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**Working Paper**

## Implications of foreign direct investment, capital formation and its structure for global value chains

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# Implications of Foreign Direct Investment, Capital Formation and its Structure for Global Value Chains

Amat Adarov and Robert Stehrer





# Implications of Foreign Direct Investment, Capital Formation and its Structure for Global Value Chains

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# Abstract

In the age of globalisation, international trade and foreign direct investment (FDI) have become integral elements of cross-country production sharing. In this paper we empirically assess the impact of FDI, as well as capital dynamics and structure, on the formation of global value chains (GVC) and trade in value added at country and sectoral levels based on a database constructed for a sample of European countries over the period 2000-2014. The analysis reveals that inward FDI is especially conducive to the formation of backward linkages while outward FDI facilitates forward GVC participation, especially in high-tech manufacturing sectors. A particularly robust influence of FDI and capital accumulation on GVC integration is identified in the textile and clothing industry. While capital accumulation in general intensifies GVC linkages for most sectors, ICT capital appears to be especially instrumental for backward integration of electrical and transportation equipment sectors.

**Keywords:** global value chains, value added trade, foreign direct investment, capital, capital composition, gravity model, fractional response model

**JEL classification:** F14, F15, F21, E22



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# 1. Introduction

One of the defining features of the world economy nowadays is the rapid rise of global value chains (GVC). Fragmentation of production processes and distribution of individual business functions across multiple countries due to improvements in cross-border connectivity and the rise of information and communication technologies has widened the opportunities to participate in international production and trade without the need to develop complete value chains within a single country. On the contrary, companies integrated in global value chains benefit by drawing on international factors of production and thereby gain greater efficiency and competitiveness. Therefore, it is not surprising that the identification of factors that facilitate the integration of countries into global value chains has become an important topic of economic research and a critical aspect for policymakers when crafting economic growth and development strategies.

However, empirical literature on the drivers of GVCs is still rather scarce (although rapidly developing), largely on account of data constraints, as consistent world input-output tables and related trade in value added data have only been assembled recently. Value chain integration is often viewed as a phenomenon qualitatively very similar to general trade integration; yet one may wonder whether factors driving GVCs differ from those facilitating economic liberalisation as more broadly defined. In this regard empirical research largely reiterates the importance of robust structural characteristics of countries, and, in particular, emphasises the role of human capital development, quality infrastructure and institutions, liberal trade and investment policies and the business climate in fostering trade in value added and a more effective integration into GVCs (see, for instance, Dollar and Kidder, 2017; OECD, 2013; UNCTAD, 2013; Taglioni and Winkler, 2014; Timmer et al., 2013, 2014). Domestic market size, economic development level, degree of industrialisation and proximity to major production hubs are also found to be important macroeconomic characteristics influencing the formation of GVCs (Baldwin and Lopez Gonzalez, 2015; Hummels et al., 2001; Johnson and Noguera, 2012; Kowalski et al., 2015; Miroudot et al., 2013; OECD et al., 2014).<sup>1</sup>

While it is intuitive that foreign direct investment constitutes an integral element of international production sharing, along with trade in intermediate products, as formation of GVCs is largely coordinated by multinational corporations, empirical research is still lacking with just a few studies trying to quantify the relationship between GVCs and FDI, mostly focusing on trade in value added in a gravity model setup (Buelens and Tirpak, 2017; Martínez-Galan and Fontoura, 2019). Likewise, the impact of domestic capital formation and its composition on GVC participation has also been hitherto overlooked in empirical research.

Our paper attempts to fill these gaps and contribute to the literature along several dimensions. First, we estimate the impact of FDI, real capital and its composition on GVC formation by looking at both bilateral value-added trade and GVC participation measures, which are related, but yet rather distinct, economic concepts. As regards the latter, we also distinguish between upstream and downstream value chain

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<sup>1</sup> For a literature review on the determinants of GVC see also Amador and Cabral, 2014; OECD et al., 2014; Taglioni and Winkler, 2014.

integration. Second, our analysis is carried out at aggregate and sectoral levels. To this end, in order to arrive at a consistent analysis at the sectoral level we develop a classification of sectors and construct a panel dataset of FDI, GVC and factors of production based on Eurostat, EU KLEMS and OECD data, which allows us to assess the longer run dynamics of European countries over the period 2000-2014 addressing such challenges as a change in NACE classification, accounting for FDI associated with special purpose entities and others. Finally, we examine the implications of capital structure by looking at ten different capital asset types, as well as distinguishing between the roles of ICT and non-ICT capital.

To this end, we compute total, backward and forward global value chain participation measures for individual countries and bilateral trade in value added for all countries in the sample based on the world input-output database (WIOD). Our empirical strategy then follows a two-fold approach. First, we analyse the determinants of bilateral trade in value added using the gravity model of trade estimated via the Poisson Pseudo Maximum Likelihood and other models, augmenting the vector of explanatory variables by bilateral FDI and trading partners' real capital stock variables. The second approach employs fractional response model analysis along with alternative estimators (Mundlak-Chamberlain correlated random effects, two-stage endogenous control regressions, fixed effects models), using GVC participation measures as a dependent variable and inward (outward) FDI and capital stock variables, *inter alia*, as explanatory variables. Besides aggregate capital stock in both cases, we also investigate the implications of ICT vs non-ICT capital, and zoom in on capital by asset types utilising the EU KLEMS capital stocks database in additional empirical exercises.

In summary, our estimates based on a European sample of countries over the period 2000-2014 suggest that FDI indeed constitutes an important driver of GVC participation and trade in value added. Inward FDI is especially conducive to the formation of backward linkages, while outward FDI facilitates forward GVC participation. Examining bilateral trade and investment relationships using the gravity model of trade, we find that both inward and outward bilateral FDI positively influence trade in value added. Pooled sectoral analysis confirms that both inward and outward FDI facilitate GVC integration, and, in particular, inward FDI is especially important for both the backward and forward integration of manufacturing sectors.

A closer look at the estimation results for individual sectors suggests that the positive impact of outward FDI on forward GVC participation is driven largely by high-tech manufacturing sectors — the machinery, transport and (especially) electrical equipment industries. A significant positive impact of inward FDI on backward GVC participation is found in the textile and clothing industry, as well as agriculture and chemical production. While the estimated marginal effects of inward FDI on backward linkages in the high-tech manufacturing sector are sizeable, they are not statistically significant. Overall, the textile and clothing production sector exhibits an especially strong across-the-board response to FDI and capital formation in terms of both upstream and downstream integration.

We then attempt to dissect the implications of capital structure at aggregate and sectoral levels, splitting real capital stock into ICT and non-ICT components, as well as checking the effects associated with capital disaggregated by asset types — residential and non-residential structures, machinery, computing equipment and other items following the EU KLEMS classification. ICT capital is generally positively associated with backward GVC participation and is especially instrumental for the backward GVC integration of the electrical and transportation equipment sectors, as well as the chemical industry. At the

same time, ICT capital appears to negatively impact the forward GVC participation of the textile and clothing industry.

The rest of the paper is structured as follows. Section 2 reviews the data and country sample and introduces the industrial classification developed in the paper. Sections 3 and 4 outline GVC measures and review the position of European countries in terms of GVC participation, FDI and capital dynamics. Section 5 estimates the impact of FDI and capital on GVC participation at country and sectoral levels as well as assesses the implications of capital structure. Section 6 estimates the effects of bilateral FDI and capital on bilateral trade in value added. Section 7 provides an overarching interpretation of the results obtained in other sections and reviews policy implications. Section 8 concludes.

## 2. Data and sample

For the purposes of econometric analysis, we compile country-level and sector-level panel datasets which include a range of aggregate and industry-level measures of global value chain participation, foreign direct investment, capital dynamics and composition by asset types as well as other measures characterising economic activity at the sectoral and aggregate levels. In addition, for gravity model analysis, we construct a bilateral dataset of trade in value added and bilateral FDI flows and stocks in addition to the conventional bilateral and country-specific variables commonly used in the gravity literature (distance, common border, etc.).

The data spans the period 2000-2014 at an annual frequency and covers 28 European countries<sup>2</sup> as listed in Table 2.1. We exclude “tax offshore” countries — Luxembourg, the Netherlands, Cyprus, Malta and Ireland, which are frequently listed in the literature as tax havens, from econometric analysis (see, e.g. Hines, 2010). However, not all variables are available for all countries for certain empirical exercises (e.g. capital by asset types for certain sectors), and thus the effective sample varies, depending on the focus of the analysis (in all cases stability and sensitivity checks were performed). We also drop countries for which the data for key variables (GVC participation, FDI, capital stock) is either missing or too short. In the end, the sample of countries that is used in the baseline regression analysis is limited to 19 countries as indicated in Table 2.1.

**Table 2.1 / Sample of countries**

Country	ISO3 code	Regression sample	Country	ISO3 code	Regression sample
Austria	AUT	Y	Hungary	HUN	Y
Belgium	BEL		Ireland	IRL	
Bulgaria	BGR		Italy	ITA	Y
Cyprus	CYP		Lithuania	LTU	Y
Czech Republic	CZE	Y	Luxembourg	LUX	
Germany	DEU	Y	Latvia	LVA	Y
Denmark	DNK	Y	Malta	MLT	
Spain	ESP	Y	Netherlands	NLD	
Estonia	EST	Y	Poland	POL	Y
Finland	FIN	Y	Portugal	PRT	Y
France	FRA	Y	Romania	ROU	
United Kingdom	GBR	Y	Slovak Republic	SVK	Y
Greece	GRC	Y	Slovenia	SVN	Y
Croatia	HRV		Sweden	SWE	Y

Source: Own elaboration.

<sup>2</sup> In the case of gravity model regression analysis, we also use a global bilateral dataset for robustness; however, including capital stock data sourced from the EU KLEMS database limits the sample to European countries. To facilitate comparability across empirical exercises in the paper we report the results for the European sample. The time period is limited by the availability of key source databases, particularly, WIOD and EU KLEMS data.

The database is constructed using data available from publicly available sources. Trade in value added and GVC participation measures are computed based on the WIOD data (2016 release). FDI stocks and flows are obtained from the Eurostat and the OECD databases. Real capital stocks, their composition by asset types and gross fixed capital formation variables are obtained from EU KLEMS, World Bank's World Development Indicators and Penn World Tables. The data for control variables, including GDP, population, real effective exchange rate (REER), manufacturing value added share, governance indicators and other variables are sourced or computed based on the data from the EU KLEMS, CEPII gravity database, World Bank's World Development Indicators and Worldwide Governance Indicators. Descriptive statistics for the variables used in the study at the aggregate and sectoral levels are reported in Appendix C.

**Table 2.2 / Classification of sectors**

SEC	NACE Rev. 2 codes	Sector description (based on NACE 2 classification)	Label
1	A	Agriculture, forestry and fishing	1_AGRI
2	B	Mining and quarrying	2_MING
3	10-12	Food products, beverages and tobacco	3_FOOD
4	13-15	Textiles, wearing apparel, leather and related products	4_TXTL
5	16-18	Wood and paper products; printing and reproduction of recorded media	5_WOOD
6	19	Coke and refined petroleum products	6_COKE
7	20-21	Chemicals and chemical products	7_CHEM
8	22-23	Rubber and plastics products, and other non-metallic mineral products	8_RUBB
9	24-25	Basic metals and fabricated metal products, except machinery and equipment	9_METL
10	26-27	Electrical and optical equipment	10_ELEC
11	28	Machinery and equipment n.e.c.	11_MACH
12	29-30	Transport equipment	12_TRAN
13	31-33	Other manufacturing; repair and installation of machinery and equipment	13_OMAN
14	D-E	Electricity, gas and water supply	14_GASW
15	F	Construction	15_CONS
16	45	Wholesale and retail trade and repair of motor vehicles and motorcycles	16_TRMO
17	46	Wholesale trade, except of motor vehicles and motorcycles	17_WHTR
18	47	Retail trade, except of motor vehicles and motorcycles	18_RETR
19	49-52	Transport and storage	19_TRSR
20	53	Postal and courier activities	20_POST
21	I	Accommodation and food service activities	21_ACCO
22	J	Information and communication	22_INFO
23	K	Financial and insurance activities	23_FINA
24	L	Real estate activities	24_REAL
25	M-N	Professional, scientific, technical, administrative and support service activities	25_PROF
26	O-U	Community social and personal services	26_SOCI
100	TOT	Country total	100_TOTL

Note: the table shows the classification of sectors used in the paper with the numerical codes (SEC), corresponding NACE Rev. 2 codes, sector full name (based on NACE Rev. 2) and short labels used for the brevity of exposition when discussing sectoral estimation results.

Source: Own elaboration.

One of the main challenges in the compilation of a harmonised panel database was the need to reconcile breaks in the data, particularly a change in the NACE classification and allocate the data to corresponding sectors (including sectors that did not exist in the earlier classification) that can be consistently traced over time and is comparable across countries. In particular, sectoral FDI data for the



period 2000-2007 (in some cases 2009) are available according to BPM5 in NACE Rev. 1; from 2008-2012 these data are available in BPM5 and according to NACE Rev. 2; and, from 2013-2016 these data are according to BPM6 and NACE Rev. 2. To address these issues we developed a sectoral classification (see Table 2.2) and allocated the data to this sectoral breakdown (the detailed mapping of sectors is available on request).

As noted earlier, the FDI data is compiled using the Eurostat and OECD data (depending on which source offers the longer series for a given country). FDI statistics of the OECD and Eurostat are essentially based on a common framework for reporting detailed FDI statistics and therefore are mutually consistent. Overall, we follow the conventions and methods used by the Eurostat/OECD framework as described in the 4th edition of the OECD Benchmark Definition of Foreign Direct Investment, (BMD4). We exclude special purpose entities (SPEs) from the data. SPEs are entities that primarily facilitate internal financing of multinational enterprises but have little or no physical presence in the host economy and thus are not associated with typical drivers and spillovers from FDI. This distorts the FDI data and adversely affects economic inference in formal analysis, particularly, for countries hosting financial centres. Additional details regarding the derivation and dynamics of the key variables of interest — GVC participation measures, FDI and capital stock dynamics — are discussed in the next sections.<sup>3</sup>

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<sup>3</sup> Deliverable 2 of CaDoVaC also discusses in detail the data compilation methodology, including a more detailed exposition of its technical aspects and challenges, as well as the structure of the harmonised database that contains the key variables (FDI, capital and GVC participation measures).

### 3. GVC participation measures

Based on the WIOD dataset (see Timmer et al., 2013, 2014), we compute trade in value added and various measures of GVC participation at aggregate national and sectoral levels following the sectoral structure outlined above. We use the most recent WIOD release available (2016 Release) covering 43 countries (EU28 Member States and 15 other major countries) and the estimated rest-of-world aggregate spanning the period 2000-2014.

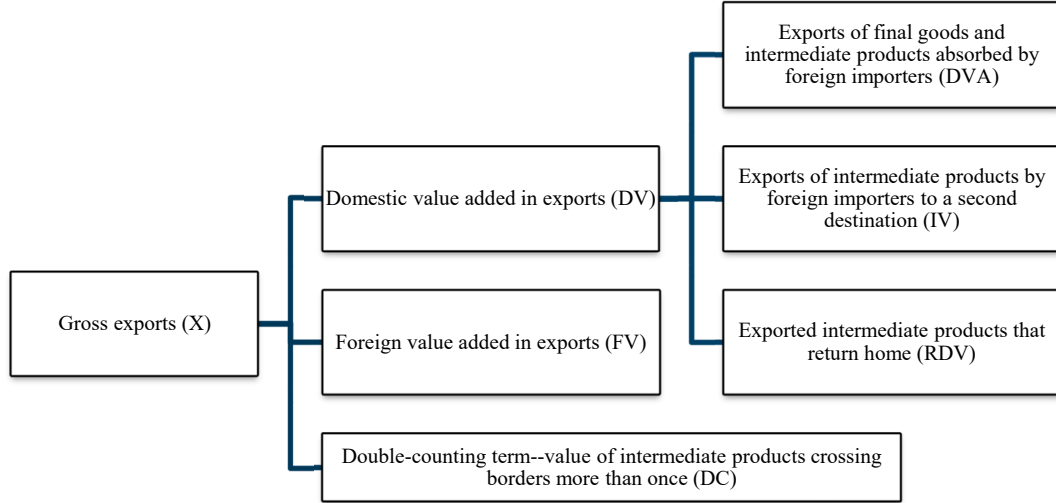
The stylised representation of the WIOD tables for a world economy comprising J countries and S sectors is shown in Table 3.1. Each table block represents the value of intermediate input flows from countries and their respective sectors indicated in the leftmost column to countries and sectors importing the inputs as indicated in the top rows. The dataset also includes information on the final use of the generated value (as opposed to intermediate use) subdivided into typical absorption elements, e.g. consumption by households, government, gross fixed capital formation, etc. Manipulation of the WIOD matrix allows the identification of the foreign and domestic value added embedded in each bilateral export flow and the computation of various GVC participation metrics.

**Table 3.1 / The structure of the WIOD database, 2016 Release**

			Use of inputs and value added by countries and sectors						Final use (households, government, GFCF)			Total use	
			Country 1			...			Country J				
			Sector 1	...	Sector S	...	Sector 1	...	Sector S	Country 1	...		Country J
Intermediate inputs supplied by countries and sectors	Country 1	Sector 1											
		...											
		Sector S											
	...	...											
		...											
		...											
Country J	Sector 1												
	...												
		Sector S											
Total value added													
Gross output													

Source: Own elaboration.

Several methods to derive value added contributions have been devised in the literature. Among seminal contributions, Hummels et al. (1998, 2001) proposed one of the earlier measures of GVC participation — foreign value added in exports or ‘Vertical Specialisation’ (VS). Daudin et al. (2011) further developed the mathematical definition for the GVC participation measure focusing on forward linkage (VS1), computed as a share of domestic value added in a country’s exports. VS and VS1, therefore, correspond to the import and export perspectives of a country’s vertical integration, and jointly reflect the total GVC participation of a country (sector). Among the current benchmark approaches to GVC participation measurement, Koopman et al. (2014) developed a methodological formalisation of a full decomposition of gross exports into value added components by sources. In particular, gross exports are decomposed into domestic value added absorbed abroad, domestic value added returned home after initial exports, foreign value added in exports and pure double-counting terms.

**Figure 3.1 / Decomposition of gross trade flows by GVC participation**

Source: Own elaboration.

We follow the Koopman et al. (2014) approach to decompose exports as indicated in Figure 3.1. Along the lines of this framework, domestic value added reflects the use of domestic inputs in the production of exports and captures de facto added value of exports to the country's GDP. Foreign value added reflects the use of imported foreign inputs in export production. Formalising, based on the WIOD database, the decomposition is achieved by pre-multiplying the Leontief inverse  $\mathbf{L} = [\mathbf{I} - \mathbf{A}]^{-1}$ , where  $\mathbf{A}$  is the input coefficient matrix, by a diagonalised vector of value added coefficients  $\hat{\mathbf{V}}$  and post-multiplying by a diagonalised vector of a country/industry's total gross exports  $\hat{\mathbf{X}}$ :

$$\mathbf{F} = \hat{\mathbf{V}} [\mathbf{I} - \mathbf{A}]^{-1} \hat{\mathbf{X}} \quad (3.1)$$

which results in a matrix of dimension JS x JS, where J denotes the number of countries (44) and S denotes the number of industries in the WIOD database (56). This matrix has then been aggregated across relevant sectors to align with our developed sectoral classification (Table 2.2), and then used to calculate various GVC-related measures by summing over the appropriate cells in this matrix. In particular, backward linkages are calculated as column sums (split by intra-industry linkages, domestic and foreign linkages) and forward linkages are calculated as row sums (split by domestic and foreign linkages). Backward GVC participation is measured as the share of the imported value added from foreign suppliers upstream in the country's exports. Forward GVC integration is measured as the domestic value added entering the exports of other countries. A combination of backward and forward integration yields a measure of a country's total GVC participation. At the aggregate country level, given country c and year t, and using the notation introduced in Figure 3.2, the GVC participation measures are computed as follows:

- › Backward GVC participation:  $GVC_{ct}^{BWI} = \frac{FV_{ct}}{X_{ct}}$
- › Forward GVC participation:  $GVC_{ct}^{FWI} = \frac{IV_{ct}}{X_{ct}}$
- › Total GVC participation:  $GVC_{ct}^{TI} = GVC_{ct}^{FWI} + GVC_{ct}^{BWI} = \frac{FV_{ct}}{X_{ct}} + \frac{IV_{ct}}{X_{ct}}$

› Relative GVC position<sup>4</sup>:  $GVC_{ct}^P = \ln(1 + \frac{IV_{ct}}{X_{ct}}) - \ln(1 + \frac{FV_{ct}}{X_{ct}})$

In the case of sector-level GVC participation measures, we also account for intra-country trade in value added between domestic sectors. The conventional measures of GVC participation scaled by gross exports ( $X_{ct}$ ) at the sectoral level have undesirable statistical properties which inhibits their economic interpretation and also presents technical challenges for their use in econometric analysis.<sup>5</sup> Therefore, at the sectoral level, instead of conventional GVC participation measures based on gross exports, we compute GVC participation scaled by gross country-sector output ( $GO_{ckt}$ ):  $\widehat{GVC}_{ckt}^{BWI} = \frac{FV_{ckt}}{GO_{ckt}}$ ,  $\widehat{GVC}_{ckt}^{FWI} = \frac{IV_{ckt}}{GO_{ckt}}$ ,  $\widehat{GVC}_{ckt}^{TI} = \widehat{GVC}_{ckt}^{FWI} + \widehat{GVC}_{ckt}^{BWI}$  for backward, forward and total GVC participation at the sectoral level, where c indicates country, k – sector and t – year. The descriptive statistics for the measures are reported in Appendix C.

**Figure 3.2 / Backward and forward GVC participation in Europe**



Note: the figure shows the scatterplot of backward GVC participation against forward GVC participation for the sample of European countries (excluding tax haven countries) for the period 2000-2014. The data for 2014 is labelled.

Source: own elaboration based on WIOD 2016 Release.

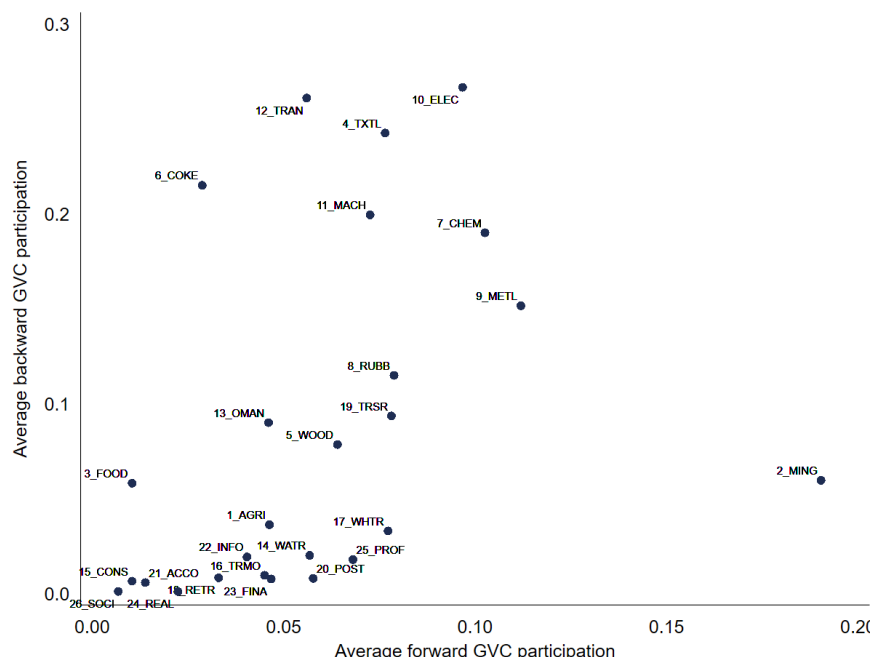
Examining international production sharing patterns within Europe (Figure 3.2), one may note that countries tend to “specialise” in backward or forward linkages. The GVC positions of countries relative to other countries in the sample were rather stable over the observed period. Over time, most countries were moving in the direction of increasing both backward and forward linkages, and therefore the

<sup>4</sup> In this case we compute forward linkages relative to backward linkages of a country. The index thus measures the extent to which a given country/sector is relatively more upstream and contributes more value added to exports to other countries than other countries contribute to their exports to the country.

<sup>5</sup> In particular, some heavily subsidised sectors may yield negative value added for some countries, which translates to negative forward GVC participation measures; the value added produced for domestic intermediate use may significantly exceed direct gross exports by the sector (especially in some service sectors) resulting in mammoth forward GVC participation values.

perceived negative relationship between  $GVC_{ct}^{BWI}$  and  $GVC_{ct}^{FWI}$  does not actually imply there is a trade-off between joining upstream or downstream production processes.

**Figure 3.3 / Average backward and forward GVC participation of sectors**

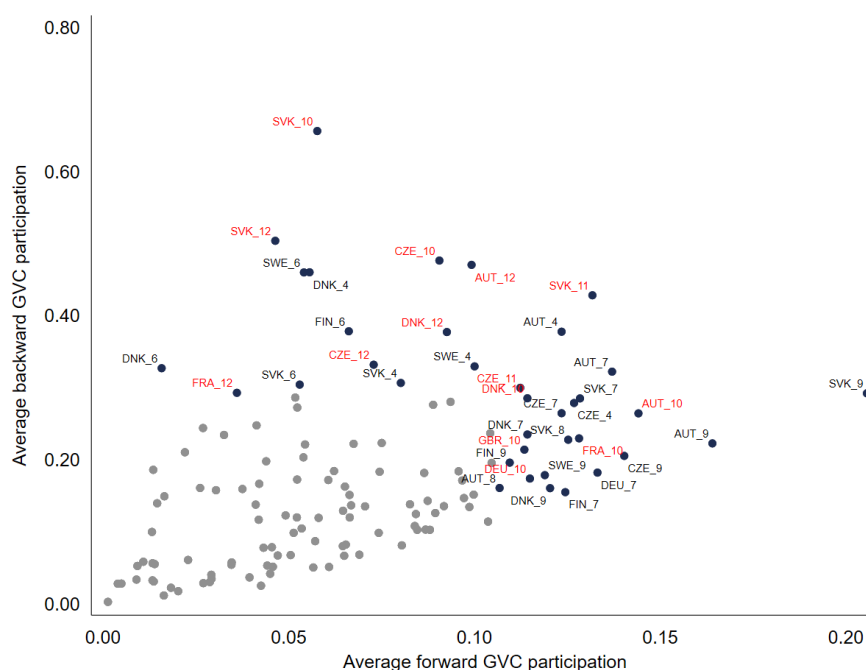


Note: the figure shows the scatterplot of backward GVC participation against forward GVC participation for the sectors (GVC participation based on gross output), averaged across the sample of countries and the period 2000-2014.

Source: own elaboration based on WIOD 2016 release.

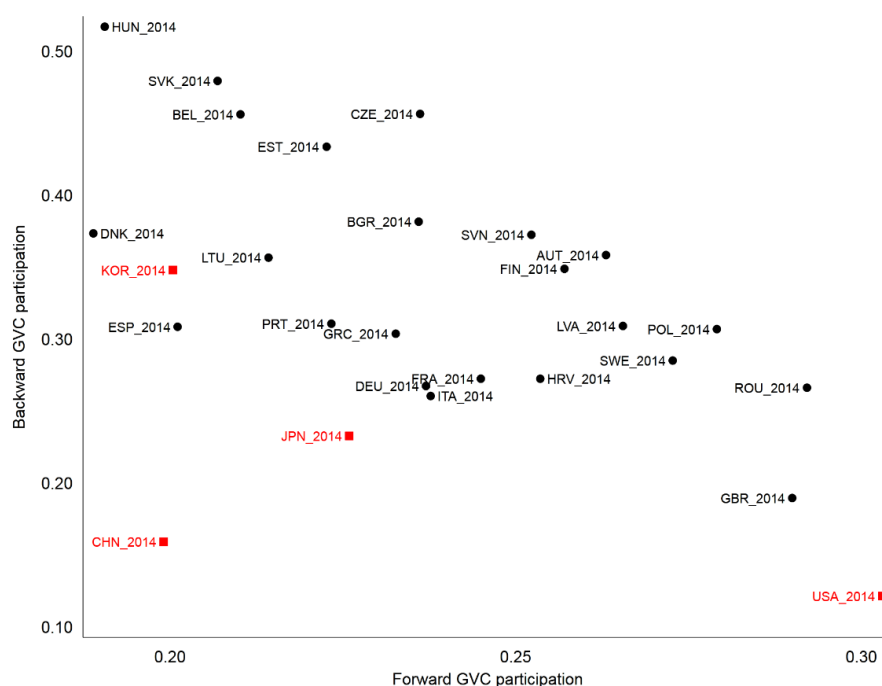
International value added linkages also vary widely across sectors – see Figure 3.3 for average forward and backward GVC participation measures based on sectoral gross output as described above ( $\widetilde{GVC}_{ckt}^{BWI}$  and  $\widetilde{GVC}_{ckt}^{FWI}$ ) computed for the European sample over the period 2000-2014. High-tech manufacturing sectors (machinery, transport equipment and electronics, coded, as described in the data section, as 12\_TRAN 10\_ELEC and 11\_MACH)<sup>6</sup>, as well as textiles and clothing sector (4\_TXTL) are characterised by a particularly high degree of backward and forward GVC participation relative to other sectors. At the same time, the chemicals (7\_CHEM), metal products (9\_METL) and mining (2\_MNG) sectors have greater forward GVC participations relative to other sectors which is consistent with their general upstream position in cross-border production processes (7\_CHEM and 9\_METL also simultaneously have a high degree of backward GVC integration). Service sectors have a generally low GVC participation intensity with the exception of transportation services (19\_TRSR). As can be seen in Figure 3.4, the cross-border production sharing in the high-tech sectors is largely attributed to Slovakia, Czech Republic and Austria with especially high levels of backward GVC participation of Slovakia in the electrical and transport equipment sectors (imported foreign value added constituting 50% or more of sectoral gross output).

<sup>6</sup> The definition of “high-tech” manufacturing sectors here is used only to refer to the group of these three sectors characterised by high value-added and exhibiting similar reaction to FDI and capital. One should note that this does not correspond to the definitions proposed, for instance, by Eurostat ([https://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:High-tech\\_classification\\_of\\_manufacturing\\_industries](https://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:High-tech_classification_of_manufacturing_industries)). Along the lines of the latter, the three mentioned sectors belong to high and medium-high technology sectors. The chemicals sectors also belong either to the high (pharmaceuticals) or medium-high technology sectors.

**Figure 3.4 / Countries and sectors with high GVC participation**

Note: the figure shows the scatterplot of backward GVC participation against forward GVC participation for countries and sectors (GVC participation based on gross output), averaged across the sample of countries and the period 2000-2014. High-tech sectors are highlighted.

Source: own elaboration based on WIOD 2016 release.

**Figure 3.5 / GVC position of European countries in comparison with peer economies**

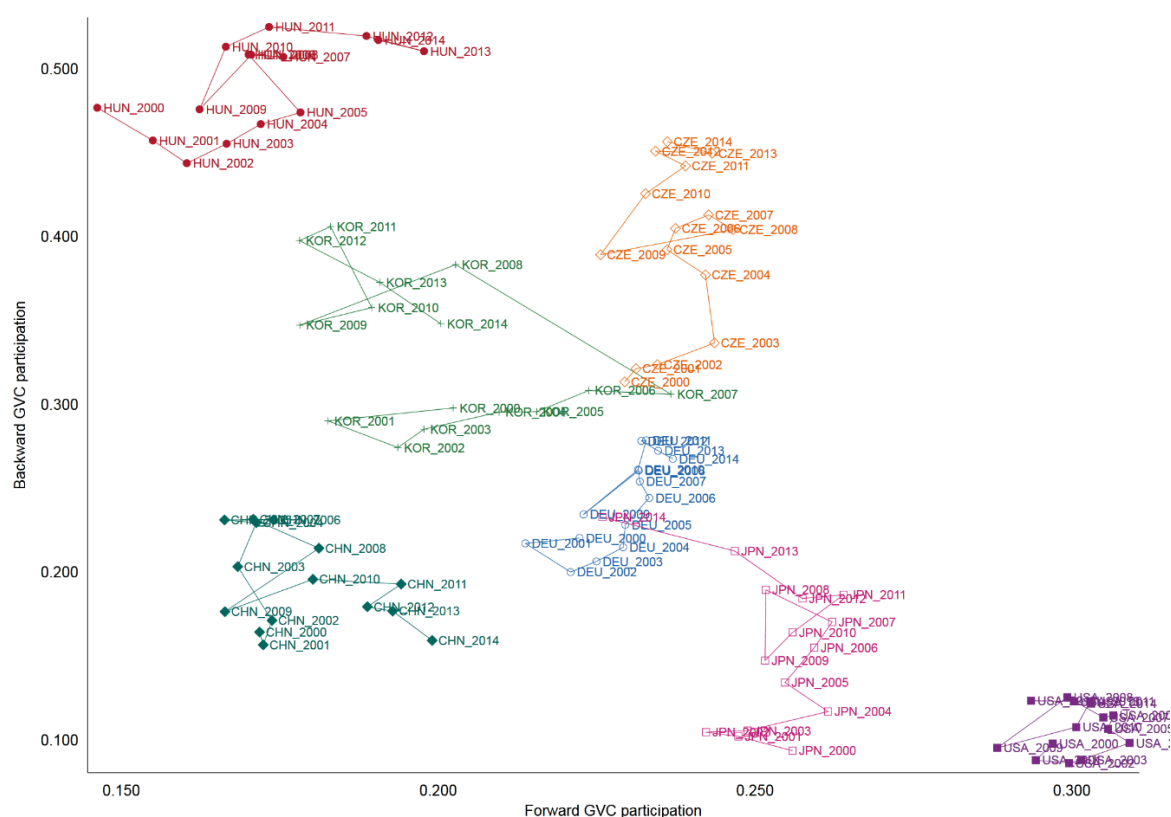
Note: the figure shows the scatterplot of backward GVC participation against forward GVC participation for the sample of European countries and selected peer economies (in red) for the year 2014.

Source: own elaboration based on WIOD 2016 release.

Comparing Europe with selected peer economies – China, Japan, South Korea and the USA – suggests that European countries have a generally higher degree of GVC integration (see Figure 3.5). Notably, the USA has a much higher degree of forward GVC participation (higher than any European country or peer economies) and, at the same time, the lowest degree of backward GVC participation. In this respect it is on the other end of the GVC spectrum in comparison with Hungary, which, on the contrary, has the highest level of backward GVC integration, while its forward GVC participation is among the lowest in the sample. European countries also “outperform” both China and Japan in terms of GVC integration, both upstream and downstream.

The relative GVC position of countries is rather stable and does not change dramatically relative to other countries (see Figure 3.6). While countries did drift gradually over the observed period 2000-2014 in the GVC “space” spanning backward and forward GVC integration, relative to other countries they tend to remain localised in a certain area. Over the span of the observed 15 years, Hungary gradually increased its forward GVC integration while maintaining its high backward GVC participation. Similarly, Czech Republic increased its backward GVC integration, while still retaining its forward GVC participation at a relatively high level. Germany gradually increased both its forward and backward GVC participation. Among the peer countries, both South Korea and Japan deepened their backward linkages, while China increased its forward GVC integration.

**Figure 3.6 / Dynamics of GVC participation of selected economies, 2000-2014**



Note: the figure shows forward and backward GVC participation of Germany, Czech Republic, Hungary, South Korea, China, Japan and USA over the period 2000-2014.

Source: own elaboration based on WIOD 2016 release.

Looking at the GVC integration across manufacturing sectors (Table 3.2), again, suggests that generally European countries are better embedded in global value chains both in terms of both upstream and downstream integration. It is only in Sector 10 (Electronic equipment manufacturing) that Japan, South Korea and the USA exhibit average forward GVC participations at relatively high levels (above 0.07) which is, however, still much lower than the forward GVC participations by frontier European countries (in particular, the forward GVC participations of Austria, Lithuania and Romania exceeds 0.14).

**Table 3.2 / GVC participation for manufacturing sectors: Europe and peer economies**

ISO3	3_FOOD		4_TXTL		5_WOOD		6_COKE		7_CHEM		8_RUBB	
	BWI	FWI	BWI	FWI	BWI	FWI	BWI	FWI	BWI	FWI	BWI	FWI
AUT	0.097	0.013	0.374	0.123	0.150	0.099	0.246	0.042	0.316	0.137	0.158	0.106
BEL	0.205	0.019	0.391	0.094	0.198	0.088	0.506	0.058	0.387	0.171	0.265	0.116
BGR	0.036	0.006	0.120	0.028	0.084	0.037	0.205	0.016	0.170	0.044	0.115	0.037
CHN	0.004	0.005	0.048	0.013	0.007	0.015	0.009	0.016	0.017	0.021	0.018	0.016
CZE	0.055	0.014	0.278	0.127	0.108	0.084	0.157	0.030	0.264	0.123	0.183	0.103
DEU	0.052	0.009	0.280	0.094	0.082	0.065	0.153	0.026	0.182	0.133	0.100	0.084
DNK	0.185	0.013	0.456	0.055	0.099	0.075	0.230	0.018	0.235	0.114	0.165	0.097
ESP	0.027	0.004	0.111	0.039	0.037	0.041	0.207	0.027	0.110	0.064	0.061	0.044
EST	0.111	0.009	0.377	0.040	0.225	0.088	0.161	0.106	0.480	0.138	0.236	0.080
FIN	0.034	0.014	0.164	0.063	0.133	0.088	0.292	0.055	0.159	0.124	0.106	0.085
FRA	0.033	0.009	0.272	0.052	0.051	0.046	0.149	0.016	0.183	0.096	0.068	0.069
GBR	0.031	0.014	0.123	0.088	0.025	0.043	0.160	0.037	0.151	0.097	0.051	0.061
GRC	0.002	0.001	0.023	0.018	0.011	0.016	0.202	0.022	0.055	0.034	0.028	0.027
HRV	0.065	0.012	0.153	0.030	0.137	0.083	0.209	0.079	0.255	0.102	0.124	0.062
HUN	0.102	0.013	0.483	0.080	0.173	0.076	0.178	0.061	0.291	0.083	0.255	0.099
ITA	0.027	0.004	0.078	0.045	0.033	0.037	0.124	0.014	0.129	0.065	0.066	0.050
JPN	0.001	0.003	0.014	0.034	0.003	0.021	0.028	0.028	0.041	0.034	0.022	0.041
KOR	0.012	0.004	0.109	0.058	0.026	0.034	0.249	0.035	0.098	0.065	0.085	0.060
LTU	0.099	0.009	0.182	0.090	0.158	0.098	0.409	0.049	0.272	0.132	0.156	0.091
LVA	0.085	0.007	0.210	0.045	0.129	0.086	0.204	1.106	0.209	0.096	0.155	0.054
POL	0.041	0.008	0.228	0.070	0.089	0.069	0.096	0.036	0.141	0.077	0.098	0.072
PRT	0.032	0.003	0.106	0.033	0.095	0.069	0.124	0.014	0.117	0.060	0.118	0.060
ROU	0.007	0.008	0.132	0.025	0.066	0.075	0.136	0.042	0.121	0.048	0.082	0.060
SVK	0.048	0.009	0.274	0.067	0.122	0.090	0.255	0.051	0.249	0.121	0.198	0.112
SVN	0.036	0.006	0.211	0.068	0.199	0.101	0.206	0.922	0.232	0.085	0.216	0.110
SWE	0.056	0.013	0.328	0.102	0.131	0.095	0.470	0.051	0.178	0.161	0.143	0.087
USA	0.006	0.003	0.021	0.023	0.010	0.020	0.028	0.014	0.024	0.049	0.014	0.024

ctd.



Table 3.2 / ctd.

ISO3	9_METL		10_ELEC		11_MACH		12_TRAN		13_OMAN	
	BWI	FWI	BWI	FWI	BWI	FWI	BWI	FWI	BWI	FWI
AUT	0.219	0.164	0.264	0.143	0.273	0.088	0.469	0.097	0.148	0.060
BEL	0.387	0.135	0.317	0.128	0.335	0.091	0.523	0.038	0.235	0.064
BGR	0.276	0.080	0.234	0.066	0.174	0.044	0.163	0.035	0.079	0.031
CHN	0.016	0.019	0.113	0.029	0.028	0.014	0.017	0.009	0.059	0.020
CZE	0.205	0.140	0.476	0.091	0.299	0.112	0.331	0.073	0.108	0.054
DEU	0.114	0.104	0.173	0.115	0.151	0.066	0.166	0.042	0.073	0.040
DNK	0.160	0.120	0.285	0.114	0.172	0.052	0.390	0.094	0.190	0.040
ESP	0.074	0.055	0.119	0.049	0.093	0.049	0.231	0.032	0.031	0.026
EST	0.299	0.106	0.588	0.129	0.419	0.126	0.470	0.122	0.206	0.055
FIN	0.197	0.109	0.184	0.062	0.212	0.055	0.302	0.044	0.064	0.063
FRA	0.103	0.087	0.229	0.128	0.223	0.075	0.292	0.036	0.037	0.027
GBR	0.106	0.088	0.215	0.112	0.186	0.087	0.189	0.073	0.047	0.054
GRC	0.079	0.079	0.051	0.044	0.033	0.028	0.053	0.035	0.014	0.016
HRV	0.166	0.121	0.209	0.108	0.109	0.068	0.243	0.055	0.191	0.072
HUN	0.267	0.134	0.609	0.053	0.335	0.133	0.562	0.101	0.214	0.062
ITA	0.080	0.065	0.123	0.062	0.118	0.047	0.116	0.042	0.056	0.020
JPN	0.035	0.035	0.056	0.075	0.040	0.028	0.047	0.016	0.016	0.015
KOR	0.081	0.046	0.163	0.083	0.083	0.023	0.135	0.013	0.069	0.033
LTU	0.153	0.140	0.317	0.144	0.248	0.114	0.191	0.151	0.126	0.047
LVA	0.328	0.117	0.351	0.112	0.296	0.088	0.302	0.062	0.099	0.052
POL	0.146	0.106	0.320	0.077	0.222	0.109	0.292	0.077	0.110	0.043
PRT	0.144	0.064	0.262	0.068	0.184	0.054	0.284	0.056	0.050	0.031
ROU	0.172	0.102	0.228	0.150	0.192	0.094	0.126	0.070	0.081	0.034
SVK	0.268	0.185	0.571	0.060	0.376	0.120	0.469	0.044	0.117	0.064
SVN	0.232	0.153	0.310	0.087	0.349	0.131	0.466	0.051	0.203	0.083
SWE	0.178	0.119	0.231	0.096	0.222	0.067	0.222	0.057	0.104	0.049
USA	0.016	0.034	0.028	0.084	0.043	0.034	0.039	0.028	0.013	0.010

Note: The table shows backward (BWI) and forward (FWI) GVC participation for the manufacturing sectors of European countries and selected peer economies (China, Japan, South Korea, the USA). GVC\_BWI\_GO and GVC\_FWI\_GO metrics are used to measure GVC participation (averages over 2000-2014), sectors are labelled as discussed in the report. Bars reflect relative magnitudes within the respective sector.

Source: own elaboration based on WIOD 2016 release.

## 4. FDI and capital dynamics in Europe

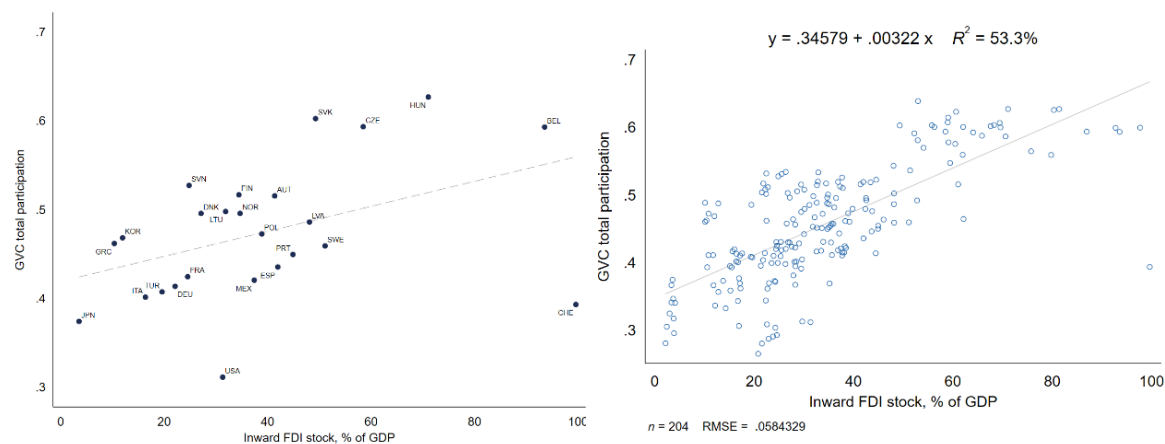
FDI, in contrast to portfolio investment, reflects the objective of gaining a lasting interest by an investor in one economy in an enterprise resident in another economy and is typically assumed if at least 10% of the voting power (or equivalent for unincorporated companies) is owned by the investor. In the analysis, we primarily focus on inward and outward FDI stocks taken as a share of GDP to accommodate for the differences in economic size between countries and convey the notion of relative FDI intensity at the aggregate country level. At the sectoral level, we compute the ratios of FDI stocks to sector value added. For bilateral gravity models we compile bilateral FDI data using OECD and UNCTAD bilateral statistics. For panel data analysis using fractional response models, we construct a consistent FDI dataset using Eurostat and OECD databases.

As noted above, we exclude SPEs from the FDI data, as well as drop “tax haven” countries from the formal analysis. Figure 4.1 shows the general positive association between inward FDI and total GVC participation, as well as illustrates the extent to which the results could be biased with SPEs and outlier tax haven countries included in the sample.

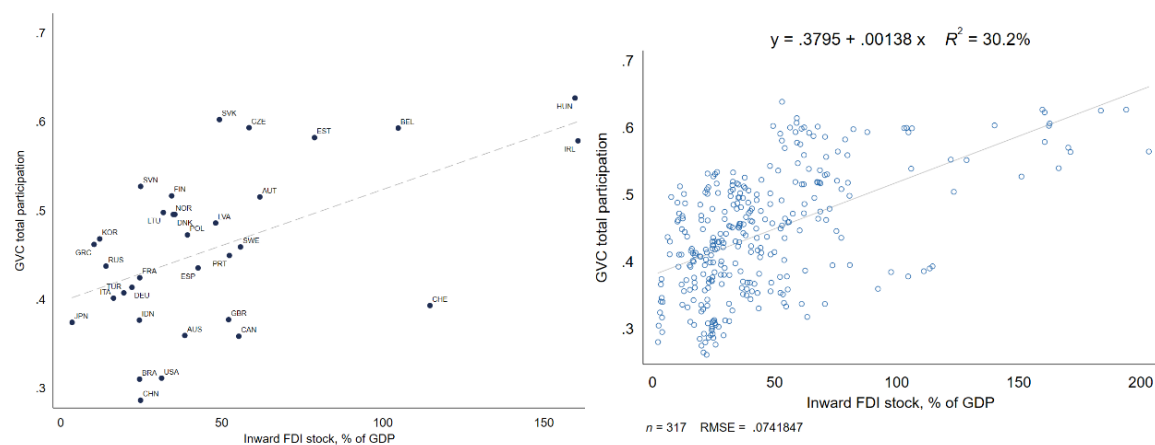
Real capital stock variables are obtained from the EU KLEMS database. For the purposes of country-level analysis, we use the ratio of capital stock to GDP and, for sector-level analysis, we use the ratio of real capital stock to sector value added. In addition to total capital stock variables, the analysis examines the impact of capital stock composition distinguishing the following ten capital asset types (the names and codes are consistent with EU KLEMS classification): (1) Total non-residential investment, OCon; (2) Residential structures, RStruc; (3) Transport equipment, TraEq; (4) Other machinery and equipment, OMach; (5) Computing equipment, IT; (6) Communications equipment, CT; (7) Computer software and databases, Soft\_DB; (8) Research and development, RD; (9) Cultivated assets, Cult; and, (10) Other Intellectual Property Products assets, OIPP. In addition, in some exercises we compute the ICT capital aggregate by summing capital over IT, CT and Soft\_DB asset types. The composition of capital stock by sectors varies significantly. Figure 4.2 shows capital stock composition based on the average across the European sample over the period 2000-2015 (associated tables are given in Appendix C). To facilitate comparability across sectors, in addition to shares of capital stock by asset types in total capital stock of a given sector, we also show the ratios of capital stock to sector value added (Panel A).

**Figure 4.1 / Relationship between GVC participation and inward FDI adjusting for SPEs**

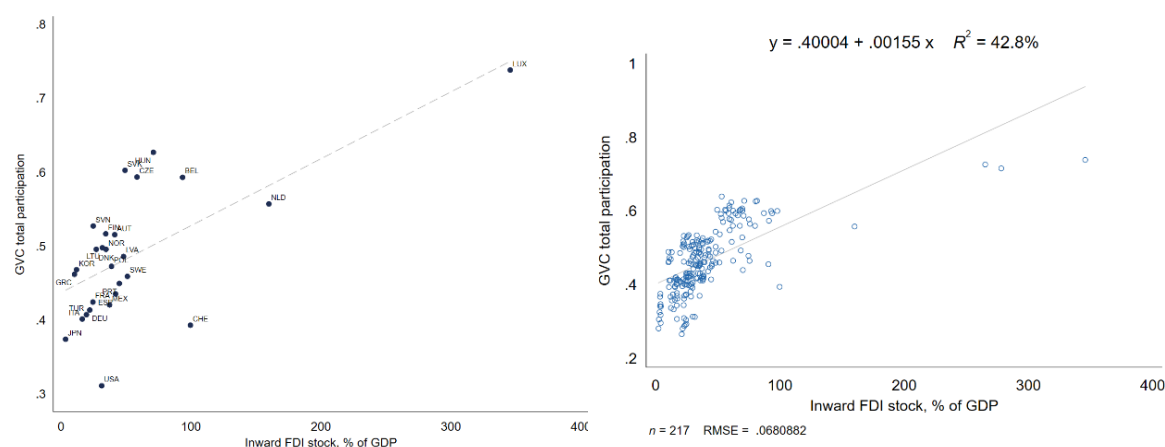
Excluding SPEs (excluding LUX and NLD)



Including SPEs (excluding LUX and NLD)



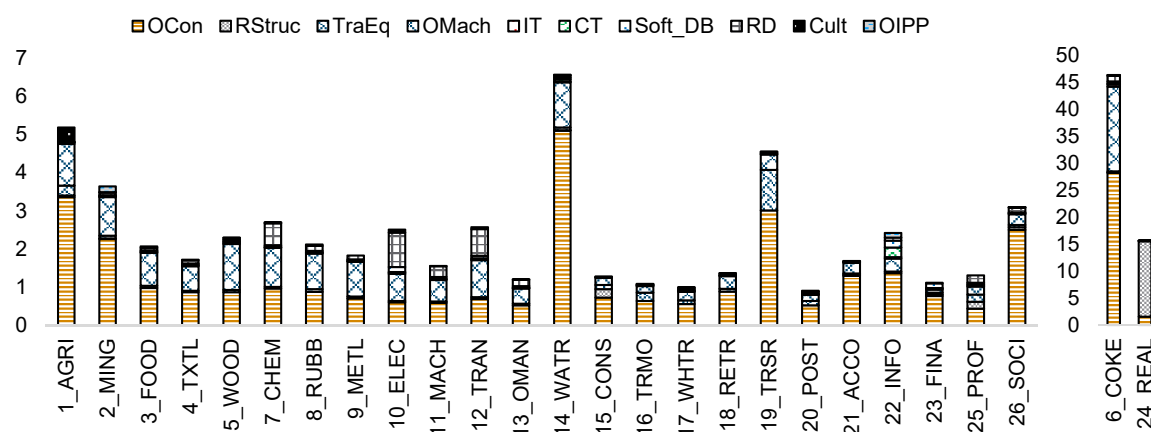
Excluding SPEs (with LUX and NLD)



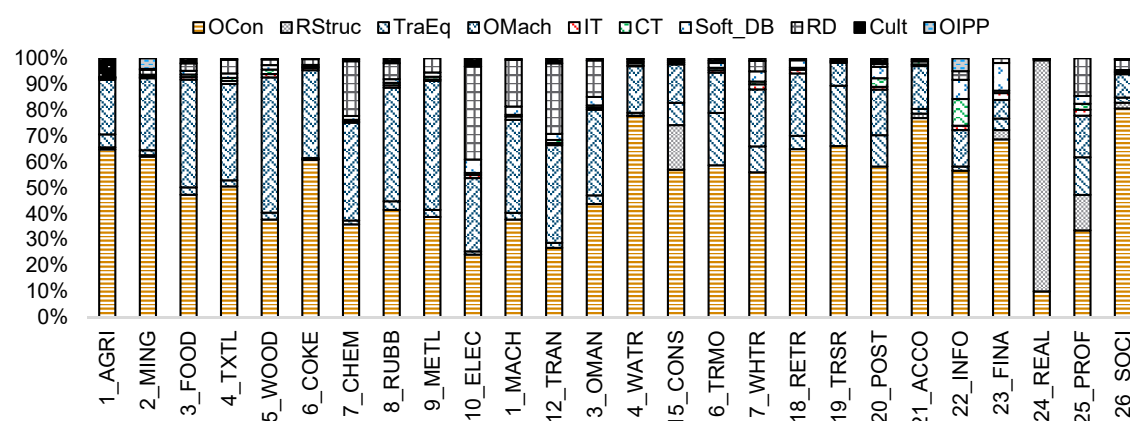
Source: own elaboration based on WIOD 2016 Release, EUROSTAT and OECD FDI data

**Figure 4.2 / Composition of real capital stock by asset types across sectors (sample averages)**

Panel A. Capital by asset types, shares of sector value added



Panel B. Composition of capital stock by asset types, %



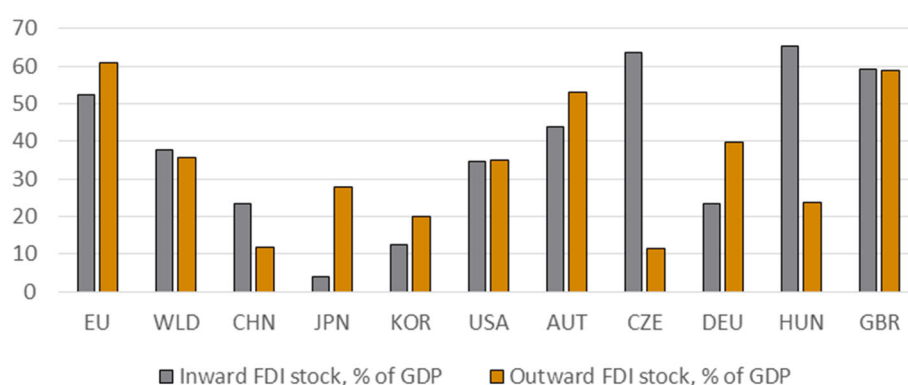
Source: own elaboration based on EU KLEMS data

In general, looking across all sectors, non-residential construction investment (OCon) and investment in other machinery and equipment (OMach) comprise the highest shares in total capital stocks. For manufacturing sectors, capital stock in other asset types is relatively more important in comparison with the primary and service sectors. In particular, research and development capital RD constitutes a significant share (17% or more) of total capital stock in the high-tech manufacturing sectors (SEC 10-12), as well as the chemicals industry (SEC 7).

In comparison with peer economies, the EU has been standing out prominently relative to its peer economies (the USA, China, Japan, South Korea) as can be seen in Figure 4.3. Both inward and outward FDI, taken as percentages of GDP, is much higher than those of the peer economies (this is also the case for nominal FDI stocks and flows). In 2018, inward FDI stock in the EU amounted to 54.8 percent of GDP and outward FDI stock constituted 60.3 percent of GDP. As one can see in Figure 4.4, the EU has been outperforming its peers in terms of overall FDI intensity throughout the 2000s. A peer

economy that comes closest to the EU in terms of FDI intensity is the USA. However, it is still significantly behind the EU: in 2018 inward FDI stock as a percentage of GDP was 36.3% and outward FDI stock as a percentage of GDP was 31.5%.

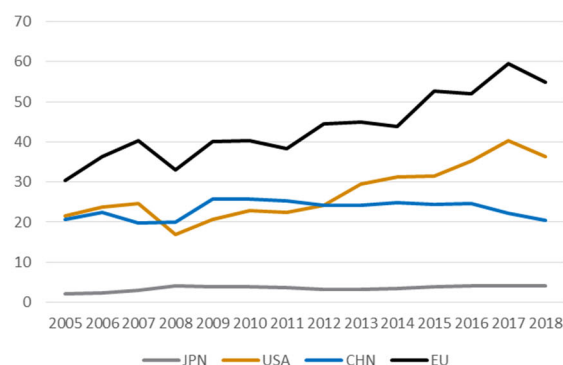
**Figure 4.3 / Inward and outward FDI stocks, 2014-2018 average**



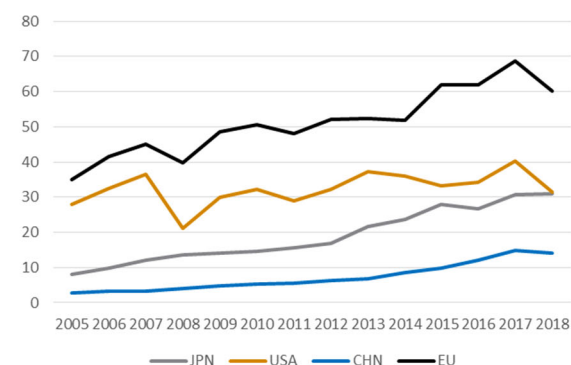
Note: the figure shows 2014-2018 average inward and outward FDI stocks as a percentage of GDP for the EU, world economy (WLD), as well as selected European and peer economies. 2014-2017 average for South Korea.  
Source: OECD FDI database, 2019.

**Figure 4.4 / Dynamics of inward and outward FDI stocks, 2004-2018**

Panel A. Inward FDI stock, % of GDP



Panel B. Outward FDI stock, % of GDP



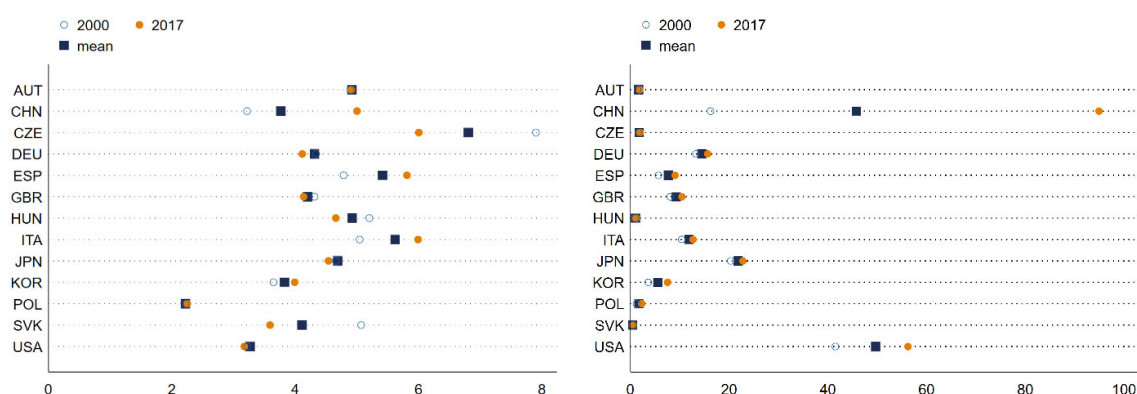
Source: OECD FDI database, 2019.

Although the volume of FDI stock in the EU declined in 2018 relative to 2017 (in particular, inward FDI stock declined by 0.2% and outward FDI stock by 5.3%), the historical trend was generally very positive: as of 2018, inward FDI stock had increased by 136.7% and outward FDI stock by 126.3% from the 2004 year levels. The FDI slowdown in 2018 also resulted in the slight decline in the FDI intensity (i.e. the ratio of FDI inward and outward stocks to GDP – see Figure 4.4).

As regards the capital stock dynamics of European countries in comparison with peer economies, there are, again, significant differences across countries. Apparently, large economies have considerably greater stocks of physical capital, and in this respect the capital stock level of the largest EU economy,

Germany, is significantly lower than that of the USA or China. It is worthwhile noting that China has made a giant leap in terms of capital accumulation over the past decade. Adjusting capital stocks to GDP indicates that peer economies are generally lower in terms of capital intensity than many European countries. As of 2017, Portugal is the leader in terms of capital intensity with the capita-to-GDP ratio of 7.7 with Greece, Latvia, Cyprus, Luxemburg and Czech Republic also dominating the list of capital intensive countries with capital-to-GDP ratios exceeding 6 (Czech Republic still maintains a high level of capital intensity despite significant declines since the year 2000 as can be seen in Figure 4.5, Panel A).

**Figure 4.5 / Real capital stock dynamics**



Note: the figure shows real capital stock (2011 constant prices) levels and intensity for selected European countries and non-European peer economies. Circles indicate 2000 and 2017 values, squares indicate 2000-2017 average value.

Source: own calculations based on Penn World Tables database (PWT 9.1 Version, 2019).

## 5. Impact on GVC participation: evidence from the fractional response model

### 5.1. MODEL SETUP

Following empirical literature and given the focus of our study on the role of FDI and capital as possible drivers of GVC participation, we estimate the following specification in our *country-level* analysis:

$$GVC_{ct} = \alpha + \beta FDI_{ct-1} + \gamma K_{ct-1} + \Psi X_{ct-1} + \varepsilon_{ct} \quad (5.1)$$

where  $GVC_{ct}$  denotes a GVC participation measure (forward, backward and total GVC participation variables used consecutively in alternative specifications);  $FDI_{ct-1}$  is the FDI measure (alternative specifications employ inward FDI stock or outward FDI stock as a share of GDP); and,  $K_{ct-1}$  denotes real capital stock as a share of GDP. The FDI and capital variables thus convey the relative capital intensity of a country.<sup>7</sup> In additional empirical exercises, we also distinguish ICT and non-ICT capital, as well as disaggregate capital by asset types as discussed in the section above.

The vector of control variables  $X_{ct-1}$  includes a range of variables deemed to be important in the literature on GVC integration: real GDP as a measure of country size; real effective exchange rate (REER) in log differences, real GDP per capita as a general measure of a country's level of economic development, real labour productivity measured as value added per hour worked by persons engaged; share of manufacturing value added in GDP as a proxy for the overall level of industrialisation of a country; real GDP growth rate; average applied import tariff rate and institutional quality indicators (World Bank's Worldwide Governance Indicators of control of corruption, regulatory quality, government effectiveness). Some of the variables are however collinear (for instance, labour productivity, per capita income and institutional quality) and thus are not included in regressions simultaneously.

We also introduce year fixed effects to control for common time-varying factors, e.g. the global or Europe-wide business cycle dynamics. In addition, we control for cross-country heterogeneity by introducing fixed effects or using time averages of continuous variables (discussed below).

As the dependent variables are bounded in the (0; 1) interval, one cannot use conventional linear panel data models. Therefore, as a baseline case, we use fractional response models in line with Papke and Wooldridge (1996) and Papke and Wooldridge (2008) which develop an estimation framework based on generalised linear model quasi-likelihood estimators with the logit or probit link function. More specifically, as the baseline model, we utilise fractional probit with standard errors clustered by country. For robustness, we also estimate fractional logit, panel fixed effects, random effects models and pooled OLS with the logistic transformation applied to the dependent variable as follows:  $GVC^{LTR} = \ln \left[ \frac{GVC}{1-GVC} \right]$ .

<sup>7</sup> As an alternative to these measures we also check the results with FDI flows and gross fixed capital formation. The flow measures are however rather volatile and results are not stable.

At the same time, introducing cross-section dummy variables to control for unobserved time-invariant heterogeneity in the given model may lead to inconsistent estimates in small samples, particularly when  $T$  (time periods) is fixed and  $N$  (cross-section units) is large - the incidental parameters problem (Neyman and Scott, 1948). Therefore, in addition to fixed effects we also use the device developed by Mundlak (1978) and Chamberlain (1984) to impose some structure on the correlation between the unobserved effects and model variables, in line with the Papke and Wooldridge (2008) suggestions, also known as correlated random effects (CRE). In essence, the Mundlak-Chamberlain transformation controls for unobserved country heterogeneity by augmenting the regression with time averages of all continuous covariates for each country instead of fixed effects, while the variables are included as deviations from respective means.

Finally, in order to deal with potential endogeneity issues, we lag explanatory variables by one period. In this regard, the potential (and likely) causal feedback from GVC participation to FDI variable is of particular concern for the hypothesis of interest. Therefore, for robustness, we also perform a range of additional estimations allowing for endogenous regressors via a 2-stage estimation procedure in line with Wooldridge (2014) which involves regressing the FDI variable on model covariates in the first stage and augmenting the fractional probit model in the second step by first-stage residuals.

*Industry-level* analysis is based on a similar specification estimated for each industry  $k$  via fractional probit with standard errors clustered by countries:

$$GVC_{ckt} = \alpha + \beta FDI_{ckt-1} + \gamma K_{ckt-1} + \Psi X_{ckt-1} + \varepsilon_{ckt} \quad (5.2)$$

In this case, as noted previously, we use backward, forward and total GVC participation based on gross output (rather than gross exports) as the dependent variable. As key explanatory variables of interest, we use the ratio of FDI to sector value added and the ratio of capital stock to sector value added. In addition, the equation is augmented by sector labour productivity and country-level variables: real GDP, manufacturing share in GDP and a change in REER.

Besides the analysis of individual sectors, we also perform estimations pooling all 26 sectors in a single model, as well as analysis of the following broad industry groups: commodity sectors (SEC 1-2), manufacturing (SEC 3-13), high-tech manufacturing sectors (SEC 10-12) and services sectors (SEC 14-26). In this case we augment the specification by sector fixed effects.

## 5.2. RESULTS: COUNTRY-LEVEL ANALYSIS

Estimations involving the baseline model (fractional probit) are reported in Table 5.1 for backward, forward and total GVC participation. Additional estimation results involving other variables and estimators are reported in Appendix A.

Controlling for time-invariant country effects and thereby making use only of within-unit variation generally renders estimates for the key variables of interest (FDI and capital stock intensity) insignificant. As discussed in the methodology section, the use of country fixed effects to control for unobserved heterogeneity leads to inconsistent estimates in small samples (and thus the results are reported merely for comparison, rather than inference, in the Appendix Table A3). Yet, the results from the



Mundlak-Chamberlain CRE model also suggest insignificance of within-country variance in explaining the impact of FDI and capital dynamics on GVC participation (in this case only GDP and REER remain statistically significant). At the same time, examining time averages using estimation also allows us to infer the role of within-country to between-country variation to some extent in explaining GVC participation. In fact, much of the variation in the key variables of interest (GVC participation, relative capital stock and FDI stock intensity) does not change much over time and within-panel variation unit variation after removing time trend and common business cycle effects, particularly the impact of the late 2000s Great Recession, is much smaller than between-panel variation. Therefore, we focus primarily on estimation results of models that also make use of cross-country variation, for instance, reported in Table 5.1 (although one should note that these results may be driven by unobserved cross-country heterogeneity).

In Table 5.1 the results are listed for backward, forward and total GVC participation with inward and outward FDI included along with the capital stock intensity variable.<sup>8</sup> Overall, we find that the inward FDI stock ratio is positively associated with backward GVC participation, while outward FDI is conducive to forward GVC participation. Both inward and outward FDI stock ratios estimates are positive and statistically significant at least at the 10% level in total GVC participation. Estimates suggest that the capital stock to GDP ratio positively affected backward and total GVC participation with high statistical significance.

**Table 5.1 / Drivers of GVC participation, country-level analysis, estimates**

	Backward		Forward		Total	
	GVC participation		GVC participation		GVC participation	
	(1)	(2)	(3)	(4)	(5)	(6)
Inward FDI stock, share of GDP	0.465*		0.062		0.502***	
	(0.252)		(0.181)		(0.156)	
Outward FDI stock, share of GDP		-0.017		0.255*		0.253*
		(0.205)		(0.132)		(0.144)
Real capital stock, share of GDP	0.135***	0.143***	-0.081***	-0.068***	0.066***	0.085***
	(0.024)	(0.021)	(0.024)	(0.023)	(0.019)	(0.017)
REER, log diff	0.026	0.057	-0.154	-0.092	-0.140	-0.048
	(0.104)	(0.158)	(0.113)	(0.122)	(0.101)	(0.120)
Labour productivity, log	0.175**	0.206*	-0.137**	-0.194***	0.045	0.015
	(0.082)	(0.113)	(0.055)	(0.066)	(0.048)	(0.074)
Real GDP, log	-0.058**	-0.074***	0.001	0.008	-0.045***	-0.052***
	(0.023)	(0.027)	(0.018)	(0.017)	(0.014)	(0.016)
Manuf. value added, % of GDP	0.010	0.012	0.004	0.005	0.010**	0.012*
	(0.007)	(0.009)	(0.004)	(0.003)	(0.005)	(0.006)
Constant	-0.291	0.070	0.004	-0.091	0.687**	0.946**
	(0.496)	(0.584)	(0.366)	(0.356)	(0.339)	(0.376)
Obs.	178	178	178	178	178	178
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Pseudo R-sq.	0.023	0.023	0.002	0.002	0.016	0.016

Note: the table shows the results of fractional regression estimations with probit link function. Standard errors clustered by countries are in parentheses. All explanatory variables are lagged by one period. \*, \*\*, \*\*\* indicate statistical significance at 10%, 5% and 1% levels respectively.

Source: own estimates.

<sup>8</sup> We also check for the sensitivity of estimates to joint inclusion and mutual influences of capital-related variables in Appendix Table A6.

**Table 5.2 / Drivers of GVC participation, country-level analysis, predictive margins**

	Backward		Forward		Total	
	GVC participation		GVC participation		GVC participation	
	(1)	(2)	(3)	(4)	(5)	(6)
Inward FDI stock, share of GDP	0.157*		0.019		0.196***	
	(0.086)		(0.056)		(0.060)	
Outward FDI stock, share of GDP		-0.006		0.079*		0.099*
		(0.069)		(0.041)		(0.056)
Real capital stock, share of GDP	0.046***	0.049***	-0.025***	-0.021***	0.026***	0.033***
	(0.008)	(0.007)	(0.007)	(0.007)	(0.007)	(0.006)
REER, log diff	0.009	0.019	-0.047	-0.028	-0.055	-0.019
	(0.035)	(0.054)	(0.035)	(0.038)	(0.039)	(0.047)
Labour productivity, log	0.059**	0.070*	-0.042**	-0.060***	0.017	0.006
	(0.028)	(0.038)	(0.017)	(0.020)	(0.019)	(0.029)
Real GDP, log	-0.020**	-0.025***	0.000	0.003	-0.017***	-0.020***
	(0.008)	(0.009)	(0.005)	(0.005)	(0.005)	(0.006)
Manuf. value added, % of GDP	0.003	0.004	0.001	0.001	0.004**	0.005**
	(0.002)	(0.003)	(0.001)	(0.001)	(0.002)	(0.002)

Note: the table shows average marginal effects associated with the estimates reported in Table 5.1. Delta-method standard errors are in parentheses. \*, \*\*, \*\*\* indicate statistical significance at 10%, 5% and 1% levels respectively.

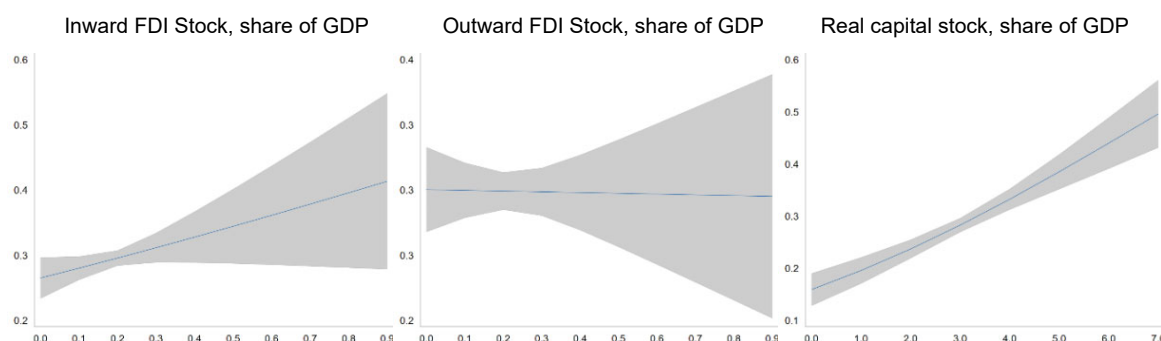
Source: own estimates.

However, in the case of forward GVC participation, the estimated impact is negative, although the magnitude of the effect is much smaller in comparison with the influence of capital stock on backward linkages. Additional estimations suggest that the result is driven largely by Poland and the UK which are both characterised by a high degree of forward GVC integration and low capital-to-GDP ratios compared to the rest of the European sample based on EU KLEMS real capital stock data.<sup>9</sup> In general, the results for forward GVC participation are less robust than those for backward GVC participation as regards sensitivity to the country sample composition, share of variance explained, significance and stability of estimates.

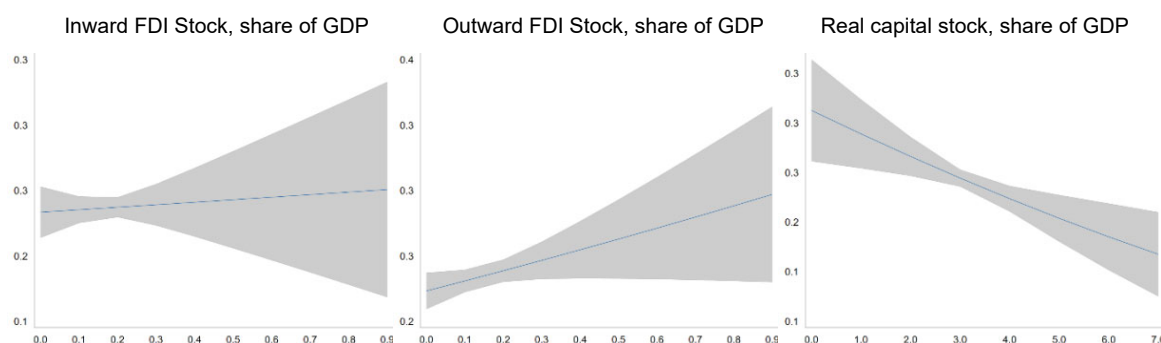
<sup>9</sup> Re-estimating the model without Poland and the UK renders the impact of capital-to-GDP ratio statistically insignificant.

**Figure 5.1 / Predictive margins for GVC participation at varying FDI and capital stock levels**

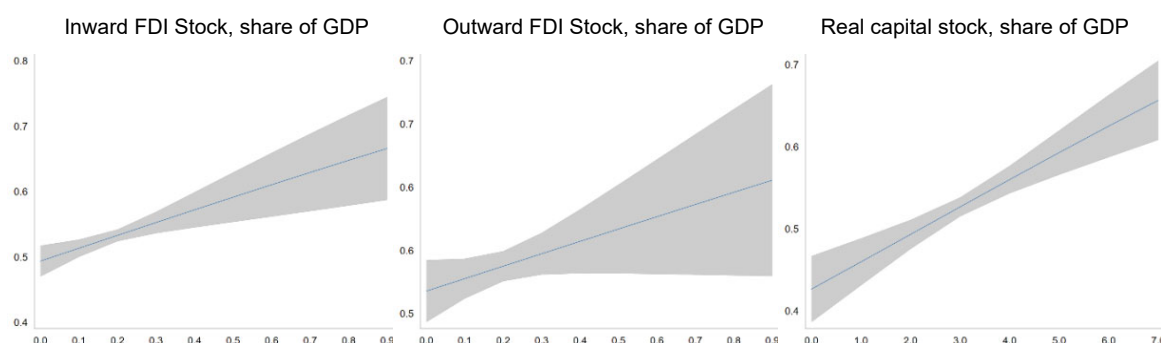
Panel A. y-axis: backward GVC participation



Panel B. y-axis: forward GVC participation



Panel C. y-axis: total GVC participation



Source: own estimates.

The use of probit-based models poses issues with the interpretation of the coefficients in terms of the magnitudes of the effects. Therefore, Table 5.2 provides the mean marginal effects computed for the respective estimates listed in Table 5.1. In addition, we check the predictive margins (expected levels of GVC participation derived on the baseline model estimates) associated with different levels of inward and outward FDI and capital intensity for all GVC integration measures. The results suggest that an increase in the inward FDI-to-GDP share by 0.1 increases backward GVC participation by about 0.016 (for reference, GVC\_BWI values for most of the countries in the sample fall into the range of 0.18-0.52 and inward FDI stock as a share of GDP varies from 0.05 to 0.66). A unit-change in the capital intensity

variable (the variable varies from 2.0 to 5.2 across the sample) induces an increase in backward GVC participation by about 0.05. The marginal effect of outward FDI on forward linkages is weaker: 0.08, although one should note that forward GVC participation varies in a narrower range of 0.15-0.28. In the case of total GVC participation, the impact of FDI variables is slightly stronger and more statistically significant.

The results imply that, at least in the case of backward and total GVC participation, domestic capital could work as a substitute to inward FDI at least in promoting downstream integration, particularly given that introducing an interaction term between FDI and capital intensity yields a statistically significant negative estimate (see Tables A1 and A2 in the Appendix).

### 5.3. RESULTS: SECTOR-LEVEL ANALYSIS

As discussed in Section 3, for the analysis at the sectoral level we develop alternative measures of GVC participation based on sector gross output:  $\widehat{GVC}_{ckt}^{BWI}$ ,  $\widehat{GVC}_{ckt}^{FWI}$ ,  $\widehat{GVC}_{ckt}^{TI}$  for backward, forward and total GVC participation respectively. These measures have better statistical properties for the pooled sectoral sample in terms of their frequency distribution and moments, are contained in the (0, 1) interval, and still offer straightforward economic interpretation and comparability across sectors. Likewise, as a measure of FDI intensity, we compute ratios of (sector-specific) FDI inward and outward stocks to sector value added, as well as real capital stock as a share of value added for each of the 26 sectors as defined in Section 2. The descriptive statistics for all sectors for these key variables of interest are reported in the Appendix Table C1.

While mixing significantly heterogeneous sectors in a single pooled estimation is not a good idea given notable differences in terms of economic function performed by services sectors and manufacturing sectors, we nevertheless start with pooled sectoral estimations based on fractional probit with standard errors clustered at the country-sector level and introducing industry fixed effects. In addition to pooled sectoral estimations, we also split sectors by broad groups: primary sectors, manufacturing and services. Within the manufacturing group we also carry out separate estimations for the high-tech manufacturing cluster comprising sectors in the production of electrical, machinery and transport equipment which have particularly high degrees of GVC participation in Europe as discussed in Section 3. The results for the pooled sectoral estimations (reported in Appendix Table B1) indicate a statistically significant positive impact of inward FDI intensity on the formation of backward production linkages in the case of the manufacturing group, as well as a positive and statistically significant effect of capital intensity on forward GVC participation in the manufacturing sectors (also manifesting in the pooled sectoral sample) and on backward GVC participation in the high-tech manufacturing cluster. Economic interpretation of the magnitudes in terms of conditional marginal effects for the pooled sample is however hindered given the significant cross-sector heterogeneity of FDI and capital intensity between services sectors, manufacturing sectors and commodity sectors.

Estimations by individual sectors reveal significant heterogeneity of the impacts across sectors, as expected. For convenience, the mean marginal effects of a unit change in FDI and capital intensity variables on backward, forward and total GVC participation along with the 95% confidence intervals are illustrated in Figures 5.2 - 5.4. The associated fractional probit regression results are reported in

Appendix B (Tables B2 and B3). In addition, Table 5.3 summarises the estimated conditional marginal effects across sectors by broad groups (sector labels are listed in Table 2.2).

**Table 5.3 / Summary of average marginal effects from estimations by individual sectors**

Dep. var.	Explanatory var.	Mean					Min	SEC (min)	Max	SEC (max)
		Commodity sectors	Manuf. sectors	High-tech manuf.	Service sectors	All sectors	All sectors	All sectors	All sectors	All sectors
		SEC 1-2	SEC 3-13	SEC 10-12	SEC 14-26	SEC 1-26	SEC 1-26	SEC 1-26	SEC 1-26	SEC 1-26
GVC_BWI_GO	Inward FDI stock, share of value added	0.176	0.064	0.069	0.015	0.048	-0.020	13_OMAN	0.479	4_TXTL
	Real capital stock, share of value added	0.002	0.051	0.052	0.001	0.022	-0.016	17_WHTR	0.160	4_TXTL
	Outward FDI stock, share of value added	0.032	0.056	0.098	0.003	0.028	-0.082	18_RETR	0.228	4_TXTL
GVC_FWI_GO	Inward FDI stock, share of value added	0.018	0.013	-0.011	0.017	0.015	-0.045	10_ELEC	0.151	4_TXTL
	Real capital stock, share of value added	0.006	0.012	0.012	0.000	0.006	-0.021	18_RETR	0.032	4_TXTL
	Outward FDI stock, share of value added	-0.034	0.014	0.035	-0.020	-0.007	-0.163	18_RETR	0.059	10_ELEC
GVC_TL_GO	Inward FDI stock, share of value added	0.187	0.074	0.057	0.036	0.064	-0.019	14_GASW	0.593	4_TXTL
	Real capital stock, share of value added	0.008	0.062	0.064	0.002	0.028	-0.020	18_RETR	0.184	4_TXTL
	Outward FDI stock, share of value added	0.007	0.068	0.131	-0.013	0.023	-0.233	18_RETR	0.239	4_TXTL

Note: the table shows the marginal effects of FDI and capital variables on GVC participation based on the baseline model estimates with sectors grouped into broad categories as indicated in the second row.

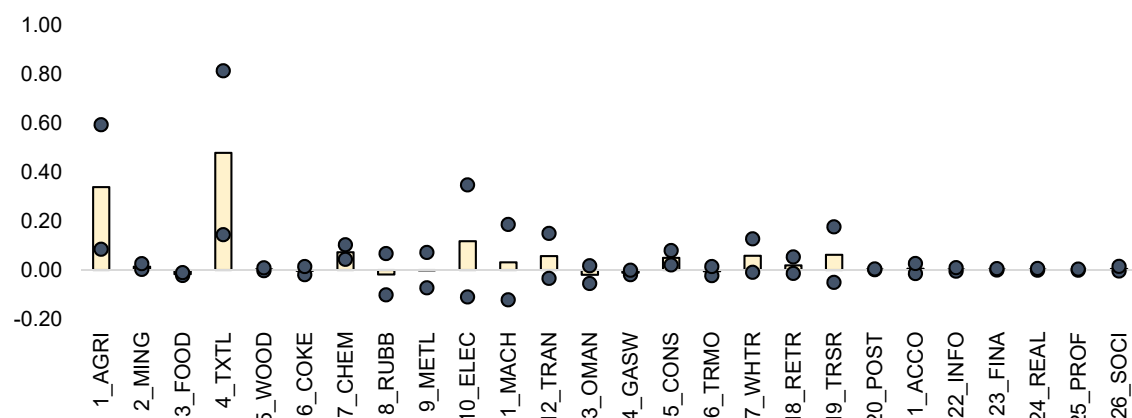
Source: own estimates.

Overall, the marginal impacts on backward and forward GVC participation produced by inward FDI is much higher than that associated with outward FDI. Also, backward production linkages are more sensitive to FDI and capital formation in comparison to forward linkages. The positive impact of outward FDI on forward GVC participation is driven largely by high-tech manufacturing sectors — the machinery, transport and (especially) electrical equipment industries. The impact of inward and outward FDI intensity on backward GVC participation is also high in magnitudes, albeit statistically significant only in the case of the influence of outward FDI stock on backward linkages of electrical equipment manufacturing (SEC 10). To a smaller extent, the positive impact of outward FDI on forward linkages is also observed for the chemicals and metals sectors.

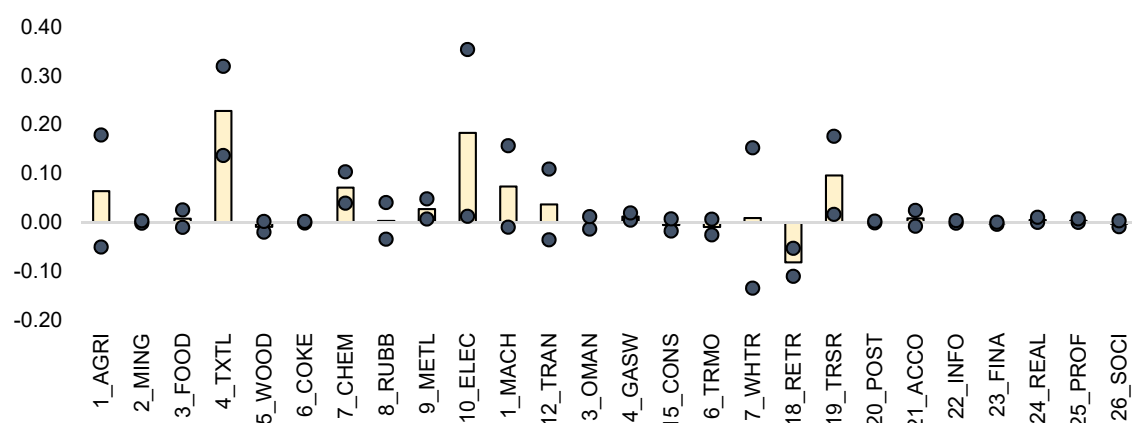
An especially strong across-the-board impact of FDI and capital formation for both backward and forward value chain integration is found for textile and clothing production (SEC 4). In particular, a unit-change in inward FDI-to-value added ratio is associated with an average increase in GVC\_BWI\_GO by almost 0.5 and in GVC\_FWI\_GO by 0.15, which are the highest marginal effects observed across the sectors. Likewise, a unit-change in the capital stock ratio to value added is associated with an increase in GVC\_BWI\_GO by 0.16 and GVC\_FWI\_GO by 0.03, again, the highest conditional marginal effects across the sample.

**Figure 5.2 / Marginal effects for backward GVC participation (GVC\_BWI\_GO): sectoral results**

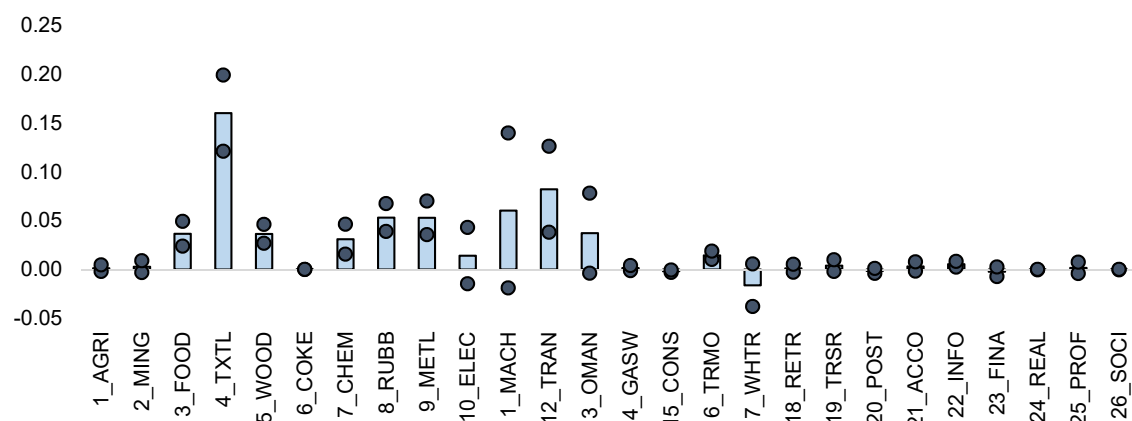
Panel A. Inward FDI stock, share of value added



Panel B. Outward FDI stock, share of value added



Panel C. Real capital stock, share of value added

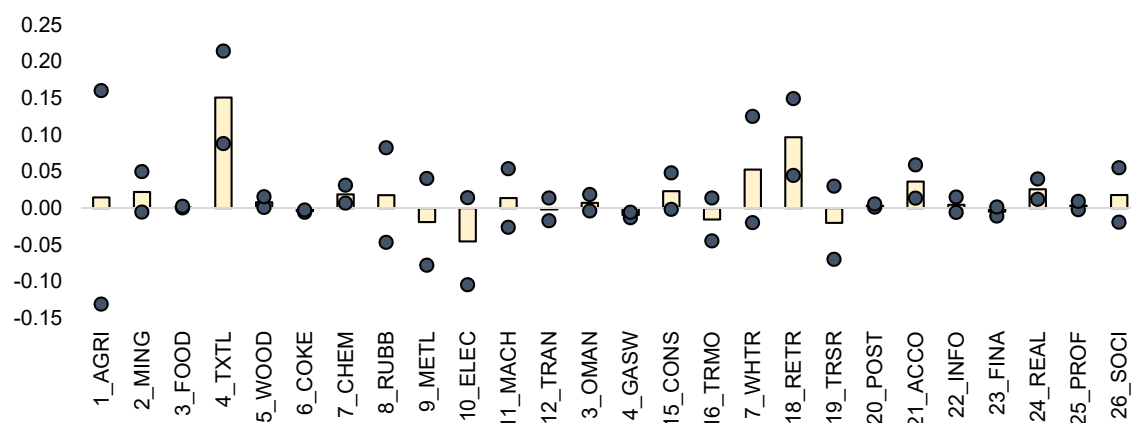


Note: the figure shows the marginal effects on GVC participation (y-axis) for different sectors along with the 95% confidence intervals, associated with the baseline model estimates.

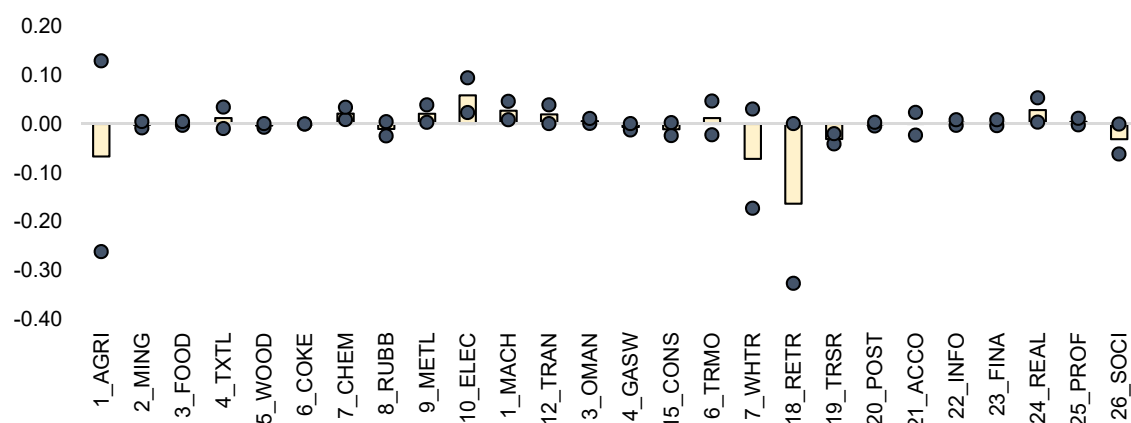
Source: own estimates.

**Figure 5.3 / Marginal effects for forward GVC participation (GVC\_FWI\_GO): sectoral results**

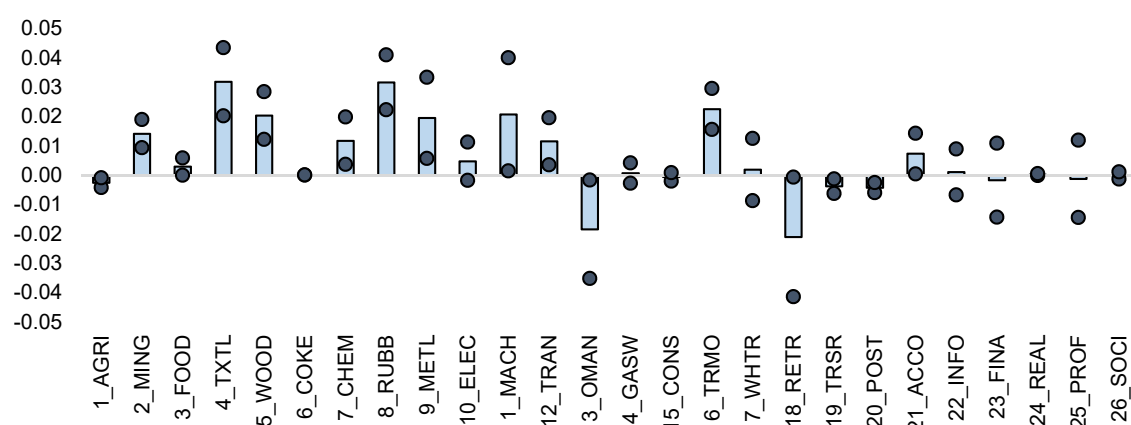
Panel A. Inward FDI stock, share of value added



Panel B. Outward FDI stock, share of value added



Panel C. Real capital stock, share of value added

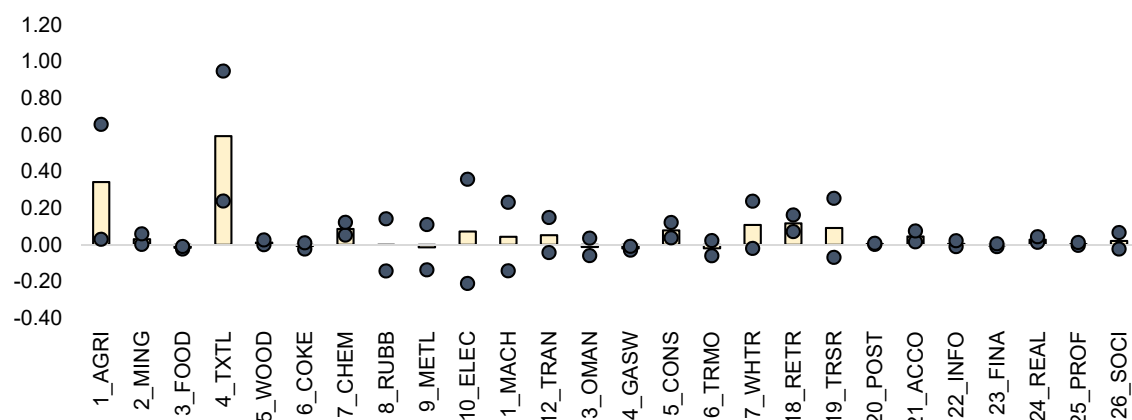


Note: the figure shows the marginal effects on GVC participation (y-axis) for different sectors along with the 95% confidence intervals, associated with the baseline model estimates.

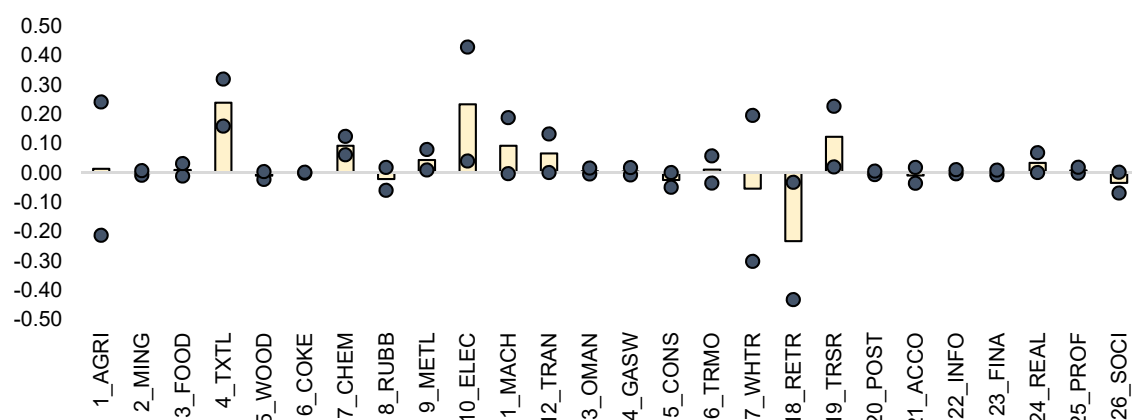
Source: own estimates.

**Figure 5.4 / Marginal effects for total GVC participation (GVC\_TL\_GO): sectoral results**

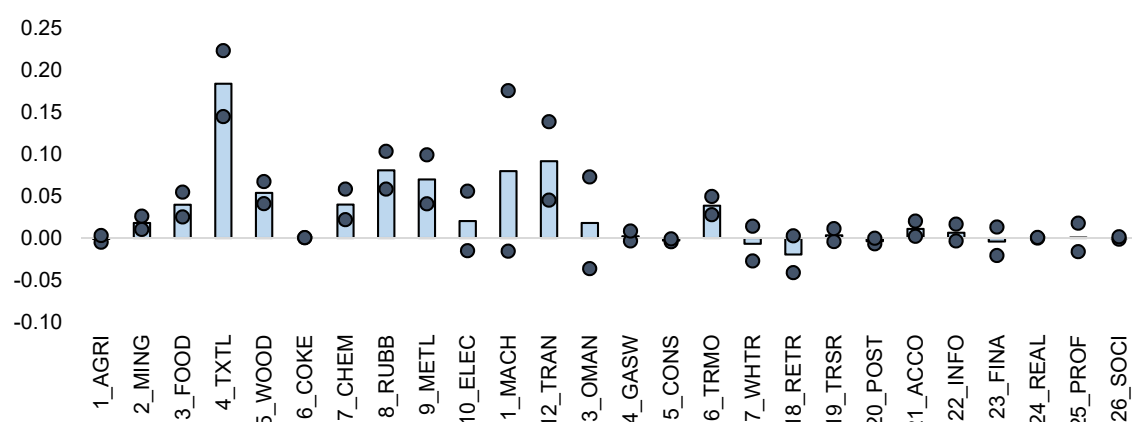
Panel A. Inward FDI stock, share of value added



Panel B. Outward FDI stock, share of value added



Panel C. Real capital stock, share of value added



Note: the figure shows the marginal effects on GVC participation (y-axis) for different sectors along with the 95% confidence intervals, associated with the baseline model estimates.

Source: own estimates.



The marginal impact of inward FDI on backward GVC participation in the agricultural sector (SEC 1) is also significant statistically and in terms of the magnitude, however, the sector de facto has a relatively low level of integration in cross-border production sharing. As regards the impact on GVC integration of the services sectors, in the transportation and storage services sector (SEC 19) an increase in outward FDI stock is associated with a notable and statistically significant positive impact on backward GVC participation, which is particularly noteworthy as the sector is among the most integrated sectors in both upstream and downstream production (see Figure 5.3). The impact on other services sectors is either not significant or the sectors are characterised by very low degrees of GVC participation.

#### 5.4. IMPLICATIONS OF CAPITAL STRUCTURE FOR GVC PARTICIPATION

In this section we evaluate the impact of capital composition on GVC participation. To this end, we estimate a sequence of fractional probit specifications (in line with the baseline model) replacing the total real capital intensity variable by its components, i.e. ten capital asset types based on the EU KLEMS data and definitions as described in Sections 2 and 4. Taking into account multicollinearity issues, particularly associated with high-technology capital, capital stock variables by asset types are included consecutively rather than jointly in a single equation, and labour productivity and manufacturing value added share variables are dropped from the specification.

Similarly to the previous empirical exercises, we estimate separate models for backward, forward and total GVC participation (based on gross exports) iterating between inward and outward FDI intensity variables (FDI stock as a share of GDP). The conditional marginal effects resulting from these estimations are summarised in Table 5.4, and selected estimated models are reported in Appendix A (Tables A6 and A7). In Table 5.4, estimations with inward FDI are denoted as Model I and those involving outward FDI are denoted as Model II. As can be seen, while the results are mostly consistent across the two models, specifications with outward FDI tend to yield greater statistical significance and higher magnitudes for the capital asset type variables.

**Table 5.4 / Impact of capital stock by asset types on GVC, country-level results (marginal effects)**

Capital asset type	Code	Backward GVC participation		Forward GVC participation		Total GVC participation	
		(I)	(II)	(I)	(II)	(I)	(II)
Total non-residential investment	OCon	0.046**	0.085***	-0.004	-0.013	0.046***	0.076***
Residential structures	RStruc	0.074**	0.061	-0.068***	-0.068***	0.012	-0.003
Transport equipment	TraEq	0.073	-0.010	-0.136	-0.132	-0.031	-0.118
Other machinery and equipment	OMach	0.171*	0.237**	0.074	0.054	0.249***	0.292***
Computing equipment	IT	2.473**	3.231***	-1.324*	-1.258*	1.264	2.068*
Communications equipment	CT	-0.052	0.362	-0.035	-0.016	-0.098	0.337
Computer software and databases	Soft_DB	0.669	1.753**	0.017	-0.077	0.660	1.618**
Research and development	RD	0.337	0.659***	-0.115	-0.132	0.206	0.471***
Cultivated assets	Cult	-0.404	-0.059	-0.262	-0.314	-0.781	-0.446
Other IPP assets	OIPP	-2.080**	-2.234***	0.652	0.696	-1.243***	-1.289**

Note: the table shows average marginal effects of real capital stock (taken as a share of GDP) by asset types in line with the EU KLEMS classification on GVC participation variables. \*, \*\*, \*\*\* indicate statistical significance at 10%, 5% and 1% levels respectively. Columns (I) and (II) indicate alternative fractional probit models associated with the estimates: (I) includes inward FDI and (II) includes outward FDI stock as a share of GDP, in addition to other control variables (GDP, REER and year fixed effects are used in the baseline).

Source: own estimates.

**Table 5.5 / Impact of capital stock by asset types on GVC participation, manufacturing sectors (conditional marginal effects)**

Capital asset type	Code	Backward GVC participation GVC_BWI_GO									
		3 FOOD	4 TXTL	5 WOOD	6 COKE	7 CHEM	8 RUBB	9 METL	10 ELEC	11 MACH	12 TRAN
Total non-residential investment	Ocon	<b>0.066***</b>	0.142	<b>0.123**</b>	0.000	0.050	<b>0.050**</b>	0.014	<b>0.065***</b>	0.018	0.089
Residential structures	RStruc	-2.074	1.766	0.673	0.024	5.981	<b>5.009***</b>	<b>4.082*</b>	4.054	<b>6.636***</b>	3.822
Transport equipment	TraEq	-0.118	-1.198	0.033	0.003	0.371	0.094	0.288	<b>1.571***</b>	0.415	-0.257
Other machinery and equipment	OMach	0.008	<b>-0.345***</b>	0.006	0.000	-0.028	0.024	<b>-0.035*</b>	<b>0.109***</b>	0.028	<b>-0.079**</b>
Computing equipment	IT	-0.124	0.086	0.051	0.008	0.282	0.179	<b>0.209**</b>	<b>1.181***</b>	-0.237	-1.212
Communications equipment	CT	-0.710	<b>0.257*</b>	<b>0.509***</b>	0.020	<b>2.655***</b>	-0.072	<b>0.206**</b>	<b>1.488**</b>	1.866	<b>2.254**</b>
Computer software and databases	Soft_DB	0.019	0.660	-0.444	0.012	-0.151	<b>-0.949***</b>	-0.124	0.079*	0.243	<b>1.684***</b>
Research and development	RD	<b>0.729***</b>	<b>1.265***</b>	<b>0.544***</b>	0.004	0.037	0.079	<b>0.176**</b>	<b>-0.102***</b>	-0.154*	<b>0.129**</b>
Cultivated assets	Cult	<b>0.161***</b>	<b>-1.942***</b>	<b>0.665**</b>	0.007	0.073	0.119	-0.076	<b>0.122***</b>	0.150	0.010
Other IPP assets	OIPP	<b>0.315***</b>	2.134	2.157	<b>0.666***</b>	0.034	0.077	0.375	<b>1.426**</b>	0.791**	<b>3.444*</b>
Forward GVC participation GVC_FWI_GO											
Capital asset type	Code	3 FOOD	4 TXTL	5 WOOD	6 COKE	7 CHEM	8 RUBB	9 METL	10 ELEC	11 MACH	12 TRAN
		3 FOOD	4 TXTL	5 WOOD	6 COKE	7 CHEM	8 RUBB	9 METL	10 ELEC	11 MACH	12 TRAN
Total non-residential investment	Ocon	<b>0.009***</b>	<b>-0.062***</b>	<b>0.061***</b>	0.000	<b>0.015*</b>	<b>-0.016***</b>	0.000	0.004	0.031	<b>0.056**</b>
Residential structures	RStruc	<b>0.469**</b>	1.337	1.161	<b>-0.011***</b>	<b>2.935**</b>	0.036	1.745	-0.063	<b>4.253**</b>	16.428
Transport equipment	TraEq	<b>0.075***</b>	<b>-0.406***</b>	0.205	0.001	<b>0.396**</b>	<b>-0.039*</b>	0.170	0.112	<b>0.412**</b>	0.063
Other machinery and equipment	OMach	<b>-0.010**</b>	-0.027	0.005	-0.000	-0.003	0.005	<b>-0.031**</b>	-0.012	<b>0.010**</b>	0.000
Computing equipment	IT	<b>0.009***</b>	<b>-0.948*</b>	-0.157	0.000	<b>0.458***</b>	<b>-0.236***</b>	<b>0.099**</b>	<b>-0.240***</b>	-0.082	-0.007
Communications equipment	CT	<b>0.036**</b>	<b>-4.235**</b>	-0.191	0.001	-0.057	-0.040	<b>0.490**</b>	<b>-0.374***</b>	<b>0.732***</b>	0.243
Computer software and databases	Soft_DB	-0.084	<b>-1.048***</b>	-0.036	0.001	-0.037	<b>-0.304***</b>	-0.383	0.030	-0.126	-0.066
Research and development	RD	0.026	<b>0.301***</b>	<b>0.300***</b>	0.000	0.022	<b>-0.095*</b>	<b>0.326***</b>	<b>0.043***</b>	-0.021	<b>0.016***</b>
Cultivated assets	Cult	<b>0.025***</b>	<b>0.867***</b>	-0.106	<b>-0.002**</b>	<b>0.162*</b>	<b>-0.011*</b>	-0.166	<b>0.013***</b>	<b>0.075**</b>	<b>0.032**</b>
Other IPP assets	OIPP	<b>-0.043**</b>	-0.819	-0.150	<b>0.034**</b>	0.242	-0.120	<b>-3.548*</b>	<b>0.233***</b>	0.150	0.202

Note: the table shows marginal effects of real capital stock as a share of sector value added by asset types (following the EU KLEMS classification as indicated by Code) on backward and forward GVC participation. Sectors are coded in line with Table 2.2. Estimates are based on baseline fractional probit models estimated separately for each sector and asset type, controlling for labour productivity, inward and outward FDI stock, REER and real GDP with standard errors clustered by country. \*, \*\*, \*\*\* indicate statistical significance at 10%, 5% and 1% levels respectively.

Source: own estimates.

The most prominent result from the aggregate estimations is revealed for computing equipment which yields estimates both statistically and economically significant, in fact, considerably higher than the effects for any other capital asset category. In particular, an increase in computing capital stock intensity by 10 pp. boosts *backward* GVC participation by at least 0.25, *ceteris paribus* (for reference, the GVC\_BWI measure varies between 0.17 and 0.52 for the European sample of countries excluding tax havens). The impact of computing capital in the case of *forward* GVC participation is, on the contrary, negative, albeit only marginally statistically significant. The impact of other machinery and equipment capital, OMach, is also significant and manifests itself both in backward GVC and total GVC participation measures. The estimates for capital embodied in residential and non-residential structures turn out to be significant statistically but the magnitudes of the economic effect are minuscule.

Since capital stock has been as a particularly important driver of production sharing in the manufacturing sector, we next make a closer inspection of the effects of capital structure for individual manufacturing sectors. The summary of the conditional marginal effects associated with a series of fractional probit estimations over each sector iterating over various capital asset types and dependent variables is listed in Table 5.5.<sup>10</sup> Statistically significant results with relatively high conditional margins, i.e. exceeding unity, are highlighted in bold red for convenience.

The results suggest that ICT capital, and, in particular, computing and communications equipment, as well as software, is generally positively associated with backward GVC participation and is especially instrumental for backward linkages of the electrical and transportation equipment sectors (SEC 10, 12), as well as the chemical industry (SEC 7). At the same time, ICT capital negatively impacts the forward GVC participation of the textile and clothing industry SEC 4 (the share of ICT capital in total real capital stock is about 4% on average for the European sample for SEC 4).

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<sup>10</sup> The baseline fractional probit model with standard errors clustered by country is estimated in each case with selected robustness checks. Estimation results are available on request.

## 6. Impact on bilateral trade in value added: evidence from the gravity model

### 6.1. MODEL SETUP

To complement the analysis on GVC participation measures, we switch the focus to bilateral trade in value added between countries and employ a well-established gravity model of trade to examine the possible implications of bilateral two-way FDI relationships between a given pair of countries, as well as their capital stock intensity and composition, for their trade in value added.

The gravity model of trade, commonly applied to gross trade flows, explains nominal values of bilateral trade (value added exports in our case) between countries  $i$  and  $j$  as a function of their economic size, proxied by GDP values, and a variety of variables that introduce positive or negative frictions to trade, proxied by distance between exporter and importer, existence of a common border and a variety of other factors. In our case we augment the conventional set of gravity model covariates by variables of interest reflecting inward bilateral FDI stocks between the trading partners (FDI of country  $i$  in country  $j$ , and, vice versa, FDI of country  $j$  in country  $i$ ) and real capital stock levels (in logs) of exporter and importer. More formally, the specification is set up as follows:

$$VAX_{ijt} = \alpha + \beta FDI_{ijt-1} + \gamma_1 K_{it-1} + \gamma_2 K_{jt-1} + \Psi X_{ij} + \varepsilon_{ijt} \quad (6.1)$$

where  $VAX_{ijt}$  denotes value-added exports from country  $i$  to country  $j$  in year  $t$ ;  $K_{it-1}$  and  $K_{jt-1}$  denote real capital stock variables (in logs);  $FDI_{ijt-1}$  is the nominal bilateral FDI stock from country  $j$  to country  $i$  (in logs). Capital and FDI variables are lagged by one period to address potential endogeneity issues.

The vector  $X$  is comprised of bilateral and country-specific control variables conventionally used in the empirical gravity model literature: GDP of countries  $i$  and  $j$ , distance between countries  $i$  and  $j$  weighted by population density, dummy variables ( $=1$  if the trade dyad  $ij$  shares a given characteristic,  $0$  otherwise) for common language, common border, common legal origin, colonial relationship in the past, preferential trade agreements (PTA) and common currency. In addition, country fixed effects and year fixed effects (alternatively some specifications use country-year fixed effects or  $ij$ -pair fixed effects) are included to address possible omitted variable bias and control for unobserved country heterogeneity, as well as time-varying factors simultaneously affecting all countries in the sample, e.g. the impact of the global recession. The inclusion of fixed effects effectively renders time-invariant, time-varying country or time-invariant pair characteristics in associated specifications redundant (various specifications are tested for robustness along with sensitivity checks).

We use Poisson Pseudo Maximum Likelihood (PPML) estimator with fixed effects and standard errors clustered by  $ij$  pairs as the baseline model, and additionally supply results for panel fixed effects (least squares dummy variable estimator) and pooled OLS for comparison. In addition to the specification involving real capital stocks of exporter and importer, we also estimate models with the capital stock split by ICT and non-ICT, as well as by capital asset types, as discussed above.

## 6.2. ESTIMATION RESULTS

Table 6.1 reports the results from the gravity model estimated for bilateral value added exports with conventional gravity covariates augmented by FDI stocks (inward FDI stock of exporter in importer's economy, and, vice versa, inward FDI stock of importer in exporter's economy) and real capital stock of both countries in the dyad. In line with the literature, PPML is the preferred model although the results are stable across specifications except for the cases when country pair fixed effects are introduced. The latter renders FDI variables insignificant statistically which could be associated with the fact that bilateral FDI positions tend to remain stable over time (after removing time trend and common business cycle effects).

**Table 6.1 / Gravity model results for bilateral trade in value added**

	PPML	PPML	PPML	FE	FE	FE	FE	FE	POLS
	1	2	3	4	5	6	7	8	9
FDI from exp. to imp., log	0.071*** (0.013)	0.072*** (0.017)	0.000 (0.011)	0.099*** (0.009)	0.094*** (0.010)	0.023*** (0.005)	0.010 (0.006)	0.089*** (0.013)	0.073*** (0.014)
FDI from imp. to exp., log	0.053*** (0.012)	0.073*** (0.018)	0.002 (0.016)	0.071*** (0.009)	0.073*** (0.010)	0.009 (0.006)	0.006 (0.006)	0.082*** (0.013)	0.109*** (0.013)
Exporter's real capital, log		-0.097 (0.348)	0.057 (0.285)				0.342** (0.145)	-0.347* (0.206)	-0.161 (0.100)
Importer's real capital, log		-0.800** (0.359)	-0.728** (0.346)				-0.475** (0.198)	-0.866*** (0.240)	-0.394*** (0.090)
Exporter's real GDP, log	0.570*** (0.042)	0.833*** (0.150)	0.952*** (0.143)	0.561*** (0.053)		0.745*** (0.043)	1.025*** (0.082)	1.044*** (0.125)	0.838*** (0.093)
Importer's real GDP, log	0.607*** (0.069)	1.129*** (0.193)	1.259*** (0.174)	0.682*** (0.052)		0.881*** (0.045)	1.124*** (0.103)	0.970*** (0.132)	0.975*** (0.091)
Weighted distance, log	-0.439*** (0.030)	-0.606*** (0.080)		-0.645*** (0.044)	-0.648*** (0.048)			-0.918*** (0.071)	-0.785*** (0.071)
Common border	0.256*** (0.050)	0.084 (0.054)		0.376*** (0.063)	0.353*** (0.066)			0.174*** (0.062)	0.237** (0.095)
Common language	0.091 (0.075)	0.303*** (0.070)		0.002 (0.070)	-0.007 (0.074)			0.005 (0.128)	-0.026 (0.105)
Colonial relationship	-0.042 (0.074)	0.087** (0.043)		-0.153** (0.073)	-0.136* (0.076)			-0.073 (0.067)	-0.203* (0.114)
Common legal origin	0.149*** (0.046)	0.209*** (0.052)		0.119*** (0.037)	0.127*** (0.040)			0.215*** (0.051)	0.339*** (0.070)
Common currency	0.165*** (0.058)	0.209*** (0.061)		-0.042 (0.044)	-0.008 (0.048)			0.006 (0.050)	-0.031 (0.068)
Trade agreement (PTA)	0.267*** (0.067)	-0.422** (0.172)		0.063 (0.057)	0.035 (0.076)			-0.119 (0.149)	-0.543*** (0.176)
Constant	-21.5*** (2.384)	-27.8*** (6.534)	-41.7*** (5.408)	-22.5*** (2.096)	11.3*** (0.444)	-36.7*** (1.665)	-48.2*** (3.033)	-24.2*** (4.038)	-28.3*** (1.797)
Obs.	5,298	2,100	2,100	5,298	5,296	5,214	2,068	2,100	2,100
adj. R-sq	0.951	0.981	0.993	0.952	0.953	0.992	0.995	0.974	0.945
Year fixed effects	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	No	Yes	No	No	No	Yes	No
Pair fixed effects	No	No	Yes	No	No	Yes	Yes	No	No
Country-year fixed effects	No	No	No	No	Yes	No	No	No	No

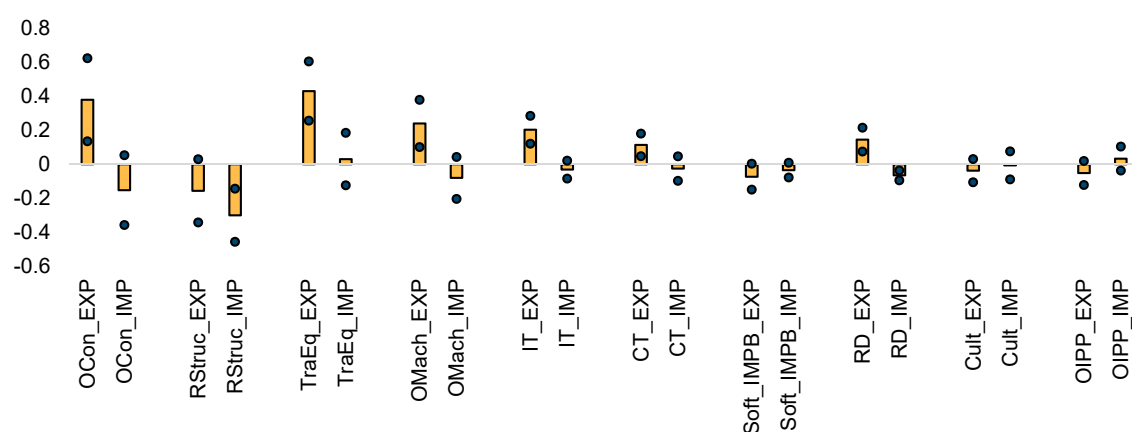
Note: the table shows the results of gravity model estimations with Poisson pseudo-maximum likelihood (PPML), fixed effects (FE) and pooled OLS (POLS). Dependent variable – trade in value added (in logs for FE model). FDI from exp. to imp., log denotes inward FDI stock from exporter to importer. FDI from imp. to exp., log denotes inward FDI stock from importer to exporter. FDI and capital stock variables are lagged by one period. Standard errors clustered by country pairs are in parentheses. \*, \*\*, \*\*\* indicate statistical significance at 10%, 5% and 1% levels respectively.

Source: own estimates.

Notably, the results show that FDI in both directions — from exporters to importers and vice versa — are strongly positively associated with value added exports. The magnitudes are also rather similar: a 1% increase in FDI stock is associated with a 0.07%-0.09% increase in value added exports. This confirms evidence from the panel analysis of GVC participation and extends the evidence to cover bilateral value added flows.

Estimates suggest that real capital stock in the importing economy is negatively associated with trade in value added. Splitting capital into ICT and non-ICT capital yields inconclusive results (see Appendix Table A8). However, further insights from disaggregating capital by asset types (estimates are illustrated in Figure 6.1) support the evidence from panel analysis based on fractional response models and suggest that capital in the exporting country is conducive to its value added exports, with particularly important roles played by transport equipment (TraEq), other machinery and equipment (OMach), non-residential investment (OCon) as well as, to a smaller extent, ICT capital and research and development capital. An increase in transport and machinery capital stock equipment by 1% is associated with an increase in value added exports by up to 0.7% which is much higher than the impact of FDI stocks (Appendix Table A8). One should however note that the capital stock variables reflect total capital stock of a country while the FDI variable reflects a bilateral relationship between exporter and importer. From the importer's perspective, estimations by asset types suggest that the negative impact on value-added exports observed for the importer's total capital stock is largely driven by a negative contribution of residential and non-residential structures.

**Figure 6.1 / Implications of capital stock composition by asset types on trade in value added**



Note: the figure shows the estimates (indicated by bars) of the marginal impact of exporter's and importer's capital by asset types from the baseline gravity model estimated via Poisson pseudo-maximum likelihood, along with the 95% confidence intervals (indicated by dots).

Source: own estimates.

## 7. Policy implications

We analysed the role of FDI, as well as capital stock and its composition, in upstream and downstream integration along value added chains using a two-fold approach: focusing on bilateral trade in value and overall GVC participation of countries at aggregate and sectoral levels, including primary sectors, manufacturing sectors and services sectors.

Summarising the empirical evidence across all empirical exercises described above, we show that, at least drawing from cross-country variation in the European sample, FDI is conducive to the formation of GVCs and, in particular, inward FDI facilitates the formation of backward linkages, while outward FDI may aid forward GVC participation, especially in high-tech manufacturing sectors. This is consistent with expectations, as multinational corporations coordinate GVCs, related economic activities and trade flows largely through their networks of foreign affiliates established via foreign direct investment (in addition to contractual relations with external firms). We, however, empirically confirm the significance of this relationship, show the magnitude of the effect and differentiated effects for outward and inward FDI at aggregate and sectoral levels. At the aggregate country level, ICT capital accumulation is strongly positively associated with backward GVC integration (both in terms of statistical and economic significance) and negatively associated with forward GVC participation. The results thus provide additional empirical support to policy prescriptions stressing the importance of policies that encourage FDI inflows, particularly as an important vehicle for the development of small economies that are constrained as regards their growth prospects by small domestic markets and generally have a limited capacity to establish competitive complete production chains on their own.

The results suggest that capital stock in general facilitates GVC integration and thus developing domestic capital may be a feasible alternative to foreign investment (particularly, to stimulate backward GVC participation). In terms of the marginal effect, however, the effectiveness of FDI as a vehicle of value chain integration is much higher in comparison with the impact of capital stock.

While it is not fully legitimate to compare the results based on the GVC participation measures to the evidence from the gravity models based on trade in value added (the latter convey the notion of value added nominal flows from the origin of value added to the ultimate importer-consumer, which is conceptually rather different from the GVC participation per se, which measures only complex value chains rather than direct trade in intermediates or final goods), in general, the bilateral gravity model also confirms the importance of FDI for trade in value added. The significance of estimates for FDI in both directions (from exporter to importer of value added, and vice versa) is indicative of both horizontal and vertical FDI motives as integral elements of GVC development by multinational corporations. The gravity model estimations imply that real capital stock in the importing economy is negatively associated with trade in value added which may seem to contradict the findings from the backward GVC participation positively influenced by capital accumulation in the panel fractional response estimations. However, as mentioned, trade in value added reflects the consumption of value added by the ultimate importer rather than the use of value added for further exports (backward GVC integration) and in this regard reflects the redundancy of capital formation for countries engaged in ultimate absorption of value added created



elsewhere. This conjecture is supported by the results we found for capital in the exporting country: positive estimates for capital stock in general, and, looking at specific asset types, particularly significant estimates for transport equipment (TraEq), other machinery and equipment (OMach), non-residential investment (OCon) as well as, to a smaller extent, ICT capital and research and development capital.

It is also important to note that the relative impacts of FDI and capital in general and its specific components (i.e. capital asset types) differ significantly across sectors. This highlights the importance of a fine-tuned approach to crafting sectoral development strategies and designing their GVC integration policy frameworks as part of broader economic development planning. More specifically, we found especially strong marginal impacts of both FDI and capital accumulation on GVC integration in the textile and clothing industry. This is especially noteworthy given that the textile sector is highly integrated in GVCs in Europe with especially strong backward production linkages.

In addition, capital accumulation supports the formation of GVC linkages for most sectors while ICT capital appears to be especially instrumental for backward integration of the electrical and transportation equipment sectors (SEC 10, 12) as well as the chemical industry (SEC 7) — the sectors which are considered as high and medium-high technology sectors. Estimations for these sectors yielded both high levels of statistical significance and high magnitudes of marginal effects. In general, ICT investment is expected to facilitate GVC participation by aiding the coordination and monitoring of economic activities over distance, which is an essential element of production fragmentation. Our empirical results emphasising the impact on backward GVC integration are also consistent with the idea that countries desire to upgrade into activities with higher value-added potential and a more downstream position along value-added chains which requires higher intensity of ICT use and therefore investment in ICT capital (indeed, these sectors are also the highest in terms of backward GVC participation as evidenced in Figure 3.3). This could also explain the evidence estimations yield for the textile and clothing industry (SEC 4), for which we find a strong negative association of ICT capital for *forward* GVC participation (the impact on backward GVC is positive, yet only marginally significant) as ICT-enabled upgrading of production processes facilitates the development of innovative high-performance fibres and materials which require more complex production chains, and thus, shifts the sector downstream implying lower forward GVC participation. In fact, for certain sectors, the highest value addition is associated with intangible activities that are also technology-intensive, requiring ICT capital. In particular, in the electronics and textile/clothing sectors those activities tend to be concentrated at the beginning of the value chain — such as pre-production design or R&D — or at its end including such post-production activities as marketing and promotion, branding, etc.<sup>11</sup>

Integrating in GVCs and upgrading their position in GVCs are obvious policy priorities for many countries as specialisation in higher value-added activities (tasks and sectors) generates larger economic benefits. Higher value-added activities however include not only downstream activities, like marketing and promotion activities, but also upstream activities like design and research and development. In this regard, as noted, FDI appears empirically to be more effective as a tool to facilitate backward GVC integration. Domestic capital formation also facilitates GVC integration. In fact, as both capital

<sup>11</sup> This relationship between value added and tasks is also discussed in the context of “smile curves”, which represents an outline between production stages in a value chain and value added, which for some sectors has an inverted U-shape. The concept of “smile curves” was first proposed around 1992 by Stan Shih, the founder of Acer in relation to the computer industry (Shih suggested that both ends of the computer production value chain generate higher value added than the middle part).



investment and FDI inflows are facilitated by similar structural factors, the ultimate sure-fire recipe is to promote strong institutions, regulatory environment, property rights protection, supportive public infrastructure and other investment-friendly policies. Besides country-specific structural factors that are conducive to trade in value added and GVC integration, bilateral and multilateral connectivity between countries and their sectors spanning value chains are equally important. In this regard, efficient border controls and cross-country logistics, integration agreements (as well as a common currency) are indeed factors that facilitate GVC integration as also evidenced by our empirical results (specifically, estimations based on the gravity model of trade).

## 8. Conclusion

This paper analyses the role of FDI and capital dynamics in the formation of global value chains. Empirical evidence suggests that FDI and capital accumulation are indeed important drivers of value added trade and GVC integration. Notably, we find important differences in the impacts FDI has on forward and backward GVC integration: in particular, inward FDI is especially conducive to the formation of backward linkages while outward FDI facilitates forward GVC participation especially in high-tech manufacturing sectors. While capital accumulation is important for both downstream and upstream integration, capital structure also matters and, in particular, ICT capital appears to be especially instrumental for the backward integration of the electrical and transportation equipment sectors.

The empirical evidence we report may help to facilitate further research focusing on the analysis of the economic role of FDI, GVC and capital accumulation, as well as inform policy makers involved in development and integration issues. Of particular interest is the analysis of the transmission channels via which capital accumulation and foreign investment facilitate GVC integration. This calls for the development of a theoretical framework that could illustrate the specific transmission mechanisms as well as shed light on the sequencing of these effects. Empirical analysis at the firm level with specific case studies would also help address these questions.

It is also important to note that our analysis is based on a sample of European countries. In this regard, undoubtedly, further research is needed to explore the relationship between FDI, capital and GVCs with a broader geographic scope to gain a more general inference on their mutual impacts as well as to identify targeted policies to facilitate GVC integration in view of the revealed evidence on the role of FDI and capital in cross-country production sharing using a broader global sample of countries, particularly, incorporating less developed countries for which successful GVC integration is a critical factor for their long-term economic development prospects in the modern age of globalisation driven by GVCs. It is known that much of cross-border production sharing takes place within Europe and the process is indeed facilitated significantly by European integration processes complemented by geographic proximity and improvements in infrastructure (this also manifests in especially high GVC participation values for certain European countries and sectors, contrasting sharply with much lower GVC participation values of peer economies like the USA, Japan and China, as shown in the descriptive part of the paper). The high degree of integration in Europe manifests not only in trade, both in final goods and intermediates, but also in significantly higher levels of FDI in comparison with peer economies. One should however note substantial heterogeneity of European countries in terms of FDI, capital accumulation and GVC integration which allows one to think that the inference drawn from the estimations reported in this paper would be consistent with evidence from a broader non-European sample of countries. There is however still only limited data available to conduct a similar analysis at the global level, particularly, KLEMS data and up-to-date international cross-country input-output data are scarce, which calls for the need to consolidate efforts to assemble the data which could enable the analysis to yield a more generic inference.

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## Appendix A: Additional country-level regression results

The appendix lists selected additional regression results, including estimations with additional covariates and results employing alternative estimators.

**Table A1 / Additional regressions, backward GVC participation.**

Dep. var.: GVC_BWI	1	2	3	4	5	6	7	8
Inward FDI stock, share of GDP	0.465* (0.252)	1.041*** (0.258)		0.921*** (0.149)	0.480** (0.243)	0.370 (0.267)	0.448 (0.319)	0.464* (0.242)
Real capital stock, share of GDP	0.135*** (0.024)		0.147*** (0.054)	0.126*** (0.043)	0.131*** (0.023)	0.167*** (0.027)	0.149*** (0.032)	0.134*** (0.023)
REER, log diff	0.026 (0.104)				0.020 (0.096)	-0.131 (0.121)	0.004 (0.102)	0.093 (0.120)
Real GDP, log	-0.058** (0.023)				-0.060*** (0.023)	-0.058*** (0.023)	-0.024 (0.023)	-0.062*** (0.021)
Labour productivity, log	0.175** (0.082)				0.168** (0.083)			0.164** (0.078)
Manuf. value added, % of GDP	0.010 (0.007)				0.011 (0.007)		0.010 (0.008)	0.011* (0.006)
Real GDP growth					-0.005 (0.005)			
Real GDP per capita						0.157*** (0.049)		
Real GDP per capita ^ 2						-0.024 (0.033)		
Avg. applied import tariff rate							-0.141 (0.339)	
Control of corruption							0.062 (0.046)	
FDI × Capital								-2.878** (1.366)
Constant	-0.291 (0.496)	-0.720*** (0.058)	-1.000*** (0.185)	-1.130*** (0.151)	-0.211 (0.530)	0.363 (0.660)	-0.395 (0.838)	-0.169 (0.472)
Obs.	178	238	238	238	178	187	173	178
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Pseudo R-sq	0.023	0.017	0.016	0.020	0.023	0.026	0.025	0.024

Note: fractional probit estimation results. Standard errors clustered by country are in parentheses. All explanatory variables are lagged by one period. \*, \*\*, \*\*\* indicate statistical significance at 10%, 5% and 1% levels respectively.

**Table A2 / Additional regressions, forward GVC participation.**

Dep. var.: GVC_FWI	1	2	3	4	5	6	7	8
Outward FDI stock, share of GDP	0.255* (0.132)	-0.038 (0.149)		-0.088 (0.153)	0.247* (0.130)	0.017 (0.153)	-0.091 (0.187)	0.276* (0.143)
Real capital stock, share of GDP	-0.068*** (0.023)		-0.023 (0.038)	-0.029 (0.035)	-0.065*** (0.023)	-0.068*** (0.025)	-0.098*** (0.028)	-0.068*** (0.023)
REER, log diff	-0.092 (0.122)				-0.089 (0.115)	0.025 (0.110)	-0.143 (0.114)	-0.098 (0.119)
Real GDP, log	0.008 (0.017)				0.010 (0.017)	-0.000 (0.019)	-0.029** (0.012)	0.010 (0.018)
Labour productivity, log	-0.194*** (0.066)				-0.187*** (0.067)			-0.200*** (0.068)
Manuf. value added, % of GDP	0.005 (0.003)				0.004 (0.003)		0.004 (0.005)	0.005 (0.003)
Real GDP growth					0.003 (0.003)			
Real GDP per capita						-0.083 (0.060)		
Real GDP per capita ^ 2						0.028 (0.024)		
Avg. applied import tariff rate							0.151 (0.231)	
Control of corruption							-0.032 (0.039)	
FDI × Capital								0.493 (0.496)
Constant	-0.091 (0.356)	-0.698*** (0.030)	-0.626*** (0.131)	-0.589*** (0.126)	-0.159 (0.370)	-0.439 (0.582)	0.115 (0.470)	-0.108 (0.363)
Obs.	178	240	240	240	178	187	173	178
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Pseudo R-sq	0.002	0.001	0.001	0.001	0.002	0.002	0.002	0.002

Note: fractional probit estimation results. Standard errors clustered by country are in parentheses. All explanatory variables are lagged by one period. \*, \*\*, \*\*\* indicate statistical significance at 10%, 5% and 1% levels respectively.

**Table A3 / Alternative estimators, backward GVC participation.**

	Frac probit	Frac logit	Mundlak CRE	2-st. endog	2-st. endog	FE	RE	POLS
	1	2	3	4	5	6	7	8
Inward FDI stock, share of GDP	0.465*	0.754*	0.016	-0.071	0.582*	0.080	0.023	0.748
	(0.252)	(0.428)	(0.158)	(0.184)	(0.350)	(0.284)	(0.230)	(0.429)
Real capital stock, share of GDP	0.135***	0.220***	-0.059	-0.048	0.143***	-0.076	0.154**	0.227***
	(0.024)	(0.041)	(0.046)	(0.047)	(0.022)	(0.088)	(0.073)	(0.044)
REER, log diff	0.026	0.062	-0.236***	-0.165***	-0.022	-0.370***	-0.534***	0.032
	(0.104)	(0.175)	(0.072)	(0.061)	(0.083)	(0.112)	(0.135)	(0.190)
Real GDP, log	-0.058**	-0.098***	-0.807***	-0.773***	-0.074***	-1.267***	-0.169***	-0.099**
	(0.023)	(0.038)	(0.171)	(0.185)	(0.023)	(0.298)	(0.049)	(0.040)
Labour productivity, log	0.175**	0.288**	0.600***	0.506***	0.196**	0.849***	0.267***	0.299*
	(0.082)	(0.138)	(0.156)	(0.168)	(0.080)	(0.220)	(0.092)	(0.145)
Manuf. value added, % of GDP	0.010	0.017	-0.011***	-0.008**	0.012*	-0.014*	0.004	0.016
	(0.007)	(0.011)	(0.004)	(0.003)	(0.007)	(0.007)	(0.015)	(0.012)
TA (Inward FDI stock, share of GDP)			0.657***					
			(0.139)					
TA (Real capital stock, share of GDP)			0.056***					
			(0.019)					
TA (REER, log diff)			11.784***					
			(1.528)					
TA (Real GDP, log)			-0.065***					
			(0.008)					
TA (Labour productivity, log)			0.227***					
			(0.024)					
TA (Manuf. value added, % of GDP)			0.006***					
			(0.002)					
Constant	-0.291	-0.396	-0.053	18.511***	0.098	30.762***	2.166	-0.453
	(0.496)	(0.830)	(0.205)	(4.568)	(0.507)	(7.581)	(1.361)	(0.861)
Obs.	178	178	178	166	166	178	178	178
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	No	No	No	Yes	No	Yes	No	No

Note: the table shows results from the fractional probit (baseline), fractional logit, Mundlak-Chamberlain correlated random effects, 2-stage endogeneous regressor models with and without country fixed effects, panel fixed effects, random effects and pooled OLS (the latter three models employ a logistically transformed GVC variable). In model 3: TA indicates panel time averages, variables enter the model as deviations from the respective panel means. Standard errors clustered by country are in parentheses. All explanatory variables are lagged by one period. \*, \*\*, \*\*\* indicate statistical significance at 10%, 5% and 1% levels respectively.

**Table A4 / Alternative estimators, forward GVC participation.**

	Frac probit	Frac logit	Mundlak CRE	2-st. endog	2-st. endog	FE	RE	POLS
	1	2	3	4	5	6	7	8
Outward FDI stock, share of GDP	0.255* (0.132)	0.436* (0.225)	-0.070 (0.080)	0.030 (0.111)	0.221 (0.218)	-0.071 (0.132)	-0.049 (0.128)	0.425 (0.248)
Real capital stock, share of GDP	-0.068*** (0.023)	-0.116*** (0.039)	0.060 (0.041)	0.075** (0.035)	-0.081*** (0.022)	0.104 (0.073)	-0.010 (0.058)	-0.118** (0.041)
REER, log diff	-0.092 (0.122)	-0.158 (0.209)	0.054 (0.054)	0.002 (0.052)	-0.123 (0.093)	0.060 (0.093)	0.149* (0.077)	-0.177 (0.229)
Real GDP, log	0.008 (0.017)	0.014 (0.030)	0.414*** (0.147)	0.488*** (0.122)	-0.001 (0.015)	0.746*** (0.228)	0.069** (0.030)	0.016 (0.032)
Labour productivity, log	-0.194*** (0.066)	-0.330*** (0.113)	-0.431*** (0.095)	-0.478*** (0.109)	-0.128*** (0.049)	-0.829*** (0.149)	-0.277*** (0.073)	-0.336** (0.122)
Manuf. value added, % of GDP	0.005 (0.003)	0.008 (0.006)	-0.004 (0.003)	-0.004 (0.003)	0.004 (0.003)	-0.005 (0.005)	-0.009** (0.004)	0.008 (0.006)
TA (Outward FDI stock, share of GDP)			-0.097 (0.181)					
TA (Real capital stock, share of GDP)			-0.039** (0.017)					
TA (REER, log diff)			-9.354*** (2.045)					
TA (Real GDP, log)			0.003 (0.009)					
TA (Labour productivity, log)			-0.164*** (0.042)					
TA (Manuf. value added, % of GDP)			0.009*** (0.003)					
Constant	-0.091 (0.356)	-0.097 (0.611)	-0.130 (0.248)	-12.015*** (2.967)	0.035 (0.344)	-18.552*** (5.801)	-1.806** (0.769)	-0.145 (0.661)
Obs.	178	178	178	166	166	178	178	178
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	No	No	No	Yes	No	Yes	No	No

Note: the table shows results from the fractional probit (baseline), fractional logit, Mundlak-Chamberlain correlated random effects, 2-stage endogeneous regressor models with and without country fixed effects, panel fixed effects, random effects and pooled OLS (the latter three models employ a logistically transformed GVC variable). In model 3: TA indicates panel time averages, variables enter the model as deviations from the respective panel means. Standard errors clustered by country are in parentheses. All explanatory variables are lagged by one period. \*, \*\*, \*\*\* indicate statistical significance at 10%, 5% and 1% levels respectively.



**Table A5 / Sensitivity of FDI and capital variables, backward GVC participation.**

	Backward GVC participation					Forward GVC participation				
	1	2	3	4	5	6	7	8	9	10
Inward FDI / GDP	0.738*** (0.229)	0.465* (0.252)			0.559* (0.339)	-0.139 (0.160)	0.062 (0.181)			
Outward FDI / GDP	-0.493*** (0.185)		-0.017 (0.205)			0.346*** (0.111)		0.255* (0.132)		0.373*** (0.136)
Real capital / GDP	0.110*** (0.021)	0.135*** (0.024)	0.143*** (0.021)	0.144*** (0.023)		-0.062*** (0.024)	-0.081*** (0.024)	-0.068*** (0.023)	-0.080*** (0.023)	
REER, log diff	-0.096 (0.114)	0.026 (0.104)	0.057 (0.158)	0.061 (0.152)	0.113 (0.124)	-0.063 (0.100)	-0.154 (0.113)	-0.092 (0.122)	-0.150 (0.116)	-0.108 (0.128)
Real GDP, log	-0.068*** (0.020)	-0.058** (0.023)	-0.074*** (0.027)	-0.073*** (0.025)	-0.082*** (0.030)	0.007 (0.016)	0.001 (0.018)	0.008 (0.017)	-0.001 (0.016)	0.025 (0.019)
Labour productivity, log	0.276*** (0.087)	0.175** (0.082)	0.206* (0.113)	0.202** (0.087)	0.107 (0.092)	-0.207*** (0.061)	-0.137** (0.055)	-0.194*** (0.066)	-0.133** (0.053)	-0.193*** (0.070)
Manuf. VA, % of GDP	0.008 (0.006)	0.010 (0.007)	0.012 (0.009)	0.012 (0.008)	0.018** (0.007)	0.005 (0.003)	0.004 (0.004)	0.005 (0.003)	0.004 (0.003)	0.001 (0.003)
Constant	-0.244 (0.433)	-0.291 (0.496)	0.070 (0.584)	0.061 (0.583)	0.932 (0.611)	-0.032 (0.338)	0.004 (0.366)	-0.091 (0.356)	0.053 (0.331)	-0.759** (0.315)
Observations	178	178	178	178	178	178	178	178	178	178
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Pseudo R-sq.	0.024	0.023	0.023	0.023	0.022	0.002	0.002	0.002	0.002	0.002

Note: fractional probit estimation results. Standard errors clustered by country are in parentheses. All explanatory variables are lagged by one period. \*, \*\*, \*\*\* indicate statistical significance at 10%, 5% and 1% levels respectively.

**Table A6 / Impact of capital composition on backward GVC participation: estimates**

	1	2	3	4	5	6	7	8	9	10
Inward FDI / GDP	0.820** (0.347)	1.240*** (0.301)	1.106*** (0.381)	0.487 (0.335)	0.648** (0.324)	0.869* (0.513)	0.895** (0.382)	0.530 (0.484)	1.108*** (0.367)	1.066*** (0.389)
REER, log diff	0.084 (0.163)	0.170 (0.203)	0.203 (0.167)	0.225 (0.227)	0.117 (0.250)	0.266 (0.259)	0.256 (0.175)	0.346 (0.220)	0.238 (0.175)	0.102 (0.158)
Real GDP, log	-0.009 (0.035)	-0.046 (0.029)	-0.041 (0.031)	-0.047 (0.034)	-0.046 (0.035)	-0.048 (0.035)	-0.063* (0.037)	-0.057** (0.024)	-0.047 (0.034)	-0.053* (0.031)
Ocon	0.135** (0.066)									
RStruc		0.217** (0.101)								
TraEq			0.212 (0.528)							
OMach				0.500* (0.294)						
IT					7.320** (3.317)					
CT						-0.155 (2.440)				
Soft_DB							1.952 (2.045)			
RD								0.987 (0.679)		
Cult									-1.181 (2.017)	
OIPP										-6.082** (3.033)
Constant	-0.639 (1.044)	0.159 (0.829)	0.347 (0.899)	0.510 (0.982)	0.497 (0.996)	0.614 (1.011)	0.944 (1.028)	0.834 (0.694)	0.534 (0.965)	0.750 (0.893)
Obs.	198	198	198	177	166	166	187	177	198	186
Pseudo R-sq	0.022	0.022	0.020	0.024	0.018	0.017	0.022	0.025	0.020	0.023

Note: fractional probit estimation results by capital asset types (capital stock as a share of GDP). Standard errors clustered by country are in parentheses. All explanatory variables are lagged by one period. \*, \*\*, \*\*\* indicate statistical significance at 10%, 5% and 1% levels respectively.

**Table A7 / Impact of capital composition on forward GVC participation: estimates**

	1	2	3	4	5	6	7	8	9	10
Outward FDI / GDP	-0.170 (0.191)	-0.248 (0.156)	-0.148 (0.187)	-0.068 (0.161)	-0.077 (0.133)	-0.055 (0.191)	-0.104 (0.167)	0.084 (0.200)	-0.088 (0.179)	-0.134 (0.175)
REER, log diff	-0.261 (0.164)	-0.307* (0.157)	-0.264* (0.141)	-0.251 (0.171)	-0.130 (0.171)	-0.214 (0.182)	-0.279* (0.143)	-0.165 (0.150)	-0.257* (0.149)	-0.240* (0.139)
Real GDP, log	-0.011 (0.019)	0.009 (0.014)	-0.008 (0.015)	-0.007 (0.016)	-0.012 (0.011)	-0.010 (0.014)	-0.001 (0.016)	-0.014 (0.011)	-0.001 (0.016)	-0.000 (0.015)
Ocon	-0.044 (0.045)									
RStruc		-0.222*** (0.061)								
TraEq			-0.430 (0.428)							
OMach				0.178 (0.146)						
IT					-4.079* (2.397)					
CT						-0.051 (1.210)				
Soft_DB							-0.250 (0.959)			
RD								-0.434 (0.443)		
Cult									-1.024 (1.457)	
OIPP										2.268 (2.246)
Constant	-0.302 (0.581)	-0.573 (0.384)	-0.414 (0.417)	-0.566 (0.456)	-0.282 (0.297)	-0.417 (0.393)	-0.639 (0.429)	-0.289 (0.286)	-0.657 (0.431)	-0.683* (0.406)
Obs.	198	198	198	177	166	166	187	177	198	186
Pseudo R-sq	0.001	0.002	0.001	0.002	0.001	0.001	0.001	0.002	0.001	0.001

Note: fractional probit estimation results by capital asset types (capital stock as a share of GDP). Standard errors clustered by country are in parentheses. All explanatory variables are lagged by one period. \*, \*\*, \*\*\* indicate statistical significance at 10%, 5% and 1% levels respectively.

**Table A8 / Gravity model results for bilateral trade in value added: ICT vs non-ICT capital**

	PPML	PPML	PPML	FE	FE	FE	FE	FE	POLS
	1	2	3	4	5	6	7	8	9
FDI from exp. to imp., log	0.071*** (0.013)	0.075*** (0.022)	-0.002 (0.015)	0.099*** (0.009)	0.094*** (0.010)	0.023*** (0.005)	0.004 (0.007)	0.097*** (0.015)	0.100*** (0.018)
FDI from imp. to exp., log	0.053*** (0.012)	0.072*** (0.023)	-0.009 (0.022)	0.071*** (0.009)	0.073*** (0.010)	0.009 (0.006)	0.005 (0.007)	0.079*** (0.016)	0.127*** (0.013)
Exporter's real ICT capital, log		0.104 (0.095)	-0.003 (0.085)				-0.003 (0.040)	-0.090 (0.063)	0.041 (0.040)
Importer's real ICT capital, log		-0.037 (0.099)	-0.082 (0.091)				-0.000 (0.037)	-0.115** (0.050)	-0.204*** (0.027)
Exporter's real non-ICT capital, log		-0.578 (0.461)	-0.178 (0.447)				0.426* (0.226)	-0.065 (0.312)	0.283 (0.257)
Importer's real non-ICT capital, log		0.156* (0.087)	-0.023 (0.182)				-0.028 (0.101)	-0.020 (0.080)	-0.160 (0.140)
Exporter's real GDP, log	0.570*** (0.042)	0.781*** (0.217)	0.861*** (0.202)	0.561*** (0.053)		0.745*** (0.043)	0.939*** (0.102)	0.964*** (0.141)	0.467*** (0.164)
Importer's real GDP, log	0.607*** (0.069)	0.979*** (0.173)	1.095*** (0.143)	0.682*** (0.052)		0.881*** (0.045)	1.036*** (0.085)	0.884*** (0.117)	0.778*** (0.043)
Weighted distance, log	-0.439*** (0.030)	-0.660*** (0.091)		-0.645*** (0.044)	-0.648*** (0.048)			-0.906*** (0.072)	-0.787*** (0.075)
Common border	0.256*** (0.050)	0.095 (0.061)		0.376*** (0.063)	0.353*** (0.066)			0.227*** (0.082)	0.242** (0.119)
Common language	0.091 (0.075)	0.371*** (0.072)		0.002 (0.070)	-0.007 (0.074)			0.011 (0.132)	-0.014 (0.124)
Colonial relationship	-0.042 (0.074)	-0.054 (0.092)		-0.153** (0.073)	-0.136* (0.076)			-0.144 (0.093)	-0.341*** (0.121)
Common legal origin	0.149*** (0.046)	0.147*** (0.053)		0.119*** (0.037)	0.127*** (0.040)			0.194*** (0.064)	0.300*** (0.078)
Common currency	0.165*** (0.058)	0.254*** (0.073)		-0.042 (0.044)	-0.008 (0.048)			-0.029 (0.057)	-0.083 (0.060)
PTA	0.267*** (0.067)	-0.158 (0.205)		0.063 (0.057)	0.035 (0.076)			-0.025 (0.136)	-0.281 (0.192)
Constant	-21.5*** (2.384)	-28.7*** (7.162)	-40.1*** (6.683)	-22.5*** (2.096)	11.3*** (0.444)	-36.7*** (1.665)	-51.1*** (3.246)	-33.9*** (4.610)	-21.6*** (2.043)
Obs.	5,298	1,566	1,566	5,298	5,296	5,214	1,547	1,566	1,566
Adj. R-sq	0.951	0.982	0.993	0.952	0.953	0.992	0.996	0.978	0.956
Year fixed effects	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	No	Yes	No	No	No	Yes	No
Pair fixed effects	No	No	Yes	No	No	Yes	Yes	No	No
Country-year fixed effects	No	No	No	No	Yes	No	No	No	No

Note: the table shows the results of gravity model estimations with Poisson pseudo-maximum likelihood (PPML), fixed effects (FE) and pooled OLS (POLS). Dependent variable – trade in value added (in logs for FE model). FDI from exp. to imp., log denotes inward FDI stock from exporter to importer. FDI from imp. to exp., log denotes inward FDI stock from importer to exporter. FDI and capital stock variables are lagged by one period. Standard errors clustered by country pairs are in parentheses. \*, \*\*, \*\*\* indicate statistical significance at 10%, 5% and 1% levels respectively.

## Appendix B: Sectoral estimation results

**Table B1 / Pooled sectoral estimation results**

	All sectors (SEC 1-26)		Commodity sectors (SEC 1-2)		Manufacturing sectors (SEC 3-13)		High-tech manuf. (SEC 10-12)		Services sectors (SEC 14-26)	
	GVC_BWI_ GO	GVC_FWI_ GO	GVC_BWI_ GO	GVC_FWI_ GO	GVC_BWI_ GO	GVC_FWI_ GO	GVC_BWI_ GO	GVC_FWI_ GO	GVC_BWI_ GO	GVC_FWI_ GO
	1	2	3	4	5	6	7	8	9	10
Inward FDI / VA share of value added	0.043 (0.030)		0.098 (0.083)		0.071* (0.041)		0.208 (0.185)		-0.012 (0.042)	
Outward FDI / VA stock, share of value added		-0.002 (0.005)		-0.007 (0.011)		-0.001 (0.004)		-0.104 (0.097)		0.007 (0.010)
Capital / VA	0.000 (0.000)	0.001*** (0.000)	0.005 (0.013)	-0.003 (0.011)	0.000 (0.000)	0.000** (0.000)	0.127* (0.067)	0.047 (0.032)	-0.014 (0.024)	0.013 (0.009)
REER, log diff	-0.260 (0.193)	-0.105 (0.141)	-0.891 (0.553)	-1.028** (0.454)	0.585** (0.264)	0.369* (0.205)	0.504 (0.368)	-0.070 (0.319)	-0.275 (0.268)	-0.154 (0.111)
Labour prod., log	0.087 (0.055)	0.125*** (0.034)	-0.021 (0.069)	0.249*** (0.029)	0.030 (0.069)	0.061* (0.037)	0.023 (0.168)	0.166** (0.070)	0.293* (0.153)	0.044 (0.029)
Real GDP, log	-0.157*** (0.023)	-0.090*** (0.015)	-0.020 (0.038)	-0.062* (0.033)	-0.068*** (0.026)	-0.036** (0.015)	-0.061 (0.049)	-0.012 (0.027)	-0.196*** (0.043)	-0.073*** (0.014)
Constant	1.033* (0.581)	-0.366 (0.354)	-0.351 (0.929)	0.364 (0.000)	0.935 (0.000)	-0.226 (0.000)	0.907 (0.000)	-0.966 (0.000)	1.379 (0.966)	-0.600 (0.382)
Obs.	3,089	2,886	277	242	1,310	1,198	382	325	1,502	1,446
Pseudo R-sq	0.200	0.080	0.039	0.131	0.063	0.041	0.046	0.015	0.158	0.055

Note: the table shows fractional probit estimation results pooling all sectors, as well as by broad sector groups. All regressions include industry fixed effects and year fixed effects. Standard errors clustered by country-sectors are in parentheses. All explanatory variables are lagged by one period. \*, \*\*, \*\*\* indicate statistical significance at 10%, 5% and 1% levels respectively.

**Table B2 / Backward GVC participation: sectoral analysis**

dep.var.: GVC_BWI_GO	(1) 1 AGRI	(2) 2 MING	(3) 3 FOOD	(4) 4 TXTL	(5) 5 WOOD	(6) 6 COKE	(7) 7 CHEM	(8) 8 RUBB	(9) 9 METL	(10) 10 ELEC	(11) 11 MACH	(12) 12 TRAN	(13) 13 OMAN
Inward FDI stock, share of value added	5.481*** (2.015)	0.120** (0.060)	-0.156*** (0.022)	1.715*** (0.654)	0.017 (0.022)	-0.012 (0.030)	0.275*** (0.056)	-0.100 (0.235)	-0.006 (0.160)	0.396 (0.394)	0.117 (0.294)	0.195 (0.161)	-0.128 (0.121)
Real capital stock, share of value added	0.022 (0.027)	0.026 (0.027)	0.328*** (0.051)	0.574*** (0.075)	0.260*** (0.036)	0.000 (0.000)	0.117*** (0.030)	0.290*** (0.039)	0.229*** (0.037)	0.047 (0.049)	0.223 (0.156)	0.281*** (0.080)	0.238* (0.136)
REER, log diff	-0.045 (0.238)	-1.440* (0.859)	-0.271 (0.449)	-0.324 (0.772)	-0.104 (0.141)	0.228 (0.697)	-0.271 (0.368)	-0.630** (0.279)	-0.420** (0.178)	0.060 (0.397)	-0.853*** (0.223)	-0.290 (0.388)	-0.875*** (0.301)
Labour productivity, log	0.255** (0.122)	0.016 (0.052)	0.788*** (0.090)	1.508*** (0.217)	0.491*** (0.015)	0.007 (0.043)	0.486*** (0.044)	0.719*** (0.125)	0.379*** (0.056)	-0.233 (0.143)	0.269 (0.214)	0.855*** (0.108)	0.396*** (0.114)
Real GDP, log	-0.137*** (0.037)	0.103*** (0.031)	-0.111* (0.065)	-0.232** (0.090)	-0.097*** (0.026)	-0.088*** (0.016)	-0.120*** (0.017)	-0.022 (0.026)	-0.134*** (0.022)	-0.115 (0.072)	0.003 (0.072)	-0.231*** (0.084)	-0.187*** (0.047)
Manuf. value added, % of GDP	-0.016 (0.024)	0.050*** (0.017)	0.029** (0.013)	0.002 (0.019)	0.040*** (0.003)	-0.026** (0.011)	0.050*** (0.004)	0.057*** (0.004)	0.030*** (0.004)	0.020 (0.018)	0.033* (0.019)	0.028 (0.017)	0.026** (0.011)
Constant	1.309 (0.922)	-5.156*** (1.137)	-2.288 (1.940)	-0.303 (2.230)	-1.466* (0.822)	2.295*** (0.417)	-0.749 (0.601)	-4.560*** (0.975)	0.422 (0.627)	3.149* (1.859)	-2.728 (2.779)	1.102 (2.107)	1.383 (1.286)
Obs.	127	150	135	113	113	81	128	102	139	129	140	113	117
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Pseudo R-sq	0.027	0.039	0.082	0.084	0.067	0.036	0.050	0.062	0.041	0.084	0.047	0.087	0.049

dep.var.: GVC_BWI_GO	(14) 14 WATR	(15) 15 CONS	(16) 16 TRMO	(17) 17 WHTR	(18) 18 RETR	(19) 19 TRSR	(20) 20 POST	(21) 21 ACCO	(22) 22 INFO	(23) 23 FINA	(24) 24 REAL	(25) 25 PROF	(26) 26 SOCI
Inward FDI stock, share of value added	-0.275** (0.123)	3.584*** (1.125)	-0.190 (0.327)	0.803* (0.487)	0.783 (0.707)	0.411 (0.380)	0.108** (0.048)	0.396 (0.784)	0.035 (0.086)	0.080 (0.070)	0.683 (0.638)	0.012 (0.029)	1.367 (1.538)
Real capital stock, share of value added	0.038 (0.033)	-0.124*** (0.045)	0.499*** (0.093)	-0.223 (0.154)	0.052 (0.087)	0.027 (0.020)	-0.077 (0.071)	0.235 (0.188)	0.123*** (0.032)	-0.111 (0.125)	-0.027 (0.046)	0.041 (0.071)	-0.005 (0.037)
REER, log diff	-0.453 (0.331)	-0.858*** (0.320)	0.119 (0.369)	-0.184 (0.165)	-0.204* (0.110)	-0.330 (0.210)	0.016 (0.243)	-0.195 (0.315)	-0.199 (0.195)	0.232 (0.368)	-1.294 (0.821)	-0.321* (0.180)	-0.656 (0.440)
Labour productivity, log	0.138 (0.156)	0.196* (0.112)	0.386** (0.175)	0.066 (0.058)	0.464** (0.234)	0.591*** (0.052)	-0.774*** (0.128)	0.169 (0.194)	0.165* (0.089)	-0.066 (0.193)	-0.291** (0.118)	-0.486** (0.229)	-0.301 (0.206)
Real GDP, log	-0.138*** (0.046)	-0.140** (0.061)	0.136 (0.095)	-0.168*** (0.065)	-0.740*** (0.074)	-0.423*** (0.046)	0.176 (0.610)	0.179*** (0.064)	-0.145*** (0.024)	-0.018 (0.042)	0.053 (0.100)	-0.234*** (0.050)	-0.023 (0.053)
Manuf. value added, % of GDP	0.038*** (0.012)	0.075*** (0.017)	0.022* (0.012)	-0.021 (0.014)	0.058*** (0.017)	-0.080*** (0.006)	0.006 (0.013)	0.063*** (0.019)	0.015* (0.008)	0.017 (0.016)	-0.017 (0.017)	-0.000 (0.011)	-0.005 (0.012)
Constant	0.378 (1.222)	-1.037 (1.803)	-7.939*** (2.335)	2.725 (1.904)	15.305*** (1.222)	9.044*** (1.290)	-4.810 (17.916)	-9.496*** (2.448)	0.854 (0.748)	-2.034 (1.455)	-2.224 (2.832)	6.195*** (2.043)	-1.309 (1.561)
Obs.	145	141	79	78	78	81	32	133	158	155	150	135	137
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Pseudo R-sq	0.036	0.074	0.065	0.052	0.101	0.197	0.041	0.050	0.033	0.032	0.209	0.028	0.016

Note: fractional probit estimation results. Standard errors clustered by country are in parentheses. All explanatory variables are lagged by one period. \*, \*\*, \*\*\* indicate statistical significance at 10%, 5% and 1% levels respectively. Dependent variable: GVC BWI based on gross output (GVC\_BWI\_GO). Sectors are denoted by labels as outlined in Table 2.2.

**Table B3 / Forward GVC participation: sectoral analysis**

dep.var.: GVC_FWI_GO	(1) 1 AGRI	(2) 2 MING	(3) 3 FOOD	(4) 4 TXTL	(5) 5 WOOD	(6) 6 COKE	(7) 7 CHEM	(8) 8 RUBB	(9) 9 METL	(10) 10 ELEC	(11) 11 MACH	(12) 12 TRAN	(13) 13 OMAN
Outward FDI stock, share of value added	-0.741 (1.111)	-0.007 (0.013)	0.028 (0.073)	0.086 (0.079)	-0.028* (0.016)	-0.007*** (0.002)	0.121*** (0.038)	-0.071 (0.052)	0.111** (0.049)	0.344*** (0.113)	0.198*** (0.072)	0.182** (0.091)	0.062** (0.027)
Real capital stock, share of value added	0.021*** (0.004)	-0.009 (0.014)	0.106* (0.063)	-0.079** (0.037)	0.147*** (0.040)	-0.000 (0.000)	0.053** (0.021)	0.031 (0.072)	0.101*** (0.027)	0.061*** (0.011)	0.168*** (0.051)	0.103*** (0.018)	-0.131* (0.069)
REER, log diff	-0.546*** (0.167)	-1.098* (0.610)	-0.628*** (0.158)	0.010 (0.252)	0.034 (0.199)	1.369 (1.263)	-1.045*** (0.332)	-0.199* (0.116)	-0.073 (0.207)	-0.181 (0.316)	-0.044 (0.200)	0.134 (0.345)	-0.837*** (0.235)
Labour productivity, log	0.126*** (0.018)	0.293*** (0.026)	0.033 (0.084)	0.073** (0.029)	0.224*** (0.021)	-0.010 (0.031)	0.202*** (0.034)	0.169 (0.139)	0.244*** (0.034)	0.271*** (0.030)	0.176*** (0.066)	0.293*** (0.068)	0.047 (0.066)
Real GDP, log	0.006 (0.019)	-0.063 (0.039)	-0.029 (0.043)	0.137*** (0.033)	0.081*** (0.027)	-0.018 (0.061)	-0.030 (0.032)	-0.025 (0.064)	-0.108*** (0.023)	0.002 (0.034)	0.071*** (0.022)	-0.276*** (0.066)	-0.046 (0.034)
Manuf. value added, % of GDP	0.056*** (0.005)	0.017*** (0.006)	0.015 (0.014)	0.062*** (0.004)	0.043*** (0.006)	0.005 (0.015)	0.034*** (0.006)	0.025* (0.014)	0.027*** (0.004)	0.024*** (0.008)	0.023*** (0.005)	0.014* (0.008)	0.037*** (0.009)
Constant	-3.462*** (0.643)	-0.391 (1.213)	-1.997* (1.129)	-6.651*** (1.076)	-5.666*** (0.859)	-1.323 (2.013)	-1.976** (0.856)	-1.728 (2.713)	0.288 (0.586)	-2.891*** (0.947)	-4.844*** (0.846)	4.445** (1.740)	-1.035 (0.927)
Obs.	101	141	133	102	108	76	121	95	128	108	123	94	110
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Pseudo R-sq	0.053	0.072	0.017	0.029	0.028	0.019	0.019	0.027	0.021	0.021	0.023	0.024	0.017

dep.var.: GVC_FWI_GO	(14) 14 WATR	(15) 15 CONS	(16) 16 TRMO	(17) 17 WHTR	(18) 18 RETR	(19) 19 TRSR	(20) 20 POST	(21) 21 ACCO	(22) 22 INFO	(23) 23 FINA	(24) 24 REAL	(25) 25 PROF	(26) 26 SOCI
Outward FDI stock, share of value added	-0.057* (0.031)	-0.410 (0.254)	0.131 (0.193)	-0.493 (0.359)	-2.166* (1.123)	-0.206*** (0.035)	-0.006 (0.016)	0.004 (0.363)	0.029 (0.033)	0.025 (0.033)	0.590** (0.265)	0.037 (0.027)	-1.635** (0.802)
Real capital stock, share of value added	0.022 (0.014)	-0.007 (0.018)	0.244*** (0.023)	0.151** (0.069)	0.466* (0.241)	-0.027 (0.020)	-0.110*** (0.032)	0.081 (0.108)	0.042 (0.029)	0.080* (0.046)	0.004 (0.007)	0.026 (0.055)	0.108* (0.059)
REER, log diff	-0.257** (0.126)	-0.268** (0.128)	-0.242 (0.225)	0.008 (0.312)	0.944* (0.501)	0.191 (0.142)	-0.420 (0.373)	-0.204 (0.318)	-0.499** (0.200)	-0.402** (0.196)	0.535 (0.376)	-0.373 (0.229)	-0.731** (0.342)
Labour productivity, log	0.252*** (0.065)	0.164*** (0.030)	0.314*** (0.022)	0.167*** (0.044)	0.220 (0.383)	-0.090*** (0.034)	0.148** (0.062)	0.241*** (0.056)	-0.093 (0.131)	0.030 (0.064)	0.148** (0.058)	0.135*** (0.039)	0.505* (0.277)
Real GDP, log	-0.074*** (0.018)	-0.073*** (0.022)	-0.010 (0.030)	-0.022*** (0.008)	0.530*** (0.079)	-0.202*** (0.009)	-0.140*** (0.039)	0.192 (0.123)	-0.026** (0.011)	-0.019 (0.030)	-0.104*** (0.026)	-0.013 (0.016)	-0.004 (0.029)
Manuf. value added, % of GDP	0.017*** (0.004)	0.010*** (0.002)	0.040*** (0.006)	0.025*** (0.002)	0.152*** (0.042)	0.010** (0.005)	-0.017 (0.012)	0.073*** (0.016)	0.012* (0.007)	0.010 (0.007)	0.023** (0.010)	0.024*** (0.009)	0.007 (0.008)
Constant	-1.042*** (0.332)	-0.890 (0.602)	-3.170*** (0.836)	-2.095*** (0.284)	-19.465*** (3.633)	4.137*** (0.225)	2.104* (1.243)	-10.004*** (3.846)	-0.749 (0.636)	-1.512 (0.992)	-0.451 (0.887)	-2.033*** (0.552)	-4.568*** (1.582)
Obs.	133	143	65	62	64	79	28	122	149	156	154	153	138
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Pseudo R-sq	0.024	0.026	0.042	0.015	0.051	0.010	0.007	0.026	0.015	0.008	0.019	0.010	0.009

Note: fractional probit estimation results. Standard errors clustered by country are in parentheses. All explanatory variables are lagged by one period. \*, \*\*, \*\*\* indicate statistical significance at 10%, 5% and 1% levels respectively. Dependent variable: GVC FWI based on gross output (GVC\_FWI\_GO). Sectors are denoted by labels as outlined in Table 2.2.

## Appendix C: Summary statistics

**Table C1 / Country-level summary statistics for main variables used in fractional probit regressions**

Variable	Obs.	Mean	St.dev.	Min	Max
Backward GVC participation, GVC_BWI	261	0.31	0.08	0.17	0.52
Forward GVC participation, GVC_FWI	261	0.23	0.03	0.15	0.29
Total GVC participation, GVC_TI	261	0.54	0.08	0.39	0.72
Relative GVC participation (forward relative to backward GVC participation)	261	-0.06	0.08	-0.26	0.08
Backward GVC participation (based on gross output), GVC_BWI_GO	261	0.07	0.04	0.01	0.21
Forward GVC participation (based on gross output), GVC_FWI_GO	261	0.05	0.02	0.02	0.09
Total GVC participation (based on gross output), GVC_TI_GO	261	0.12	0.06	0.03	0.29
Inward FDI stock, share of GDP	261	0.24	0.11	0.06	0.66
Outward FDI stock, share of GDP	261	0.17	0.15	0	0.69
Inward FDI stock, share of value added	258	0.27	0.13	0.06	0.76
Outward FDI stock, share of value added	258	0.19	0.16	0	0.77
Real capital stock, share of GDP	261	3.24	0.77	1.44	5.16
Real capital stock, share of value added	258	3.67	0.85	1.64	5.73
Real effective exchange rate index (2010 = 100), log diff	206	0.01	0.04	-0.13	0.14
Real GDP (constant 2010 USD), log	261	26.41	1.61	23.37	28.92
Labour productivity (gross value added in USD per hour worked), in 2010 prices, log	250	3.42	0.6	2.07	4.3
Manufacturing, value added (% of GDP)	261	15.77	4.12	7.24	24.19
Real GDP growth, annual %	261	2.15	3.89	-14.81	11.89
GDP per capita, PPP (constant 2011 international \$) , log	261	10.3	0.32	9.32	10.74
Research and development expenditure (% of GDP)	257	1.64	0.94	0.36	3.91
Average applied import tariff rate, %	261	2.52	0.51	2.09	4.22
WGI Control of Corruption index	244	1.1	0.79	-0.19	2.47



**Table C2 / Sector-level summary statistics for selected variables used in fractional probit regressions**

Variable	SEC	Obs.	Mean	St.dev.	Min	Max	SEC	Obs.	Mean	St.dev.	Min	Max	SEC	Obs.	Mean	St.dev.	Min	Max
Backward GVC participation (based on gross output), GVC_BWI_GO	1	210	0.03	0.03	0.01	0.18	2	225	0.06	0.05	0.01	0.4	3	161	0.06	0.05	0	0.28
Forward GVC participation (based on gross output), GVC_FWI_GO		210	0.05	0.03	0.01	0.13		225	0.18	0.1	0.04	0.52		161	0.01	0	0	0.02
Total GVC participation (based on gross output), GVC_TI_GO		210	0.08	0.05	0.02	0.29		225	0.24	0.13	0.05	0.65		161	0.07	0.05	0	0.29
Inward FDI stock, share of value added		207	0.03	0.05	0	0.41		222	0.42	0.41	0	2.4		161	0.5	0.58	0.04	3.13
Outward FDI stock, share of value added		169	0.01	0.01	0	0.08		204	1.46	3.05	0	22.09		158	0.51	0.79	0	4.47
Real capital stock, share of value added		207	4.99	2.56	0.97	12.74		222	3.48	2.54	0.65	14.06		161	2.01	0.89	0.59	4.8
Backward GVC participation (based on gross output), GVC_BWI_GO	4	143	0.23	0.14	0	0.49	5	141	0.08	0.05	0.01	0.18	6	110	0.21	0.11	0.05	0.52
Forward GVC participation (based on gross output), GVC_FWI_GO		143	0.08	0.04	0.01	0.15		141	0.06	0.03	0.01	0.11		110	0.03	0.02	0.01	0.08
Total GVC participation (based on gross output), GVC_TI_GO		143	0.31	0.16	0.01	0.57		141	0.14	0.08	0.02	0.29		110	0.24	0.12	0.07	0.59
Inward FDI stock, share of value added		143	0.13	0.11	0	0.55		141	0.32	0.36	0	1.87		109	1.31	1.42	0	6.49
Outward FDI stock, share of value added		121	0.14	0.24	0	1.5		126	0.27	0.62	0	3.96		85	1.95	7.75	0	53.94
Real capital stock, share of value added		143	1.71	0.84	0.75	3.49		141	2.22	0.87	0.66	5.22		110	41.28	176	0.27	1572
Backward GVC participation (based on gross output), GVC_BWI_GO	7	150	0.19	0.09	0.03	0.46	8	130	0.11	0.07	0.01	0.27	9	164	0.15	0.07	0.05	0.35
Forward GVC participation (based on gross output), GVC_FWI_GO		150	0.1	0.04	0.02	0.17		130	0.08	0.03	0.02	0.16		164	0.11	0.04	0.04	0.23
Total GVC participation (based on gross output), GVC_TI_GO		150	0.29	0.12	0.05	0.59		130	0.19	0.09	0.03	0.42		164	0.26	0.11	0.1	0.55
Inward FDI stock, share of value added		150	0.57	0.25	0.05	1.28		130	0.14	0.1	0	0.41		164	0.22	0.18	0.01	0.72
Outward FDI stock, share of value added		144	0.55	0.61	0	4.15		111	0.12	0.14	0	0.64		152	0.22	0.27	0	1.28
Real capital stock, share of value added		150	2.58	1.55	1.11	9.77		130	2.08	0.98	1	5.49		164	1.78	0.59	0.87	3.67
Backward GVC participation (based on gross output), GVC_BWI_GO	10	153	0.26	0.15	0.03	0.69	11	163	0.2	0.1	0.02	0.47	12	141	0.26	0.14	0.03	0.53
Forward GVC participation (based on gross output), GVC_FWI_GO		153	0.09	0.03	0.03	0.17		163	0.07	0.03	0.01	0.15		141	0.06	0.02	0.02	0.13
Total GVC participation (based on gross output), GVC_TI_GO		153	0.35	0.16	0.05	0.75		163	0.27	0.13	0.03	0.59		141	0.32	0.15	0.06	0.61
Inward FDI stock, share of value added		153	0.23	0.23	0.01	1.2		163	0.31	0.2	0	0.81		141	0.37	0.35	0	1.72
Outward FDI stock, share of value added		127	0.24	0.4	0	2.34		145	0.33	0.38	0	2.15		117	0.3	0.38	0	1.58
Real capital stock, share of value added		153	2.39	1.84	0.54	16.58		163	1.5	0.89	0.62	5.46		141	2.43	1.1	0.53	6.12

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Table C2 / cont.

Variable	SEC	Obs.	Mean	St.dev.	Min	Max	SEC	Obs.	Mean	St.dev.	Min	Max	SEC	Obs.	Mean	St.dev.	Min	Max
Backward GVC participation (based on gross output), GVC_BWI_GO	13	132	0.09	0.05	0.01	0.23	14	184	0.02	0.02	0	0.09	15	219	0.01	0.01	0	0.04
Forward GVC participation (based on gross output), GVC_FWI_GO		132	0.05	0.02	0.01	0.09		184	0.06	0.03	0.02	0.12		225	0.01	0.01	0	0.03
Total GVC participation (based on gross output), GVC_TI_GO		132	0.14	0.07	0.02	0.28		184	0.08	0.04	0.02	0.21		225	0.02	0.01	0	0.05
Inward FDI stock, share of value added		132	0.71	0.63	0.02	4.35		184	0.32	0.38	0	1.54		222	0.05	0.05	0	0.23
Outward FDI stock, share of value added		125	0.81	1.2	0	9.15		174	0.21	0.29	0	1.18		213	0.04	0.06	0	0.41
Real capital stock, share of value added		132	1.19	0.46	0.46	2.42		184	6.33	2.71	2.75	17.2		222	1.23	1.14	0.25	6.69
Backward GVC participation (based on gross output), GVC_BWI_GO	16	104	0.01	0.01	0	0.04	17	104	0.03	0.02	0	0.09	18	104	0.01	0.01	0	0.04
Forward GVC participation (based on gross output), GVC_FWI_GO		104	0.05	0.02	0.01	0.11		104	0.08	0.02	0.02	0.13		104	0.04	0.03	0	0.09
Total GVC participation (based on gross output), GVC_TI_GO		104	0.06	0.03	0.01	0.13		104	0.11	0.04	0.02	0.18		104	0.04	0.04	0	0.12
Inward FDI stock, share of value added		104	0.18	0.12	0.02	0.6		104	0.33	0.15	0.06	0.85		104	0.16	0.12	0.02	0.48
Outward FDI stock, share of value added		90	0.09	0.09	0	0.32		89	0.18	0.13	0.02	0.47		90	0.13	0.12	0	0.52
Real capital stock, share of value added		104	1.06	0.48	0.28	2.57		104	0.98	0.29	0.43	1.76		104	1.36	0.4	0.8	2.34
Backward GVC participation (based on gross output), GVC_BWI_GO	19	109	0.1	0.12	0.01	0.45	20	56	0.01	0	0	0.02	21	215	0.01	0.01	0	0.03
Forward GVC participation (based on gross output), GVC_FWI_GO		109	0.08	0.02	0.03	0.13		56	0.06	0.01	0.03	0.08		222	0.01	0.01	0	0.04
Total GVC participation (based on gross output), GVC_TI_GO		109	0.17	0.13	0.05	0.52		56	0.07	0.02	0.04	0.1		222	0.02	0.01	0	0.07
Inward FDI stock, share of value added		109	0.09	0.11	0	0.44		56	0.67	1.13	0	3.75		219	0.09	0.1	0	0.81
Outward FDI stock, share of value added		107	0.11	0.22	0	1.2		43	1.37	3.68	0	16.65		186	0.05	0.11	0	0.85
Real capital stock, share of value added		109	4.46	1.66	1.76	9.04		56	0.92	0.66	0.16	3.1		219	1.65	0.73	0.58	4.36
Backward GVC participation (based on gross output), GVC_BWI_GO	22	241	0.02	0.01	0	0.07	23	232	0.01	0.01	0	0.05	24	234	0	0	0	0.04
Forward GVC participation (based on gross output), GVC_FWI_GO		241	0.04	0.02	0.01	0.1		232	0.05	0.02	0.02	0.09		243	0.02	0.01	0	0.08
Total GVC participation (based on gross output), GVC_TI_GO		241	0.06	0.03	0.01	0.15		232	0.05	0.02	0.02	0.11		243	0.02	0.01	0	0.11
Inward FDI stock, share of value added		238	0.36	0.34	0	2.65		229	1.39	1.02	0	8.23		240	0.17	0.19	0	1.07
Outward FDI stock, share of value added		230	0.2	0.39	0	3.82		226	1	0.83	0	3.79		236	0.04	0.06	0	0.29
Real capital stock, share of value added		238	2.26	1.09	0.78	5.82		229	1.03	0.46	0.33	2.61		240	15.55	3.34	7.7	22.89

ctd.

**Table C2 / cont.**

Variable	SEC	Obs.	Mean	St.dev.	Min	Max	SEC	Obs.	Mean	St.dev.	Min	Max	SEC	Obs.	Mean	St.dev.	Min	Max
Backward GVC participation (based on gross output), GVC_BWI_GO	23	232	0.01	0.01	0	0.05	24	234	0	0	0	0.04	25	206	0.02	0.01	0	0.06
Forward GVC participation (based on gross output), GVC_FWI_GO		232	0.05	0.02	0.02	0.09		243	0.02	0.01	0	0.08		206	0.07	0.02	0.02	0.16
Total GVC participation (based on gross output), GVC_TI_GO		232	0.05	0.02	0.02	0.11		243	0.02	0.01	0	0.11		206	0.09	0.03	0.02	0.21
Inward FDI stock, share of value added		229	1.39	1.02	0	8.23		240	0.17	0.19	0	1.07		205	0.45	0.68	0	4.99
Outward FDI stock, share of value added		226	1	0.83	0	3.79		236	0.04	0.06	0	0.29		203	0.33	0.61	0	4.98
Real capital stock, share of value added		229	1.03	0.46	0.33	2.61		240	15.55	3.34	7.7	22.89		205	1.21	0.44	0.47	2.2
Backward GVC participation (based on gross output), GVC_BWI_GO	26	179	0	0	0	0	1-26	4210	0.08	0.11	0	0.69						
Forward GVC participation (based on gross output), GVC_FWI_GO		179	0.01	0	0	0.01		4232	0.06	0.05	0	0.52						
Total GVC participation (based on gross output), GVC_TI_GO		179	0.01	0	0	0.02		4232	0.13	0.14	0	0.75						
Inward FDI stock, share of value added		179	0.01	0.02	0	0.1		4209	0.36	0.58	0	8.23						
Outward FDI stock, share of value added		174	0.01	0.02	0	0.17		3845	0.38	1.53	0	53.94						
Real capital stock, share of value added		179	3.03	1.6	1.12	7.39		4210	4.1	29.2	0.16	1572						

**Table C3 / Composition of real capital stock by asset types across sectors (sample averages), shares of sector value added**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
	1 AGRI	2 MING	3 FOOD	4 TXTL	5 WOOD	6 COKE	7 CHEM	8 RUBB	9 METL	10_ELEC	11 MACH	12_TRAN	13_OMAN
OCon	3.36	2.26	0.98	0.87	0.87	28.17	0.97	0.88	0.71	0.61	0.59	0.69	0.53
RStruc	0.04	0.02	0	0	0	0.05	0	0	0	0	0	0	0
TraEq	0.26	0.07	0.06	0.04	0.06	0.22	0.04	0.07	0.05	0.03	0.04	0.05	0.04
OMach	1.09	1.01	0.86	0.64	1.2	15.68	1.02	0.93	0.91	0.71	0.56	0.97	0.4
IT	0.03	0.01	0.02	0.02	0.03	0.39	0.01	0.02	0.01	0.03	0.02	0.02	0.01
CT	0.01	0.02	0.02	0.02	0.04	0.22	0.02	0.02	0.02	0.02	0.01	0.03	0.01
Soft_DB	0.01	0.02	0.03	0.03	0.04	0.34	0.04	0.03	0.03	0.13	0.05	0.06	0.04
RD	0.01	0.07	0.06	0.09	0.05	1.01	0.57	0.13	0.1	0.9	0.28	0.7	0.17
Cult	0.37	0.01	0.04	0.01	0.01	0.15	0.02	0.04	0	0.08	0.01	0.05	0.01
OIPP	0	0.15	0	0	0	0.01	0.01	0	0	0	0	0	0

	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)
	14_WATR	15_CONS	16_TRMO	17_WHTR	18_RETR	19_TRSR	20_POST	21_ACCO	22_INFO	23_FINA	24_REAL	25_PROF	26_SOCI
OCon	5.1	0.73	0.64	0.56	0.89	3.01	0.53	1.3	1.37	0.77	1.57	0.44	2.5
RStruc	0.01	0.22	0	0	0	0	0	0.03	0	0.04	13.93	0.18	0.07
TraEq	0.07	0.11	0.22	0.1	0.07	1.06	0.11	0.03	0.04	0.05	0.05	0.19	0.06
OMach	1.18	0.19	0.17	0.22	0.33	0.4	0.16	0.28	0.34	0.08	0.05	0.21	0.28
IT	0.02	0.01	0.01	0.02	0.02	0.02	0.01	0.01	0.04	0.03	0.01	0.03	0.02
CT	0.06	0	0.01	0.01	0.01	0.02	0.03	0.02	0.25	0.01	0.01	0.03	0.01
Soft_DB	0.04	0.01	0.02	0.04	0.04	0.03	0.04	0.01	0.18	0.12	0	0.04	0.02
RD	0.05	0.01	0.01	0.04	0	0	0.01	0	0.08	0.02	0	0.19	0.12
Cult	0.02	0	0.01	0.01	0.01	0.01	0.02	0.01	0	0	0	0	0.01
OIPP	0.01	0	0	0	0	0	0	0	0.12	0	0	0	0.01

**Table C4 / Composition of real capital stock by asset types across sectors (sample averages), shares of total real capital stock**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
	1_AGRI	2_MING	3_FOOD	4_TXTL	5_WOOD	6_COKE	7_CHEM	8_RUBB	9_METL	10_ELEC	11_MACH	12_TRAN	13_OMAN
OCon	64.86%	62.09%	47.34%	50.58%	37.83%	60.92%	35.93%	41.51%	38.80%	24.30%	37.82%	26.85%	43.80%
RStruc	0.77%	0.55%	0.00%	0.00%	0.00%	0.11%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
TraEq	5.02%	1.92%	2.90%	2.33%	2.61%	0.48%	1.48%	3.30%	2.73%	1.20%	2.56%	1.95%	3.31%
OMach	21.04%	27.75%	41.55%	37.21%	52.17%	33.91%	37.78%	43.87%	49.73%	28.29%	35.90%	37.74%	33.06%
IT	0.58%	0.27%	0.97%	1.16%	1.30%	0.84%	0.37%	0.94%	0.55%	1.20%	1.28%	0.78%	0.83%
CT	0.19%	0.55%	0.97%	1.16%	1.74%	0.48%	0.74%	0.94%	1.09%	0.80%	0.64%	1.17%	0.83%
Soft_DB	0.19%	0.55%	1.45%	1.74%	1.74%	0.74%	1.48%	1.42%	1.64%	5.18%	3.21%	2.33%	3.31%
RD	0.19%	1.92%	2.90%	5.23%	2.17%	2.18%	21.11%	6.13%	5.46%	35.86%	17.95%	27.24%	14.05%
Cult	7.14%	0.27%	1.93%	0.58%	0.43%	0.32%	0.74%	1.89%	0.00%	3.19%	0.64%	1.95%	0.83%
OIPP	0.00%	4.12%	0.00%	0.00%	0.00%	0.02%	0.37%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)
	14_WATR	15_CONS	16_TRMO	17_WHTR	18_RETR	19_TRSR	20_POST	21_ACCO	22_INFO	23_FINA	24_REAL	25_PROF	26_SOCI
OCon	77.74%	57.03%	58.72%	56.00%	64.96%	66.15%	58.24%	76.92%	56.61%	68.75%	10.05%	33.59%	80.65%
RStruc	0.15%	17.19%	0.00%	0.00%	0.00%	0.00%	0.00%	1.78%	0.00%	3.57%	89.18%	13.74%	2.26%
TraEq	1.07%	8.59%	20.18%	10.00%	5.11%	23.30%	12.09%	1.78%	1.65%	4.46%	0.32%	14.50%	1.94%
OMach	17.99%	14.84%	15.60%	22.00%	24.09%	8.79%	17.58%	16.57%	14.05%	7.14%	0.32%	16.03%	9.03%
IT	0.30%	0.78%	0.92%	2.00%	1.46%	0.44%	1.10%	0.59%	1.65%	2.68%	0.06%	2.29%	0.65%
CT	0.91%	0.00%	0.92%	1.00%	0.73%	0.44%	3.30%	1.18%	10.33%	0.89%	0.06%	2.29%	0.32%
Soft_DB	0.61%	0.78%	1.83%	4.00%	2.92%	0.66%	4.40%	0.59%	7.44%	10.71%	0.00%	3.05%	0.65%
RD	0.76%	0.78%	0.92%	4.00%	0.00%	0.00%	1.10%	0.00%	3.31%	1.79%	0.00%	14.50%	3.87%
Cult	0.30%	0.00%	0.92%	1.00%	0.73%	0.22%	2.20%	0.59%	0.00%	0.00%	0.00%	0.00%	0.32%
OIPP	0.15%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	4.96%	0.00%	0.00%	0.00%	0.32%

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