

# Analytical frameworks for global value chains: An overview

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In a keynote speech at a seminar on global value chains (GVCs), Richard Baldwin delivered wittily, with his mischievous smile, a rather provocative statement: “The term ‘global value chains’ doesn’t describe what we see today in the world economy”<sup>1</sup> because:

- The world economy is not global; it remains regionally segregated, such as Factory Asia, Factory Europe, and Factory North America.
- What matters is not value (added) but jobs, especially good jobs.
- Production systems are not configured as a linear sequence of production stages like chains but consist of complex networks of hubs and spokes.

This is alarming. However, it is also true that many people now use the term “GVCs”—often inconsistently across contexts.

With that as the backdrop, this chapter cultivates some common ground for approaching this new area of academic interest by tracing the development of relevant studies. This is not an encyclopedic literature survey; it focuses only on the strands of research that explicitly consider vertical (supply–use) relations of cross-border production sharing and their impact on distributing value among the parties—which is at the heart of GVC studies.<sup>2</sup>

The first section of the chapter considers why GVC studies are important from the viewpoint of their contribution to the history

of international trade theories. The second traces the development of the GVC concept, with some reference to the evolution of global production networks. The third introduces the main theoretical achievement in GVC studies. The fourth summarizes the challenges for a quantitative description of GVCs, particularly for the innovative use of multicountry input-output tables. The fifth addresses pressing issues for advancing GVC research. The last section presents some meta-methodological considerations on the development of GVC analyses.<sup>3</sup>

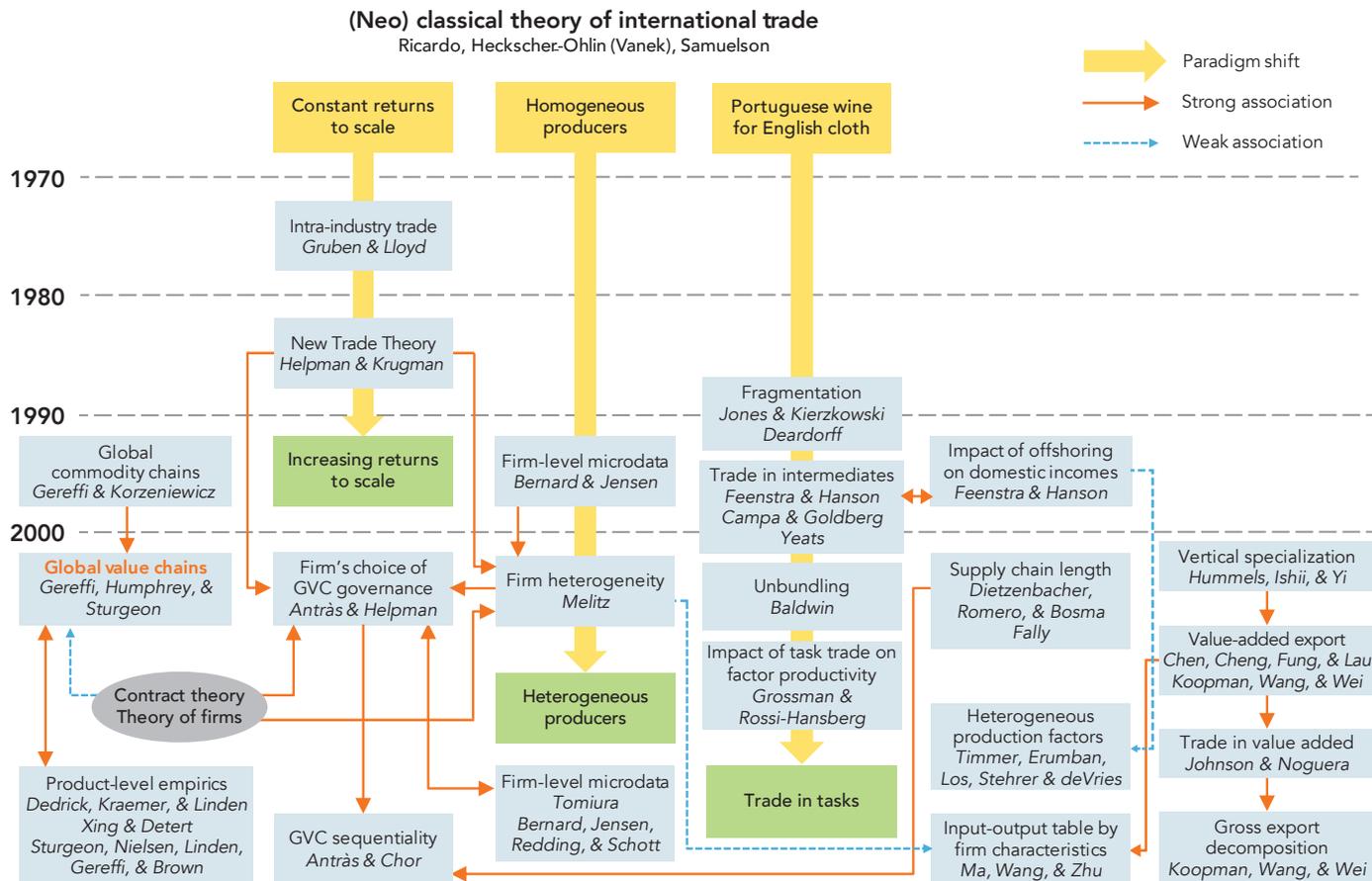
## The global value chain paradigm: New-New-Trade Theory?

Since David Ricardo established the foundation of international trade theory two centuries ago, mainstream thought, from Heckscher-Ohlin to Samuelson, has hinged on three classic premises (figure 1.1):

- Markets are perfectly competitive, and producers operate at constant returns to scale.
  - An industry consists of homogeneous producers.
  - Countries trade only final products—traditionally phrased as Portuguese wine for English cloth—and each product is made using the production factors of only the exporting country.
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**FIGURE 1.1** Genealogical map of analytical frameworks for global value chains



Source: Author's drawing.

The first premise was shaken in the 1970s and 1980s when a new school of thought, New Trade Theory, emerged. Its key feature, pioneered by Krugman (1979, 1980) and generalized by Helpman and Krugman (1985), was the theoretical scope for considering production technology with increasing returns to scale (paired with the love of variety), which underpins the analytical frameworks of international trade under imperfect competition. The models provided a plausible explanation for the prevalence of intra-industrial trade between countries with similar technology and resource endowments—a phenomenon that cannot be explained by the orthodox notion of comparative advantage.<sup>4</sup>

The evolution of theoretical frameworks is generally driven by the need to fill a gap between a newly discovered stylized fact and the predictions of prevailing models. Just as the empirical findings on intra-industry trade, notably those of Grubel and Lloyd (1975), were followed by New Trade Theory, so too was the second classic premise of homogeneous producers reconsidered following evidence in the late 1990s. Bernard and Jensen's (1995, 1999) detailed examination of firm-level microdata revealed substantial heterogeneity in firm productivity between exporters and nonexporters in a given industry. Melitz (2003) pioneered

an explanation for these observations, advancing in the quest for what was later called New-New Trade Theory. By assuming a fixed cost of entering export activities, the model considers the mechanism of a firm's endogenous selection on market entry or exit and thereby provides a powerful explanation for the coexistence of heterogeneous firms within an industry.<sup>5</sup>

A third wave of reconstructing classical theory is now under way, and the literature on GVCs is generally linked to this development strand. With the dramatic advance of transportation modes and information and communication technology, production processes can now be "sliced" into several production segments, each corresponding to a particular task—such as design, parts procurement, assembly, and distribution. These segments are relocated, often across national borders, to the places where the tasks can be performed most efficiently. Thus the core subject of the literature today is not only the movement of final products, as classical theories have focused on (under the third premise), but also the cross-national transfer of tasks, or the value added generated by these tasks.

The main characteristic of the GVC paradigm is the variety of its intellectual origins. The initial theory of production fragmentation (Jones and Kierzkowski 1990) was followed by

increasing observations of trade in intermediate goods (Feenstra and Hanson 1996b; Campa and Goldberg 1997; Yeats 1998), which brought about further elaboration of key concepts such as unbundling (Baldwin 2006) and trade in tasks (Grossman and Rossi-Hansberg 2008a).

In parallel, methodological frameworks also advanced in sociology. Drawing on analytical scopes of academic fields, from business management to industrial organization theory, a comprehensive study on the structure and mechanism of value distribution among countries led to the term “global value chains” (Gereffi, Humphrey, and Sturgeon 2005).

The empirical aspect of GVC studies is newer. Earlier value-added analyses based on firms’ business records (Dedrick, Kraemer, and Linden 2008; Xing and Detert 2010) are now complemented by input-output analysis, in which various GVC metrics were devised using multicountry input-output databases, such as trade in value added (Johnson and Noguera 2012) and supply chain length (Dietzenbacher, Romero, and Bosma 2005; Fally 2011).

One of the key integrating forces was Antràs and Helpman (2004), who featured the legacies of both the New Trade Theory (increasing returns to scale) and the New-New Trade Theory (firm heterogeneity) in a study based on the frameworks of contract theory, while contract theory can be associated with sociologists’ approaches to GVCs. The properties of the model were carried over to Antràs and Chor (2013), who further incorporated the methodological progress in input-output economics.

The interdisciplinary characteristic of the GVC paradigm allows for large-scale research collaboration across the social sciences, as demonstrated in this report. Topics in the GVC literature, some of which are highly politically relevant, include:<sup>6</sup>

- Industrialization strategy (full-set versus GVC-driven industrialization).
- Labor issues (impact of globalization on employment and income distribution).
- Regional development (trickle-down effect through domestic production linkages).
- Innovation and technological spillovers (learning through GVC participation).
- Economic crisis (propagation of external shocks on production and trade).
- Supply chain resilience (impact of natural or human-caused disasters on supply chains).
- Environmental protection (carbon footprints and global governance).
- Consumer protection (food safety and certification).
- Poverty alleviation (fair trade and corporate social responsibility).
- Trade regimes (World Trade Organization and regional trade agreements).
- National accounts (statistical bias of gross trade data).

## Concept development

The concept of GVCs did not follow a linear development path. The basic images of the term were conceived and fostered in

various scientific subfields in different ways at different times. The ideas only recently started to cross over academic borders, and they continue to evolve along dynamic interactions of theories and empirics.

### **Unbundling economies: Baldwin’s historical perspective**

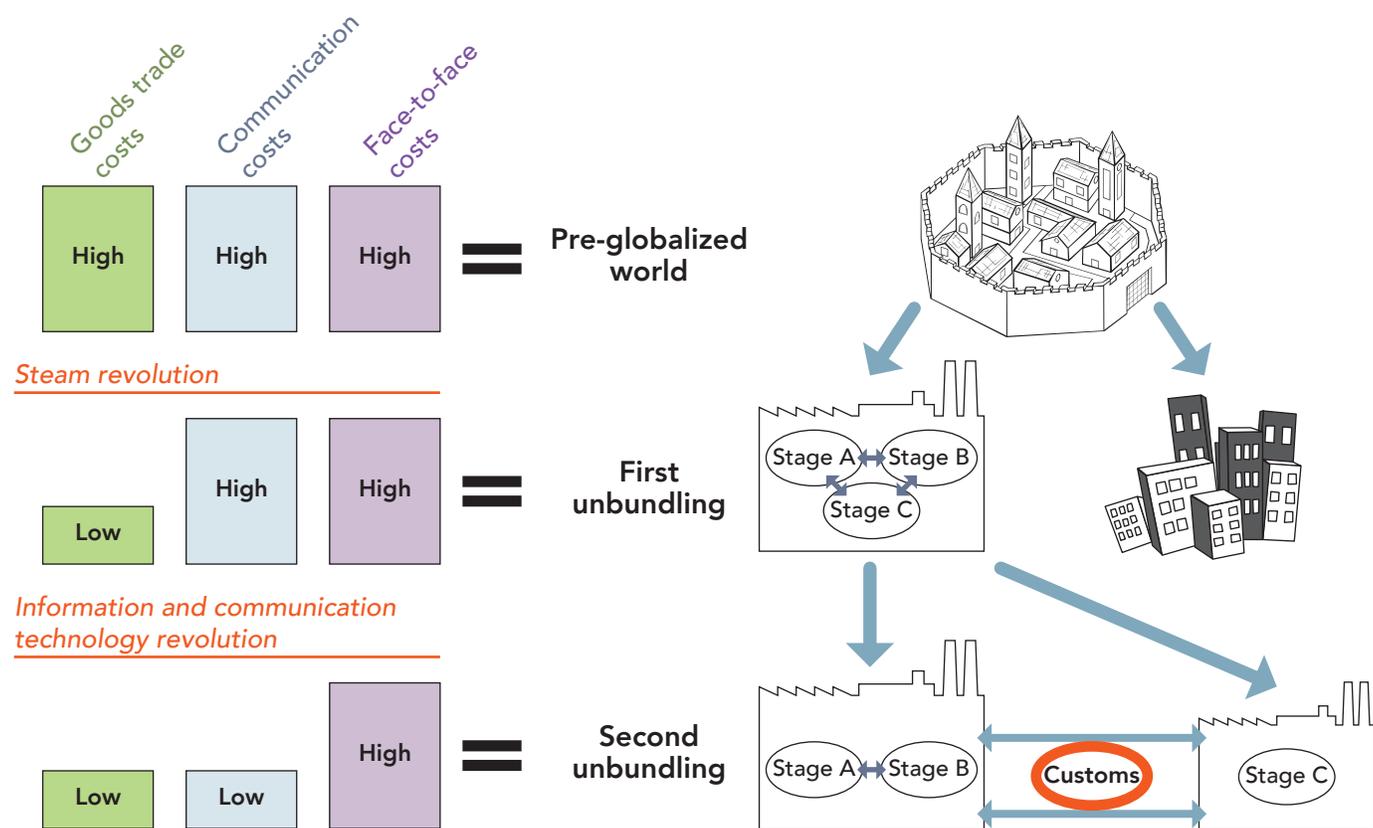
When the movement of goods, people, and ideas was not as frictionless as it is today, economic activities were organized mostly within the boundaries of a small-scale community (figure 1.2).<sup>7</sup> Farmers harvested wheat and milled flour for a bakery a few blocks away, and the baker baked loaves of bread for the neighbors who walked into the shop every morning. Economic self-sufficiency was achieved with the points of production and consumption in close proximity. Extraterritorial business was rare, except perhaps for the merchant voyages of a sailing ship or the Silk Road caravans. And those cross-border trades dealt only with a handful of luxury items such as spices and silk products, sold at high prices to compensate for the risk incurred and the time spent during the journey.

International trade began to develop at the beginning of the 19th century when steam engines rapidly improved land transport (by locomotives) and water transport (by steamships), triggering unprecedented expansion of trade activities beyond local communities. The economies of scale from mass logistics further lowered transportation costs. The point of consumption was unbundled from the point of production, and goods travelled all over the world in search of the most profitable markets.

Paradoxically, the geographical unbundling of economies between production and consumption coincided with the agglomeration of production activities in large-scale factories in industrial zones. Because of the increase in potential customers created by international trade, the mass production system became an appropriate manufacturing mode at the time. The key to high productivity in manufacturing is the division of labor, as seen in Adam Smith’s classic example of pin-making,<sup>8</sup> where workers specialize in a particular task to raise their competencies through intensive learning of a specific routine. However, division of labor entails delicate coordination among the different stages because the variety of tasks must collectively produce a homogeneous product. Accordingly, the different productive functions were brought together under the same roof (a factory) to facilitate communication and create harmony among the various tasks.

The information technology revolution in the 1980s completely changed this picture. With telexes, facsimiles, and the Internet—along with high-speed international communication networks—it became cheaper and easier to coordinate production units in different locations. Sales forecasts and procurement schedules could be instantly delivered to production lines, and the electronic profiles of minute product designs and specifications could be shared with and adjusted by every production site. Productive functions no longer had to be confined within proximate spaces. The technological unbundling of production activities has accelerated, with some segments relocated across borders to exploit the cost differentials of production factors in various countries.

**FIGURE 1.2** Three cascading constraints of globalization



Source: Adapted from Baldwin 2013.

**Vertical integration**

Richard Baldwin’s unbundling concept captures one important aspect of the dynamics of the world economy. But there is another critical dimension of the analytical perspective for the development of GVCs.

In the beginning of the 20th century Henry Ford devised and implemented a business model that aimed to integrate various segments (functions) of a production process under a single capital and management umbrella through the acquisition of a variety of companies. The model, later known as a vertical integration strategy, became a modus operandi in the era of mass production.<sup>9</sup>

Early studies of vertical integration focused on market imperfections. A firm integrates other entities to redress pre-existing market power distortions, such as double marginalization, free-riding, or entry foreclosure (Tirole 1989).

Another strand of thought considers the preclusion of transaction costs as a main motive for vertical integration, where internalizing production activities is a measure to avoid the potential costs of establishing formal business relations at arm’s length.

Given these benefits of integration, why then do some firms not choose to integrate? Because the internal arrangement of

activities involves nontrivial administrative and bureaucratic costs. Accordingly, the governance schemes are chosen to minimize the production inefficiencies attributed to a trading relationship by weighing the transaction costs of spot-market dealings against the bureaucratic costs of unified hierarchical organizations (firms).<sup>10</sup>

From the viewpoint of transaction cost economics the costs of concern include not only the direct costs of writing, monitoring, and enforcing contracts, but also the ex post performance inefficiencies caused by contractual hazards within the relationship. One of the basic tenets of transaction cost economics is that contracts are incomplete—in that the terms of exchange between the parties cannot be disciplined ex ante because of information asymmetry.<sup>11</sup> When the parties are locked in to the transaction, the incompleteness of contracts evokes contractual hazards of various types, yet vertical integration pre-empts these hazards by internalizing ex post quasi-rents into the unified objective function of the integrated firm. So vertical integration becomes a preferred mode of organizing value chains when the benefit of attenuating the opportunistic behavior of parties within the relationship outweighs the cost of inefficiently allocating resources associated with bureaucratic arrangements (Joskow 2003).

And today vertical integration in the multicountry dimension refers to the emergence of business entities called multinational corporations. Foreign direct investment by multinational corporations is the main driver of global production networks, decisively influencing the distribution of value added across countries.<sup>12</sup>

Accordingly, there are four modes of organizing value chains, along the axes of whether the task is done in-house or outsourced and of whether it is carried out domestically or across national borders (figure 1.3).

### Value chains and global value chains

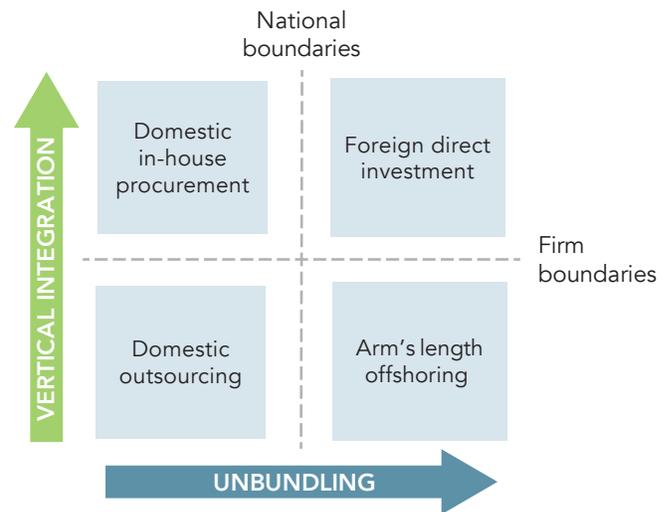
The term “value chains” was conceived in business management studies. Porter (1985) tailored the concept as a basic framework for developing a corporate strategy to promote firm competitiveness by directing attention to the entire system of activities involved in producing and consuming a product. A corporate entity is first decomposed into a set of business activities with individual functions that constitute analytical units for diagnosing the firm’s competitive advantage. When a firm has a relatively atomized organizational structure, the task of each unit (business activity)—such as product design, materials procurement, marketing, and distribution—tends to be defined in a way to pursue the individual objective of that particular unit, which may or may not conflict with the objective of other units. However, in the value chain perspective all activities should be collectively organized to ensure the optimal functioning of the corporate entity as a whole. To this end, the nature of linkages between activities (value chains) is carefully examined—just as if drawing an anatomical chart of a firm—to internalize potential externalities through cross-functional coordination, which is an important source of the firm’s competitive advantage.<sup>13</sup>

In contrast, GVC studies originated in sociology. Unlike Porter’s value chain concept, which is concerned primarily with how firm strategies can be renovated by shifting the focus to the configuration of business activities, GVC studies consider the generation and transfer of value within the system as a consequence of firm efforts to optimize production networks and, conversely, the mechanism of how the value distribution structure affects the firm’s choice of the organizational form of international production networks. GVC analysis is not a global extension of Porter’s value chain approach because the scope and motivation differ, as described below.<sup>14</sup>

### Typology of global value chains

The main objective of GVC studies is to explore the interplay between value distribution mechanisms and organization of the cross-border production–consumption nexus. The concept was first collectively framed in the discussions of the Global Value Chains Initiative (2000–05), sponsored by the Rockefeller Foundation,<sup>15</sup> and further crystallized by Gereffi, Humphrey, and Sturgeon (2005), whose analytical focus rests on the governance structure of organizing international production networks. Who are the players in the game? What kinds of rules exist? Is it a competitive or a cooperative play? What generates the winning opportunities? In

FIGURE 1.3 Modes of organizing value chains



Source: Author’s drawing, based on Kimura and Ando 2005.

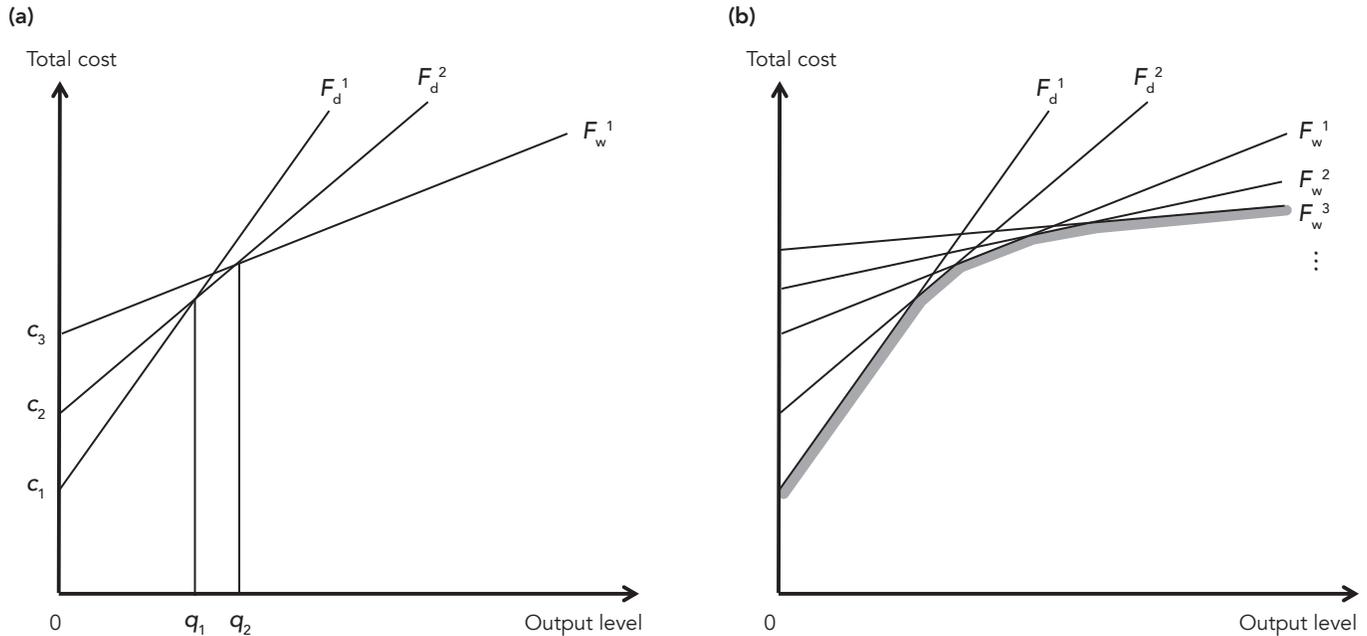
answering these questions, GVC studies pay attention to the forms of transactions, codified or otherwise, between stakeholders. This is because the way transactions are made reflects the structure of power relations between the parties, which ultimately determines the scope and magnitude of value distributions within the game.

The vertical integration type of GVC is based on the hierarchical structure that assumes an absolute and unidirectional control of the parent company over its subsidiaries. The activities and performance of subsidiaries are strictly monitored and assessed in line with their headquarter management strategies. In contrast, outsourcing options tend to generate leveled relationships between clients (buyers) and subcontractors (service suppliers), and the power exercise is more or less mutual, unlike the vertical integration type.

Within this dichotomy, Gereffi, Humphrey, and Sturgeon (2005) set out a GVC typology in a higher resolution spectrum in accord with power relations between the contracting parties. Figure 1.4 illustrates five variants of GVC governance. The rectangles represent the firm’s boundary, and their size indicates the strength of bargaining power in relation to the other party. The arrows show the direction and extent of business intervention in the partners’ activities, which can be supportive, such as to draw “win-win” scenarios in the long-term perspective, or predatory, by focusing on uptakes of quick profits in the short run. Toward the right of the diagram, the clients (the headquarters in the case of the “hierarchy” type) possess greater bargaining powers and so are considered to exert a strong influence over the distribution of value added. (See annex 1.1 for a detailed description.)

Gereffi, Humphrey, and Sturgeon (2005) also considered the dynamics of the GVC configuration by factoring out three parameters: complexity of transactions, ability to codify transactions, and capabilities in the supply base (known as the “3 C’s model”—Complexity, Codifiability, and Capabilities). For example, the



**FIGURE 1.5** Optimal form of outsourcing options

Source: Author's drawing, based on Jones and Kierzkowski 1990.

These features are represented by line  $F_w^1$ , which has a flatter slope for increased productivity and a higher intercept for an extra top-up of the fixed cost (from  $c_2$  to  $c_3$ ). Then, the optimal form of production will switch from domestic outsourcing to cross-border outsourcing (offshoring) at the output level  $q_2$ .

In this light, it is possible to consider where multiple countries are involved in the production process ( $F_w^2$ ,  $F_w^3$ , ...). Different schedules can be drawn for various outsourcing options, as in figure 1.5b, and the shaded boundary defines the optimal form of production arrangement at each level of output.

The model's implications for a global production arrangement are threefold. Other things being equal, the production process will be more prone to international fragmentation when:

- The targeted market is larger, so that it has more room to absorb the increased supply of goods from the organization of more efficient divisions of labor across borders.
- The costs of connecting the production activities in different countries are less inhibitive.
- The countries in the production networks are more diverse in their factor costs, so there is a better chance for offshoring firms to exploit comparative advantage.

### **Impacts of offshoring on domestic factor incomes and welfare**

The offshoring model was further developed to address income distribution and welfare—a natural response to mounting political concerns about the potentially detrimental effect of offshoring on the domestic labor market (the industrial hollowing-out problem).<sup>20</sup>

Traditionally, the effect of international trade on the labor market has been considered in regard to a resource shift between industrial sectors caused by import competition, without much attention to the change in the within-sector composition of different types of labor. Newer globalization literature seizes on this point, recognizing that offshoring is a cross-border movement of a production activity corresponding to a task for a particular type and skill of labor.<sup>21</sup>

Feenstra and Hanson (1996a, 1996b) considered the impact of offshoring that follows the liberalization of foreign ownership in developing countries. Substantial movements of capital from developed countries to developing countries are accompanied by transfers of some segments of production processes that are considered more skill-intensive by the standard of developing countries but less skill-intensive by the standard for developed countries. Accordingly, the demand for labor becomes skewed toward higher skilled labor in the light of the respective skill standard of each economy, so the relative wages of low-skilled labor fall in both developed and developing countries.<sup>22</sup>

Grossman and Rossi-Hansberg (2008a) then introduced a “trade in tasks” concept to explain how an increase in offshoring feasibility affects the productivity and factor incomes of the offshoring country. They emphasized the need to shift the analytical focus from goods, as in the conventional trade theory (Portuguese wine for English cloth), to tasks that line up in a production process, in order to capture the rising prevalence of offshoring activities in a firm's business strategies.

In the model the offshoring feasibility is parameterized as an improvement in the coordination capability between the firm's

headquarters and its foreign suppliers through transportation and communication technologies. The sensitivity to the change in offshoring feasibility is assumed to vary across different types of tasks. Some tasks (such as those akin to codified description) are easy to offshore, while others (such as those relying on personal tacit knowledge) are not.<sup>23</sup>

The impact of the improved prospect for offshoring is considered through three channels:

- **A labor-supply effect.** Moving some tasks to foreign countries frees up the domestic labor that would otherwise carry out these tasks, so it has an effect analogous to increasing the supply of labor in the market. Such an implication, widely discussed in the mass media and political circles, generally evokes opinions against a firm's offshoring activities for fear of lowering the real wages of offshored labor or losing domestic jobs when wages are sticky.
- **A relative-price effect.** A country offshores low-skilled labor when its cross-country comparative advantage is weaker in that type of task than in the tasks of high-skilled labor. The country would then specialize in exporting goods that are intensive in high-skilled labor, as conventional trade theory predicts. Accordingly, if an increase in exports leads to a deterioration in the country's terms of trade, it would create a negative impact on the welfare of its high-skilled labor through the Stolper–Samuelson mechanism. (However, this effect comes into play only when the country is large enough to affect the international relative prices of goods.)
- **A productivity effect.** This effect is a unique feature of the model that is not fully considered in other studies on the topic. When the prospect for offshoring improves—say, by an increase in communication capabilities—an offshoring firm's profitability will rise in proportion to the extent that the firm relies on the offshoring business. Such a productivity effect is equivalent to the consequence of factor-augmenting technological progress, so it is able to bring a positive impact on the employment of domestic workers (across all industries) whose task levels are similar to those of offshored labor.

The net impact of offshoring on factor incomes is the sum of these three effects. And in most cases the empirical consideration is reduced to whether the productivity effect will dominate the other two effects—if so, the argument turns in favor of offshoring activities.<sup>24</sup>

### **Firm's choice of an organizational form of global value chains**

The factors that determine whether a transaction is mediated through markets or within firm boundaries have long been a subject of inquiry in industrial organizational theory. The question has been addressed in many ways since Ronald Coase documented his insights on the nature of the firm,<sup>25</sup> and it has been brought into the international context in studies on intrafirm trade and multinational corporations.

Antràs (2003), one of the earliest efforts in pursuing this direction, synthesized firm theory under incomplete contracts (Grossman and Hart 1986) and international trade theory under

imperfect competition (Helpman and Krugman 1985) to explain the asymmetric prevalence of intrafirm trade in capital-intensive industries and between capital-abundant countries. The firm's dual motives for minimizing transaction costs (by assigning property rights) and factor costs (by exploiting comparative advantages) are analyzed in the unified theoretical framework. The model expands the margins of analytical scope in figure 1.3 to cover the range of value chain variations for both spatial and organizational dimensions.

Antràs and Helpman (2004) introduced another dimension to the analysis: firm heterogeneity. Drawing on Melitz (2003), Antràs and Helpman investigated the impact of within-sector heterogeneity in firm productivity on the firm's globalization decision. The model predicts that different degrees of entry cost to global activities bring about the productivity ranking among firms on the choice of globalization modes. The most productive firms would choose to undertake foreign direct investment, the next most productive firms would choose to engage in arm's length offshoring, and so on down to the least productive firms, which would choose to engage only in domestic procurement.

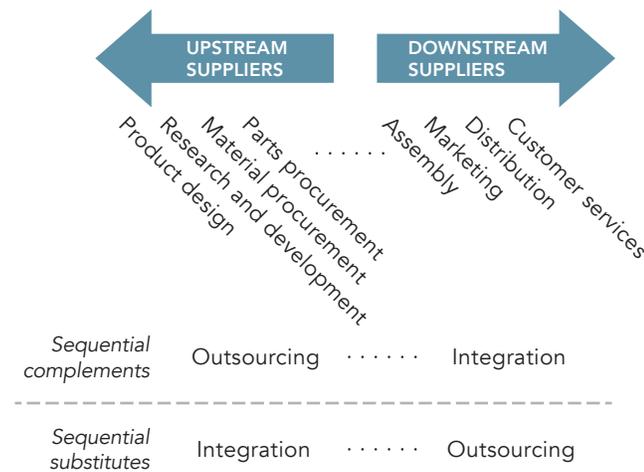
Further to these approaches, Antràs and Chor (2013) shed new light on the line of analyses by considering a technological ordering of production stages—a crucial attribute of value chains—to address the traditional make-or-buy question for each segment of a production process along a value chain. Incompleteness of contract, as previously defined, entails strategic consideration by a lead firm (final good producer) in choosing the form of value chain governance. And the key prediction of the model is that the lead firm should differentiate the governance forms between upstream and downstream suppliers for optimizing the gains from the set of transactions.

The model identifies two types of value chains, determined by the nature of the final product: sequential complements and sequential substitutes. The type of sequentiality that characterizes the production process affects the lead firm's decision on the governance arrangements along that value chain (figure 1.6). For sequential complements the lead firm chooses to integrate downstream suppliers while outsourcing its upstream production stages. For sequential substitutes upstream suppliers are vertically integrated, while the transactions with downstream suppliers are carried out at arm's length. (See annex 1.2 for a brief description of the argument.)<sup>26</sup>

The property-rights theory on the firm's choice of an organizational form is highly resonant with the sociologists' analytical insights about value chain governance because, broadly speaking, both approaches engage the contractibility of transactions as a core parameter of the models. The topic is thus one of the most promising areas for extensive interdisciplinary dialogue on synergetic development of the GVC analysis.

### **Empirical challenges**

The rapid progress of empirical analysis on GVCs has been backed up by two substantial changes in the research environment. One

**FIGURE 1.6** Sequential choices for organizing value chains

Source: Author's drawing.

is the increasing availability of relevant data and statistics, especially multicountry input-output tables and firm-level microdata. The other is the advance in data-processing capacity of personal computers for handling these massive datasets as well as the information and communications infrastructure that allows for efficient shared use of the databases. What was impossible 20 years ago is common practice today, and the empirical challenges of GVC analysis are entering a new phase of development.

### Mapping global value chains by firm business records

The initial efforts to quantitatively describe GVCs can be found in studies that use firm-specific business records. These studies typically aim to identify the composition of inputs procurement or the sales networks of a product on the basis of data provided by the manufacturers themselves or from the teardown reports of private consulting companies—or, for the average breakdown of an industry's generic product type, the information from the relevant industry associations (Sturgeon and others 2013).

Earlier studies of this kind include Dedrick, Kraemer, and Linden (2008), who analyzed the value-added structure of four representative products—Apple's iPod and video iPod and Hewlett Packard's and Lenovo's laptop personal computers—using information from business reports.<sup>27</sup> They found that a video iPod with a retail price of \$299 in 2005 was associated with a breakdown of \$144 for the product's factory cost, \$75 for distribution margins and \$80 for the profit of the lead firm (Apple), while within the factory cost only \$3.86 was estimated for the assembly services in China. The original motivation of the study was to investigate how firms benefit from technological innovation through production sharing, but it came to elucidate a separate and even more alarming question about the validity of conventional trade statistics based on gross values.

In this context, Xing and Detert (2010) addressed U.S.–China trade imbalances. iPhones were not sold in China in 2009, which implies that China's exports of iPhones to the United States were

equivalent to the U.S. trade deficit of the product in relation to China. The study shows that the U.S. deficit of \$1.9 billion for iPhone trades is reduced to \$73 million if viewed in value-added terms and broken down to include the deficits with other countries such as Japan and Germany, which are the core parts suppliers.

These product-level approaches are useful in drawing the actual structure of production chains because they directly use data provided by individual firms rather than resorting to statistical inference. But the weakness is apparent in the flipside.<sup>28</sup>

First, these approaches have limited applicability when considering macroeconomic issues such as trade policies, because the analytical focus is cast only on a particular product or on the activity of a few firms. This is far from sufficient to capture the entire value flows in the national context.

Second, as Dedrick, Kraemer, and Linden (2008) pointed out, most firm data do not explicitly present compensation of employees, an important component of value-added items in the national accounting framework, but merge it with other types of production costs.

Third, because values are generated at every point of the production process, the value-added analysis should be able to trace all the production stages along the entire supply chain. However, the product-level approach considers only the value-added structure of direct input suppliers (the first tier), leaving the rest of the value-added stream untracked. For example, a hard-disk drive in an iPhone contains subparts produced in different countries and thereby requires further decomposition of the value-added sources.

### Mapping global value chains by input-output tables

Given the limitations of the conventional approach, multicountry input-output tables have received increased attention. A multicountry input-output table provides a comprehensive map of international transactions of goods and services in a massive dataset that combines the national input-output tables of various countries at a given point of time. Because the tables contain information on supply–use relations between industries and across countries—which are totally absent from foreign trade statistics—it is possible to identify the vertical structure of international production sharing. And unlike the product-level approach, input-output analysis covers an entire set of industries that make up an economic system, thus enabling the measurement of cross-border value flows for a country or region. Theoretically, such analysis has the capacity to track the value-added generation process of every product in every country at every production stage.

The input-output approach has weaknesses as well. Sturgeon and others (2013) pointed out the limitations of (multicountry) input-output analyses arising from the statistical characteristics of input-output tables. First, the table's sectoral classification is based on industrial categories so that the value-added of a specific task such as product design or assembly cannot be identified. Second, transactions are recorded on a domestic basis, so production activities are circumscribed by territorial borders rather than by the nationality that the produced goods

are associated with, which may cause (analytically) inappropriate attribution of value added among countries.<sup>29</sup> Third, information on the nature of specific transactions is totally absent from input-output statistics, making qualitative analyses of value chains difficult, if not impossible.

In a nutshell the product-level approach is relevant for analyzing qualitative aspects of individual value chains, such as the form of governance arrangement or the mode of technological transfer between parties, while the multicountry input-output approach captures a general picture of value chain configuration in the larger context from a systematic point of view. They are not exclusive substitutes but must be employed in a complementary manner, depending on the type of research questions.

GVC studies using input-output tables have become increasingly common in the last decade. Their origin can be traced back to Hummels, Ishii, and Yi (2001), who introduced the concept of vertical specialization—defined as the amount of imported intermediate inputs used to produce an exported good or, put differently, the import content of exports, which is presented as a measure of international production sharing.

Chen and others (2004) first brought the idea into the value-added context in relation to the statistical distortion caused by ignoring the presence of processing trade and by measuring international trade in terms of gross exports. Here the long-debated issue of U.S.–China trade imbalances was fully considered in the value-added perspective. Koopman, Wang, and Wei (2012) further developed and methodologically formalized the approach for separating China’s national input-output matrices into two components, one for the export processing sectors and one for the rest of the economy.<sup>30</sup> They showed that the foreign content of value added in China’s manufacturing exports was

about 50% in 2002, more than double what would have been obtained by a straightforward application of the vertical specialization metric. It quantitatively demonstrates the importance of measuring trade in value added terms, as well as the significant analytical impact of overlooking processing trade.

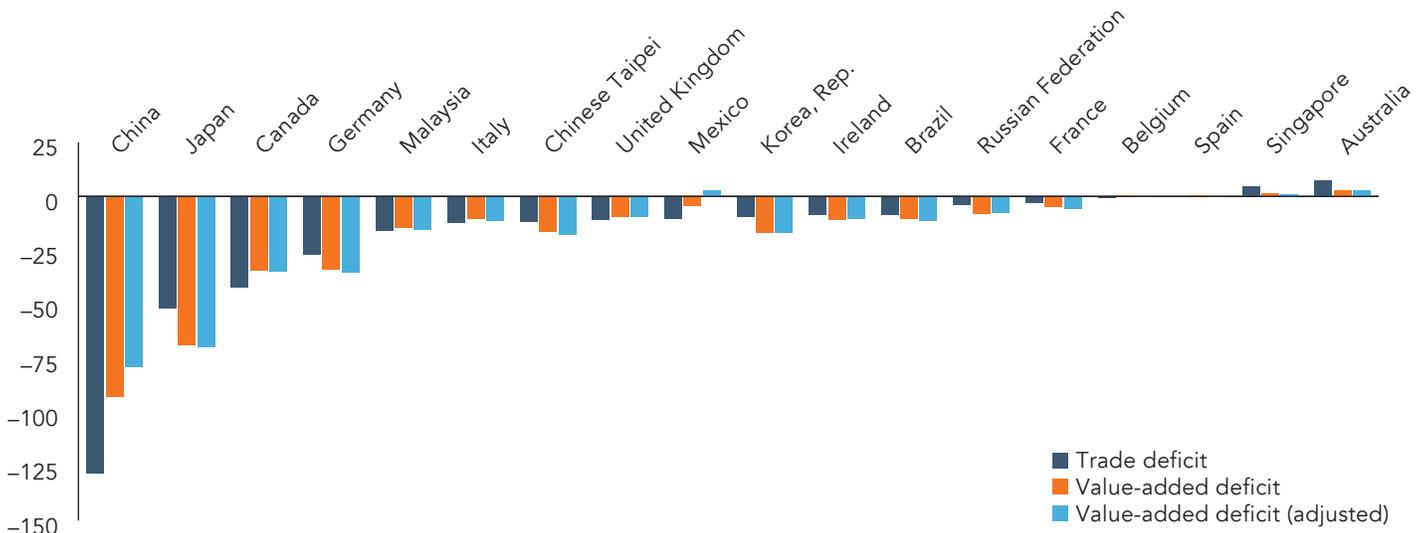
While these empirical exercises rely on the national input-output tables of individual countries, Daudin, Riffart, and Schweiguth (2006) used the database of the Global Trade Analysis Project to construct a multicountry input-output table of 70 countries and their composite regions in order to calculate the domestic value-added content of exports, alongside indices of vertical specialization and regionalization. Johnson and Noguera (2012) calculated the ratio of value-added exports to gross exports as a metric of international production sharing, again using the Global Trade Analysis Project database.<sup>31</sup> They extensively discussed the impact of production sharing on the scale of bilateral trade balances with respect to multiple countries, not to mention the U.S. trade deficit with China, which shows a 30–40% drop in value added terms from the traditional calculation (figure 1.7).<sup>32</sup>

Bems and Johnson (2012) present an interesting extension of the trade in value added approach to international macroeconomics by proposing the concept of the value-added real effective exchange rate. Real effective exchange rates are commonly used to measure country export competitiveness by evaluating the magnitude of price adjustments necessary to clear the external imbalances or, put differently, the extent of nominal exchange rate misalignments.

Conventional real effective exchange rates are often calculated from a weighted basket of consumer price indices, where weights are based on bilateral gross trade flows. However, with

**FIGURE 1.7** Bilateral trade and value-added balances for the United States, by partner, 2004

\$(billions)



Source: Author’s drawing, based on Johnson and Noguera 2012.

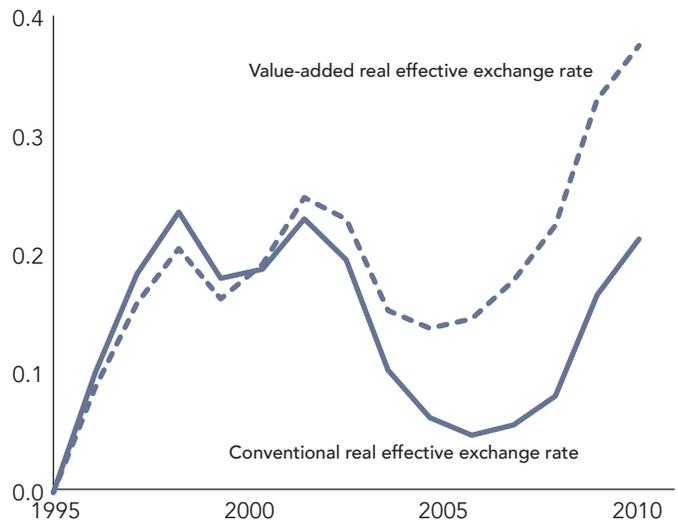
rapid globalization, conventional rates became an inappropriate measure in two respects. First, because real effective exchange rates are used to assess country export competitiveness in the world market, approximating price developments with consumer price indices is not ideal because consumer price indices summarize the prices of products whose value-added origins could be fragmented across different countries. Second, using the same line of logic, the values of gross trade flows cannot serve as unbiased weights because they do not represent today's economic reality of increasing production sharing among countries.

The value-added real effective exchange rate overcomes these problems by using gross domestic product (value-added) deflators, instead of consumer price indices, to measure price changes, and bases its weights on value-added bilateral trade flows, instead of gross trade flows. Figure 1.8 shows that the gap between China's conventional and value-added real effective exchange rates increased substantially from 2000 onward.<sup>33</sup>

One of the most recent achievements in this strand of analyses is from Koopman, Wang, and Wei (2014), who devised a full decomposition method of gross exports into various sources of value added. Gross exports are first decomposed into four categories: domestic value added absorbed abroad, domestic value added first exported then returned home, foreign value added, and pure double-counted terms; each category is then further decomposed by trading mode (figure 1.9). The result is a complete picture of the value-added generation process, in which

**FIGURE 1.8** China's real effective exchange rates

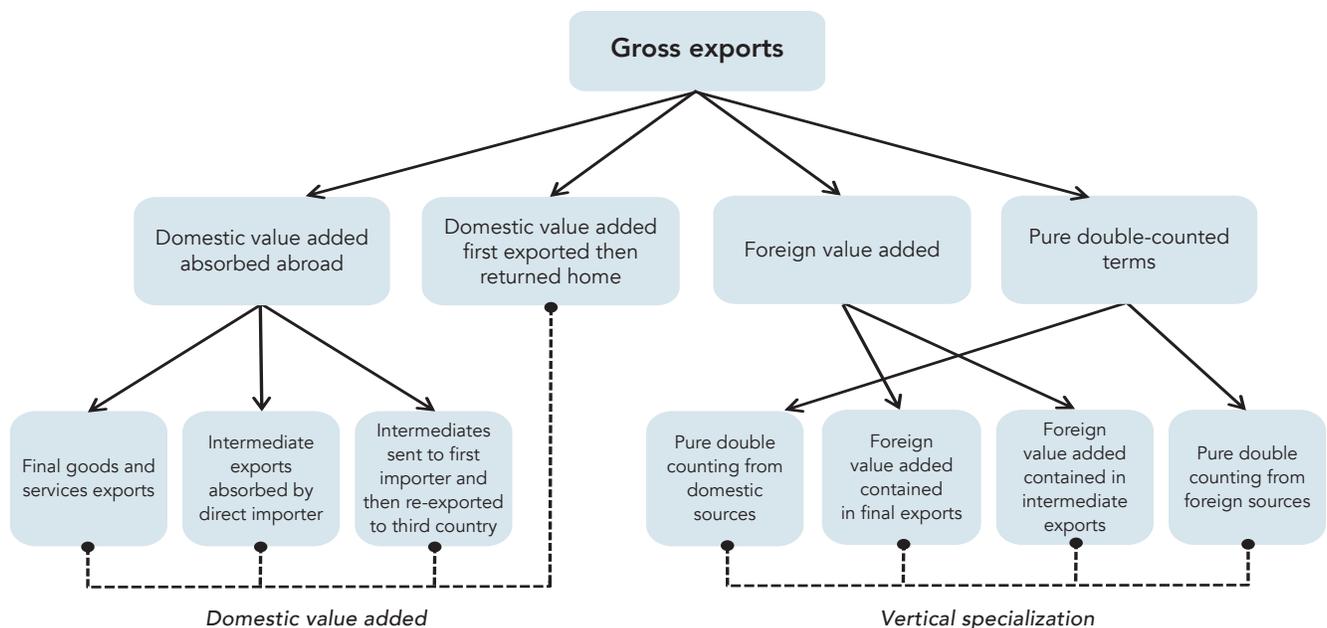
Change from 1995 value (%)



Source: Author's drawing, based on Bems and Johnson 2012.

various preceding formulas for measuring value-added trade are systematically integrated into a single accounting framework. In particular, the method enables the isolation of double-counting elements in gross exports, which have long haunted trade economists conducting empirical analyses.

**FIGURE 1.9** Gross trade accounting framework



Source: Author's drawing, based on Koopman and others 2016.

Note: This figure is a revised version from the one presented in Koopman, Wang, and Wei 2014 in response to the comment by Los, Timmer, and de Vries 2016.

For trade policies the channels of domestic value added first exported then returned home have important implications. For example, the antidumping measure that the European Commission imposed on the import of footwear from China and Viet Nam in 2006 is known to have had a detrimental impact on service industries in the European Union because these imported items contained considerable value added originating in the European design and distribution sectors. Such consequences could have been avoided by due reference to a detailed presentation of the value-added sources of traded products.<sup>34</sup>

### **Heterogeneity considered**

Another important development in the quantitative analyses of GVCs, with a theoretical foundation in Melitz (2003), is accounting for within-sector heterogeneity in firm characteristics when constructing input-output tables. Conventional input-output tables do not differentiate the input structure of different types of producers in the same industry. However, export-oriented firms, especially those in the processing trade, generally have higher import intensity in sourcing intermediate inputs than do domestic-oriented producers. This implies that conventional input-output tables, which provide information only on the average input structure across all types of producers, may bias analytical results for countries where processing trade is prevalent (notably China and Mexico).

As stated earlier, Koopman, Wang, and Wei (2012) were first to formally address this problem, by presenting a method to split the Chinese input-output tables into subaccounts that align export processing activities with the rest of the sector. Tang, Wang, and Wang (2014) further elaborated the approach, by considering variation in such firm characteristics as size (large scale or small to medium scale) and ownership structure (domestic or foreign, private or state-owned). They also used the Chinese input-output tables but combined them with data from China's industrial census and trade statistics by firm type. Importantly, the information on ownership structure allows the impact of China's privatization program on domestic value-chain upgrading to be assessed.

Ma, Wang, and Zhu (2015) integrated these approaches by considering firm heterogeneity in dual dimensions—trading mode (processing exporters or normal exporters plus nonexporters) and firm characteristics (domestic-owned or foreign-owned). Using the information of ownership structure, they worked out the distribution of domestic value added according to factor ownership, which contributes to the conversion of measurement from gross domestic product to gross national income by taking into account firm heterogeneity.<sup>35</sup>

Heterogeneity can also be considered from a geographic perspective. The current setup of multicountry input-output tables regards a country as a point of transaction in global production networks. However, a national economy has a spatial dimension. Brazil and China cannot be treated the same way in the input-output matrices that Costa Rica and Singapore are. Inomata and Meng (2013) introduced the Transnational Interregional Input-Output Table for China, Japan, and Korea, constructed by the Institute of Developing Economies, which links the interregional

input-output tables of respective countries into a single matrix to account for regional heterogeneity within a country in a multicountry input-output framework. The table allows for economic linkages across borders to be studied on a region-to-region basis—say, between Huanan in China and Kyushu in Japan.<sup>36</sup>

Domestic linkages between regions are particularly relevant when considering regional (within-country) development. For example, China built strong economic linkages with neighboring countries after the launch of the Reform and Open-Door Policy in 1978, but the benefit of economic globalization was not equally shared within the country. Income disparities immediately widened between coastal and inland regions, and it took time for the positive impact from abroad to trickle down to inner China through domestic linkage effects. In this sense, regional aspects are crucial in accounting for the process of economic development, especially for spacious and less integrated economies.<sup>37</sup>

Finally, consider heterogeneity in labor markets. The impact of GVCs on employment has been the subject of heated discussion, especially around the industrial hollowing out problem. Earlier globalization debates addressed the issue primarily in terms of the industrial structural change brought about by opening the domestic economy to global competition (leading to identification of declining, stagnant, and expanding industries). The current arguments from the GVC perspective engage in more microscopic analysis by looking into the wealth distribution at the task level within production chains, often epitomized by the so-called “smiley curve.”

Along these lines, Timmer and others (2014) conducted empirical research on value-added distribution among heterogeneous labor markets with different types of skill (upon recognizing that each task in the production processes can be associated with a particular level of labor skill). They employed the European Commission-funded World Input-Output Database augmented by the EU KLEMS database for information on factor inputs, in which three types of labor (low skilled, medium skilled, and high skilled) were identified on the basis of educational attainment. For most of the countries in the database the value-added share of high-skilled labor increased substantially from 1995 to 2008, while that of less-skilled labor declined. The results agree with the findings of Feenstra and Hanson (1996a, 1996b) and have important implications for recent political events in Europe and the United States.<sup>38</sup>

### **Distance matters: “length” analyses of value chains**

The theory of fragmentation predicts that if the production process of a good has the potential for further segmentation by the change in production technologies or consumption markets, then there is an opportunity for a finer division of labor that will lead to better allocation of resources and lower marginal cost of production. This is especially true with access to international markets, because the differences in factor endowments (and thus comparative advantage) are even more salient across borders.<sup>39</sup>

Accordingly, the study on fragmentation concerns the number of production stages in a production process—comparing alternative technologies that produce the same good, one with few

production stages and another with many. Empirical research requires an overall perspective for the entire structure of the production sequence. What matters is not only the strength (magnitude) of production linkages, but also the length of the linkages, determined by the number of production stages.

The traditional input-output approach to analyzing production networks is generally concerned with the interconnectedness or strength of linkages between industries. The “length” dimension of production linkages was first addressed by the input-output model of average propagation length developed by Dietzenbacher, Romero, and Bosma (2005). The average propagation length model represents the average number of production stages lining up in every branch of production networks, so it effectively measures an industry’s fragmentation.<sup>40</sup> Dietzenbacher and Romero (2007) further applied the model to the international context by analyzing the cross-national linkages of major European economies using the 1985 European multi-country input-output table.

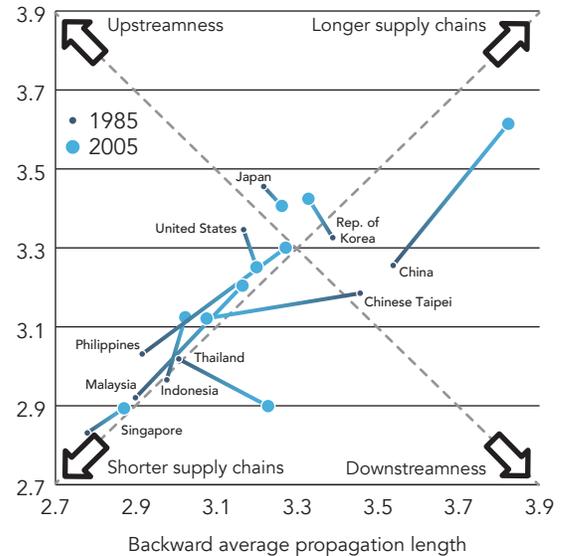
Fally (2011) developed a model for measuring fragmentation that was based on a philosophy similar to that of the average propagation length model. The major difference is that Fally’s model, as well as Antràs and others’ (2012) variation, captures the average number of production stages by pegging the endpoint of the sequence at final consumption, which enables measuring the distance to final demand of a product along the production chains. Those studies rely on national input-output tables of the United States and other selected countries, but De Backer and Miroudot (2012) later applied Fally’s (2011) model to the inter-country input-output tables of the Organisation for Economic Co-operation and Development covering 56 countries for 1995, 2000, and 2005.<sup>41</sup>

One application of the “length” model in the GVC context is to identify countries’ (or industries’) relative position within the global production system. If a country’s representative production chains toward final products are longer than those toward primary products, the country is considered to operate in a relatively upstream position (and conversely if a country’s representative production chains toward final products are shorter than those toward primary products, the country operates in a relatively downstream position). Because the average propagation length can be measured both in forward (cost-push) and backward (demand-pull) directions along production lines, it is possible to identify the relative position of a country within the global production networks by comparing the pairs of forward-length and backward-length values.

Inomata (2008) and Escaith and Inomata (2013) are among the earliest efforts to develop the idea of measuring the relative production positions of countries. They elucidated the structural change of the regional production system in two dimensions, using data for East Asia (figure 1.10). With the horizontal axis for backward average propagation length and the vertical axis for forward average propagation length, the bottom-left to top-right direction presents the changes in the entire length of the supply chains that countries participate in, and the top-left to bottom-right direction draws the relative line position of each

**FIGURE 1.10** Relative line position of countries in the regional production networks of East Asia, 1985, 2005

Forward average propagation length



Source: Author’s drawing, based on Escaith and Inomata 2013.

country within the regional production networks (as determined by the ratio of forward and backward average propagation lengths). For example, China moved along the path that is farthest from the bottom-left to top-right diagonal, indicating that it stayed in the most downstream segment of the regional supply chains throughout the period, which reflects the country’s dominant role as a final assembler of regional products.<sup>42</sup>

The line position of industries and countries within a production system is particularly important for considering the variations in sectoral characteristics along value chains—for example, value-added ratios as signified by the “smiley curve” (Baldwin, Forslid, and Ito 2016; Ye, Meng, and Wei 2015) or the mode of value chain governance (Antràs and Chor 2013).

## So, what’s next?

Perhaps the most pressing issue for the GVC research community is to accelerate the development of relevant data. Until now, a large share of empirical work for testing GVC governance models of firm theory has relied on data from official merchandise trade statistics.<sup>43</sup> Some country databases (such as the Related Party Trade Database from the U.S. Census Bureau) contain information on whether shipping involves transactions between related or nonrelated parties, which can be used to sketch out the presence of multinational firms in international trade.<sup>44</sup>

Despite the observable advantages of the data (notably accessibility and availability), researchers face several challenges to using it appropriately. Antràs (2011) set out four of them. First, the product-level information aggregates the sourcing decisions

of multiple firms, so some approximation is imposed for testing the model of firm-level sourcing behavior. Second, the data do not provide information about the users of the products being shipped, so it is impossible to identify which sector of the economy has absorbed the imported product (or even whether it is for intermediate use or final consumption). Third, as for the shipping between related parties, the data tell neither which party is owned by whom, nor the degree of control or ownership share of the parent company. The second and third points pose a practical problem when relating observations in intrafirm trade with the characteristics of importers (headquarters, in the case of backward integration), as modeled in Antràs (2003). Fourth, the data report only the information on incoming and outgoing shipments from the viewpoint of a home country. But multinational firms often engage in global sourcing, involving shipments between third countries (for example, Apple headquarters in the United States may source Korean Samsung's inputs being shipped to Foxconn factories in China for assembly).

Firm-level microdata, which have become increasingly available in recent years, may provide the information needed to develop empirical tools that overcome these problems.<sup>45</sup> The benefit of the datasets rests on their representativeness of various aspects of firm operations. For example, the Basic Survey of Japanese Business Structure and Activities (Kigyo-katsudou kihon chosa toukei) by Japan's Ministry of Economy, Trade, and Industry, has annual survey data (mandatory under the Statistics Act of Japan) that cover multiple types of information on firms, such as sales, costs, employment, capital expenditures, exports, imports, and foreign direct investment.<sup>46</sup>

Even so, unlike those Japanese data, many firm-level microdata come from one-shot industrial surveys and thus are available only for particular countries in particular years. The datasets also differ in the dimensions of representativeness. Accordingly, in order to apply these datasets to a general equilibrium setup like the input-output system, they should be used, for example, to provide combined structural information for estimating the relevant coefficients along with appropriate constraints and a balancing algorithm.

Another aspect to consider is the integration of databases, especially of multicountry input-output tables. Currently, various institutions construct competing tables, each designed for a specific analytical objective, so their presentation format, sectoral classification, and types of ancillary information (such as environmental accounts) differ.<sup>47</sup>

A team at the University of Sydney recently launched the Global Multi-Region Input-Output Lab, which aims to build a cloud-computing platform that allows participants to use each other's individually developed statistical resources. The information from the aforementioned multicountry input-output databases, together with national accounts and foreign trade statistics, are expected to be input in the platform. Then, a highly detailed regional-sectoral taxonomy (the root classification) linked to the data pool will serve as a feedstock from which

researchers can choose any combination of regions or sectors to assemble the multicountry input-output tables most suited to their research interests. By developing a Wikipedia-like common e-infrastructure, the lab's setup optimizes the use of available information, enhances flexibility in data construction, and saves resources by avoiding duplication of work among different institutions (Lenzen and others 2017).

## Meta-methodological considerations

GVC studies have evolved along three distinctive modes of analyses: spot analysis, sequence analysis, and network analysis. Gary Gereffi's earlier model, global commodity chains, considered the power relation between a lead firm and a set of multiple subcontractors that operate at different tiers along production chains (Gereffi and Korzeniewicz 1994). "One versus many" was thus the basic setup for analyzing the nature of governance. In contrast, Gereffi, Humphrey, and Sturgeon (2005) and later studies moved the analytical target to one-to-one transactions within a particular pair of a lead firm and a supplier (Bair 2008). So the modal shift in GVC studies among sociologists was from sequence (that is, one versus many) to spot (that is, one versus one) analysis—or, in the Euclidean sense of the word, from one-dimensional to zero-dimensional spatiality.

In international trade theories the analytical focus of GVC studies has been primarily on a particular supply–use relation between trading partners, especially for a firm's "make-or-buy" choice of intermediate inputs. The dominant mode of analysis has thus been spot analysis, yet Antràs and Chor (2013) have opened a new path toward sequence analysis by considering a technological ordering of production stages (from zero-dimensional to one-dimensional spatiality).

Input-output economics has by its nature always been concerned with a sequence, whether in the traditional Leontief impact models or in the latest supply chain length models. However, recent work engages network theory by applying the concept of network centralities to input-output matrices (Carvalho 2012; Escaith 2014) and thereby shows some movement from sequence to network analysis (from one-dimensional to two-dimensional spatiality).

These observations suggest that the analytical frameworks of GVC studies are diverging rather than converging over time—and that the prospect for overall consolidation of methodologies is limited in the near future. However, this is not necessarily bad news. The diversity and multiplicity of methodological frameworks imply that a wider scope of analysis is available. It is only a matter of how best to combine the relevant frameworks in an appropriate way for each research question, just as with integrating various tasks into an optimal configuration of production chains. Keeping and facilitating interdisciplinary dialogues are essential, and the *Global Value Chain Development Report* will serve as a core platform for this end.

## ANNEX 1.1

# Typology of global value chains

Gereffi, Humphrey, and Sturgeon (2005) set out a typology of five global value chains (GVCs) on the basis of the structure of power relations between the contracting parties.

### **Market-type global value chain**

Producing a commodity of a generic nature does not require any specific investment in production facilities for a particular transaction, so both customers and suppliers have countless choices for alternative partners. They are connected mainly through open spot-market transactions in a shoulder-to-shoulder relationship. Also, the procurement of a generic commodity will not necessitate an exchange of detailed product specification between contractors because the key information is mostly reduced to the preset price of the product that can be found in a book of catalogs. The transaction cost for changing business partners is almost negligible, leaving the value chains in a constant state of flux because of their high price elasticity.

### **Modular-type global value chain**

In business management or industrial engineering the word “module” generally refers to a composite of subcomponents grouped by the types of functions that are assumed in making up the final product.<sup>48</sup> The possibility of different combinations of differentiated modules enables producers to design multiple variants of a product. By the same token, if a complex transaction can be accommodated in the supply base by adjusting the combination of multipurpose equipment, the supplier will not have to incur transaction-specific investment (no hold-up problem) and is thus able to spread the equipment’s use across a wide range of potential clients. Even though the information to be delivered between the contractors may be considerable (say, for producing a complex product), the relative codifiability of transactions, as presumed in this type of GVC governance, compresses the volume of interventions, and the supplier is able to take overall control of its own production process. This implies that the transaction cost for changing business partners remains relatively low.

### **Relational-type global value chain**

When the manufacturing process involves specialized equipment (for example, the mold for a product of a particular shape), transactions become asset-specific, and the contracting parties become mutually dependent. The equipment for a specific purpose has limited scope for alternative uses, so its productivity will drop considerably when it is applied in other contexts. Accordingly, the service suppliers (the holders of the specialized equipment) are not motivated to look for other potential clients. But it is also difficult, or at least costly, for the client to expect the same level of performance from other third suppliers without these specialized facilities. As a result, both parties have little incentive to search for alternative business relations. Further, reinvestment in the specialized equipment for raising productivity deepens the asset-specificity of the transaction, thus trapping the parties in even more mutually dependent relationships.

### **Captive-type global value chain**

This type of transaction assumes an overwhelming disparity in power exercise among the parties, as seen in the business relations between a lead firm of global brands and its subcontracting local small companies. Service suppliers are expected to follow the client’s instructions word for word and are subject to strict surveillance on product quality and delivery times. Unlike suppliers in the market-type GVC, captive service suppliers have neither sufficient productive capacity to enjoy the scale of mass production, nor the specialized production facilities needed to claim its uniqueness, as attributed to the suppliers in the relational-type GVC. The availability of only mediocre production capability greatly narrows their opportunities to look for alternative business relations, imposing a captive position toward their clients.

### **Hierarchy-type global value chain**

As stated earlier, this type of GVC generally refers to the relations within a vertically integrated firm, as with multinational corporations.

## ANNEX 1.2

### Governance arrangements along a production sequence

In the setup of Antràs and Chor (2013), in which a contract is incomplete, a lead firm (final good producer) and a supplier (intermediate input producer) need to bargain ex post over their respective share of an incremental surplus (quasi-rent) generated at the corresponding stage of the production sequence. Following Grossman and Hart (1986), the lead firm acquires a better bargaining position and thus gains a higher share of the surplus when its supplier is integrated than when its supplier remains independent.<sup>49</sup>

Since the supplier's investment is assumed to be relation-specific to the lead firm's final product (for example, investing in the mold for a distinctive shape), the investment has no value outside this production sequence, which causes a familiar hold-up problem, such that the vertically integrated supplier tends to underinvest in its production capacity in anticipation of exploitation by the lead firm.

So the lead firm faces tradeoffs. If it integrates the supplier, it can extract a higher share of the surplus from that particular production stage, but doing so may induce underinvestment by the supplier, which would constrain the output or quality of the final product.

Here, the lead firm's strategic space depends critically on the nature of the final product that it produces. Suppose that the product has a quite elastic market demand, so that the lead firm is able to generate larger revenues by producing more. Since the investment decision of each intermediate input supplier depends on the prospect of final product turnover, which further depends on how much the upstream suppliers prior to the current production stage have already invested in their production capacities, it follows that higher investment by upstream suppliers induces more investment by downstream suppliers.

In contrast, if the lead firm has substantial market power and thus operates along an inelastic downward-sloping demand curve, the firm's revenue function becomes highly concave to (quality-adjusted) output, and marginal revenues fall at a relatively fast rate along the production sequence. As a result, the large upstream investment dampens the revenue prospect of downstream suppliers by reducing the value of undertaking future investment. The former investment options of suppliers are called sequential complements, and the latter sequential substitutes.<sup>50</sup> And the type of sequentiality that characterizes the production process affects the lead firm's decision about the organizational form of value chains.

Recall the lead firm's tradeoffs: the rent-extraction opportunities by integration, on the one hand, and the investment inefficiencies caused by such integration, on the other. On this basis, the lead firm should weigh the costs and benefits of integrating the suppliers.

For sequential complements the investment-curbing effect of integration is more costly in upstream production stages because it dampens the positive spillover of investment incentives to the downstream suppliers. So the lead firm should seek better bargaining positions by integrating downstream segments of the production process, rather than upstream ones. For sequential substitutes, the potential underinvestment by the upstream suppliers can be compensated for by the downstream suppliers. The lead firm is then able to place a relatively high weight on the rent-extraction motive in the upstream stages without worrying too much about the overall underinvestment.

The corollary of the argument is summarized in figure 1.6 by a couple of the lead firm's decisions about the organization of value chains.

## Notes

1. Global Value-Chain Training and Research Workshop, June 30–July 11, 2014, University of International Business and Economics, Beijing, China.
2. A particular concern is the difficulty of delineating a boundary between GVC studies and international trade literature. Apparently, these two areas overlap in many respects, and the relevant work is frequently cross-referenced. However, the characterization of GVC studies stated here aims to limit the number of references relating to the vast range of important literature in international economics.
3. Throughout this chapter the following terms are considered to carry more or less the same meaning: international (cross-border) production sharing, international (cross-border) fragmentation of production, the second unbundling, trade in tasks, and vertical specialization, each referring to the process and consequence of offshoring activities.
4. This theoretical breakthrough paved several development pathways in the days that followed. Aided by the analytical model of oligopoly formalized in the theory of industrial organization, it factored in the strategic aspects of trade policies using the language of game theory. Also, the element of increasing returns was further embodied and advanced in other subfields of economics, such as the endogenous growth model and the new economic geography (spatial economics).
5. As a result, industry became an inappropriate analytical unit for the study of international trade. See the later discussion on firm heterogeneity for the empirical challenges to tackle this problem.
6. A more extensive discussion of these topics can be found in many other GVC-related materials. See especially the comprehensive review in OECD (2013).
7. See Baldwin (2006) for the comprehensive argument of his view introduced in this section.
8. Smith (1776, p. 15): “One man draws out the wire, another straightens it, a third cuts it, a fourth points it, a fifth grinds it at the top for receiving, the head; ... and the important business of making a pin is, in this manner, divided into about eighteen distinct operations, which, in some manufactories, are all performed by distinct hands....”
9. Ronald Coase is said to have opened the horizon for theorizing about the mechanism of vertical integration. Until then, a firm was conceptualized as a production set that defines and implements the most efficient arrangement for transforming inputs into outputs through multiple interactions with markets. That is, markets and firms were considered to be complementary in their respective functions. Coase’s insight about the nature of the firm has altered this view. Markets and firms are more like substitutes, in the sense that they are just different types of coordination arrangements for resource allocation; one through the price mechanism and the other through entrepreneurship. So, for the issue of vertical integration, “What has to be explained is why one integrating force (the entrepreneur) should be substituted for another integrating force (the price mechanism)” (Coase 1937, p. 398).
10. Milberg and Winkler (2013) point out that transaction cost economics essentially operates within the static framework of constrained optimization such that firms would choose the most efficient form of value chain governance (make-or-buy) in the face of a given set of transactional and bureaucratic cost structures. The resource-based approach, in contrast, focuses on the dynamic interplay among parties, where lead firms actively engage in strategic maneuvers for turning the cost structures to their own favor, such as spurring competition among suppliers or promoting supply-base capabilities. It is also important to consider the role of government in affecting the choice of value chain arrangement where markets may fail. The provision of public goods such as transport infrastructure gives a straightforward example. The underinvestment caused by the hold-up problem presents another case of market failure due to information asymmetry which calls for government intervention to, say, tighten up contract enforcement schemes. These issues are discussed in chapter 1 of Blyde (2014), with respect to Latin American and Caribbean economies.
11. For example, even in the case of a dispute, the arbitrator cannot judge whether the delivered good may accord with the product specification or whether the supplier has put sufficient effort into its productive activities. Contracts cannot be written on sales revenues, either.
12. Firms may carry out foreign direct investment for market-seeking purposes (horizontal foreign direct investment) rather than for exploiting factor cost differences (vertical foreign direct investment). In the former case, foreign direct investment may not be associated with vertical integration.
13. For example, the Toyota Production System, well known for its just-in-time delivery, can be considered as an ultimate form of value chain management, where information sharing and task coordination across different divisions are implemented and achieved at the highest level of synchronization.
14. There are other terminologies of a similar kind in the field. Global supply chain is a generic label for a physical input-output sequence of value-adding activities across borders, used mainly in business studies that focus on logistics management or trade facilitation (how to reduce costs and lead times for delivery). Global commodity chain, as developed in Gereffi and Korzeniewicz (1994, p. 2), addresses wealth distribution by showing “how production, distribution, and consumption are shaped by social relations (including organizations)....” In this sense, global commodity chains can be considered a predecessor to the GVC concept in spirit, though their analytical frameworks are somewhat different (producer-driven and buyer-driven chains of global commodity chains, compared with the five types of GVC governance in figure 1.4).
15. See Gereffi and Kaplinsky (2001).
16. Sectoral examples include bicycles (from hierarchy to market), apparel (from captive to relational), fresh vegetables (from market to relational), and electronics (from hierarchy to modular).
17. The governance structure of value chains is particularly important for generating and diffusing the knowledge-based capital that leads to innovation and industrial upgrading. See the case studies in Kawakami and Sturgeon (2011) for East Asian economies and Blyde (2014) for Latin American and Caribbean economies about the industries that are learning and upgrading through participation in GVCs.
18. Deardorff (2001, p. 122) defines fragmentation as “the splitting of a production process into two or more steps that can be undertaken in different locations but that lead to the same final product.”
19. The original setup in the study postulates that the firm invests in a new production facility for the fragmented tasks rather than outsourcing

them, so there is an extra span in the upward shift of the cost curve in the diagram.

20. *The Economist* 2004.
21. In the United States the issue has evolved in a wider context: whether jobs are destroyed by foreign competition or by technological progress. U.S. workers are competing with cheap labor abroad and with robots at home, and which of those is a worse enemy has been a topic of heated debate. See, for example, Spence (2011) for a discussion of the impact of globalization on U.S. job markets along the dimensions of tradeable versus nontradeable sectors and high-skilled versus low- and medium-skilled labor.
22. However, the declining relative wage does not necessarily make unskilled workers worse off because, from a general equilibrium perspective, the increased supply of goods to the market brought about by finer division of labor may lower the goods prices of both countries through trade, perhaps offsetting the nominal wage reduction.
23. See, for example, Blinder (2009). In the base model of Grossman and Rossi-Hansberg (2008a) only low-skilled labor is assumed to be feasible for offshoring.
24. The implication of offshoring between similar countries is discussed in Grossman and Rossi-Hansberg (2008b).
25. See endnote 9. Legros and Newman (2014) give an overview for the recent arguments on firm boundaries.
26. For the empirical specification the study refers to the latest development in quantifying an industry's upstreamness and downstreamness by employing the input-output model of Antràs and others (2012). Also, Alfaro and others (2015) develops the benchmark model of Antràs and Chor (2013) with three extensions. First, it considers asymmetric differences in input contractibility; second, it incorporates the productivity heterogeneity of final good producers (as in Antràs and Helpman 2004); and third, it accommodates the case in which integration is not feasible for certain segments of the production processes because of external factors.
27. If nonacademic literature is included, Tempest's (1996) account of the Barbie Doll is one of the earliest.
28. The product-level approaches introduced here should be strictly distinguished (in terms of the scope of analyses) from the strand of studies using industrywide microdata of firms, such as those available from industrial censuses.
29. The efforts to alleviate these potential drawbacks are introduced below in the section on firm heterogeneity.
30. The same exercise is carried out in De La Cruz and others (2011) for Mexico, where processing trade is also prevalent.
31. Los, Timmer, and de Vries (2015) implement a similar exercise but with a different motivation. They conduct a longitudinal analysis of the tension between a force toward regionalization and one toward globalization in the organization of international production networks. They conclude that increasing globalization (less segmentation into regional blocs) has been a dominant trend during the period of analysis.
32. To be precise, the Institute of Developing Economies was the first to develop and publish such measurements in the 1980s for seven Asian countries and the United States using the reference year of 1975. However, the measurements were called the impact of final demand on value added rather than trade in value added. The major database for trade in terms of value added today is the Organisation for Economic Co-operation and Development–World Trade Organization Trade in Value-Added database. The latest release (reference year 2015) covers 34 industries for 64 countries (including rest of the world). For a general description of the data, see [www.oecd.org/sti/ind/tiva/tivasourcesandmethods.htm](http://www.oecd.org/sti/ind/tiva/tivasourcesandmethods.htm). For a quick guide to the concept of the trade in value added, see Inomata (2014) or WTO and IDE–JETRO (2011).
33. The increasing gap between the values of two indicators is accounted for mainly by the shift of the base from consumer price index to gross domestic product deflators, rather than the change in weights from gross to value added terms.
34. One of the key properties of the accounting framework for trade in value added is the mathematical identity between a country's total trade balance measured in gross terms and that in value added terms. Kuboniwa (2014a, 2014b) provide rigorous proofs of the relevant propositions.
35. Similar efforts have been made by Ahmad and others (2013) for Turkey, by Fetzer and Strassner (2015) for the United States, and by Piacentini and Fortanier (2015) for member countries of the Organisation for Economic Co-operation and Development. Liu and others (2016) extend the method to the application in environmental analyses. If carbon emissions from production activities are regarded as negative value added, the carbon footprint analysis using multicountry input-output tables can also be considered one form of GVC studies (especially the topic on the political interplay among countries over production-based accounts and consumption-based accounts of carbon emissions).
36. Other efforts with a similar motivation include Cherubini and Los (2013) for Italy, Dietzenbacher, Guilhoto, and Imori (2013) for Brazil, and Meng, Wang, and Koopman (2013) for China. These studies embed the respective country's interregional input-output table in the European Commission–funded World Input-Output Database.
37. See further discussion in Meng, Wang, and Koopman (2013).
38. Offshoring activities alone cannot explain whether globalization will create or destroy domestic jobs because the structural changes in labor markets are also triggered by technological innovations and switches in consumer demand.
39. See the model of Jones and Kierzkowski (1990).
40. However, Dietzenbacher, Romero, and Bosma (2005) do not explicitly use the word "fragmentation."
41. Recent studies aim to decompose the length model into domestic and international segments, which enables one to depict the "genuine" international fragmentation of the production process. These efforts include Hagiwara (2016) on the average propagation length model and Wang and others (2016) on the Antràs and others (2012) model.
42. The more formal documentation of the idea is in Miller and Temurshoev (2015) and Wang and others (2016), although their models have different specifications and are more rigorously articulated than those in Inomata (2008) and Escaith and Inomata (2013).
43. See, for example, Antràs (2003) and Bernard and others (2010).
44. In the U.S. data, partners are related if either party owns at least 10% of the other party.
45. Tomiura (2007) is one of the earliest studies using firm-level microdata. It applies the data to an investigation of the relation between

firm productivity and globalization decisions and derives results that are consistent with the predictions of Antràs and Helpman (2004) about the productivity ranking of different globalization modes.

46. The data cover only medium and large firms with 50 or more employees and whose paid-up capital is more than 30 million yen. However, given that global sourcing matters for large enterprises, the threshold is unlikely to limit the analyses.
47. The European Commission-funded World Input-Output Database and EXIOBASE, the Organisation for Economic Co-operation and Development's Inter-Country Input-Output Tables, Purdue University's Global Trade Analysis Project Multi-Regional Input-Output Database, and the University of Sydney's Eora Database, among others. Dietzenbacher and Tukker (2013) introduce the major multicountry input-output table projects, and Inomata and Owen (2014) discuss the analytical implication of using different databases.
48. For example, a modular car may consist of a power-management module (a composite of compressors and charge controls), a drive-assisting module (a composite of sensors, cameras, light emitting diodes), and so on.
49. Grossman and Hart (1986) define integration as the purchase by one firm of the residual rights of control over another firm's assets. While transaction cost economics is concerned with inefficiencies arising from both the ex post haggling by the parties over quasi-rents and the consequent ex ante underinvestment (and its negative impact on ex post performance), the property-rights literature focuses on the impact of property-rights assignment (the choice of organizational form) on ex post bargaining, which is assumed to be efficiently conducted, and that, in turn, affects the party's decision about ex ante investment.
50. More specifically, sequential complementarity and substitutability are determined by the relative magnitudes of (1) the market demand elasticity for the final product and (2) the elasticity of substitution among intermediate inputs. If (1) is larger than (2), the investment options are sequential complements; otherwise, they are sequential substitutes. In the usual sense of the word the suppliers' investments are always complementary. Only when the standard complementarity of intermediate inputs is dominated by the effect of a quick erosion of revenue prospect due to the low demand elasticity of the final product does the relation turn from complements to substitutes.

## References

- Ahmad, N., S. Araujo, A. Lo Turco, and D. Maggioni. 2013. "Using Trade Microdata to Improve Trade in Value-Added Measures: Proof of Concept Using Turkish Data." In *Trade in Value Added: Developing New Measures of Cross-Border Trade*, edited by A. Mattoo, Z. Wang, and S.-J. Wei, 187–219. Washington, DC: World Bank.
- Alfaro, L., P. Antràs, D. Chor, and P. Conconi. 2015. "Internalizing Global Value Chains: A Firm-Level Analysis." National Bureau of Economic Research (NBER) Working Paper No. 21582, NBER, Cambridge, MA.
- Antràs, P. 2003. "Firms, Contracts, and Trade Structure." *Quarterly Journal of Economics* 118 (4): 1375–1418.
- . 2011. "Grossman-Hart (1986) Goes Global: Incomplete Contracts, Property Rights, and the International Organization of Production." NBER Working Paper No. 17470, NBER, Cambridge, MA.
- Antràs, P., and D. Chor. 2013. "Organizing the Global Value Chain." *Econometrica* 81 (6): 2127–204.
- Antràs, P., D. Chor, T. Fally, and R. Hillberry. 2012. "Measuring the Upstreamness of Production and Trade Flows." *American Economic Review: Papers & Proceedings* 102 (3): 412–16.
- Antràs, P., and E. Helpman. 2004. "Global Sourcing." *Journal of Political Economy* 112 (3): 552–80.
- Bair, J. 2008. "Analysing Global Economic Organization: Embedded Networks and Global Chains Compared." *Economy and Society* 37 (3): 339–64.
- Baldwin, R. 2006. *Globalisation: The Great Unbundling(s)*. Helsinki: Economic Council of Finland.
- . 2013. "Global Supply Chains: Why They Emerged, Why They Matter, and Where They Are Going." In *Global Value Chains in a Changing World*, edited by D. Elms and P. Low, 13–59. Geneva: World Trade Organization.
- Baldwin, R., R. Forslid, and T. Ito. 2016. "Unveiling the Evolving Sources of Value Added in Exports." Joint Research Program Series No. 161, Institute of Developing Economies–Japan External Trade Organization (IDE–JETRO), Chiba City, Japan.
- Bems, R., and R. Johnson. 2012. "Value-Added Exchange Rates." NBER Working Paper No. 18498, NBER, Cambridge, MA.
- Bernard, A. B., and J. B. Jensen. 1995. "Exporters, Jobs, and Wages in U.S. Manufacturing, 1976–1987." *Brookings Papers on Economic Activity, Microeconomics* Vol. 1995 (pp. 67–119), Washington, DC.
- Bernard, A. B., J. B. Jensen, S. J. Redding, and P. K. Schott. 2010. "Intrafirm Trade and Product Contractibility." *American Economic Review: Papers & Proceedings* 100 (2): 444–48.
- Blinder, A. 2009. "How Many U.S. Jobs Might Be Offshorable?" *World Economics* 10 (2): 41–78.
- Blyde, J. S., ed. 2014. *Synchronized Factories: Latin America and the Caribbean in the Era of Global Value Chains*. New York: Springer.
- Campa, J., and L. Goldberg. 1997. "The Evolving External Orientation of Manufacturing Industries: Evidence from Four Countries." NBER Working Paper No. 5919, NBER, Cambridge, MA.
- Carvalho, V. M. 2012. *Input-Output Networks: A Survey*. A report for the European Commission (EC) under the Complexity Research Initiative for Systemic Instabilities consortium agreement. Brussels: EC.
- Chen, X., L. Cheng, K. C. Fung, and L. Lau. 2004. "The Estimation of Domestic Value-added and Employment Induced by Exports: An

- Application to Chinese Exports to the United States." In *China and Asia: Economic and Financial Interactions*, edited by Y. W. Cheung and K. Y. Wong. New York: Routledge.
- Cherubini, L., and B. Los. 2013. "Regional Employment Patterns in a Globalizing World: A Tale of Four Italies." Paper presented at the Bank of Italy workshop, "Global Value Chains: New Evidence and Implications," Rome, June 22.
- Coase, R. 1937. "The Nature of the Firm." *Economica* 4 (16): 386–405.
- Daudin, G., C. Riffart, and D. Schweisguth. 2006. "Who Produces for Whom in the World Economy?" Document de travail No. 2009–18, Observatoire Français des Conjonctures Économiques, Paris.
- Deardorff, A. V. 2001. "Fragmentation in Simple Trade Models." *North American Journal of Economics and Finance* 12 (2): 121–37.
- De Backer, K., and S. Miroudot. 2012. "Mapping Global Value Chains." Working Paper Series No. 1677, European Central Bank, Frankfurt.
- Dedrick, J., K. Kraemer, and G. Linden. 2008. *Who Profits from Innovation in Global Value Chains? A Study of the iPod and notebook PCs*. Report prepared for the Sloan Industry Studies Annual Conference, Boston, May 1–2.
- De La Cruz, J., R. B. Koopman, Z. Wang, and S. J. Wei. 2011. "Estimating Foreign Value-Added in Mexico's Manufacturing Exports." Office of Economics Working Paper, 2011–04A, U.S. International Trade Commission, Washington, DC.
- Dietzenbacher, E., and A. Tukker. 2013. "Global Multiregional Input-Output Frameworks: An Introduction and Outlook." *Economic Systems Research* 25 (1): 1–19.
- Dietzenbacher, E., and I. Romero. 2007. "Production Chains in an Interregional Framework: Identification by Means of Average Propagation Lengths." *International Regional Science Review* 30 (4): 362–83.
- Dietzenbacher, E., I. Romero, and N. S. Bosma. 2005. "Using Average Propagation Lengths to Identify Production Chains in the Andalusian Economy." *Estudios de Economía Aplicada* 23 (2): 405–22.
- Dietzenbacher, E., J. Guilhoto, and D. Imori. 2013. "The Role of Brazilian Regions in the Global Value Chain." School of Economics, Business and Accounting Working Paper 2013–15, University of São Paulo, São Paulo.
- The Economist*. 2004. "The Great Hollowing-Out Myth." February 19.
- Escaith, H. 2014. "Mapping Global Value Chains and Measuring Trade in Tasks." In *Asia and Global Production Networks: Implications for Trade, Incomes and Economic Vulnerability*, edited by B. Ferrarini and D. Hummels, 287–337. Mandaluyong, Philippines and Cheltenham, U.K.: Asian Development Bank and Edwards Elgar Publishing.
- Escaith, H., and S. Inomata. 2013. "Geometry of Global Value Chains in East Asia: The Role of Industrial Networks and Trade Policies." In *Global Value Chains in a Changing World*, edited by D. Elms and P. Low, 135–57. Geneva: World Trade Organization.
- Fally, T. 2011. *On the Fragmentation of Production in the US*. Boulder, CO: University of Colorado-Boulder.
- Feenstra, R. C., and G. H. Hanson. 1996a. "Foreign Investment, Outsourcing, and Relative Wages." In *The Political Economy of Trade Policy: Papers in Honor of Jagdish Bhagwati*, edited by R. C. Feenstra, G. M. Grossman, and D. A. Irwin, 89–127. Cambridge, MA: Massachusetts Institute of Technology (MIT) Press.
- . 1996b. "Globalization, Outsourcing, and Wage Inequality." *American Economic Review* 86 (2): 240–45.
- Fetzer, J. J., and E. H. Strassner. 2015. "Identifying Heterogeneity in the Production Components of Globally Engaged Business Enterprises in the United States." Working Paper WP2015–13, Bureau of Economic Analysis, Washington, DC.
- Gereffi, G., J. Humphrey, and T. Sturgeon. 2005. "The Governance of Global Value Chains." *Review of International Political Economy* 12 (1): 78–104.
- Gereffi, G., and M. Korzeniewicz, eds. 1994. *Commodity Chains and Global Capitalism*. Westport, CT: Praeger.
- Gereffi, G., and R. Kaplinsky, eds. 2001. *The Value of Value Chains: Spreading the Gains from Globalisation*. Special issue of the Institute of Development Studies Bulletin (IDS) Bulletin. Brighton, U.K.: IDS.
- Grossman, G. M., and E. Rossi-Hansberg. 2008a. "Trading Tasks: A Simple Theory of Offshoring." *American Economic Review* 98 (5): 1978–97.
- . 2008b. "Task Trade between Similar Countries." NBER Working Paper No. 14554, NBER, Cambridge, MA.
- Grossman, S., and O. Hart. 1986. "The Costs and Benefits of Ownership: A Theory of Vertical and Lateral Integration." *Journal of Political Economy* 94 (4): 691–719.
- Hagiwara, T. 2016. "Decomposition of Average Propagation Length." Paper presented at the 24th International Input-Output Conference, Seoul, July 4–8.
- Helpman, E., and P. Krugman. 1985. *Market Structure and Foreign Trade*. Cambridge, MA: MIT Press.
- Hummels, D., J. Ishii, and K-M. Yi. 2001. "The Nature and Growth of Vertical Specialization in World Trade." *Journal of International Economics* 54 (1): 75–96.
- Inomata, S. 2008. "Average Propagation Lengths: A New Concept of the 'Distance' between Industries, with an Application to the Asia-Pacific Region." *Sangyo-Renkan* 16 (1): 46–55.
- . 2014. "Trade in Value Added: Concept, Development, and an East Asian perspective." In *A World Trade Organization for the 21st Century*, edited by R. Baldwin, M. Kawai, and G. Wignaraja, 48–70. Cheltenham, U.K.: Edward Elgar.
- Inomata, S., and A. Owen. 2014. "Comparative Evaluation of MRIO Frameworks." *Economic Systems Research* 26 (3): 239–44.
- Inomata, S., and B. Meng. 2013. "Transnational Interregional Input-Output Tables: An Alternative Approach to MRIO?" In *Sustainability Practitioner's Guide to Multi-Regional Input-Output Analysis*, edited by J. Murray and M. Lenzen, 33–42. Champaign, IL: Common Ground Publishing.
- Johnson, R. C., and G. Noguera. 2012. "Accounting for Intermediate Production Sharing and Trade in Value Added." *Journal of International Economics* 86 (2): 224–36.
- Jones, R., and H. Kierzkowski. 1990. "The Role of Services in Production and International Trade: A Theoretical Framework." In *The Political Economy of International Trade*, edited by R. Jones and A. Krueger, 31–48. Oxford, U.K.: Basil Blackwell.
- Joskow, P. L. 2003. "Vertical Integration." In *Handbook of New Institutional Economics*, edited by C. Menard and M. Shirley, 319–48. New York: Springer.
- Kawakami, M., and T. Sturgeon, eds. 2011. *The Dynamics of Local Learning in Global Value Chains: Experiences from East Asia*. New York and Basingstoke, U.K.: Palgrave Macmillan.

- Kimura, F., and M. Ando. 2005. "Two-dimensional Fragmentation in East Asia: Conceptual Framework and Empirics." *International Review of Economics and Finance* 14 (3): 317–48.
- Koopman, R., Z. Wang, and S. Wei. 2012. "Estimating Domestic Content in Exports when Processing Trade is Pervasive." *Journal of Development Economics* 99 (1): 178–89.
- . 2014. "Tracing Value-Added and Double Counting in Gross Exports." *American Economic Review* 104 (2): 259–94.
- Koopman, R., Z. Wang, S. Wei, and K. Zhu. 2016. "Tracing Value-Added and Double Counting in Gross Export: Reply to the Comment by Bart Los, Marcel Timmer, and Caaitzen J. de Vries." Draft Manuscript.
- Kuboniwa, M. 2014a. "Trade in Value Added Revisited: A Comment on R. Johnson and G. Noguera, Accounting for Intermediates: Production Sharing and Trade in Value Added." Discussion Paper Series A, No. 599, Institute of Economic Research, Hitotsubashi University, Tokyo.
- . 2014b. "Fundamental Theorem on the Relationship between Trade Balances in Value Added and Gross Terms: Amendment." Discussion Paper Series A, No.600, Institute of Economic Research, Hitotsubashi University, Tokyo.
- Legros, P., and A. Newman. 2014. "Contracts, Ownership, and Industrial Organization: Past and Future." *Journal of Law Economics and Organization* 30 (S1): i82–i117.
- Lenzen, M., A. Geschke, M. Abd Rahman, Y. Xiao, E. Dietzenbacher, S. Inomata, K. Kanemoto, B. Los, D. Moran, R. Reyes, H. den Bäumen, A. Tukker, T. Walmsley, T. Wiedmann, R. Wood, and N. Yamano. 2017. "The Global MRIO Lab—Charting the World Economy." *Economic Systems Research* 29 (2): 158–86.
- Liu, Y., B. Meng, K. Hubacek, J. Xue, K. Feng, and Y. Gao. 2016. "'Made in China': A Reevaluation of Embodied CO2 Emissions in Chinese Exports Using Firm Heterogeneity Information." *Applied Energy* 184: 1106–13.
- Los, B., M. Timmer, and G. de Vries. 2015. "How Global Are Global Value Chains? A New Approach to Measure International Fragmentation." *Journal of Regional Science* 55 (1): 66–92.
- . 2016. "Tracing Value-Added and Double Counting in Gross Exports: Comments." *American Economic Review* 106 (7): 1958–66.
- Ma, H., Z. Wang, and K. Zhu. 2015. "Domestic Content in China's Exports and Its Distribution by Firm Ownership." *Journal of Comparative Economics* 43 (1): 3–18.
- Melitz, M. J. 2003. "The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity." *Econometrica* 71 (6): 1695–725.
- Meng, B., Z. Wang, and R. Koopman. 2013. "How are Global Value Chains Fragmented and Extended in China's Domestic Production Networks?" IDE Discussion Paper Series No. 424, IDE–JETRO, Chiba, Japan.
- Milberg, W., and D. Winkler. 2013. *Outsourcing Economics: Global Value Chains in Capitalist Development*. Cambridge, U.K.: Cambridge University Press.
- Miller, R., and U. Temurshoev. 2015. "Output Upstreamness and Input Downstreamness of Industries/Countries in World Production." *International Regional Science Review*.
- Ng, F., and A. Yeats. 1999. "Production Sharing in East Asia: Who Does What for Whom, and Why?" Policy Research Working Paper 2197, World Bank, Washington, DC.
- OECD (Organisation for Economic Co-operation and Development). 2013. *Interconnected Economies: Benefitting from Global Value Chains*. Paris: OECD.
- Piaccantini, M., and F. Fortanier. 2015. "Firm Heterogeneity and Trade in Value Added." OECD Working Paper No. 2015/23, OECD, Paris.
- Porter, M. E. 1985. *Competitive Advantage, Creating and Sustaining Superior Performance*. New York: Free Press.
- Smith, Adam. 1776. *An Inquiry into the Nature and Causes of the Wealth of Nations*. Reprinted in 1976. Oxford, U.K.: Oxford University Press.
- Spence, M. 2011. "The Impact of Globalization on Income and Employment: The Downside of Integrating Markets." *Foreign Affairs* 90 (4): 28–41.
- Sturgeon, T., P. Nielsen, G. Linden, G. Gereffi, and C. Brown. 2013. "Direct Measurement of Global Value Chains: Collecting Product- and Firm-Level Statistics on Value Added and Business Function Outsourcing and Offshoring." In *Trade in Value Added: Developing New Measures of Cross-Border Trade*, edited by A. Mattoo, Z. Wang, and S-J. Wei, 289–320. Washington, DC: World Bank.
- Tang, H., F. Wang, and Z. Wang. 2014. "The Domestic Segment of Global Supply Chains in China under State Capitalism." Working Paper No. 186, Federal Reserve Bank of Dallas Globalization and Monetary Policy Institute, Dallas.
- Tempest, R. 1996. "Barbie and the World Economy." *Los Angeles Times*, September 22.
- Timmer, M., A. Erumban, B. Los, R. Stehrer, and G. de Vries. 2014. "Slicing Up Global Value Chains." *Journal of Economic Perspectives* 28 (2): 99–118.
- Tirole, J. 1989. *The Theory of Industrial Organization*. Cambridge, MA: MIT Press.
- Tomiura, E. 2007. "Foreign Outsourcing, Exporting, and FDI: A Productivity Comparison at the Firm Level." *Journal of International Economics* 72 (1): 113–27.
- Wang, Z., S. Wei, X. Yu, and K. Zhu. 2016. "Characterizing Global Value Chains." Working Paper No. 578, Stanford Center for International Development, Stanford, CA.
- WTO (World Trade Organization) and IDE–JETRO (Institute of Developing Economies–Japan External Trade Organization). 2011. *Trade Patterns and Global Value Chains in East Asia: From Trade in Goods to Trade in Tasks*. Geneva: WTO.
- Xing, Y., and N. Detert. 2010. "How the iPhone Widens the United States Trade Deficit with the People's Republic of China." Asian Development Bank Institute (ADBI) Working Paper Series No 257, ADBI, Tokyo.
- Yeats, A. J. 1998. "Just How Big is Global Production Sharing?" Policy Research Working Paper 1871, World Bank, Washington, DC.
- Ye, M., B. Meng, and S-J. Wei. 2015. "Measuring Smile Curves in Global Value Chains." IDE Discussion Paper No. 530, IDE–JETRO, Chiba, Japan.

