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CONCEPTUAL ASPECTS OF GLOBAL VALUE CHAINS

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ABSTRACT

I offer an overview of some key conceptual aspects associated with the rise of global value chains (GVCs). I outline a series of alternative interpretations and definitions of what the rise of GVCs entails, and I trace the implications of these alternative conceptualizations for the measurement of the phenomenon, as well as for elucidating the key determinants and implications of GVC participation, both at the country level and at the firm level. In the process, I offer some speculative thoughts about the future of GVCs in light of the advent of an array of new technologies.

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1 Introduction

In the last few decades, a series of technological, institutional, and political developments have fueled a significant globalization of production processes across countries.[1] More and more firms now organize production on a global scale and choose to offshore parts, components or services to producers in foreign and often distant countries. The typical "Made in" labels in manufactured goods have become archaic symbols of an old era. These days, most goods are "Made in the World."

Some aspects of this new wave of globalization are not particularly novel. Significant and sustained increases in the trade-to-GDP ratio had been experienced in the past. The period 1870-1914, for instance, witnessed a major increase in international trade flows, largely fueled by the invention of the steamship, and that period is often referred to as the "First Globalization". Similarly, international trade in raw materials and intermediate inputs has been a prominent feature of world trade flows since time immemorial. For example, Assyrian merchants who settled Kanesh (in modern-day Turkey) in the 19th Century BCE imported luxury fabrics and tin from Aššur, and they also traded copper and wool within Anatolia (Barjamovic et al., 2019).

Despite these precedents, there is a common-held view that the transformation of the world economy since the 1980s has some distinctive features, and that interpreting the so-called rise of global value chains (GVCs) as simply an intensification of trade integration across countries misses several key dimensions of this phenomenon.

The aim of this paper is to offer a succinct overview of some key conceptual aspects associated with the rise of GVCs. The paper will offer alternative interpretations and definitions of what the rise of GVCs entails, and it will later trace the implications of these alternative conceptualizations for the measurement of the phenomenon, as well as for elucidating the key determinants and implications of GVC participation, both at the country level but also at the firm level. In the process, this paper will also offer some speculative thoughts about the future of GVCs in light of the advent of an array of new technologies.

Outline of the Paper The paper is structured as follows. It will first present a broad conceptualization of the rise of GVCs, one that interprets this phenomenon as an increase in the extent to which the goods and services transacted across borders are intermediate inputs rather than final goods (as emphasized in traditional conceptual frameworks of international trade). According to this broad definition, GVCs are tightly related to the use of foreign value added (embodied in materials, intermediate inputs or "tasks") in production, particularly for exports. The unit of analysis in this broad approach is typically the country-industry, thus allowing this body of work to connect with a recent empirical literature focused on computing and documenting the observed growth in the extent to which foreign value added is used in production in specific countries and industries.

[1] Three types of developments were particularly key: (i) the information and communication technology (ICT) revolution, (ii) an acceleration in the rate of reduction in man-made trade barriers, and (iii) political developments that brought about a remarkable increase in the share of world population participating in the capitalist system (see Antràs, 2015, for more details).

Despite this literature's overwhelming focus on country- and industry-level studies, it will be argued that one can similarly apply this broad definition of GVCs to firm-level analyses of international trade. At the theoretical level, the paper will highlight that it is fruitful to conceptualize GVC participation at the firm-level, particularly in environments in which firms have some market power and production processes feature increasing returns to scale. In other words, GVC participation (even when interpreted in a broad sense) is ultimately a firm-level phenomenon, and hence much can be learned from conceptualizing it in this manner. The measurement of GVC participation at the firm-level is at an infant stage relative to the much more mature literature measuring GVC participation at the country-industry level, but this paper will argue that many of the measures that have been developed in world Input-Output analyses can be fruitfully adopted at the firm-level, thereby opening the door for empirical analyses of the causes and consequences of GVC participation at the firm-level (the original plan was to carry these analyses in Chapters 2 and 3 of the 2020 World Development Report). This incursion into the measurement of GVC participation will also lead to a critical reevaluation of the merits and limitations of the most widely used measures of GVC participation.

The broad conceptualization of the rise of GVCs might suggest that there is nothing fundamentally new about this latest wave of globalization. It just entails more (or deeper) integration across countries, but it is shaped by the same factors as traditional trade flows and it carries largely the same implications. Although it will be highlighted that even this broad view of GVCs delivers many novel insights, this paper will also develop a narrower definition of GVCs that emphasizes several distinctive characteristics of the rise of GVCs. This narrower conceptualization of GVCs highlights that GVC participation is often (and increasingly) associated with transactions that are very different in nature from the type of anonymous, one-shot transactions that permeate traditional trade theory. The various firms and plants participating in a GVC often exchange highly customized inputs on a repeated basis, with the contracts governing these relationships being highly incomplete and hard to enforce. Furthermore, firms spend significant time and resources designing the organizational structure of these production networks (e.g., whether transactions occur within or across firm boundaries).

From this alternative relational conceptualization of GVCs emerges a richer analysis of GVCs, one that puts at the center stage the major actors (multinational firms, lead firms in GVCs, etc.) that play a leading role in shaping GVC activity and foreign direct investment (FDI) flows, and one that underscores the importance of institutional factors in shaping the location of global production. By explicitly modeling the mechanisms by which the division of the gains from specialization are divided across firms, this relational approach also delivers novel lessons regarding the implications of GVC participation for inequality and for development. Finally, this novel approach also provides a rich set of predictions regarding how an increase in automation or the adoption of digital technologies might affect the landscape of the international economy and affect different agents in society.

On the empirical front, this relational approach to GVC activity has largely focused on case

studies and, in a few cases, on more representative datasets that provide some information on the ownership decisions of firms (see Antràs, 2015). A burgeoning literature is attempting to build more systematic measures of relational GVC activity, and later, this paper will build on this literature to suggest a measure of relational GVC participation based on transaction-level customs data from the World Bank's Export Dynamics Database (EDD). It will also be discussed how one can build on transaction-level trade data to construct country- and industry-level narrow GVC participation measures analogous to those developed in the literature embracing the broad approach to GVC activity.

Beyond expositing these alternative conceptualizations of GVCs, this paper will put them to work to provide some guidance for the empirical work in various chapters of the 2020 World Development Report. First, it will delineate various key determinants of GVC participation and will present hypothesis regarding the relative importance of these determinants depending on the type of GVC activity (broad or relational) one focuses on. Second, it will also build on the conceptual framework to highlight several notable implications of GVC participation for economic performance at the firm level, but also for growth, poverty, inequality, and market structure at the country level. Third, it will use the conceptual framework to speculate on the future of GVCs.

Table 1 offers a succinct summary of some of the key ideas in this paper.

2 A Broad View of Global Value Chains

In presenting the broad or traditional conceptualization of the rise of GVCs in recent decades, it is useful to begin with a broad definition of a GVC and of GVC participation:

Definition: "A global value chain or *GVC* consists of a series of stages involved in producing a product or service that is sold to consumers, with each stage adding value, and with at least two stages being produced in different countries. A firm *participates* in a GVC if it produces at least one stage in a GVC."

As is clear from these definitions, a GVC is defined as a production process that embodies value added (e.g., labor services) from at least two countries. As such, this notion of GVCs naturally relates this phenomenon to the increasing use of foreign value added in production, especially when that production is destined for exports. The definition above is agnostic about the specific form in which foreign value added is embodied in production, though it is often associated with either international trade in raw materials (e.g., tin or aluminum), in intermediate inputs (e.g., car parts), or in tasks (e.g., back-office services). Similarly, the above definition is consistent with various configurations of global value chains, including simple "spider-like" structures – in which multiple parts and components converge to an assembly plant – and "snake-like" structures – in which value is created sequentially in a series of stages (see Baldwin and Venables, 2013, or Antràs and de Gortari, 2019).

Regardless of the specific shape GVCs take, the possibility of fragmenting production across borders gives rise to a finer international division of labor and greater gains from specialization.

Table 1. An Overview of Some Key Concepts

	Broad / Traditional	**Narrow / Relational**
Definition	Basic: Increased used of *foreign value added in production*, especially in production destined for exports	Basic: Increased used of foreign value added in production, especially in production destined for exports, but *focusing on inter-firm and intra-firm transactions involving customized inputs and relational contracting* (distinct from anonymous, spot trades in homogeneous goods)
Conceptual framework	GVCs essentially entail a *finer international division of labor* (trade in parts and components, tasks)	GVCs entail a *finer international division of labor*, but also involve: - nontrivial matching between importers and exporters - relationship-specific investments by all parties - inter-firm and intra-firm flows of goods, technology and credit in environments with limited contractual security - governed by incomplete contracts enforcement
Empirical measures	- Country- and industry-level measures of (i) foreign value added in production and in exports (related to backward and forward GVC participation indices); - Analogous measures at the firm-level	- Case studies; - Analyses of intrafirm trade flows or global ownership patterns; - Empirical work on persistence in firm-level trading relationships; - Measures based on HS products (anonymous vs relational)

GVCs allow resources to flow to their most productive use, not only across countries and sectors, but also within sectors across stages of production. As a result, GVCs magnify the growth, employment, and distributional impacts of standard trade. Under this "hyper-specialization" interpretation of GVCs, traditional determinants of international trade (such as factor endowments, geography, institutions, market size) are naturally also relevant for the extent to which countries and industries get embedded in GVCs, though the way in which these traditional determinants affect GVC flows is sometimes distinct from how they affect traditional trade flows, as will be discussed below.

In sum, unlike in traditional conceptualizations of international trade, which focus on international transactions that involve only two countries (an exporting country and an importing country), GVCs entail production processes that often cross borders multiple times and that often involve more than two countries. This leads to a rich set of determinants and consequences of GVC participation, but it also creates important challenges for the measurement of GVC activity in the world. Before overviewing the main determinants and consequences of GVC participation, it is useful to explain these measurement challenges and how they have been surmounted in economic research.

Measurement

The main challenge facing the measurement of GVC arises from the fact that customs data, the standard source for international trade flows, provides information on where the transacted good or service was produced, but not on how it was produced, i.e., which countries contributed value to it. Similarly, customs data record where the transacted good is flowing to, but not how it will be used, i.e., whether it will be fully consumed (absorbed) in the importing country, or whether it will be re-exported after the importing country adds value to it. With the goal of tracing value-added trade flows across countries, a body of work has combined information from customs offices together with national Input-Output tables to construct global Input-Output tables. The most widely used world Input-Output tables are: (a) the World Input-Output Database (WIOD), a collaborative project led by researchers at the University of Groningen; (b) the OECD TiVA database, and (c) the Eora Global Supply Chain Database, constructed by a team of researchers at the University of Sydney. At a very broad level, this collaborative projects can be thought of as a "scaled up" version of product-level studies (such as Dedrick, Kraemer and Linden's 2010 well-known case study of the iPod), attempting to break out the distribution of the financial value embedded in a product across the many participants in its supply chain. Figure 1 provides a schematic version of one such WIOT.[2]

With these global Input-Output tables at hand, it is then straightforward to devise alternative measures to document the extent to which production process have become globalized in recent

[2] The WIOT in Figure 1 considers a world economy with J countries (indexed by i or j) and S sectors (indexed by r or s). In its top left $J \times S$ by $J \times S$ block, the WIOT contains information on intermediate purchases by industry s in country j from sector r in country i. In the table, these intermediate input flows are denoted by Z_{ij}^{rs}. To the right of this block, the WIOT contains an additional $J \times S$ by J block with information on the final-use expenditure in each country j on goods originating from sector r in country i. These final consumption flows are denoted by F_{ij}^{r} in the table. The sum of the $(J \times S) + J$ terms in each row of a WIOT represents the total use of output of sector r from country i, and naturally coincides with gross output in that sector and country (denoted by Y_i^r).

Figure 1: The Structure of a World Input-Output Table

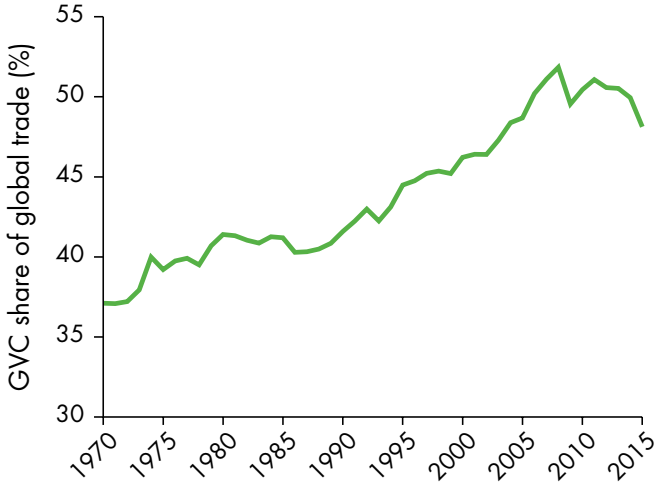
			Input use & value added							**Final use**			**Total use**
			Country 1			⋯	Country J			Country 1	⋯	Country J	
			Industry 1	⋯	Industry S	⋯	Industry 1	⋯	Industry S				
Intermediate inputs supplied	Country 1	Industry 1	Z_{11}^{11}	⋯	Z_{11}^{1S}	⋯	Z_{1J}^{11}	⋯	Z_{1J}^{1S}	F_{11}^{1}	⋯	F_{1J}^{1}	Y_1^1
		⋯	⋯	Z_{11}^{rs}	⋯	⋯	⋯	Z_{1J}^{rs}	⋯	⋯	⋯	⋯	⋯
		Industry S	Z_{11}^{S1}	⋯	Z_{11}^{SS}	⋯	Z_{1J}^{S1}	⋯	Z_{1J}^{SS}	F_{11}^{S}	⋯	F_{1J}^{S}	Y_1^S
	⋯	⋯	⋯	⋯	⋯	Z_{ij}^{rs}	⋯	⋯	⋯	⋯	F_{ij}^{s}	⋯	Y_j^s
	Country J	Industry 1	Z_{J1}^{11}	⋯	Z_{J1}^{1S}	⋯	Z_{JJ}^{11}	⋯	Z_{JJ}^{1S}	F_{J1}^{1}	⋯	F_{JJ}^{1}	Y_J^1
		⋯	⋯	Z_{J1}^{rs}	⋯	⋯	⋯	Z_{JJ}^{rs}	⋯	⋯	⋯	⋯	⋯
		Industry S	Z_{J1}^{S1}	⋯	Z_{J1}^{SS}	⋯	Z_{JJ}^{S1}	⋯	Z_{JJ}^{SS}	F_{J1}^{S}	⋯	F_{JJ}^{S}	Y_J^S
Value added			VA_1^1	⋯	VA_1^S	VA_j^s	VA_J^1	⋯	VA_J^S				
Gross output			Y_1^1	⋯	Y_1^S	Y_j^s	Y_J^1	⋯	Y_J^S	⋯			

years, and the extent to which various countries and sectors participate in global value chains. At the world level, Borin and Mancini (2019) develop a natural measure of the importance of GVC trade in total international trade. Building on global Input-Output tables, they identify the share of a country's exports that flow through at least two borders.[3] It is important to emphasize that these exports encompass two broad types of GVC trade. On the one hand, GVC trade includes transactions in which a country's exports embody value added that it has previously imported from abroad. This type of GVC participation is often referred to as backward GVC participation. On the other hand, GVC trade also comprises transactions in which a country's exports are not fully absorbed in the importing country, and instead are embodied in the importing country's exports to third countries. The latter form of GVC participation is often dubbed forward GVC participation. As Figure 2 indicates, the overall share of GVC trade in total world trade grew very significantly in the 1990s and early 2000s, but it appears to have stagnated or even declined in the last 10 years. Still, about one-half of world trade appears to be related to global value chains.

The two components of GVC participation, backward and forward, can also easily be computed at the country and even country-sectoral level. When doing so, it becomes clear that the expansion of GVC activity has occurred in an uneven way in the world. On the one hand, there are regions in the world (such as Europe and East Asia) that are deeply involved in GVCs, while GVC participation is much smaller in other parts of the world, most notably Latin America and Africa. On the other hand, even when countries actively participate in GVCs, the sectoral composition of these GVC flows are also quite diverse. Some countries have largely specialized in agricultural GVCs (such as Ethiopia) or in the natural resource segments of GVCs (such as Chile or Norway). Other countries are largely involved in the manufacturing segments of GVCs, with relatively less developed economies (such as Tanzania) specializing in low-tech (or limited) manufacturing, and more developed economies (such as Mexico, Slovakia or China) participating in high-tech (or advanced) manufacturing processes. In addition, it is useful to distinguish a subset of countries (e.g., India) that have largely specialized in the services embodied in GVCs, and a small set of very advanced economies (e.g., United States, Germany or Japan) playing a significant role in the provision of innovative goods and services. Figures 3 illustrates the extent to which GVC participation has

[3] See also Wang et al. (2013). Other important papers on the measurement of GVC participation include the pioneering work of Hummels et al. (2001), Johnson and Noguera (2012), and Koopman et al. (2014).

Figure 2: The Importance of GVC Trade in World Trade



Sources: WDR 2020 team, using data from Eora26 database; Borin and Mancini (2019); and Johnson and Noguera (2017). See appendix A for a description of the databases used in this Report.

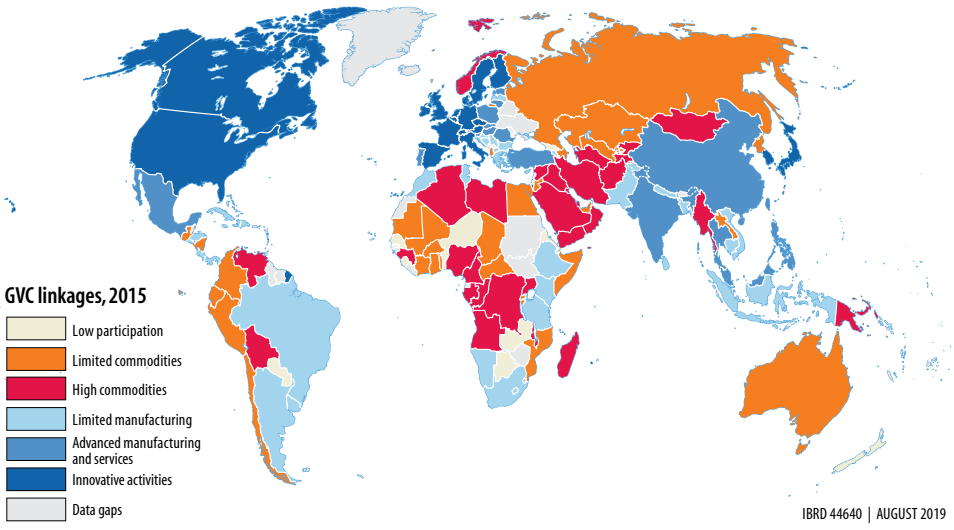
been uneven across countries.

Despite their widespread use in economic research, it is important to emphasize two key limitations of global Input-Output tables. First, because they rely on fairly aggregated Input-Output data, the resulting sectoral disaggregation of GVC flows is pretty coarse, and thus these data sources miss a significant amount of GVC activity occurring within these broadly-defined sectors. For instance, one can compute the origin of "fabricated metal products" in the production of "motor vehicles" in the United States, but where tires, car engines or windshield wipers originate from cannot be inferred from these datasets. A second key shortcoming of world Input-Output tables is that, in constructing them, researchers are forced to impose strong assumptions to back out certain bilateral intermediate input trade flows that cannot be readily read from either customs data or national Input-Output tables.

A different, more granular approach to measuring the degree to which production processes are fragmented across countries was first suggested by Yeats (2001) and consists of computing the share of trade flows accounted for by industry categories that can be safely assumed to contain only intermediate inputs (as reflected by the use of the words "Parts of" at the beginning of the product description). Yeats (2001) found that intermediate input categories accounted for about 30% of OECD merchandise exports of machinery and transport equipment in 1995, and that this share had steadily increased from its 26.1% value in 1978. Yeats classification has continued to be refined in recent years based on the Broad Economic Categories (BEC) product classification made available by UNCTAD.[4]

[4]See https://unstats.un.org/unsd/tradekb/Knowledgebase/50090/Intermediate-Goods-in-Trade-Statistics.

Figure 3: Uneven sectoral specialization in GVCs



Source: WDR 2020 team, based on the GVC taxonomy for 2015 (see box 1.3).

2.1 Determinants of GVC Participation

In the workhorse conceptual frameworks developed to understand traditional trade flows, such as the Heckscher-Ohlin model of trade, factor endowments are a key determinant of the structure of international trade. Skilled-labor abundant countries gain comparative advantage in producing skilled-intensive goods, while they benefit from importing low-skill-labor intensive goods from low-skill labor abundant economies. Similarly, countries with a large availability of arable land or of natural resources (relative to their endowment of other factors of production) are expected to specialize and export primary products.

In a world of global value chains, factor endowments play an analogous role in shape specialization, but they also affect the positioning of countries in GVCs. For instance, natural resource rich countries are expected to feature high levels of forward GVC participation because their exports of natural resources are used in a variety of downstream production processes that typically cross several borders. Similarly, and although agricultural products are much closer to final consumption than natural resources are, tariff escalation practices often leave less-developed countries specializing in the most upstream stages of agricultural GVCs, that is, exporting raw products before processing.[5]

By the same logic, one would expect physical capital abundant countries or skilled-labor abundant countries to specialize upstream or downstream depending on the relative physical capital intensity or relative skilled-labor intensity of upstream versus downstream stages. According to a widely used U.S.-based sectoral measure of upstreamness (see Antràs et al., 2012), upstream sectors in U.S. manufacturing appear to be more capital intensive and more skilled-labor intensive

[5] Tariff escalation is the practice of setting higher import duties on semi-processed products than on raw materials, and higher still on finished products (see WTO Glossary).

than downstream sectors. One might then expect physical capital-abundant and skilled-abundant countries to feature relatively high levels of forward GVC participation and relatively low levels of backward GVC participation. The evidence in Chapter 2 of the 2020 World Development Report finds support for the predicted link between low-skilled-labor abundance and downstream GVC positioning, but this same chapter shows that physical-capital scarce countries tend to specialize upstream rather than downstream. Nevertheless, the link between physical capital abundance and GVC positioning is blurred by the fact that GVCs often come hand-in-hand with FDI capital inflows. To provide a specific example, Nigeria is a relatively physical-capital scarce country, and oil extraction is a relatively physical-capital intensive process, but large FDI inflows have conferred Nigeria comparative advantage in that relatively upstream production stage. As a result, Nigeria features a large level of forward GVC participation relative to its backward GVC participation level (over the 1990-2015, the former's average was 0.26, while the latter's average was 0.09).

The international exchange of goods and services is subject to a large degree of contractual insecurity (Antràs, 2015). Weak contract enforcement is a significant deterrent of traditional trade flows, but its incidence on GVC trade is likely to be disproportionately large. Part of the reason for this magnified effect will be elucidated later, when discussing our relational conceptualization of GVCs. Yet, even when sticking to the view of GVCs as mere engines of hyper-specialization, multi-stage production processes with significant complementarities across production stages will tend to be particularly sensitive to contractual institutions (see Acemoglu et al., 2007). In plain words, the performance of a global value chain is often severely impacted by the strength of its weakest link, and thus production delays or mishaps driven by weak contract enforcement might be particularly harmful in GVCs. In sum, the quality of a country's institutions and its political stability are expected to be important determinants of GVC participation and might affect GVC trade disproportionately more than traditional trade. Chapter 2 of the 2020 World Development Report finds support for this hypothesis.

Empirical work in international trade emphasizes that trade costs have a significant negative effect on trade flows. There are various possible sources of trade costs, ranging from geographical features (such as remoteness), inefficient infrastructure, regulatory barriers (e.g., tariffs and quotas), or delays in clearing customs. There are at least two reasons to believe that trade costs might have a disproportionately negative effect on the GVC component of trade flows. First, the "weakest-link" mechanism invoked in the previous paragraph applies also to production delays associated with impediments to trade (such as customs delays). Second, and relative to traditional trade, higher trade costs not only increase the prices at which imported goods are consumed, as in traditional trade, but they also increase the cost of imported intermediate inputs, which get passed down the value chain and translate into higher costs associated with a country's exports, thereby further depressing GVC participation.

Regional trade agreements, or trade agreements more broadly, are a particularly effective mechanism to reduce trade barriers between the signing countries. Consequently, one would expect that GVCs are particularly active among countries that have signed regional trade agreements. Indeed,

GVC activity is particularly intense among EU and ASEAN members, but it should be noted that other regional trade agreements, such as Mercosur, appear to have been much less successful in generating GVC participation among its members.

Trade costs not only affect the overall GVC participation of countries, but they might have a significant effect in the positioning of countries in GVCs. In sequential (or snake-like) GVCs, trade costs compound along the value chain and have a higher incidence on downstream stages than on upstream stages. As Antràs and de Gortari (2019) demonstrate, this leads remote countries to specialize in upstream stages, and more central countries to specialize in more downstream stages. An implication of this fact is that we might expect the effect of trade costs to be more significant for backward GVC participation indices than for forward GVC participation indices.

Empirical work in international trade also emphasizes the role of market size in shaping bilateral trade flows. Larger economies are expected to export more (since they produce more), and they are also expected to import more (since their income is larger). An often-underappreciated aspect of the gravity model of trade, the most successful empirical model of bilateral trade flows, is that it provides a straightforward explanation for why the ratio of trade to output tends to be smaller for larger economies.[6] Whether a larger market size is associated with a higher or lower level of GVC participation is less clear, however. On the one hand, with sequential multi-stage production processes, larger countries naturally tend to attract a larger set of stages than small countries do. Furthermore, to minimize cross-hauling of semi-processed goods, the set of stages countries specialize in are often contiguous. As a result, larger countries are less likely to use imported inputs in their exports and should, other things equal, record lower levels of backward GVC integration. On the other hand, by their sheer size, large countries are likely to be geographically close to world demand for final goods, and thus their more "central" location should make them more prone to specialize downstream (see Antràs and de Gortari, 2019), and thus record higher backward GVC integration on account of their centrality.

2.2 Consequences of GVC Participation

How has the rise of GVCs affected the economies in which GVC participation has grown disproportionately? How might a rise in protectionism, by undoing some of the forces in recent decades, affect those same economies? Is protectionism costlier in the age of GVCs? These are the questions that will next concern us.

A first important insight already anticipated above is that by a allowing a finer international division of labor, the growth of GVCs is associated with greater income gains from trade than a commensurate expansion of traditional trade. Intuitively, GVCs allow countries to benefit from the comparative advantage of other countries not only at the sectoral level, but also at the stage level within sectors. As a result, models of trade featuring global Input-Output links (such as Caliendo and Parro, 2013, or Antràs and de Gortari, 2019) typically deliver larger gains from trade

[6] Note that, in a world without input trade, if exports between countries i and j are given by $X_{ij} = Y_i Y_j / k$, then k must be equal to world GDP, and the trade share is $\sum_{j \neq i} X_{ij}/Y_i = 1 - (Y_i/Y_{world})$.

than models without those links.[7] Furthermore, the resulting magnified costs of protectionism in a world of GVCs are exacerbated by environments in which the multiple stages involve in production feature especially high levels of complementarity (see Fally and Sayre, 2018, or Baqaee and Farhi, 2019). As we will discuss more extensively in section 3, when conceptualizing GVCs at the firm level, rather than at the country-sector level, it will also be clear that part of the reason for these magnified real income gains stems from the fact that, by lowering input costs and allowing an expansion of firm scale, GVCs tend to increase the productivity of firms.

It is well understood that the aggregate income implications of trade liberalization are also amplified in environments in which, via enhanced technology diffusion, an economy's growth rate might also be positively affected by trade opening (see, for instance, Sampson, 2015). If increased GVC participation enhances technology diffusion across countries, it would thus seem plausible that the rise of GVCs has a larger effect on growth rates than traditional trade does. It is fair to say, however, that the broad conceptualization of GVCs developed so far does not elucidate whether GVCs are a particularly effective vehicle of technology diffusion. We will return to this point later in the paper.

Although GVCs are expected, on average, to generate increases in aggregate income, they also generate nontrivial effects along the income distribution. Much of the literature on the implications of production fragmentation has in fact focused on studying how it shapes the distribution of income, and more specifically, the distribution of wage income within countries. The Stolper-Samuelson theorem, one of the key tenets of the canonical conceptualization of traditional international trade, indicates that deeper trade integration is likely to increase wage inequality (the relative wage of skilled versus unskilled workers) in relatively advanced, skilled-labor abundant countries, while it is expected to decrease wage inequality in less developed, skilled-labor scarce countries.

In a world of fragmentation, however, the validity of the Stolper-Samuelson theorem is undermined. More specifically, it is widely accepted both theoretically and empirically, that increased production fragmentation leads to increased wage inequality in both advanced and less-developed countries (see Goldberg and Pavcnik, 2007). There are at least three reasons for this.

First, when production is offshored to less developed economies, the labor force in those economies finds themselves being employed in new production processes and tasks that might have been perceived to be low-skilled labor intensive in advanced countries, but that are instead skilled-labor intensive relative to the outside opportunities of workers in less developed countries (see Feenstra and Hanson, 1996, 1997). Hence, offshoring increases the relative demand for skilled workers in less developed economies and puts upward pressure on wage inequality.

A second force towards increased wage inequality in less developed economies stems from the fact that GVCs are often more skill sensitive than traditional trade flows, partly because they often produce goods that are destined for quality-sensitive consumers in rich countries (Verhoogen,

[7] Arkolakis, Costinot and Rodríguez-Clare (2012) show that the costs of moving to autarky are shaped by the share of imports in a country's total spending. In their model of sequential GVCs, Antràs and de Gortari (2018) instead obtain a formula in which the costs of moving to autarky depend on the share of spending in goods that embody *any* foreign value (regardless of whether those goods themselves are imported or not).

2008), and partly due to high complementarities among the various stages of production carried in different countries (Kremer and Maskin, 2003, Antràs, Garicano and Rossi-Hansberg, 2006).[8]

A third force toward increase wage inequality in skilled-labor scarce countries is related to the fact that firms in GVCs tend to adopt more capital-intensive techniques than comparable domestic firms (Bernard et al., 2018). Physical capital deepening and upgrading contributes to the increase in the relative demand for skilled workers due to capital-skill complementarity, namely the fact that physical capital (and capital equipment, in particular) is less substitutable with skilled labor than it is with unskilled labor (Griliches, 1969, Krusell et al., 2000).

Although GVCs may increase income inequality in less developed economies, their impact on poverty is much less clear cut. On the one hand, the high-quality sensitivity of GVCs often lead them to marginalize the least skilled agents in society, and the increased opportunities they provide for more skilled agents might further deteriorate the livelihood of the less well off (e.g., by bidding up the price of housing or of other services). On the other hand, the positive effects of GVC participation on overall income and income growth are likely to trickle down to everyone in society. Those directly favoring from GVC integration will use their larger incomes to demand more local goods and services, which will generate novel opportunities for other agents in society, even those with relatively few skills. Furthermore, higher aggregate income can support a deeper welfare state that can ensure that the gains from integration are more evenly spread. Finally, GVC integration in certain regions of a country, can incentivize internal migration within countries, which can be a powerful mechanism to reduce poverty. In practice, it appears that GVCs have contributed to lifting millions of individuals out of poverty in some countries (such as China), but they may have failed to do so in other less developed countries. Chapter 3 of the 2020 World Development Report presents evidence that in Vietnam, poverty reduction was greater in locations with a higher presence of GVC activity.

For particularly underdeveloped countries, it is also often argued that GVCs may facilitate industrialization by reducing the range of required "capabilities" that these countries must be endowed with to be able to produce and export industrial goods. For example, in the auto industry, countries can participate in GVCs even when they might not have any domestic car makers or any domestic provider of car engines. On the other hand, more sophisticated tasks in value chains require skills and capabilities that many underdeveloped countries lack. As a result, the rise of GVCs might lead less developed economies to specialize in relatively low-value added segments of production with little scope for upgrading. In addition, tariff escalation practices by developed economies tend to reduce the value added that can be captured by less developed producers when attempting to remain competitive vis à vis other countries.[9] In sum, it may be simpler to "industrialize" in the age

[8] Production fragmentation also qualifies the link between trade integration and wage inequality in advanced economies. Grossman and Rossi-Hansberg (2008) argue that offshoring may increase wage inequality in advanced economies by *less* than traditional trade would.

[9] Consider the following example. A car assembler in a small, less developed economy faces fixed foreign input costs of $7,000, while a fixed sale price of $9,000 in rich countries. It can thus capture value added of $2,000 per car. Nevertheless, if rich countries set a 20% import tariff on assembled cars, to remain competitive, the car assembler will need to reduce its export price to $7,500, and thus local value added is reduced to $500. Thus, a 20% import

of GVCs, but the returns to doing so might not be as high as they were in the past. Furthermore, these effects interact with the gradual increase in automation, as will be discussed later in the paper.

The impact of trade liberalization on the environment also needs to be reevaluated in a world of GVCs. The transportation of goods across long distances generates CO_2 emissions that directly harm the environment, but in GVCs, the same value added is often shipped multiple times before reaching final consumers. Thus, the volume of CO_2 emissions generated in transporting goods in GVCs appear to be associated with a larger environmental harm than traditional trade. Similarly, the fact that GVCs foster "hyper-specialization" would appear to indicate that the pollution haven hypothesis might apply particularly intensely to GVCs, as lead firms from large industrialized nations may locate "dirty" production stages in countries where environmental norms are laxer, thus avoiding the cost of stringent environmental regulations.

It is important to emphasize, however, that there are at least two reasons that suggest that environmental concerns associated with globalization might instead be alleviated in the age of GVCs. First, as argued above, GVCs have the potential to accelerate growth in the economies that participate in them actively, and it is well understood that the demand for environmental regulation tends to increase when income rises (or, in economic jargon, environmental quality is a normal good). Second, GVCs are often an effective vehicle of technology transfer, so it seems plausible that they will also constitute an effective vehicle of clean technology transfer. In order to better elucidate this mechanism, however, it will be necessary to develop richer conceptual frameworks of GVCs, a task to which this paper will shortly turn to.

This section concludes with a very brief overview of some other macroeconomic consequences of GVCs (these are explained in greater detail in Chapter 4 of the 2020 World Development Report). Relative to traditional trade, in which producers compete head-to-head to service foreign markets, GVCs are associated with a higher degree of complementarity in production across countries, as productivity and demand shocks travel upstream and downstream along value chains. This translates into a faster and more intense transmission of shocks across countries (as exemplified by natural disasters such as the 2011 Tohoku earthquake), and at a more aggregate level, it also leads to higher co-movement of output and prices across countries (i.e., larger business-cycle synchronization and inflation spillovers).[10] GVCs also weaken the effects of movements in exchange rates on the trade balance. For instance, the positive effect of depreciations on the competitiveness of exports, is stymied by the increased cost of the foreign value added used in production.

3 A Firm-Level Approach to Global Value Chains

A common feature of both the conceptual framework and empirical measures described so far is that they advocate an analysis at the country level or, at best, at the country-industry level. Indeed, in

tariff on final goods can reduce value added in less developed economies by 75%.

[10] In the presence of inventories, GVCs are also expected to generate differential volatility at different stages of the chain (see Ferrari, 2019).

neoclassical frameworks in which production technologies feature constant returns to scale, there is little hope to generate predictions at a more granular level (i.e., at the firm or plant level). Furthermore, Input-Output tables and publicly available international trade statistics are reported at the industry- (or product-level) rather than at the firm level.

In the real world, however, it is not countries or industries that participate in international trade, but rather firms. In line with this simple observation, economic research in international trade has undergone a dramatic transformation in the last twenty years, one that has placed firm-level international strategies at the center stage. This intellectual revolution was fueled by the increased availability of longitudinal plant and firm-level datasets that permitted researchers to unveil a series of new facts that challenged the validity of existing models (see Bernard and Jensen, 1995). At the theoretical level, the seminal paper in the literature is that of Melitz (2003), which focuses on the exporting decisions of heterogeneous firms within an industry. In Melitz' framework, firms are assumed to produce differentiated products under technologies featuring increasing returns to scale. Product differentiation confers market power to firms, while scale economies are associated with firms facing fixed cost of production and of distribution. The decision of a firm on whether to export to a given foreign market is shaped by a comparison of the potential operating profit obtained in that foreign market with the fixed costs associated with distributing products in that market.

Although the canonical model in this firm-level approach to international trade was written in a setting in which international trade involves the exchange of only final goods, as in traditional conceptualizations of trade, an active literature has adopted similar ideas to understand the rise of GVCs. In the presence of fixed costs of engaging in global sourcing (i.e., of importing intermediate inputs), one would expect that the use of imported inputs in production will demand that importers attain a minimum efficient scale of production, with smaller and less productive firms in an industry being excluded from GVC participation (see Antràs and Helpman, 2004, Halpern, Koren, and Szeidl, 2015, Gopinath and Neiman, 2014, Antràs, Fort and Tintelnot, 2017). The combination of scale economies and fixed costs of importing and exporting also provides a natural explanation for the fact that firms that are large enough to be able to amortize the fixed costs associated with importing will also tend to be large enough to find exporting successful. Selection into importing thus naturally is associated with firms engaged in backward GVC participation according to the definition developed in our broad conceptualization of GVCs (i.e., the use of foreign value added in exporting). Similarly, firms exporting intermediate inputs, are likely to engage in forward GVC participation, as the firms importing their products are likely to be exporters themselves.

When adopting a firm-level approach one can also distinguish global value chains that are organized by a lead firm, which incurs the bulk of the fixed costs associated with setting up the network of producers in a given production process, and global value chains that are more decentralized in nature, with individual producers incurring costs to set up links upstream and downstream from them (see Bernard, Moxnes, and Ulltveit-Moe, 2018, Antràs and de Gortari, 2019).

3.1 Measurement

Firm-level datasets containing information on the import and export transactions of firms can be fruitfully used to construct measures of GVC participation similar in nature to those discussed above based on the country- industry information in global Input-Output tables. More specifically, transaction-level customs datasets of the type available from the World Bank's Export Dynamics Database can be used to identify the set of firms in a country that participate in trade, further distinguishing firms that export, firms that import and firms that both export and import. When a given firm in a given country both imports and exports, it is natural to conclude that this firm participates in GVCs.

To map this definition more precisely to the definition of backward GVC participation developed in country-industry studies, one would ideally also resort to product-level information to verify that the goods imported by an exporting firm are indeed intermediate inputs (rather than final goods), so that one can more comfortably conclude that this firm is indeed using foreign value-added in their production destined for exports. Without linking customs-level data across countries, it is much harder to come up with analogous firm-level measures of forward GVC participation. The reason for this is that even when a firm is identified as an exporter of intermediate inputs (rather than of final goods), it is virtually impossible to establish whether those inputs are fully absorbed in the importing country, or whether they are re-exported to third markets by the importing firms after having added value to them. We envision a future in which researchers will be able to conduct more satisfactory analyses with linked customs-data datasets from a variety of countries, but this future is not yet here.

It should be stressed that the above firm-level measures only identify the extensive margin of GVC participation, while industry-level measure based on global Input-Output tables also capture the intensity of GVC participation. Computing intensive measures of GVC participation at the firm-level data is however challenging, particularly in situations in which complementary census-level information is not available. The reason for this is that customs-level data have no information on firms' domestic purchases of inputs and on firms' domestic sales of goods. As a result, it is difficult to infer the ratio of foreign inputs used in production, and it is even more challenging to disentangle the foreign-input content of exports from the foreign-content of overall production (see Kee and Tang, 2016, for an attempt using processing trade in China).

Firm-level information on importing and exporting can also be used to shed light on the extent to which global Input-Output tables provide an accurate description of value-added trade flows across countries. Even when the entries of these tables provide an accurate account of the origin of inputs in a country's industrial production, the standard methods used to compute bilateral value-added trade flows from these tables assume that the same combination of inputs is used in production regardless of the destination of sales of a country and industry's output. As demonstrated by de Gortari (2018) with firm-level evidence from Mexico, in practice, firms selling output to different markets use very different combinations of sources of inputs, and this has significant implications for the type of bilateral value-added trade flows one infers from global Input-Output tables. For

instance, because Mexican exports to the U.S. embody a disproportionate amount of U.S. value added relative to Mexican exports to other countries, de Gortari estimates that the share of U.S. value in U.S. imported Mexican manufactures is 30%, rather than the 17% one would infer from standard techniques applied to global Input-Output tables.[11]

We now turn to elucidate the determinants and consequences of GVC participation through the lens of this firm-level approach to GVCs. To be clear, many of the forces outlined in the initial traditional conceptualization of GVCs continue to hold under this novel approach, so the focus will be on outlining distinct implications that arise in the present context.

3.2 Determinants of GVC Participation

Firm-level GVC participation is shaped by many of the same forces that shape GVC participation at the country-industry level. Firms in countries with large endowments of factors that are used intensively in certain segments of GVCs will be more prone to participate in GVCs, while trade costs and institutional quality continue to play a key role in shaping the likelihood that GVCs flow across a given country. The firm-level perspective, however, carries at least two important new lessons.

First, for some of the determinants of GVC activity, the relevant endowments might be better measured at the firm level than at the country level. For instance, even in countries with relatively low levels of educational attainment, some firms might be able to participate in relatively skilled-labor intensive value chains if certain firms in that country manage to attract a critical mass of skilled workers to work for them. On the other hand, it is much harder for individual firms to surmount the obstacles posed by an unfavorable geography, by deficient infrastructure, or by weak contract enforcement (see, however, our discussion of relational GVC below). Similarly, market size certainly matters for whether firms participate or not in GVCs, but often what is relevant is that firm size is sufficiently high, both to be able to amortize the fixed costs associated with GVC participation, and also to be able to fulfill large-volume orders from comparably large importers in other countries.

The second key lesson arising from a firm-level conceptualization of GVCs is that to better understand the extensive margin of participation, it is fruitful to separate determinants that are likely to affect the fixed cost of participation from determinants that are likely to impact GVC profitability conditional on participating.[12] This is because the relative magnitude of these effects is likely to shape the characteristics (size, productivity, etc.,) of firms participating in GVCs in a given country.

[11] Apart from qualifying the type of implications that one can draw from aggregated Input-Output tables, firm-level data can also be fruitfully used to test more systematically the validity of the "proportionality" assumptions that go into the construction of those data.

[12] Antràs, Fort and Tintelnot (2017) identify a significant divergence between the extent to which foreign countries generate cost savings for U.S. firms offshoring in those countries and the fixed costs associated with sourcing from these countries. For instance, China is estimated to offer significant cost savings, but the initial set up cost to be able to source from that country appears to be especially high.

3.3 Consequences of GVC Participation

The consequences of GVC participation also become significantly richer when adopting a firm-level approach to GVCs. Such a focus makes it clear that participation in GVCs generates aggregate income gains partly by increasing the productivity of firms. There are in turn two forces that shape these productivity improvements. On the one hand, there is a direct effect coming from the fact that the use of foreign value added in production is associated with firms being able to secure inputs from abroad at lower cost than they would from domestic suppliers. On the other hand, this reduction in costs coupled with the exporting associated with GVCs tend to increase the scale of operation of firms engaged in GVCs, and this tends to reduce their average costs in the presence of scale economies. In sum, GVC participation enhances firm-level productivity, a fact that has been confirmed empirically by Amiti and Konings (2007), Goldberg et al. (2010) and De Loecker et al. (2016), among many others.

These productivity effects imply that import competition shocks can carry significantly richer implications when they entail surges in imports of final goods (as in traditional trade) and when they partly entail an increase in imports of intermediate inputs. In the latter case, the positive productivity effects at the firm-level can lead to unexpected implications for scale and employment at the firm level. For instance, Antràs, Fort and Tintelnot (2017) show that U.S. firms that started importing from China after this country's accession to the WTO also increased their sourcing from domestic suppliers in the United States.

Envisioning GVC participation as a firm-level phenomenon also helps conceptualize why GVCs might be a particularly powerful vehicle of technology transfer. The reason for this is that unlike in formulations of traditional trade, in which firms from different countries compete against each other, GVCs constitute networks of firms with common goals, such as minimizing production costs or maximizing profits associated with the production chain. Surely, the incentives of agents in GVCs are not always aligned, and the division of the gains generated by GVCs naturally generates distributional conflict, but downstream firms typically gain from productivity enhancements of upstream producers in their chains, and vice versa. A direct implication of this simple observation is that firms from advanced countries importing or exporting goods to less developed economies might find it beneficial to share process and product innovations with their GVC co-participants in those less advanced economies. In sum, technology transfer is particularly fluid within GVCs.

As emphasized in our broad conceptualization of GVCs, a country's participation in GVCs can also constitute a significant source of increased income inequality. More specifically, the growth in aggregate income stemming from countries joining GVCs is often coupled with nontrivial increases in wage inequality. The firm-level approach to GVCs provides a more fleshed-out version of this mechanism, as the type of large firms often participating in GVCs (especially in manufacturing) tend to be larger, more skilled intensive, and more capital intensive than other types of firms (Bernard et al., 2008).

A study of GVC activity at the firm level further introduces novel dimensions associated with the distributional consequences of trade integration. For instance, in the presence of scale economies

and fixed costs of participation, large firms will tend to benefit disproportionately from GVC participation due the cost-savings associated with importing and the expansion in scale afforded by exporting. As a result, the size distribution of firms is likely to be significantly more skewed in a world of GVCs than in a world without them. This suggests the intriguing hypothesis that the rise of "superstar" firms in the U.S. and other advanced economies (see Autor et al., 2017) might be partly associated with the rise of GVCs.

Furthermore, it is a well-established fact that large firms tend to face lower price elasticities of demand than smaller firms, and that cost reductions are often only partially passed on to prices, and particularly so by large companies. As a result, the growth of GVC activity appears to be a potential contributor to the recently documented widespread rise in average markups and in the dispersion of these markups (see De Loecker et al., 2019). In fact, De Loecker et al. (2016) provide direct evidence from India showing that input trade liberalization was associated with an increase in the markups charged by Indian firms importing inputs from abroad. Chapter 3 of the 2020 World Development Report also provides preliminary evidence that increasing GVC participation appears to be associated with rising markups in developed countries but with falling markups in developing countries. The latter fact suggests that the relative bargaining power of agents in GVCs might be key for the distribution of the gains from GVC activity, an issue to which we will return in section 4.

A rise in markups associated with GVCs is likely to reflect more than the necessary increase in price-cost margins required to cover the increased fixed costs associated with a more complex sourcing or exporting strategy. As a result, GVC participation is also likely to increase the profit rate of these companies, thereby generating a force towards a lower share of an economy's income being paid to labor. Similarly, lead firms in GVCs often transfer their relatively capital-intensive production techniques and automation practices to their foreign production facilities in less developed economies, which might result in further shifts in the distribution of income away from labor and on to capital. There are of course many possible explanations for the observed global decline in the labor share (see Karabarbounis and Neiman, 2013), but the rise in GVC activity appears to be a likely contributor to this trend.

In terms of other macroeconomic implications of the rise of GVCs, the fact that firms participating in GVCs tend to be large and tend to engage in both importing and exporting provides a natural explanation for the fact that following large depreciations, import growth often tracks export growth closely, thus reducing the effectiveness of depreciations in reducing trade imbalances (see Blaum, 2018).

4 A Relational View of Global Value Chains

Although research adopting the broad approach to GVCs has provided valuable novel insights, modeling global production sharing as simply an increase in the extent to which foreign inputs (or foreign value added) is used in production misses important distinctive characteristics of the

recent rise of GVCs. In other words, the definition of GVCs adopted so far may be too broad to do full justice to the novel landscape that has emerged in the world economy in the last thirty years. The rise of GVCs entails much more than the intensification of the type of trade in raw materials and homogeneous intermediate inputs that has existed since the Bronze Age. It is also much more than importing and exporting firms transacting with each other in world markets. The expansion of GVCs entails a finer international division of labor but it also involves a number of additional features. Four of these distinctive features are particularly important.

First, the process by which agents co-participating in GVCs match with each other is not frictionless. Fixed costs of exporting and importing partly reflect the costs of finding suitable suppliers of parts and components or suitable buyers of one's products. For this reason, these fixed costs are better understood as sunk costs, which naturally create a "stickiness" among participants in a GVC.

A second source of lock-in in GVC relationships is related to the fact that GVC participants often undertake numerous relationship-specific investments (such as purchasing specialized equipment or customizing products) which would obtain a much-depressed return were GVC links to be broken. The need to customize inputs, coupled with quality sensitivity considerations, renders the above matching between buyers and sellers particularly important. If a firm suddenly faces an increase in the demand for their goods, it cannot easily scale up by buying more foreign inputs from some centralized market. There are typically only a handful of suppliers worldwide that can provide the additional necessary customized inputs necessary to scale up.

Third, firms participating in GVCs do not only engage in trade in tangible goods with other members of their value chains. GVCs often involve large flows of intangibles, such as technology, intellectual property and credit. The exchange of these intangibles is significantly more complex than that of simple goods or services.

Fourth, the prevalence of lock-in effects and flows of intangibles within GVCs is made particularly relevant by the limited contractual security governing transactions within these chains. GVC often involve transactions for which a strong legal environment is particularly important to bind producers together and to preclude technological leakage. And yet, GVC are often conducted in situations in which this strong legal environment is missing because cross-border exchange of goods cannot generally be governed by the same contractual safeguards that typically accompany similar exchanges occurring within borders. As a result, GVC participants are left to employ repeated interactions among them to build a governance that provides implicit contract enforcement. As in the case of matching frictions and relationship-specificity, this force contributes to the "stickiness" of GVC relationships.

In sum, these considerations lead to a novel, relational conceptualization of GVCs in which the focus is shifted away from the mere allocation of value added across countries resulting from anonymous, spot exchanges of goods and services. Instead, a new paradigm emerges in which the identity of the specific agents participating in a GVC is crucial. Within these GVCs, contracting is often relational in nature, and thus more likely to exhibit persistence than in transactions involving

raw materials and homogeneous inputs.

An extreme version of this type of relational contracting arises when parties involved in a GVC altogether by-pass the market mechanism and decide to transact within firm boundaries, by having the buyer vertically integrate the seller or vice versa. The prevalence of intrafirm trade flows in world trade flows exemplifies the importance of relational aspects in the growth of GVCs. For instance, U.S. customs data suggest that, in recent years, close to one-half of U.S. imports involve related-party transactions (see Antràs, 2003). At the global level, intrafirm trade has been estimated to account for about one-third of world trade flows.

Nevertheless, the internalization of transactions in a GVC is just one of the many organizational responses to the contractual vagaries associated with cross-border transactions. In an influential study, Gereffi, Humphrey, and Sturgeon (2005) elaborate a much more extensive taxonomy of potential governance forms within GVCs, and various researchers have built on their work to shed light on the relative prevalence of these governance forms through a number of interesting case studies.

Although the relational approach to the study of GVCs is concerned with the same phenomena as the more traditional approach discussed earlier in this paper, these literatures have largely evolved in isolation. These separate paths are partly explained by the significantly different sources of data used in these different literatures, as discussed next.

4.1 Measurement

Measuring participation of firms in relational GVCs is notoriously difficult. First of all, because relational GVCs activity entails firm-to-firm links, it presents the same difficulties outlined in section 3 regarding measuring participation at the firm level. But more importantly, the distinctive characteristics of relational GVCs call for a narrower empirical definition of this type of GVCs, one that excludes firm-level GVC participation associated with the exchange of fairly homogeneous goods in spot transaction.

Given these difficulties, it is no surprise that progress on this area has been rather scant. The most influential work on the relational nature of GVCs tends to focus on particular case studies of specific sectors and countries, which allow the researcher to paint a more colorful and realistic picture of the web of relationship sustaining global production in that sector. The extensive and influential of Gary Gereffi provides a good example of this (see for instance, Gereffi, 1994, on the apparel industry, Sturgeon et al., 2008, on the automobile industry or Bamber and Gereffi, 2013, on the medical device industry in Costa Rica). More recently, Rocco Macchiavello and Ameet Morjaria have studied in detail the relational nature of contracting in various agricultural markets in less developed economies, such as their work on the flower industry in Kenya (see Macchiavello and Morjaria, 2013) or their work on the coffee value chain in Rwanda (Machiavello and Morjaria, 2019).

One of the initial goals of the 2020 World Development Report was to attempt to provide a bridge between this case-study-based literature and the broader empirical literature on GVC

participation. The idea was to develop firm-level and product-level measures of the extent to which the GVC participation of firms is relational in nature, and the extent to which international transactions associated with a given product tend to be relational in nature. More specifically, the aim was to exploit the panel nature of some of the datasets available from the World Bank's Exporter Dynamics Database (EDD) to construct measures of the observed persistence of firm-to-firm transactions, perhaps partialling out various natural determinants of persistence (such as exchange rate volatility). This is very much in line with the measure of "relationship stickiness" proposed by Martin et al. (2018), which they compute using detailed firm-to-firm export data from France. The hope was to "scale up" this approach and apply it to various countries, with the initial goal of verifying whether there was a significant positive rank-correlation in product-level stickiness across countries. Such a finding would indicate that there is a significant product-level dimension to stickiness that is likely to render GVC participation in certain goods particularly prone to be relational in nature. With such finding at hand, one could use standard industry concordances to construct a global Input-Output table that separates trade flows associated with traditional versus relational transactions, thereby allowing one to construct broad industry-level measures of *relational* GVC participation for the comprehensive set of countries in the Eora Global Supply Chain Database. Due to time constraints, such analysis was not conducted in time for the 2020 World Development Report, but hopefully it will be carried out in future work.

4.2 Determinants of GVC Participation

In a world of relational GVCs, the effect of factor endowments on GVC participation is largely analogous to the one developed above for the broad notion of GVCs (both at the country-industry and at the firm level). A key novel aspect, however, is that as mentioned above, the relational approach to GVCs provides a straightforward explanation for why GVC activity and FDI flows go hand in hand. When tight control over foreign production processes is necessary (perhaps because the legal environment does not suffice to discipline the behavior of suppliers or to avoid the leakage of intellectual property), lead firms might decide to rely on integrated suppliers and assemblers in foreign countries. This results in intrafirm trade and FDI flows. For this same reason, countries that put in place policies that are FDI *friendly* (such as establishing credible mechanisms to reduce the risk of expropriation or offering tax breaks for new investments by foreign companies) are more likely to be able to participate in GVCs.

The stickiness of relational GVCs also makes them particularly vulnerable to supply chain disruptions. For this reason, firms participating in relational GVCs are likely to be particularly sensitive to the availability of skilled labor in the economies in which they operate. Furthermore, in relational GVCs, informational flows and communication are particularly important, which suggests that language skills (such as a good command of English as a second language) might be particularly relevant for GVC participation.

The relational nature of GVCs also considerably reinforces the role of institutional quality as a significant determinant of GVC participation. Having said this, institutional quality and relational

GVCs interact in subtle ways. On the one hand, the emphasis this approach places on contractual insecurity naturally implies that production processes involving high degrees of customization (i.e., more relationship-specific investments), and for which a thick "secondary" market is missing, are likely to be located in countries with strong institutional quality (Levchenko, 2007, Nunn, 2007). The reason for this is that in those countries, lead firms are in a better position to discipline the behavior of producers and avoid costly production delays or quality debasements. Nevertheless, and as argued above, the same forces that make relational GVC rely intensively on institutional quality also make GVC links particularly "sticky", which fosters the emergence of reputational mechanisms of cooperation which might partly substitute for the absence of formal contracting. In addition, under some circumstances, vertical integration may serve as a direct (albeit imperfect) substitute for strong contract enforcement in countries hosting GVCs. Because relational GVCs feature significant flows of credit and intellectual property, a country's financial institutions and IPR protection policies also constitute important determinants of GVC participation.

The effects of trade costs on GVC participation need also be qualified when GVCs are relational in nature. As reiterated above, supply chain disruptions are particularly costly when firms participating in these chains cannot easily resort to alternative producers when some of the links in the chain fail to provide components or services in time or under pre-specified terms. With that in mind, trade delays associated with inefficient or corrupt customs offices might act as a particularly large deterrent for relational GVCs requiring coordination and in-time delivery. Furthermore, in the presence of weak contract enforcement, the emergence of cooperation among producers in GVCs is fostered by repeated interactions among the several agents participating in the chain, interactions that may be severely curtailed by remoteness or insufficient air connectivity.

The lock-in effects associated with costly search and relationship-specific investments also have implications for the role of market size in attracting GVC activity. Beyond the factors identified by the above broad conceptualization of GVCs, in settings with relational GVCs, a large market might serve the role of reducing search frictions (Grossman and Helpman, 2005), and may also facilitate resorting to alternative suppliers in the presence of production disruptions.

4.3 Consequences of GVC Participation

How will economies be impacted by participating in relational GVCs? Many of the effects discussed under the broad conceptualization of GVCs continue to apply, but one can identify three particularly distinctive aspects of relational GVCs that have significant ramifications for understanding the consequences of GVCs.

First, the relational approach clarifies the role of GVCs as vehicles of technology transfer. GVC participation is not just about using foreign value added in production or about engaging in importing and exporting. A GVC is made up of inter-firm and intra-firm relationships which govern the transfer of tangible goods, but also the transfer of information and technology involved in making a product or providing a service. The scope for absorbing foreign technology is thus particularly large in relational GVCs. Furthermore, the sticky nature of relational GVCs make them

particularly prone to benefits from learning-by-importing and learning-by-exporting via repeated interactions with highly productive firms in advanced economies. Similarly, the transfer of clean environmental standards to less developed economies might be most efficiently carried out via relational GVCs.

A second key consideration is that the combination of incomplete contract enforcement and the lock-in effects stemming from search frictions and relationship-specific in relational GVCs give rise to transaction prices between buyers and sellers that tend to be bilaterally negotiated, and that are thus not fully disciplined by market-clearing conditions. This observation has a number of implications for the consequences of relational GVCs. Countries should concern themselves not only with fostering the participation of their local firms in GVCs, but should also be mindful of the bargaining power that their firms will have vis à vis large foreign firms. The implications of GVCs for the emergence of superstar firms with huge scale, high market power and large profit rates are exacerbated by the disproportionate bargaining power that these large firms might have vis à vis their suppliers. More specifically, large lead firms might be able to buy parts and components at relatively lower prices (via volume discounts, playing suppliers against each other, etc.), while also being able to sell at higher prices (if they are themselves key suppliers to downstream producers). This strong bargaining power enhances the profitability of large firms engaged in relational GVCs, but might come at the cost of a lower "share of the pie" accruing to smaller and less powerful firms in less developed economies. These effects might be compounded in countries with unfavorable geographical features or weak institutions, as large firms might react to the risk of facing production disruptions in those countries by setting up "back-up" suppliers elsewhere, thereby further eroding the bargaining power of suppliers in distant or weak contracting countries. Indeed, as mentioned above, Chapter 3 of the 2020 World Development Report reports evidence suggesting that increasing GVC participation appears to be associated with *falling* markups in developing countries. Beyond distributional concerns, Antràs and Staiger (2012) also show that the fact that international prices are often bilaterally negotiated carries important implications for the role of design of international trade agreements.

A third set of novel mechanisms by which relational GVCs might affect inequality relates to the disproportionate importance of the matching between buyers and sellers. Because the identity of these producers matters, especially in situations in which sensitivity to quality is high, relational GVCs may set off "a war for talent" in which the price of particularly attractive producers, or the wage of particularly skilled individuals might be disproportionately bid up relative to a world without relational GVCs. This constitutes another mechanism by which GVCs might exacerbate inequality in the distribution of income.

5 The Future of GVCs

This paper has so far focused on overviewing some key conceptual aspects related to GVCs, and has attempted to develop a set of predictions regarding the key determinants and implications of

the rise of GVCs observed in the last thirty years. In this concluding section, this chapter will leave the comfort zone of predicting the past, and will venture into the much more treacherous terrain of attempting to predict the future.[13]

Although the current political environment would be rife for a discussion of how a continuing escalation of trade tensions between the U.S. and other countries might affect the future geography of global production, this concluding section will instead focus on speculating on the future of GVCs in light of the advent of an array of new technologies, such as digital platforms, blockchain, automation, and 3D printing. Some readers will be disappointed by this focus, but there are at least two reasons for it. First, new technologies are here to stay, while the current trade "strifes" between the U.S. and its major trading partners are very much in flux and, as of the time of writing (December of 2019), it is not clear that they will develop into an all out "trade war". Second, if an increase in trade barriers indeed materializes for a significant amount of time, the effects it would generate would largely be the mirror image of those following the decline in trade barriers in the last thirty years, as already hinted in section 2.2. Instead, the effects of new technologies are quite distinct in nature and deserve a separate discussion.

How will the future of GVCs be shaped by new technologies? Will the recent (post 2008) slowdown and retrenchment in GVC participation continue in the next few decades? Or are we perhaps in the cusp of a new wave of globalization? And how will new technologies reshape the role of GVCs as a possible engines of development? This final section will apply the conceptual framework developed in previous sections to offer some tentative answers to these questions.

5.1 Digital Technologies

Consider first the case of digital technologies. It is clear that global value chains are rapidly changing under the pressure of digital innovation. First and foremost, digital technologies encourage GVC participation by reducing many of the barriers that firms face when attempting to join GVCs. For instance, digital platforms (such as Amazon, Alibaba or Mercado Libre) facilitate the matching of buyers and sellers, thus reducing the initial fixed costs associated with GVC participation.[14] Extending access to high-speed internet and expanding e-commerce thus has the potential to greatly facilitate increased GVC participation by relatively small firms, and also for firms in countries with bad infrastructure (which now gain the ability to specialize in segments of global value chains that specialize in the provision of services via digital technologies rather than the provision of physical goods via transport infrastructure). These same technologies also enhance the management of inventories, and of logistics more broadly, thereby improving participation even in manufacturing segments of GVCs (see Fort, 2017).

Furthermore, digital platforms (via rating systems) and open distributed ledgers (such as blockchain) enhance verification and monitoring, thus reducing informational frictions and opening

[13] As Niels Bohr famously put it,"prediction is very difficult, especially if it's about the future".

[14] Note that many digital platform companies offer parallel business-to-consumers and business-to-business platforms.

the door for countries with weak institutions to bypass a key factor limiting their participation in GVCs. Similarly, in situations in which language barriers remain significant (e.g., in the provision of certain services), the application of big data and machine learning techniques has the potential to provide much more efficient translation services (see Brynjolfsson et al., 2019). In sum, one would expect the unstoppable advance of digital technologies to provide a new tailwind to ensure the continuing growth in GVC activity worldwide.

Apart from these effects on the efficiency of GVCs, it is also important to acknowledge some potential distributional effects originating specifically from these novel technologies. For instance, the same reputation mechanisms GVCs rely on to verify seller and buyer quality may foster concentration, thus making it harder for entrants to compete. Within existing relational firm-to-firm GVC activity, novel technologies might also have implications for the relative bargaining power of the different participants in GVCs. For instance, digital platforms might allow large buyers in rich countries to gain information on a larger number of potential suppliers, thus enhancing their ability to have these suppliers compete with each other. This in turn may lead to better terms of trade for lead firms in rich countries, at the expense of a lower share of the gains from GVCs accruing to producers in less developed economies. Furthermore, digital platforms themselves have been accumulating vast amounts of information on the users of their platforms, and this certainly enhances their ability to use this information to their advantage, either by locking in buyers with particularly well tailored recommendations, or by price discriminating in particularly effective ways. As a result, digital platform firms also pose new challenges for regulators seeking to ensure fair competition and prevent abuse of market power.

The specific features of relational GVCs emphasized in section 4 suggest that the efficiency and distributional consequences following from the increasing adoption of digital technologies might not be orthogonal to each other. More specifically, because verification and monitoring serve as a substitute for the need for implicit contract enforcement, they may lead to an erosion of the "stickiness" of GVC relationships. This in turn may well generate negative effects on the productivity of firm-to-firm transactions. Indeed, recent work by Machiavello and Morjaria (2019) suggests that in coffee value chains in Rwanda, increased competition was associated with a lower use of relational contracts between mills and farmers, and this breakdown in relational contracts lowered mills' efficiency and output quality.

5.2 Automation and 3D Printing

Although new technologies have the potential to raise productivity, they sometimes can prove to be quite disruptive, especially when they lead to a reduction in the demand for workers. The example of industrial automation and robotics is a case in point. At first glance, automation constitutes an alternative to offshoring for firms in rich countries seeking to lower their labor costs. Because automation and offshoring appear to be substitutes, one would then expect improvements in automation to lead to an increasing amount of reshoring over time. This fact might be particularly concerning to less developed economies, which might view automation as a threat to their ability

to leverage their cheap labor to get a foot on the door of GVCs. These fears might be compounded by the fact that large multinational companies typically design their production processes with their home market factor prices in mind, and might then impose these same production processes possibly involving large amounts of automation, in their host countries (see Rodrik, 2018). In other words, participation in GVCs might lead to the diffusion of automation to less developed economies, thereby aggravating the reduction in demand for labor caused by automation in less developed economies.

The substitutability between automation and offshoring is, however, much less clear-cut in practice. Automation by firms in developed countries tend to decrease their costs, enhance their productivity and thereby increase their demand for intermediate inputs, many of which continue to be sourced from less developed economies. Whether automation increases or reduces the extent to which firms in less developed economies participate in GVCs is thus an empirical matter. Building on recent work by Artuc et al. (2018), Chapter 6 of the 2020 World Development Report presents preliminary evidence suggesting that automation in industrial countries appears to have, in fact, boosted imports from developing countries, although the effect is heterogeneous across sectors and countries.

Even when automation might not have a negative impact on GVC participation, it is important to emphasize that it is likely to aggravate the effects of increased GVC participation on inequality. The mechanism here is closely related to the capital-skill complementarity effect already mentioned in section 2.2. Similarly to physical capital investments, automation typically complements skilled labor while substituting unskilled labor, thereby exerting upward pressure on the relative demand for skilled workers, and thus on wage inequality. As a result, even when the effects on employment might be attenuated by productivity effects, automation is likely to be associated with a decreasing share of workers in less developed economies directly gaining from GVCs flowing through their economies.

Automation is often associated with industrial robots, but there has recently been some debates about the role of 3D printing on the future of GVCs. Will 3D printing lead to large volumes of reshoring therefore depressing GVC participation and trade flows? In answering this questions, the mechanisms at play are very much similar to those applying to automation more broadly. The trade-reducing effects of 3D printing are obvious, but one should also take into account their positive effect on productivity and input demand, and the fact that 3D printers do not print goods out of thin air. In addition, by making consumer goods produced by 3D printers cheaper, the demand for these same goods is increased, and as long as 3D printers are not available everywhere, they may generate a short-run spur to trade flows. Indeed, this is consistent with the findings of Freund et al. (2018), who show that the dramatic shift of production of hearing aids via 3D printing actually increased international trade in hearing aids by roughly 60 percent.

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