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Determinants of Global Value Chain Participation: Cross-Country Evidence

Abstract

The past decades witnessed big changes in international trade with the rise of global value chains. Some countries, such as China, Poland, and Vietnam rode the tide, while other countries, many in the Africa region, faltered. This paper studies the determinants of participation in global value chains, based on empirical evidence from a panel data set covering more than 100 countries over the past three decades. The evidence shows that factor endowments, geography, political stability, liberal trade policies, foreign direct investment inflows and domestic industrial capacity are very important in determining participation in global value chains. These factors affect participation in global value chains more than traditional exports.

JEL-Codes: F130, F140, F230, O200.

Keywords: global value chain, factor endowments, trade policy, foreign direct investment, institutions.

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1 Introduction

In the early 1990s, Argentina tried to develop a homegrown auto industry, hiding behind an average tariff of more than 13 percent. Over the past two decades, Argentina's auto exports have stagnated at a dismal 0.2 percent of global auto exports. Around the same period, General Motors (GM), one of the world's largest automakers, set up GM Poland to import Opel cars for the large Polish domestic market. In 1994, production activities of GM Poland started, and today, Poland is one of the world's major auto exporting countries. Similar to the auto industry in Poland, Vietnam's electronics sector expanded sharply in less than a decade. Today, Vietnam is the world's second largest smartphone exporter, producing 40 percent of Samsung's global mobile phone products and employing 35 percent of its global staff. Ten years ago, Vietnam barely exported electronics products.

What sets Argentina, Poland, and Vietnam apart is their very different participation in global value chains (GVCs). In fact, the meteoric rises of Poland and Vietnam and the faltering of Argentina are not unique. China's World Trade Organization (WTO) accession in 2001 ushered a new wave of GVCs which gave rise to "Factory Asia" (Baldwin, 2016), while a large part of the Africa, South Asia and Latin America regions is being left behind with little integration into GVCs (see Figure 1).

As discussed in Antràs (2016), what distinguishes GVC trade from traditional trade are the intense firm-to-firm interactions characterized by contracting and specialized products and investment. What factors determine GVC participation across countries? Do factors that affect traditional trade have differential impacts on GVC trade? This paper studies the determinants of GVC participation based on empirical evidence stamped from a panel data set covering more than 100 countries over the past three decades. The time period reflects the growing international fragmentation of production and the sample includes countries in all geographical regions and at all stages of development. This large cross-country variation makes the data set uniquely suitable to estimate the marginal impact of different potential determinants on GVC participation and assess their relative importance. While many papers explain the GVC phenomenon from various angles, the strategy of this paper is to provide a unified empirical framework to test jointly the role of the different determinants highlighted

in the literature as being important for trade in general, or for GVC trade in particular.[1] We focus on widely-used measures of backward GVC participation, mainly drawing on the EORA database, which capture the import content of exports, that is, how much imported materials are used in countries' exports. We consider seven broad types of determinants emphasized in the trade literature: (i) factor endowments, (ii) geography, (iii) domestic industrial capacity, (iv) trade policy and foreign direct investment (FDI), (v) institutional quality, (vi) connectivity, and (vii) macroeconomic factors.

However, establishing causality is challenging in the cross-country setting as some of the potential determinants, such as tariffs and FDI inflows, are endogenous to GVC participation. To this end, we rely on instrumental variables (IVs) estimation in the cross-country regressions, and a difference-in-difference framework following Rajan and Zingales (1998) in the cross-country cross-sector regressions. The use of IVs also mitigates biases in the construction of the GVC participation variables, which hinges on the use of international input-output tables that may have measurement problems. Our IV selections are guided by existing trade theories and strong empirical evidence.

The results from our cross-country decadal panel and our cross-country IV regressions show that the key determinants of backward GVC participation are, in order of importance, factor endowments, geographical location, political stability, tariffs and FDI inflows, and domestic industrial capacity. We show that our IVs have the expected coefficients and significant explanatory power with high first-stage F-statistics. Our second-stage IV coefficient estimates are larger in magnitude than the corresponding least squares coefficient estimates suggesting that measurement errors and reverse causality are important in biasing the least squares results. Our findings are robust to the inclusion of alternative determinants and controls. Moreover, broad sector analysis suggests that the overall findings are largely driven by manufacturing. Cross-country cross-sector panel regression analysis in a difference-in-difference framework further confirms that institutional quality, factor endowments, trade policies, FDI, and connectivity matter for GVC participation.

Finally, we extend our analysis to show that the most determinants have larger impacts

[1]For theoretical models on GVCs and international production fragmentation, please refer to Feenstra and Hanson (1997), Feenstra (1998), Antràs and Helpman (2004), Romalis (2004), Nunn (2007), Antràs and Helpman (2008), Chor (2010), Antràs (2016), and Antràs and De Gortari (2020).

on GVC trade than on traditional trade. We analyze forward GVC participation, which captures the domestic value added that is used in a bilateral partner's export production. Results again confirm the importance of these factors in explaining GVC participations.

This paper contributes to several strands of the trade literature. First, the paper relates to the empirical literature on the determinants of GVC participation.[2] We expand the existing analyses in terms of country, time, and variable coverage, but also with regards to the methodology by addressing potential endogeneity concerns using IV and difference-in-difference estimations. By embedding the determinants in a unified framework, we are able to estimate their marginal contributions and identify their relative importance to GVC participation. Second, the paper relates to the literature on the measurement of GVC participation.[3] Our study uses an improved measure of GVC participation which avoids a double-counting problem.[4] Finally, the paper contributes to the literature on international production sharing and GVCs.[5]

This paper is organized as follows. In Section 2, we define the GVC participation measures and motivate our selection of determinants. We present the baseline empirical specifications in Section 3. The regression results on the determinants of GVC participation are shown in Section 4, followed by robustness checks in Section 5. Section 6 concludes. We refer the readers to the Appendix for the data descriptions and sources.

2 GVC Measures and Determinants

2.1 Defining and Measuring GVC Participation

From imports of pistons used as intermediates in car manufacturing in Morocco to Chilean exports of copper used in refrigerators produced by firms in China and Mexico, GVC partic-

[2] See Baldwin and Taglioni (2012), Brooks and Ferrarini (2012), Noguera (2012), Blyde (2014), Cheng et al. (2015), Kowalski et al. (2015), United Nations (2015), Buelens and Tirpak (2017), Balié et al. (2019), and Ignatenko et al. (2019). While the literature is vast, the studies so far establish strong correlations but no causal links.

[3] See e.g., Hummels et al. (2001), Koopman et al. (2014), Johnson and Noguera (2017), and Miller and Temurshoev (2017).

[4] The measure was introduced and developed in Borin and Mancini (2015, 2019).

[5] See Baldwin (2012) for a discussion on GVC participation as a new industrialization strategy and Feenstra (1998) and Timmer et al. (2014) for reviews of the literature on foreign outsourcing and on GVCs.

ipation is multifaceted and diverse across countries. This paper mainly focuses on backward GVC participation measures that have been recently developed in the empirical literature, drawing on newly available international input-output tables, including the EORA database, the Trade in Value Added (TIVA) database and the World Input-Output Database (WIOD).

A country's backward GVC participation measures the import content of its exports relative to the country's total gross exports. Those imported inputs are predominantly made up of foreign value added but can also contain domestic value added which has been previously exported. The import content of export measure was first introduced by Hummels et al. (2001) using national input-output tables and was more recently computed by Borin and Mancini (2015) and Wang et al. (2013, 2016) based on international input-output tables. This measure takes into account indirect effects (known as the Leontief inverse matrix) where imported inputs are embodied in domestic output, sometimes at several stages, before being used as inputs for exports.

As a robustness check, we also consider forward GVC participation. A country's forward GVC participation measures the domestic value added in exports that is used by the country's bilateral partner countries for export production as percent of the country's total gross exports. In other words, it captures the portion of domestic value added that is not directly consumed by the bilateral partner (which is the final stage in the value chain). For example, final apparel exports from Bangladesh that are exported to and consumed in the United States (US) would not be accounted for in this measure. The measure was developed in Borin and Mancini (2019) based on a bilateral source-based decomposition of exports.[6] Both backward and forward GVC participation measures are such that their construction ensures that trade flows cross at least two country borders – a key characteristic of a GVC.

The country-level backward and forward GVC participation measures are additionally decomposed into measures for four broad sectors: agriculture, mining, manufacturing, and services. In order to obtain these measures, we split the country-level numerator into these

[6]For a technical discussion of these and other GVC measures, see Aslam et al. (2017) and Borin and Mancini (2015, 2019). Koopman, et al. (2014) propose an alternative forward GVC participation measure: a country's domestic value added that is used by third countries for export production. We do not use this measure as it double-counts the domestic value added component if it is used in the downstream processes of multiple countries (e.g., petroleum) and thus can counterintuitively exceed 1 as a share of the country's gross exports.

four sectors and divide each by the country's total exports. Using these alternative measures by broad sector sheds light on which sectors are driving the aggregate cross-country results. Finally, both types of GVC participation measures are also available at the country-sector level for an analysis of cross-country cross-sector determinants of GVC participation.

In addition to studying the "intensity" of GVC participation, as measured by the shares in gross exports, we are also interested in the levels of GVC participation (i.e., the numerator of the "intensity") and in the levels of gross exports. Comparing the factors that affect GVC participation shares with their influence on GVC participation levels and on export levels indicates which determinants matter beyond traditional exports.

The main data source for the GVC participation measures is the EORA database described in Lenzen et al. (2013), which covers 190 countries over the period 1990-2015 using a 26-sector harmonized classification.[7] The decomposition of country-level GVC participation measures into agriculture, mining, manufacturing, and services also draws on the EORA database and our cross-country cross-sector analysis relies on GVC participation measures for eight manufacturing sub-sectors in that database, listed in the Appendix.[8]

There are several limitations to using international input-output tables to measure GVC participation. A major limitation is related to the distorted statistics that international input-output tables are based on.[9] In particular for lower-income countries that often do not produce national supply-use tables, the EORA data are based on interpolations and estimations, and therefore subject to measurement errors. There is also a concern regarding the lack of firm-level heterogeneity in the conceptual measure of GVC participation which may also lead to errors.[10] All these measurement errors in the EORA GVC data may bias

[7] The number of countries in our estimating sample is at most 121 due to missing data on determinants and to the exclusion of countries with problematic (negative) values for the GVC participation measures (Liberia, Moldova, Mauritius, South Sudan, Sudan, and Zimbabwe).

[8] In robustness checks we use as alternative sources the TIVA database 2016 and 2018 editions covering 64 countries over the periods 1995-2011 and 2005-2015, respectively, the WIOD 2013 release covering 40 countries in the period 1995-2011 and the WIOD 2016 release covering 43 countries in the period 2000-2014, described in Timmer et al. (2015, 2016). Further details, summary statistics and correlations among the GVC participation measures are provided in the Appendix. One interesting fact to note from the correlations is that the cross-country correlation between backward and forward GVC participation is negative.

[9] United Nations (2019) describes the major limitations in detail and proposes solutions to help substantially improve the input-output coefficients used in the current international input-output tables.

[10] The GVC literature emphasizes governance of lead firms and their relationship with suppliers as a major feature of GVC trade but such information is unavailable in current international input-output tables.

least-squares coefficients toward zero in regressions. We will use IVs to address this issue.

2.2 Determinants of GVC Participation

This section motivates the choice of determinants of GVC participation examined in the paper. We consider seven broad types of determinants: (i) factor endowments, (ii) geography, (iii) domestic industrial capacity, (iv) trade policy and FDI, (v) institutional quality, (vi) connectivity, and (vii) macroeconomic factors. The definitions, detailed data sources, summary statistics, and correlations of the variables are provided in the Appendix.

2.2.1 Factor Endowments

Factor endowments are crucial in determining international specialization (Heckscher-Ohlin model) and may also shape the positioning of countries in GVCs.[11] We focus on three types of endowments: (a) natural resources, (b) labor, which is separated into low-skilled and middle to high-skilled, and (c) capital. An abundance of natural resources in a country, such as copper and iron ore, is naturally linked to high forward GVC integration, since agricultural products and commodities are used in a variety of downstream production processes that typically cross several borders. Low-skilled labor in lower-income countries is often an entry point to downstream assembly-type stages of production associated with high content of imported inputs in a country's exports (high backward GVC participation) and exports of final goods (low forward GVC participation). But advancing to more skill-intensive tasks in the value chain increases forward GVC participation. Finally, these production processes require capital investments, hence capital endowment should induce GVC participation.

2.2.2 Geography

Trade costs due to geography and distance can determine which country to import products from and can shape a country's positioning in GVCs.[12] In sequential (or snake-like) GVCs, trade costs compound along the value chain and have a higher incidence on downstream

[11] Empirical evidence on the influence of factor endowments on country-sector trade patterns is widely available following the study by Romalis (2004).

[12] See, for example, Eaton and Kortum (2002) and Antràs and De Gortari (2020).

stages than on upstream stages. This may encourage more remote countries to specialize in upstream stages and more central countries to specialize in downstream stages. Inefficient transport and logistics services and weak competition in these services amplify trade costs in many manufacturing GVCs with multiple border crossings and can offset other competitive advantages like low labor costs. Empirical evidence shows that bilateral GVC links are strongly positively correlated with geographic proximity and that countries' backward GVC participation is negatively associated with their higher distance to the closest manufacturing hub.[13] We expect geography - measured by geographical distance to GVC hubs China, Germany, and the US - to play an important role for GVC participation.

2.2.3 Domestic Industrial Capacity

It is well established by gravity models that countries with a larger domestic industrial capacity have more traditional trade.[14] However, for GVC trade, the relationship between domestic industrial capacity and GVC participation is not clear. On the one hand, to minimize cross-hauling of semi-processed goods in different stages, countries often specialize in contiguous stages of production in GVCs. Countries with a larger domestic industrial capacity may have a larger set of contiguous stages which reduce the use of imported inputs relative to domestic inputs in their exports. This may lead to lower backward GVC participation. On the other hand, countries with a larger domestic industrial capacity may demand more final goods for domestic consumption, which may lead them to specialize in downstream stages of production embodying more foreign value added and thus could increase backward GVC participation. Finally, a larger domestic industrial capacity implies a larger domestic supplier base which reduces search frictions and facilitates the replacement of domestic suppliers in face of production disruptions and may increase domestic value added and forward GVC participation.[15] Thus, the overall effect of domestic industrial capacity - measured by domestic manufacturing value added - on GVC participation is ambiguous and can only be determined empirically.

[13] See Kowalski et al. (2015) and Buelens and Tirpak (2017).
[14] See, for example, Arkolakis et al. (2012).
[15] See Kee (2015) for evidence of this mechanism in Bangladesh.

2.2.4 Trade Policy and Foreign Direct Investment

Trade policy and FDI are important for traditional trade but they may play even larger roles for GVC trade, as intermediates and semi-finished products cross international borders multiple times. Regulatory barriers on imports and exports such as tariffs or quotas increase trade costs, with consequences for countries' participation and positioning in GVCs. Reducing such barriers can have an amplified benefit for internationally fragmented production - especially when production stages are organized sequentially across borders - by lowering not only the price of final goods but also the input costs faced.[16] Tariffs imposed by partner countries can also increase the costs of exports.[17] Emerging evidence shows that tariffs on imports of final goods and intermediates and tariffs faced in export markets are negatively associated with GVC participation.[18] Deep preferential trade agreements (PTAs) go beyond traditional market access issues and include policy areas such as movement of capital, investment, visas, and intellectual property rights (World Bank, 2019). A strong role of deep PTAs in fostering GVC participation is also shown in recent studies.[19]

Similarly, countries can attract FDI to overcome relative scarcity in capital, technology, and knowledge, and thus integrate into GVCs. When tight control over foreign production processes is necessary (perhaps because of weak contractual enforcement or weak protection of intellectual property), lead firms might prefer vertical integration of suppliers over an arm's length relationship, resulting in FDI flows and intra-firm trade. Empirical evidence suggests that openness to FDI is positively associated with backward GVC participation.[20] Trade

[16] See Yi (2003, 2010) and Antràs and De Gortari (2020) for large magnification impacts of tariffs when intermediates trade and multistage production are considered in general equilibrium trade models. Caliendo and Parro (2015) add to trade in intermediates also linkages across sectors and derive larger welfare gains from trade liberalization relative to models with no trade in intermediates and sectoral linkages.

[17] Trade preferences given to Bangladesh by the EU induced greater firm entry into exports to the EU and then growth in exports to all markets (Cherkashin et al., 2015). But evidence shows that in the long-run preferential access per se is insufficient for export success. Complementary domestic policies are needed, including low import tariffs, reduced regulatory burden, and enhanced connectivity (Fernandes et al., 2019a).

[18] See Cheng et al. (2015) and Kowalski et al. (2015). The importance of lower tariffs on intermediates to foster export performance is also confirmed at a micro level (Bas and Strauss-Kahn, 2015; Pierola et al., 2018).

[19] See Orefice and Rocha (2014), Kowalski et al. (2015), Johnson and Noguera (2017), and Laget et al. (2018).

[20] See Kowalski et al. (2015) for FDI openness at the country level and Buelens and Tirpak (2017) for FDI stocks at the bilateral level. Cheng et al. (2015) show that higher FDI restrictiveness is related to lower GVC participation in low-tech manufacturing.

policies and FDI have also been identified as important factors for moving up GVCs, based on firm-level evidence for China and Bangladesh.[21] Hence, we expect tariffs and FDI (as well as deep PTAs) to be significant in determining GVC participation. But these determinants may be subject to endogeneity concerns that we address in detail in Section 3.1.

2.2.5 Institutional Quality

As discussed in Antràs (2016), what distinguishes GVC trade from traditional trade are the intense firm-to-firm interactions characterized by contracting and specialized products and investment. Weak contract enforcement is thus a significant deterrent not only for traditional trade, but also for GVC trade.[22] Because the performance of a GVC depends on the strength of its weakest link, production delays driven by weak contract enforcement might be particularly harmful in GVCs. In addition, the presence of relationship-specific investments (e.g., the customization of products) and the exchange of large flows of intangibles (such as technology, intellectual property and credit) reinforces the potential role of institutional quality as a significant determinant of relational GVC participation. Some emerging evidence finds a correlation between a stronger rule of law and stronger GVC integration.[23] We expect institutional quality to be important in determining GVC participation.

2.2.6 Connectivity

Transport costs remain, according to surveys of developing country suppliers, the main obstacle to entering, establishing, or upgrading in GVCs.[24] The geographic centrality of a country can attract downstream production stages in GVCs. But geographic centrality is more related to centrality in the transport network than to distance. Thus, logistics and communication infrastructure, port and customs efficiency, and information technology networks could be important for trade in general and especially for GVC trade in particular.

[21] See Kee (2015) and Kee and Tang (2016).

[22] A body of work establishes institutional quality as a comparative advantage factor in determining export patterns: Acemoglu et al. (2007), Levchenko (2007), Nunn (2007), Costinot (2009), and Chor (2010).

[23] See Kowalski et al. (2015).

[24] See OECD and WTO (2013). Hummels and Schaur (2013) find that a day of delay in transit due to different transport mode choice has a tariff equivalent of 0.6 to 2.1 percent, and the most sensitive flows are for a type of GVC trade, i.e., trade in parts and components. Similar magnitudes for the cost of a one-day delay in inland transit are found by Djankov et al. (2010).

The quality of the national road infrastructure also matters for timely delivery to global markets. Moreover, the use of the internet and a common language could also facilitate GVC participation. Studies show a stronger role of logistics performance for trade in parts and components than for trade in final goods, and provide evidence that unpredictable land transport keeps most Sub-Saharan African countries out of GVCs.[25] Given that our sample includes a wide range of countries with diverse logistics infrastructure and language used, we are able to examine the impact of connectivity on GVC trade.

2.2.7 Macroeconomic Factors

Macroeconomic factors, in particular related to real exchange rates, can play a role for GVC participation. The degree of financial development of countries is a source of comparative advantage but there is still limited understanding of whether financial factors affect GVC participation.[26] Our sample coverage of developed and developing countries allows us to study how these macroeconomic factors may impact trade and GVC participation.

3 Empirical Specification

We examine the factors that influence GVC participation by exploiting variation across countries and over time in GVC participation and in determinants. We estimate the impact of country decadal averages of the determinants on country decadal average GVC participation by least squares between effects (LS-BE). The main specification is given by:

$$Y_{ct} = \beta_0 + \beta_1 * \mathbf{X}_{ct} + I_t + \varepsilon_{ct}, \tag{1}$$

[25] See Ansón et al. (2017) for estimates of the sensitivity of bilateral trade in parts and components and in final goods to logistics performance. See Christ and Ferrantino (2011) for evidence on Sub-Saharan Africa. A positive correlation between broad infrastructure - including communication, electricity, roads, and power - and overall GVC participation in manufacturing is provided by Cheng et al. (2015). Linguistic proximity is shown to matter for bilateral GVC links in Buelens and Tirpak (2017) and Ignatenko et al. (2019). At a micro level, evidence on the role of unpredictability in imports' border clearance times, regional road density and internet access for firm export performance are shown, respectively, by Vijil et al. (2019), Rodríguez-Pose et al. (2013) and Fernandes et al. (2019b).

[26] See Beck (2003), Manova (2008), and Manova (2015). Exchange rate volatility is shown to be negatively related to bilateral GVC trade by Ignatenko et al. (2019).

where c and t stand for country and decade subscripts, respectively. Y is a measure of GVC participation in shares or in levels or a measure of gross exports, and $\mathbf{X}$ is a vector including the determinants described in Section 2.2, I_t are decade fixed effects, and ε is an independent and identically distributed error (i.i.d). We use LS-BE estimation for the cross-country panel regression specified in Equation (1), where the panel includes up to three observations per country, each covering a decadal average. The coefficients are identified via cross-country variations in GVC participation and the determinants within a decade.

There are two justifications for this approach. First, GVC participation and some determinants change very slowly within countries from year to year. This is the key reason why we do not rely on a country-year panel and within effects estimation for Equation (1).[27] Decadal averages of GVC participation and determinants exhibit more meaningful variation than year-to-year observations and they may wash out measurement issues in GVC participation due to errors in input-output tables (see Section 2.1). Moreover, the use of decadal averages allows to maximize country coverage as countries remain in the estimating sample even if GVC participation or some determinants are observed only in a few of decade's years. Second, in contrast to small within-country changes, GVC participation measures and determinants exhibit large cross-country variability. LS-BE estimation exploits this variability to identify more precisely the impacts of the different determinants on GVC participation. The decade fixed effects in Equation (1) allow to account for technological shocks or the global financial crisis affecting all countries.

We consider the following dependent variables in Equation (1): (i) the share of backward GVC participation in gross exports, which captures the intensity of GVC trade relative to traditional exports; (ii) the level of backward GVC participation (logs); and (iii) gross exports (logs). A statistically significant positive coefficient of a factor in the GVC participation share regression indicates that the factor has a stronger impact on the level of GVC participation relative to traditional exports. An insignificant coefficient of a factor in the GVC participation share regression implies the factor does not have a differential impact on GVC trade relative to traditional exports. We also decompose backward country-level

[27] Most coefficients in Equation (1) cannot be precisely estimated in a within effects cross-country panel regression.

GVC participation measures into four broad sectors - agriculture, mining, manufacturing, and services - which are used as separate dependent variables in Equation (1).

However, some determinants, namely tariffs and FDI inflows, could be endogenous or simultaneously determined with GVC participation. There are two opposing forces at play regarding reverse causality from GVC participation to tariffs and FDI inflows. First, countries that participate in GVCs may lower tariffs and attract FDI so GVC firms can have access to cheaper imported inputs or better domestic inputs produced by FDI firms. This force confounds with the direct impact of tariffs and FDI on GVC participation and causes their LS-BE coefficient estimates to be too large in magnitude. Second, countries that participate in GVCs may have political economy reasons to raise tariffs and restrict FDI inflows in order to protect domestic firms from competition. This force causes LS-BE estimates for tariffs and FDI to be too small in magnitude. To add to ambiguous reverse causality, measurement errors in the construction of GVC participation variables due to the usage of international input-output tables may bias LS-BE estimates towards zero. Ultimately, depending on which force dominates, LS-BE estimates for the impacts of tariffs and FDI on GVC participation could be biased upward or downward.

3.1 Instrumental Variables

To address these endogeneity and measurement error biases, we rely on IVs which isolate the effects of tariffs and FDI inflows on GVC participation. To obtain consistent estimates, the IVs should be jointly significant in explaining tariffs and FDI inflows with meaningful first-stage coefficients and F-statistics, and at the same time, the IVs should not be correlated with the second-stage regression errors in order to satisfy exclusion restrictions. In other words, the IVs should be relevant and exclusion restrictions require that these IVs only affect GVC participation through tariffs and FDI and do not have significant direct impacts on GVC participation once tariffs and FDI are included in the second-stage regressions, conditional on all other right-hand side variables.[28]

[28] According to Wooldridge (2012), instrument exogeneity means that the IV should have no partial effect on the dependent variable, after controlling for the right-hand side variables, and the IV should be uncorrelated with the omitted variables.

However, in this aggregate cross-country setting, it is highly challenging to find reasonable IVs that are both relevant and meet the exclusion restrictions. To this end, we rely on existing trade theories and on solid empirical evidence to guide our choice of meaningful IVs and we conduct econometric tests to establish the strength of our identification. Below we describe the set of IVs that we use to explain average tariffs imposed on manufacturing products and FDI inflows for more than 100 countries in our regressions. The detailed data sources for the IVs are provided in the Appendix.

3.1.1 Import Elasticity

Classic trade theory since Bickerdike (1907) asserts that the optimal tariff set by a welfare-maximizing government for a country with market power is higher than zero, while the optimal tariff for a small open economy is zero. This positive relationship between tariffs and the market power of a country that is well-established empirically has long been referred to as the terms-of-trade theory of trade policy.[29] For our analysis we need a proxy for market power that is not affected by GVC participation in order to satisfy the exclusion restriction. One way to assess the market power of an importing country is to estimate the export supply elasticity it faces as is done by Broda et al. (2008) for a set of 15 countries. Our choice is to use import demand elasticity estimates from Kee et al. (2008) that are available for more than 100 importing countries thus ensuring very good coverage of our sample.[30] These elasticities represent the slope of the import demand function of the countries and are based on a GDP function that controls for countries' factor endowments. While the elasticities are estimated at the country-HS 6-digit product level, our measure of the import demand elasticity for each country's manufacturing sector is obtained as an average of the elasticities of all its manufacturing products. Countries with more elastic import demand may impose lower tariffs in order to minimize the deadweight loss which leads to a negative relationship between import elasticity and tariffs.

The exclusion restriction requires that the import elasticity does not have a direct impact

[29] See Broda et al. (2008) and Bagwell and Staiger (2011) for evidence of this relationship for a sample of pre-WTO accession countries.

[30] These elasticity estimates are used to study the effect of WTO tariff commitments by Bagwell and Staiger (2011) and the general equilibrium impact of trade liberalizations in GTAP models.

on GVCs other than through tariffs, conditioning on all other right-hand side variables. In theory, the import demand elasticity may depend on preferences, income and domestic substitutes. Given that the estimated elasticity is multilateral in nature (not bilateral partner country specific), and that we control for domestic industrial capacity and factor endowments which both may affect domestic substitutes as well as institutional quality which may reflect income and preferences, it is reasonable to assume that the import elasticity meets the exclusion restriction.

3.1.2 Population

Terms-of-trade theory also implies that countries with a larger total population may have more market power and thus impose higher tariffs. Hence, total population is relevant in explaining tariffs. We allow for the effects of import elasticity and total population to be related, so their interaction term is also included as an additional IV. Moreover, total population plays a dual role in our IV strategy as more populous countries may attract larger FDI inflows to serve their domestic markets. Such FDI inflows will be either import-substituting or market-seeking and may lead to further exporting and GVC participation. Hence, total population is relevant for explaining FDI inflows.

GVC participation should not affect a country's total population, and populous countries (such as India and Brazil) do not necessarily have higher GVC participation. There may be concerns that population could affect GVC participation through other channels, such as business environment, domestic suppliers and labor. However, since institutional quality, domestic industrial capacity and factor endowments are included in the regressions, the concerns may be mitigated. Thus, conditioning on these right-hand side variables, it is plausible that population affects GVC participation only through tariffs and FDI inflows and satisfies the exclusion restriction.

3.1.3 Statutory Corporate Tax Rates

Foreign affiliates of a multinational company (MNC) are subject to corporate income taxes in the FDI host country. Higher corporate taxes in the host country reduce the after-tax return to investment for the MNC and hence may discourage stronger investment flows. Gravity

regressions for MNC affiliates' location choices and investments drawing on economic geography models provide extensive evidence that high corporate income tax rates are negatively associated with FDI inflows.[31] Using statutory corporate tax rates as an instrument for FDI inflows could satisfy the exclusion restriction, as a priori there is no clear relationship between corporate tax rates and GVC participation other than through the FDI channel, conditioning on institutional quality, domestic industrial capacity and endowments.

3.1.4 Transitional Economy Status

The late 1980s ushered the fall of communism and gave rise to a group of countries that embraced market capitalism and abandoned central planning, collectively referred to as transitional economies (IMF, 2000). Most of these economies are the former Soviet Union and its satellite states, including Poland, Hungary, and Bulgaria, while other countries are in East Asia, such as China and Vietnam. These transitional economies opened up engaging in tariff and FDI liberalization, and several were subsequently successful in participating in GVCs. We use the transitional economy status as an instrument for tariffs and FDI inflows, and since a priori GVC participation is not correlated with the transitional economy status of the countries, that status satisfies the exclusion restriction, conditioning on institutional quality, factor endowments and domestic industrial capacity.

3.1.5 Instrumental Variables Summary and Tests

In summary, we have two endogenous variables in our reduced form specification Equation (1): tariffs and FDI inflows. We use five excluded exogenous variables as instruments: import elasticity, total population, the interaction between import elasticity and total population, statutory corporate tax rates, and transitional economy status. We test for weak IVs in the first-stage regressions, based on the Kleibergen-Paap Wald F-statistic, which indicates that these IVs jointly have significant explanatory power for tariffs and for FDI inflows if the F-statistic is higher than the critical value given by Stock and Yogo (2005). We also test that (the instrumented) tariffs and FDI inflows can jointly explain GVC participation, based on

[31] See e.g. Desai et al. (2004), Head and Mayer (2004), and Mutti and Grubert (2004).

the weak-instrument-robust Anderson-Rubin Wald test in the second-stage regressions. We expect the IV estimates of the coefficients on tariffs and FDI inflows to be larger in magnitude than the LS-BE estimates of those coefficients if measurement errors and political economy forces dominate the confounding reverse causality forces.[32]

4 Main Results

4.1 Least Squares Between Regressions

Starting with the determinants of backward GVC participation shares, Column (1) of Table 1 shows the baseline LS-BE estimates of Equation (1). Most coefficients have the expected signs and are significant. Factor endowments jointly matter for backward GVC participation, with a strong F-statistic of 6.84, which is significant at the 99% level. Larger land and/or natural resources endowments are linked to lower backward GVC participation shares, while abundance in capital is associated with higher backward GVC participation shares. But geography and domestic industrial capacity also matter. A shorter distance to the GVC hubs is positively correlated with backward GVC participation. Countries with larger domestic industrial capacity (i.e., a potentially larger pool of domestic suppliers) exhibit lower backward GVC participation shares, as domestic inputs may be used to replace imports.

Countries' openness to trade and FDI is also a predictor for the intensity of backward GVC participation. Lower tariffs and larger FDI inflows are associated with higher backward GVC participation shares across countries. Better institutional quality measured by a higher score in the political stability index is linked to higher backward GVC participation. Exchange rate appreciation is unrelated to backward GVC participation, which is not surprising, given that appreciation stimulates imports by reducing its prices, but can also reduce export competitiveness due to higher export prices.[33] The R-squared in Column (1)

[32] We also tried using lagged tariffs and FDI, as well as neighboring countries tariffs and FDI as instruments. In these cases, the second-stage results are very similar, with IV estimates of the coefficients on tariffs and FDI being larger in magnitude than the corresponding LS-BE ones. Reed (2015) shows that lagged endogenous variables are valid IVs if the lagged endogenous variables do not affect current period dependent variable and if the lagged endogenous variables are correlated with the current period endogenous variables. These results are available upon request.

[33] This result is consistent with the finding of Amiti et al. (2014) who show that low aggregate exchange rate

indicates that the different determinants considered explain more than half of the variation in backward GVC participation shares across countries.

In Columns (2)-(6) of Table 1, we modify the baseline regression by including alternative or additional control variables or by changing the estimating sample. First, in Column (2) we replace exchange rate appreciation by a measure of misalignment whose effect on GVC participation remains insignificant. Next, in Column (3) we include alternative measures of trade openness related to membership in PTAs (NAFTA, EU, MERCOSUR, ASEAN) and deep integration efforts. The estimated coefficients show that countries' EU or ASEAN membership are linked to significantly higher backward GVC participation shares. Third, to understand whether the patterns identified are driven by a particular type of countries, we drop high-income countries as defined by the World Bank income classification, from the estimating sample in Column (4).[34] This sample exhibits substantially less cross-country variation but several patterns identified in Column (1) still hold, namely the strong negative impact of tariffs and distance to GVC hubs and the strong positive impact of political stability on backward GVC participation. Fourth, we add as a proxy for non-tariff trade costs and connectivity a measure of the time to import in Column (5) and a control for the importance of females in the labor force in Column (6). The baseline results in Column (1) remain robust. We also include other control variables, such as the credit to GDP ratio, measures of the quality of logistics infrastructure, internet infrastructure, the prevalence of spoken English in the regressions, but these variables were all insignificant.[35]

To understand which sectors within the economy are driving the aggregate results presented in Table 1, we estimate Equation (1) separately for each of the backward GVC participation measures by broad sector - agriculture, mining, manufacturing, and services.

pass-through and disconnect observed in the data is due to the fact that large exporters are simultaneously large importers, with high-market-share and high-import-intensity.

[34] Since many countries change income status during our sample period, we use a time-varying World Bank income classification to identify high-income countries.

[35] These results are available upon request. A different type of robustness checks uses GVC participation measures based on alternative TIVA and WIOD databases. These databases' time, and importantly, country coverage is much more limited than EORA's, as they focus on high- and middle-income countries. Thus, the cross-country variation in GVC participation and in determinants is much smaller. But the broad patterns of results are similar to those in Tables 1 and 6 though weaker in significance. The estimates that remain significant for backward GVC participation are the negative impact of natural resource endowments, distance to GVC hubs and domestic industrial capacity and the positive impact of political stability.

The results are presented in Table 2 and show clearly that the findings at the aggregate level are largely driven by GVC participation in manufacturing. All the determinants identified above influence backward GVC participation in manufacturing in the same direction as in our baseline estimates. Low-skilled labor positively affects GVC participation in agriculture, while middle or high-skilled labor negatively affects GVC participation in mining. GVC participation in services responds positively to stronger political stability, but negatively to domestic industrial capacity and to the abundance of land.

Overall the results of LS-BE regressions suggest that tariffs and FDI inflows are important in determining GVC participation of a country. Factor endowments are also important, and so are political stability, proximity to GVC hubs as well as domestic industrial capacity.

4.2 Two-Stage Least Squares Regressions

The estimates in Table 1 could be inconsistent due to potential endogeneity of tariffs and FDI inflows and to potential measurement error in the GVC participation variable. To address these concerns, we adopt an IV strategy relying on import elasticity, total population, their interaction, corporate tax rates, and transitional economy status as our five IVs. We estimate the baseline between effects specification in Column (1) of Table 1 by two-stage least squares. The corresponding first-stage between regressions are presented in Columns (1) and (2) of Table 3. All IVs exhibit the expected signs and statistical significance. Countries with more elastic import demand have lower tariffs, but the negative impact of the import elasticity on tariffs diminishes with country size. The separate impact of total population on tariffs is positive and significant at the 90% level, while countries with larger populations also attract more FDI inflows. But FDI inflows respond negatively to higher corporate tax rates. Finally, transitional economy status is associated with lower tariffs.

Column (1) of Table 4 presents the second-stage IV between estimates. Compared to the LS-BE estimates of Column (1) of Table 1, the estimates for tariffs and FDI inflows are larger in magnitude, suggesting that measurement errors in GVC participation and political economy-driven reverse causality are important in biasing the corresponding LS-BE estimates towards zero. Jointly, the null hypothesis that tariffs and FDI inflows are not important in explaining GVC participation is strongly rejected. Likewise, the null hypothesis

of endowments not being important in explaining GVC participation is also strongly rejected. Similar to the results in Column (1) of Table 1, countries with larger endowments of land and/or natural resources exhibit significantly lower backward GVC participation shares, while those with stronger abundance in capital exhibit significantly higher GVC participation shares. Moreover, countries located far from GVC hubs or those with larger domestic industrial capacity exhibit significantly lower backward GVC participation.

4.2.1 Issues with Weak IVs and Statistical Inference

A concern with the second-stage IV estimates is that they could be biased and the statistical inferences made above invalid if the IVs are weak. That is, if the IVs included cannot explain the two endogenous variables, tariffs and FDI inflows, then the second-stage results are questionable. Unfortunately, the econometric theory of IV between estimators with two endogenous variables is not yet developed. The existing econometric theory focuses on cross-sectional IV estimation, with i.i.d. error terms as discussed in Andrews et al. (2019). To properly test for weak IVs, we collapse our cross-country decadal panel data set into a single-period cross-country data set, by taking for each variable's average over time within each country. In addition to enabling to properly test for weak IVs, this cross-sectional specification allows for heteroskedasticity to be addressed. Columns (3) and (4) of Table 3 present the first-stage cross-sectional regressions, with standard errors robust to heteroskedasticity. Comparing Column (3) to Column (1) and Column (4) to Column (2) in Table 3, it is clear that the first-stage cross-sectional regressions are very similar to the first-stage between regressions. The first-stage F-statistics for tariffs and FDI individually are strongly significant. Jointly, the Kleibergen-Paap F-statistic for the first-stage is 10.39, which is larger than the critical value of 8.78, as given in Table 1 of Stock and Yogo (2005), and also larger than the rule of thumb of 10 widely used in empirical research relying on IV estimation. In Table 4, Column (2) presents the second-stage estimates of the cross-sectional regression which are very similar to those of the IV between regression in Column (1). The Anderson-Rubin Wald test for weak-instrument-robust inference for the second-stage is 3.43, which is significant at the 99% level, rejecting the null hypothesis that tariffs and FDI jointly are not important in determining GVC participation. The high Kleibergen-Paap rk LM

statistic of 22.07 also rejects the null hypothesis that the regression is under-identified. For completeness and ease of comparison, Column (3) presents the second-stage cross-sectional regression LS estimates which are smaller in magnitude than the IV estimates. Finally, in Column (4) the five IVs are directly included in the second-stage cross-sectional regression and we cannot reject the null hypothesis that jointly these IVs are not significant and do not have a direct impact on GVC participation.

4.3 Relative Importance of the Determinants

Overall, the between and the cross-sectional IV estimates paint the same picture that tariffs and FDI inflows are important in determining backward GVC participation of a country. In addition, factor endowments, political stability, geographical proximity to GVC hubs, and domestic industrial capacity are crucial in affecting backward GVC participation. To assess the marginal contributions of the different determinants, we conduct a thought exercise described below, based on the IV cross-sectional estimation results in Column (2) of Table 4, and we report the results in Table 5. First, we partial out all the included exogenous variables such as distance, political stability, and factor endowments for a regression that includes only the endogenous variables: tariffs and FDI. The R-squared of 0.056 gives the marginal contribution of tariffs and FDI in explaining backward GVC participation. Next, we add back the other determinants one at a time and we assess the changes in the R-squared. After adding distance to GVC hubs, the R-squared increases to 0.145, indicating the marginal R-squared contribution of distance is 0.089 (=0.145-0.056). Adding all factor endowments, the new R-squared is 0.238, suggesting that their marginal contribution is 0.182 (=0.238-0.056). Overall, factor endowments can explain 43% of the backward GVC participation shares in the IV cross-sectional regression, which is the most important determinant, followed by distance (21%), political stability (18%), tariffs and FDI (13%), and domestic industrial capacity (4%), while exchange rate appreciation has no explanatory power.

5 Extensions

5.1 Determinants of Forward GVC Participation

Table 6 repeats the same exercises to understand the determinants of forward GVC participation shares. Column (1) presents the baseline LS-BE estimation for forward GVC participation, similar to Column (1) of Table 1. Unreported results show that findings are maintained adding alternative or additional controls or changing the sample as in Columns (2)-(6) of Table 1. Columns (2) and (3) of Table 6 reproduce for forward GVC participation shares the IV estimation as in Table 4. The corresponding first-stage results are the same as those in Table 3 for which we were able to reject the null hypothesis of weak IVs.

The IV estimates in Columns (2) and (3) of Table 6 show that factor endowments play an important role, but in the opposite direction of what was found for backward GVC participation. Countries with stronger endowments of land and/or natural resources show significantly higher forward GVC participation. These endowments lead to high forward participation because commodities are used in a variety of downstream production processes that typically cross several borders. In contrast to backward GVC participation, capital stock has no effect on forward GVC participation, while labor matters. Countries with a stronger abundance in low-skilled labor exhibit lower forward GVC participation, whereas countries with a higher supply of medium- and high-skilled labor exhibit higher forward participation. As expected, shorter distance to GVC hubs, as well as larger domestic industrial capacity are associated with higher forward GVC participation.

Forward GVC participation is higher in countries with higher tariffs while it is not significantly linked to FDI inflows. Perhaps surprisingly, political stability has a negative and significant effect on forward GVC participation. This finding is likely to reflect a sample composition effect as countries with the highest forward GVC participation are low-income or fragile and conflict countries richly endowed with natural resources but receiving weak FDI inflows and having deficient institutions.[36] Exchange rate appreciation is unrelated to forward GVC participation, possibly as higher export prices hurt both domestic value added

[36] The five countries with the highest average forward GVC participation shares in the 2010s are Libya, Democratic Republic of Congo, Guinea, Algeria, and Iraq.

embodied in bilateral partners' exports (numerator) as well as gross exports (denominator). Note that the IV estimates presented in Columns (2) and (3) are larger in magnitude for tariffs, consistent with the previous findings, indicating that measurement errors and political economy-driven reverse causality are important.

5.2 GVC vs Traditional Trade

In another extension, we examine whether the various determinants affect GVC participation differently from traditional exports. Table 7 shows the IV between estimates of Equation (1) using as the dependent variables backward and forward GVC participation in levels in Columns (1) and (2) and gross exports in Column (3). The IV cross-sectional estimates are presented in Columns (4)-(6) while LS-BE estimates are omitted due to space constraints.

The noticeable patterns emerging from Table 7 are as follows. Several determinants are more important in explaining backward GVC participation in levels than traditional exports, as seen from the comparison of coefficients in Column (1) to those in Column (3) or of coefficients in Column (4) to those in Column (6). Specifically, tariffs, distance, and land endowments affect backward GVC participation more negatively than traditional trade, while domestic industrial capacity has a smaller positive impact on GVC trade than on traditional trade. This explains the negative effects of land endowments, domestic industrial capacity, distance, and tariffs on backward GVC participation shares in Table 1. By contrast, the positive effects of capital endowments, political stability, and FDI inflows on backward GVC participation shares in Table 1 imply that these factors have stronger positive effects on GVC trade than on traditional exports, as is confirmed by comparing the effects in Columns (1) and (3) or in Columns (4) and (6) of Table 7.

Some determinants are more important in explaining forward GVC participation in levels than traditional exports, as evidenced by contrasting coefficients in Columns (2) and (3) or in Columns (5) and (6) of Table 7. Domestic industrial capacity has a larger positive effect on forward GVC participation than on traditional trade, while FDI has a smaller positive impact on GVC trade than on traditional trade. This explains the positive effect of domestic industrial capacity and the negative effect of FDI on forward GVC participation shares in Table 6. The significant negative effect of low-skilled labor, political stability, and distance

on forward GVC participation shares in Table 6 imply that such factors have more negative or smaller positive effects on forward GVC trade than on traditional exports.

5.3 Cross-Country Cross-Sector Difference-in-Difference Analysis

The cross-country regression models described in previous sections use IVs to establish causality between determinants and GVC participation. However, there may be a concern that the IV strategy is not sufficient given that some other determinants, such as factor endowments, institutions, and connectivity may also be endogenous. As an alternative approach, we use country-sector data with year-to-year variability and apply the country-sector difference-in-difference regression model inspired by the Rajan and Zingales (1998) framework. This framework relies on interactions between a country's factor endowments and the intensity with which a sector uses a particular factor and has been used to link countries' sectoral trade performance to various sources of comparative advantage: factor endowments (Romalis, 2004), institutions (Levchenko, 2007; Nunn, 2007; Costinot, 2009), and financial development (Beck, 2003; Manova, 2008).[37] We use this difference-in-differences regression model to estimate the role of several determinants in explaining GVC participation and exports at the country-sector level:

$$Y_{cst} = \beta_0 + \beta_1 \mathbf{X}_{ct-3} * \mathbf{m}_s + \beta_2 \mathbf{Z}_{cst-3} + I_{ct} + I_s + \varepsilon_{cst} \tag{2}$$

where c, s and t stand for country, sector, and year subscripts, respectively. Y is a measure of GVC participation in levels or a measure of gross exports, $\mathbf{X}$ is a vector of country factor endowments, $\mathbf{m}$ is a set of sectoral intensities of use of these endowments from a benchmark country (the US), $\mathbf{Z}$ is a vector of country-sector trade policies, which include tariffs imposed at home on imports of final goods, and on imports of intermediate inputs, and tariffs imposed by destination markets and ε, is an i.i.d. error.[38] The specification controls for country-year fixed effects I_{ct} that account for differences across countries both in time-varying

[37] Theoretical underpinnings for this framework in a trade context are provided by Chor (2010) who extends the seminal Eaton and Kortum (2002) trade model and estimates the importance of various sources of comparative advantage for trade patterns in an integrated framework.

[38] The sectoral intensities and the tariffs and FDI measures used are described in the Appendix.

macroeconomic conditions, such as country-level FDI inflows, political stability, and domestic industrial capacity, as well as in time-invariant factors like geography. The regression also controls for sector fixed effects I_s that account for sector-specific technology and productivity. The interaction terms allow the effects of factor endowments on GVC participation or exports to differ across sectors according to their intensity of use. For example, the interaction term for skilled labor shows that an increase in skilled labor endowments may improve exports or GVC participation of the skilled labor-intensive sectors more than that of other sectors.[39]

This difference-in-differences model remedies the reverse causality that may exist in cross-country regressions in three ways. First, it is unlikely that strong sectoral GVC participation may cause changes to the country-level determinants. Second, the model assumes that sectors differ largely for technological reasons in their intensity of use of endowments, which allows results to be given a causal interpretation.[40] Third, using a 3-year lag structure for determinants and including the country-year and sector fixed effects mitigates the risk of reverse causality. Moreover, the use of the lag structure allows GVC participation and exports to adjust slowly to changes in the determinants.[41] Overall, we believe that this comparative advantage-type of specification enables us to identify the causal impact of different determinants on GVC participation and exports at the country-sector level and thus complements our previous cross-country analysis.

Table 8 provides the estimates for Equation (2). Columns (1) to (3) show that factor endowments and trade policy determine a country-sector's backward and forward GVC participation levels as well as traditional exports. Specifically, countries relatively more endowed with skilled labor have a comparative advantage in exporting sectors that are skill-intensive, and they exhibit stronger backward and forward GVC participation. Countries with larger abundance in capital exhibit larger exports and stronger GVC participation in capital-intensive sectors. Countries with larger natural resources endowments export more

[39] Our cross-country cross-sector specification follows closely the Nunn (2007) and Chor (2010) comparative advantage models that explain trade flows in levels. We use it for GVC participation in levels but not for GVC participation as a share of gross exports as there is no conceptual basis to consider those measures in this framework.

[40] This assumption is inspired by Rajan and Zingales (1998) and implies that there are no restrictions (other than cost) preventing access by certain sectors to skilled labor.

[41] As a robustness check we use 5-year and 1-year lag structures and the results (available upon request) are qualitatively similar.

and have stronger GVC participation of natural-resource intensive sectors. Importantly, countries with stronger institutional quality have a comparative advantage in exports and in GVC participation of contract-intensive sectors. Importantly, conditioning on countries' factor endowments, trade policies play an important role for GVC participation and exports. Sectors that face lower tariffs in their destination markets or lower tariffs on intermediate inputs exhibit stronger GVC participation and exports.

To compare the strength of different determinants, Figure 2 shows the standardized beta coefficients corresponding to the estimates in Table 8. Hypothetical examples are useful to provide an economic interpretation to the coefficients. If Ghana increased its skilled labor share (7.5 percent in 2012) to the cross-country median (20 percent), its backward GVC participation level and exports would grow by 42 percent, and its forward GVC participation level would grow by 39 percent at the sample mean of sectoral skill intensity. If Mozambique improved its rule of law index to the cross-country median, its forward GVC participation and export levels would grow by 32 percent, and its backward GVC participation would grow by 29 percent at the sample mean of sectoral contractual intensity.

Two robustness checks are performed on the cross-country cross-sector analysis. First, we add country-sector level FDI to vector $\mathbf{Z}$. Given that, to the best of our knowledge, country-sector-year level FDI inflows data are not available for a wide range of countries, we use FDI announcement data from the fDi Markets Database for the period 2003-2015 as a proxy for FDI inflows, following the approach of Hallward-Driemeier and Nayyar (2019). Specifically, we cumulate the number of cross-border greenfield FDI projects announced from 2003 onwards for each country-sector. The estimates show that FDI has a positive and significant marginal impact on country-sector GVC participation levels and on gross exports. Second, we show that countries with a higher internet penetration exhibit significantly higher GVC participation and gross exports in sectors that use technology more intensively. These results are presented in Tables A7 and A8 of the Appendix.

Overall the results from this difference-in-differences framework based on the cross-country cross-sector regressions are consistent with the previous results based on IV cross-country regressions, highlighting the importance of endowments, institutional quality, tariff and FDI, and connectivity in determining GVC participation.

6 Concluding Remarks

The topic of GVC participation is not new, having been the object of much theoretical and empirical interest in recent years. The objective of this paper is to provide a unified empirical framework to test jointly the role of different determinants highlighted in the literature as being important for trade in general, or for GVC trade in particular, based on data for more than 100 countries over the last three decades. Results based on our IV cross-country estimates and difference-in-difference country-sector's analysis suggest that factor endowments, geographical distance, political stability, trade policy and FDI, and domestic industrial capacity are all very important in explaining GVC participation. Some of these determinants, such as trade policy, FDI, geographical distance, and factor endowments affect GVC trade more than traditional trade. These findings are robust to alternative controls and country samples, and to different measurements of GVC participation. By embedding the determinants in a unified framework, we are able to estimate their marginal contributions and assess their relative importance for GVC participation.

Given that GVCs are often characterized as trade with intense firm-to-firm interactions via contracting and specialized products and investment, it is perhaps not surprising that factors such as tariffs and FDI, which affect traditional trade would have an amplified effect on GVC trade. However other factors, such as domestic industrial capacity, are found to play a different role for GVC trade, due to a unique ability to cultivate domestic suppliers and allow countries, such as China, to climb up value chains (by increasing domestic value added). We hope that the patterns we identified will be useful in guiding future theoretical and empirical studies of GVC formation and growth.

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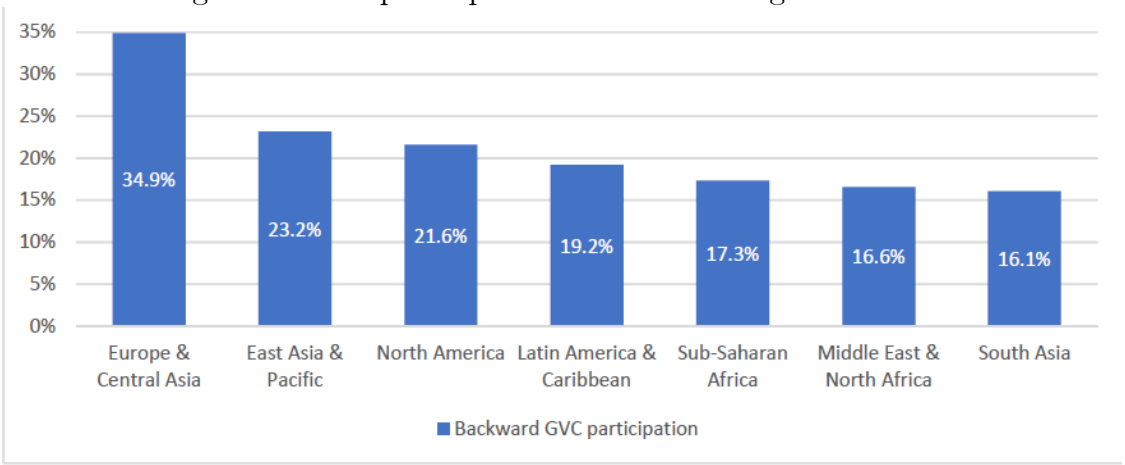
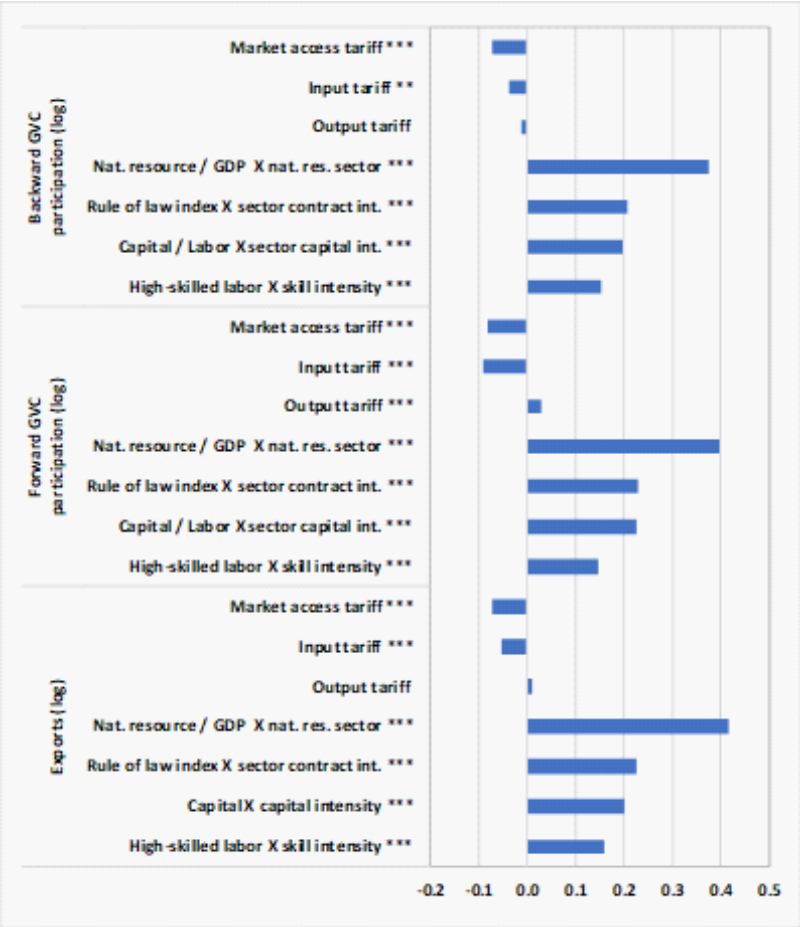
Figure 1: GVC participation across world regions in 2010s



Notes: Averages shown cover the period 2010-2015. Backward GVC participation measures the import content of exports relative to total exports.

Figure 2: Standardized coefficients for determinants of country-sector GVC participation and exports



Notes: Standardized beta coefficients corresponding to the estimates in columns (1)-(3) of Table 8 are shown. ***, **, and * indicate significance levels of 1%, 5%, and 10%, respectively.

Table 1: Dependent variable: Backward GVC participation shares (EORA)

	(1)	(2)	(3)	(4)	(5)	(6)
Regressions	LS - BE	LS - BE	LS - BE	LS - BE	LS - BE	LS - BE
Avg. tariff rate (%)	-0.006***	-0.006***	-0.004*	-0.006***	-0.005**	-0.006***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
FDI inflows (log)	0.023**	0.023**	0.019*	-0.009	0.017*	0.022**
	(0.010)	(0.010)	(0.011)	(0.013)	(0.010)	(0.010)
Distance to GVC hubs	-0.104***	-0.103***	-0.111**	-0.119***	-0.116***	-0.103***
(log)	(0.036)	(0.035)	(0.048)	(0.044)	(0.038)	(0.036)
Political stability index	0.030*	0.029*	0.024	0.040**	0.034*	0.025
	(0.016)	(0.016)	(0.019)	(0.019)	(0.017)	(0.017)
Domestic industrial capacity	-0.027***	-0.028***	-0.027***	0.000	-0.015*	-0.027***
(log)	(0.008)	(0.008)	(0.009)	(0.011)	(0.009)	(0.008)
Resources rents / GDP	-0.003**	-0.003***	-0.002**	-0.002	-0.003***	-0.003**
(%)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Capital / GDP (log)	0.044*	0.046*	0.025	0.033	0.034	0.050*
	(0.025)	(0.025)	(0.029)	(0.026)	(0.027)	(0.025)
Land / GDP (log)	-0.020***	-0.019***	-0.014**	-0.014	-0.019***	-0.020***
	(0.006)	(0.006)	(0.007)	(0.009)	(0.007)	(0.006)
Med/High-skilled labor	0.012	0.012	0.005	-0.005	0.015	0.006
/ GDP (log)	(0.015)	(0.015)	(0.016)	(0.016)	(0.017)	(0.016)
Low-skilled labor	0.009	0.010	0.011	0.018	0.007	0.011
/ GDP (log)	(0.015)	(0.015)	(0.016)	(0.016)	(0.016)	(0.015)
Exch. rate	0.000		0.000	-0.000	0.214	0.000
appreciation	(0.000)		(0.000)	(0.000)	(0.403)	(0.000)
Misalignment		0.000				
		(0.000)				
NAFTA			0.046			
			(0.068)			
EU			0.079*			
			(0.044)			
MERCOSUR			0.020			
			(0.071)			
ASEAN			0.133**			
			(0.056)			
No. of trade partners			-0.011			
(log)			(0.038)			
Depth of Agreement			0.009			
(log)			(0.023)			
Time to import					0.000	
(log)					(0.001)	
Female participation						0.001
(log)						(0.001)
Observations	290	290	266	194	191	290
R-squared	0.528	0.530	0.546	0.464	0.505	0.532
Number of countries	121	121	119	88	109	121
Decade fixed effects	YES	YES	YES	YES	YES	YES

Notes: LS standard errors in parentheses. Column (4) estimates are based on a sample excluding high-income countries; ***, **, and * indicate significance levels of 1%, 5%, and 10%, respectively.

Table 2: Dependent variable: Sectoral backward GVC participation shares (EORA)

	(1)	(2)	(3)	(4)
Regressions	LS - BE	LS - BE	LS - BE	LS - BE
Sector	Agri.	Comm.	Manu.	Serv.
Avg. tariff rate (%)	-0.000	-0.000	-0.004***	-0.001
	(0.000)	(0.000)	(0.002)	(0.000)
FDI inflows (log)	0.001	-0.001	0.023***	0.001
	(0.001)	(0.001)	(0.009)	(0.003)
Distance to GVC hubs (log)	-0.002	0.004	-0.098***	0.005
	(0.004)	(0.004)	(0.031)	(0.010)
Political stability index	0.001	-0.001	0.016	0.008*
	(0.002)	(0.002)	(0.014)	(0.004)
Domestic industrial capacity	-0.001	0.001	-0.020***	-0.007***
(log)	(0.001)	(0.001)	(0.007)	(0.002)
Rents from resources / GDP	0.000	0.001***	-0.004***	-0.000
(%)	(0.000)	(0.000)	(0.001)	(0.000)
Capital / GDP (log)	-0.002	0.001	0.056***	-0.003
	(0.003)	(0.003)	(0.021)	(0.007)
Land / GDP (log)	0.000	0.001	-0.016***	-0.003*
	(0.001)	(0.001)	(0.005)	(0.002)
Med/High-skilled labor / GDP (log)	0.002	-0.003**	0.004	0.001
	(0.002)	(0.002)	(0.013)	(0.004)
Low-skilled labor / GDP (log)	0.004**	-0.001	0.004	0.006
	(0.002)	(0.002)	(0.013)	(0.004)
Exch. rate appreciation	0.000	0.000	0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Observations	290	290	290	290
R-squared	0.300	0.656	0.605	0.362
Number of countries	121	121	121	121
Decade fixed effects	YES	YES	YES	YES

Notes: LS standard errors in parentheses. ***, **, and * indicate significance levels of 1%, 5%, and 10%, respectively.

Table 3: First-stage regressions

	(1)	(2)	(3)	(4)
Regressions	LS - BE	LS - BE	LS	LS
VARIABLES	Avg. tariff rate (%)	FDI inflows (log)	Avg. tariff rate (%)	FDI inflows (log)
Import elasticity	-37.038***	0.243	-38.720***	0.782
	(10.604)	(1.864)	(10.259)	(1.880)
Import elasticity*Population (log)	2.307***	-0.053	2.351***	-0.068
	(0.606)	(0.107)	(0.594)	(0.111)
Population (log)	-1.154	1.174***	-0.991	1.113***
	(1.387)	(0.244)	(1.508)	(0.332)
Statutory Corporate Tax Rate	-0.075	-0.025**	-0.022	-0.041***
	(0.071)	(0.013)	(0.111)	(0.013)
Transitional Economy Status	-4.318***	0.343	-4.641***	0.408*
	(1.500)	(0.264)	(1.391)	(0.239)
Distance to GVC hubs (log)	-0.826	0.385	-1.733	0.641*
	(2.144)	(0.377)	(1.925)	(0.336)
Political stability index	-0.890	0.439***	-0.854	0.421***
	(0.818)	(0.144)	(0.785)	(0.157)
Domestic industrial capacity	-2.221**	-0.127	-2.364*	-0.072
(log)	(0.937)	(0.165)	(1.289)	(0.217)
Rents from resources / GDP	-0.016	-0.000	-0.042	0.007
(%)	(0.053)	(0.009)	(0.041)	(0.011)
Capital / GDP (log)	0.997	0.091	0.784	0.170
	(1.169)	(0.205)	(1.256)	(0.200)
Land / GDP (log)	-0.029	-0.050	-0.003	-0.055
	(0.298)	(0.052)	(0.355)	(0.074)
Med/High-skilled labor / GDP (log)	-0.778	-1.093***	-1.233	-0.932***
	(1.154)	(0.203)	(1.436)	(0.257)
Low-skilled labor / GDP (log)	0.112	-0.019	0.227	-0.065
	(0.718)	(0.126)	(0.558)	(0.105)
Exch. rate appreciation	0.001	-0.001	0.001	-0.000
	(0.004)	(0.001)	(0.002)	(0.000)
Observations	290	290	121	121
R-squared	0.480	0.863	0.465	0.851
Number of countries	121	121	121	121
Sanderson-Windmeijer F test	NA	NA	12.69***	7.02***
Kleibergen-Paap Wald test for Weak IV	NA		10.39**	
Decade fixed effects	YES	YES	NO	NO

Notes: LS standard errors in parentheses for Columns (1) and (2); Robust standard errors in parentheses for Columns (3) and (4); ***, **, and * indicate significance levels of 1%, 5%, and 10%, respectively.

Table 4: Dependent variable: Backward GVC participation shares (EORA)

	(1)	(2)	(3)	(4)
Regressions	IV - BE	IV	LS	LS
Avg. tariff rate (%)	-0.011***	-0.009***	-0.005***	-0.004**
	(0.004)	(0.003)	(0.001)	(0.002)
FDI inflows (log)	0.038*	0.030*	0.018*	0.014
	(0.020)	(0.018)	(0.010)	(0.010)
Distance to GVC hubs (log)	-0.090**	-0.112***	-0.118***	-0.080*
	(0.038)	(0.041)	(0.044)	(0.046)
Political stability index	0.017	0.031**	0.040***	0.034**
	(0.019)	(0.014)	(0.014)	(0.015)
Domestic industrial capacity	-0.040***	-0.031**	-0.022**	-0.023
(log)	(0.015)	(0.012)	(0.008)	(0.027)
Rents from resources / GDP	-0.003**	-0.003***	-0.003***	-0.003**
(%)	(0.001)	(0.001)	(0.001)	(0.001)
Capital / GDP (log)	0.045*	0.033	0.034	0.030
	(0.026)	(0.024)	(0.023)	(0.023)
Land / GDP (log)	-0.021***	-0.019***	-0.019**	-0.021***
	(0.006)	(0.007)	(0.007)	(0.007)
Med/High-skilled labor / GDP (log)	0.018	0.009	0.005	-0.010
	(0.016)	(0.014)	(0.014)	(0.030)
Low-skilled labor / GDP (log)	0.011	0.017	0.015	0.015
	(0.016)	(0.018)	(0.019)	(0.019)
Exch. rate appreciation	-0.000	-0.000	0.000	-0.000*
	(0.000)	(0.000)	(0.000)	(0.000)
Import elasticity				0.084
				(0.250)
Import elasticity X Population (log)				-0.009
				(0.014)
Population (log)				0.024
				(0.037)
Statutory Corporate Tax Rate				0.000
				(0.001)
Transitional Economy Status				0.039
				(0.034)
Observations	290	121	121	121
R-squared	0.483	0.472	0.503	0.530
Number of countries	121	121	121	121
F stat for excluded IV				1.41
AR Wald test for weak IV robust inference		3.43***		
KP rk LM statistic for underidentification		22.07***		
Decade fixed effects	YES	NO	NO	NO

Notes: LS standard errors in parentheses for Column (1); Robust standard errors for Columns (2)-(4); ***, **, and * indicate significance levels of 1%, 5%, and 10%, respectively.

Table 5: Marginal Contributions

(1) Included Variables	(2) R-squared	(3) Marginal R-Squared	(4) Share of Contribution (%)
Tariff + FDI	0.056	0.056	13
Tariff + FDI + Distance to Hubs	0.145	0.089	21
Tariff + FDI + Political Stability	0.132	0.076	18
Tariff + FDI + Dom. Ind. Cap.	0.073	0.017	4
Tariff + FDI + Endowments	0.238	0.182	43
Sum		0.42	100

Notes: R-squared in Column (2) is constructed based on the coefficients of Column (2) of Table 4, by including only the variables listed in Column (1). The marginal R-squared in Column (3) measures the change in R-squared in Column (2) when compared to the R-squared of including only tariffs and FDI equal to 0.056. Column (4) calculates the shareof contribution of the additional variables in the sum of all marginal R-squared.

Table 6: Dependent variable: Forward GVC participation shares (EORA)

	(1)	(2)	(3)	(4)	(5)
Regressions	LS - BE	IV - BE	IV	LS	LS
Avg. tariff rate (%)	0.001	0.004**	0.004*	0.000	-0.001
	(0.001)	(0.002)	(0.002)	(0.001)	(0.001)
FDI inflows (log)	-0.008	-0.006	-0.002	-0.006	-0.008
	(0.006)	(0.012)	(0.012)	(0.005)	(0.005)
Distance to GVC hubs (log)	-0.042*	-0.052**	-0.043**	-0.036*	-0.044*
	(0.021)	(0.023)	(0.019)	(0.019)	(0.023)
Political stability index	-0.018*	-0.011	-0.017*	-0.022*	-0.015
	(0.010)	(0.011)	(0.010)	(0.011)	(0.011)
Domestic industrial capacity	0.010*	0.011	0.006	0.007**	-0.007
(log)	(0.005)	(0.009)	(0.008)	(0.003)	(0.012)
Rents from resources / GDP	0.002***	0.002***	0.002***	0.002**	0.002**
(%)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Capital / GDP (log)	-0.012	-0.014	-0.010	-0.008	-0.004
	(0.015)	(0.015)	(0.017)	(0.017)	(0.017)
Land / GDP (log)	0.009***	0.011***	0.010***	0.009**	0.009**
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Med/High-skilled labor / GDP (log)	0.017*	0.016	0.019*	0.019*	0.011
	(0.009)	(0.010)	(0.011)	(0.011)	(0.016)
Low-skilled labor / GDP (log)	-0.030***	-0.032***	-0.034***	-0.032***	-0.035***
	(0.009)	(0.009)	(0.010)	(0.010)	(0.010)
Exch. rate appreciation	-0.000	0.000	0.000	-0.000	0.000*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Import elasticity					-0.117
					(0.113)
Import elasticity X Population (log)					0.009
					(0.007)
Population (log)					0.003
					(0.018)
Statutory Corporate Tax Rate					-0.000
					(0.001)
Transitional Economy Status					-0.009
					(0.019)
Observations	290	290	121	121	121
R-squared	0.409	0.341	0.344	0.394	0.436
Number of countries	121	121	121	121	121
Decade fixed effects	YES	YES	NO	NO	NO

Note: LS standard errors in parentheses for Columns (1) and (2); Robust standard errors for Columns (3)-(5); ***, **, and * indicate significance levels of 1%, 5%, and 10%, respectively.

Table 7: GVC vs Traditional Trade

	(1)	(2)	(3)	(4)	(5)	(6)
Regressions	IV - BE	IV - BE	IV - BE	IV	IV	IV
Dependent variables	BGVC (log)	FGVC (log)	Exports (log)	BGVC (log)	FGVC (log)	Exports (log)
Avg. tariff rate (%)	-0.069**	-0.002	-0.044**	-0.058**	-0.004	-0.042**
	(0.028)	(0.026)	(0.020)	(0.023)	(0.022)	(0.018)
FDI inflows (log)	0.492***	0.292**	0.428***	0.424***	0.295**	0.421***
	(0.151)	(0.141)	(0.111)	(0.138)	(0.130)	(0.123)
Distance to GVC hubs (log)	-0.475*	-0.303	0.073	-0.566**	-0.268	0.046
	(0.288)	(0.269)	(0.211)	(0.221)	(0.216)	(0.154)
Political stability index	0.088	-0.037	0.037	0.148	-0.064	0.047
	(0.140)	(0.130)	(0.103)	(0.123)	(0.130)	(0.094)
Domestic industrial capacity	0.455***	0.696***	0.567***	0.516***	0.688***	0.576***
(log)	(0.111)	(0.104)	(0.082)	(0.096)	(0.088)	(0.088)
Rents from resources / GDP	-0.004	0.022***	0.032***	-0.006	0.022***	0.031***
(%)	(0.008)	(0.007)	(0.006)	(0.007)	(0.008)	(0.009)
Capital / GDP (log)	0.286	0.082	0.178	0.268*	0.122	0.180
	(0.193)	(0.181)	(0.142)	(0.158)	(0.170)	(0.127)
Land / GDP (log)	-0.128***	-0.013	-0.067*	-0.119**	-0.011	-0.063*
	(0.048)	(0.045)	(0.035)	(0.047)	(0.040)	(0.037)
Med/High-skilled labor / GDP (log)	-0.076	-0.022	-0.070	-0.098	0.008	-0.065
	(0.123)	(0.115)	(0.090)	(0.115)	(0.133)	(0.080)
Low-skilled labor / GDP (log)	0.038	-0.189*	0.018	0.029	-0.222*	0.005
	(0.117)	(0.110)	(0.086)	(0.101)	(0.131)	(0.071)
Exch. rate appreciation	0.000	0.000	0.000	0.000*	0.000*	0.000**
	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	290	290	290	121	121	121
R-squared	0.920	0.925	0.950	0.924	0.923	0.949
Number of country	121	121	121	121	121	121
Decade fixed effects	YES	YES	YES	NO	NO	NO

Notes: LS standard errors in parentheses for Columns (1)-(3); Robust standard errors for Columns (4)-(6);
BGVC is backward GVC participation in levels (logs) and FGVC is forward GVC participation in levels (logs);
***, **, and * indicate significance levels of 1%, 5%, and 10%, respectively.

Table 8: Country-Sector Analysis

	Dependent variables:		
	Backward GVC participation (log)	Forward GVC participation (log)	Exports (log)
	(1)	(2)	(3)
3-year lag skilled labor endowment X skill intensity	0.087***	0.082***	0.087***
	(0.005)	(0.005)	(0.005)
3-year lag capital endowment X capital intensity	0.002***	0.002***	0.002***
	(0.000)	(0.000)	(0.000)
3-year lag nat. resource endoment X nat. resource intensity	0.103***	0.107***	0.111***
	(0.008)	(0.009)	(0.009)
3-year lag rule of law index X contract intensity	1.087***	1.202***	1.182***
	(0.051)	(0.050)	(0.048)
3-year lag average output tariff	-0.430	1.309***	0.505*
	(0.301)	(0.313)	(0.287)
3-year lag average input tariff	-1.977**	-4.938***	-3.283***
	(0.787)	(0.881)	(0.790)
3-year lag average market access tariff	-6.185***	-6.866***	-5.959***
	(0.354)	(0.377)	(0.360)
Country*Year FE	Yes	Yes	Yes
Sector FE	Yes	Yes	Yes
Observations	14,387	14,387	14,387
R-squared	0.919	0.907	0.913

Notes: Robust standard errors in parentheses. ***, **, and * indicate significance levels of 1%, 5%, and 10%, respectively.

1 On-line Appendix

1.1 Data for Cross-Country Analysis

Table A1 presents the detailed definitions and data sources for the variables used in the analysis. Summary statistics for the country level variables are provided in Table A2 while their correlations are shown in Tables A3 and A4.

The sectors in the EORA database are defined as follows. Agriculture includes fishing; mining and quarrying is a separate sector; manufacturing includes food and beverages; textiles and wearing apparel; wood and paper; petroleum, chemicals and non-metallic minerals; metal products; electrical and machinery; transport equipment; and other manufacturing. Services covers recycling; electricity, gas and water; construction; maintenance and repair; wholesale trade; retail trade; hotels and restaurants; transport; post and telecommunications; financial intermediation and business activities; public administration; and education, health and other services. We exclude from our analysis the following three sectors: private households; others; and re-exports and re-imports.

Regarding factor endowments, all variables are measured as a ratio to real GDP. Low-skilled labor endowments follow the ILO's definition of low skill (skill level 1), based on the International Standard Classification of Occupations. Likewise, medium/high-skilled labor refers to the ILO's definition of medium and high skill (skill levels 2-4). We use the real capital stock from the Penn World Tables to measure capital endowments. Regarding natural resource endowments, we use the country's land area as well as the rents from natural resources, both taken from the World Development Indicators (WDI).

We use the average manufacturing tariff rate from WDI and the level of FDI inflows from UNCTAD. Geography is captured by a country's total distance (in kilometers) to the main global GVC hubs, China, Germany, and the US from CEPII. For domestic industrial capacity we use manufacturing value added from WDI. To measure a country's institutional quality, we use the political stability index from the World Governance Indicators database. We also include a measure of exchange rate appreciation based on changes in the average nominal exchange rate from WDI.

To assess the role of PTAs, we include indicator variables for a country's participation in PTAs: the North American Free Trade Agreement (NAFTA), the EU, ASEAN, and the Southern Common Market (MERCOSUR), the number of PTA partners and a measure of the depth of those PTAs, both taken from the Content of Deep Trade Agreements database of Hofmann et al. (2017).

To capture aspects related to connectivity, we add alternatively, the time to clear imports from the Doing Business Database, the Logistics Performance Index' overall score, the share of the population that uses the internet from WDI and the share of people that speak English as a second language from Melitz and Toubal (2014). We also include a measure of domestic credit as percent of GDP from WDI to capture a country's financial development and the share of females in the total labor force from WDI. As an alternative to exchange rate depreciation we use a measure of exchange rate misalignment relative to an equilibrium exchange rate following Couharde et al. (2017).

1.2 Data for Cross-Country Cross-Sector Analysis

For country-sector specifications, we estimate the impact of country-sector determinants in year t-3 on country-sector GVC participation in year t, effectively covering the period 1999-2015. Summary statistics for the EORA GVC participation shares and all the determinants at the country-sector level are provided in Table A5 and correlations among all determinants at country-sector level are provided in Table A6.

We interact each country-year determinant with its corresponding sectoral intensity of use across manufacturing sub-sectors to obtain measures that vary at the country-sector-year level. For labor endowments we use the country-level share of high-skilled workers following the ILO's definition of low skill (skill levels 3 and 4) based on the International Standard Classification of Occupations. We interact the country skilled labor endowment with a benchmark measure of skill intensity in the US defined as the ratio of skilled workers to unskilled workers by sector taken from the NBER-CES Manufacturing Industry Database. For capital endowments, we use the ratio of real capital stock to total employment at the country level from Penn World Tables which we interact with a benchmark measure of capital intensity in the US by sector taken from the NBER-CES Manufacturing Industry Database.

To capture natural resources endowments, we interact the natural resources to GDP ratio from WDI with an indicator for natural resource intensive sectors based on Braun (2003). For country institutional quality we use the rule of law index from the World Governance Indicators database which is interacted with the measure of contract intensity proposed by Nunn (2007). The measure of contract intensity is determined by the share of specialized and customized intermediate inputs used in the production of the final good for each sector based on a U.S. input-output table.[42]

Additionally, our model controls for three types of tariff measures: tariffs imposed at home on imports of the sector, tariffs imposed at home on imports of intermediate inputs used by the sector, and tariffs imposed in destination markets on exports of the sector. The tariffs draw on a newly constructed database by Felbermayr et al. (2019), which is based on the UN-TRAINS and IDB databases, as well as on WITS import and export data. To compute the three types of tariff measures, we draw on tariff and trade data at the reporting country-HS6-digit-partner country-year level from WITS.

First, to construct tariffs imposed at home on imports of the sector we first aggregate tariffs (taking the simple average) and imports (taking the sum) to the EORA sector level. We then sum imports across countries of origin to obtain import weights which are used to compute tariffs imposed at home on imports of a sector as a weighted-average tariff at the reporting country-EORA sector-year level.

Second, we construct tariffs imposed at home on imports of intermediate inputs used by the sector as follows. We keep tariff data and import data only for HS 6-digit products classified as intermediates according to the UN Broad Economic Categories (BEC) classi-

[42] Nunn uses data on the fraction of each input that is not sold in an organized exchange nor reference-priced according to Rauch (1999) to construct the share of intermediate inputs that require specialized and customized business relationships. Nunn's contract intensity measure (based on Rauch's liberal classification) is available at the 3-digit ISIC revision 2 level which is concorded to the eight manufacturing sectors in the EORA database based on industries' verbal descriptions.

fication.[43] We then aggregate tariffs (taking the simple average) and imports (taking the sum) to the EORA sector level. We then sum imports across countries of origin to obtain import weights which are used to compute an auxiliary measure of tariffs on imports of BEC intermediates at the reporting country-EORA sector-year level. Then, based on the US Input-Output table for 2005 from WIOD which was aggregated to the eight EORA manufacturing sectors, we construct for each sector the share of its total intermediate inputs that originates in each of the eight EORA sectors. Finally, we combine these I-O table weights with the auxiliary tariffs on imports of BEC intermediates to construct a weighted-average tariff on intermediate inputs at the reporting country-EORA sector-year level.

Third, to construct tariffs imposed in destination markets on exports of the sector, we aggregate tariffs (taking the simple average) and exports (taking the sum) to the EORA sector level. Then, we sum exports across destination markets to compute export weights at the reporting country-EORA sector-year level which allows us to construct a weighted-average of the tariffs the destination markets impose.

Finally, we also rely on the fDi Markets Database which allows us to construct a proxy for FDI at the country-sector-year for a limited sample period 2003-2015, following the approach of Hallward-Driemeier and Nayyar (2019). Specifically, we define a measure of the number of cross-border greenfield FDI projects announced cumulating it from 2003 onwards for each country-sector (summing across the projects from any origin country).

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[43] The UN BEC classifies goods into capital, consumption and intermediate goods.

Table A1: Variable Definitions and Data Sources

Variable name	Definition	Source
Avg. tariff rate	Applied tariff rate to manufactured products, weighted mean (in %)	WDI
FDI inflows (log)	Logarithm of net foreign direct investment inflows (in millions of USD)	UNCTAD
Distance to GVC hubs (log)	Logarithm of sum of distance to China, Germany and the US (capital city-to-capital city)	CEPII
Political stability index	Political Stability and Absence of Violence/Terrorism: Estimate	World Governance Indicators
Domestic industrial capacity (log)	Manufacturing value added (in current USD) obtained by multiplying nominal GDP with the share of manufacturing in value-added	WDI
Low-skilled labor share / real GDP (log)	Logarithm of the share of employment of skill level 1 (low) according to the International Standard Classification of Occupations in total employment https://www.ilo.org/public/english/bureau/stat/isco/isco08/index.htm	ILO
Med/High-skilled labor share / real GDP (log)	Logarithm of the share of employment of skill levels 2-4 (med-high) according to the International Standard Classification of Occupations in total employment https://www.ilo.org/public/english/bureau/stat/isco/isco08/index.htm	ILO
Rents from resources % GDP	Total natural resources rents as a percentage of GDP	WDI
Land / real GDP (log)	Logarithm of land area (sq. km) divided by real GDP (in constant 2010 USD)	WDI
Capital / real GDP (log)	Logarithm of real capital stock (in constant 2011 national prices in mil. 2011 US$) divided by real GDP (in constant 2010 USD)	Penn World Tables 9.0, WDI
Exch. rate appreciation	Change in nominal exchange rate (increase is an appreciation)	WDI
NAFTA	Indicator variable equal to 1 if the country is a member of NAFTA, and 0 otherwise	Content of Deep Trade Agreements
EU	Indicator variable equal to 1 if the country is a member of the EU, and 0 otherwise	Content of Deep Trade Agreements
ASEAN	Indicator variable equal to 1 if the country is a member of ASEAN, and 0 otherwise	Content of Deep Trade Agreements
MERCOSUR	Indicator variable equal to 1 if the country is a member of MERCOSUR, and 0 otherwise	Content of Deep Trade Agreements
Nb. of PTA partners (log)	Logarithm of the number of Preferential Trade Agreement (PTA) partners	Content of Deep Trade Agreements
Depth of PTAs (log)	Logarithm of the number of provisions in deep PTAs as described in Hoffman et al. (2017)	Content of Deep Trade Agreements
Exch. rate misalignment	Real exchange rate misalignment relative to an equilibrium exchange rate based on the model described in Couharde et al. (2017)	CEPII
Credit / GDP	Domestic credit to private sector as a percentage of GDP	WDI
Time to clear imports (log)	Logarithm of the number of days required to import based on the Doing Business 06-15 methodology	Doing Business database
Logistics performance index	Overall score of the logistics performance index obtained as a weighted average of the country scores on six key dimensions: efficiency of the clearance process (i.e., speed, simplicity and predictability of formalities) by border control agencies, including customs; quality of trade and transport related infrastructure (e.g., ports, railroads, roads, information technology); ease of arranging competitively priced shipments; competence and quality of logistics services (e.g., transport operators, customs brokers); ability to track and trace consignments; timeliness of shipments in reaching destination within the scheduled or expected delivery time.	LPI database
Internet use	Percentage of the population that uses the internet	WDI
English as second language (%)	Percentage of the population that speaks english as a second language	Melitz and Toubal (2014)
Female labor force partic. (%)	Share of females in total labor force	WDI
Import elasticity	Average for each country of the import demand elasticities estimated by Kee, Nicita, and Olarreaga (2008) for all its manufacturing products defined as those with HS 6-digit codes higher than HS 290000.	Kee, Nicita, and Olarreaga (2008)
Total population (log)	Logarithm of the total number of inhabitants.	WDI
Corporate income taxes (%)	Statutory corporate income tax rate in percentage points.	Tax Foundation (2019)
Transitional economy status	Indicator variable for countries that transitioned from communism to a capitalist regime.	IMF (2000)
High-skilled labor share (%)	Share of employment of skill levels 3 and 4 (high) according to the International Standard Classification of Occupations in total employment https://www.ilo.org/public/english/bureau/stat/isco/isco08/index.htm	ILO
Capital / labor (log)	Real capital stock (in constant 2011 national prices in mil. 2011 US$) divided by total employment	Penn World Tables 9.0
Rule of law index	Rule of Law: Estimate	World Governance Indicators
Skill intensity	Ratio of skilled workers to unskilled workers at the 2-digit level of SIC revision 1987 concorded to the eight sectors in the EORA database based on industries'verbal descriptions.	NBER-CES Manufacturing Industry Database
Capital intensity	Ratio of capital to employment at the 2-digit level of SIC revision 1987 concorded to the eight sectors in the EORA database based on industries'verbal descriptions.	NBER-CES Manufacturing Industry Database
Natural resource intensity	Indicator variable for natural resource intensive sectors in the EORA database (wood and paper; petroleum, chemicals and non-metallic minerals; and metal products)	Braun (2003)
Contract intensity	Share of specialized and customized intermediate inputs used in the production of the final good for each industry 3-digit ISIC revision 2 industry based on a U.S. input-output table. Specialized and customized intermediate inputs are those not sold on an organized exchange nor reference-priced according to Rauch (1999) s relationships. The 3-digit ISIC revision 2 level is concorded to the eight sectors in the EORA database based on industries'verbal descriptions.	Nunn (2007)
Technology intensity	Indicator variable defining whether an ISIC sector is technology-intensive or not, based on research and development expenditure incurred in the production of manufactured goods.	UNIDO
Average output tariff	Tariffs imposed at home on imports of the sector are constructed by first aggregating tariffs (taking the simple average) and imports (taking the sum) to the EORA sector level. Then imports are summed across countries of origin to obtain import weights which are used to compute tariffs imposed at home on imports of a sector as a weighted-average tariff at the reporting country-EORA sector-year level.	WITS, TRAINS and Felbermayr, Teti and Yalcin (2019)
Average input tariff	Tariffs imposed at home on imports of intermediate inputs used are constructed by first keeping tariff data and import data only for HS 6-digit products classified as intermediates according to the UN BEC classification. The simple average of tariffs is taken and imports are summed at the EORA sector level. Imports are summed across countries of origin to obtain import weights which are used to compute an auxiliary measure of tariffs on imports of BEC intermediates at the reporting country-EORA sector-year level. Then, based on the US Input-Output table for 2005 from WIOD which was aggregated to the eight EORA manufacturing sectors, we construct for each sector the share of its total intermediate inputs that originates in each of the eight EORA sectors. Finally, we combine these I-O table weights with the auxiliary tariffs on imports of BEC intermediates to construct a weighted-average tariff on intermediate inputs at the reporting country-EORA sector-year level.	WITS, TRAINS and Felbermayr, Teti and Yalcin (2019)
Average market access tariff	Tariffs imposed in destination markets on exports of the sector are constructed by first taking the simple average of tariffs and summing exports at the EORA sector level. Then, exports are summed across destination markets to compute export weights at the reporting country-EORA sector-year level which allows us to construct a weighted-average of the tariffs the destination markets impose.	WITS, TRAINS and Felbermayr, Teti and Yalcin (2019)
FDI projects	Sum of announced greenfield FDI projects from all source countries for a given country-sector-year, cumulative since 2003. Sectors are concorded to the 8 manufacturing EORA sectors.	

Table A2: Summary Statistics

	No. of obs.	Average	Median	St. Dev.
Summary statistics based on country averages in the 1990s, 2000s and in the 2010s				
EORA backward GVC participation share	290	23.39%	20.85%	13.21%
EORA forward GVC participation share	290	19.16%	18.35%	6.85%
EORA backward GVC participation (log)	290	7.54	7.30	2.42
EORA forward GVC participation (log)	290	7.44	7.32	2.35
Total exports (log)	290	16.12	16.06	2.22
Med/High-skilled labor / GDP (log)	290	-16.64	-16.84	1.33
Low-skilled labor / GDP (log)	290	-18.62	-18.62	1.50
Rents from resources / GDP	290	6.60	2.34	9.77
Land / GDP (log)	290	-12.83	-12.64	2.02
Capital / GDP (log)	290	-12.11	-12.13	0.46
Avg. tariff rate (%)	290	7.64	5.25	6.93
FDI inflows (log)	290	6.92	7.02	2.08
Distance to GVC hubs (log)	290	10.02	10.07	0.30
Political stability index	290	0.01	0.02	0.87
Domestic industrial capacity (log)	290	22.51	22.39	2.26
Exch. rate appreciation	290	-13.55	0.00	220.77
Exch. rate misalignment	290	-7.59	0.59	66.49
NAFTA	289	0.02	0.00	0.15
EU	289	0.11	0.00	0.30
ASEAN	289	0.05	0.00	0.22
MERCOSUR	289	0.04	0.00	0.20
Nb. of PTA partners (log)	266	2.64	2.71	0.93
Depth of PTAs (log)	266	4.95	5.00	1.50
Time to clear imports (log)	191	2.97	2.98	0.67
Female labor force partic. (%)	290	40.67	43.69	8.85
Instruments				
Import elasticity	290	1.36	1.23	0.46
Import elasticity X Population (log)	290	22.44	19.75	9.30
Population (log)	290	16.20	16.10	1.69
Corporate tax rate (%)	290	28.72	30.00	8.92
Transition economy status	290	19.31%	0.00%	39.54%

Table A3: Correlations among country GVC measures and Exports

	EORA BGVC part. share	EORA FGVC part. share	EORA BGVC part. (log)	EORA FGVC part. (log)	Total exports (log)
EORA BGVC part. share	1				
EORA FGVC part. share	-0.4492*	1			
EORA BGVC part. (log)	0.3721*	-0.026	1		
EORA FGVC part. (log)	0.0836	0.2394*	0.9431*	1	
Total exports (log)	0.1728*	0.098	0.9409*	0.9588*	1

Table A4: Correlations among country determinants

	Medium and high-skilled labor / GDP (log)	Low-skilled labor / GDP (log)	Rents from resources / GDP	Land / GDP (log)	Capital / GDP (log)	Avg. tariff rate (%)	FDI inflows (log)	Distance to GVC hubs (log)	Political stability index	Domestic industrial capacity (log)	Exch. rate appreciation	Exch. rate misalignment	NAFTA	EU	ASEAN	MERCOSUR	Nb. of PTA partners (log)	Depth of PTAs (log)	Time to clear imports (log)	Female labor force partic. (%)
Medium and high-skilled labor / GDP (log)	1																			
Low-skilled labor / GDP (log)	0.8710*	1																		
Rents from resources / GDP	0.1810*	0.1109	1																	
Land / GDP (log)	0.6471*	0.5969*	0.3942*	1																
Capital / GDP (log)	0.4718*	0.5594*	0.1109	0.2922*	1															
Avg. tariff rate (%)	0.4006*	0.4043*	0.1151	0.2766*	0.2009*	1														
FDI inflows (log)	-0.5608*	-0.4919*	-0.1220*	-0.4833*	-0.2029*	-0.3978*	1													
Distance to GVC hubs (log)	0.2971*	0.4145*	0.1626*	0.3456*	0.0688	0.2336*	-0.1737*	1												
Political stability index	-0.6501*	-0.6458*	-0.2431*	-0.4188*	-0.3321*	-0.2995*	0.2106*	-0.2427*	1											
Domestic industrial capacity (log)	-0.5031*	-0.4488*	-0.1989*	-0.4495*	-0.1937*	-0.2947*	0.8369*	-0.2061*	0.1165*	1										
Exch. rate appreciation	0.0197	-0.0055	0.0306	-0.0263	-0.0036	-0.0925	-0.0402	-0.0772	0.0199	-0.0728	1									
Exch. rate misalignment	-0.1999*	-0.2317*	-0.0211	-0.1885*	-0.2150*	0.0096	0.1286*	-0.1006	0.1499*	0.1429*	-0.0015	1								
NAFTA	-0.1686*	-0.1435*	-0.0643	-0.0325	-0.1448*	-0.1031	0.3108*	-0.062	0.0514	0.3013*	0.0102	0.0262	1							
EU	-0.3591*	-0.4119*	-0.2315*	-0.3361*	-0.1358*	-0.2659*	0.2391*	-0.4902*	0.3820*	0.2549*	0.0234	0.1101	-0.0628	1						
ASEAN	-0.033	0.0037	-0.0108	-0.2009*	0.1900*	-0.0851	0.1696*	0.1961*	-0.0036	0.1697*	0.0149	0.0095	-0.0399	-0.0914	1					
MERCOSUR	-0.0541	0.0347	-0.0803	0.1069	-0.048	0.0576	0.0568	0.3505*	-0.0177	0.0964	-0.2565*	0.0317	-0.0358	-0.0819	-0.0521	1				
Nb. of PTA partners (log)	-0.1452*	-0.2490*	-0.0824	-0.2071*	0.0784	-0.2109*	0.0965	-0.5317*	0.1790*	0.0368	0.1024	0.0243	-0.0468	0.4424*	-0.0513	-0.3473*	1			
Depth of PTAs (log)	-0.2778*	-0.3475*	-0.2472*	-0.2506*	-0.1089	-0.3458*	0.2115*	-0.5462*	0.3324*	0.1583*	0.0421	0.0585	0.0213	0.5440*	-0.2378*	-0.1385*	0.8679*	1		
Time to clear imports (log)	0.7113*	0.6749*	0.3705*	0.6604*	0.3393*	0.4097*	-0.5043*	0.2623*	-0.5605*	-0.4218*	-0.2512*	-0.1123	-0.1749*	-0.3514*	-0.1855*	0.0848	-0.3080*	-0.3651*	1	
Female labor force partic. (%)	0.1361*	-0.0182	-0.1364*	0.1071	-0.1796*	-0.1807*	-0.0611	-0.0374	0.1747*	-0.1324*	0.0244	0.0703	0.0226	0.1618*	-0.0103	0.0047	0.0359	0.1852*	0.0567	1

Table A5: Summary statistics on country-sector GVC participation measures and determinants

	Number of observations	Average	Median	Standard deviation
Summary statistics based on country-sector current year in period 1999-2015				
EORA backward GVC participation (log)	14387	4.57	4.40	3.15
EORA forward GVC participation (log)	14387	3.96	3.71	3.10
Exports (log)	14387	5.94	5.85	3.04
Summary statistics based on country 3-year lags in period 1999-2015				
High-skilled labor share (%)	14387	22.02	20.64	13.23
Capital / labor (log)	14387	11.24	11.44	1.30
Rents from resources / GDP	14387	23.51	23.42	2.17
Rule of law index	14387	0.09	-0.12	0.95
Internet use	8871	32.88	25.47	28.44
Summary statistics based on sector				
Skill intensity	13319	0.37	0.40	0.12
Capital intensity	13319	60.50	45.30	41.22
Natural resource intensity	14387	0.37	0.00	0.48
Contract intensity	13319	0.58	0.59	0.18
Technology intensity	8243	0.20	0.00	0.40
Summary statistics based on country-sector 3-year lags in period 1999-2015				
Average output tariff	14387	0.07	0.06	0.07
Average input tariff	14387	0.06	0.05	0.06
Average market access tariff	14387	0.04	0.03	0.04
Number of FDI projects	3743	13.80	14.08	2.03

Note: Summary statistics are based on the estimating sample used in Table 8.

Table A6: Correlations among country-sector determinants

	High-skill endowment X skill intensity	Capital endowment X capital intensity	Nat. resource endowment X nat. resource intensity	Rule of law X contract intensity	Average output tariff	Average input tariff	Average market access tariff	Number of FDI projects	Internet X IT intensity
High-skill endowment X skill intensity	1								
Capital endowment X capital intensity	0.2715*	1							
Nat. res. endow. X nat. res. intensity	0.0648*	0.6496*	1						
Rule of law X contract intensity	0.6177*	0.0925*	-0.0182*	1					
Average output tariff	-0.4490*	-0.2446*	-0.1917*	-0.4113*	1				
Average input tariff	-0.4596*	-0.2104*	-0.0915*	-0.4357*	0.8965*	1			
Average market access tariff	-0.1697*	-0.0962*	-0.1265*	-0.1671*	0.3014*	0.2561*	1		
Number of FDI projects	0.2217*	0.1205*	-0.0745*	0.1628*	-0.1366*	-0.1765*	-0.1171*	1	
Internet X IT intensity	0.3326*	0.2441*	-0.1586*	0.3585*	-0.2109*	-0.1875*	-0.1404*	0.1599*	1

Table A7: Determinants of country-sector GVC participation shares adding FDI

	Backward GVC participation (log)	Forward GVC participation (log)	Exports (log)
	(1)	(2)	(3)
3-year lag skilled labor / labor X sector skill intensity	0.100***	0.073***	0.102***
	(0.010)	(0.010)	(0.009)
3-year lag capital / labor X sector capital intensity	0.002***	0.001***	0.001***
	(0.000)	(0.000)	(0.000)
3-year lag nat. resource / GDP X nat. resource intensity	0.068***	0.128***	0.094***
	(0.018)	(0.018)	(0.018)
3-year lag rule of law index X sector contract intensity	0.812***	1.019***	0.961***
	(0.108)	(0.098)	(0.096)
3-year lag average output tariff	0.437	1.479***	1.211***
	(0.420)	(0.414)	(0.370)
3-year lag average input tariff	-0.733	-1.336	-0.181
	(0.936)	(1.009)	(0.916)
3-year lag average market access tariff	-6.414***	-8.564***	-6.794***
	(1.166)	(1.423)	(1.139)
3-year lag number of FDI projects	0.307***	0.346***	0.289***
	(0.029)	(0.030)	(0.028)
Country*Year FE	Yes	Yes	Yes
Sector FE	Yes	Yes	Yes
Observations	3,617	3,617	3,617
R-squared	0.877	0.893	0.882

Notes: Robust standard errors in parentheses. ***, **, and * indicate significance at 1%, 5%, and 10% levels, respectively.

Table A8: Determinants of country-sector GVC participation shares adding internet

	Dependent variable is:		
	EORA backward GVC participation (log)	EORA forward GVC participation (log)	Exports (log)
	(1)	(2)	(3)
3-year lag skilled labor endowment X skill intensity	0.100***	0.099***	0.101***
	(0.007)	(0.007)	(0.007)
3-year lag capital endowment X capital intensity	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)
3-year lag nat. resource endoment X nat. resource intensity	0.062***	0.043***	0.061***
	(0.012)	(0.013)	(0.013)
3-year lag rule of law index X contract intensity	1.180***	1.319***	1.240***
	(0.107)	(0.098)	(0.101)
3-year lag average output tariff	-1.592***	0.656*	-0.580*
	(0.380)	(0.346)	(0.349)
3-year lag average input tariff	-0.984	-3.723***	-2.084**
	(0.867)	(0.920)	(0.861)
3-year lag average market access tariff	-6.474***	-7.264***	-6.480***
	(0.417)	(0.420)	(0.419)
3-year lag internet X IT intensity	0.009***	0.010***	0.010***
	(0.002)	(0.001)	(0.001)
Country*Year FE	Yes	Yes	Yes
Sector FE	Yes	Yes	Yes
Observations	8,911	8,911	8,911
R-squared	0.913	0.907	0.910

Notes: Robust standard errors in parentheses. ***, **, and * indicate significance levels of 1%, 5%, and 10%, respectively.