# Comprehensive trade agreements, domestic institutions, and GVC integration: firm-level evidence

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## Abstract

There is considerable evidence that the deepening of trade integration has uneven distributional consequences for local firms, depending on their productivity. It is also well established that institutional differences across countries are an important source of comparative advantage in global trade and production. What has received less attention is the interplay between these two at the firm level in the context of the recent rise in GVCs. To fill the gap, this paper asks whether (and why) the differences in the quality of domestic institutions across countries mediate the distributional effect of deep integration on firms' integration in GVCs? To answer this question, I measure GVC integration at the micro- (firms) and the deepening of preferential integration at the macro- (country) levels and combine these with conventional measures of the quality of domestic institutions for 124 countries between 2006 and 2020. Leveraging the differential effect of trade integration on firms with different levels of productivity across different institutional environments, I find that when the regulatory quality of domestic institutions is high, the deepening of trade integration increases productive firms' participation in GVCs - an effect that is not detected when the quality is low. By bringing the question of local institutions into the discussion of participation in GVCs and the distributional consequences of deep integration, the paper shows that the effect of trade liberalization on firms is conditioned not only on the heterogenous characteristics of firms, such as productivity, but also on the quality of local institutions.

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## Introduction

There is considerable evidence that country-level trade integration has uneven distributional consequences for local firms: productive firms win and export more while unproductive lose and leave (Melitz 2003; Bernard et al. 2003; Baccini, Pinto, et al. 2017; Topalova and Khandelwal 2011). There is also strong evidence that the quality of domestic institutions is an important determinant of nations' comparative advantage in trade (Acemoglu et al. 2001; Hall and Jones 1999; Coase 1992; North 1990). What has received little attention is the interplay between these two (firm- and country-level) advantages in the context of GVCs.

This gap exists for several reasons. In the GVC literature, theoretical study of GVCs (Gereffi et al. 2005; Gereffi 2018) and empirical analysis of trade in GVCs (Taglioni and Winkler 2016; WB 2020; Laget et al. 2020) have been institutional-free and focused on developed countries because of the limitation in the cross-country firm-level data (Johnson 2018; Baccini and Dür 2018). In the main models of trade, firms' decisions and behaviour is analyzed under frictionless market conditions, where institutional differences across countries, in terms of contracts enforcement, regulations and laws related to manufacturing and enterprise development, and the like, are not expected to determine the outcome of trade integration for firms. The key determinant in this context is firms' characteristics, such as size and productivity. In practice, however, the quality of institutional environment is an important source of comparative advantage (Nunn 2007; Levchenko 2007) that can change when and how firms with various characteristics are gaining from liberalization.

In the context of GVCs, the role of domestic institutions and local government is even more important because GVCs involve not only cross-border trade (export-import) but also production and supply chains. More constructive institutional environment can help local firms to specialize in producing high value-added (VA) inputs and products and establish more production linkages with foreign suppliers and buyers. As research indicate (Eckhardt and Poletti 2018), while the role of government in the development of global commodity chains (GCCs), the conceptual father of GVCs, has always been viewed as central, the effect of various configurations of domestic institutions on GVC integration of countries (and their firms) “remains surprisingly under-researched” (Eckhardt and Poletti 2018, 3). While the joint effect of trade integration and firm productivity may explain a lot of variations in firms’ participation in GVCs (Amiti and Konings 2007; Antràs and Helpman 2004; Goldberg et al. 2010; Baccini et al. 2018), bringing the “institutions back into the study of GVCs” (Eckhardt and Poletti 2018, 3) (De Marchi et al. 2018; Gereffi 2018), is also necessary for a better understanding of how and why more trade integration may lead to more participation of firms (and their countries) in GVCs.

To fill the gap, this paper asks whether the differences in the quality of domestic institutions across countries mediate the distributional effect of deep integration on firms’ participation in GVCs? I argue that the deepening of trade integration increases GVC participation of productive firms in countries where the quality of domestic institutions is high, and that this effect remains robust to the adjustment for several country and firm level factors and additional tests. In other words, the reallocation effect of trade liberalization on firms is conditioned not only on the heterogenous characteristics of firms, such as productivity, but also on the quality of formal domestic institutions, which has received scant attention in the intersection of the literature in trade and GVC.

I further show that the effect of good regulatory institutions, which backs up the stability of supply chain relations, is important for firms to participate more in GVCs. Because trade in GVCs can be characterized as being more customized, relationships-specific (i.e., dependent on the durability of supplier-buyer relations), and contract intensive, firms’ success depends on the level of certainty and clarity of rules and regulations that can guarantee the stability of supplier-buyer relations and eliminate the costs (and risks) associated with switching frequently to new suppliers of inputs without prolonged interruption in their supply chains. As trade integration gets deeper, firms in countries where the quality of contract enforcement and regulations is better can establish more production linkages with GVCs than firms with similar level of productivity in other countries.

The paper uses a repeated cross-section dataset that brings together macro (country-level) data for deep trade integration (using the Design of Trade Agreements (DESTA)), the quality of domestic institutions (using the World Governance Indicators (WGI)), micro (firm-level) indicators (using the World Bank Enterprise Surveys (WBES)), and other variables for 124 countries between 2006 and 2020. I measure the GVC integration of firms by calculating their GVC participation indicator, which is the sum of backward and forward linkages in constant USD, following the input-output approach developed by Koopman et al. 2014. I measure deep integration at the country-level as the average cumulative index of depth (comprehensiveness) of all PTAs signed by each country in the dataset. This variable is monadic and captures a single country's engagement in preferential trade liberalization. For the baseline models, I measure the quality of domestic institutions as the simple average of the WGI. I also estimate the effect of each dimension individually and use the firm-level assessment of domestic institutions as alternative measures of regulatory quality. The empirical approach is a multiplicative difference-in-difference (DID) strategy that exploits the variations in the effect of deep integration across different levels of firm productivity and quality of domestic institutions. The main results of double interaction with split samples remain robust to the inclusion of alternative measures of institutions and covariates as well as in the framework of a triple difference strategy and sensitivity test.

The paper makes several contributions. First, it empirically brings the question of domestic institutions into the discussion of firms' participation in GVCs and the distributional consequences of trade integration in this context. Second, it uses firm-level (micro) survey data that includes a large number of developing countries to measure GVC participation and productivity indicators. Third, it derives a cumulative measure of the depth of integration from dyadic PTA data to measure the average monadic "deepness" of preferential trade liberalization. Further, given that macro-level data on GVC are still lagging behind traditional trade statistics, despite recent improvements in GVC data and statistical approaches (Koopman et al. 2014; UN 2018, 2009), undertaking micro-level analysis of GVCs and trade is extremely important to understand how and when firms (and their countries) participate in GVCs. To the best of my knowledge at the stage of implementation of this analysis, there are no other similar studies addressing similar questions.

Conceptually, this paper builds on several streams of the literature that show: a) that trade liberalization has important distributional consequences for the economy (Baccini, Pinto, et al. 2017; Baccini et al. 2022); b) that the quality of domestic institutions is an important source of countries' comparative advantage in trade and development (Nunn 2007; Levchenko 2007; Acemoglu et al. 2001; La Porta et al. 2008); c) that supplier-buyer relations in GVCs under incomplete contracts are more sticky, because trade in GVCs requires customized inputs or processes that specific firms can provide (Grossman and Helpman 2005; Antràs 2003; Antras and Chor 2021); and most importantly on few published studies, d) that put forward the question of the link between the quality of domestic institutions and participation in GVCs theoretically (Eckhardt and Poletti 2018) and empirically for firms in one country (Ge et al. 2020; Boehm 2022) and for countries in one region (Dollar and Kidder 2017).

The structure of the paper is as follows. The next section will present the conceptual framework and hypotheses. The second section will describe the data, variables, and the empirical approach. The final two sections will present and discuss the results, followed by a concluding section.

## Conceptual framework

### The reallocation effect of deep integration on firms in GVCs

Trade integration has uneven reallocation effect on firms: it creates winners and losers among firms, depending on their levels of productivity (Melitz 2003; Bernard and Jensen 1999). Previous works based on Melitz 2003 model of trade show that the differences in productivity across firms are the key determinant of participation in and gain from trade integration for two reasons. First, compared to non-exporters, firms that want to export face higher fixed costs, i.e., costs that are sunk and irrecoverable after the initial investment and do not change as the scale of production increases. As a result, only fast growing, efficient, and productive firms can afford to meet the initial competition pressure arising from trade integration and remain above the productivity line required for survival in the foreign market. Second, after trade liberalization, the removal of barriers reduces the variable costs (e.g., wages and inputs) due to increased competition. Since marginal (per unit increase in) fixed costs remain constant and marginal variable costs decrease with more production, the effect of the economies of scale kicks in for more efficient and productive producers that aim to engage with new suppliers and buyers after the signing of new PTAs (Baccini, Osgood, et al. 2017).

Therefore, after states step into the deeper waters of trade integration, only firms with a total productivity level that is higher than the minimum threshold required for survival in both foreign and domestic markets can afford to extend their production linkages and supply chain relations beyond borders and fully participate in GVCs as buyers of foreign inputs as well as suppliers of inputs for other countries. These firms are the winners of trade integration as they can take advantage of lower tariff and non-tariff barriers and not only import from upstream countries but also add value to the production of downstream countries through export. Less productive firms that do not meet the competitive productivity threshold in the foreign market but meet the minimum productivity level at home remain focused only on the domestic market, and do not export after trade integration . They may still import foreign parts for assembly and domestic consumption and benefit from cheaper inputs through backward production linkages, but they do not add value to the production and export of other countries. Less productive firms that do not meet either domestic or foreign productivity thresholds , do not survive after trade liberalization and are forced to close production altogether. These firms are the losers of trade integration.

The relationship between firms' productivity and integration in GVCs through establishing more backward (as buyers of other firms' inputs) and forward (as suppliers of inputs for other firms) follow the same logic outlined by Melitz 2003 in the context of traditional export: more productive firms win from trade integration and participate more in GVCs while less productive firms fail to do so and lose. While winning and losing in new (new) trade theories (NNTT) is measured in terms of revenue, here we define win and lose in terms of more participation in GVCs as buyers and suppliers. When countries sign more comprehensive (deeper) trade agreements, the minimum threshold of productivity required for survival in the foreign market changes because of a reduction in trade barriers and the costs of production. Productive and already exporting firms find more opportunities to connect to GVCs. Once they enter a GVC process, these firms can afford to invest further in upgrading their production processes, specialise in higher VA activities, and customize their products according to the need of their buyer-firms, effectively establishing long-term production linkages.[1]

Therefore, the effect of trade integration on productive firms' gains and participation in GVCs will increase as trade integration gets deeper, i.e., deep integration has greater reallocation effect than shallow integration on the participation of more productive firms in GVCs.

### Institutional differences as a source of comparative advantage in GVCs

The distributional effect of international institutions is one key factor determining firms' participation in GVCs. The other is the quality of the institutional environment within which firms operate and make their decisions. As new institutionalism argues, nations' comparative advantage and economic development are the direct consequences of the quality of their institutions. Countries with low-quality institutions (LQI), i.e., weak rule of law and regulations, political instability, high corruption, and low contract enforcement, show much less economic progress and experience more underdevelopment than countries that have high-quality institutions (HQI) (Acemoglu et al. 2001; Hall and Jones 1999; Coase 1992).

In international trade, much of the differences in the pattern of export across countries have empirically been linked to the differences in the overall quality of their domestic institutions (Nunn and Trefler 2014; Chor 2010). High quality of various dimensions of domestic institutions that are geared toward the development of private sector, i.e., financial regulations (Beck et al. 2003; Manova 2013), labour regulations (Costinot 2009; Cunat and Melitz

1. As shown elsewhere (Razeq 2022), unlike traditional trade, trade in GVCs indeed increases more in the long rather than in the short run under deeper trade integration. Results in these two chapters are consistent: deep integration increases VA trade in the long run for more productive firms in HQI.

2012; Baccini et al. 2022), regulatory and judicial institutions (Long 2010), intellectual property rights institutions (Ang et al. 2014), and legal and contractual enforcement institutions (Ottaviano 2008) among others, have consistently shown a strong and positive effect on gain from trade than LQI.

In the context of GVCs, the same strong mediating effect of domestic institution is expected. With the globalization of production and rise of GVCs, the role of local institutions supporting domestic production and trade has not become obsolete. In contrast, domestic institutions are more important than before for GVC integration because they can be relied on to improve the quality of production and determine the intensity and size of firms' participation in export and GVCs. The differences in the quality of domestic institutions across countries, therefore, are a source of comparative advantage that can significantly mediate the joint effect of deep trade integration and productivity and lead to uneven distribution of gains from trade in GVCs among firms.

*H1: deep trade integration increases productive firms' participation in GVCs if the overall quality of domestic institutions is high.*

## The regulatory quality of domestic institutions and GVCs

Regulatory quality of formal institutions that are geared toward the private sector, i.e., the "quality of contract enforcement, property rights, shareholder protection, and the like," are important determinants of trade and development (Levchenko 2007, 791). As North (1990) argues, "the inability of societies to develop effective, low-cost enforcement of contracts is the most important source of both historical stagnation and contemporary underdevelopment" (p. 54). In common law countries, for example, where these regulations are more rigid than in civil law countries, more rapid growth in trade and market relations are observed (Chong and Zanforlin 2000; La Porta et al. 2008; Knack and Keefer 1995). As Levchenko (2007) and others (Nunn 2007; Acemoglu et al. 2005) show, the differences in the pattern of trade among countries can be explained more by the presence of strong legal and regulatory institutions than traditional economic factors such as physical capital and skilled labour combined. More recent works with firm-level data show that in countries where prices and wages are coordinated rather than determined by the markets, i.e., the regulatory quality and the effect of market institutions are weak, firms' revenue does not change after trade liberalization. In contrast, where the regulatory quality of institutions that foster competition and market-based exchange is high, trade liberalization brings more opportunities (and revenue) for those firms that are productive (Baccini et al. 2022).

The same general logic applies to trade in GVCs. In the absence of a strong legal and regulatory environment in an upstream (supplier) country B, for example, even the most productive and large downstream (buyer) firms from country A may find it too costly to establish production linkages with firms from B. If in country C, where regulation obstacles concerning labour, customs, contracts, and similar issues are low, and there are firms that can produce the required parts and components, buyers from A may be willing to pay an even higher sunk cost and invest more in GVC relations with firms from C and not B in order to secure a long-term and stable supply chain for their production. One recent example is the opening of Volkswagen's assembly plant and its joint investment with Siemens to produce and test its first African electric cars in Rwanda, a country that scores high in WGI in the region and has been on a steady growth path in recent years.[2]

In the context of GVCs, there are at least three more characteristics of supplier-buyer relations that explain why the mediating effect of good quality of the domestic regulatory environment may be important for integration of firms in GVC. These are product (relationships) specificity, high costs of keeping inventory, and contract intensity. First, under trade in GVCs, products require a specific set of technologies, resources, and features that only particular upstream producers can deliver. Product specificity leads to relationship specificity, when downstream buyers cannot "rely on spot markets" for immediate fulfillment of their contracts (Levchenko 2007, 791). The specificity of supplier-buyer relationships or, to use Antras and Chor (2021)'s term, the "stickiness" of contracts in GVCs, makes it costly (if not impossible) for buyers to change their suppliers swiftly when needed to preserve the steady flows of their

2. Volkswagen press release available here.

supply chains. The higher the specificity of products and relationships, the higher the effect of good institutions on firms' participation in GVCs as trade becomes more open.

Furthermore, more reliance on just-in-time (JIT) logistics as an inventory cost-reduction strategy (Pisch 2020), which is a defining feature of international supply chains these days, also makes firms' decision within GVCs more sensitive to uncertainty associated with low regulatory and institutional quality. Finally, because GVCs involve a set of fragmented production processes involving trade in multiple customized parts and components, trade in GVCs is also more contract-intensive than traditional trade, i.e., in the making of one item in GVCs, several transactions (and contracts) may be involved (Dollar and Kidder 2017; Nunn 2007). Thus, a higher degree of contract intensity increases the importance of good regulations for firms aiming to participate in GVCs as trade barriers decrease.

These features of GVC amplify the significance of good regulatory environments for the stability and resilience of supply chains through a decrease in uncertainty and associated costs. The risk and costs associated with under-fulfillment or non-enforcement of contracts increases for buyers when the quality of regulatory environment in the supplier's country decreases.

*H2: deep trade integration increases productive firms' participation in GVCs if the quality of regulatory institutions and contract enforcement is high.*

## Dataset and variables

### Dataset

The dataset is based on survey responses of firms operating in 124 developing and developed countries between 2006 and 2020.[3] The key advantage of using the WBES is that it covers a large number of firms in developing countries, which are rarely covered by commercial firm-level datasets. WBES contains information on firms' characteristics (location, size, ownership), operation (capacity utilization, export, sales), and inputs (origin of resources, labour,

3. The current methodological standards and questionnaires was introduced in 2006, which makes a few surveys conducted before 2006 incomparable.

assets).[4] To these data, I calculate and add annual monadic variables for PTAs (based on DESTA), the quality of institutions (based on WGI, Polity V, and Ease of Doing Business (EODB)), country-level characteristics (from World Development Indicators (WDI)), average tariffs (from Trade Analysis Information System (TRAINS) and World Integrated Trade Solution (WITS)), and the concordance between 2-digit ISIC 3.1 reported in WBES, 4-digit ISIC 3.1, HS 2017, and BEC 5 at the 4-digit level (from UN Comtrade) for the calculation of GVC participation. Together this compiled dataset makes it possible to measure firm-level GVC integration, the depth of country-level preferential trade integration, and the quality of local institutions, as well as to exploit the differences across firms, industries, countries, and time.

The unit of observation, thus, in this paper is firm-industry-country-year (*fict*). Industry is defined at the ISIC 3.1 4-digit level. The structure of the dataset is repeated cross-sections (not longitudinal). This structure is determined by two characteristics of the WBES. First, the number of surveys across country and year is unbalanced, i.e., it varies across countries and time in the sample. At various years throughout the 2006–2020 period, the World Bank (WB) conducted four waves of surveys. Although most countries have two or three waves conducted, there are a few countries in the dataset with one wave and two countries with a fourth wave. Furthermore, each wave is implemented on a new representative sample of firms, which means that firms are not identifiable across the waves.

Note that since approximately 60% of firms in the dataset report 0% when asked about the percentage of annual sales that is exported directly or indirectly, the measures of GVC that I calculate from the WBES are only for less than 40% of firms that participate in exporting. Among these exporting firms, not all report on the key variables needed for the calculation of the GVC participation variable. For this reason, I am able to calculate the outcome variable for 17,748 observations, and in the full model, we can use 9,719 observations because of the lack of values for PTAs and/or productivity. Note also that firms include those that are oper-

4. WBES also contain questions on firm-level perception of local and institutional environment, which allow to measure the stringency of issues that they face. These questions can provide a firm-level alternative to the WB's Ease of Doing Business (EODB) dataset, which has been suspended because of external concerns over the transparency and accuracy of estimation. See here.

ating in the formal sector. Since the WBES collects all financial variables in local currency units (LCUs), financial variables, such as sales, are in different currencies. To deal with this, I convert all financial variables into USD, using the International Monetary Fund's (IMF) official exchange rates (annual average), and then deflated them to 2010 prices using the WB's annual gross domestic product (GDP) deflator for the United States (US).

### Dependent variable

The outcome variable, $log(GVC_{fict})$, is the log of GVC participation in constant USD (2010=100) and is calculated for each firm in a specific country, industry, and year, using the WBES. GVC participation is the sum of foreign value added contained in the export of country A and domestic value added of country A contained in export of other countries. This variable, therefore, captures both forward and backward production linkages and is a trade-specific measure of GVC integration. To calculate this variable, I follow the input-output approach that is used to calculate GVC statistics at the country level (Koopman et al. 2014) and take the following steps. First, I calculate the total value of export (in constant USD, 2010=100) for each firm, using the WBES information on the percentage of total sales that is exported directly or indirectly, i.e., through an intermediary. Second, I rely on WBES information about the origin of inputs (i.e., foreign or domestic origin) to distinguish between domestic VA (DVA) and foreign VA (FVA) to export for each firm. More specifically, DVA is the share of material inputs of domestic origin in firms' export and FVA is the share of material inputs of foreign origin in firms' export (both in constant USD, 2010=100). Third, I use the concordance tables between ISIC 3.1 and HS 2017 at 4-digit level (UN Statistics) and manual matching to identify BEC 5 class at 3-digit level for each firm. This allows to identify the end-use classification (i.e., intermediate products, final consumption, or capital goods) of firms' DVA. Of interest here is the intermediate designation of products. Fourth, that part of DVA that is exported for intermediate consumption gives us the DVX value. Finally, the sum of FVA and DVX gives us the GVC participation measure.

### Main interaction terms

The main independent variable is the interaction between the deepness of trade integration at the country level and firm productivity at the firm level: $Depth_{ct} \times Productivity_{fict}$. More specifically, the Depthct of trade integration for a single country is based on a continuous measure of depth of PTAs from the DESTA dataset: Depth Rasch Index – DRI (Dür et al. 2014). DRI captures the extent to which a PTA covers beyond-tariffs trade issues and rarely negotiated trade areas (e.g., property rights, investment, services, procurement policies): the more extensive is the coverage, the deeper is a PTA. In DESTA, this measure is specific to each PTA and does not vary across countries and years: a country may sign several PTAs of various depths in one year and not sign any in the next few years. To capture the depth of preferential trade integration for each country across time, I use DRI to calculate an average annual cumulative measure of the deepness of preferential integration for each country in DESTA. In other words, the $Depth_{ct}$ in this paper is the annual cumulative sum of the depth of all PTAs that a country has entered annually since the 1980s divided by the cumulative sum of PTA numbers.

$Productivity_{fict}$ is measured as the log of total labour productivity, i.e., total sales per unit of labour cost (in constant USD, 2010=100). This partial measure of productivity is used here instead of total factor productivity (TFP) for two reasons.[5] First, not all variables required for the calculation of TFP, i.e., the cost of raw material, finished products, and capital, are not available for a large number of exporting firms. Second, although theoretically TFP is argued to be a more comprehensive measure of productivity than labour productivity, in practice, the two measures are highly and positively correlated; in addition, the latter is less sensitive to certain methodological choices and provides a more straightforward measure and interpretation of firm-level cost-growth relation.[6]

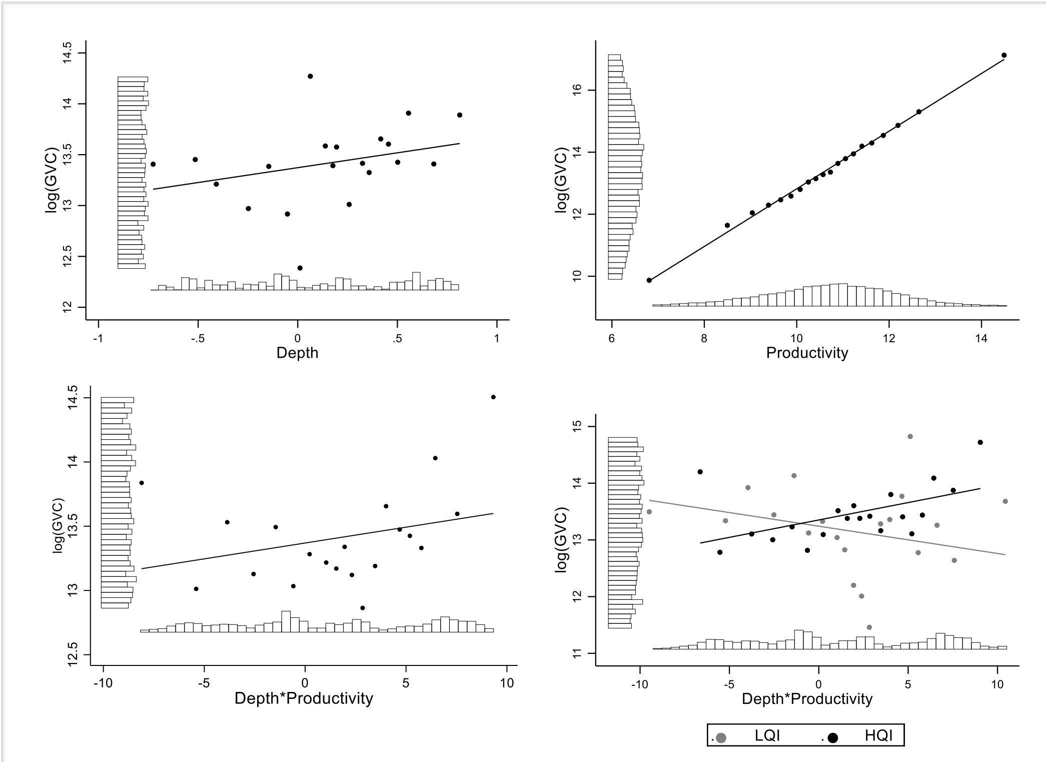
5. TFP for firm-industry level is calculated and provided by the WB in a separate dataset for less than 30% of observations. Using this variable produces inconsistent results because GVC variables cannot be calculated because of missing values for other indicators. For more on the method of calculation of TFP, see the WBES documentation, available here.

6. Furthermore, as argued by others, since TFP depends on the level of capital accumulation, it is not a more fundamental measure of productivity and growth, compared to labour or capital productivity, and its construction and interpretation is subject to several strong assumptions (Lipsey and Carlaw 2004; Murray 2016). For a more in-depth discussion of the differences between labour, capital, and total productivity, see Altomonte and di Mauro

The measure of the quality of domestic institutions *Institutions* is based on the average of WGI estimates and captures several dimensions of the quality of domestic institutions, such as Voice and Accountability, Political Stability (VA), Political Stability and Absence of Violence/Terrorism (PV), Government Effectiveness (GE), Regulatory Quality (RQ), Rule of Law (RL), and Control of Corruption (CC). As an alternative measure of institutions that is theoretically more important in the context of GVCs, I use the quality of contract enforcement from the EODB dataset, which is also a continuous measure. Both continuous measures are then used to derive dummies that identify countries with low (below the median) and high (above the median) quality of institutions and contract enforcement, i.e., LQI and HQI. To make sure that there is no reverse feedback from other variables on the quality of institutions, I use the 2005-year values for all institutional variables in order to "fix" them at the year before the time-span of our data begins (Wooldridge 2010, 73-75), and then calculate their averages and dummies. In order words, variable *Institutions* remains constant. Figure 1 plots that relations between the main variables. Summary statistics and correlation matrix are presented in Tables 1 and 2 in Appendix A.

(2022, 8-35).

**Figure 1:** Binned scatter plots of main variables [7]




Note: binned scatter plots implemented by reghdfe with robust SE and country-level controls. Histograms of frequencies for each variable are along the respective axes. The height of histograms is not related to scales of plotted axes.

## Controls

I control for standard firm-level characteristics that are not highly correlated with the outcome and the main interaction terms but are important in determining GVC participation. Firm-level controls specified in the Tables include *Age* (the log of the total number of years since the establishment has been in operation),[8] *Assets* (proxied by the cost for firm to re-

7. Binned scatterplots are scatterplots with reduced visual noise (through binning of the independent variable) and have the capacity to include covariates, FE, clustering method, and the distribution of scattered variables. *binscatterhist* (Stepner 2013; Pinna 2020) used here performs high-dimension FE regression (*reghdfe*) to calculate residuals before plotting the scatter. See also *binsreg* Cattaneo et al. (2021).

8. Adding the square of age variable in addition to log of age in the right-hand side of the equation is often recommended to model more accurately the effect of age, which may have a non-linear relationship with the outcome. For instance, the effect of age could be negative until, say, the age of 10, and then turn positive thereafter.

purchase all of its machinery),[9] *Foreign Technology* (a dummy for the use of technology licensed from a foreign firm), and *Innovation* (a dummy if the firm reported new product, new process, or any R&D spending over the past three years). I do not include other variables that are highly correlated with the main interaction terms and the outcome, such as *Size, Ownership, and Skills*; the differences in the levels of these variables are captured by firm-level controls that are included.

At the country-level, I control for traditional controls such as the overall size of the economy *(log(GDP))*, trade *(log(Export))*, and the level of development of physical infrastructure ( *Infrastructure*), proxied by the number of fixed telephone subscriptions per 100 people of population. Controlling for the level of physical infrastructure in the context of GVC is important because countries with better logistics provide better supply chain conditions for firms.[10] All these three indicators are from the WDI. To control for the level of multilateral liberalization, I also include the average MFN rates *(log(MFN Av.))* at the 4-digit ISIC 3.1 level (UN TRAINS, 2021).[11]

**Adjusting controls:** In multiplicative models such as the one implemented in this paper, potential country- and firm-level characteristics may influence both the main independent and the dependent variables and cause the detected interaction effect. Simply including these controls by themselves will lead to incorrect and false-positive results. As suggested by others (Keller 2014; Yzerbyt et al. 2004; Baccini et al. 2022), these control variables need also to be adjusted for the main interaction terms and included in the right-hand side of the model in addition to the main interaction variables. To meet this requirement, I interact firm-level controls with country-level term, i.e., $Depth_{ct}$, and country-level controls with firms-level term,

Because we have only four waves at maximum, this issue is not of a serious concern here, and including the squared value of age does not change the results. Some firms report unrealistically high number of years (over 500 years) in the market; these values are turned into missing values. The frequency of these high values is less than 1% in the distribution of age measure.

9. Note that the WB use this variable as a proxy for capital in the calculation of TFP (see WBES documentations online).

10. In terms of firm and country level control variables, as Pietrobelli et al. 2021 show in Table 1 of their paper, GVC participation is affected primarily by policies related to the creation of an enabling business environment (i.e., institutions), elimination of trade obstacles (i.e., integration), improvement of transport and digital infrastructures (i.e., infrastructure), and others.

11. World MFN weighted average (%) tariffs are from WITS, UNCTAD TRAINS dataset. Since this variable is at the industry level, it is interacted with both terms of interaction.

i.e., $Productivity_{fict}$. This will allow us to confidently conclude that added control variables drive the outcome only in the presence of the effect of the main interaction terms.

### Empirical strategy

This paper is concerned with the effect of deep integration on GVC participation of firms given firm productivity and the institutional environment within which firms operate and participate in GVC. To assess this conditional effect, I take a difference-in-differences (DID) approach and implement a multiplicative double interaction model with country-year and industry FE (Angrist and Pischke 2009, 48-51). Using double interaction is a way to capture the DID effect. However, since the argument states that domestic environment may still change the way Depth and Productivity influence GVCs over time, I stratify the sample across a third variable, *Institutions*, which distinguish between LQI and HQI at the country level, as described in the previous section.

Using a double interaction with stratification across a third variable is equivalent to a triple differences (TD) strategy (or a DIDID), which could be established as a triple interaction model that looks for the change in GVC participation given the differences across the levels of deep integration, productivity, and institutions in the same model. However, for the simplicity of interpretation, we can achieve the same goal in capturing these differences through double interaction with split samples based on different levels of a third variable, i.e., the quality of institutions. As noted in other fields such as corporate finance (Atanasov and Black 2016), health science (Wing et al. 2018), and economics (Olden and Møen 2020), a powerful alternative to TD "is to limit the sample in a way that makes the third difference unnecessary" (Atanasov and Black 2016, 256). It is also advised that "researchers almost always present triple difference specification results as a supplement to a main DID specification" (Wing et al. 2018, 461). This is what I do in this paper: the main strategy is a double DID with split samples based on the levels of institutional quality dummies. The results of TD estimates are presented for robustness check (see Appendix C).

I run ordinary least squares (OLS) regressions with standard errors clustered at the country-year level and split samples for LQI and HQI. In its most detailed form, the multiplicative OLS model used in this paper is:

$$\begin{aligned} log(GVC_{fict}) = & \beta_0 + \beta_1 Productivity_{fict} + \beta_2 (Productivity_{fict} \times Depth_{ct}) + \\ & \gamma Z_{fict} + \nu (Z_{fict} \times Depth_{ct}) + \eta (M_{ct} \times Productivity_{fict}) + \\ & \delta_{ct} + \tau_i + \epsilon_{fict}, \end{aligned} \tag{1}$$

where $log(GVC_{fict})$ is the log of dependent variable at the firm-industry-country-year level. $Productivity_{fict}$, $Depth_{ct}$, and their interaction are the main independent variables. $\beta_0, \beta_1, \beta_2, \gamma, \nu$, and $\eta$ are the coefficients. The key coefficient of interest is $\beta_2$, which I expect to be positive because both variables theoretically have a positive effect on the dependent variable. $\delta_{ct}$ and $\tau_i$ are country-year and is industry fixed effects. Country-year fixed effects absorb time-variant differences across countries, whereas industry fixed effects absorb time-invariant differences across industries. Since we include $\delta_{ct}$, I am unable to estimate the coefficient of $Depth_{ct}$, i.e., it is absorbed by the country-year fixed effects. $\epsilon_{ict}$ accounts for all residual determinants of the outcome variable. The matrices of $Z_{fict}$ (in interaction with the country-level main interaction term $Depth_{ct}$) and $M_{ct}$ ( in interaction with firm-level main interaction term $Productivity_{fict}$) include standard firm- and country-level controls, respectively.

## Concerns about the identification strategy and remedies

There are several possible questions related to the empirical strategy used in this paper that I discuss below.

**The main interaction terms:** Variable $Depth_{ct}$ strongly varies across countries but weakly across country-year. Variable $Productivity_{fict}$, in contrast, varies across firms, industry, and year; in addition, the correlation between the two variables is weak (0.17; see Table 3 in Appendix A). For this reason, $Depth_{ct}$ is not the predictor of $Productivity_{fict}$, which is further confirmed if we regress the latter on the former with the main covariates and country, year, and industry FE.[12] The interaction of these two variables results in a term that varies significantly at the lowest level of observations, i.e., firm, industry, country, and year.

**Multicollinearity:** Overfitting and multicollinearity are the usual concerns about adding too many terms in multiplicative models when adjusting for covariates. A classic response to these concerns is to not interact controls by covariates or alternatively to mean-center all variables before implementing the analysis. Regarding the first solution, as described above, omitting the interaction between control and the main interaction terms will lead to incorrect specification, and the second one is argued to be an overstated concern. As recent works show, "the problem of multicollinearity in multiplicative interaction models has been overstated" (Brambor et al. 2006, 70), because an increase in multicollinearity among the interaction terms is expected. The main goal of "including covariate interaction terms is not to estimate their effects per se, but rather to control for their effects" on the main interaction term and rule out alternative explanations arising from those controls (Keller 2014, 8). The only way to do this is to look at the changes in the effect of the main interaction term when we vary it by controls through interaction. If the main effect from the interaction term does not change, then we can be confident that alternative explanations arising from the identified controls do not affect the estimations. Regarding the second solution, while mean-centering variables decrease the VIF of some variables, it does increase the correlation among other variables, making the matter actually worse, and in light of previous discussion in this paragraph, mean-centering is unnecessary.[13] As Hayes et al. 2012 notes, an improvement to the "model coefficients and standard errors have nothing to do with reduced multicollinearity that results from mean centering" (p. 289). This conclusion is also supported by other advanced methodological works on the subject (Iacobucci et al. 2016; Shieh 2011).

**Sampling:** Theoretically, firms from countries that engage more in deep preferential integration export more and participate more in GVCs. For this reason, GVC participation may

12. Results are available upon request.
13. Results are available upon request.

be driven mostly by firms that are in deeply integrated countries. Two pieces of evidence address this concern. First, the WBES draws a new representative sample of firms for each new wave of surveys. Firms are not selected for their size, sales, or export, which could bias their selection for the purpose of this paper. Second, the correlation between GVC and Depth variables is low (see Table 2 in Appendix A), and because firms from developing countries are not overrepresented in the dataset, the GVC participation of firms from deeply integrated countries do not drive the results.

**Pre-trends:** Deep integration differentially affects industries across countries because tariff reduction is heterogeneous across industries and countries. For this reason, some industries in some countries might have already been on a steeper upward trend in terms of trade liberalization and firms' participation. These differential trends can potentially bias the outcome toward firms that are in deeply integrated countries and industries. To account for different trends across industries within the same country (and for different trends between industries with the same ISIC 3.1 code across different countries), I follow others on this issue (Antràs and Chor 2018, 187, Levine et al. 2018) and test for country-industry specific time trends by including country-industry dummies with linear time variables in the main models with double as well as triple interactions. If the results remain unchanged to this inclusion, the possibility of bias arising from differential trends can be ruled out, providing support for the parallel-trend assumption at the country-industry level.

**Additional country-level controls:** While all models include key firm- and country-level controls, it is not possible to completely address the issue of omitted variables (Baccini et al. 2022). However, to check for the robustness of our finding against the omission of important covariates, I take two additional steps. First, I identify and include in the main models with double (and for robustness check, also in triple) interactions several other country-level characteristics that are conceptually and statistically correlated with both *Depth* and *Institutions* and could potentially explain away the differences in the effect of the main interaction terms across different levels of institutions on GVC participation. If the inclusion of additional covariates does not absorb the direction and significance of the effect of interaction terms in the main models, then we can be confident that the effect observed in the main models is not confounded by these covariates.

For example, high *economic globalization and informational globalization* scores, i.e., access to the internet, television, and free press, could be the key mechanism mediating the effect of interaction terms on GVC participation. The other potential mechanism could be the *historical origin of the national judicial and legal system*. Higher costs and uncertainty of business decisions as well as weaker contract and property rights regulations are associated with countries whose legal and judicial institutions have civil rather than common law origin (Levchenko 2007; La Porta et al. 2008; Pistor 2005). Countries that score high in expert-opinion indices, such as the *EODB* indicator, or attract more *foreign capital (FDI)*, or have a higher *GDP per capita* may also be overly represented in HQI and drive the results. Therefore, I include these additional covariates in the main models of interaction with and besides the main interaction terms to see if they can provide a more powerful explanation than the quality of institutions measures. Second, I also implement a sensitivity analysis (Cinelli et al. 2020) of the specified models to the omission of unobserved confounds that could be as strong as *Productivity*, which is the main independent variable. Again, the expectation is that our results will not change dramatically if the identification strategy taken in this paper is indeed causal.

**Negative weights:** OLS with fixed effects (FE) is a common tool for DID analysis. When the treatment effect is homogenous across treated units, the common trends assumption is satisfied, and the FE estimator is just a linear combination of the treatment effects across all treated units. Since the treatment is homogenous, the relationship between the residualized outcome and residualized treatment will still be linear even after removing the FE.

However, when a treatment is applied heterogeneously across units in different countries and years, and analysts control for location- and time-specific periods FE, OLS with FE may no longer be “a consistent estimator of the average treatment effect” (Gibbons et al. 2019, 1) (Roth et al. 2021).

This is because the FE estimator places more negative weights[14] on observations that are treated in a later period because of the expectation that the effect of the treatment is less prominent in the later than in earlier treated units, i.e., when a unit is treated in an earlier period, it remains treated in the later periods. While overall negative weights are a natural consequence of correctly specified FE and are not in and of themselves a cause for concern when treatment is homogenous, they can severely bias the estimation when treatment timing is staggered for a large number of observations, which is the case in this study.
One way to check for the severity of the issue is to omit late-treated observations. If we implement a triple interaction model with data for only two years, the results should be similar to those obtained with all years included.

## Results

Table 1 shows the main results with firm- and country-level controls. Models 1–3 include all firms, regardless of their institutional environment. These models show the joint effect of double interaction term among Depth and Productivity on GVC participation of firms. More specifically, Model 1 assesses this effect with country, year, and industry FE, and Model 2 includes country-year and industry FE. In all these models, the coefficient of Depth is not shown. As explained before, this is because Depth gets absorbed by FE because of collinearity. Model 3, in addition, includes country-industry specific time trends. As Models 1–3 show, the coefficient of double interaction among Depth and Productivity is always positive and significant, which implies that the effect of deeper integration on GVC participation is positive when conditioned on firm-level productivity, i.e., the conditional effect of both variables is positive. These models show that productive firms participate more in GVCs when their countries enter deeper trade agreements. In other words, deep trade integration has a significant distributional effect on GVC integration at the firm-level because it enables more productive

14. Negative weights are proportional to the residuals from a regression of treatment on country and year fixed effects, scaled by the sum of the squared residuals across all observations.

firms to stay and less productive firms to exit from GVC trade. These results remain positive and significant when Model 3 also includes country-industry time trends, i.e., linear time trends for each country-industry. The coefficient of interaction term does not change in sign and significance, suggesting that these trends do not explain a substantial portion of the variation in the outcome.

To test if the quality of formal domestic institutions mediates the effect of deep trade integration on GVCs integration across different levels of productivity (H1), Models 4 and 5 split the full sample into LQI (below the median level) and HQI (at or above the median level) environments, using the average WGI variable at 2005 baseline as described in the Data section. While for LQI, the coefficient of $Depth \times Productivity$ does not show any significant effect on GVC participation, there is a strong and positive effect on participation of firms located in HQI countries. In other words, HQI does make a significant difference in the reallocation effect of deep trade integration among productive and unproductive firms.[15]

15. While a small sample size is the main suspect in yielding insignificant results, a simple power test for LQI shows that a much smaller sample size of <320 observations would be enough to obtain statistically significant results (at 5%). In addition, a two-tailed test of equal means between LQI and HQI for the response variable confirms that the difference between the two groups is not equal to zero and is highly significant. The overall F-statistics for Model 4 is also significant at 1% level. Therefore, insignificant result for LQI is not because of the power and sample size. Results are available on request.

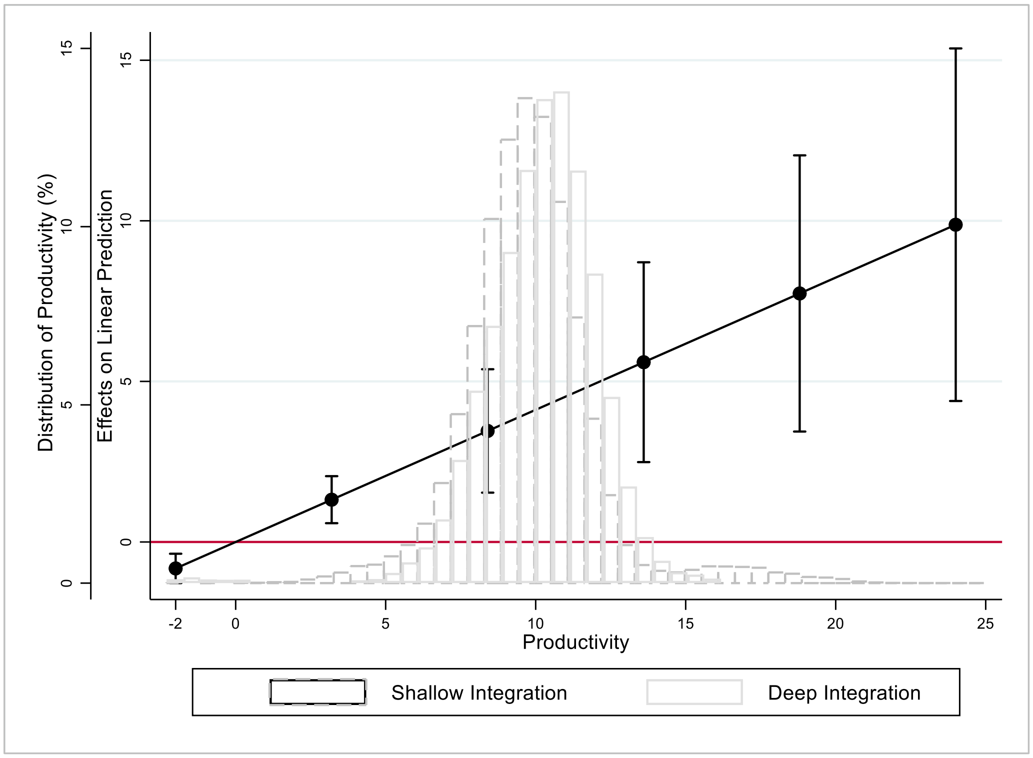
**Table 1:** The reallocation effect of deep trade integration on GVC integration of firms for different levels of firm productivity and the quality of domestic institutions

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| | logGVC) | | | | |
| | Full sample | | | Split sample by the quality of domestic institutions | |
| | | | | Low Quality | High Quality |
| Depth | - 6.247*** | | | | |
| | (1.147) | | | | |
| Productivity | -0.1478 | 0.450 | 0.751 | -0.125 | 1.633 |
| | (0.656) | (0.865) | (0.898) | (1.020) | (1.087) |
| **Depth*Productivity** | **0.368*****| **0.323*****| **0.408*****| **0.282** | **0.412*****|
| | **(0.082)** | **(0.094)** | **(0.101)** | **(0.200)** | **(0.117)** |
| Constant | -21.401* | -1.862*** | -25.449 | -0.400 | -2.675*** |
| | (12.50) | (0.479) | (19.835) | (0.585) | (0.605) |
| Observations | 9,719 | 9,719 | 9,719 | 3,296 | 6,423 |
| R-squared | 0.626 | 0.636 | 0.681 | 0.709 | 0.589 |
| Firm-level controls | ✓ | ✓ | ✓ | ✓ | ✓ |
| Country-level controls | ✓ | ✓ | ✓ | ✓ | ✓ |
| Country-year FE | | ✓ | ✓ | ✓ | ✓ |
| Industry FE | ✓ | ✓ | ✓ | ✓ | ✓ |
| Country FE | ✓ | | | | |
| Year FE | ✓ | | | | |
| Country-industry time trends | | | ✓ | | |

Note: OLS with standard errors clustered at the country-year level in parentheses. The unit of observation is firm-industry-country-year. Industry is defined at ISIC3.1 4-digit level. *** p<0.01, ** p<0.05, * p<0.1

To ease the interpretation of results, Figure 2 plots the average marginal effect of shallow and deep integration on GVC participation of firms at different levels of productivity for HQI (Model 5, Table 1). Overall, the plot suggests that the effect of deep integration on firms' participation in GVCs increases as the productivity of firms increases. An elastic marginal effect with double interaction for HQI means that, when the quality of institutions are good, productive firms participate more in GVCs after trade liberalization.

**Figure 2:** Average marginal effect of deep trade integration on GVC integration of firms for different levels of firm productivity in countries with HQI

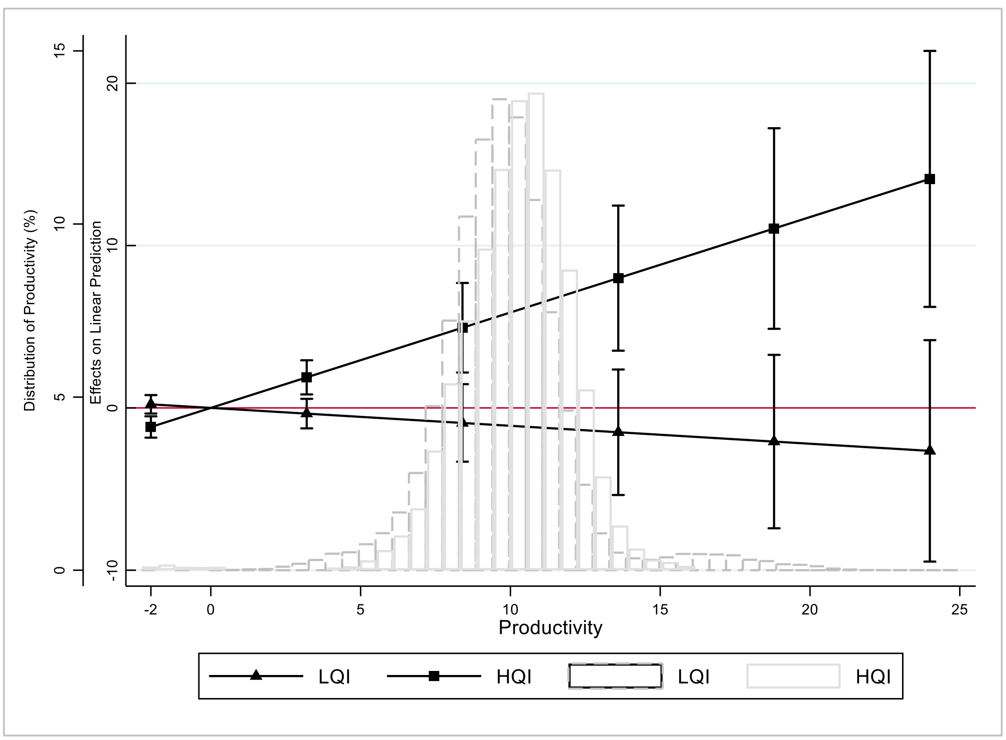



Note: Marginal prediction for HQI sub-sample is based on Model 5, Table 1. The histogram shows the distribution of Productivity for countries with shallow and deep preferential trade liberalization; 95% confidence interval.

As noted, double interaction with the split sample across a third variable is equivalent (and preferable due to the ease of interpretation) to a triple interaction strategy. To check if the robustness of the results from Models 4 and 5 are confirmed when we look at the differences between the effects of deep integration across different levels of institutions and firms in terms of productivity in the same model, I also implement a triple difference by interacting the continuous average WGI variable at 2005 baseline directly with $Depth \times Productivity$ (see Table 5 Appendix C). The strong mediating effect of institutions on GVC participation of firms across different levels of depth and productivity is confirmed and in line with Models 4 and 5 in Table 1. The coefficients of double interaction term (Model 2, Table 1) and triple interaction term (Model 2, Table 5 Appendix C) also remain robust with the inclusion of additional country-level covariates (see Tables 4 and 5 in Appendix C).

Figure 3 shows the average marginal effect of triple interaction at 95% CI (see also Table 5 in Appendix). The marginal effect of trade liberalization for different levels of productivity and institutional quality shows a strong and positive effect for HQI. The CIs for HQI remain above the zero line and do not overlap with LQI, i.e., the means of these two groups are different. LQI has a downward trend but covers the zero line too, indicating that the environment may have no and even a negative effect on firms' participation in GVCs after trade integration. More productive firms in LQI may actually disintegrate from GVCs after trade liberalization. In other words, the distributional effect of trade liberalization given firms' productivity works in the HQI environment.

**Figure 3:** Average marginal effect of deep trade integration on GVC integration of firms for different levels of firm productivity and quality of domestic institutions




Note: Marginal prediction based on using Model 2 in Table 5 Appendix C. The histogram shows the distribution of Productivity for LQI and HQI countries; 95% confidence interval.

Another way to simplify the interpretation of the results of a three-way continuous interaction term is the analysis of simple slopes. An analysis and pair-wise comparison of simple slopes for GVC participation of firms shows significant (at 1%) within-group differences for both productive and unproductive firms across different institutional environments and across-group differences for productive and unproductive firms in HQI environments. This comparison confirms that HQI enables productive firms to integrate more completely in GVCs after the deepening of trade integration.

Because the main variable that captures the quality of institutions is an average of all six dimensions of WGI (2005), it may be that consistently robust results for HQI described above are driven by only one or a few strong dimensions of WGI estimates. Table 2 deals with this concern. Models 1–6 estimate the joint effect of Depth and Productivity conditioned on different dimensions of institutional quality. They split the full sample into low (below the median level) and high (at or above the median level) institutional environments, using VA, PV, GE, RQ, RL, and CC at 2005 baseline. Since each of these dimensions captures different aspects of political, regulatory, and judicial institutions, some of them are more directly related to the private sector development than others. For example, by definition, those most directly dealing with firms and production are RQ, which captures the quality of policies and regulations geared toward private sector agents and their development, and RL, which captures confidence in the quality of regulations, quality of contract enforcement, property rights, and the courts. Results show that productive firms in countries that score high in these dimensions integrate more in GVCs after trade liberalization than other firms. Results consistently show that the mediating effect of HQI across all six constitutive dimensions of the WGI indicator remains significant for productive firms in HQI countries.

For each dimension of institutions, Figure 4, plots the marginal effects of deep integration across different levels of productivity for firms in HQI, using Table 2, i.e., Models 2, 4, 6, 8, 10, 12. The slope for RQ plot is slightly more elastic than other dimensions, especially when the productivity of firms increases.

**Table 2:** The reallocation effect of deep trade integration on firms' GVC integration for different levels of firm productivity across different institutional dimension

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | log(GVC) | | | | | | | | | | | |
| | WGI indicators (2005) | | | | | | | | | | | |
| | Voice/Accountability (VA) | | Political Stability/ Absence of Violence (PV) | | Government Effectiveness (GE) | | Regulatory Quality (RQ) | | Rule of Law (RL) | | Control of Corruption (CC) | |
| | LQI | HQI | LQI | HQI | LQI | HQI | LQI | HQI | LQI | HQI | LQI | HQI |
| Productivity | -0.946 | 2.195 | 0.554 | 0.663 | 0.145 | 1.278 | -1.134 | 1.786* | 0.190 | 0.897 | -0.846 | 2.092** |
| | (0.932) | (1.348) | (1.163) | (0.918) | (0.912) | (1.104) | (1.084) | (0.981) | (1.008) | (1.204) | (0.980) | (1.056) |
| **Depth* Productivity** | **0.313**** | **0.408***** | **0.282*** | **0.431***** | **0.368**** | **0.409***** | **0.280** | **0.446***** | **0.115** | **0.388***** | **0.287** | **0.383***** |
| | **(0.143)** | **(0.143)** | **(0.151)** | **(0.109)** | **(0.146)** | **(0.123)** | **(0.194)** | **(0.114)** | **(0.167)** | **(0.121)** | **(0.189)** | **(0.110)** |
| Constant | 0.182 | -2.667*** | -0.581 | -2.805*** | -0.485 | -2.528*** | -0.053 | -2.85*** | -1.758*** | -2.457*** | 0.228 | -2.617*** |
| | (0.567) | (0.655) | (0.564) | (0.602) | (0.527) | (0.690) | (0.595) | (0.642) | (0.613) | (0.668) | (0.574) | (0.591) |
| Observations | 3,502 | 6,217 | 3,782 | 5,921 | 3,248 | 6,471 | 3,370 | 6,349 | 3,847 | 5,872 | 3,333 | 6,386 |
| R-squared | 0.688 | 0.601 | 0.648 | 0.634 | 0.703 | 0.590 | 0.686 | 0.602 | 0.695 | 0.581 | 0.697 | 0.601 |
| Firm-level controls | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Country-level controls | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Country-year FE | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Industry FE | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

Note: OLS with standard errors clustered at the country-year level in parentheses. The unit of observation is firm-industry-country-year. Industry is defined at ISIC3.1 4-digit level. *** p<0.01, ** p<0.05, * p<0.1

**Figure 4:** Average marginal effect of deep trade integration on firms' GVC integration for different levels of firm productivity across different dimensions of HQI

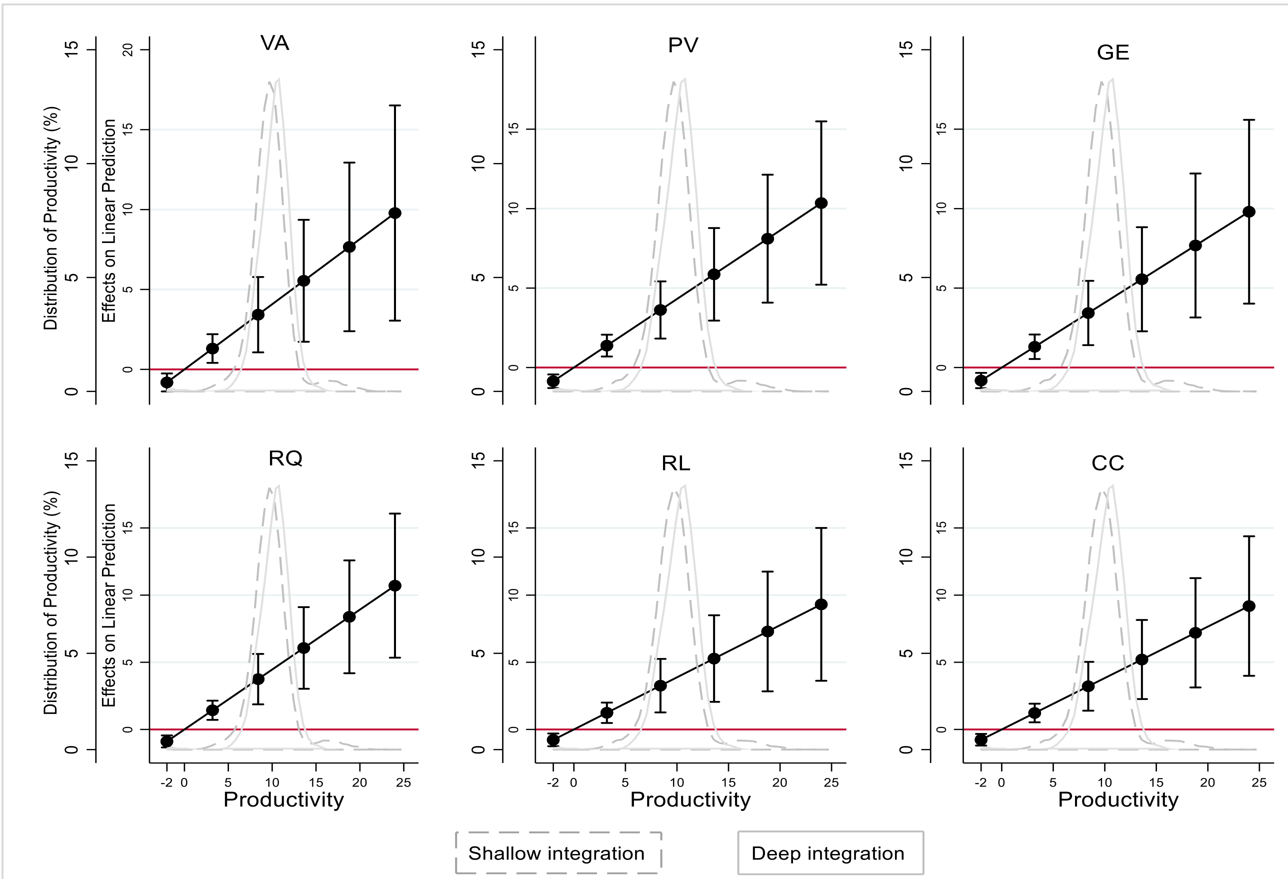



Table 3 presents the results from an interaction between Depth and Productivity given the quality of contract enforcement and regulations in several important-for-production areas (H2). The measure of contract enforcement is from the EODB (Models 9 and 10). Other measures are firm-level assessment from WBES (Models 1–8). In magnitude, the reallocation effect of HQI on GVC integrations after the deepening of trade integration for productive firms is twice that of LQI.

**Table 3:** The reallocation effect of deep trade integration on GVC integration of firms for different levels of firm productivity and regulatory quality of institutions and contract enforcement [16]

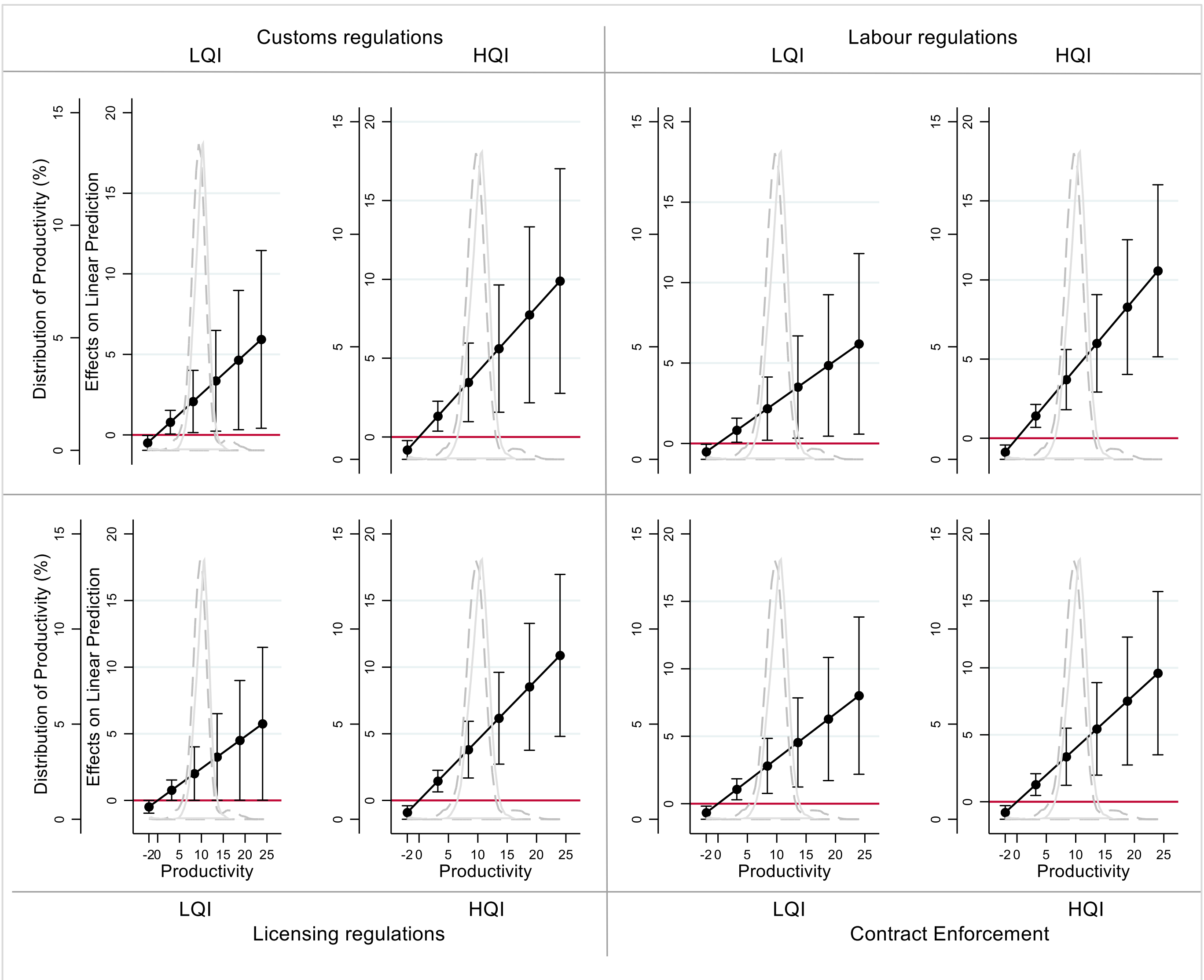
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| | Customs regulations | | Labour regulations | | Licensing regulations | | Contract Enforcement | |
| | LQI | HQI | LQI | HQI | LQI | HQI | LQI | HQI |
| Productivity | 0.729 | -0.237 | 0.791 | -0.012 | 1.336 | -0.655 | -0.311 | 1.356 |
| | (0.906) | (1.278) | (1.013) | (1.049) | (0.853) | (1.238) | (0.923) | (1.259) |
| **Depth*Productivity** | **0.247**** | **0.412***** | **0.258**** | **0.441***** | **0.240*** | **0.453***** | **0.334***** | **0.400***** |
| | **(0.117)** | **(0.151)** | **(0.119)** | **(0.116)** | **(0.122)** | **(0.129)** | **(0.124)** | **(0.130)** |
| Constant | -1.395** | -2.708*** | -2.027*** | -1.457* | -1.951*** | -2.093** | -1.709*** | -2.051*** |
| | (0.550) | (0.781) | (0.557) | (0.772) | (0.509) | (0.813) | (0.547) | (0.689) |
| Observations | 6,070 | 3,615 | 6,006 | 3,469 | 5,282 | 4,105 | 3,933 | 5,629 |
| R-squared | 0.662 | 0.617 | 0.648 | 0.637 | 0.660 | 0.628 | 0.665 | 0.624 |
| Firm-level controls | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Country-level controls | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Country-year FE | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Industry FE | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

Note: OLS with standard errors clustered at the country-year level in parentheses. The unit of observation is firm-industry-country-year. Industry is defined at ISIC3.1 4-digit level. *** p<0.01, ** p<0.05, * p<0.1

Since the effects for LQI across all areas are significant at least a 10% level of significance, we can estimate the marginal effects for both institutional environments. Figure 5 plots the marginal effects of deep integration for both LQI and HQI. Note that all plots in this paper are within 95% CI. In line with previous results, more elastic marginal effect lines for HQI show that the distributional effect of trade integration is higher in HQI environments across different levels of productivity than in LQI.

16. The computation of the indicator is based on the rating of the obstacle as a potential constraint to the current operations of the establishment.

**Figure 5:** Average marginal effect of deep trade integration on GVC integration of firms for different levels of firm productivity and regulatory quality of institutions and contract enforcement




**Other measures of GVCs:** The importance of good regulations and contracts for GVC integration after trade liberalization is also confirmed by other outcome variables. I estimate the effect of triple interaction among Depth, Productivity, and Institutions on other indicators of GVC activities, i.e., DVX, FVA, and forward (DVX>FVA) and backward (DVX<FVA) linkages (Table 7 Appendix C). The mediating effect of institutions is positive and significant. Results

are similar to our main findings with GVC participation variables for both components of GVC participation index: FVA and DVX, with a larger effect on downstream than upstream GVC trade represented by FVA and DVX, respectively. From the perspective of production linkages, the effect on backward (downstream/buyers/final producers) is positive as well. These outcomes are reasonable because downstream firms import inputs and components that are tailored to their specification from abroad to process or assemble and then export, e.g., furniture or semi-finished parts for furniture assembly. Since downstream products are more differentiated and customized, supplier-buyer relations are more relationship-specific and sensitive to JIT delivery and contract intensity, the reallocation effect of deep integration on productive firms increases as the regulatory quality of institutions increases. These results provide additional support for H2.

For forward-oriented (upstream/supplier) firms, i.e., forward linkages, the effect of interaction is negative and small. Since upstream firms export less customized inputs and more raw materials, e.g., lumber used by other countries to make furniture, they involve supplier-buyer relations that are less relationship-specific and less sensitive to JIT delivery and contract intensity. For this reason, we observe that the effect of deep integration on productive firms decreases when the regulatory quality of institutions increases. The mediating effect of a strong regulatory environment may cause firms' disintegration from forward GVC linkages as they become more productive. I cannot say that these firms switch from forward to backward GVC integration as they become more productive because firms are not identified across time in the dataset. Future research must elaborate more on the differential effect of integration on upstream and downstream firms and their change in position.

### Additional tests

As noted in the empirical strategy section, pre-trends and other confounders may seriously affect the validity of results. Because tariffs are reduced heterogeneously across industries and countries, some industries in some countries and year may be on a steeper growth curve. To account for different trends across industries within the same country (and for different trends between industries with the same ISIC 3.1 code across different countries), I include country-industry dummies with a linear time variable in the main double interaction as well as in triple interaction models for a robustness check (Model 3 in Table 1 and Model 3 in Table 5 Appendix C). The main results remain unchanged for this inclusion, which indicates that differential trends within the specified group are not driving the results.

Although all models include a large number of firm- and country-level controls, there may be other country-level unaccounted for observed confounders that could potentially explain away the effect of double and triple differences described above. To address this concern, I take a more conservative approach (Baccini et al. 2022) and include in the main models several other potential country-level characteristics (i.e., globalization, historical foundation of institutions, business climate, capital inflows, and income), in interaction with (and in addition to) Depth and Productivity. Including confounders does not absorb the direction and significance of the effect of the main interaction terms (see Tables 4 and 5 Appendix C), which means that the effect observed in the main models are not confounded by additional country-level factors associated with integration and institutions. I test these additional covariates to see if they are more powerful mechanisms than the overall quality of institutions that explain the differences in the conditional effect of deep integration and productivity on firms' participation in GVCs.

In addition, I also implement a sensitivity analysis (Cinelli et al. 2020) of the specified models to the omission of *unobserved* confounders that I define to be at least as strong as *Productivity*, which is the main independent variable, in their explanatory power. Results show (see Table 8 and Figure 2 Appendix D) that point estimates for an unobserved confounding that could be twice or even three times stronger than the benchmark variable *Productivity* remain significant and within the limits of positive effect boundaries. This test also suggests that the identification strategy with the specified variables in this paper is indeed causal.

## Conclusions

This paper used micro- and macro-level data to measure GVC participation at the firm and deep trade integration at the country levels. It examined the distributional consequences of deep trade integration for firms' integration in GVCs across different levels of institutional quality and firm productivity. The main findings are threefold. First, the paper showed that firm productivity explains most (but not all) the differences in firms' participation in GVCs, as preferential liberalization becomes more comprehensive. Second, it showed that the reallocation effect of deep integration is stronger in HQI than in LQI. As trade integration gets deeper at the country level and trade and non-trade barriers are removed, firms that are in HQI environments integrate and participate more in GVCs than firms that are in LQI environments. Third, among other dimensions of domestic institutions, the regulatory quality of institutions and low cost of contract enforcement may be more important for GVC integration because of the specialized and contract-dependent nature of GVCs.

Together, these findings imply that the effect of deep liberalization on firms is conditioned not only by the heterogenous characteristics of firms, such as their productivity, but also by the quality of local institutions. Under the globalization of production and proliferation of trade integration, the role of domestic institutions has not become obsolete. In contrast, as results in this paper show, the quality of domestic institutions continues to exert influence over new and more globalized patterns of trade and production that are assumed to be exogenously imposed on countries, especially in the developing world. While countries interested in increasing their welfare gains from the globalization of production and the deepening of trade relation may not have control over all success mechanisms, they very much have control over improving the quality of their domestic institutions, i.e., as a strong source of comparative advantage for GVCs. The case of Vietnam and its successful participation in GVCs (not just export) can be explained by its ability to have better institutions than other countries in its income group. The other emerging case is Rwanda and its effort to attract and maintain global producers by improving the regulatory and bureaucratic quality of its institutions. Therefore, the proliferation of deep integration and trade in GVCs cannot serve as a useful development tool unless the local regulatory and governance conditions are improved.

A strong reallocation effect from trade integration on firms' participation in GVCs in HQI may also suggest that firms (and the public) in HQI may be more divided on the benefits from more GVC integration and trade than firms (and the public) in LQI. In broader terms, backlash against globalization and offshoring may be a more developed-country phenomenon, while private and public interests in developing countries remain interested in an open trade system. Since I do not find negative (and significant) effects on firms' participation in GVCs in LQI, we cannot conclude that most losers are concentrated in LQI environments, which are mostly developing and emerging economies. What is clear, however, is that the quality of domestic institutions is a source of comparative advantage for GVCs' integration under trade liberalization, and their improvement must be an essential element of policies geared toward GVC integration. The key implication is that the proliferation of deep integration and trade in GVCs will not yield significant economic welfare locally, as hoped, unless the local regulatory and governance conditions are improved.

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# Appendix A

**Table 1:** Summary statistics

| | N | Mean | St.Dev | min | max | skewness |
|---|---|---|---|---|---|---|
| log(GVC) | 9719 | 13.536 | 2.485 | 3.202 | 25.365 | .038 |
| Depth | 9719 | .131 | .468 | -1.433 | .922 | -.089 |
| Productivity | 9719 | 10.626 | 1.672 | 1.613 | 20.485 | .132 |
| Institutions (WGI Av.), 2005 | 9719 | -.025 | .755 | -1.664 | 1.691 | .612 |
| Institutions (WGI Av.) dummy, 2005 | 9719 | .661 | .473 | 0 | 1 | -.68 |
| Voice/Accountability, 2005 | 9719 | 1.64 | .48 | 1 | 2 | -.582 |
| Political Stability, 2005 | 9703 | 1.61 | .488 | 1 | 2 | -.452 |
| Government Effectiveness, 2005 | 9719 | 1.666 | .472 | 1 | 2 | -.703 |
| Regulatory Quality, 2005 | 9719 | 1.653 | .476 | 1 | 2 | -.644 |
| Rule of Law, 2005 | 9719 | 1.604 | .489 | 1 | 2 | -.426 |
| Control of Corruption, 2005 | 9719 | 1.657 | .475 | 1 | 2 | -.662 |
| Contract Enforcement, 2005 | 9576 | 1.599 | .49 | 1 | 2 | -.405 |
| Age | 9719 | 2.993 | .779 | 0 | 5.394 | -.359 |
| Assets | 9719 | 13.487 | 2.535 | -6.48 | 26.142 | -.376 |
| Innovation | 9719 | .559 | .496 | 0 | 1 | -.239 |
| License | 9719 | 1.75 | .433 | 1 | 2 | -1.158 |
| Av. MFN | 9719 | 1.511 | .92 | -2.659 | 3.787 | -.733 |
| log(GDP) | 9719 | 25.892 | 1.652 | 20.339 | 29.604 | -.152 |
| log(Export) | 9719 | 10.559 | 1.747 | 2.441 | 14.482 | -.366 |
| Infrastructure | 9719 | 17.924 | 12.135 | .058 | 58.362 | .649 |
| Depth*Productivity | 9719 | 1.563 | 5.152 | -15.877 | 15.3 | .023 |
| Depth*Age | 9719 | .401 | 1.485 | -5.391 | 4.743 | .053 |
| Depth*Assets | 9719 | 1.859 | 6.526 | -25.095 | 19.716 | -.016 |
| Depth*Innovation | 9719 | .085 | .371 | -1.433 | .922 | .343 |
| Depth*License | 9719 | .23 | .851 | -2.867 | 1.845 | -.04 |
| Depth*Av. MFN | 9719 | .03 | .761 | -3.3 | 1.956 | -.501 |
| Productivity*Av. MFN | 9719 | 15.762 | 9.786 | -33.348 | 58.422 | -.517 |
| Productivity*log(GDP) | 9719 | 275.626 | 48.763 | 44.534 | 533.957 | -.117 |
| Productivity*log(Export) | 9719 | 112.835 | 27.646 | 19.234 | 243.119 | -.082 |
| Productivity*Infrastructure | 9719 | 196.454 | 143.809 | .218 | 965.485 | .9 |

**Table 2:** Correlation of main variables

| | log(GVC) | Depth | Productivity | Institutions (av. 2005) | Age | Assets | Innovation | License | Av. MFN | log(GDP) | log(Export) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| log(GVC) | | | | | | | | | | | |
| Depth | 0.12 | | | | | | | | | | |
| Productivity | 0.63 | 0.17 | | | | | | | | | |
| Institutions (av. 2005) | 0.2 | 0.6 | 0.3 | | | | | | | | |
| Age | 0.18 | 0.08 | 0.10 | 0.18 | | | | | | | |
| Assets | 0.61 | 0.13 | 0.66 | 0.27 | 0.20 | | | | | | |
| Innovation | 0.06 | 0.10 | 0.03 | 0.07 | 0.12 | 0.08 | | | | | |
| License | -0.14 | -0.06 | -0.09 | -0.04 | -0.03 | -0.17 | -0.13 | | | | |
| Av. MFN | -0.09 | -0.31 | -0.15 | -0.26 | -0.08 | -0.16 | -0.03 | 0.06 | | | |
| log(GDP) | 0.16 | 0.01 | 0.10 | 0.14 | 0.10 | 0.11 | 0.11 | 0.03 | -0.03 | | |
| log(Export) | 0.18 | 0.10 | 0.14 | 0.21 | 0.09 | 0.11 | 0.11 | 0.03 | -0.09 | 0.94 | |
| Infrastructure | 0.13 | 0.34 | 0.32 | 0.51 | 0.10 | 0.25 | -0.04 | -0.01 | -0.24 | 0.19 | 0.28 |

**Table 3:** Correlation of covariates

| | Depth | Institutions (av. 2005) |
|---|---|---|
| Depth | 1 | |
| Institutions (av. 2005) | 0.58 | 1 |
| Economic Globalization | 0.59 | 0.71 |
| Common Law | -0.32 | -0.04 |
| Ease of Doing Business Av. Score (2005) | 0.46 | 0.56 |
| log(GDPpc) | 0.41 | 0.70 |
| log(Inward FDI) | 0.01 | 0.23 |
| Informational Globalization | 0.38 | 0.63 |

## Appendix C

**Table 4:** Double difference with covariates

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| | log(GVC) | | | | | | | |
| Productivity | 0.450 | -0.173 | 0.533 | 0.078 | -0.037 | 0.360 | 0.336 | 1.520 |
| | (0.865) | (1.154) | (0.842) | (0.971) | (0.954) | (1.097) | (0.899) | (1.125) |
| **Depth*Productivity** | **0.323*** ** | **0.288*** ** | **0.332*** ** | **0.302*** ** | **0.237*** ** | **0.297*** ** | **0.324*** ** | **0.218** ** |
| | **(0.094)** | **(0.092)** | **(0.094)** | **(0.097)** | **(0.091)** | **(0.098)** | **(0.094)** | **(0.101)** |
| Constant | -1.862*** | -1.775*** | -1.859*** | -1.856*** | -1.714*** | -1.754*** | -1.830*** | -1.732*** |
| | (0.479) | (0.487) | (0.478) | (0.487) | (0.479) | (0.495) | (0.473) | (0.5317) |
| Observations | 9,719 | 9,719 | 9,719 | 9,576 | 9,719 | 9,061 | 9,719 | 8922 |
| R-squared | 0.636 | 0.636 | 0.636 | 0.635 | 0.637 | 0.637 | 0.636 | 0.637 |
| Firm-level controls | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Country-level controls | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Economic Globalization | | ✓ | | | | | | |
| Common Law origin | | | ✓ | | | | | |
| EODB | | | | ✓ | | | | |
| log(GDPpc) | | | | | ✓ | | | |
| log(Inward FDI) | | | | | | ✓ | | |
| Informational Globalization | | | | | | | ✓ | |
| All | | | | | | | | ✓ |
| Country-year FE | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Industry FE | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

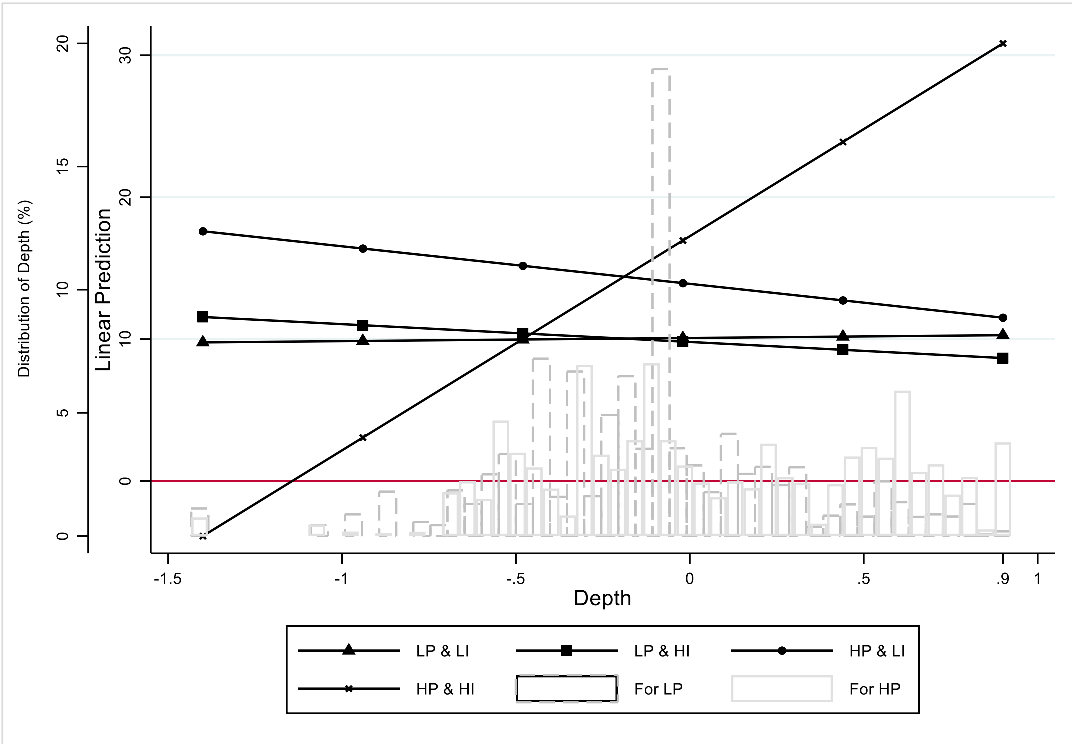
Note: OLS with standard errors clustered at the country-year level in parentheses. The unit of observation is firm-industry-country-year. Industry is defined at ISIC3.1 4-digit level. *** p<0.01, ** p<0.05, * p<0.1

**Table 5:** Triple difference with covariates

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
|---|---|---|---|---|---|---|---|---|---|
| | log(GVC) | | | | | | | | |
| Depth | -5.522*** | | | | | | | | |
| | (1.282) | | | | | | | | |
| Productivity | -0.363 | 0.213 | 0.531 | 0.244 | 0.358 | -0.134 | -0.257 | 0.207 | 0.554 |
| | (0.641) | (0.819) | (0.832) | (1.196) | (0.791) | (0.888) | (0.902) | (0.895) | (1.024) |
| Depth*Productivity | 0.284*** | 0.239*** | 0.349*** | 0.296 | 0.247*** | 0.789* | 1.079 | 0.397 | 1.051 |
| | (0.084) | (0.089) | (0.099) | (0.363) | (0.090) | (0.419) | (0.856) | (0.680) | (0.968) |
| Depth*Institutions | -2.719** | | | | | | | | |
| | (1.211) | | | | | | | | |
| Productivity*Institutions | 0.039 | 0.039 | -0.009 | 0.041 | 0.040 | 0.050 | -0.038 | 0.033 | 0.017 |
| | (0.038) | (0.045) | (0.049) | (0.052) | (0.044) | (0.053) | (0.053) | (0.047) | (0.053) |
| **Depth*Productivity*Institutions** | **0.191*** ** | **0.205*** ** | **0.203*** ** | **0.219** ** | **0.233*** ** | **0.291*** ** | **0.324** ** | **0.227** ** | **0.349** ** |
| | **(0.070)** | **(0.076)** | **(0.075)** | **(0.095)** | **(0.072)** | **(0.091)** | **(0.141)** | **(0.110)** | **(0.139)** |
| Constant | -19.621 | -1.924*** | -26.159 | -1.928*** | -1.913*** | -1.975*** | -1.880*** | -1.922*** | -1.984*** |
| | (12.927) | (0.443) | (19.824) | (0.461) | (0.443) | (0.451) | (0.434) | (0.434) | (0.448) |
| Observations | 9,724 | 9,719 | 9,719 | 9,719 | 9,719 | 9,576 | 9,719 | 9,719 | 9,576 |
| R-squared | 0.628 | 0.637 | 0.682 | 0.637 | 0.637 | 0.636 | 0.638 | 0.637 | 0.638 |
| Firm-level controls | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Country-level controls | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Economic Globalization | | | | ✓ | | | | | |
| Common Law origin | | | | | ✓ | | | | |
| Ease of Doing Business Av. Score | | | | | | ✓ | | | |
| log(GDPpc) | | | | | | | ✓ | | |
| Informational Globalization | | | | | | | | ✓ | |
| All | | | | | | | | | ✓ |
| Country-year FE | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Industry FE | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Country FE | ✓ | | | | | | | | |
| Year FE | ✓ | | | | | | | | |
| Country-industry time trends | | | ✓ | | | | | | |

Note: OLS with standard errors clustered at the country-year level in parentheses. The unit of observation is firm-industry-country-year. Industry is defined at ISIC3.1 4-digit level. *** p<0.01, ** p<0.05, * p<0.1

**Figure 1:** Average marginal effect of triple difference test




## Pairwise comparison of lines

I further implement a pair-wise comparison of simple slopes. It confirms a strong and significant effect for HQI. The comparison of the following groups is statistically and highly significant (at 1%), which are also robust and statistically significant (at 5%) after applying the Bonferroni's adjustment:

- Unproductive firms in HQI and LQI (LP & HI line vs LP & LI line)
- Productive firms in HQI and unproductive firms in LQI (HP & HI line vs LP & LI line)
- Productive and unproductive in HQI (HP & HI line vs LP & HI line)
- Productive firms in HQI and LQI (HP & HI line vs HP & LI line)

The differences in means of the following lines are not significant, i.e., we cannot compare the marginal effect of the following groups with confidence:

- Productive and unproductive firms in LQI (HP & LI line vs LP & LI line)
- Productive firms in LQI and unproductive firms in HQI (HP & LI line vs LP & HI line)

**Table 6:** Triple difference with all WGI indicators

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | log(GVC) | | | | | |
| | Voice/ Accountability | Political Stability | Government effectiveness | Regulatory quality | Rule of Law | Control of Corruption |
| Productivity | 0.422 | 0.284 | 0.276 | 0.214 | 0.235 | 0.334 |
| | (0.769) | (0.804) | (0.828) | (0.809) | (0.831) | (0.830) |
| Depth*Productivity | 0.165* | 0.305*** | 0.247*** | 0.190** | 0.273*** | 0.263*** |
| | (0.094) | (0.092) | (0.088) | (0.088) | (0.087) | (0.092) |
| Productivity*Institutions | 0.085** | 0.000 | 0.030 | 0.028 | -0.017 | 0.055 |
| | (0.037) | (0.038) | (0.045) | (0.050) | (0.041) | (0.046) |
| **Depth*Productivity*Institutions** | **0.163*** ** | **0.113*** | **0.205*** ** | **0.256*** ** | **0.236*** ** | **0.161** ** |
| | **(0.055)** | **(0.067)** | **(0.074)** | **(0.087)** | **(0.075)** | **(0.068)** |
| Constant | -1.767*** | -1.909*** | -1.954*** | -1.935*** | -2.017*** | -1.948*** |
| | (0.446) | (0.452) | (0.443) | (0.444) | (0.443) | (0.449) |
| Observations | 9,719 | 9,703 | 9,719 | 9,719 | 9,719 | 9,719 |
| R-squared | 0.638 | 0.637 | 0.637 | 0.637 | 0.637 | 0.637 |
| Firm-level controls | Yes | Yes | Yes | Yes | Yes | Yes |
| Country-level controls | Yes | Yes | Yes | Yes | Yes | Yes |
| Country-year FE | No | Yes | Yes | Yes | Yes | Yes |
| Industry FE | Yes | Yes | Yes | Yes | Yes | Yes |

Note: OLS with standard errors clustered at the country-year level in parentheses. The unit of observation is firm-industry-country-year. Industry is defined at ISIC3.1 4-digit level. *** p<0.01, ** p<0.05, * p<0.1

**Table 7:** Triple difference with other GVC variables

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| | log(GVC) | log(DVX) | log(FVA) | Forward | Backward |
| Productivity | 0.213 | 0.255 | 0.318 | 0.092 | -0.092 |
| | (0.819) | (0.854) | (0.978) | (0.101) | (0.101) |
| Depth*Productivity | 0.239*** | 0.278*** | 0.184* | 0.012 | -0.012 |
| | (0.089) | (0.104) | (0.106) | (0.019) | (0.019) |
| Productivity*Institutions | 0.039 | -0.019 | 0.066 | 0.001 | -0.001 |
| | (0.045) | (0.050) | (0.060) | (0.007) | (0.007) |
| **Depth*Productivity*Institutions** | **0.205*** ** | **0.155*** | **0.201** ** | **-0.021** ** | **0.021** ** |
| | **(0.076)** | **(0.083)** | **(0.095)** | **(0.010)** | **(0.010)** |
| Constant | -1.924*** | -2.250*** | -3.710*** | 0.696*** | 0.304*** |
| | (0.443) | (0.483) | (0.511) | (0.069) | (0.069) |
| Observations | 9,719 | 8,966 | 7,711 | 9,719 | 9,719 |
| R-squared | 0.637 | 0.582 | 0.584 | 0.287 | 0.287 |
| Firm-level controls | Yes | Yes | Yes | Yes | Yes |
| Country-level controls | Yes | Yes | Yes | Yes | Yes |
| Country-year FE | No | Yes | Yes | Yes | Yes |
| Industry FE | Yes | Yes | Yes | Yes | Yes |

Note: OLS with standard errors clustered at the country-year level in parentheses. The unit of observation is firm-industry-country-year. Industry is defined at ISIC3.1 4-digit level. *** p<0.01, ** p<0.05, * p<0.1

## Appendix D

### Sensitivity analysis

In experimental (full models) settings, where all factors are accounted for, the bias is zero and the estimated value of the outcome Y is equal to the effect (u) of the Treatment D given other observable covariates X. In observation studies (restricted models) such as this one, where it is not possible to measure and account for all factors, there is at least one unobserved confounded Z, an omitted variable (OV), which makes the estimated value of Y biased (b). The gap between b and u, i.e., "the discrepancy of what we wish to know and what we actually have" (Cinelli et al. 2020, 3), create the OV bias (OVB) that is the major threat to the identification strategy in all observation studies.

While it is impossible to identify and account for all OV (observables or not), several statistical tools exist that help to answer how do the point estimate and standard error of the restricted models compared to the full models. One such test is sensitivity analysis with R and Stata sensmakr packages that I implement here to assess the severity of OVB and its threat to nullify the research conclusions (Cinelli et al. 2020; Cinelli and Hazlett 2020). Results are listed in Table 8. In addition to point estimates and standard errors for both partial and full models, sensitivity analysis produces four additional statistics that are used to assess the severity of threat coming from the association of a hypothetical unobserved confounding with the residual variances of both the treatment and the outcome.

**Table 8:** Sensitivity analysis

**Panel A**

**Estimates with partial model (Model 2, Table X):**

| Treatment: | Est. | S.E. | t-value (H0 =0) | $R^2_{Y\sim D\|X}$ | $RV_{q=1}$ | $RV_{q=1, \alpha=0.05}$ |
|---|---|---|---|---|---|---|
| Interaction term | 0.205 | 0.0496 | 4.1370 | 0.18% | 4.17% | 2.21% |

**Panel B**

**Estimates with full model and bounds on OVB:**

| Bounds | Est. | S.E. | t-value (H0 =0) | $R^2_{Y\sim Z\|X,D}$ | $R^2_{D\sim Z\|X}$ |
|---|---|---|---|---|---|
| Twice as strong as Productivity | 0.199 | 0.05 | 3.97 | 0.01% | 2.47% |
| Three-times as strong as Productivity | 0.196 | 0.05 | 3.89 | 0.01% | 3.7% |

Note: df=9449.

Panel A includes partial $R^2$ of the treatment D with the outcome Y, given covariates X ($R^2$ Y~D|X) and associated with it robustness value (RVq=1) and its statistical significance (RVq=1, $\alpha$ =0.05) for $R^2$ Y~D|X, using the observed partial model. Panel B show the partial $R^2$ of residual variance of the treatment D explained by the omitted variable Z, given covariates X ($R^2$D~Z|X), partial $R^2$of residual variance of the outcome Y explained by the omitted variable Z, given X and D ($R^2$Y~Z|D, X), and bounds on OVB statistics, which benchmark the maximum strength of unobserved confounders by several multiples (two and three here) of the explanatory power of a strong observed covariate, which is *Productivity* in our case.

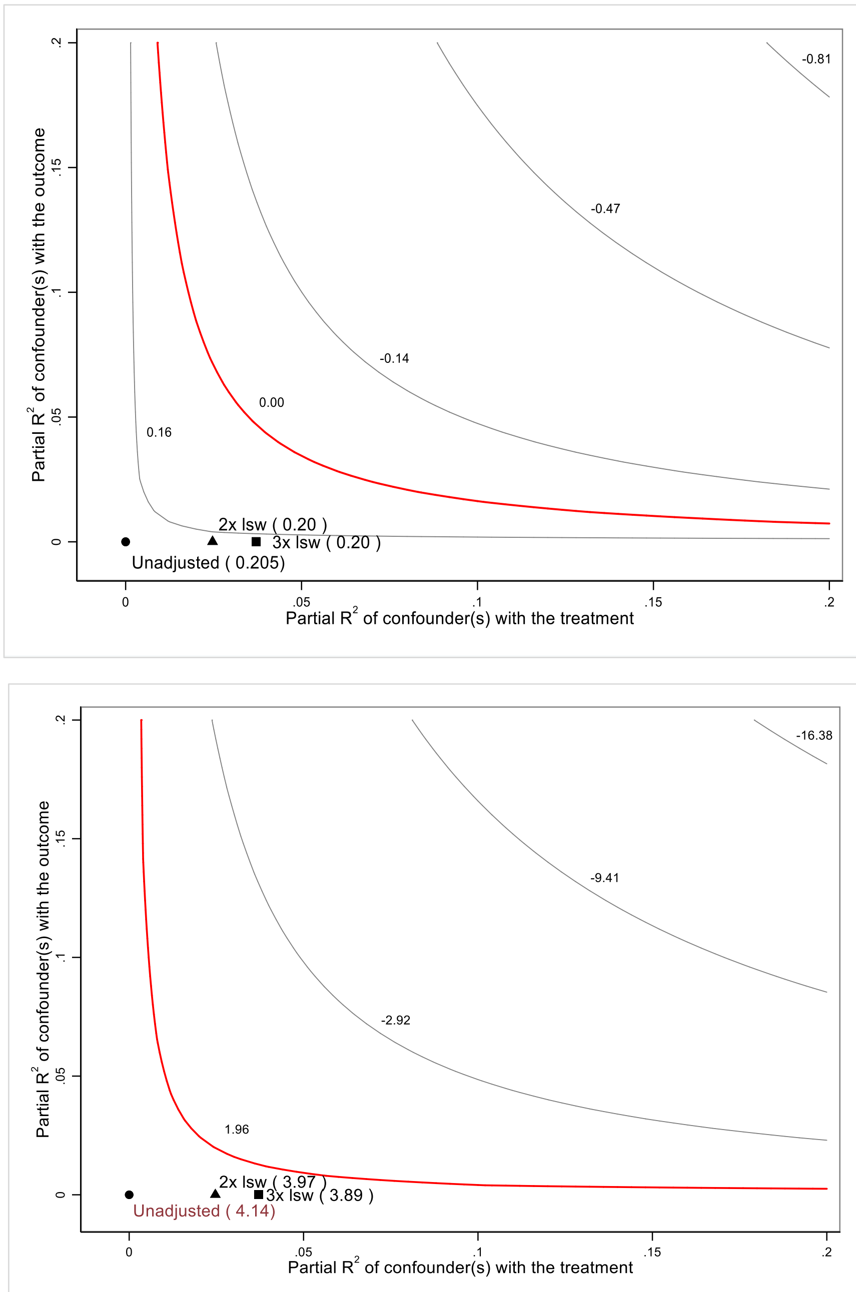
In our context, the sensitivity analysis notations are as follows: Y is the outcome variable (log(GVC)), D is the treatment variable *(Depth×Productivity×Institutions)*, X is the matrix of observed covariates (firm- and country-level controls and country-year and industry dummies), Z is the unobserved confounding (the source of OVB), and the benchmark variable for a bound on the strength of Z is Productivity, i.e., we want to know the power of an unobserved confounding x-time as strong as our benchmark variable to explain away our estimated effect of Model 2, Table 5 Appendix C.

Given this information and result, the verbose interpretation of sensitivity statistics is as follows:

- $R^2$ Y~D|X: An extreme confounder (Z) that explains 100% of the residual variance of the log(GVC) would need to explain at least 0.18% of the residual variance of the Treatment to fully account for the observed estimated effect.
- RVq=1: Unobserved confounders (Zs) that explain more than 4.17% of the residual variance of both the Treatment and the log(GVC) are strong enough to bring the point estimate 0.2053 to 0 (a bias of 100% of the original estimate).
- RVq=1, $\alpha$=0.05: Unobserved confounders (Zs) that explain more than 2.21% of the residual variance of both the Treatment and the log(GVC) are strong enough to bring the estimate to a range where it is no longer "statistically different" from 0 (a bias of 100% of the original estimate), at the significance level of $\alpha$ = 0.05.
- Bounds statistics show the maximum strength of unobserved confounders, bounded by a multiple (twice or three times) of the observed explanatory power of the chosen benchmark covariate, i.e., *Productivity*, with the Treatment and the *log(GVC)*.

The general rule of thumb is that the partial $R^2$ of the unobserved confounding with the outcome ($R^2$ Y~Z|X,D) and the partial $R^2$ of the unobserved confounding with the Treatment ($R^2$D~Z|X) should be a less than robustness value (RVq=1) of the partial R2 of treatment with the outcome ($R^2$Y~D|X). Since both statistics (0.01% and 2.47%) are below the required threshold (4.17%), an unobserved confounding that may be twice and even three times as strong as Productivity does not explain away the observed estimate in Model 2 Table 5 Appendix C. Theoretically, identifying observed variables that are two or three times stronger than the variable *Productivity*, while meeting other statistical criteria for inclusion, is difficult if not impossible. For this reason, I conclude that our results hold the sensitivity to a strong OV test. However, since the $R^2$D ~Z|X is not less than $R^2$ Y ~D|X (2.47% and 3.7% are more than 0.18%), I cannot say that an extreme confounder explaining all residual variation of the outcome and as strongly associated with the treatment as Productivity will not be able to overturn this paper's conclusions.

**Figure 2:** Plotting sensitivity of results to unobserved confounding: point estimate (first plot) and t-value (second plot)




Sensitivity plots are based on Table 8. The horizontal axes show the residual share of variation of the treatment that is hypothetically explained by unobserved confounding, $R^2$D~Z|X. The vertical axes show the hypothetical partial $R^2$ of unobserved confounding with the outcome variable, $R^2$Y ~Z|D,X. The contours show what estimate for outcome would have been obtained in the full regression model, including unobserved confounders. These charts plot the coefficients and their associated t-values obtained from such regression, accordingly. The circle markers indicate the coefficient (first plot) and t-value (second plot) of the unadjusted interaction coefficient from Table 5, Model 2 that we have estimated based on our empirical strategy. The triangle and square markers indicate adjusted estimates with different hypothetical degrees of confounding bound to 2-times and 3-times multiples of degrees of association that the strongest covariate, i.e., Productivity, maintains with the treatment and the outcome. As we can see, point estimates for an unobserved confounding that could be twice and three times stronger than the benchmark variable Productivity remain positive and below the zero-effect (bold red) line, meaning that a confounding with 2-times and 3-times multiples of strength would not be able to turn the estimation of our models to zero or turn it negative.