Combining the Global Value Chain and global I-O approaches

Discussion paper

Dr. Stacey Frederick
Research Scientist
Center on Globalization, Governance & Competitiveness (CGGC), Duke University
Durham, NC USA
Contact of the author: sf54@duke.edu or stacey.frederick@gmail.com

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List of Acronyms

Abbreviation	Full Text
CGGC	Center on Globalization, Governance & Competitiveness (CGGC)
CtG	Capturing the Gains
EA	Environmental Account
GDP	Gross Domestic Product
GNI	Gross National Income
GPN	Global Production Network
GTAP	Global Trade Analysis Project
GVC	Global Value Chain
HS	Harmonized System
I-O	Input-Output
MiWi	Made in the World Initiative
NAS	National Accounting System/National Account Statistics
NSI	National Statistical Institutes
NSO	National Statistics Office
PIIE	Peterson Institute for International Economics
SEA	Socio-Economic Account
SUT	Supply-Use Table
WB	World Bank

I. Summary

This discussion paper describes the existing gap between the work of traditional global value chain (GVC) academics and that of economists, international NGOs and statistical agencies analyzing global production fragmentation. Whereas both groups are engaging in research that seeks to explain why and how production of goods and services is dispersed around the world, the two groups have different objectives for their work and use different types of data to conduct analysis.

The purpose of the paper is to explore how these two approaches can be combined. GVC studies compare or describe an industry- or product-specific value chain across countries and regions. For goods producing industries, this type of research requires (at least) national-level data on *multiple* socio-economic indicators along an industry's *entire* supply chain (from raw materials through end products) and *value chain*, which encompasses the intangible activities or "soft skills" (or services) that add value, but do not physically alter the product (i.e., design, sourcing, branding, customer service). GVC studies typically revert to primary data collection efforts to acquire this information with minimal use of industrial, trade and employment statistics based on standardized classification systems produced by national statistical offices (NSOs) and further disseminated and analyzed by international NGOs.

Whereas primary data is used over statistical data in part due to the research methods traditionally employed by social scientists, there are also several limitations of the standardized data available to conduct studies at this level of specificity. The first limitation is the lack of routine data collection on the actual activities that take place at the establishment level by industry. The second is the lack of *detail* available across countries at a product by industry level and the third is the lack of a classification system that links the production-related stages for an industry along its supply chain. The paper proposes two possible solutions to overcome these data limitations and introduces ways in which existing data sources can be readily used in GVC studies

The first is to add questions related to "business functions" to existing national surveys. Data in this regard has been collected on a trial basis in at least Europe and Canada, but has yet to be widely adopted. If this method moves forward, an internationally agreed upon classification system for business functions should be developed to enable data collection and comparison on a global basis.

A second proposal is to review the ISIC classification system with respect to industry-specific groups and classes (i.e., three and four-digit). A promising new avenue would be to use the value chain reference model to establish alternative aggregations of basic ISIC activities like the alternative ISIC aggregation for statistical measurement within the manufacturing sector, or the information and communication sector.

These aggregations should be supplementary information based on offshoring of business functions, use of intermediate inputs, basic classes of goods produced and end-markets. The reason for doing so would be that the domestic or global operation of enterprises, especially

larger enterprises, cannot be well reflected in the current ISIC. Harmonization of enterprises into groups of similar make-up would improve the GVC analysis and would improve the input for the supply-use tables; harmonization could be achieved in terms of industry, of domestic sourcing or internationally sourcing of value-adding activities (i.e., business functions), of supply chain position and of end-market industry.

Rather than completely revising the ISIC system or developing an entirely new survey, the process of creating a new breakdown of the existing classification system that more accurately reflects the activities of businesses today could begin by adding questions related to the aforementioned concepts to existing national surveys. A relatively simple example of what this process might look like is described in the appendix and can be viewed on the North Carolina Textile Connect website.

Current research of global production fragmentation by international organizations is using global supply-use tables (SUTs) or a global input-output table (I-O) to derive the relative contributions of countries to a specific global industry network, or more specifically, show the foreign content in a country's exports broken down by partner country. Those partner countries could very well be indirectly involved in the foreign content of exports.

The measurement of global SUTs starts from data collected on an industry by product basis using ISIC (or a related industry classification) and CPC (or related product classification). So, the outcome of the breakdown of foreign content in a country's exports is an outcome of the data which have been put into the global SUTs.

GVC analysis and SUT analysis seem to be at two ends of the data spectrum. However, using the same classifications and therefore the same input data would open up possibilities to related the results of the work in these two fields.

II. Introduction

Objectives

- Provide better statistics on globalization
- Identify limitations of existing research methods: GVCs and SUTs
- Identify limitations of classification systems
- Determine if policymakers and academics look at research using GVCs the same
- Case for developing an international classification system for GVCs

Benefits

- Ability to link data along a supply chain (using I-O data) and the ability to link to other indicators of interest to economic development based on other classification systems and qualitative knowledge.

Current Situation

Existing research labeled as GVC is conducted by a wide group of researchers including social scientists, economists, political scientists, geographers, historians, operations management and country specialists among others.

- Traditional GVC academic researchers conduct value chain analysis, but they do not make use of available statistics to provide a "quantitative" backing for their results and the process of creating the GVC diagram is based on anecdotal evidence rather than I-O data. Social scientists begin analysis by conducting secondary, qualitative research and observing the situation via interviews with the most important actors in the industry.
- Economists use I-O data to analyze industries, but existing classification systems are limited in their ability to identify firms' engaging in the industry-specific intangible "value-adding" activities.
    - Economists conduct analysis by identifying data available to them and constructing equations to explain observed phenomenon.
    - Much of the recent work by GVC economists focuses on quantifying and measuring growth in trade of intermediate products. This is not a new concept, but using the phrase "global value chain" to market new developments in this field is recent.
    - New "GVC" economists measuring GVCs are comparing competitiveness of economies broadly rather than in specific industries. The new metrics developed come a long way in improving the way countries are broadly compared, but not in comparing countries in a specific industry.

Challenges to Collaboration

- Interdisciplinary approach needed
    - Difficult to talk and write across disciplines and literatures; need common languages and frameworks.
- Different motives of existing groups
    - Economic development – poverty elimination, equitable gain
    - Profit maximization
    - International benchmarking and developing metrics to measure globalization

III. Global Value Chain Approach Review

A. Background

Global Value Chain (GVC) research can theoretically be viewed as a type of industrial organization research. Industrial organization research is centered on the ways ***people (incl. firms***[1]***)***, ***places***, *and* ***processes*** are linked to each other in the global economy. A common element in industrial organization research is the use of a chain-based organizational structure. Chain-based research uses the concept of a chain as a construct to describe the *organization* and *geography* of production in the global economy. Chain-based organizational structures are used in different disciplines by different names to conduct industrial organization research, such as

- Supply chain (Management)
- Firm value chain and value system (Management/Economics)
- Global value chain; value-added chain (Sociology)
- Industrial cluster (All)
- Production network; Global production network (GPN); filière (Geography)

There are three main sciences that analyze industrial organization; Management Science, Sociology and Geography. Each overlap in various areas, but all three draws from some extent from the field of Economics (Figure 1).

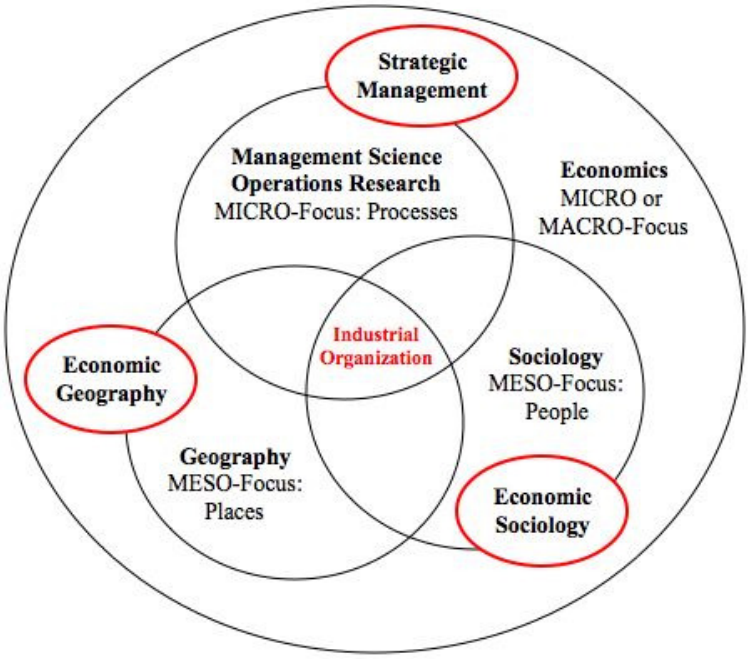


Figure 1: Economic and Industrial Organization Disciplines and Levels of Analysis
Source: Author

[1] The term Firm in this paper should be understood as Enterprise, as defined in the 2008 SNA and the ISIC, Rev.4, manual

Each discipline also overlaps with the others in some fields of application (Figure 2). The overlaps result in the fields of strategic management, economic sociology and economic geography.

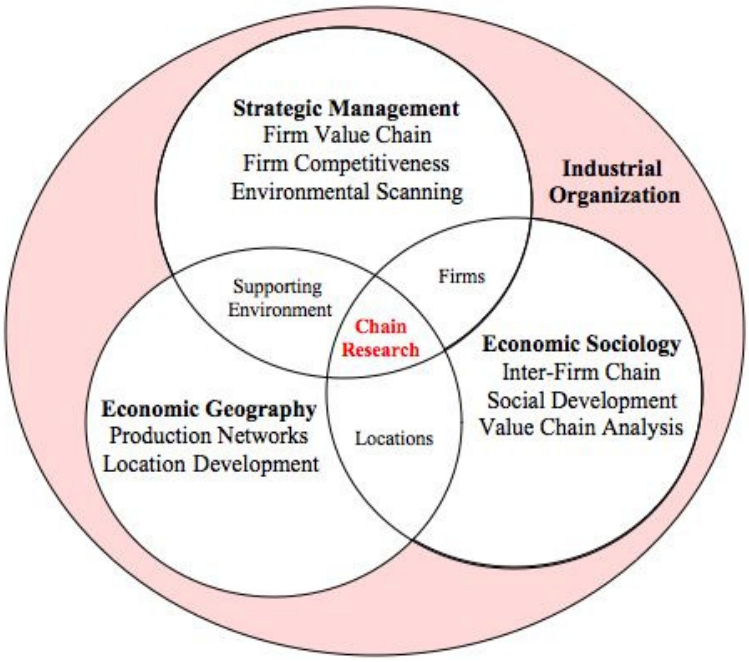


Figure 2: Chain-based Industrial Organization Research Disciplines
Source: Author

A chain can be used to provide a *structure* to map the range of internal and external actors and their actions that directly and indirectly affect the decision-making process. A value chain *conceptual framework* can also be used to analyze the competitive position of a firm (or geographic location) in a given industry vis-à-vis other firms or locations (Kogut, 1985). Each discipline uses a chain-based organizational structure to explain industrial organization subject matter. Strategic management focuses on economic competitiveness whereas economic sociology and geography tend to focus more on economic development.[2]

Research that falls under the traditional label of "GVC" originated from the global commodity chain (GCC) concept. In 1986, two World-Systems theorists, Terrence K. Hopkins and Immanuel Wallerstein, defined GCC as a "network of labor production process whose end results is a finished product" (Hopkins & Wallerstein, 1986). The GCC concept was initially developed to understand the geographic expansion and contraction of early modern capitalism, but by the mid-1990s, it was adopted by development scholars to capture the emerging patterns of postwar industrialization, such as the fragmentation and geographic spread of production activities, and development challenges in export-oriented industries (Lee, 2010). This reformulation of the GCC concept was encapsulated in the collected volume *Commodity Chains and Global Capitalism* (Gereffi & Korzeniewicz, 1994). The development-oriented GCC approach was the first to analyze both firm and inter-firm networks on a local and global scale,

[2] For a detailed comparison of these disciplines, see Chapter 1 of (Frederick, 2010) and (Frederick & Cassill, 2009) comparing value chains and industry clusters.

permitting researchers to forge the macro-micro links between firms previously assumed to be discreetly contained within global, national, and local units of analysis (Gereffi, 1994).

The GVC framework emerged in the early 2000s to combine aspects of several different industrial organization backgrounds including commodity chains, networks, industrial districts and clusters (CGGC, 2005; Gereffi, Humphrey, Kaplinsky, & Sturgeon, 2001; Gereffi, Humphrey, & Sturgeon, 2005). In 2000, a group of researchers from these various scholarly backgrounds came together to develop a common framework using a standard set of terms to describe the complex network relationships between firms that often span wide geographic areas. This marked the beginning of the *Global Value Chains Initiative,* and lead to the development of a growing research approach called GVC analysis. The *GVC Initiative* is housed at the Center on Globalization, Governance & Competitiveness (CGGC) at Duke University.

B. Traditional Global Value Chain framework and theories

A GVC refers to the *full range* of activities that firms and workers do to bring a good or service from its conception to its end use and beyond. This includes the activities related to producing, distributing and transporting the product (supply chain), as well as other value-added activities that do not necessarily result in physical alterations. These "intangible" activities include research and development, design, marketing and support services.

The activities that comprise a global value chain can be contained within a single firm or divided among different firms. Similarly, GVC activities can be contained within a single geographical location or spread around the world. The global value chain concept encompasses all stages in the innovation to commercialization process and can be used to analyze any product or service (CGGC, 2005).

Benefits of the Value Chain Approach

A value chain approach systematically forges the division between the macro (global/societal), meso (inter-firm), and micro (firm) units of analysis used to analyze the global economy and provides a way to see how each influences the others:

- On the macro level, it seeks to understand the roles and impacts of international institutions, organizations and standards on how and where new and existing products and technologies are developed and located;
- On the meso level, it seeks to understand the types and impacts of inter-firm relationships and national institutions (i.e. industrial policy) on economic development and a product's innovation to commercialization lifecycle.
- On the micro level, it seeks to understand how individual firms and/or the attributes of a particular product create opportunities or risks to the development of an industry or technology, or the development of such within a particular geographic location.

The GVC framework is divided into four building blocks that can be used to describe the structure, dynamics and relationships among stakeholders in global value chains: input-output

structure, geography, governance and institutions. These four building blocks can be translated into steps used to carry out a value chain research approach and analysis (see below).

1. ***Input-output structure:*** includes all supply chain segments (inputs, components, final products, distribution/sales) and value-adding activities (research, design, marketing and support services).[3]
2. ***Geographic scope*****:** the industry-specific mix of activities in the input-output structure is often carried out in different parts of the world and countries participate in industries by leveraging their competitive advantages in assets. Usually developing countries offer low labor costs and raw materials, while wealthier nations with more advanced education systems control research and development, design and marketing. As a result, firms in widely separated locations affect one another more than they have in the past.
3. ***Governance:*** is about power and the ability of a firm (or organization or institution) to exert control along the value chain by setting and/or enforcing parameters under which others in the chain operate (see below).
4. ***Institutional context*****:** identifies how local, national and international conditions and policies shape the globalization of each stage of the value chain. GVCs are embedded within economic, social and environmental institutional dynamics.

i. GVC Governance[4]

Governance in GVCs refers to the "authority and power relationships that determine how financial, material, and human resources are allocated and flow within a chain" (Gereffi, 1994). Chain governance exists when some firms work to the parameters set by other powerful firms in the chain (Humphrey & Schmitz, 2008). The firm that sets the parameters to which other firms in the chain must comply is referred to as the *lead firm*. The relationships lead firms have with their suppliers can be supportive and designed to promote mutually beneficial growth for all parties, or greedy and focused on realizing a quick profit in the short-term (Frederick & Gereffi, 2009b). In the first GVC governance approach developed by (Gereffi, 1994), governance was described in terms of "driving," in which chains could be described as producer- or buyer-driven.

- *Producer-driven chains*: large, transnational, integrated industrial enterprises play the key part in governing the chain. This pattern of governance is found in capital- and technology-intensive sectors such as automobiles, aircraft, and electrical machinery.

- *Buyer-driven chains*: large retailers, brand-name merchandizers and trading firms play the central role in organizing decentralized production networks through outsourcing. This type is typical in labor-intensive, consumer-goods industries like apparel, footwear, toys and consumer electronics.

Subsequent research realized the need to develop a dynamic typology that could also describe more complicated patterns of power relations between firms in GVCs, with different governance

[3] See the value chain overview video demo on the North Carolina in the Global Economy website for an overview.
[4] Ponte and Sturgeon (2014) provide an updated perspective on the concept of GVC governance as "normalizing" in terms of realigning a given practice to be compatible with standard or norm and add in the concept of "orders of worth." They combine this concept with governance as linkages to create a micro, meso and macro level framework.

forms often co-existing at the same time. This has led to the formulation of more elaborated forms of GVC governance to accommodate this complexity, notably the five-fold GVC governance typology that describes governance in terms of linkages (Gereffi et al., 2005). The five connections between industry activities (outlined below) within a chain can be described along a continuum extending from the market, characterized by "arm's-length" relationships, to hierarchical value chains illustrated through direct ownership of production processes (vertical integration). Between these two extremes are three network-style modes of governance: modular, relational, and captive. Network-style governance represents a situation in which the lead firm exercises power through coordination of production vis-à-vis suppliers (to varying degrees), without any direct ownership of the firms.

i. *Market:* involves transactions that are relatively simple, information on product specifications is easily transmitted, and producers can make products with minimal input from buyers. In market-based governance, price is typically the driving factor.

ii. *Modular:* occurs when a product requires the firms in the chain to undertake complex transactions that are relatively easy to codify.

iii. *Relational:* interactions between buyers and suppliers are characterized by the transfer of information and knowledge based on mutual reliance regulated through reputation, social and spatial proximity, family and ethnic ties, and the like. Tacit knowledge builds over time in relational chains, which makes it difficult to easily switch suppliers.

iv. *Captive:* in these chains, small suppliers are dependent on a few buyers that often wield a great deal of power and control. Such networks are frequently characterized by a high degree of monitoring and control by the lead firm.

v. *Hierarchy:* describes chains characterized by vertical integration and managerial control within a set of lead firms that develops and manufactures products in-house. This usually occurs when product specifications cannot be codified, products are complex, or highly competent suppliers cannot be found (Frederick & Gereffi, 2009b; Gereffi et al., 2005).

Governance Structure: Determinants and Dynamism

These five vertical linkage patterns can be associated with predictable combinations of the three distinct variables: (1) the complexity of transactions, (2) the ability to codify transactions, and (3) capabilities in the supply base. If one of these three variables changes, then firm governance patterns tend to change in predictable ways. For example, if a new technology renders an established codification scheme obsolete, modular value chains are likely to become more relational, and if competent suppliers cannot be found, captive networks and even vertical integration become more prevalent. Conversely, rising supplier competence might result in captive networks becoming more relational and better codification schemes set the stage for modular networks (Table 1).

Table 1: Firm-Level Governance Variable Combinations & Dynamics

Governance Type			Transaction Complexity	Ability to Codify Trans.	Capabilities in the Supply Base		
GCC	**GVC**					Low ↑ — ↓ High	Degree of Explicit Coordination*
Assumed	Market		(1) ↓ Low / High / High / High / High	↑ High / High / (3) Low / High / Low (4) ↓	(5) ↑ High / High / High / Low / Low (6) ↓		
Buyer-Driven	Modular	Network Org. Forms					
	Relational						
Producer-Driven	Captive						
	Hierarchy		(2) ↑				

Source: (Gereffi et al., 2005); *Coordination also relates to power asymmetry. Dynamics of changes in governance: (1) Increasing complexity of transactions also reduces supplier competence in relation to new demands; (2) Decreasing complexity of transactions and greater ease of codification; (3) Better codification of transactions; (4) De-codification of transactions; (5) Increasing supplier competence; (6) Decreasing supplier competence.

It is important to note that firm-level governance is the theory in the GVC framework. It has a set of variables and provides an explanation of how governance is likely to change when the three factors shift over time. The theoretical framework does not, however, provide a way to measure or quantify this, so interpretation of the theory is subjective.

ii. Upgrading

Upgrading refers to the strategies used by countries and other economic stakeholders to maintain or improve their positions in the global economy. Upgrading is a multi-dimensional process that seeks to increase the economic competitiveness (profits, employment, skills) and/or social conditions (working conditions, low incomes, education system) of a firm, industry, or workers.

Upgrading involves a learning process through which firms acquire knowledge and skills—often through their relationships with other enterprises in the value chain or through supporting markets—that can be translated into innovations or improvements that increase the value of their goods or services (Frederick & Gereffi, 2009a). Economic upgrading is defined as firms, countries or regions moving to higher value activities in GVCs in order to increase the benefits (e.g. security, profits, value-added, capabilities) from participating in global production. Upgrading strategies are generally differentiated in the following (Frederick & Gereffi, 2011, 2013; Frederick & Staritz, 2012; Humphrey & Schmitz, 2002):

- ***Process upgrading:*** reorganizing the production system or introducing new technologies to gain efficiency.
- ***Product upgrading:*** shifting to more sophisticated products with higher unit prices.
- ***End market upgrading:*** diversifying to new buyers or new geographic or product markets (particularly important in the context of stagnating demand in traditional export markets such as the US and the EU-15 and increasing demand in fast-growing emerging domestic or regional markets).
- ***Linkages/supply chain upgrading:*** establishing backward manufacturing linkages within the supply chain, in particular to the textile industry.

- ***Functional upgrading:*** increasing the range of functions or changing the mix of activities to higher value tasks, e.g., moving beyond direct production-related activities to input sourcing, logistics/distribution, product development, design and branding.

While most GVC research has been focused on economic upgrading, there is an increasing interest in social upgrading. Social upgrading refers to "the process of improvement of the rights and entitlements of workers as social actors, which enhances the quality of their employment" (Barrientos, Gereffi, & Rossi, 2011). Social upgrading can be divided into two components: measurable standards and enabling rights. Measurable standards include type of employment (formal and informal), wage level, social protection and working hours. Enabling rights are less easily quantified and include the freedom of association, the right to collective bargaining, non-discrimination, voice and empowerment (Barrientos & Smith, 2007).

C. Value chain research approach (mapping & analysis)

A value chain research approach is widely used by academics and practitioners to conduct detailed research on the structure and dynamics of global industries to understand where, how, and by whom economic, social and environmental value is created and distributed. In practice, research questions center on development and competitiveness issues and analysis seeks to identify potential leverage points and bottlenecks in the chain. Economic developers often use the results of a value chain analysis to devise industrial policies and strategic plans for firms or countries.

The four building blocks of the GVC framework can be translated into a two-part research approach composed of *value chain mapping* and *value chain analysis*. The first two building blocks, input-output and geography, describe the structure of the chain, and the second two, firm-level governance and institutions, provide an analytical lens to evaluate how and why the current people, places, and processes are organized. Value chain mapping is the process of identifying the geography and activities of stakeholders involved from taking a good or service from raw material to production and then to the consumer. Value chain analysis seeks to determine the role dynamic factors (governance, institutions and inter-firm relationships) play in influencing the location, development and competitiveness of a product or service. This also includes identifying potential interventions and leverage points to initiate change.

Value Chain Mapping

Definition: "Determine what exists and where it is located (economic organization): includes a process and methods to be used to identify and map the structural elements of the value chain, including qualitative and quantitative secondary and primary data sources"

1. *Input-output:* who are the stakeholders (public and private) that currently or have the potential to develop or commercialize materials, products and technologies?
   - Collect information on products, markets and firms.
     - Resources include market reports, journal articles and government labor market and trade data sources
   - Conduct secondary and primary research on firms

2. *Geography*: where does each link in the value chain take place around the world?
    - Identify and compare where firms, products and markets are located (similar to above on an international level)
    - Determine a nation's footprint in the industry's value chain

Value Chain Analysis

Definition: "Determine how and why the current economic organization exists and how it might evolve in future by analyzing inter-firm relationships and institutions. The objective of value chain analysis is to determine how and where power is exerted along the chain and by whom (firms or institutions). This is analyzed to determine the relative impact firms and institutions have on innovation, commercialization and risk and potential leverage points in the chain where interventions could be made to effect systemic change and industry behavior."

3. *Firm Governance*: who are the most powerful, innovative firms in the chain; why? Which activities are most important to the product and market and who is doing them?
    - Literature review on governance topics in the industry being analyzed
    - Determine how and if relationships differ by product, market and/or geography
    - Develop metrics to describe and measure the impact different types of relationships have on economic development and product commercialization.

4. *Institutions & Industrial Policy*: what are the roles and impacts of local, national and international institutions and stakeholders?
    - Conduct background research on policy issues in the following key areas: trade, industrial/economic development, labor/social and environmental.
    - Compare the effectiveness of different policies on innovation in different countries.

Examples of Outcomes of Analysis

The outcomes of value chain studies are based on the desired outcomes from clients, but generally fall into the following areas:

1. Benchmarking: providing the client with the outcomes of parts 1 and 2 – in many cases our clients (governments, NGOS, industry associations) do not have a good idea of what the entire input-output process looks like or who the key countries (or states) are in each segment of the chain.

2. Policy recommendations: we often provide policy recommendations at the country (or state or regional) level based on best practices and strategies used by countries and industries in comparable situations.

3. Upgrading recommendations: based on the outcomes we provide ways in which firms and countries can improve or expand their position in the given industry. We provide suggestions on how to do this by (1) improving the process, (2) improving their products,

(3) moving or expanding into new geographic markets or (4) expanding the range of business functions provided.

4. Visual analytic applications to disseminate research results that present data in a holistic and systematic way. Visual analytics creates a way to combine and format all the data sources into the organizational structure of the value chain framework. NC in the Global Economy, California in the Nano Economy and the Textile Connect websites are examples of web-based applications that use the value chain as an organizational structure to provide results to a larger audience.

IV. Classifications and Data Sources

A. Data sources used in GVC studies[5]

The following lists the types of data available to conduct GVC studies:

- *Survey data/interviews*: the primary source of information in GVC studies is interviews with key firm and supporting organization stakeholders. In most cases, data is collected via open-ended interviews rather than through formal surveys.

- *Industry/market analysis*: much of the background research in GVC studies comes from the results of secondary literature from previous studies (i.e., scholarly literature such as journal articles) and market reports published by contract research organizations and industry associations. These organizations can be viewed as both data sources and to some extent as competitors to academic research institutions engaging in GVC research. Examples include: Marketline, Euromonitor and Standard & Poor's, as well as industry-specific research organizations.

- *Business environment*: data on the business infrastructure of a country (i.e., policies, educational institutions, incentives, etc.) is collected from government websites, reports and official documents.

- *Trade statistics*: Detailed international merchandise trade statistics are available from the websites of UNSD[6], OECD and Eurostat, among others. Statistics of international trade in services (by services category and partner country) are available – in less detail than merchandise trade – from the websites[7] of these same organizations. Whereas the level of detail in trade data is adequate to conduct industry-specific analysis, most GVC studies do not take full advantage of it to analyze the footprint of country in a particular industry or to evaluate changes over time. Trade data can only be used to describe the product, geographic end market and to some extent the backward/forward linkage characteristics of a country in a particular industry. Trade data cannot be used to track functional

[5] Appendix 4: Methods used in three industries (apparel, auto, electronics) provides examples of GVC studies.
[6] See http://comtrade.un.org/
[7] See for instance http://unstats.un.org/unsd/servicetrade/default.aspx

upgrading, industry or buyer end market upgrading, domestic backward/forward linkages or process upgrading.

- *Industrial statistics and I-O data*: Industrial statistics are available to some extent from the UN data portal[8], from the OECD data portal[9] and from UNIDO, but are rarely used in GVC studies. Conjecture on why this is the case are (1) lack of awareness of availability and (2) difficulty in obtaining data. The level of detail available for some countries is adequate to provide a high-level snapshot of a country's position in an industry, but four-digit (or beyond to product-level) is ideal. With the exception of pilot studies conducted by the author to "map" industry value chains, national and international I-O data are not used in GVC country and industry-specific studies.

The use of quantitative indicators or even trade and economic activity data is not widely used in GVC studies. Sturgeon and Gereffi (2009) review three groups that have used data in GVC analysis, but these are not widely used: Technological Classification of Exports (Lall, 2000), Trade-data Archaeology, and Intermediate Goods Trade (Sturgeon & Memedovic, 2011). The last paper seeks to improve the existing data gap in industry and supply-chain specific data, by using novel classifications for final and intermediate goods trade, overall; for "customized" and "generic" intermediate goods; and in three industries oft-cited as being at the forefront of global economic integration: (1) electronics, (2) automobiles and motorcycles, and (3) apparel and footwear.

There is a need to develop better tools for evaluating the impact of GVCs and the role that specific categories of firms and national industries play within them. For this, better data are required. While linking trade statistics to enterprise-level statistics contained in business registers, developing international I-O and trade in value added databases, and formulating entirely new GVC-oriented economic statistics are important, there are also considerable benefits from mining and re-working existing data sets (Sturgeon & Memedovic, 2011).

B. Existing data sources, classification systems and databases

Data used to study industrial organization falls into the following categories or focus areas and is collected by enterprises or establishments, products and individuals (see Appendix 2: Basic data sources for a review).

- International trade by product/service (products)
- Industrial statistics by economic activity (establishment)
- Labor and occupation statistics (individuals or establishments)

Levels of data

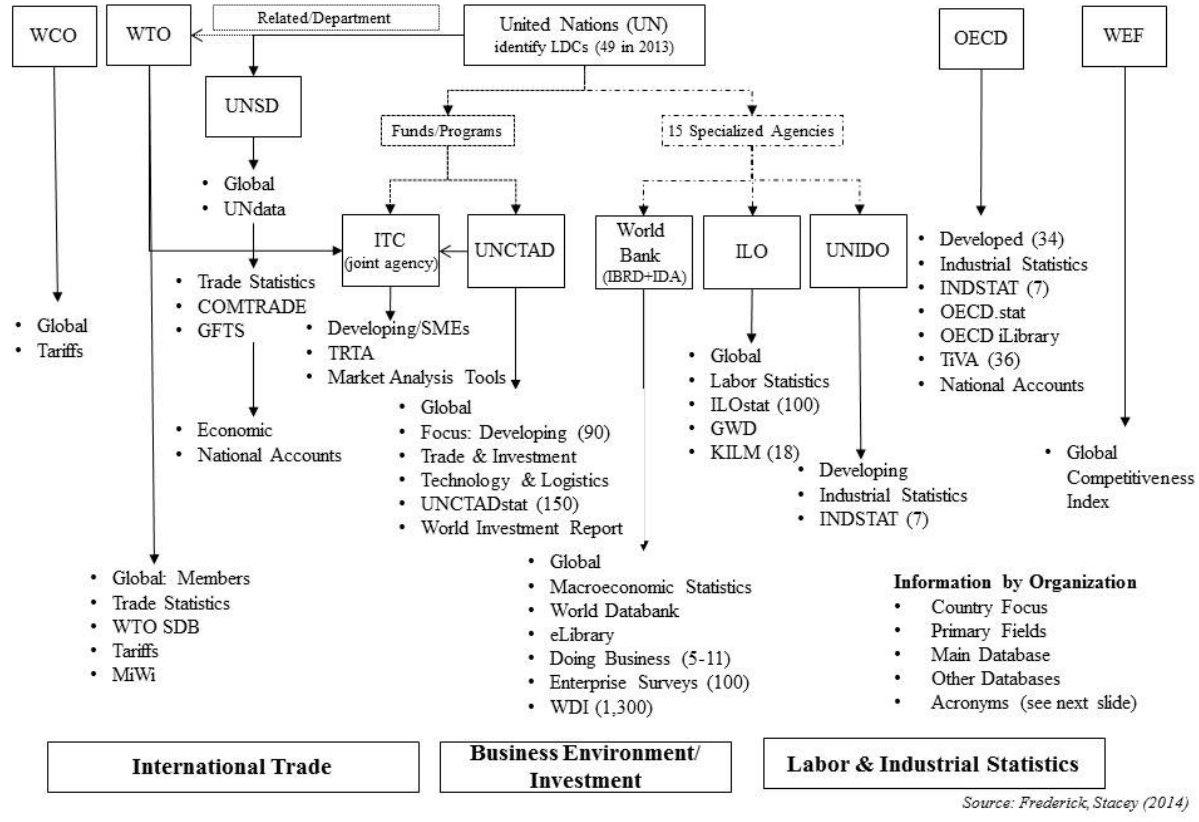
- National (establishment-level, by country) micro data
- National (country-level) aggregate public data sets
- International datasets (compilations of national-level data)

[8] See http://data.un.org
[9] See http://stats.oecd.org/index.aspx?r=951255

Primary data is available from administrative sources (such as Customs administration) or is collected through business surveys from enterprises or establishments by national statistical offices or other national agency (like the central bank). The compiling agency (usually the NSO) harmonizes the incoming data into a database format applying some basic checks. The ability to access this "micro data" varies by country, but in most cases it is only for special projects and requires a security clearance. Micro data is thereafter further standardized and aggregated, and published at the national and sub-national levels by NSOs. Access to the data may be free or fee-based and is available via electronic databases or PDF format.

International organizations collect this information from national NSOs to populate international databases, typically in a particular focus area (Figure 3). The database may represent (1) the data as it was collected from the NSO with minimal harmonization to facilitate data extraction, (2) further modified data to facilitate international harmonization, (3) additional estimates by the international organization and/or (4) indicators based on calculations performed by the organization using one or multiple data points. In a few cases international organizations collect primary data through their own surveys.

Figure 3: International Organizations: Focus Areas and Databases/Sets



Source: Author

C. New classification and data source: business functions

Having data on the business functions of establishments or enterprises will benefit GVC analysis in terms of operationalizing the concept of functional upgrading. As articulated in Sturgeon and Gereffi (2009), "if key GVC-related questions are not asked on any official survey and do not exist on any administrative form, then existing data resources can never yield adequate results. Thus, there is an urgent need to collect new information."

A business function classification divides the activities of an establishment or enterprise into "core" and "support" functions. The core productive function has been designated as "production" (Porter, 1985), the "core function" (Nielsen, 2008) and "operations" (S. Brown, 2008). Even though a business function may be designated as a core function, the function can be partially or even completely outsourced (Sturgeon & Gereffi, 2009). Firms typically have a main output, be it a product or service. The main operational function that produces this output is associated with the firm's standardized industrial code. Instead of counting all output and employment under this classification, business function lists permit measurement of economic activity (e.g. employment, occupations, wages, etc.) in other functions as well.

Furthermore, collecting data by business function enables researchers to systematically identify activities that are performed by the firm (in-house) or by third parties (outsourced) and the geography of where the activities take place (domestic/home country or offshore). This is related to what some have called "trade in tasks." Business function surveys over the last ten years have focused on identifying trends related to these concepts rather than identifying the unique activities undertaken by establishments in different industries. Understanding business function fragmentation is important for GVC studies, but identifying the unique mix of functions integral to a particular *industry* is equally important.

In the GVC realm, Sturgeon has been the primary voice on collecting and standardizing data at the level of business functions (Sturgeon, 2008; Sturgeon & Gereffi, 2009) and has worked with statistical agencies and academic researchers in North America and Europe in hope of more wide-spread standardized and adoption (Claire Brown, Sturgeon, & Cole, 2013; Sturgeon, 2013). The concept of business functions, however, originates from Porter's interpretation of a value chain, which took the firm as the unit of analysis. In his work, a firm engaged in nine business functions, divided into five core and four supporting functions. In GVC studies, the business functions concept relates to the idea of "value-adding activities," however the scope of reference is the *entire chain* of activities for an industry rather than an individual firm. In practice, both interpretations are valid because business functions are carried out at the firm-level and can be carried out by firms at each stage of an industry's supply chain.[10]

An internationally agreed upon classification system for business functions does not yet exist, however several groups have generated lists ranging from between six and 12 activities. In Table

[10] See (Frederick, 2010; Frederick & Cassill, 2009) for a comparison of the value chain concept at the firm versus industry level and how to two can be combined.

2, the business function lists in use or proposed are compared to each other and the GVC concept of value-adding activities based on the author's interpretation.[11]

Table 2: Comparison of Business Function Categories & Definitions

VA Activities	Business Function			Core/Support		
GVC	**Sturgeon (2009)**	**Eurostat (2008)**	**Porter (1985)**	**Sturgeon**	**Eurostat**	**Porter**
Research & Development	Product or service development	Research & development (b)	Technology development	Core	Support	Support
Design & Development	Technology and process development	Engineering and related technical services (b)		Support	Support	Support
Distribution/ Logistics	Procurement (a)	Distribution and logistics	Procurement	Core	Support	Support
Production	Intermediate input and materials production	Core/primary business functions: production of final goods or services (& secondary functions if related to core)	Operations	Core	Core	Core
Production	Operations (industry code)			Core	Core	
Distribution/ Logistics	Transportation, logistics, and distribution	Distribution and logistics	In & out-bound logistics	Core	Support	Core
Marketing & Branding	Marketing, sales and account management	Marketing, sales and after sales services	Marketing & sales	Core	Support	Core
Service	Strategic management	Administrative and management functions	Service	Core		Core
Management-Related Activities						
Not included	Customer and after-sales service	Marketing, sales and after sales services	Service	Support	Support	Core
	General management	Administrative and management functions	HRM & firm infrastructure	Support	Support	Support
	Human resource management (HRM)		HRM	Support		Support
	Firm infrastructure, building maintenance and IT systems	ICT services	Firm infrastructure	Support	Support	Support

Sources: category correlations by author from the following sources, (Porter, 1985); (Nielsen, 2008); (Sturgeon & Gereffi, 2009); p.23 and adapted from U.S. BLS Mass Layoff Statistics Program. In a previous paper (Sturgeon, 2008), only ten business functions were included, but this paper separated them into core and support functions.

Notes (a): I'd consider distribution/logistics to be related to transporting the product whether it is inbound or outbound; I'd consider procurement to be related to sourcing and the parallel to "sales" on the downstream side. Strategic decision-making related to procurement, such as making the decision on whether to "make or buy" inputs, would fall under strategic management. (b) Seven business functions (plus a residual "other" category) were identified using the European Central Product by Activity classification (CPA) in 2008. In the 2012 survey, engineering and R&D were combined.

Developing a standardized list of business functions and collecting representative data will provide GVC researchers with information needed to conduct analyses that is currently only

[11] The specific functions used in the Canadian SIBS surveys (Industry Canada, DFAIT, & Statistics Canada, 2009, 2012) and the eight functions included in the United States' NOS survey (Clair Brown & Sturgeon, 2010) are not included, however they use similar terminology.

available by interviewing firms or reviewing secondary literature. However the usefulness of the new typology will depend on how the classification system is correlated to or embedded within the existing ISIC system. If the concept of business functions is adapted, how an establishment is labeled in the ISIC system also needs to be reconsidered because industry-specific, business function data is needed for GVC studies.

D. Limitations of the ISIC system and availability of data

This section reviews some of the limitations of ISIC, the international standard industrial classification for all economic activity and other impediments to using industrial statistics in GVC research.

The first limitation of the ISIC system is that only agriculture, mining and manufacturing-related codes are industry-specific (sections A-C) for goods-producing industries.. Activities such as professional, scientific and technical activities, transportation and storage and wholesale and retail trade are either not industry-specific, or the level of data is at a higher-level of aggregation than the manufacturing codes. This is particularly important in "buyer-driven" chains in which GVC theory suggests that lead firms classified in manufacturing add the majority of value (i.e., realizing the most profit) to the final product while contracting out the processing of the goods.

The ISIC[12] structure resembles a supply chain, but the system is not *industry* supply chain specific. Rather its 17-21 sections can be viewed as a complete supply chain production model that begins with raw materials (agriculture and mining), moves on to processing and manufacturing, then wholesale, retail, service and supporting industries (design, government, business services, etc.). Resultantly, what is often used to define an industry is a small set of classification codes such as those that represent manufacturing for durable goods production. However, this often omits many other important, value-adding activities in an industry such as input production, distribution, management, marketing, non-manufacturing buyers, and supporting industries that fall outside of the narrow scope of an industry.

For example, the textile and apparel industries are contained entirely within the manufacturing sector.[13] However, many of the most profitable areas are not contained in *manufacturing* as a transformation of material in a new product, but rather in the research, design, marketing, distributing and retailing of products. Based on extensive research of the U.S. textile and apparel industries, several limitations of limiting the definition of the textile and apparel industries to these codes have been identified (Frederick, Cassill, Godfrey, & Little, 2007a, 2007b):

1) *Raw materials* that are directly part of the textile supply chain such as: cotton farms, cotton gins, sheep farms, petroleum refineries and resin manufacturers.
2) *Fibers* are the basis of textile production, but man-made fibers are considered to be in the chemical sub-sector rather than within the textile sub-sectors.
3) *Final products* that are not made *entirely* of textile inputs, yet utilize textile components. The markets for these products represent growth areas for textile materials and should be acknowledged as significant buyers of textile components.

[12] Adapted from (Frederick, 2008) based on NAICS codes.
[13] Textiles, textile products and apparel are represented by ISIC 17/13 and 18/14 or NAICS codes 313, 314 and 315.

Examples of products include composites, sporting goods, air filters, air bags, cleaning tools, and mattresses.

4) *Input industries* that are vital to the textile supply chain, such as chemical manufacturers, packaging and labeling companies, and machinery, equipment, and software producers. In some cases these functions are carried out by the textile manufacturers; however, in many cases these are separate companies that provide significant services to the textile complex.
5) *Wholesalers* of textile components (yarn & fabric) and final textile products (apparel and home & interiors).
6) *Management, marketing, and retail companies* that primarily sell textile final products (apparel and home & interiors). These companies do not manufacture textiles, but they are responsible for many of the value-adding functions such as design, distribution, marketing, and branding of textile products.
7) *The supporting environment*, which is vital to the formation and performance of the industry, and includes utilities, business services, finance, research, trade associations, colleges, training & testing centers, government and other regulatory entities, is omitted.

Secondly, firms are classified under *one* ISIC code rather than several codes based on the percentage of their business activities or products sold. A third limitation is that researchers do not know how a company is classified in aggregated government statistics (i.e., ISIC/NAICS) and in the U.S., different agencies may assign different codes. This is a significant limitation in terms of identifying types of buyers.

Take the following example. A company is headquartered in the United States and employs approximately 5,000 people engaged in activities related to the apparel industry. Twenty years ago the company was considered a "brand manufacturer" and the majority of the firm's workers were engaged in manufacturing or assembling apparel. However, over the years the company changed its business model. First the company "offshored" production via foreign investments in nearby countries and later the company moved out of production altogether and now outsources all production to third parties. Even with this change in business model, the company's employment has remained constant, just the skills of the workers has changed from manufacturing-related to management, marketing and design. How should the company be classified using the ISIC system? They are still in the apparel industry, but their domestic activities are not in manufacturing. Are they classified under ISIC 18, manufacturer of wearing apparel, or are they considered part of the wholesale or management industry? If they are classified as a manufacturer, there needs to be an additional survey that collects supplementary data on the business functions, basic classes of the goods produced and end markets in conjunctions with overseas manufacturing activities of the firm. It is also through the supplementary information and use of alternative classification of this company in ISIC that the occupational classification of the workforce of the company can be related to the ISIC activities of the firm. Alternatively ISIC data could be linked to occupational data and the activities of the firm could be identified by profiling the labor force.

In order to gain a better understanding of how ISIC codes are being applied in specific industries, a study by industry experts should be conducted using micro-data to identify how existing lead firms that are factory-less goods producers should be classified building on the ISIC system.

Beyond the limitations of the ISIC system, there are three other main issues related to using industrial statistics in GVC studies. First, ISIC and the data collected based on it tends to be too aggregated or overly broad to provide the industry-specific data needed in GVC studies. A recent paper by Sturgeon and Memedovic (2011) finds evidence of deepening global economic integration, but note that the degree and character are highly dependent on the characteristics of specific products, processes, routines and regulations that prevail in ***particular industries***. As such the authors recommend policy development take industry-specific characteristics into account and avoid "over-generalizations, blanket statements, and blunt policy instruments" with an eye towards gaining a better understanding of the factors underlying industry differences. In order to understand these industry-specific characteristics, data beyond the one and two-digit ISIC levels is needed.

The second issue concerns the availability of data. GVC studies often focus on or at least include developing countries where data tends to be collected on a very limited basis, and if it is, may not be widely disseminated or available in an easy to use format (e.g., PDF versus electronic access). The third issue concerns the harmonization of data. Countries collect data at different levels of detail using various revisions of the ISIC system, use different sampling frames, ask questions related to different variables and/or use different terms to describe similar concepts. Even though international collections of data exist, researchers still need to evaluate country-level metadata to ensure comparability of information over time and across countries for a particular industry. This can be a time consuming and arduous task, particularly when studying a new industry.

E. Limitations of the GVC research approach

The analysis and policy recommendations provided in GVC studies are often based on **qualitative data** and are therefore subjective. Policymakers need to have concrete evidence to support the decision-making process in order to justify investments and wide-spread policy changes.

> "A major impediment to using qualitative research and conceptual theories to support specific policy interventions is the lack of comparable and detailed data on the industrial capabilities of firms, industries, and countries and the roles that they play in the global economy. The GVC framework provides a conceptual toolbox, but quantitative measures are lacking. While the development of objective, industry-neutral measures of GVC governance is a laudable goal and survey questions are currently being fielded to collect data on the governance character of inter-firm linkages in both cross-border and domestics sourcing relationships,[14] better information to characterize the roles of firms, regions, and countries in GVCs is urgently needed" (Sturgeon & Gereffi, 2009).

[14] Specifically, Statistics Canada, in an international sourcing survey currently being tested, asks firms if relationships with important suppliers are simple market relationships or something more complex, and if transactions involve the exchange of codified or tacit information.

Purpose. Whereas the majority of GVC studies are labeled as "GVC analysis", many studies either have a primary focus on the first two "mapping" parts of the framework (input-output and geography), one of the two "analysis" components (governance, institutions; identification of power) or simply on identifying upgrading strategies and constraints and providing policy recommendations. In order to provide a thorough analysis or recommendations, a detailed mapping process needs to occur. If a study only focuses on the "mapping" components then it is purely descriptive and could also be labeled as an industry or market report.

Repeatability. Given that most GVC studies are not based on industrial or trade classification systems, the ability to easily update, expand or replicate a study is limited.

Time-consuming. Conducting a thorough GVC mapping and analysis is an arduous and time-consuming process that often takes between six months to a year depending on the number of people on the research team.

V. Developing an Industry-Neutral Value Chain Reference Model[15]

This section introduces a value chain reference model (VCRM), and how it can be used as a classification system and as a means to visually represent an industry's value chain. The model is industry-neutral and can be modified to fit to any industry. It is also scalable as it can be used to map industry structure with a local to global focus.

The VCRM provides a holistic framework that includes the entire supply chain, from raw materials through retail, plus the value-added business functions along the chain. The reference model also includes end markets, a concept that is of particular importance for intermediate products that are often used in final products in multiple industries. Lastly the model includes the supporting environment that provides the infrastructure and public policy that can facilitate or hinder an industry's competitiveness. The VCRM represents both a visual depiction of the structure of an industry as well as a conceptual model of industrial organization.

The VCRM has been applied to several industries by the author. It has been used as a classification system in research reports as well as the basis of a web-based information management system, visual analytics and learning tools. A brief introduction to existing applications of the VCRM is provided in Appendix 3: Applications of the VCRM.

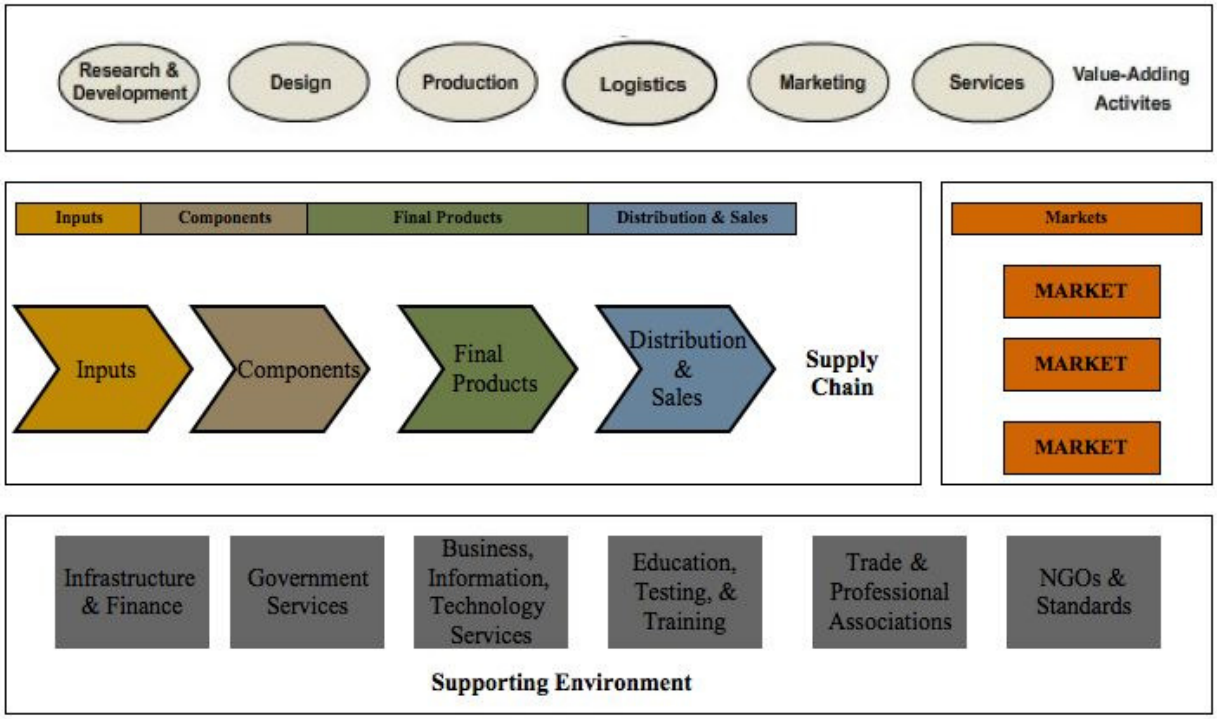
A. The Value Chain Reference Model (VCRM)

The value chain concept is commonly used as an organizational structure to visual, classify and analyze people, places, and processes and their linkages in the global economy. The VCRM presented in this paper provides an industry-neutral, scalable visual template of the local to global stakeholders and the input-output activities that link these activities and actors together.

[15] Section adapted from (Frederick, 2008)

In the VCRM, the value chain is conceptualized as a combination of parts that work together to produce final products and services for end markets. The four parts include value-adding activities or business functions, the supply chain, end-use markets, and the supporting environment (Figure 4).

Figure 4: Four Parts of the Value Chain Reference Model



Source: Frederick (2010)

i. Value-Adding Activities (Business Functions)

The value-adding activities are the broadest six[16] classifications of the steps that may be required to create a product or service and represent the functional activities that members engage in or support. The six activities include research and product development, design, production, logistics (physical distribution and logistics management/sourcing), marketing and branding, and strategic management (

Table 3). These activities are viewed as a series of business functions stakeholders can engage in to bring a product from concept through to consumers. Each of these varies in degree of importance, depending on the product and market the firm focuses on. A firm may engage in one or all six of these activities.

[16] Six activities are commonly listed in GVC studies, however more activities could be included (see the "

New classification and data source: business functions" section).

Including the value adding-activities as part of the model provides a way to showcase all the functions a firm can engage in that may not require physically transforming the product. This model provides a way to both separate and link the activities required to physically transform a product through the input-output structure (supply chain) of the chain from the separate activities that add value to a product (value-adding activities). This overcomes several of the previously mentioned limitations of the ISIC system.

Table 3: Value-Adding Activities (Business Functions)

Value-Adding Activity	Description
Research and Development	Companies, organizations, institutions, etc. that engage in research and/or new product development. This includes both activities related to improving the physical product or process as well as market and consumer research.
Design and Technical Development	People and companies that offer aesthetic design services for products and components throughout the value chain. Design and style activities are used to attract attention, improve product performance, cut production costs, and give the product a strong competitive advantage in the target market. Design can also refer to "engineering" or industrial design in which the focus is placed on optimizing the relationship between materials and function.
Production (good or service)	Or manufacturing; this step is the actual production of the product.
Distribution and Logistics	Inbound and outbound companies and processes involved in transporting products between all stages in the value chain (full-package) or between two stages. This function includes companies that are involved in physically transporting products as well as managing or providing technology and equipment for supply chain coordination. Logistics can involve domestic or overseas coordination.
Marketing and Branding	All activities and companies associated with pricing and setting a brand/company image such as branding or advertising any product, service, or entity in the supply chain. These companies frequently do not make any physical alternations to the product.
Sales and Services	This category includes selling the product to the customer and the activities associated with retailing, customer and after-sales services.

Source: adapted from Frederick (2010)

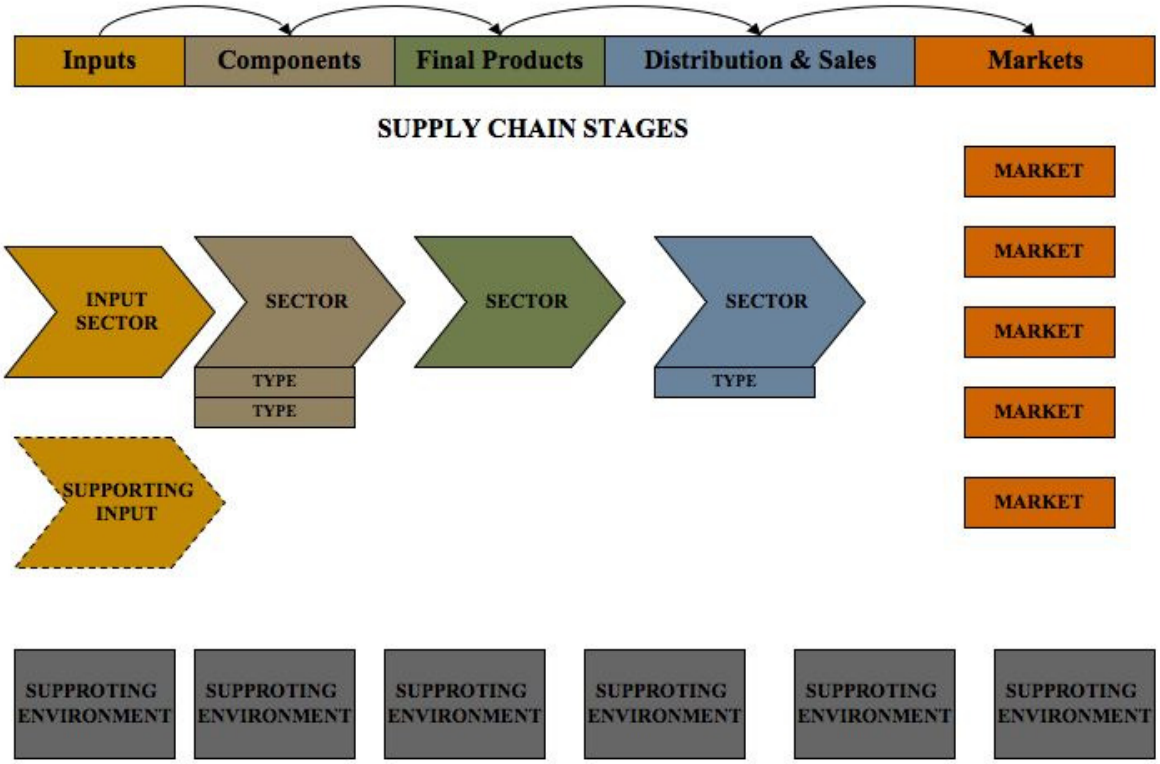
ii. Supply Chain

The second part, the supply chain and end-use markets, represent an expansion of the production and logistics activities in the simple value chain. Expansion of these two steps results in an input-output process that has four basic stages that vary based on the market the supply chain feeds into: inputs, components, final product manufacturing, and distribution and sales. These make up the production-related links in the chain and between each of these steps is the distributing of products from one place to the next, also referred to as logistics. Each of the markets represents unique combinations of the four parts of the supply chain that lead to the creation of final *end-user* products.

The supply chain represents the unique input-output process of an industry that begins with raw materials and continues through the making of components and subassemblies, final product manufacturing, distribution and sales. In the value chain visual, the supply chain is broken into five colors; each represents one of the basic stages in the supply chain. The large arrows represent the main stages in the supply chain, whereas the boxes listed directly below a large arrow represent specific *types* of products.

The supply chain portion of the reference model can be linked to the international standard industrial classification (ISIC) system of all economic activities or national level systems that are based on this system. In the applications of this model for the textile and apparel industries, the boxes in the chain correspond to North American Industrial Classification System (NAICS) codes. In the visual, the large arrows represent NAICS sub-sectors (three-digit codes) and the boxes listed directly below large arrows represent U.S. industry groups or industries (4-6-digits). Having an established set of codes that can be used to identify participants in the value chain allows both establishments and industry statistics to be identified through a variety of sources.

Figure 5: Parts of the Supply Chain



Source: Frederick, S. (2010).

As previously mentioned, the ISIC/NAICS structure resembles a supply chain, but the system is not *industry* supply chain specific. There has been increasing interest in recent years to discover a systematic way to expand coverage of traditional industries to include all the members of an industrial complex. One way to accomplish this is by using the Benchmark Input-Output (I-O) Accounts prepared by the U.S. Census Bureau based on the five-year U.S. Census. The I-O accounts show the value of what is produced by each industry (make table) and the value of what

is consumed by each industry and final users in the economy (use table) (Horowitz & Planting, 2006). Other researchers (Feser & Bergman, 2000; Feser & Isserman, 2005; Porter, 2003) have used the Benchmark I-O Accounts to identify economic clusters based on common trading patterns *and* spatial proximity, but not to identify extended supply chains without geographic constraints (see section below on Mapping: Industry-specific value chains using VCRM & I-O tables for further development of this concept).

Having an established process and set of codes that can be used to identify participants in the value chain allows both establishments and industry statistics to be identified through a variety of sources. Examples of sources for establishment data in the U.S. include Dun & Bradstreet and Reference USA and industry statistics can be collected from national and state government agencies, trade associations, and independent consulting organizations.

One of the advantages of basing the model on a standardized classification system is the ability to link it to other establishment, process and product-based classification systems. Comparison and crosswalk files can be created for product classification systems used to analyze trade patterns (i.e., Harmonized System (HS), Standard International Trade Classification (SITC)) as well as country specific systems such as the General Name for Economic Activities in the European Union (NACE) codes. Integrating these systems enables the development of a global value chain model.

iii. Distribution & Sales and End-Use Markets

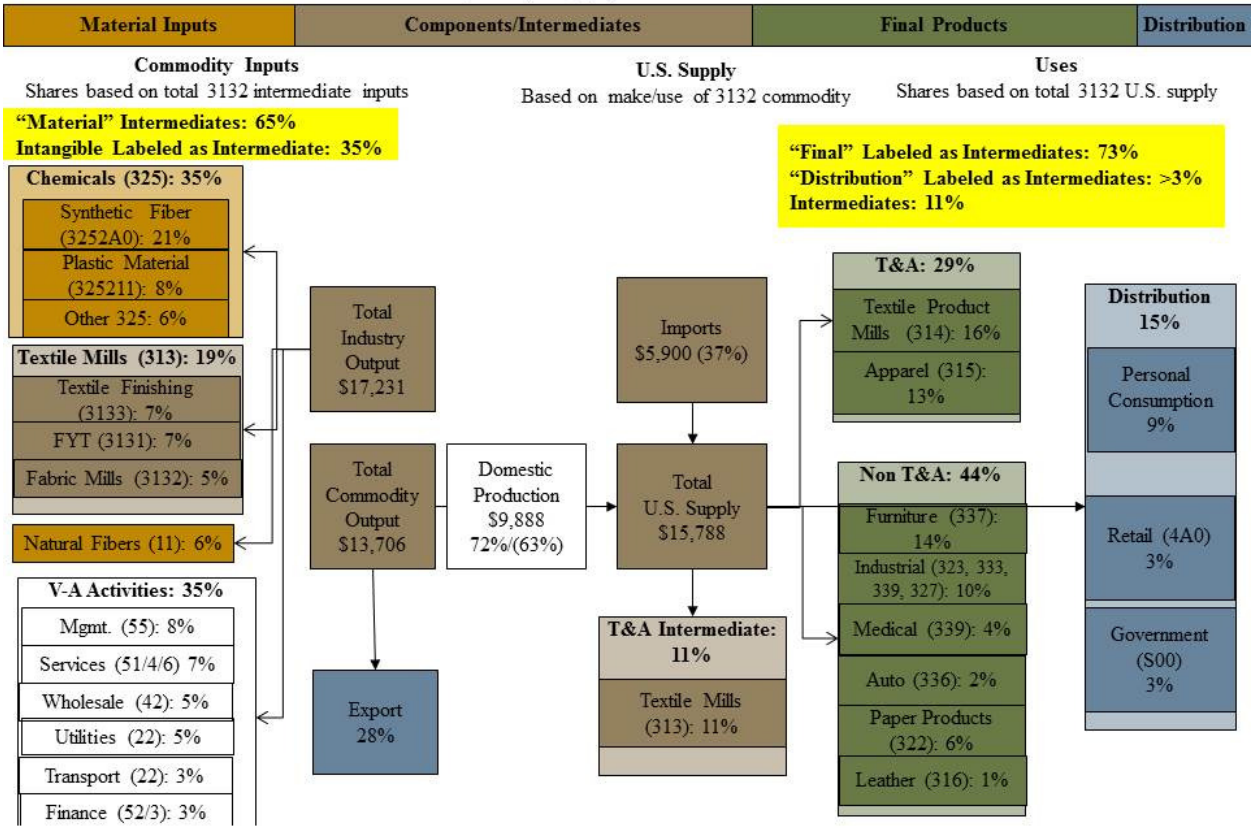
There are three broad types of final product market distribution channels and buyers. The key distinction is based on the purpose for purchasing the product. Consumer retail markets are consumer products and services (such as clothes and household items) that can be purchased via brick and mortar retail outlets, catalogs, or via the Internet. Consumer products are produced for personal use. Industrial markets are for products that are purchased by firms that are used to run or operate a business (such as machinery, equipment and building materials). Industrial products typically purchased by a business for further processing or for use in conducting the activities of the business. Institutional (Public-Use) markets are for products purchased for public use by public "institutions." Institutional buyers include firms in the hospitality (hotels, restaurants), medical (hospitals), contract (offices), and government (military, prisons, schools).[17]

End markets are included as a separate concept from the industry because many products, particularly at the raw materials and components stages, feed into more than one final product. For example, a textile fabric is classified under ISIC 17 (textiles), which is typically aggregated with ISIC codes 18 (wearing apparel) and sometimes 19 (leather and footwear) to represent the "textile and apparel industry."[18] However textile fabrics are actually an intermediate input into several industries including furniture, industrial products, medical devices and motor vehicles (see Figure 6 for an example using the U.S. fabric industry as an example).

[17] The consumer channel most closely relates to the "consumption goods" in SNA or "household consumption" in BEC and EUC. Industrial goods are related to capital goods in all three.
[18] Codes in ISIC Rev. 3; in ISIC Rev.4, codes include 13, 14 and 15 respectively.

Rather than develop a new taxonomy, the ISIC sections and manufacturing-related industries can be used as a basis to classify end markets and distribution channels as well as industries. End market classifications have been developed and used in studies of the textile and apparel industries and for the electronics industry.[19] Efforts to create end market classifications also exist as part of international efforts to develop I-O tables that include domestic production data and international trade data. The two main classifications include the Broad Economic Categories (BEC) and End-Use Categories (EUC), which also have correspondence tables. The nine EUC's are used in the OECD's Bilateral Trade Database by Industry and End-Use Category (BTDIXE). Of the nine EUC, five categories (packed medicines, personal computers, passenger cards, personal phones and precious goods) help to identify the end market of final products that have multiple inputs, one code separates intermediate goods from final goods (intermediate goods) and two codes designate "final products" and distinguish between products destined for the consumer market and the industrial market (household consumption and capital goods). The final category, "miscellaneous" covers products that do not fall into any of the eight other categories.

Figure 6: U.S. Textile Fabric Supply Chain (based on U.S. Benchmark I-O 2007)



Source: 2007 Benchmark I-O Accounts; Values $US Millions; calculations by Frederick (2014, Aug 27). (*): Not all values/shares shown. Domestic Production accounts for change in inventory as well (Domestic Production: US Commodity - Exports - Change in Inventory).

Source: Author, from (U.S. BEA, 2013a, 2013b). Textile fabric is represented by NAICS (2007) code 3132.

[19] End market used in the electronics industry included aerospace, automotive, computers, consumer electronics, industrial, medical and telecommunications (Frederick & Gereffi, 2013).

iv. Supporting Business Environment

The fourth part of the model is the external supporting business environment, which includes both the local to global entities that support and influence internal stakeholders. Members of the supporting business environment can be separated into six categories: business, information, and technology services, education, testing, and training, government services, infrastructure and finance, NGOs and standards, and trade and professional organizations.
The organizations in each of these categories provide rules and resources to internal actors in the value chain. Members of the supporting environment are responsible for establishing and enforcing institutions in various form such as norms and customs, regulations, policies, laws, international trade agreements, taxes, quotas, subsidies, licenses, anti-corruption, property rights, etc. that can facilitate or hinder the movement of a product or service along its value chain. The geographic scope of influence ranges from local through national to global, and the focus of their activities can be economy-wide or industry-specific. Economy-wide activities provide the basic structure on which all economic activities rely including transportation, communication, financial, and business-related and public services that cross-cut multiple industries. Furthermore, the actors can represent public or private interests.

B. The VCRM classification

The supply chain portion of VCRM is based on existing classification systems, but the VCRM also represents a new classification system to represent an industry's entire supply and value chain. Existing classification systems are either industry-specific or process-specific however the VCRM classification can be used for both. The firms, resources, and supporting entities included in the supply chain of the VCRM can be classified based on their place in the supply chain, the value adding-activities they engage in, the markets they serve, and by the supporting environment organizations and institutions they are affiliated with. The process is based on the four parts of the value chain reference model. [20]

1. The process begins by determining which of the six ***value-adding activities*** a firm engages in at a particular establishment. Instead of having all establishments associated with manufacturing, firms may also be associated with distribution/logistics functions as well as pre- and post-production activities. This overcomes one of the major limitations of ISIC codes.

2. The next step is to determine the parts of the ***supply chain*** the establishment performs the selected value-adding activities for. An establishment may select a position in one or multiple supply chain stages: inputs, components, final products, or distribution and sales. Furthermore, the establishment can be affiliated with one or more types (or products) within the sector. For example is a user chooses fabric, woven, narrow, nonwoven, and knitted types are all options.

3. The third step is to determine which ***end-use markets*** the final products produced from the establishment's goods or services feed into. Combining these first three pieces of

[20] A web-based version of this process is currently used for the account creation process on *NC Textile Connect* and *SC Textile Connect* websites (Frederick, 2010).

information begin the process of creating *complete* industry supply chains by product and by end-use market. Providing a means to collect this type of information systematically provides a means to fill the current information gap in the specific capabilities of firms.

4. The next step in the process seeks to determine the *specific* products an establishment produces or conducts other value-adding activities for. The addition of product information builds a more comprehensive database of existing firm capabilities. In addition to the creating a list of products a firm currently produces, it is also helpful to be aware of the products a firm is *capable* of producing. To determine capabilities, it is helpful to know the inputs to production an establishment can process. To facilitate this process, a predetermined list of specific inputs should be created to choose from.

These are the first steps to create a uniform process to collect information related to the capabilities of specific firms. Additional data items that can be added include specifications for components, machinery, final products or standard certifications (Frederick, 2010).

Both firms and members of the external supporting environment can go through the process. The supporting environment process mirrors the firm process with the addition of two steps prior to selecting value-adding activities. First, members of the supporting environment are asked to affiliate their organization with one of the following six categories of supporting organizations and then to designate the geographic scope of their services. Options include local (includes anything at the state level and below, including counties and cities), national (country level), and international (global). This helps firms to identify local resources by their respective activities. After these questions, the supporting institution follows the same set of questions as an establishment.

VI. Linking Traditional & Emerging GVC Research Approaches

This section describes the general process to link the two methods including the data sources that would be used in each part of the process.

A. Mapping: Industry-specific value chains using VCRM & I-O tables

There is not a standardized way to "draw" or "map" the structure of a global value chain. Each GVC researcher employs his own method in this process, with the majority of researchers basing this on his interpretation of key actor. The reason for this is likely three-fold. First, most GVC researchers are not economists, and therefore are not familiar with the availability of datasets or metrics that could be used to guide the mapping process in a systematic way. Second, the frame of reference for GVC studies is often dictated by a client and does not fit neatly within the scope of industrial organization classification systems (Gereffi, Brun, Lee, & Turnipseed, 2012; Gereffi, Brun, Stokes, & Guinn, 2013).[21] Lastly, as with most contract research, the process used

[21] However it should be noted that even if the request is for a specific product, this product is still embedded within a more aggregated level of each classification system and identifying where products fit can lend insight into analysis on complementary products and processes.

to conduct analysis *is* also a competitive advantage. Publishing a detailed methodology is common in academic literature, but is less common in market research.

I-O data could be used to create "benchmark" supply chains to show the commodities going into industries and vice versa. As a starting point, GVC maps should be constructed for each of the two-digit ISIC codes for all manufacturing and agriculture-related codes (sections A-C in ISIC Rev.4). A similar process could be used to develop GVC maps for service industries. Mapping a GVC for a service is different because in many cases it can be viewed as an "overlay" to a goods producing GVC and it has an industry-neutral "supply chain-like" flow of its own. This process has been completed by the author using data for the United States textile and apparel industries and seven industries on the NC in the Global Economy website however it could be replicated using international I-O tables. For the textile and apparel industries detailed files that break up the various segments of the chain using HS, SITC and ISIC/NAICS codes have been developed. The division of the textile and apparel industry codes between intermediate and final goods was compared to the BEC divisions and the two had similar results. The limiting factor is that BEC only breaks the codes into two parts (intermediate and final), whereas there are more than just two main nodes in the chain.

Three recent reports on the electronics industry also provide a list of HS codes by supply chain position. In a report prepared by Frederick and Gereffi (2013) for Costa Rica, the HS codes used to analyze the industry are listed by product category (pgs. 53-60). Information was also collected on the ***end markets*** served by individual electronics firms, which was also used to provide aggregate statistics on the end markets served by the electronics industry in Costa Rica. Similarly in a report led by Sturgeon, Gereffi, Guinn, and Zylberberg (2013) for Brazil, HS codes are provided based on intermediate or final product and end market (pg. 96-101). Both studies use the codes outlined in (Sturgeon & Memedovic, 2011) as a starting point. To illustrate how different researchers choose to visualize or map this information, see Figure 7 comparing the electronics GVC maps provided in the two studies below.

Once the industry-specific chains are developed, concordance files are readily available to link to other international classification systems for products and occupations among other things. Efforts to link these statistics to world input-output tables are also underway. The WIOD appears to be the most focused in this area and the OECD-WTO TiVA project also mentions this as a focus area.

B. Analysis: "Quantify" GVC perspective with industrial data

GVC studies can be improved by using existing data based on industrial statistics to quantify the GVC theories of governance and upgrading. Annex 5: Potential Ways to "Measure" Upgrading lists the main types of upgrading used in GVC studies and provides examples of (1) how it is (or could be) measured using readily available datasets, (2) how it could be measured by linking data from other classification systems or datasets and (3) additional information and/or datasets needed.

i. Improvements to GVC analysis using I-O datasets

There are several ways GVC analysis could be improved using existing data. For example, I-O data can be used to find the share of key inputs to particular ISIC industry compared to domestic production (backward linkages). End market (product) shifts/upgrading can be evaluated by identifying changes over time in the industries (downstream) that purchase the commodities (upstream) over time or this information could be compared using national I-O tables for different countries. With a world I-O table, one could track the shifts in end markets over time and using national data, determine which countries are shifting to the new markets and which countries are lagging behind. One can also use I-O tables and trade data to evaluate end market (geographic) shifts/upgrading. This is of particular importance for fast growing economies that are currently key exporters, but may shift to supply products and services to the domestic economy as population and demand increase in the home countries.

ii. Improvements to GVC analysis using trade data

GVC analysis can also be improved by incorporating more detailed trade data. This can be used to analyze product upgrading and geographic end market upgrading. Trade data is used to describe these types of upgrading in the textile, apparel and electronics industries (Frederick, Bair, & Gereffi, 2014; Frederick & Gereffi, 2011, 2013; Frederick & Staritz, 2012). This will also be expanded in a forthcoming World Bank apparel project. This project will include a variety of datasets on industrial economic activities and labor market data.

iii. Using the VCRM to guide GVC analysis

The VCRM can also serve as the organizing structure to guide value chain analysis of competitive dynamics and relationships (Frederick, 2010). In the research approach, the degree to which firms in the supply chain engage themselves in the value-adding activities determines their position in the global industry. They can be viewed from the perspective of a firm or the entire chain/inter-firm network. Firms can facilitate this process by interacting with the institutions that make up the global supporting environment. Furthermore, firms can upgrade or create a unique advantage by interacting with other parts of the supply chain, or by focusing on different markets (Frederick, 2008; Frederick & Cassill, 2009). The VCRM can be used as part of a process firms go through to determine where they are in the value chain. This visual process can be used as the basis of an educational or competitiveness tool used to determine the structure of an industry as well as potential strategies and tactics.

C. Steps to a combined approach

In order to evaluate GVC dynamics, classification systems are needed that enable establishments to be classified along five* dimensions: industry (including products by industry), supply chain position, end markets, value-adding activities (or business functions) and occupations.
Table 4 lists the availability of classification systems in each area and the type of upgrading it pertains to.

Existing economic activity and product classification systems were originally created decades ago when the activities of establishments and the end-use and industry of products could be much more narrowly-defined. Resultantly, the concepts of industry, supply chain, end market and activity-specificity are all embedded in these systems to some extent, but all four are combined in a non-uniform fashion. In Annex 6: ISIC Rev.4 Sections Correlation to Value and Supply Chain Stages, the ISIC Rev. 4 sections are correlated to the value chain stages and supply chain positions they generally represent for goods producing industries. In the ISIC system, the majority of the codes represent a "service" industry, however in reality establishments that provide services often do so for a specific industry. However in the ISIC system there is not a way to separate out these activities by industry (in detail). For example, one could map out all of the stages in the accommodation and food service activities industry however this industry also represents one of the main categories of buyers for goods producing industries within the manufacturing sector (i.e., food, furniture, textiles, etc.).

Table 4: Classification Focus Areas: Existing Systems & Relationship to Upgrading

Focus	Existing Classification Systems	Notes	Type of Upgrading
Industry (and product)-specific	ISIC – two-digit codes in sections A-C (32 in Rev. 4) can be a starting point for benchmark chains	Correlations to product-specific systems (i.e., HS, CPC) exist	Product (industry-specific)
Supply chain-specific	ISIC resembles supply-chain stages, but only industry-specific for agriculture, mining and manufacturing (A-C)	BEC provides separation of primary, processed unfinished and finished and intermediate and final	Supply chain; backward/forward linkages
End market-specific	Industry[22] and Buyers: BEC & EUC (linked to ISIC & HS) Geography: HS		End market
Value-adding activity-specific "Business Functions"	Business function classifications (Europe, USA and Canada); international classification system does not yet exist	Business functions will need to be fully linked to ISIC/HS/CPC; Or, industry-specific codes can be added to ISIC for sections beyond A-C	Functional
Occupation-specific	ISCO	ISCO can be correlated to ISIC	Functional; Process

Source: Author

[22] Industry end markets are more important as a means to classify intermediate goods than final products.

VII. Appendices

Appendix 1: Background, objectives & methods of stakeholders interested in GVCs

Research labeled "GVC" can be broken into the following groups

- *Academics:* people based at universities, many of which have research centers engaged in contract-type research
    - Social science: the GVC framework primarily originated from a group of international researchers from economic sociology and geography backgrounds engaged in economic development research (Annex 1).
    - Economists: value chain research by economists traditionally focused on the firm as the primary unit of analysis and was centered on maximizing competitiveness at the firm level. In recent years "new" GVC researchers have emerged – whereas the majority of the work from these groups is not labeled as GVC, they are engaging in research that will enable "quantifying" GVC activity (Annex 2).
- *International NGOs and national governments:* these groups are the primary funders of GVC-related research. They are primarily interested in how studies using a GVC lens can guide policymaking and economic development (Annex 3).
- *Statistical agencies:* these groups are responsible for collecting and disseminating data that can be used to measure and benchmark the performance of countries and industries (Annex 4).

Academic Divide: Traditional GVC Social Scientists & "GVC" Economists

Annex 1 includes the "traditional" group of GCC, GVC and GPN researchers; this group primarily consists of the creators of the GVC framework and the GPN framework and others that work at affiliated research centers. The data used to conduct a traditional GVC study and the resulting analysis is primarily *qualitative*. Information is typically conducted by collecting basic industry-specific statistics, gathering secondary information from journal articles, reports and market research and through primary data collection via interviews or surveys with firms and supporting organizations.

A significant component of many GVC is simply data gathering. Given that most government officials and international NGOs are policy or development specialists rather than industry specialists, simply knowing where to find information, let alone analyze it, is both a daunting and arduous task. The group in Annex 2 includes research centers and economists that have started to engage in "GVC" research, primarily over the last five years. Prior to this, value chain-like research focused at the firm-level and was primarily composed of groups that followed the frameworks of Porter. Unlike traditional GVC studies, economists first look to available datasets to guide research and prioritize developing *quantitative* results. Economists acknowledge that data is imperfect, but prefer to have measurable outcomes versus subjective analysis.

The interest in GVCs for economists is largely related to what Baldwin refers to as the "second unbundling" (Baldwin, 2009). The first unbundling came from trade theory, and was based on comparative advantage and sectors were the unit of analysis. The second unbundling is based on

trade in tasks and started in mid-1980s (Grossman & Rossi-Hansberg, 2008). It occurred due to (1) decrease in trade costs, (2) policies, (3) demand and (4) technological change (De Backer & Miroudot, 2013).[23]

The groups below are international organizations that either contract out GVC related research or have staff that work with outside groups to conduct value chain studies. Nearly all of these groups have published GVC guides, toolkits and handbooks on how to do value chain research (see Annex 3: International Organizations Engaged in GVC Research for the main publications by organization). These organizations are primarily interested in GVC research as a framework to guide policymaking that provides equitable development that factor in economic, social and/or environmental concerns.

Interest in GVCs by international NGOs and national governments has been a recent phenomenon that started roughly a decade ago, but intensified in 2008/2009 with the onset of the global economic crisis. Prior to this, the majority of GVC research was conducted in academic institutions and research outputs were primarily developed for inclusion in scholarly journals. Today the majority of GVC studies are in the form of reports sponsored by national governments or international agencies on behalf of their constituents.

The organizations in Annex 4 are international, regional and national statistics agencies responsible for collecting industrial and/or trade statistics. These groups are all, in some way, leading the charge in exploring how to make better use of available data and/or create new surveys in areas with limited data availability such as business function data.

[23] Baldwin prioritizes technology change as the primary driver.

Appendix 2: Basic data sources

Table 5 presents databases compiled by international organizations related to different economic and social indicators ranging from international trade to economic activities. These databases are compiled from national statistical offices (NSOs) unless otherwise noted. These should all be data sources regularly used in GVC studies, but in practice the majority only uses international data on trade in goods from UNCOMTRADE.

Table 5: International Statistics Databases by Classification Area and Organization

Classification Area	Organization	Database	Statistical Systems	Digit level	Years	Countries
Int'l Trade: Goods	UNSD	COMTRADE	HS: 92,96,02,07, AR SITC: Rev1,2,3,4, AR BEC	HS: 2,4,6 SITC: 1-5 BEC: N/A	1988-present 1962-present 1988-present	
Int'l Trade: Services	OECD UN	TISP ServiceTrade			1970-2011	34 OECD
Labor: Employment	ILO	LABORSTA ILOSTAT	ISIC: 58, R2, R3, R4	ISIC:1,2	1969-2008 2009-2010	230
Labor: Occupations	ILO	LABORSTA ILOSTAT	ISCO: 58, 68, 88 ISCO: 68, 88, 08	ISCO: 1,2 ISCO: 1,2	1969-2008 2009-2010	230
Labor: Education	ILO	LABORSTA ILOSTAT	ISCED: 76, 97 ISCED: 97	1-6	1969-2008 2009-2010	230
Labor: Employment Status	ILO	LABORSTA ILOSTAT	ICSE: 58, 93		1969-2008 2009-2010	230
Industries/ Economic Activities	UNIDO-OECD UNIDO-OECD OECD OECD	INDSTAT4 INDSTAT2 STAN STAN	ISIC Rev3; Rev4 ISIC Rev3 ISIC Rev3 ISIC Rev4	ISIC: 4D ISIC: 2D ISIC: 2D ISIC: 2D	1990-2011 1963-2011 2000-2010	135 166 32 OECD 15 OECD
Products	UNSD	ICPS	LIP		1950-2010	
National Accounts	UNSD	UNData	ISIC	1D	1964-present	200+
Output + Int'l Trade	UNIDO	IDSB: NSO + COMTRADE	ISIC Rev3 + HS ISIC Rev4 + HS	ISIC: 4D ISIC: 4D	1990-2001 2000-2011	93 55

Source: Author; AR: as Reported

Table 6 describes the main regional and international efforts to collect and develop national, regional and international datasets and indicators related to I-O or supply-use data. Of the I-O efforts underway, the one that could be considered the closest to GVC analysis is the WIOD. Outcomes from this project provide the most detail at the industry/product level and an equal focus is on correlating production and trade data to socio-economic and environmental indicators. Similar to the information available in Table 5, I-O data and the indicators that can be produced using these datasets are not currently used in GVC studies, but should be.

Table 6: Comparison of I-O Related Datasets

Variable/Dataset	STAN I-O	STAN BTDIxE (2013)	GTAP8 (2012)	WIOD	TiVA (May 2013)	Asian I-O
Publisher	OECD	OECD	Purdue/ GTAP	ECFP7/ Eurostat/ GGDC	OECD/ WTO	IDE-JETRO
Countries	48	152	129	40	57	10
Years	'95, '02, '05	1990-2012	2004, 2007	1995-2011	1995, 2000, 2005, 2008, 2009	
Economic Activities (Industries)/Products	37	66	57	35/59	18	
ISIC Revision	ISIC Rev3	ISIC Rev3 ISIC Rev4	ISIC Rev3	ISIC Rev2/ CPC[24]	ISIC Rev3	
End Uses	No	EUC (9)	BEC	BEC	EUC (9)	
Trade Data	No	HS6D-ISIC		HS6D	BTDIxE	
Services	No	No		No	Yes-TISP	
Economic Indicators	No	No		2	39[25]	
SEA Indicators	No	No	No	Yes	Yes	
EA Indicators	No	No	Some	Yes	No	
I-O or SUT	I-O		I-O	SUT	I-O →SUT	
Description	I-O TBLs (modified)	I-O TBLs (modified) + Int'l Trade	I-O + Int'l Trade	NSA + SUT + Int'l Trade + SEA + EA	I-O + Int'l Trade + Services	
Classification Systems	ISIC	ISIC + HS + EUC	ISIC + HS + BEC	ISIC + CPA + HS + BEC + SEA + EA	ISIC + HS + EUC + TIS	

Source: Author

[24] Technically based on NACE Rev1 and CPA (European counterparts)
[25] Calculate trade in value-added rather than just value-added

Appendix 3: Applications of the VCRM

Information Management System and Online Directory
This VCRM can be used as an online information management system and platform for a website directory to disseminate and collect business information among members of an industry. The VCRM is used to bring together and organize information from diverse resources available to an industry. By displaying this system as a web based application, users are able to traverse the information for each stage of the value chain through the use of a visual depiction.

This type of industry resource can serve four primary functions: describe, promote, and explain an industry value chain; provide a comprehensive repository of data; create a medium for increased collaboration among government, academia, and industry; and serve as a learning tool (Frederick, 2008). There are currently two examples that use the VCRM as the basis of an industry-specific information directory for the textile value chain: *NC Textile Connect* (www.nctextileconnect.com) and *SC Textile Connect* (www.sctextileconnect.com). These two websites were created by the author and are maintained by North Carolina State University, College of Textiles. These sites are designed to increase awareness of these states' textile industries and increase collaboration among its respective members.

The *Textile Connect* sites provide industry information based on the VCRM applied to the textile value chain. Major sections of the website include: textile research, trade data, local to global events, news, publications, business information, and a directory of all the members of each state's textile complex. All information on the websites is classified and searchable by the value chain classification system and visual representation. The value chain visual is interactive, and when clicked, each box in the value chain proceeds to a unique page for that part of the value chain. On each unique value chain page are links to all of the other sections of the website (events, trade data, publications, consumer market data, news, companies) but only the resources within each section that pertain to that part of the value chain (Frederick, Dunning, & Cassill, 2009).

Companies can create a login and password to add their profiles to the database or edit their existing profile. In doing so, this portal allows administrators to collect contact information from the textile community to facilitate future dialogue. Firms can identify potential buyers and suppliers using this comprehensive database and economic developers can use the site to identify firms and support within their areas by each part of the value chain.

Value Chain Visual Analytics
Another website resource that connects the parts of the value chain is found on the North Carolina in the Global Economy (NCGE) (www.NCGlobalEconomy.com) website at Duke University (CGGC, 2014). This website analyzes seven of North Carolina's major industries (including textiles) based on the same value chain model. The ability to apply the same reference model to other industries creates a way for researchers to identify commonalities among industries undergoing similar development trajectories.

The value chains on the NCGE site are all interactive models that exhibit additional ways industry data and statistics can be connected to the value chain model. For example, when the

user places the cursor over the supply chain boxes, a description of each NAICS-based activity appears along with statistics from QCEW on the number of firms, employees, and average annual wages per employee in North Carolina.

Visualization is also used as an analytical tool on the NCGE site. By placing the mouse over the supporting industries or value-adding activities boxes, the stages in the supply chain that are highly impacted by these areas are highlighted, in addition to a description of activities and statistics when available. Additionally, the firm structures of the top five employers in each NC industry are mapped on the value chain. This is accomplished by identifying all of subsidiaries and accompanying NAICS codes for each establishment within a firm and relating this back to the value chain model (CGGC, 2014).

The goal of the project is to simplify understanding of industrial organization, international trade and economic development patterns by integrating empirical and analytical data with user-friendly, web-based visualizations. A more recent example, also created by the author, combines the concepts behind Textile Connect and NCGE. The California in the Nano Economy website (www.CaliforniaNanoEconomy.org) is both an educational resource and an information directory of firms and organizations engaged in all aspects of nanotechnology research through production for all impacted industries.

Appendix 4: Methods used in three industries (apparel, auto, electronics)

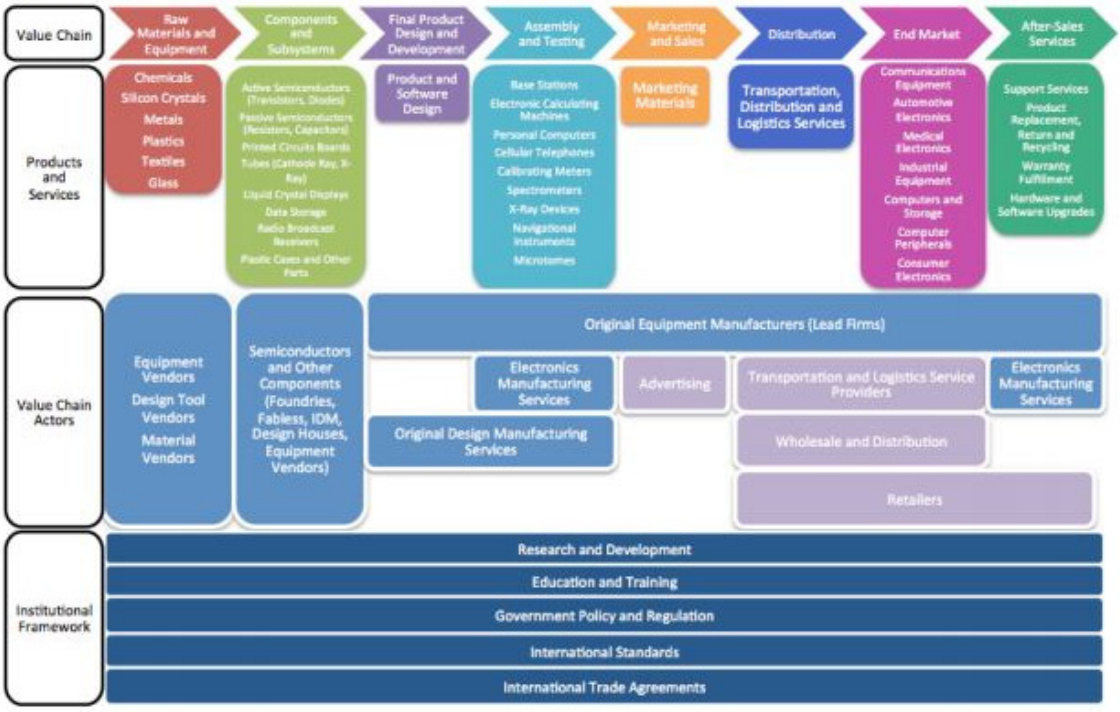
This section provides a profile of how the GVCs of three well studied industries have been analyzed, including the methods used, to identify overlaps in methodology. For a complete listing of studies for these industries and others, see www.globalvaluechains.org.

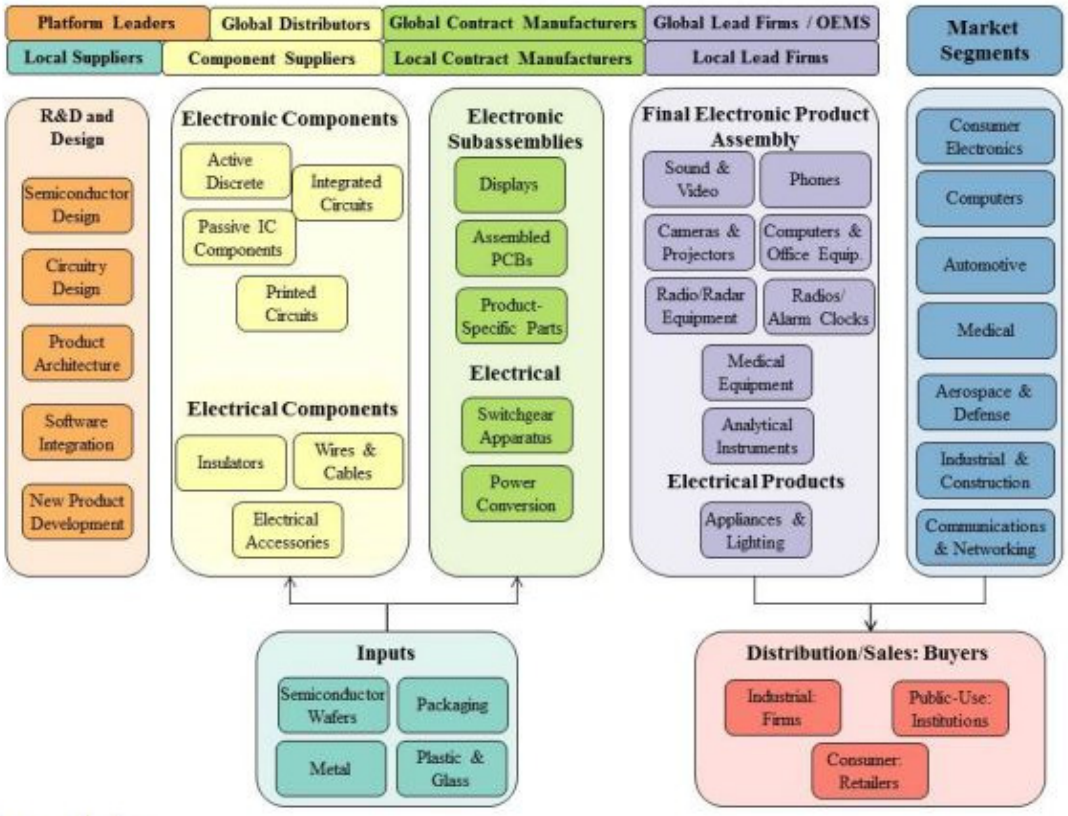
Studies on the global apparel industry have primarily been written by Gary Gereffi and more recently by Stacey Frederick and Cornelia Staritz (Frederick & Gereffi, 2011; Frederick & Staritz, 2012; Gereffi & Frederick, 2010). A number of researchers also specialize on a country-specific basis including Meenu Tewari (India), John Pickles (Eastern Europe, China) and Mike Morris (Africa) to name a few.

The following 15 studies (2003-2014) all use a GVC framework to analyze the automotive industry: (Abe, 2013; Conteras, Carrillo, & Alonso, 2012; De Backer & Miroudot, 2013; Gereffi & Guler, 2010; GERPISA, 2010; Humphrey & Memedovic, 2003; Kaplinsky, 2005; Sturgeon & Memedovic, 2011; Sturgeon, Memedovic, Van Biesebroeck, & Gereffi, 2009; Sturgeon & Van Biesebroeck, 2011; Sturgeon, Van Biesebroeck, & Gereffi, 2007, 2008, 2009; van Biesebroeck & Sturgeon, 2010).

GVC research on the electronics industry has been carried out by Tim Sturgeon and colleagues (Frederick & Gereffi, 2013; Sturgeon, 2003, 2007; Sturgeon et al., 2013; Sturgeon & Kawakami, 2010a, 2010b, 2011; Sturgeon & Lee, 2004; Sturgeon & Memedovic, 2011). Electronics industry research has also been conducted by economists engaged in product "teardown" studies by researchers at Research Institute of the Finnish Economy (ETLA) and the Sloan Personal Computing Industry Center (PCIC) at UC-Irvine.

Figure 7: Electronics GVC Maps (Brazil & Costa Rica Country Report)





Sources: Top (Sturgeon et al., 2013); Figure 8: The Electronics Global Value Chain Map; Bottom (Frederick & Gereffi, 2013); Figure 1: The Electronics Global Value Chain

VIII. Annexes

Annex 1: GVC-GPN-GCC Researchers Centers (Academics-Social Sciences)

#	Organization	Focus Areas	People
1	Duke University, Center on Globalization, Governance & Competitiveness (CGGC)	Home GVC Initiative; all theoretical and industry topics; CtG	Gary Gereffi*, Stacey Frederick, Karina Fernandez-Stark
2	MIT, Industrial Performance Center (IPC)	Governance; Business Functions; Definitions; Automotive; Electronics	Tim Sturgeon*
3	University of Manchester (UK); Brooks World Poverty Institute	Social upgrading; CtG; GPN	Stephanie Barrientos; Martin Hess
4	Open University (UK)	Rent/Profit	Raphael Kaplinsky*
5	University of Cape Town, South Africa; Policy Research in International Services and Manufacturing (PRISM)	Africa	Mike Morris*
6	University of Sussex, Institute for Development Studies (IDS)	Industrial upgrading	Hubert Schmitz*, John Humphrey*
7	Danish Institute for International Studies (DIIS)	Theory; Africa	Stefano Ponte, Peter Gibbon
8	UNC-Chapel Hill	Apparel, India, Eastern Europe, Asia, GPN; CtG	Meenu Tewari, John Pickles
9	National Singapore University (NUS)	GPN	Neil Coe, Henry Yeung
10	University of Colorado	Social; Institutional Governance, Apparel, CtG	Jennifer Bair
11	Austrian Research Foundation for International Development (OFSE)	Apparel; CtG;	Cornelia Staritz

Source: Author; Notes (*): indicates person involved in original GVC framework planning

Annex 2: New GVC Economists

#	Organization	People	Focus Areas/ Projects
1	The New School (NY), Schwartz Center for Economic Policy Analysis (SCEPA)	Will Milberg, Deborah Winkler	
2	University of Groningen, Groningen Growth & Development Centre (GGDC)(Netherlands)	Marcel Timmer, Bart Los, Erik Dietzenbacher	WIOD
3	Graduate Institute/CEPR (Switzerland)	Richard Baldwin	
4	Research Institute of the Finnish Economy (ETLA)	Timo Seppälä	Case Studies; Electronics
5	IDE-JETRO	Bo Meng Satoshi Inomata	Measuring GVCs/GFTS Asian IO TBLs (Meng, Zhang, & Inomata, 2013)
6	UC-Irvine, Personal Computing Industry Center (PCIC) (Sloan Center)	Kenneth Kraemer, Jason Dedrick	Case Studies; Electronics
7	Center for Global Trade Analysis, Global Trade Analysis Project (GTAP), Purdue University, Department of Agricultural Economics		GTAP
8	Peterson Institute for International Economics (PIIE)		Measuring GVCs/GFTS
9	Vienna Institute for International Economic Studies (WIIW)	Robert Stehrer	WIOD Measuring GVCs/GFTS
10	Harvard	Michael Porter	Firm VC; Clusters; USA
11	UC-Davis; NBER	Robert Feenstra	Production Fragmentation; Int'l Economics (Late '90s)

Source: Author

Annex 3: International Organizations Engaged in GVC Research

#	Int'l Org.	Key VCA Publications & Events	Focus Areas	People
1	OECD	(OECD, 2013) OECD WP Globalization of Industry Meeting Theme 1: GVCs (2011)	Measuring GVCs/GFTS Trade Policy/G20 TiVA[26]	Koen De Backer Sébastien Miroudot Norihiko Yamano Nadim Ahmad Dorothée Rouzet
		(OECD, 2008) Global Conference on Enhancing the Role of SMEs in GVCs (2007)	SMEs	Mariarosa Lunati
		(OECD, 2007)	Upgrading	
2	World Bank	(Taglioni & Winkler, 2014)	Measuring GVCs/GFTS Trade & Invest Policy/G20 Country/Sector Studies	Daria Taglioni
		(Cattaneo, Gereffi, & Staritz, 2010)	Crisis	Bernard Hoekman (former) Olivier Cattaneo (former)
		(FIAS, 2007) (FIAS, 2006)	CSR	
3	WTO	(Elms & Low, 2013) (WTO & IDE-JETRO, 2011)	Measuring GVCs/GFTS MiWi/Trade in Tasks Trade Policy/G20	Hubert Escaith Andreas Maurer Pascal Lamy (former)
4	UNIDO	(UNIDO, 2011) (Sturgeon & Memedovic, 2011)	Measuring GVCs/GFTS Country/Sector Studies	Olga Memedovic
5	UNCTAD	(UNCTAD, OECD, & WTO, 2013) (UNCTAD, 2013)	Measuring GVCs/GFTS Investment Policy/G20	James Zhan Xiaoning
6	ILO	(Herr & Muzira, 2009) (Schmitz, 2005)	Better Work Initiative Labor Policy/G20	Arianna Rossi
7	WEF	(WEF, 2012)		

Source: Author; In addition to the groups listed above, nationally-based aid organizations (e.g., USAID, DFID) have also been supporters of the GVC framework.

[26] Other members of the OECD TiVA team include Colin Webb, Agnes Cimper, Guannan Miao and Bo Werth (OECD, 2013).

Annex 4: Statistical Agencies Interested in GVCs

#	Organization	Key Publications	Focus Areas/ Projects	Surveys
1	UNSD		Measuring GVCs/GFTS	
2	USITC		Measuring GVCs/GFTS GTAP w/other data	
3	Eurostat & European NSOs	(Sturgeon, 2013) (Alajääskö, 2009) (Nielsen, 2008)	Measuring GVCs/GFTS Business Functions WIOD & WORKs	International Sourcing Statistics (ISS): (Eurostat, 2001-2006, 2009-2011)
4	Statistics Canada & Foreign Affairs and International Trade (DFAIT), Canada		Business Functions	Survey of Innovation and Business Strategy (SIBS): (2009, 2012)
5	National Science Foundation (NSF)	(Claire Brown et al., 2013)	Business Functions	National Organizations Survey (NOS) (Clair Brown & Sturgeon, 2010)
6	Statistics Netherlands	(Statistics Netherlands, 2009, 2011)	Measuring GVCs/GFTS Linking	
7	Statistics New Zealand	LBD Research	Measuring GVCs/GFTS Linking	
8	Japan - METI		Measuring GVCs/GFTS	
9	COMEX		Measuring GVCs/GFTS	

Source: Author; Notes: Linking: linking business characteristics with trade data

Annex 5: Potential Ways to "Measure" Upgrading

Upgrading Type	Existing Datasets/Examples	Linking Economic Activity (ISIC) to Existing Datasets[27]	New Datasets/ Information Needed
Functional Upgrading	• WIOD: SEA Worker-Skill Level (ISIC-ISCED-97)[28] • CtG Economic/Social Upgrading (Barrientos, Gereffi, & Rossi, 2010) • U.S. BRDIS: R&D investment (NSF-NCSES, 2010)	• Occupational data (ISIC-ISCO); share of workers industry by occupation • Patent Statistics – R&D & Design (ISIC-IPC-CPC); Trademarks – Marketing/Branding (firm-level; microdata) • Bibliometric analysis – research	Business function data
Backward Linkages	• TiVA: foreign value-added share of gross exports • Increase in production output or employment (ISIC) in upstream ISIC • Trade data: export/import of inputs compared to other countries	• HS-ISIC/I-O: share of inputs imported vs. domestic purchases	I-O: identify benchmark upstream sectors
End Market	• Geographic end market: Trade data: export shifts	• Buyer end market: I-O downstream shifts in final-use categories	Industry end-market classification system (ISIC); add national survey questions
Product	• Trade data: increase in export unit values • Trade data: shift to products in industry with higher unit values		Trade data based on quantities
Process	• Productivity: increase in industrial output/worker; • Increase in capital expenditures • Machinery imports		
Social	• Increase in wages/employment by ISIC (INDSTAT)		Nationality of management
Firm ownership	• Domestic vs. FDI by ISIC • WIOD SEA: investment or capital flow data (?)		
Country-Level Benefits	• Increase in domestic value-added (gross & TiVA) • Increase in employment • Increase in tax income		
Strength of Institutions	• Educational programs availability	• Trade & tariff data (HS); • Trade preference programs (impact on import/export partners)	
Governance		• Firm concentration ratio	

Source: Author

[27] Potential additions to international input-output efforts
[28] Also applicable for social upgrading

Annex 6: ISIC Rev.4 Sections Correlation to Value and Supply Chain Stages

ISIC Section	ISIC Description	Value-Adding Activity (to Goods Industry)	Supply Chain Position (to Goods Industry)	Industry Type
A	Agriculture, forestry and fishing	Production	Raw materials; Components & Final	Goods
B	Mining and quarrying	Production	Raw materials; Components & Final	Goods
C	Manufacturing	Production	Components & Final; Buyers (All)	Goods
D	Electricity, gas, steam and air conditioning supply		Buyers (Industrial); Supporting Environment	Service
E	Water supply; sewerage, waste management and remediation activities		Buyers (Industrial); Supporting Environment	Service
F	Construction		Buyers (Industrial)	Service
G	Wholesale and retail trade; repair of motor vehicles and motorcycles	Distribution/Logistics; Marketing/Sales	Buyers (Consumer)	Service
H	Transportation and storage	Wholesale/Logistics	Intermediaries; Buyers	Service
I	Accommodation and food service activities		Buyers (Institutional)	Service
J	Information and communication	Distribution/Logistics; Marketing/Sales	Components & Final; Supporting Environment	Goods; Service
K	Financial and insurance activities		Supporting Environment	Service
L	Real estate activities		Supporting Environment	Service
M	Professional, scientific and technical activities	R&D; Design	Whole Supply Chain	Service
N	Administrative and support service activities	Marketing/Sales; Services (After-Sale)	Whole Supply Chain	Service
O	Public administration and defense; compulsory social security		Buyers (Institutional)	Service
P	Education		Buyers (Institutional); Supporting Environment	Service
Q	Human health and social work activities		Buyers (Institutional)	Service
R	Arts, entertainment and recreation		Buyers (Institutional)	Service
S	Other service activities		Buyers (Institutional)	Service
T	Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use			
U	Activities of extraterritorial organizations and bodies			

Source: Author Interpretation; see Steps to a combined approach section

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