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Determinants of Global Value Chain Participation: Cross-country Analysis

Biswajit Banerjee[†] and Juraj Zeman[§]

Abstract

This paper examines the factors that influence the four most common measures of GVC participation, separately for the sample of countries included in the WIOD and TiVA database. For both samples, country size is an important driver of GVC indicators. Participation in GVCs varies by industry groups and their technological classification. The influence is strongest for high-tech manufacturing, followed by high-tech services. Real exchange rate has a significant positive relationship with the VAX ratio and forward linkage. The findings on the other covariates are sample sensitive.

JEL code: F02, F14, F23

Key words: Global value chains, VAX ratio, Backward linkage, Forward linkage, GVC participation rate, GVC position index.

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1 Introduction

The nature of international trade has undergone a marked transformation during the last few decades as a result of the growing prevalence of global value chains, GVCs (Baldwin, 2013; OECD, 2013). Different stages of production of a wide range of goods and services have become increasingly fragmented and dispersed across many countries. Under such production arrangements, components of products move through manufacturing centers with value being added at each stage. This phenomenon has been spearheaded by multinational corporations against the backdrop of a number of propitious factors that have enabled them to gain greater access to foreign markets, exploit the large productivity-adjusted wage differences between the home country and foreign countries, and overcome difficulties inherent in the long-distance coordination and monitoring of production processes. These factors include, inter alia, the liberalization of trade and capital flows by national governments, decrease in transport costs, and advances in production, information and communication technologies.[1]

With the rise of GVCs, a growing proportion of trade in goods and services has been in intermediate goods. Consequently, conventional trade statistics do not portray accurately the contribution of gross exports to a country's value added and economic growth. In this setting, in order to obtain a proper assessment of the changes that are occurring in trade patterns and the growing interlinkages in the global economy, a major goal of researchers has been to go beyond the veil of gross trade flows and measure trade in value added and GVC participation directly (Johnson and Noguera, 2017).

The measurement of trade in value added and GVC participation requires the construction of an international input-output table by combining harmonized input-output and/or supply and use tables with estimates of balanced bilateral trade. The method of calculating trade in value added was first proposed by Hummels et al. (2001), and the accounting framework was further developed and improved by Johnson and Noguera (2012), Koopman et al. (2010, 2014), Wang et al. (2017a and 2017b), and Borin and Mancini (2020). This accounting framework facilitates the decomposition of gross exports into domestic valued added in exports, return domestic value added in import content of exports, and foreign value added in exports. On the basis of this decomposition, various concepts and metrics have been proposed for measuring trade in value added and GVC participation.

[1] See Amador and Cabral (2016) for a survey the literature on the drivers and measures of GVCs.

The most common indicators analyzed by researchers include the VAX ratio, a measure of the share of domestic value added in gross exports; the backward linkage index, a measure of the extent to which domestic firms use imported intermediate goods and services for exporting activity; the forward linkage index, a measure of the degree to which a given country's domestic value-added in gross exports are used by partner countries as inputs in their own exports; GVC participation rate, measured by the sum of the backward linkage index and forward linkage index; and GVC position index, measured by the ratio of the forward linkage index to the backward linkage index (see Banga, 2014; ECB, 2019; OECD, 2019). A complementary measure to the degree of GVC participation is the length of GVC, which indicates the number of production stages involved in the chain (Wang et al., 2017b).

The universal availability of several international input-output data sets developed under various data initiatives have generated considerable research on GVCs.[2] The empirical work has focused mainly on developing novel indicators to measure GVC participation,[3] and investigating developments in these indicators for the world in the aggregate, for individual countries in the aggregate and across sectors, and for trade between bilateral partners. The methodology has encompassed documenting the trends and patterns, explaining cross-country variations by eyeballing graphical illustrations or using simple pair-wise correlation analysis with various country-specific characteristics, and estimating multivariate regressions. The econometric studies on the determinants of GVC indicators are still relatively few but increasing. As Kowalski et al. (2015) note, there is no common model-based methodology for exploring the determinants. Several studies have estimated regression equations based on the gravity model of trade (e.g., Baldwin and Taglioni, 2013; Buelens and Tirpak, 2017; Choi, 2013; Ignatenko et al., 2019; and Johnson and Noguera, 2017). Kowalski et al. (2015) argue that the gravity model approach misses some of the key features of GVC trade and does not explain why countries engage in production networks on aggregate. Econometric studies on the determinants of GVC indicators at the aggregate country or

[2] These data sets include the Trade in Value-Added Statistics (TiVA, covering 63 countries), World Input Output Database (WIOD, 43 countries), Eora Multi-Region Input Output (MRIO) database (189 countries).

[3] Two notable recent studies in this regard are Borin and Mancini (2020) and Wang et al. (2017a). Noting that the conventional export decomposition scheme of Koopman et al. (2014) applies only to aggregate exports and suffers from certain mismeasurements, Borin and Mancini (2020) propose an alternative framework for value-added accounting of trade flows at the aggregate, bilateral and sectoral levels. Wang et al. (2017a) approach GVC participation from the production perspective instead of the trade perspective. They decompose GDP and final goods production of a country/sector into pure domestic activities and GVC production activities. Based on this accounting framework, they define new measures of backward linkage (namely, percentage of a country's final goods production contributed by both domestic and foreign factors that involve cross-country production sharing activities) and forward linkage (namely, domestic value added generated from GVC production and trade activities as a share of GDP).

sector level examine the role of country-specific structural and policy related factors (e.g., Kersan-Škabić, 2019; Kowalski et al., 2015; Stehrer and Stöllinger, 2015; and Vrh, 2018).

This paper adds to the small but growing number of econometric studies that have examined in a multivariate framework the determinants of GVC participation indicators at the aggregate country level. The paper has three notable features. First, separate regression equations are estimated for the VAX ratio, backward and forward linkages of GVC, and GVC participation rate using the beta regression method. A comparison of the results of the separate regressions for the GVC indicators brings out their interconnectedness. Second, export composition is classified into five groups representing low-tech manufacturing exports, medium- and high-tech manufacturing exports, low-tech services exports, medium- and high-tech service exports, and "other" exports. The results of the regression exercise confirm Banga's (2014) assertion that such a disaggregated classification of export composition is more informative in explaining cross-country variations in GVC participation than a simple two-way distinction between manufacturing and non-manufacturing exports. Third, the paper examines the impact of the real effective exchange rate (REER) on GVC participation indicators, an aspect that has not received much attention in the literature.[4] The regression exercise based on the WIOD and TiVA samples indicates that the REER is positively related to the VAX ratio, in effect implying that the exchange elasticity is smaller for value-added exports than for gross exports.[5]

The paper examines separately two different data sets: one sample of 43 countries included in the World Input Output Database (WIOD) for the period 2000–2014, and another sample of 64 countries included in the Trade in Value Added (TiVA) database for the period 2005–2015. The results based on the two data sets shed light on their sensitivity to sample differences. Since the sample differences reflect differences in both sample period and country composition, regression analysis is also carried out separately for two sub-samples of countries in the TiVA data set. The country composition of one of the TiVA subsamples is the same as for the WIOD sample.

[4] However, see Caraballo and Jiang (2016). Several recent studies have noted that the impact of the conventional measure of REER on gross exports performance has weakened with the rise of GVC participation, and attention is being focused on constructing GVC-adjusted REER. (e.g., Ahmed et al., 2017; Bems and Johnson, 2015; European Central Bank, 2019; de Soyres et al., 2018; Patel et al., 2017; Powers and Riker, 2013; Uddin, 2017; and Varela and Lovo, 2016). It would seem that only Ahmed et al. (2017) have estimated the exchange rate elasticity of value-added exports, and they found it to be considerably lower than the exchange rate elasticity of gross exports.

[5] The impact of the REER on a GVC participation indicator expressed as a ratio to gross exports reflects the exchange rate elasticity of the value added component in the numerator relative to the exchange rate elasticity of gross exports.

The rest of the paper is organized as follows. Section 2 provides a selective overview of the literature. Section 3 describes the data and methodology. Section 4 presents the results of the econometric analysis, and Section 5 concludes.

2 Selective Literature Overview

The evolution of GVC participation at the global, regional, country and sector levels is well documented.[6] As countries have become more integrated into the international production processes, the VAX ratio has declined over time and the extent of backward linkage has risen. At the same time, forward linkage also has exhibited a rising trend.[7] Consequently, the GVC participation rate, measured as the sum of the backward and forward linkage indices, has increased substantially. The levels and the temporal changes in the GVC indicators vary widely across regions, countries, and sectors. An important aim of empirical studies has been to identify the patterns in GVC participation and the factors influencing them. This section reviews the findings on some of the factors commonly considered in the literature. The empirical findings are mixed. The results are sensitive to methodology, country composition of the sample and time coverage.

GDP/Per capita GDP. There is considerable descriptive and econometric evidence that indicate that larger or more developed countries (proxied by GDP and per capita GDP, respectively) tend to have a higher ratio of value-added exports to gross exports and, correspondingly its flip side, a smaller share of foreign value added in gross exports (i.e., lower backward linkage).[8] However, a notable contrary result is the finding of Johnson and Noguera (2011 and 2012), based on simple correlation analysis, that aggregate VAX ratios for the 94 countries in their sample in 2004 did not co-vary strongly with GDP per capita.[9] Higher VAX ratio and lower backward linkage for larger countries are generally explained in terms of these countries having greater scope for sourcing intermediate inputs domestically (De Backer and Miroudot, 2014; Kowalski et al., 2015; Lopez-Gonzalez, 2012).

The findings on the relationship between forward linkage and country size or per capita GDP are mixed. A European Central Bank (2019) study notes that larger economies in the euro area are

[6] The literature is vast. Notable studies include Baldwin (2013), Banga (2014), European Central Bank (2017 and 2019), Hummels et al. (2001), Ignatenko et al. (2019), Johnson and Noguera (2012 and 2017), Kowalski et al. (2015), OECD (2013), Taglioni and Winkler (2016), World Bank (2017), and World Trade Organization (2019). Also, see Amador and Cabral (2016) for a survey of the literature on the drivers and measures of GVC.
[7] The rising trend in both backward and forward linkages has reversed to a decreasing trend since 2015 on a global scale and the trend in global trade has flattened.
[8] See, for example, European Central Bank (2019), Foster-McGregor and Stehrer (2013), Hummels et al. (2001), Ignatenko et al. (2019), Kowalski et al. (2015), Stehrer and Stöllinger (2015), Taglioni and Winkler (2016) and Vrh (2018).
[9] Johnson and Noguera (2012) do not report on whether the finding was similar for other years.

located more upstream than the smaller economies, reflecting the presence of production chains in which intermediate goods and services are produced by the larger economies and exported to smaller countries in the region for assembling processes. However, van der Marel (2015) did not find a significant relationship between GDP per capita and a country's location within the supply chain for his sample of 58 countries based on data for 2009/2010: the pair-wise correlation between GDP per capita and the distance from final demand in the production chain (a measure of "upstreamness") was not statistically significant. Our calculations based on estimates of forward linkage for a sample of 39 countries presented in Lopez-Gonzalez (2012) indicate that the bivariate relationship between forward linkage and real per capita GDP_PPP had changed between 1995 and 2005. In 1995, the relationship was best portrayed by a cubic function, composed of an initial inverted U-shape at lower levels of development and followed by a U-shaped relationship at higher levels. However, in 2005 there was no significant relationship between the two variables. Based on the OECD's TiVA data base for 57 countries covering the period 1995–2009, Kowalski et al. (2015) obtained a positive significant coefficient on real GDP in the multivariate regression equation for forward linkage.

Many studies report a positive relationship between the GVC participation rate and per capita GDP. van der Marel (2015) found that in his sample of 58 countries in 2009/2010 richer countries tended to participate in GVCs at an increasing rate. Our calculations based on estimates of GVC participation rate provided by Lopez-Gonzalez (2012) indicate an inverted U-shaped bivariate relationship in both 1995 and 2005: GVC participation rate initially increased with per capita GDP and then decreased beyond a certain threshold. Using data from the EORA database for 189 countries covering the period 1990–2013, Ignatenko et al. (2019) obtained a significant positive relationship between the GVC participation rate and per capita GDP. However, they point out that this result could not be replicated if the sample was restricted to 50 countries that are typically included in other databases of value-added. In their study on euro area countries covering the period 2000–2014, European Central Bank (2019) also found the GVC participation rate to be higher for countries with higher per capita GDP, after controlling for the influence of institutional factors. Based on manufacturing sector data for 40 countries covering the period 1995–2011, Stehrer and Stöllinger (2015) obtained a significant positive relationship between the GVC participation rate and a variable measuring a country's GDP relative to that of Germany. In contrast, Kersan-Škabić (2019) observed that the influence of per capita GDP on the GVC participation rate was significant and positive for the EU-28 and EU-15 countries but not significant for EU-NMS. Also, perusing the graphical illustration of the GVC participation rate for 61 countries in 2011, Criscoulo et al.

(2015) and Taglioni and Winkler (2016) concluded that participation was higher for the smaller economies.

Composition of exports. Cross-country variation in GVC indicators is to a large extent driven by variations in the composition of exports. Johnson and Noguera (2011, 2012) noted that in their sample the aggregate VAX ratio was lower for countries that had a higher share of manufacturing in total exports. They explained this phenomenon in terms manufacturing exports being characterized by a higher degree of vertical specialization (i.e., having a higher import content) than non-manufacturing exports. This feature of manufacturing exports also explains the finding of Kowalski et al. (2015) that the higher is the share of manufacturing sector in GDP, the greater is the extent of backward linkage and the lower is the degree of forward linkage.

Researchers have also documented that technological characteristics of industries and the share of services and natural resources in total exports are likely to influence participation in GVCs. Banga (2014) observed that the VAX ratio was higher and the backward linkage was lower for low-tech industries compared with medium and high-tech industries, reflecting lower fragmentation of production processes in low-tech industries. Supporting evidence is provided by estimates of VAX ratios in various technology-intensity groups in manufacturing calculated by Olczyk and Kordalska (2017) for nine central and east European countries over the period 1995–2011. As for the relationship between the overall GVC participation rate and the share of high-tech manufacturing products in total exports, Kersan-Škabić (2019) obtained contrasting results for different country groups in the European Union: the relationship was negative for the old member states (EU-15), positive for the new member states (EU-NMS) and not statistically significant for EU-28. Kersan-Škabić does not offer any explanation for the contrasting results, but it could be a reflection of EU countries being more integrated in regional than in global supply chains.

Services participate differently in GVCs than manufacturing. Since services are less prone to vertical specialization, their forward linkage is stronger than backward linkage in most countries (De Backer and Miroudot, 2013; Ignatenko et al., 2019; Taglioni and Winkler, 2016). The composition of services forward linkage varies considerably. Ignatenko et al. (2019) document that business and financial services, wholesale and retail trade, and post and telecommunication have very high forward linkages, reflecting limited used of foreign inputs in their production. Moreover, the GVC participation rates of these service activities are higher than that of manufacturing. In an econometric study on EU countries, Kersan-Škabić (2019) found that the share of services in total exports had a positive significant impact on the overall GVC participation rate in the EU-15, but a

negative significant impact in the EU-NMS, suggesting that the composition of services exports in the EU-15 and EU-NMS was different.

Some studies have observed that resource-intensive countries tend to have higher VAX ratios, lower backward linkage, and higher forward linkage and GVC participation rate (European Central Bank, 2019; Foster-McGregor and Stehrer, 2013; Ignatenko et al., 2019; Taglioni and Winkler, 2016; and World Trade Organization, 2019).

Labour skill composition. Several studies have noted that the expansion of GVCs has been associated with increased demand for skilled labour. The shift away from unskilled workers towards skilled workers reflects the increased organizational and operational complexity of supply chains and increased use of skill-intensive services inputs. Analysis of 2008 data for a sample of high- and middle-income countries from the TiVA database by Taglioni and Winkler (2016) indicate a positive correlation between share of workers with tertiary education and GVC participation from the buyer's perspective (backward linkage). In their multiple regression exercise based on data for 120 countries covering the period 2001–2014, Farole et al. (2018) found a positive and significant relationship between backward linkage and the relative demand for skilled labour (measured as wages paid to produce exports to skilled versus unskilled labour). A panel fixed effect analysis by the European Central Bank (2019), based on annual data for 35 industries in 40 countries covering the period 1995–2009, also shows that share of high-skilled labour (measured by share of high-skilled hours worked in total hours) is positively associated with backward GVC participation. In contrast, Stehrer and Stöllinger (2015) report that for manufacturing exports of 26 EU Member States during the period 1995–2011 the share of high-skilled labour had no significant impact on backward linkage, but the share of medium-skilled labour had a negative and significant impact.

Vrh (2018) obtained a negative and significant relationship between skill intensity (measured as a share of hours worked by high-skilled workers in total hours worked) and the VAX ratio in the manufacturing sector of the EU-15 and EU-NMS over the period 2000–2011. She considered this result surprising, but it is consistent with findings reported in the previous paragraph of a positive relationship between skill intensity and backward linkage.

The findings on the relationship between skill intensity and GVC forward linkage are mixed. Taglioni and Winkler (2016) note that for their sample of high- and middle-income countries in 2008 the share of workers with tertiary education was positively correlated with GVC participation

from the seller's perspective. However, in their panel-cross section regression exercise, Farole et al. (2018) found a positive and significant correlation between GVC participation as a seller and the relative demand for skilled labour only for high-income countries, but no significant relationship for the other income groups and the overall sample. In the European Central Bank (2019) study, there was no significant relationship between GVC forward linkage and the share of high-skilled hours worked in total hours.

European Central Bank (2019) for euro area countries and Ignatenko et al. (2019) for a sample of 189 countries obtained a positive and significant relationship between the GVC participation rate and a measure of the educational attainment of the labour force. However, Stehrer and Stöllinger (2015) found that the share of high-skilled workers in the labour force was negatively associated with the GVC participation rate in the manufacturing sector in EU countries.

Capital intensity. Discussions of the influence of capital intensity on GVC indicators are scant. van der Marel (2015) found a positive relationship between capital intensity and forward linkage: the pair-wise correlation between physical capital endowment relative to GDP and distance from final demand in the supply chain was positive and significant. However, physical capital endowment was not significantly related to the overall GVC participation rate. In his multivariate regression exercise, Ramondo (2016) found a positive and significant relationship between the capital-labour ratio and VAX ratio in the manufacturing sector. However, the results obtained by Landesmann et al. (2015) and Olczyk and Kordalska (2017) suggest no significant relationship between physical capital endowment and the VAX ratio. Landesmann et al. (2015) failed to find any significant relationship between an industry's export performance and its capital coefficient (measured as ratio of capital to gross output) in the European Union. Olczyk and Kordalska (2017) observed a negative and significant impact of capital coefficient on both gross exports and value-added exports of the manufacturing sector in central and east European countries, but the strength of the impact was very similar for both export measures.

Foreign direct investment. The type and extent of GVC participation is shaped by the nature of foreign direct investment. Thus, FDI driven by the resource-seeking motive is expected to be associated with higher VAX ratio and forward linkage. In contrast, vertical efficiency-seeking FDI directed towards export-processing entails considerable imports of intermediate inputs and can be expected to be positively correlated with backward linkage. If the distance from final demand in the production chain is large, there should also be high positive correlation between FDI and forward linkage.

The empirical findings on the impact of FDI on GVC participation are sensitive to methodology., Vrh (2018) obtained a negative and significant relationship between inward FDI stock and the VAX ratio for the sample of EU member states in the fixed effect regressions estimated by the ordinary least squares (OLS) method. However, inward FDI had a slightly positive or no effect on the VAX ratio of EU-15 countries in the equation estimated by the generalized method of moments (GMM). In their augmented gravity model, Buelens and Tirpák (2017) found that bilateral FDI stock was positively associated with the bilateral import content of exports. In line with this finding, Kowalski et al. (2015) and Stehrer and Stöllinger (2015) found a positive and significant relationship between backward linkage and inward FDI stock (as ratio to GDP) in their regression exercises without country fixed effects. However, in the presence of country fixed effects, Stehrer and Stöllinger (2015) found no significant relationship between inward FDI and backward linkage. Kowalski et al. (2015) found no significant impact of inward FDI stock on forward linkage, suggesting that FDI in their sample of countries was more associated with exports that were absorbed in the destination country rather than with exports for further processing in the destination country and then re-exported to third markets.

Kersan-Škabić (2019) found that the relationship between inward FDI stock (as ratio to GDP) and the GVC participation rate was negative and significant in EU-15 countries but positive and significant in EU-New Member States. Stehrer and Stöllinger (2015) report a positive association between inward FDI stock and the GVC participation rate of the manufacturing sector in EU member states when only time fixed effects were included in the regression equation but not when both time and country fixed effects were taken into account. A European Central Bank (2019) study that had country fixed effects included in the model specification found that, in the euro area, the stock of FDI in a sector had no significance as an explanatory variable for the GVC participation rate of the sector.

Real exchange rate. The impact of exchange rates on trade has decreased with the rise of GVCs (Ahmed et al., 2017; de Soyres et al., 2018; and Varela and Lovo, 2016). The effect of change in REER on export performance is weaker the greater is the import content of exports. Varela and Lovo (2016) report that when the share of imported intermediates of Polish firms in gross exports was greater than 30 percent, the effect of REER on export participation faded.[10] Ahmed et al. (2017) note that the responsiveness of exports to changes in the REER was lower for countries that were more tightly integrated in German supply chains than for countries that were more loosely

[10] See Albinowski et al. (2016) for the detailed study.

integrated. In addition, using a panel framework covering 46 countries over the period 1996–2012, Ahmed et al. (2017) found that the responsiveness of domestic value-added exports to changes in REER was lower compared to responsiveness of gross exports, and attributed this outcome to possible complementarities between foreign and domestic value added. This finding would mechanically imply a positive relationship between REER and the VAX ratio. Indeed, Caraballo and Jiang (2016) found a positive and significant relationship between REER and the VAX ratio for a sample of 39 countries from the WIOD data base covering the period 1995–2009. They explained the association of currency appreciation with a higher VAX ratio as a reflection of lower relative prices of foreign intermediates translating more into a domestic-foreign substitution of intermediates than into a substitution of high value-adding activities.

Institutional quality. Kowalski et al. (2015) and the 2017 Global Value Chains Report (World Bank, 2017) note that with the rising complexity of international transactions the role of institutions has become increasingly important for deepening GVC participation. Ignatenko et al. (2019) report that better contract enforcement and the rule of law facilitate both backward and forward linkages. Analysis by Taglioni and Winkler (2016) suggests that better contract enforcement may be more important for emerging market countries. In their regression exercise for the WIOD country sample, the contract enforcement variable did not have a significant impact on GVC integration either as a buyer or seller. However, contract enforcement had a significant positive impact for the OECD country sample.

van der Marel (2015) detected a positive and significant pair-wise correlation between rule of law and the overall GVC participation rate. A European Central Bank (2019) study found that political stability boosts overall GVC participation. Dollar et al. (2016) obtained a positive correlation between the overall GVC participation rate at the industry level and all measures of institutional quality. They also found that higher technology industries were more sensitive to institutional quality and had higher participation in complex GVCs in countries that had better institutions.

3 Data and methodology

The main objective of this paper is to estimate the drivers of different indicators of GVC participation. In particular, the indicators of interest include the VAX ratio, backward linkage index, forward linkage index, and GVC participation rate. One set of these indicators is constructed from the 2016 release of the World Input-Output Database and another set is constructed from the 2018 version of the TiVA data base, applying the accounting framework developed by Koopman et al.

(2010, 2014). The WIOD data base contains annual world input-output tables on 56 industries in 43 countries plus the rest of the world covering the period 2000–2014.[11] The TiVA data base contains information on 36 industries in 64 countries covering the period 2005–2015 [12] (see Appendix Table A for country list of the WIOD and TiVA data bases). For each data set, separate regression equations are estimated for each of the GVC participation indicators with the same set of explanatory variables. The definitions of the GVC participation indicators also are the same in both data sets. Additional regression equations are estimated for two subsamples of the TiVA data base: one subsample includes countries same as those in the WIOD data base (List A countries), and the second subsample includes countries that are exclusive to the TiVA data base (List B countries). We compare the regression results based on the WIOD and the whole TiVA data base, as well as the regression results based on the two subsamples of the TiVA data set. These comparisons shed light on the sensitivity of the results to sample differences with respect to country and period coverage and underlying methodology in the compilation of the world input-output tables.

The values of the four GVC participation indicators of interest fall in the standard unit interval (0, 1). The OLS estimation method is not appropriate in such situations as it may yield fitted values for the outcome variable that exceed the lower and upper bounds. Hence, the beta regression method, first proposed by Ferrari and Cribari-Neto (2004), is used to estimate the regression equations. All the regressions are estimated with time fixed effects and country fixed effects, and robust standard errors are applied to correct for heteroscedasticity and serial correlation. Time fixed effects resolve the problem of omitted variables that vary over time but are constant across countries, and country fixed effects control for factors that differ across countries but are constant over time.

The parameters of the beta regressions are estimated using the logit link function for the conditional mean. The coefficients in the beta regressions indicate the changes in the log-odds of the outcome variable per unit change in the independent variables. For ease of interpretation of the results, the *margins* command in STATA is used to estimate the marginal effects of the independent variables on the conditional mean. For illustrative purpose, we also plot the predictive margins (predicted values) of each GVC participation indicator at different levels of GDP_PPP. As robustness check and in view of the widespread utilization of the OLS method in earlier studies on drivers of GVC

[11] See Timmer et al. (2015)
[12] The TiVA online database can be accessed from http://oe.cd/tiva or via https://www.wto.org/english/res_e/statis_e/miwi_e/miwi_e.htm. See Jones et al. (2014) for a discussion of the similarities and differences between WIOD and TIVA data bases.

participation, we compare the marginal effects obtained in the beta regressions with the those obtained in regressions estimated by the OLS method.

The regression equations take the following form:

$$GVCPI_{it} = \beta_1 \log(GDP\_PPP_{it-1}) + \beta_2\, shareX\_mfgLT_{it} + \beta_3\, shareX\_mfgMHT_{it} + \beta_4\, shareX\_servLT_{it} + \beta_5\, shareX\_servMHT_{it} + \beta_6 \log(TertiaryED_{it}) + \beta_7 \log(CapCoef_{it}) + \beta_8 \log(FDI\_stock_{it-1}) + \beta_9 \log(REER_{it}) + \beta_{10}\, CorControl_{it} + \mu_t + \eta_i + \varepsilon_{it}$$

where $GVCPI_{it}$ is the GVC participation indicator of interest relating to country *i* at time *t;* μ_t denotes time fixed effect; η_i denotes country fixed effect; and ε_{it} is the error term. GDP_PPP_{it-1} refers to gross domestic product in constant 2011 international dollars lagged by one period and is a measure of the size of economy. The *shareX_* variables indicate a country's export composition and are defined as sectoral share in total exports, and *mfgLT, mfgMHT, servLT*, and *servMHT* refer to low-tech manufacturing, medium- and high-tech manufacturing, low-tech services and medium- and high-tech services, respectively.[13] *TertiaryED* is a proxy for labour skill and is measured as the share of workers with tertiary education; *CapCoef* represents the physical capital endowment of a country and is defined as the ratio of capital stock to gross output; FDI_stock_{t-1} denotes the stock of inward foreign direct investment as percentage of GDP lagged by one period; *REER* refers to CPI-based real effective exchange rate; and *CorControl* stands for the control of corruption estimate and is a proxy for governance.[14] Definitions of the dependent and explanatory variables and the sources of data are presented in Table 1.

[13] The classification of manufacturing and services sectors into low-tech and medium- and high-tech categories is in accordance with OECD (2011). Also, see Ignatenko (2019), Annex Table 1; and Olczyk and Kordalska (2017), f.n. 6.

[14] Our measure of education as a proxy for labour skill is in line with Taglioni and Winkler (2016). Unlike Stehrer and Stöllinger (2015) and Vrh (2018), we do not measure labour skill by the share of hours worked by workers in particular skill groups in total hours worked because the relevant data is not available in the second release of the WIOD data base. It is likely that tertiary education may not be a good measure of actual skills of workers since education quality is very heterogeneous across countries. Measures of cognitive and non-cognitive skills based on the PIAAC (Program for International Assessment of Adult Competencies) proficiency levels for literacy may be more appropriate. Unfortunately, PIAAC data is not available for the entire sample period. The OECD only provides international data from the three rounds of PIAAC data collection that took place in 2012, 2015 and 2017 (see https://nces.ed.gov/surveys/piaac/datafiles.asp).
We exclude the lagged dependent variable from the specification since our focus is on explaining the cross-section pattern rather than time series dynamics of GVC indicators. We also do not include a measure of trade barriers as an explanatory variable because of lack of data for the entire sample period for all the countries in the sample.

Table 1: Definition of dependent and explanatory variables entered in the regression equations

Variable	Definition	Source	URL
VAX ratio	Ratio of domestic value-added exports to total gross exports.	WIOD, TiVA, own calculations	http://www.wiod.org/database/wiots16; TiVa (http:/oe.cd/tiva)
Backward linkage index (BL)	Ratio of foreign value-added content of exports to the economy's total gross exports.	WIOD, TiVA, own calculations	http://www.wiod.org/database/wiots16; TiVa (http:/oe.cd/tiva)
Forward linkage index (FL)	Ratio of domestic value-added exported to third countries to the economy's total gross exports.	WIOD, TiVA, own calculations	http://www.wiod.org/database/wiots16; TiVa (http:/oe.cd/tiva)
GVC participation rate (BL+FL)	This indicator combines both backward linkage and forward linkage.	WIOD, TiVA, own calculations	http://www.wiod.org/database/wiots16; TiVa (http:/oe.cd/tiva)
GDP_PPP	GDP at purchasing power parity measured in constant 2011 international dollars.	World Bank	https://data.worldbank.org/indicator/NY.GDP.MKTRPRKD
shareX_mfgLT	Share of low-tech manufacturing exports in total exports. Low-tech manufacturing comprises NACE Rev. 2 codes C10-C18, C22-C25, and C31-C33.[1]	Socio Economic Accounts (SEA), TiVA, own calculations	http://www.wiod.org/database/seas16; TiVa (http:/oe.cd/tiva)
shareX_mfgHT	Share of medium- and high-tech manufacturing exports in total exports. Medium- and high-tech manufacturing comprises NACE Rev. 2 codes C19-C21 and C26-C30.[1]	SEA, TiVA, own calculations	http://www.wiod.org/database/seas16; TiVa (http:/oe.cd/tiva)
shareX_servLT	Share of low-tech services exports in total exports. Low-tech services comprise NACE Rev. 2 codes G45-G47 and H49-H53.[1]	SEA, TiVA, own calculations	http://www.wiod.org/database/seas16; TiVa (http:/oe.cd/tiva)
shareX_servHT	Share of medium- and high-tech services exports in total exports. Medium- and high-tech services exports comprise NACE Rev. 2 codes I, J58-J63, K64-K66, L68, M69-M75.[1]	SEA, TiVA, own calculations	http://www.wiod.org/database/seas16; TiVa (http:/oe.cd/tiva)
TertiaryED	Share of workers with tertiary education.	EconMap_2.4	http://www.cepii.fr/CEPII/en/bdd_modele/presentation.asp?id
CapCoef	Ratio of capital stock to gross output	SEA, TiVA, own calculations	http://www.wiod.org/database/seas16
FDI stock/GDP	Stock of inward foreign direct investment as percentage of GDP	UNCTADstat	https://unctadstat.unctad.org/wds/ReportFolders/reportFolders.aspx
REER	Annual average CPI-based real effective exchange rate index; 2010 = 100 (increase represents appreciation).	BIS	https://www.bis.org/statistics/eer.htm?m=6%7C381%7C676
CorControl	Control of Corruption captures perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as "capture" of the state by elites and private interests. Estimate gives the country's score on the aggregate indicator, in units of a standard normal distribution, i.e. ranging from approximately -2.5 to 2.5, where the higher the index the less the corruption indicated.	World Bank	http://info-worldbank.org/governance/wgi/

[1] See Ignatenko (2019), Annex Table 1; Olczyk and Kordalska (2017), f.n. 6; and OECD (2011).

The descriptive statistics for both the WIOD and TiVA samples are shown in Table 2. The mean values of backward linkage, forward linkage, GVC participation rate, GDP_PPP, share of both low-tech and high-tech manufacturing exports in total gross exports, and control of corruption index were higher for the WIOD sample than for the TiVA sample. Whereas, the mean values of the VAX ratio, shares of both low-tech and high-tech services exports in total exports, inward foreign direct investment to GDP ratio and capital intensity were lower for the WIOD sample compared with those for the TiVA sample. The differences in mean values of the variables were due to differences in both country composition and sample period. The differences between the WIOD sample and TiVA list A countries are due to difference in the sample period, as the country composition of the two samples are the same. The differences between TiVA list A countries and TiVA list B countries are due to difference in country composition, as the period coverage of the two subsamples are the same.

Table 2: Descriptive statistics for dependent and explanatory variables

		WIOD		TiVA, Entire sample		TiVa, List A countries[1]		TiVa, List B countries[2]	
		Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation
VAX ratio	ratio	0.703	0.117	0.742	0.118	0.73	0.12	0.767	0.11
Backward linkage index (BL)	ratio	0.288	0.122	0.258	0.118	0.27	0.12	0.233	0.11
Forward linkage index (FL)	ratio	0.232	0.071	0.197	0.067	0.19	0.057	0.211	0.082
GVC participation rate (BL+FL)	ratio	0.52	0.097	0.455	0.092	0.46	0.092	0.444	0.093
GVC position index (FL/BL)	ratio	1.111	0.334	1.162	1.497	0.954	0.776	1.601	2.328
GDP_PPP	$	1.55E+12	2.84E+12	1.27E+12	2.61E+12	1.68E+12	3.08E+12	3.97E+11	3.14E+11
shareX_mfgLT	ratio	0.259	0.104	0.241	0.106	0.228	0.088	0.266	0.133
shareX_mfgHT	ratio	0.332	0.161	0.271	0.157	0.301	0.153	0.207	0.147
shareX_servLT	ratio	0.167	0.12	0.19	0.08	0.196	0.078	0.176	0.083
shareX_servHT	ratio	0.142	0.145	0.159	0.137	0.179	0.149	0.118	0.093
TertiaryED	%	21.072	11.658	20.757	11.972	22.011	11.96	18.123	11.59
CapCoef	Ratio	1.532	0.327	2.171	0.393	2.24	0.34	2.025	0.455
FDI stock/GDP	%	73.776	194.963	85.015	200.614	91.504	233.834	71.387	98.917
REER	Index, 2010=100	96.868	10.855	104.7	11.954	104.205	9.946	105.762	15.379
CorControl	Index, -2.5 to +2.5	0.9	0.952	0.704	1.022	0.889	0.945	0.315	1.072

[1] TiVA List A countries are those that correspond to the countries in the WIOD sample (see Appendix A).
[2] TiVA List B countries are those that do not correspond to the countries in the WIOD sample (see Appendix A)

4 Empirical results

We first discuss in detail the regression results based on the WIOD data set. Thereafter, we highlight the similarities and differences between the results for the WIOD and whole TiVA data sets. This is followed by a comparison of the regression results for the two subsamples of the TiVA data set, and for the WIOD sample and TiVA List A countries.

Regression results based on the WIOD data set

Beta regression estimates

The beta regression results based on the WIOD data set displayed in Table 3 show an interesting interconnection between the results for the different GVC participation indicators. The variables that have a significant influence on the VAX ratio in a particular direction have a significant impact in the same direction on forward linkage. The direction of influence of the explanatory variables on backward linkage is opposite to that on the VAX ratio (since backward linkage is the flip side of the VAX ratio) and forward linkage. The net impact of the covariates on the GVC participation rate depends on the relative strength of their opposite influences on backward linkage and forward linkage. For 5 out of the 10 explanatory variables (namely, GDP_PPP, share of high-tech manufacturing exports in total exports, capital intensity, REER, and control of corruption) the impact on backward linkage dominates their opposing influence on forward linkage. For 2 of the 10 explanatory variables (namely, share of low-tech services exports in total exports and inward FDI stock), their influence on forward linkage is stronger than on backward linkage.

The evidence indicates that the larger is the size of the economy the higher is the share of domestic value added in gross exports (VAX ratio) and the lower is the foreign value-added content in exports (backward linkage). Despite a strong positive bivariate correlation between the VAX ratio and forward linkage, there is no evidence of a significant association between the size of the economy and forward linkage, after controlling for the influence of other variables. This suggests that even small countries that typically source inputs from abroad have become increasingly involved in forward linkages. This can happen if fragmentation of production processes has increased and supply chains have become longer. The regression results also indicate that smaller economies are more integrated in GVCs than larger economies: the relationship between GVC participation rate and the size of the economy is negative and significant. This result is in sharp contrast to the finding of the European Central Bank (2019) for the euro area that richer economies have a higher GVC participation rate.

Table 3: Beta Regressions of GVC Participation Indicators, WIOD sample (2000-2014)

	VAX ratio	Backward linkage (BL)	Forward linkage (FL)	GVC participation rate (FL+BL)
log(lag(GDP_PPP))	0.30612 *** (0.05522)	-0.31956 *** (0.05645)	-0.02978 (0.04943)	-0.30555 *** (0.03708)
shareX_mfgLT	-1.18024 *** (0.29336)	1.26117 *** (0.30737)	-1.16817 *** (0.22604)	-0.25519 (0.17941)
shareX_mfgHT	-2.42778 *** (0.23708)	2.41324 *** (0.24755)	-1.94762 *** (0.17872)	0.29591 ** (0.13496)
shareX_servLT	-1.03254 *** (0.28525)	1.02351 *** (0.30382)	-1.30163 *** (0.23217)	-0.36354 ** (0.17931)
shareX_servHT	-1.67267 *** (0.31407)	1.70341 *** (0.32779)	-1.66756 *** (0.33214)	-0.1535 (0.18149)
log(TertiaryED)	0.01532 (0.09909)	-0.11228 (0.09945)	-0.00023 (0.08310)	-0.13006 * (0.07275)
log(CapCoef)	0.29123 *** (0.05397)	-0.30273 *** (0.05721)	0.13198 ** (0.06383)	-0.23233 *** (0.03926)
log(lag(FDI stock/GDP))	0.02003 (0.01483)	-0.02606 * (0.01495)	0.08927 *** (0.02246)	0.04305 *** (0.01144)
log(REER)	0.35416 *** (0.06202)	-0.4639 *** (0.06310)	0.26532 *** (0.05714)	-0.0966 ** (0.04081)
CorControl	-0.11455 *** (0.02939)	0.09249 *** (0.02955)	-0.01686 (0.02989)	0.07251 *** (0.01751)
Time fixed effect	Yes	Yes	Yes	Yes
Country fixed effect	Yes	Yes	Yes	Yes
Log pseudolikelihood	1580.466	1591.404	1644.117	1654.231
Wald chi-sq	48556.09 ***	56452.28 ***	13540.32 ***	51486.82 ***
N	582	582	582	582

*** significant at the 1 percent level; ** significant at the 5 percent level; * significant at the 10 percent level

The marginal values implied by the beta regression coefficients indicate that, ceteris paribus, a 1 point increase in the lagged value of log GDP_PPP increases the VAX ratio by 0.062 points and lowers the backward linkage and GVC participation rate by 0.064 points and 0.076 points, respectively (see Table 4). Figure 1 displays the predictive margins (predicted values) of the conditional means of the various GVC indicators at different levels of lagged log GDP_PPP, keeping all other covariates at their mean levels. The figure bears out the weak association between forward linkage and GDP_PPP.

Table 4: Marginal effects on conditional mean of GVC Participation Indicators, WIOD sample

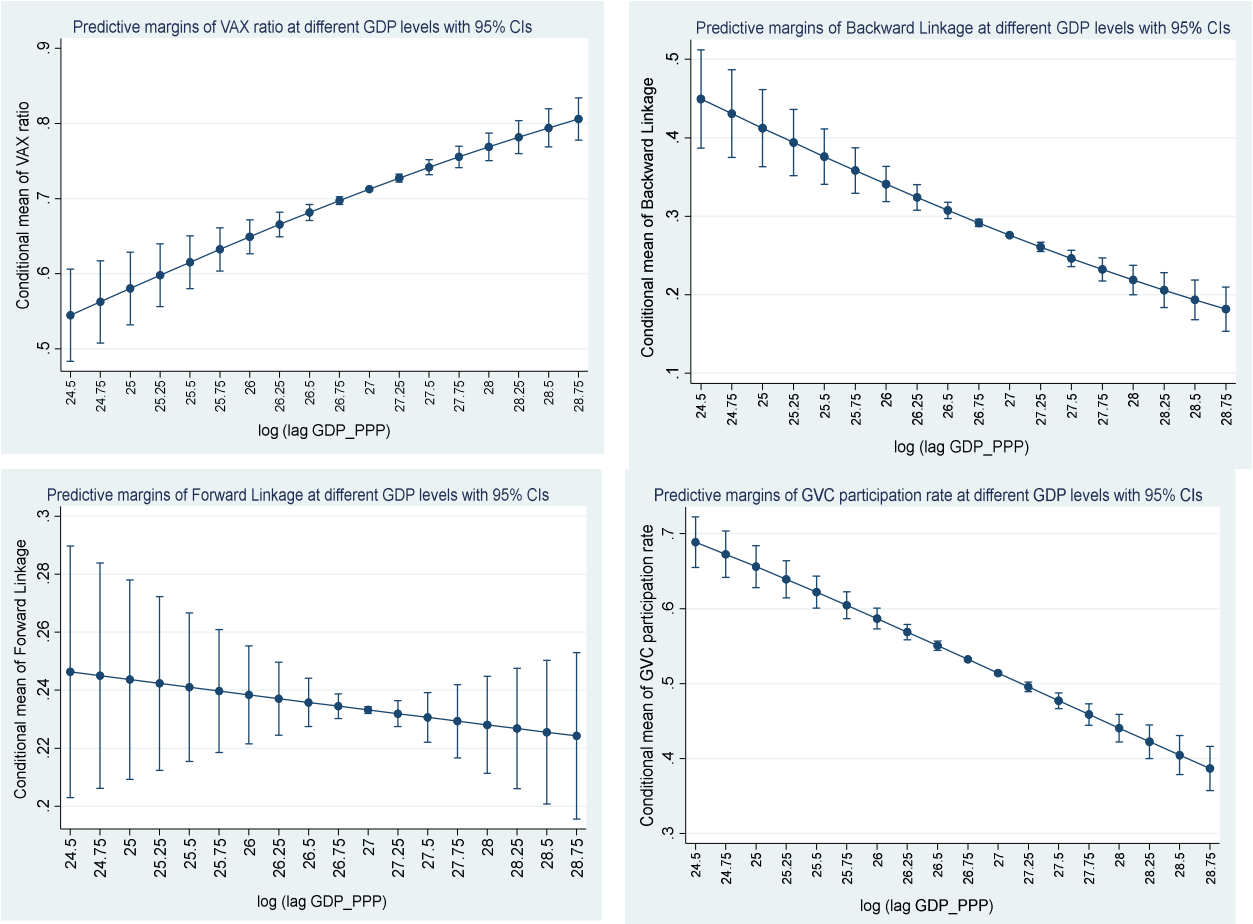
	VAX ratio	Backward linkage (BL)	Forward linkage (FL)	GVC participation rate (FL+BL)
Beta regressions				
log(lag(GDP_PPP))	0.06242 ***	-0.06356 ***	-0.00522	-0.07621 ***
shareX_mfgLT	-0.24067 ***	0.25083 ***	-0.20479 ***	-0.06365
shareX_mfgHT	-0.49506 ***	0.47996 ***	-0.34143 ***	0.07381 **
shareX_servLT	-0.21055 ***	0.20356 ***	-0.22819 ***	-0.09068 **
shareX_servHT	-0.34108 ***	0.33879 ***	-0.29234 ***	-0.03829
log(TertiaryED)	0.00312	-0.02233	-0.00004	-0.03244 *
log(CapCoef)	0.05939 ***	-0.06021 ***	0.02314 **	-0.05795 ***
log(lag(FDI stock/GDP))	0.00409	-0.00518 *	0.01565 ***	0.01074 ***
log(REER)	0.07222 ***	-0.09226 ***	0.04651	-0.02409 ***
CorControl	-0.02336 ***	0.01840 ***	-0.00296	0.01809 ***
OLS regressions				
log(lag(GDP_PPP))	0.06918 ***	-0.07341 ***	0.00051	-0.07290 ***
shareX_mfgLT	-0.17212	0.17812	-0.23667 **	-0.05855
shareX_mfgHT	-0.45157	0.44371 ***	-0.37804 ***	0.06567
shareX_servLT	-0.17975	0.17411	-0.26511 ***	-0.09100
shareX_servHT	-0.30599 **	0.30589 **	-0.37183 ***	-0.06594
log(TertiaryED)	0.00805	-0.01866	-0.01291	-0.03157
log(CapCoef)	0.06625 ***	-0.06773 **	0.01919	-0.04854 ***
log(lag(FDI stock/GDP))	0.00455 **	-0.00510	0.01500	0.00990
log(REER)	0.06032 **	-0.07180 ***	0.04744 **	-0.02436
CorControl	-0.02333 **	0.02029 **	-0.00355	0.01674 **

*** significant at the 1 percent level; ** significant at the 5 percent level; * significant at the 10 percent level

Participation in GVCs varies by industry groups and their technological classification. In the regression equations, the size, sign and the statistical significance of the coefficient on a particular industry group show how the impact differs vis-a-vis the base reference industry category (viz., agriculture and natural resources). For example, the coefficients on all the industry groups included in the equation for backward linkage are positive and significant, implying that their foreign value added content is significantly higher than that for agriculture and natural resources. On the flip side, the VAX ratio and forward linkage of agriculture and natural resources are significantly higher than

the other industry categories. A comparison of the coefficients on different industry groups indicates their differential impact on GVC participation. [15]

Figure 1: Predictive Margins of GVC participation indicators at different GDP levels



High-tech manufacturing industries participate differently in GVCs than the other industry groups. The VAX ratio and forward linkage are significantly lower and the backward linkage is significantly higher for high-tech manufacturing exports compared to exports of other industry groups. This is indicative of high-tech manufacturing exports having a higher degree of vertical specialization and a more downstream position in the supply chain. The integration in GVCs is greater for high-tech manufacturing exports than for other categories of exports: the coefficient on high-tech manufacturing exports in the equation for the GVC participation rate is positive and significant and its size is considerably higher than the coefficients on the other export categories.

[15] Pairwise comparisons of the coefficients of the various industry covariates were carried out to determine whether their differences were statistically significant.

The impact of low-tech manufacturing exports and low-tech services exports on the various GVC participation indicators is not statistically significantly different.[16] Their share of domestic value added in gross exports (VAX ratio) is significantly higher and the foreign value-added content in exports (backward linkage) is significantly lower than those for high-tech services exports and high-tech manufacturing exports. This reflects lower fragmentation of production processes in low-tech industries, and is in line with the findings of Banga (2014). There is no statistically significant difference between high-tech services, low-tech services and low-tech manufacturing with regard to their impact on forward linkage and the GVC participation rate.

The larger is the physical capital endowment of a country relative to output the higher is the VAX ratio and smaller is the backward linkage. This suggests that relatively capital abundant countries have greater scope for sourcing intermediate inputs domestically. Consistent with this pattern, there is a significant negative relationship between the GVC participation rate and physical capital endowment. The association between physical capital abundance and forward linkage is positive and statistically significant, indicating that physical capital abundance is associated with an upstream GVC position.

Higher stocks of inward FDI are connected with higher forward linkage and higher GVC participation rate. This is indicative of FDI being associated with a more upstream position in GVCs and a longer distance from final demand in the production chain. At the same time, inward FDI is negatively associated with backward linkage, in contrast to the finding of a positive relationship in previous studies based on the OLS method of estimation with only time fixed effects. This suggests that, in the sample of countries covered in the analysis, FDI was influenced more by the resource-seeking motive than by the efficiency-seeking motive.

The real exchange rate (REER) has a significant positive association with the VAX ratio, in line with the finding of Caraballo and Jiang (2016). As explained earlier in the discussion of the literature review, this finding is a manifestation of the exchange rate elasticity of export value added being smaller than the exchange rate elasticity of gross exports. The same reasoning applies to the positive and significant coefficient on REER in the equation for forward linkage. REER also has a significant negative association with backward linkage and the overall GVC participation rate,

[16] For all the GVC participation indicators, the null hypothesis that the coefficients on low-tech manufacturing and low-tech services were equal could not be rejected even at the 10 percent level of significance.

suggesting that loss of competitiveness from an appreciated real exchange rate hinders integration into GVCs.

In contrast to the findings of many earlier studies, the regression results do not show a significant role for the proxy variable for labour skill in explaining variations in GVC participation. The coefficient on the share of workers with tertiary education is not statistically significant in the equations for the VAX ratio, backward linkage and forward linkage. Also, contrary to the pattern observed in earlier studies, the influence of tertiary education on the GVC participation rate is negative and weakly significant. The inclusion of an alternative proxy measure for labour skill does not make any difference to the results. The equations were also estimated with education measured as average years of schooling, but the coefficient on this measure also turned out to be statistically insignificant in all the equations. The statistically insignificant coefficient on the different measures of education suggests that formal education may not be a good proxy for labour skills as educational quality is likely to be heterogeneous across countries.

The regression results confirm that good governance facilitates GVC integration. Backward linkage and the GVC participation rates are higher the better is the perception of control of corruption. The coefficient on the VAX ratio is negative and statistically significant. This is essentially a reflection of countries with better record of control of corruption attracting production processes in the GVC that are import-intensive rather than domestic-resource intensive.

Ordinary Least Squares estimates

Since much of the literature on drivers of GVC has utilized the OLS method of estimation, it is of interest to compare the estimates of the beta regressions with those of the OLS regressions. As Table 4 shows, the marginal effects obtained from the beta regression and OLS methods for GDP_PPP, shares of high-tech manufacturing exports and high-tech services exports in total exports, capital intensity and control of corruption index are broadly comparable in size, sign and statistical significance. For low-tech manufacturing exports and low-tech services exports, the results of the two estimation methods are similar only for forward linkage. Unlike in the beta regressions, these two covariates do not have a statistically significant relationship with the other GVC indicators. The findings on REER are similar only for the VAX ratio and backward linkage. A most striking difference is that the coefficient on inward FDI stock is not statistically significant in

the OLS regressions[17] but is significant for backward linkage, forward linkage and GVC participation rate in the beta regressions.

Regression results based on the whole TiVA data set

The regression equations for the entire TiVA sample shown in Table 5 confirm the pattern of interconnection between the results for the different GVC participation indicators that was observed for the WIOD sample. Also, the findings for the TiVA and WIOD samples are similar for GDP_PPP, shares of high-tech and low-tech manufacturing exports, and high-tech services exports in total exports, and REER. The influence of all these variables is in the same direction in both the samples and, with a few exceptions, they are statistically significant drivers of the various GVC participation indicators.

Several variables that do not have a significant influence in the WIOD sample are found to have a significant influence in the case of the TiVA sample. These include GDP_PPP and control of corruption index for forward linkage, high-tech services exports for the GVC participation rate, and tertiary education for the VAX ratio, backward linkage and forward linkage. In the TiVA sample, the share of workers with tertiary education is positively associated with the VAX ratio and forward linkage, and negatively related to backward linkage. This finding on the education variable is contrary to the pattern observed in earlier studies discussed in the literature review section.[18]

Some variables have a significant influence in the WIOD sample but not in the TiVA sample. These variables include share of low-tech services exports for all the GVC participation indicators, inward FDI stock for forward linkage, and control of corruption index for the VAX ratio and backward linkage. In addition, the relationship between capital intensity and the GVC participation indicators are in opposite directions in the two samples.

[17] In a OLS regression specification that included time fixed effects but not country fixed effects, the coefficient on inward FDI stock was statistically significant in the equations for the VAX ratio, backward linkage and GVC participation rate, in line with the findings of Kowalski et al. (2015).
[18] Notably, the finding on the influence of education on backward linkage is contrary to the result obtained by Taglioni and Winkler (2016) based on the TiVA data set, but their study was for the year 2008 only.

Table 5: Beta Regressions of GVC Participation Indicators, TiVA entire sample (2005–2015)

	VAX ratio	Backward linkage (BL)	Forward linkage (FL)	GVC participation rate (FL+BL)
log(lag(GDP_PPP))	0.2945 ***	-0.2943 ***	-0.1852 ***	-0.2617 ***
	(0.07054)	(0.07054)	(0.05871)	(0.04430)
shareX_mfgLT	-0.54201 *	0.54207 *	-0.87997 ***	-0.01899
	(0.28377)	(0.28378)	(0.20459)	(0.21625)
shareX_mfgHT	-1.57118 ***	1.5716 ***	-0.9969 ***	0.70714 ***
	(0.28315)	(0.28314)	(0.21712)	(0.22045)
shareX_servLT	0.65021	-0.65039	0.20708	-0.21563
	(0.55001)	(0.54993)	(0.34491)	(0.35065)
shareX_servHT	-0.62335 **	0.62383 **	-1.12972 ***	0.44726 *
	(0.28669)	(0.28671)	(0.28753)	(0.26844)
log(TertiaryED)	0.21237 *	-0.21274 *	0.14939 *	-0.2863 ***
	(0.11275)	(0.11274)	(0.08645)	(0.09388)
log(CapCoef)	-0.27765 **	0.27775 **	-0.04237	-0.05943
	(0.11275)	(0.12843)	(0.06357)	(0.06705)
log(lag(FDI stock/GDP))	-0.02891	0.02891	0.03762 **	0.04317 **
	(0.02769)	(0.02768)	(0.01662)	(0.02123)
log(PEER)	0.36548 ***	-0.36546 ***	0.14104 **	-0.13448 ***
	(0.06944)	(0.06943)	(0.06519)	(0.05107)
CorControl	0.02009	-0.02017	0.07518 **	-0.00349
	(0.03591)	(0.03589)	(0.03128)	(0.02547)
Time fixed effect	Yes	Yes	Yes	Yes
Country fixed effect	Yes	Yes	Yes	Yes
Log pseudolikelihood	1589.378 ***	1589.423 ***	1805.99 ***	1146.957 ***
Wald chi-sq	71232.87	71239.45	28367.98	30287.63
N	555	555	555	555

*** significant at the 1 percent level; ** significant at the 5 percent level; * significant at the 10 percent level

Subsample analysis of TiVA data set

To identify the influence of country coverage on the findings, we carry out subsample analysis of the TiVA data set. The differences between countries that overlap with the WIOD sample (List A countries) and the additional countries that are exclusive to the TiVA data set (List B countries) can be discerned from the subsample regressions displayed in Table 6.

However, the strength of the relationships between the GVC participation indicators and the explanatory variables, as indicated by the sizes of the estimated coefficients, for the WIOD sample are noticeably different from those for the TiVA sample. There are some other notable differences as well, as pointed out below. These differences can be attributed to dissimilarities between the two data sets in country coverage and sampling period. As noted earlier, the TiVA data set includes a larger number of countries but covers a shorter time interval than the WIOD data set.

The notable differences are as follows. First, the influence of low-tech manufacturing exports, low-tech and high-tech services exports, tertiary education, and REER on the VAX ratio and backward linkage is statistically significant for List A countries but not for List B countries. Second, inward FDI stock and control of corruption index have no statistically significant association with the VAX ratio and backward linkage in List A countries but are significant drivers in List B countries. Third, the coefficients on capital intensity in the equations for the VAX ratio, backward linkage and forward linkage and the coefficient on low-tech service exports for the forward linkage equation are statistically significant for both List A and List B countries but have opposite signs. Fourth, country size is a significant driver of forward linkage for List A countries, but there is no evidence of a significant association in the case of List B countries. It is the opposite case for the coefficients on high-tech manufacturing exports and control of corruption control for forward linkage: the association is significant in List B countries but not in List A countries.

WIOD vs TiVA List A countries

Not surprisingly, since the list of countries is the same in the WIOD and TiVA List A samples, the regression results for most variables are qualitatively similar (see Tables 3 and 6). However, there are a few notable differences that can be likely ascribed to differences in sampling period and data compilation methodology. First, the sizes of the coefficients on all the explanatory variables are noticeably different between the two samples. Second, the influence of low-tech services exports on the VAX ratio, backward linkage and forward linkage is opposite the two samples. Third, unlike in the WIOD sample, control of corruption index does not have a significant impact on the VAX ratio and backward linkage in the TiVA List A sample. Fourth, the negative relationship between GDP_PPP and forward linkage is statistically significant in the TiVA List A sample but not in the WIOD sample.

5 Conclusions

A number of different indicators have been proposed by researchers to measure participation of a country in GVCs and these shed light on the phenomenon from different perspectives. The most common of these indicators include the VAX ratio, backward linkage index, forward linkage index, and overall GVC participation rate. Using the beta regression method of estimation, this paper examines the factors that influence the various measures of GVC participation. Separate regression equations are estimated for the WIOD and TiVA sample of countries for each of the GVC participation indicators with the same set of explanatory variables. Regression equations are also estimated for two subsamples of the TiVA data base. The explanatory variables in the regression

equations include country-specific characteristics and policy-related factors similar to those that have been highlighted in the GVC literature.

Table 6: Beta Regressions of GVC Participation Indicators: TiVA subsample List A & List B countries, 2005-2015.

	VAX ratio		Backward linkage (BL)		Forward linkage (FL)		GVC participation rate (FL+BL)	
	List A	List B	List A	List B	List A	List B	List A	List B
log(lag(GDP_PPP))	0,22369*** (0.07610)	0,49394*** (0.15504)	-0,22352*** (0.07611)	-0,49361*** (0.15499)	-0,19553*** (0.05740)	0,05911 (0.12237)	-0,2617*** (0.04430)	-0,318*** (0.10717)
shareX_mfgLT	-0,68872* (0.39967)	-0,42095 (0.31137)	0,68872* (0.39966)	0,42093 (0.31135)	-0,51385** (0.23344)	-0,77761*** (0.24103)	-0,01899 (0.21625)	-0,61922*** (0.17288)
shareX_mfgHT	-1,5501*** (0.40310)	-1,9271*** (0.32357)	1,55043*** (0.40308)	1,92783*** (0.32357)	-0,37908 (0.24352)	-1,82666*** (0.25781)	0,70714*** (0.22045)	0,19024 (0.26584)
shareX_servLT	1,13512* (0.59287)	-0,31841 (0.80891)	-1,13509* (0.59286)	0,31812 (0.80874)	1,61725*** (0.34248)	-2,06273*** (0.48072)	-0,21563 (0.35065)	-1,5175*** (0.44472)
shareX_servHT	-0,92172** (0.42832)	-0,06425 (0.39256)	0,92231** (0.42828)	0,0645 (0.39256)	-0,10494 (0.28039)	-1,83646*** (0.33222)	0,44726* (0.26844)	-1,5161*** (0.25808)
log(TertiaryED)	0,33343** (0.13932)	0,13279 (0.14905)	-0,33391** (0.13932)	-0,13317 (0.14904)	-0,03629 (0.10482)	0,30231*** (0.10851)	-0,2863*** (0.09388)	0,15094* (0.08770)
log(CapCoef)	0,23387** (0.10241)	-1,09296*** (0.21207)	-0,23368** (0.10243)	1,09286*** (0.21209)	0,20575*** (0.06709)	-0,29273*** (0.09206)	-0,05943 (0.06705)	0,36883*** (0.07930)
log(lag(FDI stock/GDP))	-0,04461 (0.03320)	0,19423*** (0.07124)	0,04459 (0.03319)	-0,19403*** (0.07122)	0,0179 (0.01888)	0,16943*** (0.03111)	0,04317** (0.02123)	0,02466 (0.02837)
log(PEER)	0,36552*** (0.08517)	0,11953 (0.12152)	-0,36547*** (0.08516)	-0,11947 (0.12152)	0,20378** (0.08093)	0,16497* (0.08867)	-0,13448*** (0.05107)	-0,01897 (0.06161)
CorControl	-0,02579 (0.03790)	0,13302** (0.06002)	0,02569 (0.03790)	-0,1331** (0.06001)	-0,01698 (0.03086)	0,1749*** (0.04756)	-0,00349 (0.02547)	0,02712 (0.04552)
Time fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Log pseudolikelihood	1120,991***	531,441***	1121,022***	531,445***	1288,043***	581,775***	1146,957***	543,427***
Wald chi-sq	43121,9	22935,47	43123,07	22937,69	19760,11	14661,54	30287,63	16885,77
N	378	177	378	177	378	177	378	177

*** significant at the 1 percent level; ** significant at the 5 percent level; * significant at the 10 percent level
Note: TiVA List A countries are those that correspond to the countries in the WIOD sample.
TiVA List B countries are those that do not correspond to the countries in the WIOD sample (see Appendix A).

A comparison of the results of the separate regression equations for the four GVC participation indicators sheds light on their interconnectedness. The variables that have a significant influence on the VAX ratio in a particular direction have a significant impact in the same direction on forward linkage. The direction of influence of the explanatory variables on backward linkage is opposite to that on the VAX ratio and forward linkage. The empirical exercise also shows that the results, including the response parameters, are sensitive to sample choice. However, there are several robust qualitative patterns.

For both the WIOD and TiVA samples, the evidence indicates that country size is an important driver of GVC participation. Smaller countries have a lower VAX ratio, stronger backward linkage, and are more integrated into GVCs. The regression results also confirm that a disaggregated classification of export composition is more informative in explaining variations in GVC participation than a simple two-way distinction between manufacturing and non-manufacturing exports. Of all the industry groupings, the influence on all the GVC indicators is strongest for high-tech manufacturing, followed by high-tech services. The impact of low-tech manufacturing exports and low-tech services exports on the various GVC participation indicators is not statistically significantly different.

A notable common finding for the WIOD and TiVA samples is the significant positive relationship of the real exchange rate with the VAX ratio and forward linkage. This is essentially a manifestation of the exchange rate elasticity of export value added being smaller than the exchange rate elasticity of gross exports. In addition, the regression results both samples indicate that a more appreciated real exchange rate hinders integration into GVCs.

The findings on the other drivers of GVC participation are mixed. Surprisingly, although capital abundance, human capital, and quality of institutions are highlighted in the literature as important factors that enable integration into GVCs, the proxy measures of these three variables have different patterns of influence between the WIOD and TiVA samples. The findings on the impact of inward FDI also are not uniform across the WIOD sample and the two TiVA subsamples.

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Appendix A. List of countries in the WIOD and TiVA samples

WIOD	TiVA	
	List A[1]	List B[2]
Australia	Australia	Argentina
Austria	Austria	Brunei Darussalam
Belgium	Belgium	Cambodia
Bulgaria	Bulgaria	Chile
Brazil	Brazil	Colombia
Canada	Canada	Costa Rica
China	China	Hong Kong, China
Cyprus	Cyprus	Iceland
Czech Republic	Czech Republic	Israel
Croatia	Croatia	Kazakhstan
Denmark	Denmark	Malaysia
Estonia	Estonia	Morocco
Finland	Finland	New Zealand
France	France	Peru
United Kingdom	United Kingdom	Philippines
Germany	Germany	Saudi Arabia
Greece	Greece	Singapore
Hungary	Hungary	South Africa
India	India	Thailand
Indonesia	Indonesia	Tunisia
Ireland	Ireland	Viet Nam
Italy	Italy	
Japan	Japan	
Korea	Korea	
Latvia	Latvia	
Lithuania	Lithuania	
Luxembourg	Luxembourg	
Malta	Malta	
Mexico	Mexico	
Netherlands	Netherlands	
Norway	Norway	
Poland	Poland	
Portugal	Portugal	
Romania	Romania	
Russian Federation	Russian Federation	
Slovakia	Slovakia	
Slovenia	Slovenia	
Spain	Spain	
Sweden	Sweden	
Switzerland	Switzerland	
Taiwan	Taiwan	
Turkey	Turkey	
United States	United States	

[1] List A countries correspond to countries which are also included in WIOD.

[2] List B countries are exclusive to the TiVA data base.