systems that can be used to define GVCs. Section 1.4 provides examples of mapping from GVC projects.

1.2 THE GLOBAL VALUE CHAIN RESEARCH APPROACH

The GVC research approach uses the value chain as its organizational structure for describing and visualizing detailed industry studies. It is inclusive as it covers all manufacturing and service-related activities from conception through end use. While a single firm or geographic location can conduct these activities, in most cases they are divided among multiple firms in locations around the world, hence the term *global value chain*.

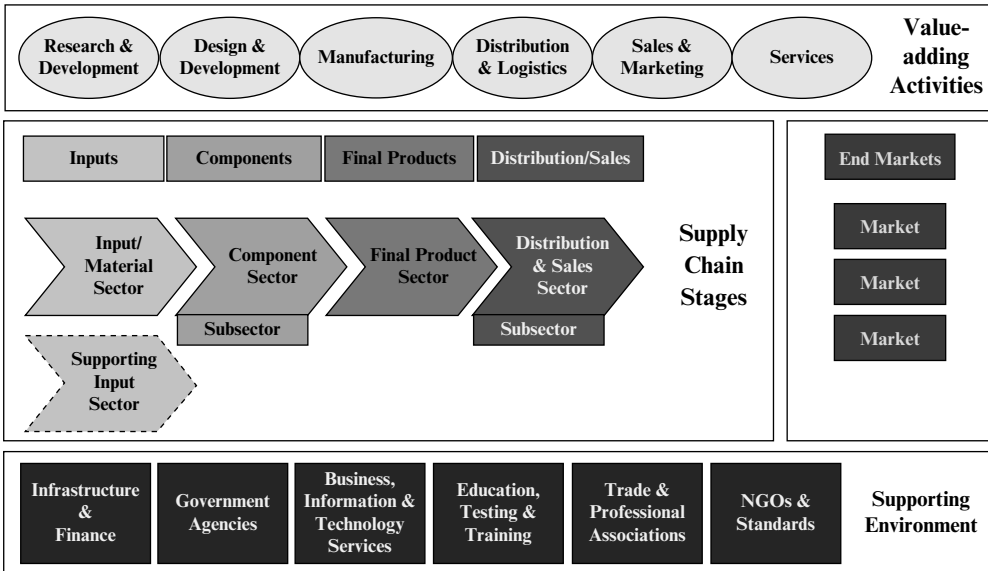
The theoretical foundation of the approach is the GVC framework, which can be broken into a two-part research process composed of value chain mapping and value chain analysis. The focus of this chapter is mapping – identifying the firms, products, activities, stakeholders and geographic locations involved in taking a good or service from concept through production to the final consumer. Simply put, it is the process of determining the ‘who and what’ to be analyzed. Value chain analysis looks at how and why these factors are linked together by analyzing the role certain factors (governance, institutions and interfirm relationships) play in influencing the location, development and competitiveness of a product or service. Understanding where, how, and by whom economic, social and environmental value is created and distributed along the chain provides critical information needed by economic developers to determine optimal interventions and leverage points to initiate change.

Developing an accurate and adequately detailed value chain map is critical because it provides the scope of what will be analyzed. If key pieces of the chain are omitted, results will provide an incomplete picture and may result in policy recommendations that are ineffective or counterproductive. As such, this chapter provides a template and taxonomy for value chain mapping to ensure all facets of the chain are included, as follows.

1.3 DEFINING GLOBAL VALUE CHAINS

1.3.1 Parts of the Global Value Chain Model

The first step in value chain mapping is identifying the structural parts of the chain. The model presented here is industry-neutral and scalable and includes a visual template and



Source: Author.

Figure 1.1 Parts of the global value chain model

taxonomy for the four key parts: (1) value-adding activities or business functions; (2) supply chain; (3) end markets; and the (4) supporting environment (Figure 1.1). The focus of GVC research can be on physical products, a service, or an enabling technology that impact goods or services.

Value-adding activities represent the six basic functions firms engage in to bring a product from concept through to creation, starting with research and design through manufacturing and distribution, and finally to marketing, sales, and services:²

- Research includes activities related to improving or developing a new physical product or process as well as market and consumer research.
- Design includes both aesthetic and engineering-related product developments. Locations classified in design engage in activities such as new product development and creating prototypes. Software and modeling tools are important for this activity.
- Manufacturing locations have a production facility and are primarily engaged in making a product that is sold to other companies in the chain or to final consumers.
- Logistics and distribution locations are involved in transporting or storing products or input materials. Firms performing this function include wholesalers, intermediaries and distribution centers and warehouses.
- Marketing and sales activities are associated with branding, advertising and retailing; these locations typically do not make physical alterations. Activities are often performed at a headquarters location.
- Locations engaged in service-related activities provide general business or after-sales services such as customer support, repair or maintenance.

The second part is the supply chain, which represents the input–output structure of the products or flow of business interactions for the product or service being mapped. It has four main stages: (1) materials/inputs; (2) components/intermediates; (3) final products; and (4) distribution/sales.³ A supporting industry stage can also be used to highlight the tools/equipment or auxiliary inputs needed along the chain. The visual flows from left to right, and it is helpful to use different colors (shown as shading here) to represent different stages in the chain. The model will have many ‘layers’ that provide more detail than the main stages. For example, each stage can be broken into sectors, which can be further disaggregated into subsectors or products. To avoid clutter, the main visual should focus on key stages and subsequent images can be included to show detailed flows as needed.

The third part of the model are the end markets of the final product or service. While this segment can be considered an extension of the supply chain, it is analytically useful to separate it. End market categories can be used to group products that share product, geographic and buyer-specific characteristics. For instance, in electronics it is useful to analyze consumer electronics separately from industrial, medical or automotive electronics. Similarly, in the apparel industry, the product specifications and requirements of institutional and industrial buyers (e.g., government agencies or businesses) are different than the consumer-retail market.

The final part of the model is the supporting environment. These are the institutional actors at the local and global levels that create and enforce the legal or societal parameters for participating in the chain. These actors include government agencies, industry associations, infrastructure and utility providers. Some provide support and regulation specific to the industry while others have an economy-wide focus.

1.3.2 The Qualitative Global Value Chain Mapping Process

Value chain mapping begins the same way one would conduct an industry or market analysis. Initial research in GVC studies starts with secondary literature and previous studies by industry or economic development associations, scholarly literature such as journal articles, and product, industry and market reports by contract research organizations (see Appendix Table 1A.1 for examples of each type). This is supplemented with interviews with key stakeholders along the chain from the public and private sectors. Box 1.1 lists the main steps to create a GVC map.

Building a value chain map based on one’s own interpretation from extensive secondary research of how an industry operates is an important step because it enables the researcher to conceptualize all the actors and products involved in a GVC and not just those easily identifiable using data. Conducting GVC analysis in this way enables shortcomings in econometric analysis to be identified.

1.3.3 Mapping Based on Standardized International Classification Systems

Once a qualitative GVC map is created, the next step is to build one based on standardized classification systems for the key elements of GVCs: products, services, firms, activities, workers, and countries. This section introduces the levels and types of data and classification systems that can be used to build a quantitative basis for GVC mapping, which is further detailed in Appendix Table 1A.2.

BOX 1.1 GVC MAPPING: QUALITATIVE RESEARCH STEPS

1. Compile a list of keywords for the industry. Take note of how different sources categorize the industry and continue to build this list throughout the research process.
2. Create a supply chain and relevant product groupings. Determine which of the four stages you are focusing on because this impacts how you describe upstream (backward) and downstream (forward) linkages. Take consumer electronics (final products) as an example. What are the main final products? These include computers, home electronics (e.g., TVs) and cell phones. What are the main components that go into these products? These include integrated circuits, circuit boards, electronic components, wires, casing, and software, among others. At this point, it is fine to have a long list of components, which can be narrowed down as the research progresses.
3. Determine the reach of the GVC. Should the chain include direct suppliers or suppliers of suppliers? For example, in the automotive value chain, an automotive parts manufacturer that sells to an assembler should be included and is identifiable, but what about a third- or fourth-tier supplier of screws used in the seatbelt? The decision is subjective and depends on the objective of the research and availability of data. The compiler should establish a threshold and communicate it to users.^a
4. Determine the types of buyers of the final products. This includes consumer, industrial, government or institutional markets. Which value-adding activities beyond manufacturing are the most important for the GVC and does it vary by buyer type?
5. How do firms interact in the chain? What are the typical distribution channels at each stage? Do firms interact directly or are products sold via third parties?
6. Identify the top countries and regions of the world for each stage. This can be achieved by identifying the locations and activities of the key firms involved and supplemented with national trade or production data described in the next section.
7. Identify leading firms for each product and market. Create company profiles using financial statements, websites, news articles and interviews. Identify common corporate structures and strategies firms are using to compete in each market.
8. Identify important institutions such as tariffs and standards and supporting stakeholders, including industry associations and government agencies.
9. Once the global template is created, national data can be layered in for countries of interest. Industry associations or export processing zones often provide details on firm activities and production output; however, there is no standardization across countries, so ability to use this to benchmark a country's position is limited.

Note: a. Sturgeon, Chapter 3 this volume, describes 'a new classification of specified intermediate goods and services' that will provide insight on how to make this determination.

The types of data described below have three levels. Primary data are referred to as firm, establishment or micro level; raw data are collected by a national agency (Customs, National Statistical Offices [NSOs], Ministry of Industry/Commerce or Labor) via electronic records or paper surveys. They are confidential and only accessible to third parties for authorized special projects. The second level provides national-level information. The compiling agency (NSO, Central Bank) modifies the microdata for its intended purpose and publishes aggregate statistics for national and subnational levels. The third level covers international compilations of national data. International organizations collect data from NSOs and populate international databases on a certain topic. Access to national and international data may be free or fee based, and available as a hard copy, an electronic document, or an online database (Frederick, 2014a).

It should be noted that these data sources can be used to build a GVC map but are insufficient to explain why and how an industry operates. GVC analysis requires firm- and product-specific information that cannot be gleaned from national statistics alone. This would require access to firm-level microdata, ideally collected using the same firm-level identification number across datasets to enable tracking over time and across variables. Unfortunately, this is not available for most countries, which is why both processes should be used.

Types of data and classification systems⁴

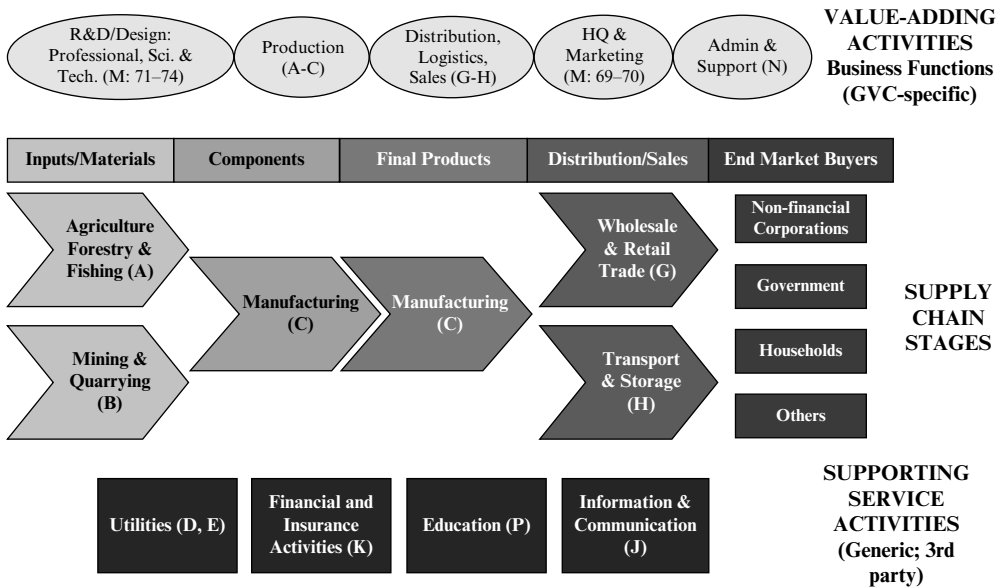
The first type classifies the activities of workers engaged in paid employment based on the International Classification of Occupations (ISCO). Data are collected from the workers within a country by the government agency responsible for producing statistics on the labor market. Whereas this classification exists, it is not widely used and countries that do collect occupational data often do so at the highest level of aggregation (nine occupations).

The second type is trade in goods (products) data based on Harmonized System (HS) codes. An exporting firm selects the HS code and a customs agent verifies the products are correctly assigned. This is the most detailed and robust dataset because HS codes are tied to tariffs, which are legally required fees. International trade also involves multiple countries and the entry of physical goods into a foreign location so security reasons for labeling and collecting data exist. Trade data allow one to identify key countries engaged in buying and supplying products on the international market, but do not cover domestic production and consumption.

Third are industrial statistics that provide information on economic indicators such as employment, wages, output, and value-added. This information is collected by NSOs from multiple sources such as enterprise surveys, financial statements and tax records, primarily for producing the National Accounts.⁵ It is used to determine the economic activities of establishments (firms) using the International Standard Industrial Classification (ISIC) system. Economic activities are classified as primary, secondary and ancillary: the primary activity accounts for the majority of value-added (or output); secondary activities are assigned if they account for a significant share of value-added; and ancillary activities are not accounted for separately. Guidelines for compiling this data exist, but unlike trade data, there is no legal mandate for collection or dissemination, so the process varies by country.⁶ The underlying data are often published by other agencies to report on industrial activities or these agencies may collect their own data using the ISIC system but with a different methodology for assigning codes. As such, a country may not publish any data or have conflicting results from different agencies.

Of the 21 one-digit ISIC codes (sections), 12 form an outline of the GVC model (Figure 1.2). However, they are not specific to one GVC because most codes outside of sections A, B and C (agriculture, mining and manufacturing respectively) are not industry specific. Institutional sectors are like end markets: non-financial corporations (industrial), households (consumer), and general government (institutional).⁷

The fourth type of data are on services, which are classified using the Extended Balance of Payments Services (EBOPS) Classification. In 2015, a new grouping for services by the Task Group on Measuring Trade in ICT Services and ICT-Enabled Services was also released, which describes where and how service activities are conducted. The limited ability to map service activities in GVCs is a critical shortcoming in terms of existing classification systems and data availability (Box 1.2).



Note: Codes in the model are based on ISIC4 and SNA sections.

Source: Adapted from Frederick (2014a).

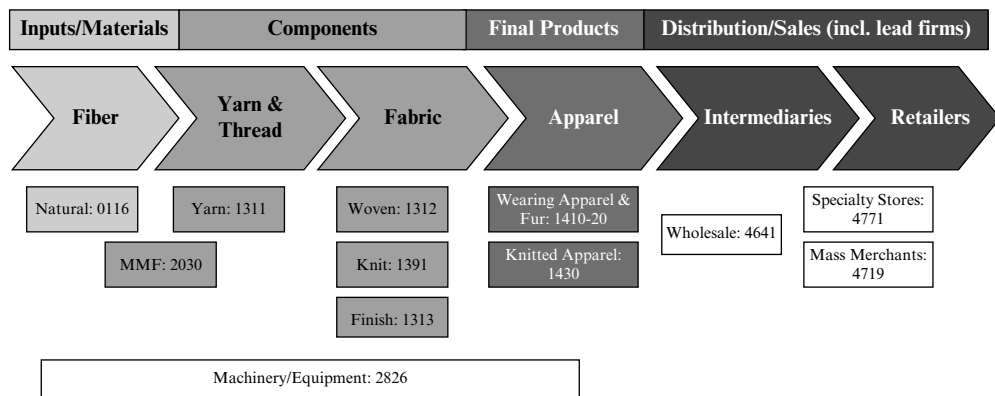
Figure 1.2 Global value chain model

BOX 1.2 LIMITATIONS OF INDUSTRIAL CLASSIFICATIONS IN MAPPING SERVICES IN GVCs

One of the difficulties in GVC mapping is the ability to link service activities. When an establishment provides service-related activities, it will not be associated with a code identifiable to an industry-specific GVC. Industry-specific codes only exist for a few service activities, even then only at the four-digit ISIC level. The following illustrates how a company in the apparel value chain might be classified based on its activities:

1. Assembles fabric into garments using materials it owns or was provided by a third party to assemble. ISIC 14: Manufacture of wearing apparel.
2. Outsources assembly to a third party; only coordinates the purchase of inputs needed for production and/or ensures the product is shipped to the final customer. ISIC 46: Wholesale trade or ISIC 52: Warehousing and support activities for transportation.
3. Is the headquarters. ISIC 70: Activities of head offices; management consultancy.
4. Conducts R&D related to the product. ISIC 72: Scientific R&D.
5. Sells the final product to the consumer. ISIC 47: Retail trade.

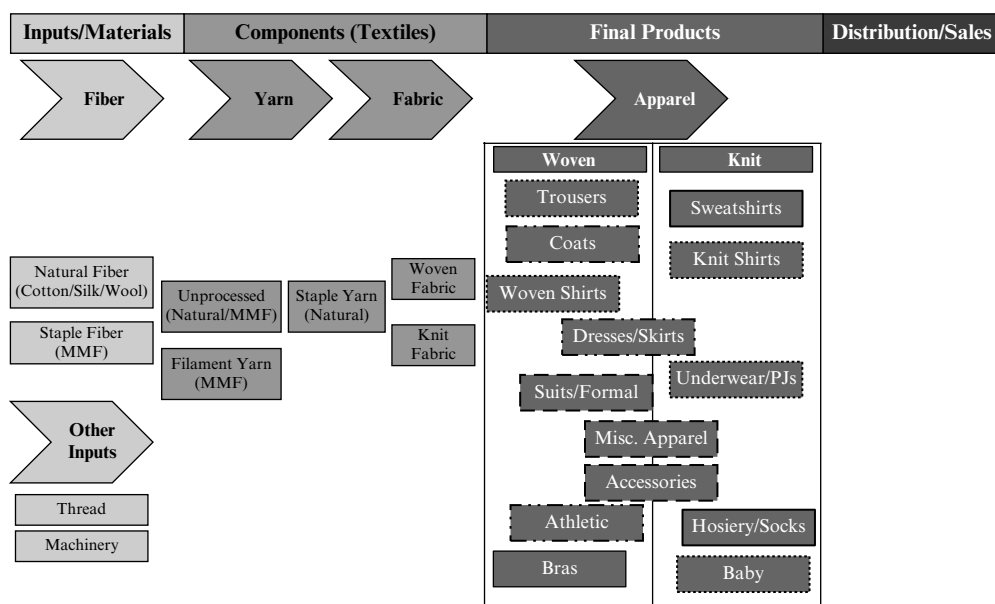
Only the first establishment above is identifiable as part of the apparel industry based on its code. This is problematic because key firms in the GVC often conduct activities 2-5 rather than engage in manufacturing directly. To overcome these issues will require collecting more data using new classifications such as the one for business functions (see Sturgeon, Chapter 3 this volume).



Note: Unshaded boxes cannot be determined using supply-and-use tables (SUTs).

Source: Author.

Figure 1.3 Apparel global value chain based on ISIC4



Source: Author.

Figure 1.4 Apparel GVC based on HS codes

The detail available in the different systems varies; HS codes are significantly more detailed than ISIC (see Figures 1.3 and 1.4). GVCs composed of products and economic activities that were significant when the classification systems were created in the 1960s–80s (such as textiles) have more detailed codes than new products and activities (such as consumer

electronics or services). Data availability also varies; service data are the least available and accessible, while trade data on physical goods are the most readily available. As such, a GVC map will look different depending on the industry and classification used.

Figures 1.3 and 1.4 are examples of the apparel GVC, with associated codes based on ISIC4 and HS codes respectively. In Figure 1.3, apparel is represented by code 14. The primary physical inputs for apparel are fabrics, which fall under ISIC4 1312 (woven) and 1391 (knitted), and prior to fabric is yarn (1311) and man-made fibers (MMF) (2030). In Figure 1.4, apparel products are represented by HS codes 61 and 62, and most textile inputs fall between 50 and 60 (codes not shown due to space limitations).

Methods of identifying relevant codes These classification systems were created by multiple organizations for different purposes several decades ago when offshoring and outsourcing were far less common. Consequently, they are not designed to analyze industries from a GVC perspective. To do so requires the use of concordance files, and reconfiguring and linking the data across systems to represent the activities of GVCs rather than industries.

The Central Product Classification (CPC) is a conversion classification for goods and services that are the result of domestic production. It enables data on the activities of establishments (ISIC) and traded goods and services (HS and EBOPS) to be analyzed together using concordances between the CPC and these classifications. Data are not collected based on CPC codes; national accountants assign CPC codes when creating supply-and-use tables (SUTs) using microdata from establishments. A second alternative classification is the Broad Economic Classification (BEC), which can be used to separate supply chain stages into primary and processed codes and intermediate and final products (Frederick, 2014a).

There are two methods for identifying relevant codes and assigning them to stages in the chain. The first is based on keyword searches of the titles of the classification system codes.⁸ The most relevant keyword for the GVC should be used to search the full list of CPC titles.⁹ For example, if mapping the medical device GVC, the word ‘medical’ is a logical starting point. This will produce a list of CPC codes that can be used to identify the corresponding ISIC, EBOPS and HS codes. Most corresponding codes do not have one-to-one relationships across classification systems, so the codes should be correlated *back* to CPC to identify other products to gauge how relevant the code is to the GVC. To ensure all codes are included, ISIC, EBOPS and HS should also be searched for keywords and any new codes identified should be reviewed in the other classification systems.¹⁰ The process of searching for keywords can be repeated as many times as needed to ensure all codes are identified. It also needs to be performed using keywords for each stage of the chain. This method provides a way to populate a value chain map with data, but it does not enable one to analyze how the stages and sectors within the GVC interact with firms in other stages.

The second method uses SUTs or input–output tables (IOTs) to identify forward and backward linkages. For intermediate inputs, the ‘Use Table’ in an SUT can be used to identify CPC codes of the products used in the output of relevant CPCs (see Figure 1.5a) or an IOT to identify relevant ISIC codes of the buyers (intermediate or final uses) of the output of the industry. The selection of the initial code(s) for the search is up to the researcher. Since these provide the average production across all the products produced by the industry, the share of an industry’s inputs supplied by upstream suppliers and the

share of an industry's output that relates to the GVC (as a subsequent input into another production process or as a final consumption good) need to be determined. This can be used to verify that the selections from the first method are accurate. Ideally this process is completed using world tables or multiple countries and years; firm-level data should be used to add additional details (Box 1.3). Certain stages of the chain, such as capital equipment and machinery, are not identifiable using SUTs because only information on the goods and services required to produce the output of the establishment are recorded.

Once the relevant codes from each classification system are identified, the researcher can simply use those codes for GVC mapping. These groups of codes represent the GVC-based classification of the industry (Frederick, 2014a). GVC models have been completed for several industries including three of the largest traded industries: textiles and apparel, automotive, and electronics, which collectively account for approximately 30 percent of global product exports.¹¹ Select sources are provided in Appendix Table 1A.4 in addition to a subset of GVC studies covering over 50 industries at varying levels of specificity from agriculture to services by the Duke Global Value Chains Center (GVCC). Other resources maintained by GVCC include the GVC Initiative website, which includes citations to a wider range of GVC research, and the North Carolina in the Global Economy website, which maps seven industries with a focus on visualizing data from multiple sources. Several other organizations such as the World Bank and the United Nations Statistics Division are also adopting and developing tools and resources using these GVC-based industry definitions. For example, the latter has organized a working group to produce a *Handbook on Accounting for GVCs* with guidelines for NSOs on data collection methods to map and measure GVC participation.

1.4 APPLICATION OF DATA-DRIVEN GVC MAPPING: COUNTRY AND STATE COMPARISONS

Based on these codes, national statistics on the number of enterprises, employment, income, turnover, and geographic location can be layered in. Value chain maps can show a country's (or other geographic area's, such as a state or province) footprint in an industry compared to other places, a country's importance to the GVC at a global or regional level, and the evolution of participation over time. The following are brief examples from existing GVC studies.

1.4.1 Example 1: Apparel Comparison Based on GVC Image of Exports

Figure 1.6 and 1.7 are examples of national export data for Vietnam and China layered onto a GVC diagram based on HS codes to show each country's global footprint. This enables one to easily see how the countries compare, and China's dominance in terms of global exports.

1.4.2 Example 2: Medical Devices: Product Focus, Exports and Longitudinal

Figures 1.8a, b and c compare the distribution of export shares by product category in the medical device GVC of Costa Rica with Mexico and Ireland. Mexico's profile is

BOX 1.3 GVC MAPPING WITH FIRM-LEVEL DATA

The following example uses the medical device industry^a in Costa Rica to illustrate how linking firm-level trade and industrial data can be used to create a more detailed GVC map. Figure 1.5a followed the process of using the national SUT to identify the main intermediate manufactured goods consumed by the 28 establishments in ISIC 3250.^b With the addition of firm-level trade data, the GVC map was elaborated for specific product categories. In Figure 1.5b, export data were used to determine thresholds for the number of firms in Costa Rica in each product category and import data enabled identification of the specific intermediate inputs for three of the four segments. For example, disposable exporters primarily purchase plastic/rubber products and medical-specific components, whereas therapeutic device exporters purchase chemicals. The visual is color coded (shaded here) based on the number of firms in different product segments. Boxes like chemicals that are not shaded indicate there are no local suppliers with that code in Costa Rica. Identifying the key inputs for companies that specialize in different product segments can also be determined through company interviews; however, this is time intensive and does not enable comparisons with other countries or changes over time. If firms use domestically produced inputs, these data should be included. In the case of Costa Rica, SUT data revealed that domestic intermediate goods and services purchases were only 9 percent, and imports accounted for 91 percent.

a. National SUT data

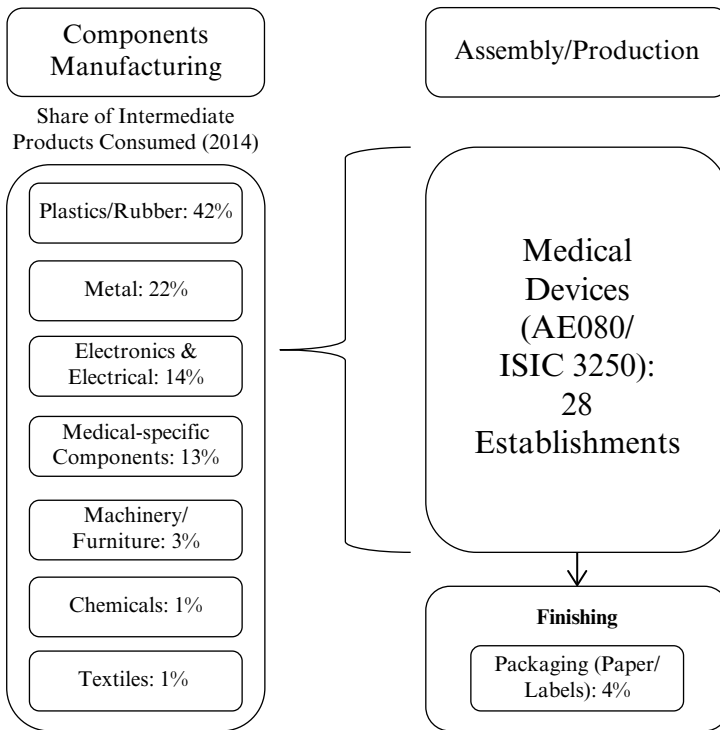
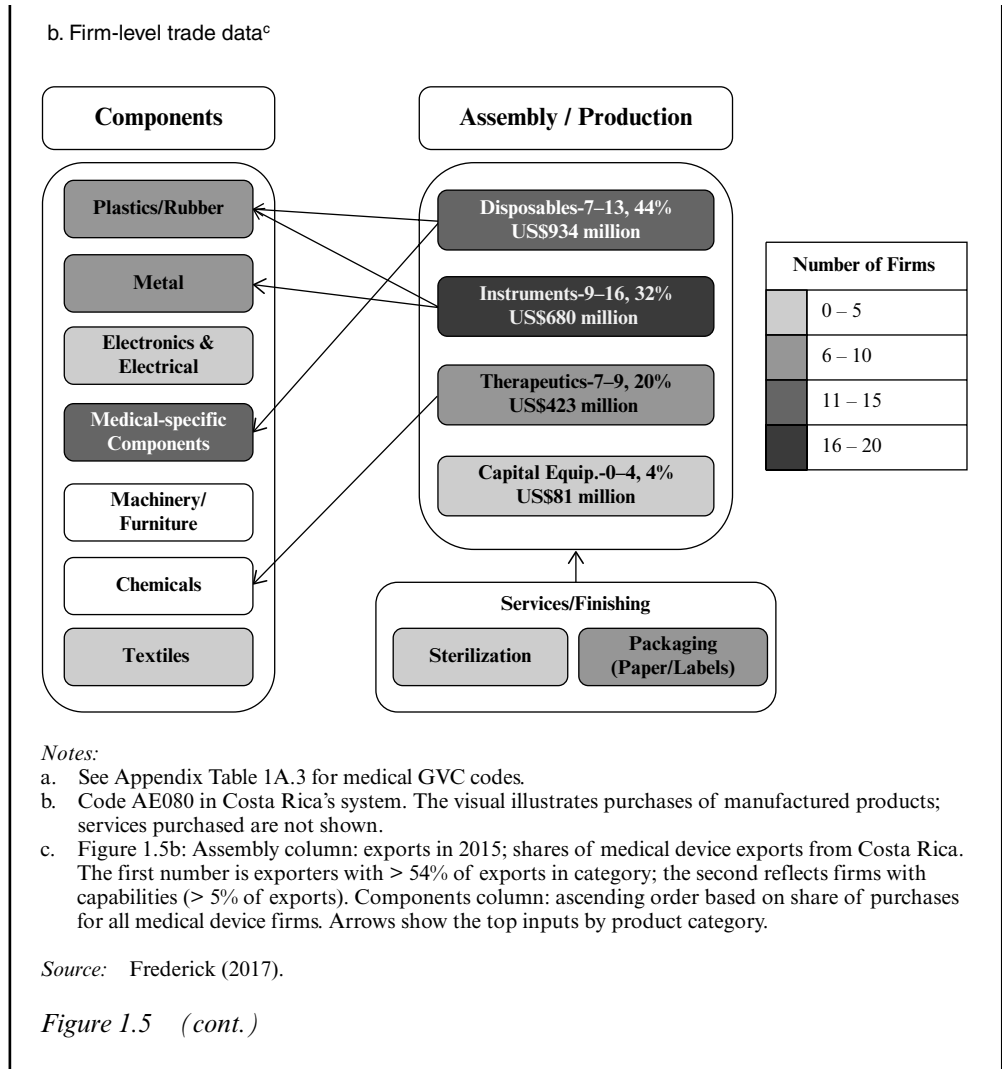
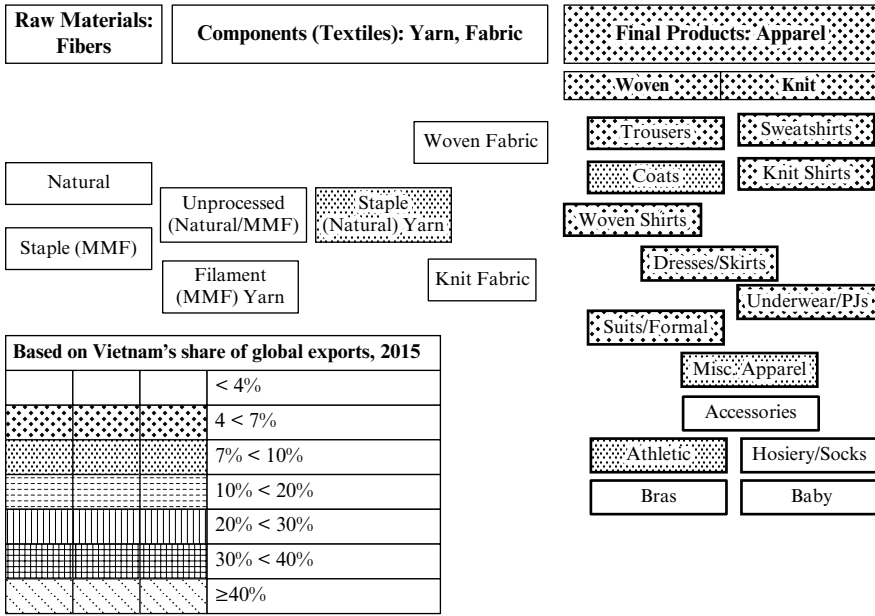


Figure 1.5 Costa Rica in the medical device global value chain

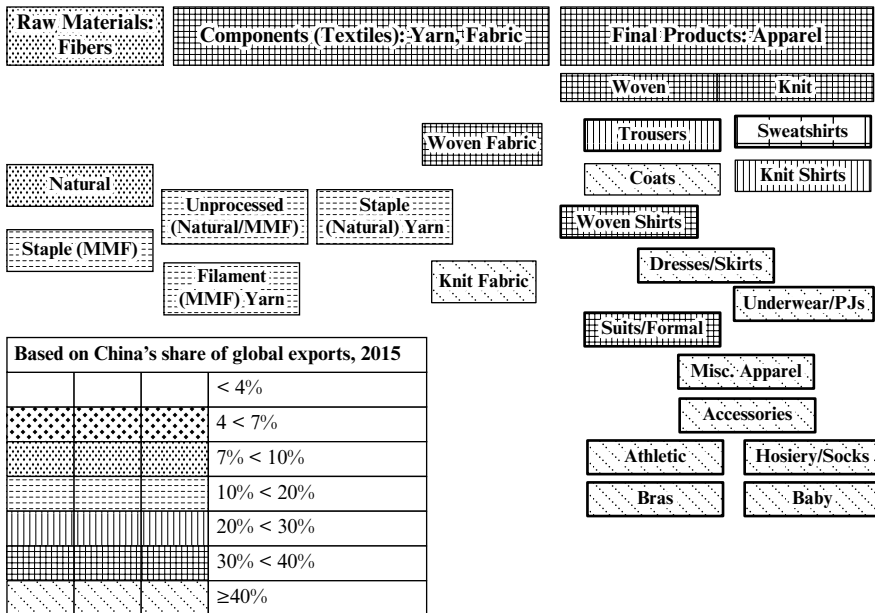


like Costa Rica's; however, their export values are much higher, whereas Ireland is more engaged in therapeutic devices. These figures quickly show that not all medical device exporting countries produce the same products or follow the same development pathways. Policymakers can use these comparisons to identify countries with export trajectories the country would like to follow. Linking export data with employment and wages can be used to identify product segments that offer higher wages.¹² In Costa Rica, average wages per employee are highest in therapeutics, followed by instruments and finally disposables (Frederick, 2017).



Source: Author.

Figure 1.6 Vietnam's footprint in the apparel GVC (2015)



Source: Author.

Figure 1.7 China's footprint in the apparel GVC (2015)

1.4.3 Example 3: Furniture: Employment, Exports and Wages by Sector

Like the example above comparing exports over time, employment data can also be used to show which product sectors within an industry are the focus of different geographic areas at a point in time. Based on furniture manufacturing employment, the top US states are North Carolina (NC), California, Texas, Indiana, and Michigan. Within segments of furniture manufacturing, North Carolina leads in household furniture employment, Michigan leads in office furniture, and Texas and California lead in furniture-related products. Visualizing the data makes it easy to see that each state's product portfolio differs (Figure 1.9).

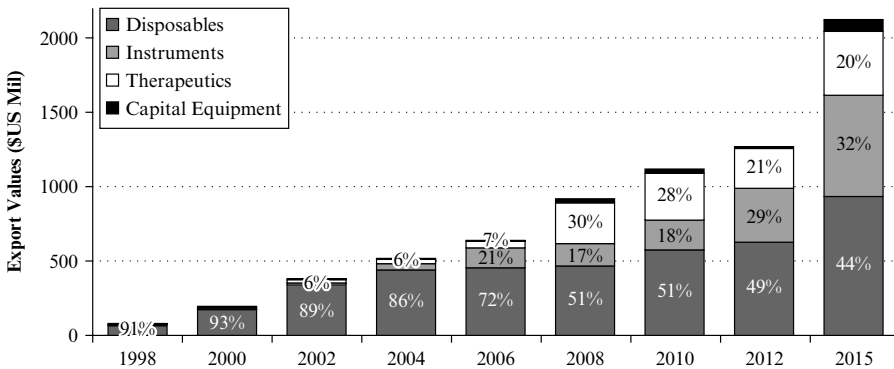
It is useful to look at a geographic area's footprint based on more than one indicator. Continuing with the furniture example, when state-level exports are considered instead of employment, the top US state is Michigan, followed by California, Texas, and NC. The top household furniture exporters are California, Michigan and NC, and the top office furniture exporters are Michigan, Texas and California. Combining analysis from these two sources provides a better picture of each state's footprint. North Carolina is the largest employer, but the fourth-largest exporter, indicating that most production is for the domestic market. Similarly, Indiana and Mississippi are both top employers but not exporters. Michigan was the fifth-largest employer; however, it was the most significant overall exporter taking the top position in office furniture and the second position in household furniture. Of the top US states, wages per worker in Michigan are also the highest with workers earning US\$22,000 more annually than workers in NC in the household and office segments. This likely indicates that exporters pay higher wages than those selling to the domestic market or firms in Michigan are more productive and/or use more capital-intensive manufacturing processes.

1.5 CONCLUSION

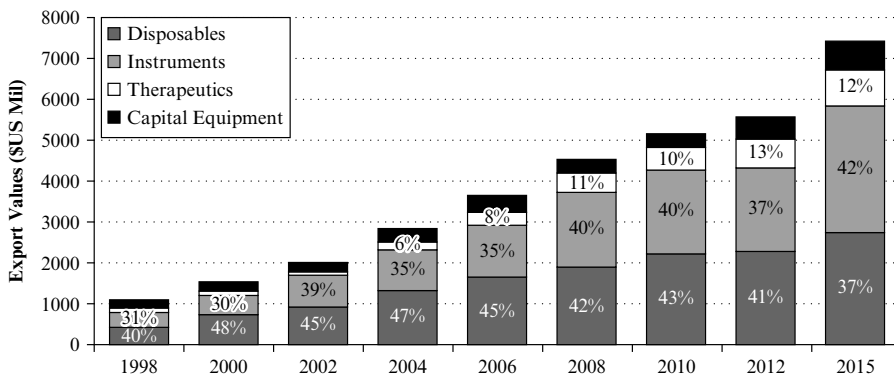
Global value chains challenge the way statistics on trade and output are collected and there is growing awareness that current statistics can give the wrong picture (De Backer and Miroudot, 2013). Existing classification systems were created at a time when outsourcing and offshoring and international production fragmentation were in their infancy. As such, there are limitations to using these classifications and data sources in GVC studies. However, policymakers make data-driven economic development decisions, so it is important to incorporate this into GVC studies and to provide results based on qualitative and quantitative approaches to provide better indicators of what happens in real life.

The ability to do this starts with GVC mapping because this is when the blueprint for analysis is established. This chapter provides an industry-neutral GVC model and taxonomy and a qualitative and quantitative mapping process that facilitates linking trade and industrial statistics into the analysis. In doing so, it introduces a GVC-based definition of an industry and provides examples from recent research projects.

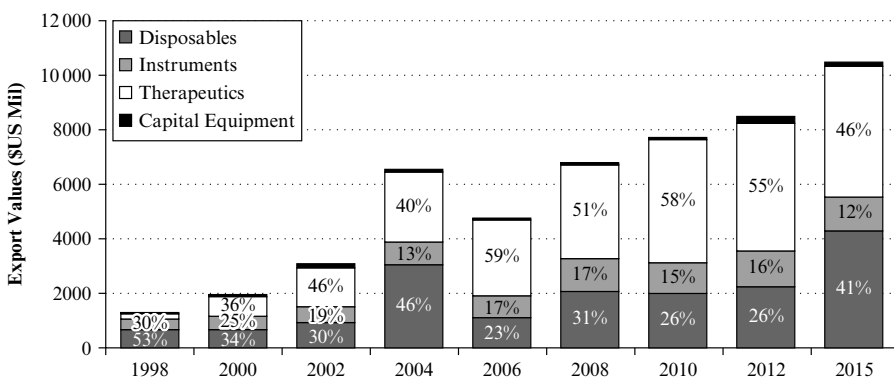
a. Costa Rica



b. Mexico



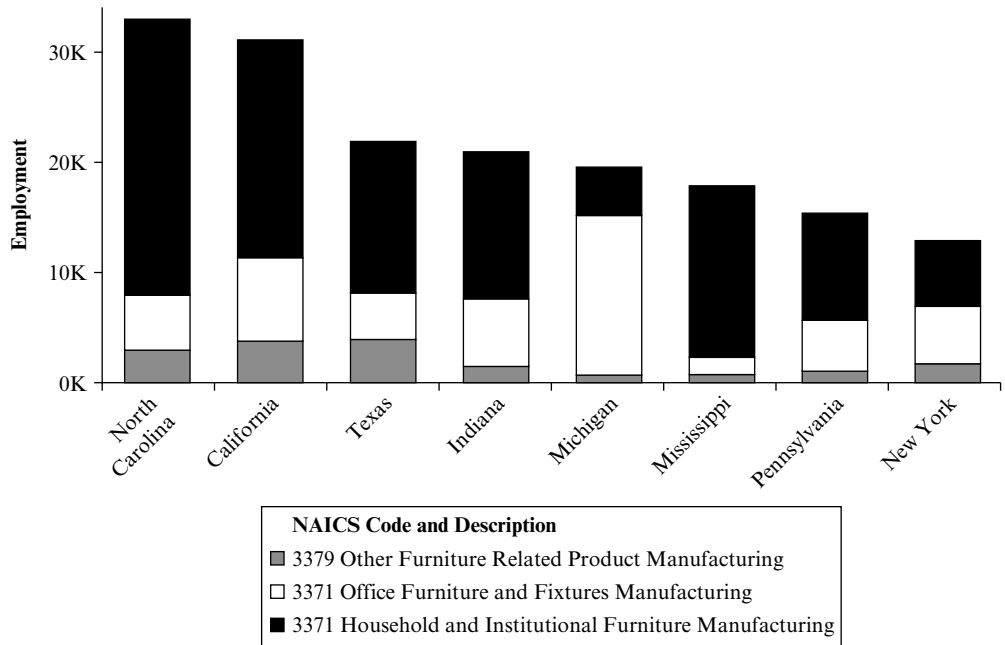
c. Ireland



Source: Data from UN Comtrade; Frederick, Mora and Jansen (2017).

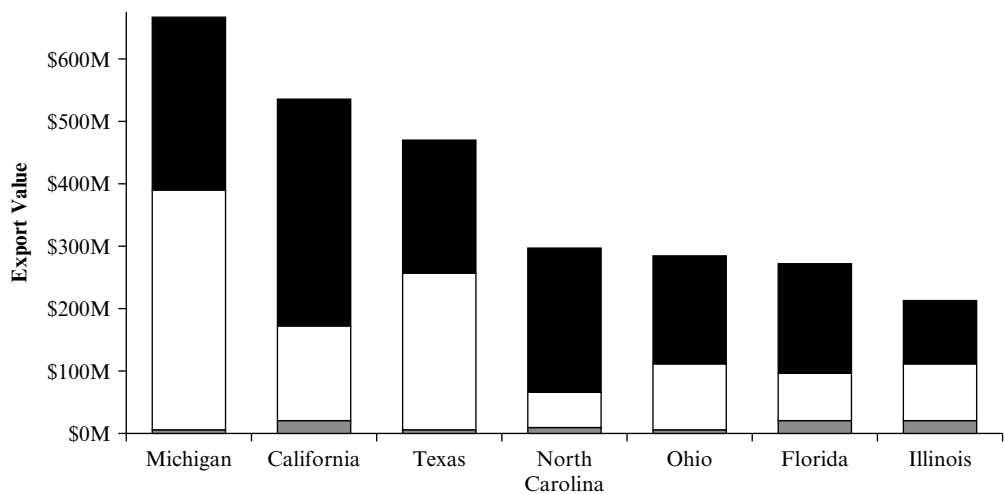
Figure 1.8 Medical exports by product category: Costa Rica, Mexico, Ireland, 1998–2015

a. Employment



Source: Author, based on data from US Furniture Industry Privately-Owned Employment, US BLS Quarterly Census of Employment & Wages.

b. Exports



Source: Author, based on data from USA Trade Online, Exports by State.

Figure 1.9 US furniture top states by type: employment and exports, 2012

NOTES

1. See the final section of this chapter and Chapter 3 by Sturgeon, Chapter 4 by Mahutga, and Chapter 5 by Chor in this volume for a continued discussion on GVC measurement.
2. The concept of value-adding activities matches the concept of the business functions described by Sturgeon, Chapter 3 this volume.
3. Some GVCs have many intermediate parts or industry-specific terminology. In these cases, additional stages or substages are needed. For example, intermediary products (between materials and intermediates) and subassemblies (between intermediates and final products). Manufacturing GVCs may also include disposal/recycling.
4. Most countries have a national system for each of the following that is based on the international system described below. These can be converted using a concordance file.
5. The information and the collection process are provided in the System of National Accounts (SNA). National Accounts data are ultimately collected to produce indicators such as gross domestic product (GDP) that are comparable across countries but are not industry specific.
6. The UN National Accounts Questionnaire has 22 tables; collection details are provided in various handbooks.
7. These are from the SNA; financial institutions and non-profit institutions service households not included.
8. Many initial versions of GVC maps were developed using keyword searches and verified by industry experts (Sturgeon and Memedovic, 2011).
9. Some descriptions include 'except,' so the results should be carefully reviewed.
10. Any classification system can be used as the starting point; however, CPC is the most inclusive and detailed.
11. These GVC models and many of the other sources listed were developed or are maintained by the author. These are not all included due to space constraints but are available by request.
12. Occupational data would be ideal; however, these are not collected by most countries and when they are, they are not available at the firm level.

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APPENDIX

Table 1A.1 *GVC mapping data sources*

Type	Examples
Journals	<i>Asia Pacific Business Review</i> <i>Cambridge Journal of Regions Economy and Society</i> <i>Economic Geography</i> <i>Economy & Society</i> <i>Environment & Planning A</i> <i>European Planning Studies</i> <i>Global Networks</i> <i>Growth and Change</i> <i>Journal of Economic Geography</i> <i>Regional Studies</i> <i>Research Policy</i> <i>Review of International Political Economy</i> <i>World Development</i>
Industry and market reports	Business Monitor EMIS Forrester Research Freedonia Frost & Sullivan Gartner IHS Global Insight IBISWorld MarketLine (also firms) Passport Standard and Poor's (S&P) (also firms)
Firms	Dun & Bradstreet/Hoovers Edgar Firm websites LinkedIn Orbis Patent Offices Reference USA
International organizations	Asian Development Bank (ADB) Duke University Global Value Chains Center (Duke GVCC) International Labour Organization (ILO) Inter-American Development Bank (IDB) Institute of Developing Economies (IDE-JETRO) Organisation for Economic Co-operation and Development (OECD) United Nations Conference on Trade and Development (UNCTAD) United Nations Industrial Development Organization (UNIDO)

Table 1A.1 (continued)

Type	Examples
Industry-specific examples	World Bank
	World Economic Forum (WEF)
	World Trade Organization (WTO)
	Automotive News (auto)
	Clarkson (shipping)
	eMarketer (electronics/IT)
	Food and Agriculture Organization (FAO) (agrofood)
Textile Intelligence (apparel)	
	World Health Organization (WHO) (medical devices)

Table 1 A.2 International classification systems details and databases

System	Applicable To	Use	Collected By	Digit Levels	Versions	International Organization	Database
HS	Goods	Imports & exports	National Customs Agencies	2, 4, 6	HS92, HS96, HS02, HS07 HS12, HS17	WCO; UNSD	UNComtrade WITS
EBOPS	Services	International trade	National Accounts	1-5	EBOPS02 EBOPS10	UNSD	ITC Trade Map UN Service Trade OECD
ISIC	Economic activities (establishments)	National Accounts Industrial statistics	NSO	1-4	Rev3 Rev3.1 Rev4	UNIDO OECD	INDSTAT OECD.STAT
ISCO	Workers (people)	IO tables Occupations/ skills	Ministry of Labour	1-4	ISCO-58 ISCO-68 ISCO-88 ISCO-08	ILO	ILOSTAT
BTDixE		Imports & exports	-	2	2010 2013	OECD	OECD.STAT
BEC	Goods	End Uses	-	19 groups	BEC: 1976 Rev2: 1984 Rev3: 1986 Rev4: 2003	UNSD	UNComtrade
CPC	Goods, services	National Accounts; Correlate ISIC and HS; SUTs	National Accounts	1-5	Prov: 1990 1.0: 1998 1.1: 2002 2.0: 2008 2.1: 2015	UNSD	-
SITC	Goods	Correlate establishment & trade data	-	1-5	Rev1, Rev2, Rev3, Rev3.1 Rev4: 2006	UNSD	UNComtrade

Table 1A.3 Medical device GVC definition based on industrial classification systems

Stage	Category	Product Examples	CPC2	ISIC4	HS07
Manufacturing	Drug delivery disposables	Needles, syringes, catheters, tubing, IV sets	48150	3250	90183
	Medical & surgical instruments	Dental instruments, forceps, medical scissors, dialysis devices, defibrillators	48130	3250	90184
			48150		90185
					90189
	Therapeutic devices	Artificial body parts, hearing aids, pacemakers, crutches, implants, prosthetics	48171	3250	9021
			48172	2660	
	Capital equipment	MRI, ultrasound, X-rays, patient monitoring systems, sterilizers	48110	2660	90181
			48121	3250	90182
			48122		9022
			48140		841920
	Other appliances	Respiration, mechano-therapy, psychological testing, breathing	48160	3250	9019
					9020
	Furniture	Dental chairs; hospital beds; wheelchairs	48180	3250	9402
3092				8713	
Medical supplies/consumables ^a	Bandages, suture materials, ostomy bags, gloves	35270	2100	3005	
		35290	2100/3250	300610	
		36990	2220	300691	
		36260	2219	401511	
Medical manufacturing services	Medical & dental instrument & supply companies	88907	3250	–	
		88747	2660		
Services	Wholesale trade services	Medical & orthopedic goods	61174	–	–
			61274		
	Retail trade services	Non-specialized & specialized stores, mail order/internet, non-store and contract basis for medical/orthopedic goods	62174	–	–
			62274		
			62374		
			62474		
	Buyers & users	Human health service providers (hospitals, specialized, other)	62574		
			9311	8610	–
			9312	8620	
	R&D services	Medical sciences & pharmacy	9319	8690	
81130			7210	–	
After-sales services	Installation, maintenance and repair of medical machines & instruments	87350	3320	–	
		87154	3313		

Note: a. Medical supplies are not medical devices but are related and included with devices in some analyses. (–) indicates code is not used for that product/stage.

Table 1A.4 *Examples of GVC reports by industry*

Groups	ISIC Rev4 Divisions	Subgroups (3–4 Digits)	Products/Duke GVCC Reports	
Food/Agriculture/ Agribusiness/ Horticulture	Food Products: 10	Fruit and vegetables (103)	Bananas (Hamrick, Couto and Fernandez-Stark, 2018), grapes, coconuts, mangoes (2)	
			Corn (2), tomatoes, onion, asparagus, alfalfa	
		Meat (101)	Beef & dairy (Lowe and Gereffi, 2009)	
			Pork/hog farming (Lowe and Gereffi, 2008)	
		Fish, etc. (102)	Shrimp & fisheries (Daly and Fernandez-Stark, 2018; Dubai, Tokuoka and Gereffi, 2010)	
		Dairy products (105)	Abdulsamad and Gereffi (2016)	
		Grain; starch products (106)	Wheat (Ahmed, Hamrick et al., 2013), maize	
		Cocoa (1073)	Cocoa (7) (Abdulsamad, Frederick and Guinn, 2015)	
		Beverages: 11	Other (1079)	Coffee (5), honey, stevia
			Spirits (1101)	Rum (Hamrick and Fernandez-Stark, 2017)
	Soft drinks; bottled water (1104)	Sugar/soft drinks (Abdulsamad et al., 2015)		
	Tobacco products: 12	Frederick and Hull (2014); Goger, Bamber and Gereffi (2014)		
Textiles & apparel	Textiles: 13		Frederick (2010)	
	Apparel: 14		Frederick and Staritz (2012); Gereffi and Frederick (2010)	
	Paper; paper products: 17		Daly, Bamber and Gereffi (2016)	
	Coke; refined petroleum products: 19		Oil & gas (Duke GVCC and NAC, 2017)	
	Chemicals; chemical products: 20		Bamber, Frederick and Gereffi (2016b)	
	Non-metallic mineral products: 23		Insulation (Dubay and Gereffi, 2009)	
	Basic metal: 24	Iron and steel (241)	Steel (Brun, 2016)	
Electrical & electronics (E&E)	Computer, electronic, optical: 26		Electronics (Frederick and Gereffi, 2016; Frederick and Lee, 2017); LEDs; solar	
	Electrical equipment: 27 (lighting, wiring; appliances)	Electric motors, generators, transformers, etc. (271)	E&E (Frederick and Gereffi, 2013) Motors (Lowe, Golini and Gereffi, 2010)	

Table 1A.4 (continued)

Groups	ISIC Rev4 Divisions	Subgroups (3–4 Digits)	Products/Duke GVCC Reports
		Batteries; accumulators (272)	Lithium-ion batteries (Lowe, Tokuoka et al., 2010b)
	Machinery & equipment: 28		Mining equipment (Bamber, Fernandez-Stark and Gereffi, 2016)
Transportation	Motor vehicles, trailers: 29		Automotive (Sturgeon, Daly and Frederick, 2016) Public transit buses (Lowe, Aytekin and Gereffi, 2009) (Frederick and Brun, 2017)
	Other transport equipment: 30	Shipbuilding (301) Rail vehicles (302) Aerospace (303)	(Lowe, Tokuoka et al., 2010a) (Bamber, Frederick and Gereffi, 2016a)
	Furniture: 31 Other: 32	Furniture (310) Medical & dental (325)	(Brun et al., 2013) (Bamber and Gereffi, 2013; Frederick, Mora and Jansen, 2017)
Infrastructure/ construction	Electricity, gas, steam, air conditioning (D)		Coal (Ahmed, Abdulsamad and Gereffi, 2013); smart grid
	Water supply; sewer, waste management & remediation activities (E)		Sewer infrastructure (Daly, Brun and Guinn, 2015)
	Construction (F)		Transportation infrastructure (Brun et al., 2014)
Services	Information communication technologies		(Frederick, Bamber and Cho, 2018)
	Offshore services		(Gereffi and Fernandez-Stark, 2010)
	Tourism		(Christian et al., 2011)
	Financial services/banking		(Frederick, 2014b)
Enabling technologies	Biotechnology		(Frederick, 2014c)
	Nanotechnology		(Frederick, 2013)

Note: All reports are available at <http://gvcc.duke.edu> or <https://globalvaluechains.org>.