Domestic Foundations of Global Value Chains*

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First version: December 2015

This version: February 2016

Abstract

We analyze the relationship between domestic value chains (DVCs) and global value chains (GVCs). Strong domestic linkages across firms cause productivity gains through gains from specialization. This increase in productivity, in turn, should make industries more competitive and facilitate the entry of firms into GVCs. Therefore, GVCs should have domestic foundations in DVCs. We provide evidence in favour of this hypothesis: DVC integration positively affects GVC integration. The results hold in particular for backward linkages, namely, when intermediates sourced from abroad are used as proxy for GVC integration.

Keywords: Domestic value chains; global value chains; input-output linkages.

JEL Classification: F14; F15; F63.

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1 Introduction

Global value chains are an important phenomenon of 21st century trade relations. Not only final products or services get traded, but intermediate steps get outsourced and production becomes more and more fragmented. GVCs are often developed by large firms that coordinate input sourcing and assembly decisions, that is they establish inter-sectoral linkages across borders. Seminal work by Hummels et al. (1998) and Hummels et al. (2001) unveiled the importance of international production sharing. These papers have established that vertical specialization, proxied by the amount of foreign value added in exports, has grown on average by 30% from the 1970s until the 1990s. In a recent contribution, Johnson and Noguera (2012) characterize the difference between value added trade and gross trade, arguing that the GVC revolution, as measured by trade in value added, is ongoing. In a similar fashion, Timmer et al. (2014) show that global fragmentation, proxied by the foreign value-added content of production, has rapidly increased since the early 1990s.

In this paper we argue, and show empirically, that GVCs have their foundations in domestic value chains (DVCs). We propose a measure of DVCs equal to the share of domestically sourced inputs in domestic output, where the latter is computed excluding foreign sourced inputs. We are able to compute this measure for 59 countries and 26 sectors in 1995, 2000, 2005, 2008 and 2011. As shown in Appendix tables A-3 and A-4, DVCs have expanded in the majority of countries and sectors.[1] This begs the question of whether the development of DVCs has an effect on – or can even be considered a precondition for – the integration into GVCs.

The mechanism linking GVC and DVC integration relates to the productivity effects of domestic production networks. Hirschman (1958) was the first to point out the importance of developing domestic inter-sectoral linkages in generating economic growth.[2] Strong domestic

[1] Appendix tables A-3 and A-4 show the growth rate in DVC computed between 1995 and 2008. The year 2011 is not used to rule out any impact of the financial crisis of 2009.

[2] More recent contributions along these lines include Bartelme and Gorodnichenko (2015); Bernard et al. (2015); Dhyne and Rubínová (2015); Furusawa et al. (2015); and Kummritz (2015). Jones (2011) describes the mechanism through which fragmentation and linkages, as represented by intermediate goods sourcing, or the standard Leontief coefficients in input output (IO) tables, contributes to total factor productivity growth. He

linkages across firms cause productivity gains through gains from specialization. This increase in productivity, in turn, should make industries more competitive and facilitate the entry of firms into GVCs, both as buyer (so-called 'backward linkages') and seller (so-called 'forward linkages').

Recent interest in GVCs as a mechanism for potential economic development sometimes appears to focus on the global aspects without much consideration of the role of the domestic economy. If one considers GVCs and global fragmentation of production as a logical step in gains from Smithian specialization, but just crossing borders, it would be useful to understand if the extent of such fragmentation and specialization in a domestic economy helps to play a role in further integration into GVCs. This could have important policy implications for developing economies considering options for integration, as it would potentially highlight the need for, or potential benefits from, increased coherence between domestic and border policies.

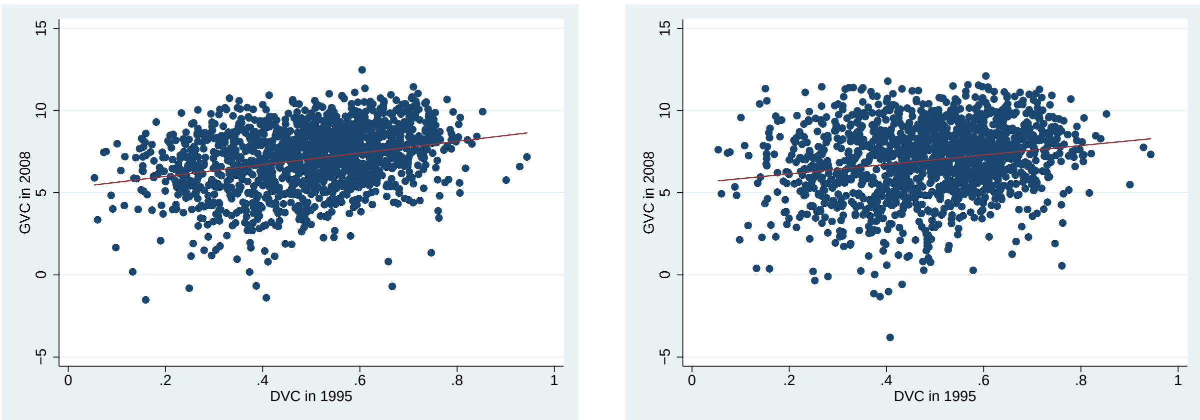
This question relating to domestic fragmentation is not just hypothetical. Deciding on a policy framework for economic development requires a correct understanding of the economic mechanisms that would argue, say, for policies supporting large, highly vertically integrated firms versus policies supporting fragmentation and cross firm linkages between small, medium and large firms. Baldwin (2009) uses the Ford River Rouge plant as an example of highly vertically integrated production, and contrasts that plant with modern car plants, where parts are outsourced and very often offshored, as an example of the 'second unbundling' leading to the development of global value chains. Recent work by Antràs et al. (2012) and Antràs et al. (2014) provides measures of the extent of domestic and international linkages, finding that while the length of domestic value chains (i.e. the number of links in a supply chain) has declined, the overall length has increased, due to the lengthening of global value chains.

We consider various measures of GVCs suggested in the literature. In particular, we build on Daudin et al. (2011), who construct measures of forward linkages (the amount of domestic

illustrates how this mechanism works for both domestically and internationally sourced intermediates.

value added in foreign exports); on Koopman et al. (2014), who decompose gross trade flows into various measures of value added; and Wang et al. (2013), who show how the measures suggested by Koopman et al. (2014) can be manipulated to differentiate between backward and forward linkages. We show that DVCs have a positive impact on GVCs, especially through backward linkages, i.e., through sourcing of intermediates from abroad. Figure 1 presents descriptive evidence for our results. Panel (i) correlates DVC in 1995 with a measure of GVC based on backward linkages (amount of imported inputs). Panel (ii) correlates DVC in 1995 with a measure of GVC based on forward linkages (amount of exported inputs). Both regression lines are positively sloped, with the correlation of GVC with the backward linkages measure being stronger than the correlation with the forward linkages measure.

Figure 1: Correlation scatterplots between DVC in 1995 and GVC in 2008



(i) Backward linkages (i2p) (ii) Forward linkages (e2p)

Notes: GVC measures: i2p defined in equation (2.2); e2p defined in equation (2.3). DVC measure defined in equation (2.6). Each point is a country-sector combination.

This paper is related to the recent literature on substitutability/complementarity between domestic and foreign inputs (Antràs et al., 2014; Blaum et al., 2015; Bartelme and Gorodnichenko, 2015). This literature finds evidence of substitutability. The evidence we provide on complementarity between DVCs and GVCs does not contradict substitutability between domestic and foreign inputs, for two reasons. First, the 'long run' results relating DVCs at the beginning of the sample period (1995) to GVCs at the end of the sample period (2008) show that initial development of DVCs leads to substitution towards foreign sourcing in the future. Second, as detailed in Section 2, we build our DVC measure as the share of domestically sourced inputs in domestic output. This measure is free of any mechanic negative correlation with GVC measures.

The remainder of the paper is organized as follows. Section 2 provides details on the measures employed to proxy for DVC and GVC, describes the data used and the identification strategy. Section 3 presents the empirical results. Section 4 concludes and suggests avenues for further research.

2 Empirical methodology

In this section we discuss the methodology to examine the role of domestic value chains for linking into global value chains. We postulate the following reduced-form model:

$$gvc_{ikt} = \alpha + \beta_1 dvc_{ikt-1} + \gamma' X + \varepsilon_{ikt}, \tag{2.1}$$

where i indexes industries; k indexes countries; t indexes time; X is a vector of controls (including fixed effects) and ε_{ikt} is a random error term. The explanatory variable of interest, dvc_{ikt-1}, is measured through different proxies for the strength of domestic intra- and inter-industry linkages, detailed in the next section. We follow Bartelme and Gorodnichenko (2015) and use one-period lags as a way of addressing the issue of contemporaneous endogenous determination of this variable.[3] The dependent variable, gvc_{ikt}, is measured through different GVC proxies that are also described in more detail in the next section.

[3] See Section 2.3 for a thorough discussion of the identification strategy.

2.1 Measuring domestic and global value chain integration

The empirical GVC literature has used and developed several measures for GVC participation that can be split up into backward and forward linkages. The former look at intermediates sourced from abroad. The latter look at domestic intermediates exported abroad. These measures are typically based on Inter-Country Input-Output (ICIO) tables, which are jl-by-ik matrices that represent supply and demand relationships between industries (i, j) within and across countries (k, l). An individual element of an ICIO matrix, m_{lk}^{ji}, gives thus the value of inputs supplied by industry j of country l to industry i of country k.

As baseline backward linkage indicator for GVC integration, we follow Baldwin and Lopez-Gonzalez (2013) and calculate from ICIO tables the amount of imported inputs, $i2p$, as:

$$i2p_{ik} \equiv \sum_{l} \sum_{j} m_{lk}^{ji}, \tag{2.2}$$

where $l \neq k$.

Analogously, our baseline forward linkage measure is the amount of exported intermediates $e2p$, given by:

$$e2p_{ik} \equiv \sum_{l} \sum_{j} m_{kl}^{ij}, \tag{2.3}$$

where $l \neq k$.

Additionally, following Hummels et al. (2001), Koopman et al. (2014), and Kummritz (2015), we calculate as alternative indicators the foreign value added content in exports $(fvax)$ and the domestic value added content in re-exports $(dvar)$ for robustness exercises. These measures take indirect linkages into account and require that the intermediates cross at least two borders. Therefore, they provide a narrower measure of GVC integration. To build them, we apply the Leontief decomposition (Leontief, 1936) to replace the gross terms in the ICIOs with value added flows in exports as follows:

$$V(I-A)^{-1}E = \begin{pmatrix} v_k^i & 0 & 0 & 0 \\ 0 & v_k^j & 0 & 0 \\ 0 & 0 & v_l^i & 0 \\ 0 & 0 & 0 & v_l^j \end{pmatrix} * \begin{pmatrix} b_{kk}^{ii} & b_{kk}^{ij} & b_{kl}^{ii} & b_{kl}^{ij} \\ b_{kk}^{ji} & b_{kk}^{jj} & b_{kl}^{ji} & b_{kl}^{jj} \\ b_{lk}^{ii} & b_{lk}^{ij} & b_{ll}^{ii} & b_{ll}^{ij} \\ b_{lk}^{ji} & b_{lk}^{jj} & b_{ll}^{ji} & b_{ll}^{jj} \end{pmatrix} * \begin{pmatrix} e_k^i & 0 & 0 & 0 \\ 0 & e_k^j & 0 & 0 \\ 0 & 0 & e_l^i & 0 \\ 0 & 0 & 0 & e_l^j \end{pmatrix} =$$

$$= \begin{pmatrix} v_k^i b_{kk}^{ii} e_k^i & v_k^i b_{kk}^{ij} e_k^j & v_k^i b_{kl}^{ii} e_l^i & v_k^i b_{kl}^{ij} e_l^j \\ v_k^j b_{kk}^{ji} e_k^i & v_k^j b_{kk}^{jj} e_k^j & v_k^j b_{kl}^{ji} e_l^i & v_k^j b_{kl}^{jj} e_l^j \\ v_l^i b_{lk}^{ii} e_k^i & v_l^i b_{lk}^{ij} e_k^j & v_l^i b_{ll}^{ii} e_l^i & v_l^i b_{ll}^{ij} e_l^j \\ v_l^j b_{lk}^{ji} e_k^i & v_l^j b_{lk}^{jj} e_k^j & v_l^j b_{ll}^{ji} e_l^i & v_l^j b_{ll}^{jj} e_l^j \end{pmatrix} = \begin{pmatrix} vae_{kk}^{ii} & vae_{kk}^{ij} & vae_{kl}^{ii} & vae_{kl}^{ij} \\ vae_{kk}^{ji} & vae_{kk}^{jj} & vae_{kl}^{ji} & vae_{kl}^{jj} \\ vae_{lk}^{ii} & vae_{lk}^{ij} & vae_{ll}^{ii} & vae_{ll}^{ij} \\ vae_{lk}^{ji} & vae_{lk}^{jj} & vae_{ll}^{ji} & vae_{ll}^{jj} \end{pmatrix},$$

where

$$v_c^s = \frac{va_c^s}{y_c^s} = 1 - a_{kc}^{is} - a_{kc}^{js} - a_{lc}^{js} - a_{lc}^{is} \qquad (c \in k, l \quad s \in i, j),$$

$$\begin{pmatrix} b_{kk}^{ii} & b_{kk}^{ij} & b_{kl}^{ii} & b_{kl}^{ij} \\ b_{kk}^{ji} & b_{kk}^{jj} & b_{kl}^{ji} & b_{kl}^{jj} \\ b_{lk}^{ii} & b_{lk}^{ij} & b_{ll}^{ii} & b_{ll}^{ij} \\ b_{lk}^{ji} & b_{lk}^{jj} & b_{ll}^{ji} & b_{ll}^{jj} \end{pmatrix} = \begin{pmatrix} 1-a_{kk}^{ii} & -a_{kk}^{ij} & -a_{kl}^{ii} & -a_{kl}^{ij} \\ -a_{kk}^{ji} & 1-a_{kk}^{jj} & -a_{kl}^{ji} & -a_{kl}^{jj} \\ -a_{lk}^{ii} & -a_{lk}^{ij} & 1-a_{ll}^{ii} & -a_{ll}^{ij} \\ -a_{lk}^{ji} & -a_{lk}^{jj} & -a_{ll}^{ji} & 1-a_{ll}^{jj} \end{pmatrix}^{-1},$$

and

$$a_{cf}^{su} = \frac{m_{cf}^{su}}{y_f^u} \qquad (c, f \in k, l \quad s, u \in i, j).$$

In the expressions above, va_c^s is the value added of industry s; y_s^c is the output of industry s; e_k^i indicates gross exports; b_{su}^{cf} refers to the Leontief coefficients; and a_{su}^{cf} denotes the share of inputs, m_{su}^{cf}, in output. Accordingly, the elements of the $V\,(I-A)^{-1}\,E$ or vae matrix are estimates of the industry-level value added origins of each industry's exports.

The backward linkage indicator $fvax$ for industry i in country k is given by:

$$fvax_{ik} \equiv \sum_{l} \sum_{j} vae_{lk}^{ji}, \tag{2.4}$$

where $l \neq k$. Thus, $fvax_{ik}$ is equal to the sum of value added from all industries j of all foreign countries l in the exports of industry i in country k.[4]

Similarly, the forward linkage indicators is given by:

$$dvar_{ik} \equiv \sum_{l} \sum_{j} vae_{kl}^{ij}, \tag{2.5}$$

where $l \neq k$. Thus, $dvar_{ik}$ is equal to the sum of value added from industry i of country k in the exports of all industries j in all foreign countries l.

For the domestic counterpart (the explanatory variable of interest in equation (2.1)) we follow a similar approach. First, we decompose an industry's output into three parts: domestically sourced inputs and value added ('domestic output') versus foreign sourced inputs. We then use as our DVC indicator the share of domestically sourced inputs in domestic output, dvc:

$$dvc_{ik} \equiv \frac{\sum_j m_{kk}^{ji}}{\sum_j m_{kk}^{ji} + va_{ik}}. \tag{2.6}$$

In other words, we calculate the share of domestic output that a firm decides to outsource instead of producing within its factory. The reason for calculating the indicator in this particular way is twofold. Firstly, we only look at domestic output (i.e. domestically sourced inputs and value added but excluding foreign sourced inputs) to avoid a mechanically negative correlation. Since our backward linkage GVC indicator measures foreign sourced inputs, an increase in the share of domestically sourced inputs could be caused by a drop in the share of foreign sourced inputs even if both variables rise in levels. An obvious solution would be to employ levels on

[4] Sourcing from ISIC Rev. 3 group C (mining industry) is excluded to avoid spurious effects based on oil imports. In addition, in Section 3.4 we use further strategies to deal with imports from the mining sector.

both sides of the model, which brings us to our second reason. We need to use shares for our independent variable to avoid an equally possible mechanically positive correlation that would be the result of any complementarity between foreign and domestic inputs in production.

To sum up, to avoid mechanical correlations we need to avoid using shares or levels on both sides of our reduced form model. Therefore, we opt for a mixed approach in which we regress our GVC indicator in levels on our DVC indicator in shares. In addition, the latter is constructed using only domestic output.

2.2 Data

For the calculation of the indicators we employ the OECD ICIO database. It is the most recent and most advanced release of ICIO tables, covering 61 countries and 34 industries for the years 1995, 2000, 2005, and 2008 to 2011. To create ICIOs, the OECD combines national IO tables with international trade data. As OECD countries have a harmonized construction methodology, potential discrepancies between national IO tables should be minor. Furthermore, the advanced harmonization across countries reduces to a minimum the use of proportionality assumptions to derive the ratio of imported intermediates in an industry's demand. The OECD has used elaborate techniques to deal with processing trade. Due to the outstanding role of processing trade in GVCs, this implies a significant improvement for the reliability of the database.[5]

The country coverage comprises developing and developed economies and therefore allows to examine the role of development in shaping the relationship between domestic and global value chains. In addition, the industry coverage includes primary, manufacturing, and services sectors. The latter play an increasingly dominant role in value chains. For the analysis, data for the years 2009, 2010 and 2011 is excluded to rule out interference of the financial crisis and the resulting reductions in global trade. Similarly, we exclude non-tradable industries, such as education, health, or construction, as well as the oil-exporting countries Saudi-Arabia and

[5] See Koopman et al. (2012) for an analysis of China's processing trade.

Brunei Darussalam.[6]

2.3 Identification

Estimation of the reduced-form equation (2.1) could be biased by reverse causality and omitted variable bias. We employ two estimation strategies that imply a trade-off between the two identification concerns. First, we estimate the following fixed-effects model using the years 1995, 2000, 2005, and 2008, which we refer to as short-run model:

$$gvc_{ikt} = \beta_1 dvc_{ikt-1} + \alpha_{it} + \alpha_{kt} + \alpha_{ki} + \varepsilon_{ikt}. \tag{2.7}$$

The variation over time allows to include a large set of fixed effects that minimize potential omitted variable concerns. In the preferred specifications, we use only the within industry-country-time variation, controlling for industry-year (it), country-year (kt) and country-industry (ki) fixed effects.

The one year lag in the explanatory variable in model (2.7) might not fully eliminate a bias stemming from reverse causality. Therefore, we complement the short-run model with a long-run model that looks only at the initial and final years in the sample, respectively 1995 and 2008:

$$gvc_{ik2008} = \beta_1 dvc_{ik1995} + \alpha_k + \alpha_i + \varepsilon_{ik}. \tag{2.8}$$

In this specification, the likelihood of reverse causality, running from gvc to dvc, is minimized, because the latter is measured in the initial year of the sample (1995), while the former is measured in the final year (2008).[7] The downside of this approach is the loss of the time dimension. Therefore, we can only control for country (k) and industry (i) fixed effects, leaving room for a potential omitted variable bias.

If both the short and long run effects point in the same direction, we can nevertheless

[6] All available countries and industries as well as the benchmark sample are listed in Appendix A.1.

[7] Most of the growth in GVC integration took place after 1995. This reinforces the identification assumption in this long run model.

conclude that there is strong suggestive evidence on the causal impact of domestic value chains on GVC integration.

3 Results

Our results indicate that a functioning DVC facilitates GVC integration. This holds in particular for GVC integration through backward linkages. For both the short-run and the long-run model we find a positive and significant coefficient on the majority of our employed GVC indicators. These results are robust to variations in the measurement of the indicators and the sample composition with respect to the years, industries, and countries included. In the preferred specification, a one percentage-point increase in DVC integration raises GVC integration by 0.5%.

3.1 DVCs as foundations

Table 1 reports the results for the simple GVC indicators $i2p$ and $e2p$, respectively defined in equations (2.2) and (2.3). These are measures of trade in intermediates. The coefficients for the DVC indicator, dvc, are all positive and statistically significant, indicating that domestic value chains facilitate GVC integration. Columns (1) and (2) give the results for the backward linkage GVC measure, imported intermediates, while columns (3) and (4) use forward linkages, exported intermediates, as dependent variable. The estimates are similar in magnitude and significance. We take the results in columns (2) and (4) as benchmark, because they include the full set of industry-country, country-year, and industry-year fixed effects. They suggest that a one percentage-point increase in DVC integration leads to a 0.5% rise in GVC integration. This implies that a one-standard-deviation increase in DVC integration raises GVC integration by approximately 2.5%.

Since our benchmark estimates only allow for within industry-country-time variation, they might hide gains that stem from variation in DVC integration across country-industries. There-

Table 1: Short-run effect of domestic value chains on trade in intermediates

	(1)	(2)	(3)	(4)
	Dependent variable			
	i2p	i2p	e2p	e2p
dvc	5.469***	0.543***	5.333***	0.528***
	[0.273]	[0.191]	[0.318]	[0.191]
Observations	4,425	4,425	4,416	4,416
R-squared	0.336	0.795	0.292	0.706

Notes: *** p<0.01, ** p<0.05, * p<0.1. Dependent variable (defined in equation (2.2) for columns (1)-(2) and equation (2.3) for columns (3)-(4)) in natural logarithms. Explanatory variable (defined in equation (2.6)) in shares and lagged by one period. Robust standard errors in parentheses. Columns (1) and (3) include industry (i) and year (t) fixed effects and the log of per capita GDP as controls. Columns (2) and (4) include industry-year (it), country-year (kt) and country-industry (ki) fixed effects.

fore, we additionally report in columns (1) and (3) results that only control for industry and year fixed effects as well as per capita GDP to capture basic country characteristics. Such a setup is in line with previous literature such as Bartelme and Gorodnichenko (2015). The estimates are subject to a stronger omitted variable bias and therefore overstate the DVC effect but the significantly larger magnitudes suggest that our benchmark estimates should be interpreted as lower bounds for the effect of DVCs on GVCs.

To address another source of endogeneity we continue by estimating our long-run model presented in equation (2.8). As outlined above, the long-run model should be free of reverse causality and thus complements the short-run analysis to establish a causal relationship between DVCs and GVCs. Table 2 reports the corresponding estimates and shows that this framework produces estimates that are qualitatively similar to, and quantitatively larger than those of the short-run model. The results confirm the positive effect of DVCs on GVCs in the long-run for backward and forward linkage measures. The difference in magnitude is likely to be caused by the reduced number of fixed effects caused by dropping the time dimension. The short-run estimates remain the benchmark result, given their more conservative results stemming from a larger number of fixed effects.

The combination of both short- and long-run results suggests that – even if reverse causality

Table 2: Long-run effect of domestic value chains on trade in intermediates

	(1)	(2)	(3)	(4)
	Dependent variable			
	i2p	i2p	e2p	e2p
dvc	5.075***	2.355***	4.928***	1.697***
	[0.510]	[0.360]	[0.561]	[0.420]
Observations	1,475	1,475	1,473	1,473
R-squared	0.260	0.784	0.241	0.712

Notes: *** p<0.01, ** p<0.05, * p<0.1. Dependent variable (defined in equation (2.2) for columns (1)-(2) and equation (2.3) for columns (3)-(4)) in natural logarithms. Explanatory variable (defined in equation (2.6)) in shares and lagged by one period. Robust standard errors in parentheses. Columns (1) and (3) include industry (i) fixed effects and the log of per capita GDP as controls. Columns (2) and (4) include country (k) industry (i) fixed effects.

and omitted variable bias cannot be tackled simultaneously – DVC integration positively affects GVC integration. In other words, a functioning DVC is an important determinant for a successful integration into GVCs.

3.2 Heterogeneity by income

In a next step, we assess whether our results are driven by a subset of countries. More specifically, we introduce an interaction term between our DVC measure and a dummy equal to one for high-income countries according to the World Bank classification in 1995 (i.e. the beginning of the sample period). This allows us to explicitly analyse the development dimension of our results. Since in particular low- and middle-income countries struggle to integrate into GVCs, it is important to detect if our results are driven by high-income countries or if they are present in the whole sample.

Table 3 gives the corresponding results. We find that none of the interactions with the high-income dummy are significant. Thus, our results are not income-specific and also extend to developing countries. The development of stronger domestic linkages could thus help these countries to subsequently link into international production networks.

Table 3: Short-run effect of domestic value chains on trade in intermediates by income level

	(1)	(2)	(3)	(4)
	Dependent variable			
	i2p	i2p	e2p	e2p
dvc	0.322	0.454*	0.516**	0.659***
	[0.230]	[0.240]	[0.233]	[0.229]
dvc*high-income	0.499	0.279	0.020	-0.413
	[0.367]	[0.336]	[0.389]	[0.344]
Observations	4,425	4,425	4,416	4,416
R-squared	0.706	0.795	0.603	0.706

Notes: *** p<0.01, ** p<0.05, * p<0.1. Dependent variable (defined in equation (2.2) for columns (1)-(2) and equation (2.3) for columns (3)-(4)) in natural logarithms. Explanatory variable (defined in equation (2.6)) in shares and lagged by one period. Robust standard errors in parentheses. Columns (1) and (3) include industry (i) and year (t) fixed effects and the log of per capita GDP as controls. Columns (2) and (4) include industry-year (it), country-year (kt) and country-industry (ki) fixed effects. High-income is a dummy equal to one if country k was classified as such in 1995 (World Bank classification).

3.3 Heterogeneity by sector

In this section, we look at whether there is heterogeneity in the results by sector. Different sectors are characterized by various degrees of relation-specificity (Nunn, 2007). The establishment of input-output relations both within and across borders entails some costs, such as the cost of codifying and transmitting tacit knowledge. If one assumes that such costs are sunk, and larger for foreign than for domestic sourcing, the prediction would be that DVC integration is less conducive to GVC integration in sectors characterized by a high degree of relation-specificity. This is because the costs of codifying and transmitting tacit knowledge should be higher these sectors.[8]

Services tend to be very relationship-specific and depend on tacit knowledge. Existing domestic linkages in this sector can therefore lead to hold-up, which in fact prevents firms from joining GVCs. To test this we interact the DVC variable with dummy equal to one for industries in the services sector.

The results in Table 4 provide preliminary evidence that relationship-specificity might in-

[8] In addition, product differentiation can cause hold-up between suppliers and buyers when switching costs are high once relationships are established. The prediction would not change if, instead of the degree of relation-specificity, the degree of product differentiation was used.

Table 4: Short-run effect of domestic value chains on trade in intermediates by sector

	(1)	(2)	(3)	(4)
	Dependent variable			
	i2p	i2p	e2p	e2p
dvc	0.435*	0.565**	0.558**	0.704***
	[0.226]	[0.234]	[0.226]	[0.228]
dvc*services	0.172	-0.082	-0.136	-0.655*
	[0.369]	[0.355]	[0.397]	[0.355]
Observations	4,425	4,425	4,416	4,416
R-squared	0.705	0.795	0.603	0.707

Notes: *** p<0.01, ** p<0.05, * p<0.1. Dependent variable (defined in equation (2.2) for columns (1)-(2) and equation (2.3) for columns (3)-(4)) in natural logarithms. Explanatory variable (defined in equation (2.6)) in shares and lagged by one period. Robust standard errors in parentheses. Columns (1) and (3) include industry (i) and year (t) fixed effects and the log of per capita GDP as controls. Columns (2) and (4) include industry-year (it), country-year (kt) and country-industry (ki) fixed effects. Services is a dummy equal to one if sector i is a services sector.

deed dampen the positive effects of DVCs. The interaction terms in the preferred specifications with the full set of fixed effects are both negative (columns (2) and (4)) albeit only significant when looking at forward linkages (column (4)). In this case, the magnitude of the coefficients indicates that there is no positive relationship between DVCs and GVCs at all in the services sector. Countries seeking to establish more links with international production networks through forward linkages should thus take the relationship-specificity of their comparative advantage sectors into account.

3.4 Robustness

We expose our results to a battery of robustness checks, starting with alternative definitions of the dependent variable. We replace the simple intermediate trade GVC measures with trade in value added measures obtained using the Leontief decomposition on ICIOs, as detailed in Section 2. The results for the long-run and the short-run model are respectively in Appendix tables A-5 and A-5. In the preferred specifications, only the backward linkages indicator $fvax$ is significant (column (2)). The forward linkages indicator $dvar$ is not significant (column (2)). When GVC involvement is measured in terms of trade in value added (narrow definition) rather than trade in intermediates (broad definition), DVCs matter only for backward linkages, i.e., the value added embodied in exports.

Moving to the explanatory variable, the benchmark estimates use the share of domestically sourced inputs in what we refer to as domestic output – the difference between total output and the value of foreign sourced inputs. The reason is that we want to create a variable that is not affected by GVC linkages. However, if the value of foreign sourced inputs is substantial, this variable might overestimate the role of domestic value chains. This might be a problem in particular for high-income economies who developed strong GVC linkages already before 1995. We therefore replace domestic output with total output in the denominator of equation (2.2).[9] The results are displayed in Appendix tables A-7 and A-8. They are qualitatively and quantitatively in line with those of Appendix tables A-5 and A-5, confirming that DVCs seem to play an especially vital role for linking into GVCs through backward linkages.

Next, we proceed to vary the sample composition.[10] First, we include previously dropped countries and industries to examine if the results are sensitive to specific countries. We find that that this does not affect the results in any meaningful way. In a next step, we include the year 2011 in the analysis. This allows assessing whether the results are dependent on a specific time period, and whether the global financial crisis is relevant for the DVC-GVC relationship. The estimates suggest that neither is the case. The only relevant change is that the previously negative but insignificant short-run effect regarding forward linkages measure by trade in value added is now statistically significant. This is thus further evidence that the results hold in particular for backward linkages. In addition, since the results for forward linkages measured using trade intermediates are not affected, we should not rule out positive effects for DVCs on forward linkages in general.

[9] That is, we compute dvc_{ik} as $\frac{\sum_j m_{kk}^{ji}}{\sum_j m_{kk}^{ji}+va_{ik}+i2p_{ik}}$, where $i2p_{ik}$ is defined in equation (2.2).

[10] The results discussed in this paragraph are available upon request.

4 Conclusions

This paper provides evidence that DVC integration positively affects GVC integration. In other words, a functioning DVC is an important determinant for a successful integration into GVCs. The results hold in particular for backward linkages, namely, when intermediates sourced from abroad are used as proxy for GVC integration. This result is in line with the FDI literature.

The results do not vary across groups of countries at different levels of economic development. Conversely, they vary across sectors. We have presented preliminary evidence which supports the hypothesis that the DVC-GVC link should matter less in sectors characterized by relation-specific investments and hold-up problems. The next step in our research is to test this hypothesis with more sophisticated and realistic measures of sectoral relation-specificity.

References

Antràs, P., D. Chor, T. Fally, and R. Hillberry, 2012, "Measuring the Upstreamness of Production and Trade Flows," *American Economic Review*, 102, 412–416.

Antràs, P., T. C. Fort, and F. Tintelnot, 2014, "The Margins of Global Sourcing: Theory and Evidence from U.S. Firms," NBER Working Paper 20772, National Bureau of Economic Research.

Baldwin, R., 2009, "Integration of the North American Economy and New-Paradigm Globalisation," CEPR Discussion Paper 7523, Centre for Economic Policy Research.

Baldwin, R., and J. Lopez-Gonzalez, 2013, "Supply-Chain Trade: A Portrait of Global Patterns and Several Testable Hypotheses," NBER Working Paper 18957, National Bureau of Economic Research.

Bartelme, D., and Y. Gorodnichenko, 2015, "Linkages and Economic Development," NBER Working Paper 21251, National Bureau of Economic Research.

Bernard, A. B., A. Moxnes, and Y. U. Saito, 2015, "Production networks, geography and firm performance," NBER Working Paper 21082, National Bureau of Economic Research.

Blaum, J., C. Lelarge, and M. Peters, 2015, "The Gains From Trade in Firm-Based Models of Importing," available at `http://econ.duke.edu/uploads/media_items/m-peters-erid-paper-1.original.pdf`.

Daudin, G., C. Rifflart, and D. Schweisguth, 2011, "Who produces for whom in the world economy?," *Canadian Journal of Economics*, 44, 1403–1437.

Dhyne, E., and S. Rubínová, 2015, "The supplier network of exporters: Connecting the dots," Presented at the 2015 ETSG conference, Paris, 10-12 September. Available at `http://www.etsg.org/ETSG2015/Papers/029.pdf`.

Furusawa, T., K. Ito, T. Inui, and H. Tang, 2015, "Offshoring, Relationship-Specificity, and Domestic Production Networks," Discussion Paper 15122, Research Institute of Economy, Trade and Industry (RIETI).

Hirschman, A. O., 1958, *The strategy of economic development*, New Haven: Yale University Press.

Hummels, D., J. Ishii, and K.-M. Yi, 2001, "The nature and growth of vertical specialization in world trade," *Journal of International Economics*, 54, 75–96.

Hummels, D., D. Rapoport, and K.-M. Yi, 1998, "Vertical specialization and the changing nature of world trade," *Economic Policy Review*, pp. 79–99.

Johnson, R. C., and G. Noguera, 2012, "Accounting for intermediates: Production sharing and trade in value added," *Journal of International Economics*, 86, 224–236.

Jones, C. I., 2011, "Intermediate Goods and Weak Links in the Theory of Economic Development," *American Economic Journal: Macroeconomics*, 3, 1–28.

Koopman, R. B., Z. Wang, and S.-J. Wei, 2012, "Estimating domestic content in exports when processing trade is pervasive," *Journal of Development Economics*, 99, 178–189.

Koopman, R. B., Z. Wang, and S.-J. Wei, 2014, "Tracing Value-Added and Double Counting in Gross Exports," *American Economic Review*, 104, 459–94.

Kummritz, V., 2015, "Global Value Chains: Benefiting the Domestic Economy?," IHEID Working Paper 02-2015, Centre for Trade and Economic Integration, The Graduate Institute, Geneva.

Leontief, W., 1936, "Quantitative Input and Output Relations in the Economic System of the United States," *Review of Economics and Statistics*, 18, 105–125.

Nunn, N., 2007, "Relationship-Specificity, Incomplete Contracts, and the Pattern of Trade," *Quarterly Journal of Economics*, 122, 569–600.

Timmer, M. P., A. A. Erumban, B. Los, R. Stehrer, and G. J. de Vries, 2014, "Slicing Up Global Value Chains," *Journal of Economic Perspectives*, 28, 99–118.

Wang, Z., S.-J. Wei, and K. Zhu, 2013, "Quantifying International Production Sharing at the Bilateral and Sector Levels," NBER Working Paper 19677, National Bureau of Economic Research.

A Appendix

A.1 Data

Table A-1: OECD ICIO country coverage

ISO3	Country	ISO3	Country
AUS	Australia	ITA	Italy
ARG	Argentina	JPN	Japan
AUT	Austria	KHM	Cambodia
BEL	Belgium	KOR	Korea
BGR	Bulgaria	LTU	Lithuania
BRA	Brazil	LUX	Luxembourg
BRN	**Brunei Darussalam**	LVA	Latvia
CAN	Canada	MEX	Mexico
CHE	Switzerland	MLT	Malta
CHL	Chile	MYS	Malaysia
CHN	China	NLD	Netherlands
COL	Colombia	NOR	Norway
CRI	Costa Rica	NZL	New Zealand
CYP	Cyprus	PHL	Philippines
CZE	Czech Republic	POL	Poland
DEU	Germany	PRT	Portugal
DNK	Denmark	ROU	Romania
ESP	Spain	RUS	Russia
EST	Estonia	**SAU**	**Saudi Arabia**
FIN	Finland	SGP	Singapore
FRA	France	SVK	Slovak Republic
GBR	United Kingdom	SVN	Slovenia
GRC	Greece	SWE	Sweden
HKG	Hong Kong, China	THA	Thailand
HRV	Croatia	TUN	Tunisia
HUN	Hungary	TUR	Turkey
IDN	Indonesia	TWN	Chinese Taipei
IND	India	USA	United States
IRL	Ireland	VNM	Viet Nam
ISL	Iceland	ZAF	South Africa
ISR	Israel		

Note: Countries in **bold** excluded in benchmark estimations.

Table A-2: OECD ICIO industry coverage

Isic Rev. 3	**Industry code**	**Industry description**
01T05	AGR	Agriculture
10T14	MIN	Mining and quarrying
15T16	FOD	Food products, beverages, and tobacco
17T19	TEX	Textiles, leather and footwear
20	WOD	Wood and products of wood and cork
21T22	PAP	Pulp, paper, paper products, printing and publishing
23	PET	Coke, refined petroleum products and nuclear fuel
24	CHM	Chemicals and chemical products
25	RBP	Rubber and plastics products
26	NMM	Other non-metallic mineral products
27	MET	Basic metals
28	FBM	Fabricated metal products
29	MEQ	Machinery and equipment n.e.c
30,32,33	CEQ	Computer, electronic and optical products
31	ELQ	Electrical machinery and apparatus n.e.c
34	MTR	Motor vehicles, trailers and semi-trailers
35	TRQ	Other transport equipment
36T37	OTM	Manufacturing n.e.c; recycling
40T41	**EGW**	**Electricity, gas and water supply**
45	**CON**	**Construction**
50T52	WRT	Wholesale and retail trade
55	**HTR**	**Hotels and restaurants**
60T63	TRN	Transport and storage
64	PTL	Post and telecommunications
65T67	FIN	Finance and insurance
70	REA	Real estate activities
71	RMQ	Renting of machinery and equipment
72	ITS	Computer and related activities
73T74	BZS	Research and development and other business services
75	**GOV**	**Public administration and defence**
80	**EDU**	**Education**
85	**HTH**	**Health and social work**
90T93	**OTS**	**Other community, social and personal services**
95	**PVH**	**Private households with employed persons**

Note: Industries in **bold** excluded in benchmark estimations.

Table A-3: DVC integration over time, country-average across sectors

ISO3	DVC in 1995	DVC in 2008	% change 1995-2008	ISO3	DVC in 1995	DVC in 2008	% change 1995-2008
LUX	0.30	0.46	53.7%	CRI	0.40	0.42	3.5%
KHM	0.24	0.34	45.5%	CHE	0.41	0.43	3.1%
MYS	0.41	0.55	35.4%	CHL	0.44	0.45	2.9%
ISL	0.41	0.50	21.4%	TWN	0.48	0.50	2.3%
AUT	0.39	0.45	17.3%	SWE	0.44	0.45	2.3%
LVA	0.46	0.53	16.1%	COL	0.39	0.40	1.7%
CYP	0.29	0.33	15.5%	AUS	0.47	0.48	0.4%
TUR	0.43	0.50	15.3%	CAN	0.38	0.38	0.3%
THA	0.44	0.50	13.9%	NZL	0.50	0.50	-0.1%
MLT	0.36	0.41	13.8%	IND	0.45	0.45	-0.9%
KOR	0.50	0.56	11.1%	PRT	0.46	0.46	-0.9%
ISR	0.38	0.42	9.4%	USA	0.43	0.42	-1.0%
CHN	0.58	0.63	9.2%	NOR	0.39	0.38	-1.5%
SVN	0.43	0.47	8.2%	GBR	0.44	0.43	-1.6%
ZAF	0.44	0.48	8.1%	ESP	0.47	0.46	-2.0%
NLD	0.44	0.47	8.0%	MEX	0.35	0.34	-2.4%
BRA	0.44	0.48	7.6%	SGP	0.56	0.54	-3.0%
VNM	0.47	0.50	7.5%	BGR	0.51	0.50	-3.2%
DEU	0.42	0.45	7.0%	HUN	0.48	0.47	-3.3%
HKG	0.37	0.39	6.4%	IRL	0.47	0.45	-3.3%
RUS	0.43	0.46	6.4%	IDN	0.43	0.41	-3.5%
BEL	0.47	0.50	6.4%	EST	0.49	0.47	-3.7%
ARG	0.39	0.41	6.0%	PHL	0.42	0.40	-5.2%
DNK	0.39	0.42	5.7%	LTU	0.45	0.42	-5.8%
FRA	0.42	0.45	5.4%	HRV	0.48	0.45	-6.5%
JPN	0.44	0.46	5.2%	SVK	0.53	0.49	-7.9%
ITA	0.46	0.49	5.1%	ROU	0.48	0.43	-10.6%
CZE	0.54	0.56	4.2%	TUN	0.39	0.35	-11.2%
FIN	0.45	0.47	3.7%	GRC	0.38	0.32	-14.9%
POL	0.48	0.49	3.5%				

Notes: Countries ranked by decreasing % change in DVC. Only countries included in benchmark estimations (listed in Table A-1) reported. DVC measure defined in equation (2.6). Country names displayed in Table A-1.

Table A-4: DVC integration over time, sector-average across countries

Industry code	**DVC in 1995**	**DVC in 2008**	**% change 1995-2008**
PTL	0.31	0.42	36.3%
NMM	0.52	0.61	17.8%
ELQ	0.58	0.67	15.3%
FIN	0.38	0.43	14.4%
TRN	0.44	0.50	13.8%
RBP	0.62	0.70	13.0%
MET	0.66	0.74	10.9%
CHM	0.60	0.67	10.5%
RMQ	0.31	0.35	10.5%
PET	0.49	0.53	8.7%
MTR	0.70	0.76	8.6%
FBM	0.54	0.59	8.4%
MEQ	0.59	0.63	8.2%
ITS	0.35	0.38	8.1%
WOD	0.63	0.68	8.0%
TEX	0.64	0.69	7.8%
PAP	0.58	0.62	7.0%
WRT	0.35	0.37	6.0%
TRQ	0.61	0.64	5.7%
FOD	0.69	0.73	4.5%
BZS	0.36	0.38	4.5%
AGR	0.41	0.42	3.2%
CEQ	0.59	0.61	2.1%
OTM	0.60	0.57	-3.5%
MIN	0.32	0.26	-18.8%

Notes: Industries ranked by decreasing % change in DVC. Only industries included in benchmark estimations (listed in Table A-2) reported. DVC measure defined in equation (2.6). Industry descriptions displayed in Table A-2.

A.2 Robustness

Table A-5: Short-run effect of domestic value chains on trade in value added

	(1)	(2)	(3)	(4)
	Dependent variable			
	fvax	fvax	dvar	dvar
dvc	5.745***	0.664***	3.878***	-0.149
	[0.307]	[0.186]	[0.316]	[0.151]
Observations	4,422	4,422	4,425	4,425
R-squared	0.336	0.725	0.252	0.797

Notes: *** p<0.01, ** p<0.05, * p<0.1. Dependent variable (defined in equation (2.4) for columns (1)-(2) and equation (2.5) for columns (3)-(4)) in natural logarithms. Explanatory variable (defined in equation (2.6)) in shares and lagged by one period. Robust standard errors in parentheses. Robust standard errors in parentheses. Columns (1) and (3) include industry (i) and year (t) fixed effects and the log of per capita GDP as controls. Columns (2) and (4) include industry-year (it), country-year (kt) and country-industry (ki) fixed effects.

Table A-6: Long-run effect of domestic value chains on trade in value added

	(1)	(2)	(3)	(4)
	Dependent variable			
	fvax	fvax	dvar	dvar
dvc	5.159***	2.745***	3.648***	0.084
	[0.543]	[0.436]	[0.531]	[0.351]
Observations	1,474	1,474	1,475	1,475
R-squared	0.294	0.714	0.236	0.793

Notes: *** p<0.01, ** p<0.05, * p<0.1. Dependent variable (defined in equation (2.4) for columns (1)-(2) and equation (2.5) for columns (3)-(4)) in natural logarithms. Explanatory variable (defined in equation (2.6)) in shares and lagged by one period. Robust standard errors in parentheses. Columns (1) and (3) include industry (i) fixed effects and the log of per capita GDP as controls. Columns (2) and (4) include country (k) and industry (i) fixed effects.

Table A-7: Short-run effect of domestic value chains on trade in intermediates – Robustness

	(1)	(2)	(3)	(4)
	Dependent variable			
	i2p	i2p	e2p	e2p
dvc (Total output)	6.090***	0.446**	6.359***	0.326
	[0.273]	[0.205]	[0.321]	[0.221]
Observations	4,425	4,425	4,416	4,416
R-squared	0.296	0.794	0.256	0.705

Notes: *** p<0.01, ** p<0.05, * p<0.1. Dependent variable (defined in equation (2.2) for columns (1)-(2) and equation (2.3) for columns (3)-(4)) in natural logarithms. Explanatory variable (defined in footnote 9) in shares and lagged by one period. Robust standard errors in parentheses. Columns (1) and (3) include industry (i) fixed effects and the log of per capita GDP as controls. Columns (2) and (4) include country (k) industry (i) fixed effects.

Table A-8: Short-run effect of domestic value chains on trade in value added – Robustness

	(1)	(2)	(3)	(4)
	Dependent variable			
	fvax	fvax	dvar	dvar
dvc (Total output)	5.606***	0.547**	5.707***	-0.325**
	[0.310]	[0.216]	[0.309]	[0.164]
Observations	4,422	4,422	4,425	4,425
R-squared	0.326	0.724	0.289	0.798

Notes: *** p<0.01, ** p<0.05, * p<0.1. Dependent variable (defined in equation (2.4) for columns (1)-(2) and equation (2.5) for columns (3)-(4)) in natural logarithms. Explanatory variable (defined in footnote 9) in shares and lagged by one period. Robust standard errors in parentheses. Columns (1) and (3) include industry (i) and year (t) fixed effects and the log of per capita GDP as controls. Columns (2) and (4) include industry-year (it), country-year (kt) and country-industry (ki) fixed effects.