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Reading the footprints: how foreign investors shape countries' participation in global value chains

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Abstract

We show that traditional gravity variables play a significant role in explaining trade flows related to global value chain participation. We find evidence that cooperation costs – measured by linguistic and geographical proximity – are more relevant for trade that reflects cross-border production sharing. Applying an augmented gravity model framework to a newly-constructed dataset we find a positive association between bilateral FDI stock and both gross bilateral trade and the bilateral import-content of exports. We confirm this finding using an empirical case study on central and eastern European countries, which from a global perspective stand out both in terms of degree of global value chain-participation and size of inward FDI stock. Overall, we show that foreign investors play an active role in shaping host economies' export structure and their participation in international production networks. Policies that attract foreign direct investment would therefore constitute an indirect way to deepen a GVC-participation.

Keywords: global value chains, value added trade, foreign direct investment, gravity model

JEL Classification Numbers: F14, F15, F21, L22

Non-technical summary

The fragmentation of production processes – a firm's decision to outsource the production of inputs to an upstream supplier it may possibly own – has become the norm nowadays, induced and facilitated by trade liberalisation, declining transport costs and improving communication technologies. As a result, products often undergo several value-enhancing intermediate stages of transformation and combination with other inputs prior to becoming final. When these sequential stages are separated by national borders, production processes (value chains) acquire an international (regional or even global), trade-creating, dimension, often referred to as global value chains (GVC). Borders may indeed be crossed multiple times during such a process and both the final and the intermediate goods and services can consequently be regarded as "bundles" of multiple national and sectorial origins. Likewise, the mapping between the geographical location of a firm and its ownership has become blurred as a result of foreign direct investment (FDI) flows.

In this paper, we explore the link between FDI and countries' participation in GVC. Our empirical analysis uses an augmented gravity model framework and a newly constructed dataset combining GVC-related metrics and bilateral FDI for 40 developed and emerging economies.

We show that traditional gravity variables play a significant role in explaining GVC-related bilateral trade, as well as the bilateral import-content of exports. We also find some evidence that cooperation costs – measured by linguistic and geographical proximity – seem more relevant for trade flows that reflect production sharing. Further, we find a positive association between bilateral FDI stock on the one hand, and bilateral trade in both final and intermediate products, and the bilateral import-content of exports on the other. While we cannot formally distinguish between arm's-length trade and affiliate sales, our results postulate that a substantial share of trade occurs within multinational firms and results directly from international outsourcing. As such, the trade-generating effect of FDI in our country sample reflects in our view primarily intra-firm trade flows.

In this paper we also present an empirical case study on central and eastern European countries (CEEC), which from a global perspective stand out both in terms of their degree of GVC-participation and the size of the inward FDI stock relative to their GDP. From the late 1980s and early 1990s onwards, these formerly centrally planned economies rapidly transformed into market economies, while strengthening their institutional environment and opening up to international trade and capital flows. CEEC have since become very open economies exhibiting strong links to the economic core of the EU. Foreign investors and the establishment of cross-border production chains drove this interconnectedness. Our main result – the positive correlation between FDI stock and GVC participation – becomes stronger if CEEC stand on the recipient side of the investment relationship.

Overall, we show that foreign investors play an active role in shaping host economies' export structure and their participation in international production networks. Therefore, policies that attract foreign direct investment also constitute an indirect way to deepen countries' participation in GVC.

1 Introduction

The fragmentation of production processes – a firm's decision to outsource the production of inputs to an upstream supplier, whom it may possibly own – has become the norm nowadays, induced and facilitated by trade liberalisation, declining transport costs and improving communication technologies. As a result, products often undergo several value-enhancing intermediate stages of transformation and combination with other inputs prior to becoming final. When these sequential stages are separated by national borders, production processes (value chains) acquire an international (regional or even global), trade-creating, dimension, known as global value chains (GVC).[2] Borders may indeed be crossed multiple times during such a process and both the final and the intermediate goods and services can consequently be regarded as "bundles" of multiple national and sectorial origins.[3]

Likewise, the mapping between the geographical location of a firm and its ownership has become blurred as a result of cross-border capital flows and foreign direct investment. A firm's decision to expand its activities abroad may reflect a variety of motives, including gaining access to new markets or taking advantage of differences in production costs (see, among others, Brainard, 1997, and Helpman, 1984). The cross-border character of a production process thus provides *a priori* little indication as to the ownership of the different production units involved in it. Indeed, both the sourcing of inputs at arm's length or from foreign affiliates would be trade creating. Whereas the former would require a contractual agreement with a foreign supplier, a prerequisite for the latter is a vertical investment (either greenfield investment, or merger or acquisition). A firm's choice ultimately depends on various factors, including firm and sector characteristics, trade and monitoring costs and risks linked to incomplete contracts (see Antràs and Helpman, 2004).

In this paper, we explore the link between foreign direct investment and countries' participation in global value chains. Our empirical analysis uses an augmented gravity model framework applied to a newly constructed dataset combining GVC-related metrics and bilateral FDI stock for 40 developed and emerging economies. We show that traditional gravity variables play a significant role in explaining GVC-related bilateral trade, as well as the bilateral import-content of exports. We also find some evidence that cooperation costs – measured by linguistic and geographical proximity – are more relevant for trade that reflects production sharing. Further, we find a positive relationship between the bilateral FDI stock on the one hand, and bilateral trade in both final and intermediate products and the bilateral import-content of exports on the other. While we cannot formally distinguish between arm's-length trade and affiliate sales, our results are consistent with the hypothesis that a substantial share of trade occurs within multinational firms and is the direct result of international outsourcing.

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[2] The terms global value chains, global supply chains, international production chains, international/cross-border production-sharing are used interchangeably in the literature and in the present paper.

[3] In many cases, fragmenting the production process is unavoidable, notably when natural resources are involved (in that case exports are fully conditional on imports). But fragmentation and the blurring of the 'made in'-attribute have also become a reality for most other products, which are likely to contain (directly or indirectly) some fraction of foreign value added.

We further investigate the link between foreign investment and participation in supply chains by focussing on CEEC,[4] which from a global perspective stand out both in terms of their degree of GVC-participation and their high levels of inward FDI-stock. From the late 1980s and early 1990s onwards, these formerly centrally planned economies rapidly transformed into market economies, while strengthening their institutional environment and opening up to international trade and capital flows. CEEC have since become very open economies and established strong links to other EU countries. The establishment of cross-border production chains drove this interconnectedness, notably in the manufacturing sector, of which the automotive industry is often presented as the prime example (see IMF, 2013). As noted by Iossifov (2014), cross-border production sharing has recently also intensified within the CEEC region, following the setting up and subsequent expansion of regional industrial clusters. During the transition period, CEEC have recorded substantial inflows of FDI. Foreign investors in the region were attracted by the double prospect of developing an export-oriented production base and accessing new, potentially fast-growing, consumer markets. The region's favourable geographic position, an important industrial tradition, a skilled labour force, relatively low production costs and its catching-up potential were all catalysers for cross-border investment. The privatisation of a large share of the industrial assets early on in the transition process greatly facilitated the entry of foreign investors. Later on, the prospect of European Union membership and access to the Single Market, and in some cases also the adoption of the euro, further stimulated the inflow of foreign capital.

Our main finding – the positive association between FDI stocks and GVC participation – becomes stronger if CEEC stand on the recipient side of the investment relationship. Bilateral FDI can thus be positively associated with the bilateral foreign footprint in exports by CEEC. At the sector level, we find evidence that the FDI stock has a positive impact on import intensity of exports, as well as on the sector's relative size within the economy. We interpret this result as further evidence on the prevalence of vertical motives of FDI in the region and its targeted use as an export-platform. We conclude that foreign investors do indeed play an active role in shaping host economies' export structure and their participation in international production networks. Policies to attract foreign investors would therefore constitute an indirect way to deepen a GVC-participation.

The remainder of the paper is structured as follows. Section 2 briefly reviews the related literature and Section 3 presents our data sources, GVC metrics and empirical strategy. Section 4 includes a descriptive analysis of cross-border production sharing. Section 5 presents results from our empirical analysis using an FDI stock augmented gravity model and also an empirical case study on CEEC. Section 6 concludes.

2 Brief review of the related literature

This paper contributes to the literature on the interaction between FDI and cross-border production sharing. The decision of a firm to set up foreign affiliates and locate certain stages of its production

[4] Our CEEC sample includes countries, which joined the EU in 2004 and 2007. The Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia and Slovenia entered the EU on 1 May 2004 and Bulgaria and Romania on 1 January 2007. Croatia, which became an EU Member State on 1 July 2013, is not included in the analysis due to data unavailability. The following five countries from the CEEC region have in the meantime adopted the euro: Slovenia (2007), Slovakia (2009), Estonia (2011), Latvia (2014) and Lithuania (2015).

process abroad, and hence becoming a multinational enterprise (MNE), depends on a number of factors including firm and sector characteristics (Antràs and Helpman, 2004), production costs, trade and monitoring costs, risks linked to incomplete contracts, etc. (Markusen, 2002). FDI motives have traditionally been classified into two broad categories: horizontal or market-seeking FDI, which is primarily motivated by the possibility of supplying local markets (Markusen, 1984), and vertical FDI which exploits location advantages such as differences in production costs (Helpman, 1984). A concept that is closely related to the latter is "export-platform" FDI, whereby foreign affiliates predominantly supply third markets, i.e. neither the home nor the host economy (Ekholm, Forslid and Markusen, 2007). FDI is thus prone to trade creation, both intra-firm and at arm's length.

The presence of foreign investment can affect host economies in multiple ways, possibly contributing to reshaping their economic and export structure. Damijan et al. (2013) find that inward FDI in CEEC has altered their export composition and positively affected total factor productivity. Amador and Cabral (2014) note that FDI is instrumental for the setting up of GVCs run by multinational corporations. Nikolovova (2013), using data for EU27 countries, finds that an increase in FDI at sectoral level is associated with higher production and higher demand for intermediate goods. Kaminsky and Ng (2005) suggest that FDI has fostered the development of production networks in CEEC leading to increased trade integration of the region. Behar and Freund (2011) find that following the 2004 EU enlargement, intra-EU trade in intermediate goods has become more sophisticated and the role of countries joining the EU as suppliers of intermediate goods for the incumbent countries has increased. Alfaro and Charlton (2009) show that the share of vertical FDI is commonly underestimated and conclude that “intra-firm trade and foreign investment activity might be better explained by complex production processes involving several stages and decisions about not only where to source inputs, but also whether to source them from inside or outside the firm.”

While structural factors, such as proximity to consumer markets and natural resource endowments play a role in the development of global value chains, Pathikonda and Farole (2016) argue that there is substantial scope for policies to contribute to this process. They distinguish between longer-term policies facilitating investment in capabilities (e.g. development of physical, human and institutional capital) and other structural policies (e.g. connectivity, market access, wage competitiveness), which help to shape the GVC participation over a shorter time horizon. Bajgar and Javorcik (2016), using data on Romanian manufacturing sector, provide evidence that the presence of MNEs has positive spillovers on the quality of exports by domestic firms. This occurs in particular via backward vertical spillovers, as MNEs demand inputs of higher quality from domestic firms. Policies promoting FDI would hence help stimulating product quality in host economies.

This paper also relates to a series of recent studies using international input-output tables. The latter investigate, among others, the following issues: the correction of multiple-counting of intermediate products in trade flows (Koopman et al., 2010); the measurement of foreign demand and trade elasticities (Bussière et al., 2013); the reshuffling of the geographical and sectorial composition of the trade basket, affecting competitiveness indicators either based on gross trade

weights, such as effective exchange rates (Bems and Johnson, 2012), (Bayoumi et al., 2013), or on the export structure, such as the revealed comparative advantage (Koopman et al., 2010); the effect on bilateral trade balances (Nagengast and Stehrer, 2014); and spillover channels across countries and sectors (Acemoglu et al., 2015).

3 Data sources, global value chain metrics and empirical strategy

When deriving global value chain metrics, one can distinguish two broad concepts. The first concept is based on gross exports and consists in disaggregating the value added embedded in them either by origin or by destination. The breakdown by origin decomposes gross exports into a domestic and a foreign value added, which can be further disaggregated by the country or sector of origin. The breakdown by destination decomposes gross exports according to the future path of the value added contained in them (see Koopman et al., 2010). It allows grouping the exported intermediate goods, once processed, by their subsequent geographic destination. A part of the processed intermediate goods remains in the country they were initially exported to, while the remainder is exported to a third country or back to the original exporter. The domestic value added embedded in the latter part corresponds to the vertical specialisation measure (VS1) introduced by Hummels et al. (2001). From an exporting country's perspective, it represents a so-called forward linkage, capturing the domestic value added that is channelled further by firms located in trading partner countries.

The second concept, introduced by Johnson and Noguera (2012), considers trade in value added. It thus establishes a direct link between the country where value originates ("value added exporter") and the country where it is absorbed ("value added importer"). This bilateral originator-absorber relationship is however artificial, as the actual itinerary, through which value added was effectively traded, is lost.

In the empirical part of this paper, we largely rely on the first concept, which allows for tracking value added in gross exports, while preserving information on the bilateral trade relationship.

We derive global value chain metrics from the World Input-Output Database (Timmer, 2012; Dietzenbacher et al., 2013), which contains annual international sector-by-sector input-output tables[5] for the period from 1995 to 2011. It covers 40 countries, including 27 EU member states, as well as a Rest-of-the-World aggregate and 35 sectors (see Annex A). We derive the global value chain metrics from both the gross exports and the final expenditures following Stehrer (2013) and Johnson and Noguera (2012) (for further details see Annex B). Data on the bilateral inward FDI stock (i.e. equity capital, reinvested earnings and intra-company loans) are taken from the UNCTAD database (UNCTAD, 2014). The inward FDI stock data by industry for CEEC are taken from the wiiw FDI database (wiiw, 2015). We obtain the gravity variables from the GeoDist

[5] It should be emphasised that international input-output tables are themselves estimates based on a number of assumptions and simplifications. For example, all firms in an industry are assumed to use the same input combination and thus the same technology; or multi-product firms are typically classified within the sector of primary production, which may distort the imputed industry technology.

database of CEPII (Mayer and Zignago, 2011; and Head and Mayer, 2014) and the linguistic similarity index from Toubal and Melitz (2014).

The empirical approach in this paper builds on a gravity model framework. Gravity models, which have become a mainstay of international trade analysis, have a strong intuitive appeal and have proven to be empirically successful in "capturing the deep regularities in the pattern of international trade" (Shepherd, 2013). Traditionally, gravity models help to explain the magnitude of gross bilateral trade flows using country-specific and country pair-specific characteristics – e.g. the bilateral distance and the presence of a common language – as well as potential frictions and/or catalysers of international trade (e.g. free trade area, common currency). In this paper, we use the gravity model framework to analyse trade flows associated with global production sharing, as well as the geographical composition of the value added embedded in trade, focussing in particular on the role of bilateral FDI.

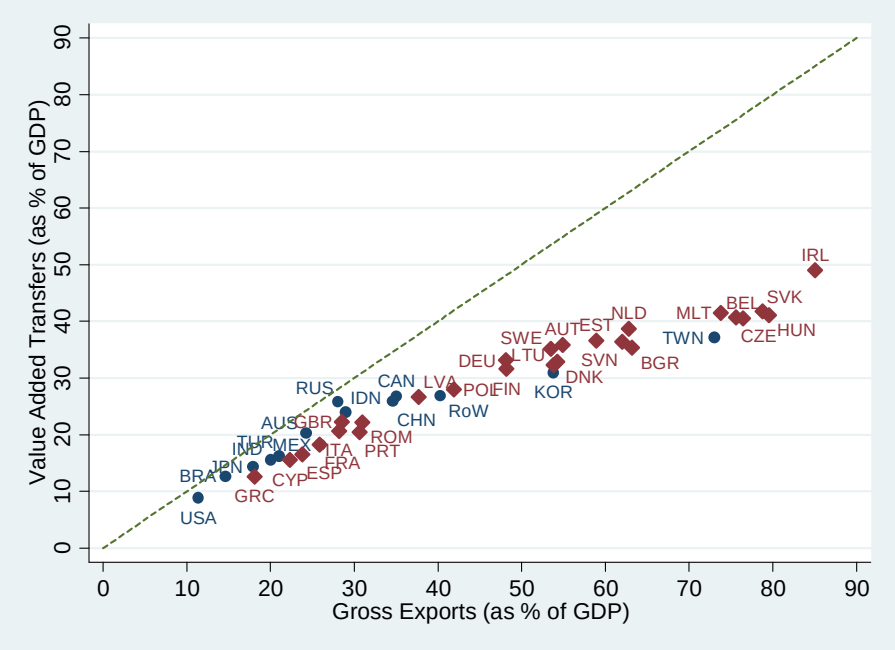
4 Cross-border production sharing – descriptive analysis

This section provides a descriptive analysis on trade flows associated with cross-border production sharing. While it generally takes a global perspective, it additionally highlights the position of CEEC, which are analysed in greater depth in a case study presented in the following section.

Export openness varies considerably across the globe. Measured in gross terms, it ranges from around 10% in the US to almost 90% in Ireland (see Chart 1). When considering exported value added, which captures the actual revenues arising from international trade, countries' export intensities, as well as their dispersion, narrow significantly. The proportion of value added exported to GDP remains nonetheless substantial, stretching from 10% of GDP in the US to around 50% in Ireland. Many EU countries, and particularly some CEEC, rank high on both measures, which makes them the most open economies worldwide.

Three general observations can be made with regard to the wedge between gross and value added exports. First, foreign inputs constitute a pre-condition for the generation of domestic value added and thus trade revenues. Second, the relative ranking of countries remains largely unchanged when employing alternative measures of exports. Third, the share of foreign value added increases with gross export openness. The size of the wedge between gross exports and exported value added can be attributed to differences in the production processes across countries as well as differences in the product composition of their export basket. These differences in turn depend on multiple factors, *inter alia* on a country's geographic location, its production factor endowments and their allocation within the economy.

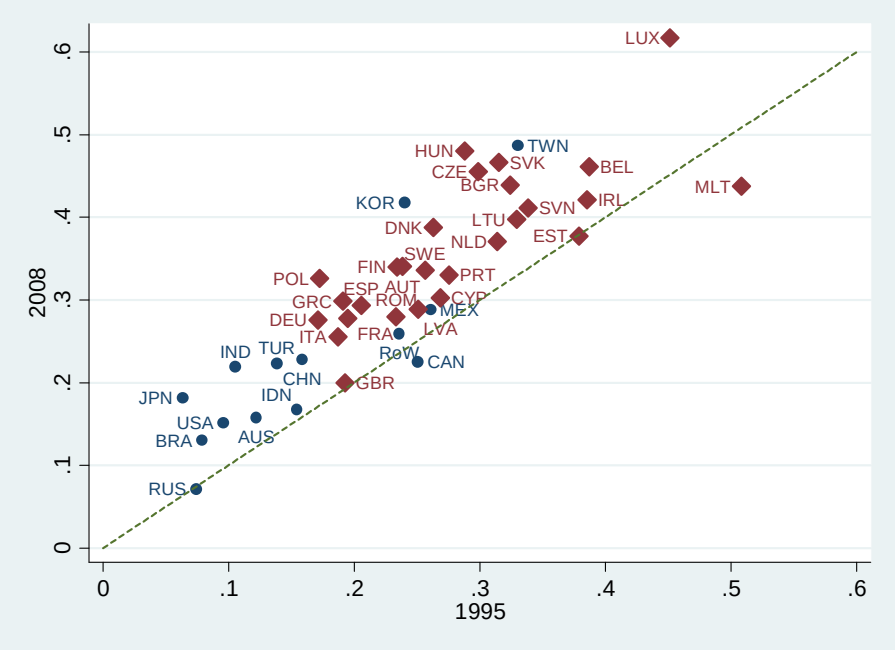
Chart 1. Export openness in 2008



Source: WIOD, authors' calculations.
Note: EU countries are shown as diamonds and Luxembourg is omitted.

The most commonly used gauge of a country's participation in international production networks is the import-content of exports. While the intensification of international production sharing and the faster rise of trade in intermediate goods compared to trade in final goods has been a global phenomenon (see Hummels et al., 2001), EU countries stand out in international comparison. Since the mid-1990s, the average share of import-content has risen from above a quarter of gross exports to just under 40% in 2008 (see Chart 2). In the wake of the global financial crisis it declined, as the 2009 global trade collapse weighed disproportionately on trade in intermediate products. As trade recovered, the import-content in exports rebounded, indicating that this decline was transitory. This is consistent with the view that the 2009 trade collapse itself resulted from a severe adverse shock to final demand, affecting in particular the production of input-intensive and more complex durable goods, for which multiple counting of trade is particularly acute. Inventory adjustments and credit supply constraints further exacerbated the drop in final demand (see, among others, Bems et al., 2012; and Ferrantino and Taglioni, 2014).

Chart 2. Evolution of the import content of exports



Source: WIOD, authors' calculations.
Note: Import content of exports refers to foreign valued added as a percentage of gross exports. EU countries are shown as diamonds.

Zooming in on exported intermediate goods that are exported further post-processing, offers a complementary view on countries' integration in production chains. The domestic value added embedded in this subset of exports then corresponds to the import-content of the trading partner's exports. This so-called forward linkage captures complementary activities between the exporting firms and its foreign downstream customers. They also measure countries' vertical specialization (Hummels et al., 2001) and hence the degree of dependence on the demand faced by the firms processing its exports in downstream countries. In a global comparison, EU countries and in particular CEEC stand out with forward linkages amounting to about 7% of their annual GDP (see Table 1, column h). This share has grown over time, revealing that their role of as suppliers of intermediate goods has strengthened.

Table 1: Gross exports by product category and origin
as percentage of gross exports unless noted otherwise; 2008

	Gross Exports					Gross Exports		Forward link (as % of GDP)
	Final goods	Intermediate goods				Domestic value added	Foreign value added	
			consumed	exported further	shipped back			
	a	b	c	d	e	f	g	h
EU	37.8	62.2	42.4	18.4	1.4	68.5	31.5	5.3
- CEEC	37.4	62.6	40.6	21.5	0.5	60.0	40.0	6.9
- rest-EU	37.9	62.1	42.6	18.0	1.5	69.5	30.5	5.2
EMEs	35.1	64.9	45.9	17.9	1.1	75.0	25.0	4.4
Advanced	29.7	70.3	52.4	14.9	3.1	82.9	17.1	2.2
Memo item								
World	32.9	67.1	48.4	16.3	2.3	73.7	26.3	3.9

Source: WIOD, authors' calculations. Note: For definition of regions please see Annex A.

Intermediate goods that are exported by CEEC and, once processed abroad, are exported to third countries, account for almost a quarter of their gross exports (Table 1, column d). This is a markedly higher share than for any other region worldwide, where exported intermediate goods are more likely to remain in the country processing them (Table 1, column c). In an international comparison, exports from CEEC also stand out for containing the highest share of foreign value added (Table 1, column g).

4.1 Gravity model with GVC-related trade flows

To complement this descriptive analysis we estimate a gravity model for GVC-related trade flows. As dependent variable, we alternate between bilateral gross exports and its subsets that capture different GVC-related characteristics.[6] Our aim is to investigate whether and how the sensitivity of different measures of bilateral trade varies with respect to traditional gravity variables (see Table 2).

The coefficients on distance, linguistic similarity and common legal origin are significant, while their sign and magnitude are in line with the literature (see Head and Mayer, 2014). The coefficient on contiguity is not significantly different from zero. Beyond these expected results, some important observations pertaining to GVC-related trade emerge: First, elasticities on distance, providing a crude proxy for trade costs, vary slightly depending on the type of trade flow considered. Final goods are indeed somewhat less responsive to trade costs, measured by distance, than intermediate goods, which may reflect the lower degree of substitutability of final relative to intermediate goods. The higher elasticity on intermediate products also points to a predominantly regional – as opposed to 'global' – character of cross-border value chains, confirming the findings of Baldwin (2012). Furthermore, the coefficient on linguistic proximity turns out higher for

[6] These are: (1) total gross exports; (2) gross exports of final (consumer) goods; (3) gross exports of intermediate goods; (4) gross exports of intermediate goods, which remain in the country after going through the production process; (5) gross exports of intermediate goods, which are embedded in country j's exports to country k; (6) gross exports of intermediate goods, which are embedded in country j's exports to country i, i.e. shipped back. Note that all trade flows considered (1-6) contain both domestic and foreign value added and that trade flows (4-6) are subsets of intermediate trade (3). Full estimation results are reported in Annex C.

intermediate goods than for final goods, underlining the importance of smooth communication and cooperation in shared production-structures.

In addition to gross exports we also regress the bilateral import-content of exports – the 'foreign footprint'[7] – on the same set of gravity variables. The foreign footprint captures the bilateral input reliance and reflects the complementarity in production for a given country pair. The estimated elasticities for the respective gravity variables are broadly comparable to those obtained in the bilateral trade gravity model, even though the coefficients on distance and on the legal origin are lower.

Table 2. Gravity variables and exports by product type

	Distance	Contiguity	Language	Legal origin
Gross Exports	**-1.05** | **-1.10**	0.22 | 0.18	**0.67** | **0.67**	**0.30** | **0.29**
Final	**-1.00** | **-1.06**	0.26 | 0.21	**0.54** | 0.54	**0.34** | **0.32**
Intermediate	**-1.10** | **-1.14**	0.21 | 0.17	**0.72** | **0.72**	**0.30** | **0.28**
Consumed	**-1.09** | **-1.13**	0.21 | 0.17	**0.71** | **0.71**	**0.30** | **0.29**
Exported further	**-1.11** | **-1.17**	0.13 | 0.08	**0.72** | **0.72**	**0.29** | **0.28**
Shipped back	**-2.23** | **-2.33**	0.36 | 0.27	**1.32** | **1.31**	**0.58** | **0.56**
'Foreign footprint'	**-0.83** | **-0.88**	**0.25** | 0.21	**0.64** | **0.64**	**0.19** | **0.17**

Note: The table reports elasticities for respective gravity variables obtained by two different specifications of a gravity model: the left-hand side of each column lists the coefficients estimated in specification with exporter and importer fixed effects (cf. Table C.1), whereas the right-hand side lists the coefficients obtained from a gravity model with mass variables (i.e. exporter and importer GDP) (cf. Table C.2). Bold figures reflect statistical significance at 5% level. 'Foreign footprint' refers to bilateral import content of exports at a country-pair level. For further details see Annex C.

Overall, the estimation results confirm our observations from the previous section. In a separate specification,[8] we use the bilateral import-content of exports relative to gross exports as dependent variable. This estimation also includes countries' GDP as proxies for their economic size. The estimated coefficient on exporter's GDP is negative, implying that the larger (smaller) the exporting country, the less (more) foreign value added it is likely to carry within its gross exports. This result underlines the propensity of small economies to source their inputs from abroad. It is therefore natural to see exports of small and open economies, such as the CEEC, containing high shares of import-content that predominantly originates in larger and neighbouring countries.

5 Global value chain participation and foreign direct investment – empirical results

In this section, we augment the standard gravity models with the bilateral FDI stock. In this way we can analyse how the latter affects the geographic pattern of international trade and the mode of countries' participation in global value chains. This section also includes a case study focusing on CEEC. Multinational firms entering a country via a direct investment are likely to spur trade between their home country and the country they are investing in, both in final and intermediate

[7] There are some conceptual differences with respect to the traditional bilateral trade gravity model. In this specification, our interest rests on the origin of the import-content in country j's overall exports (across all destinations) – which becomes the dependent variable, following a similar approach as Rahman and Zhao (2013) - rather than on the bilateral trade flow between country i and country j.

[8] Not reported in this paper, but available upon demand.

products. This could result from higher intra-firm trade, but also from a more intensive trade with multinational firm's traditional input-providers in their home countries.

We estimate a gravity model for gross exports from country i to country j in year t (X_{ijt}), regressing it on the bilateral inward FDI stock (FDI_{jit}), while controlling for the bilateral distance ($dist_{ij}$, in logs), contiguity ($contig_{ij}$,), the common language index (cl_{ij})[9] and the common legal origin ($comleg_{ij}$) (Eq. 1). The setup includes exporter-year (φ_{it}) and importer-year (φ_{jt}) fixed effects to account for unobservable factors affecting trade at the level of the exporter and importer, respectively, in a given year. We estimate the gravity model by ordinary least squares (OLS) and report an alternative specification using the non-linear Poisson Pseudo-Maximum Likelihood estimator as a robustness test (see Annex D).

The coefficient on the FDI stock is positive and statistically significant across all specifications, which confirms that foreign direct investment is positively associated with bilateral trade integration, i.e. a country exports more to a country that has provided direct investment (see Table 3). The coefficients on distance, linguistic proximity and common legal origin remain significant with the expected sign, while the coefficient on contiguity turns significant compared to the model specification without FDI stock. In line with our previous results, we observe some variation in the coefficients of the respective explanatory variables when different types of exports are used as dependent variables. One observation that emerges for exports of intermediate goods is that the coefficient on the FDI stock is somewhat higher for intermediate goods with a lower degree of finalisation (Table 3, columns 5 and 6). Overall, the estimated coefficients for FDI stock for exported final and intermediate products are broadly comparable, which does not allow us to discriminate between horizontal or vertical motives behind foreign investment.

$$\ln X_{ijt} = \delta_0 + \delta_1 \ln dist_{ij} + \delta_2 contig_{ij} + \delta_3 cl_{ij} + \delta_4 comleg_{ij} + \delta_5 \ln FDI_{jit} + \varphi_{it} + \varphi_{jt} + \epsilon_{ijt} \qquad (1)$$

[9] The common language index takes into account the linguistic proximity of two languages, even if they are formally distinct. All other things equal, a higher linguistic similarity should facilitate cooperation via lower interpretation and communication costs.

Table 3. Bilateral exports

	Gross exports	Final goods	Intermediate goods	Intermediate goods, which are processed and…		
				… consumed	… exported further	… shipped back
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
Distance	-0.713***	-0.654***	-0.736***	-0.736***	-0.724***	-1.556***
	(0.0415)	(0.0458)	(0.0413)	(0.0423)	(0.0438)	(0.0795)
Contiguity	0.289***	0.336***	0.289***	0.291***	0.231**	0.509**
	(0.101)	(0.111)	(0.103)	(0.102)	(0.106)	(0.205)
Language	0.491***	0.388*	0.529***	0.534***	0.496***	0.914**
	(0.189)	(0.220)	(0.189)	(0.191)	(0.188)	(0.430)
Common Legal Origin	0.166***	0.164**	0.167***	0.163***	0.150**	0.305**
	(0.0582)	(0.0644)	(0.0582)	(0.0582)	(0.0602)	(0.123)
FDI stock	0.161***	0.167***	0.165***	0.163***	0.170***	0.314***
	(0.0140)	(0.0152)	(0.0142)	(0.0144)	(0.0147)	(0.0268)
Observations	9,381	9,381	9,381	9,381	9,381	9,381
R-squared	0.931	0.927	0.924	0.926	0.916	0.905
Exporter-Year FE	YES	YES	YES	YES	YES	YES
Importer-Year FE	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: The panel includes annual observations over the period 2000-2011. The models include robust variance estimates yielding heteroscedasticity-consistent standard errors and bilateral distance used as a clustering variable.

We then run the same set of regressions using bilateral imports as a dependent variable, M_{ijt}, in order to assess the complementarity between bilateral imports and the bilateral FDI stock (Eq. 2). The positive and significant coefficients on the FDI stock across different specifications suggest that foreign investments are associated with higher trade integration also on the import side (see Table 4). This is compatible with both the horizontal and the vertical motives for FDI. An example of the former would be for instance retailer networks distributing final products imported from the retailer's country of origin for final consumption in the host country. An example of the latter would be the assembly and finalisation of products sold to the host country market or further exported. More generally, the estimated positive relationship supports the hypothesis of substantial intra-firm trade between multinationals and their foreign affiliates, whereby these multinationals "carry" products that are then sold or processed in the host country, *de facto* establishing intermediate and/or final links within a cross-border supply chain. The marginally higher coefficient on the bilateral FDI stock in the export equation relative to the import equation suggests that the vertical motive for FDI may be slightly dominating the horizontal one. The higher elasticity of foreign direct investment for the intermediate goods compared to the final goods in the import equation also supports this interpretation.

$$\ln M_{ijt} = \delta_0 + \delta_1 \ln dist_{ij} + \delta_2 contig_{ij} + \delta_3 cl_{ij} + \delta_4 comleg_{ij} + \delta_5 \ln FDI_{jit} + \varphi_{it} + \varphi_{jt} + \epsilon_{ijt} \quad (2)$$

Table 4. Bilateral imports

	Gross imports	Final goods	Intermediate goods	Intermediate goods, which are processed and...		
				... consumed	... exported further	... shipped back
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
Distance	-0.756***	-0.717***	-0.779***	-0.770***	-0.783***	-1.557***
	(0.0424)	(0.0469)	(0.0425)	(0.0427)	(0.0472)	(0.0788)
Contiguity	0.292***	0.286***	0.304***	0.316***	0.206*	0.525**
	(0.103)	(0.110)	(0.104)	(0.103)	(0.109)	(0.206)
Language	0.363	0.377	0.349	0.351	0.300	0.778*
	(0.240)	(0.270)	(0.231)	(0.236)	(0.237)	(0.445)
Common Legal Origin	0.149**	0.180**	0.147**	0.145**	0.149**	0.327***
	(0.0657)	(0.0732)	(0.0643)	(0.0645)	(0.0679)	(0.125)
FDI stock	0.148***	0.139***	0.158***	0.156***	0.165***	0.321***
	(0.0144)	(0.0157)	(0.0149)	(0.0149)	(0.0163)	(0.0272)
Observations	9,381	9,381	9,381	9,381	9,381	9,381
R-squared	0.927	0.923	0.920	0.923	0.911	0.922
Exporter-Year FE	YES	YES	YES	YES	YES	YES
Importer-Year FE	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: The panel includes annual observations over the period 2000-2011. The models include robust variance estimates yielding heteroscedasticity-consistent standard errors, while distance is used as a clustering variable.

Finally, we investigate how the bilateral FDI stock affects the bilateral import-content of gross exports ($VAiX_o^i$), again using an augmented gravity model (Eq. 3). The bilateral relationship of interest is thus between the exporter and the originator – both of the import-content and the FDI stock – rather than the destination country, explaining the change in notation.

$$\ln VAiX_{o_t}^i = \delta_0 + \delta_1 \ln dist_{io} + \delta_2 contig_{io} + \delta_3 cl_{ij} + \delta_4 comleg_{ij} + \delta_5 \ln FDI_{oit} + \varphi_{it} + \varphi_{ot} + \epsilon_{iot} \quad (3)$$

Our main finding so far – a positive association of the bilateral FDI stock and the bilateral import content of exports – holds, suggesting significant analogies between the geographical compositions of the FDI stock and the bilateral production sharing links (see Table 5).

Table 5. Bilateral import content of exports

VARIABLES	Foreign footprint (1)	Foreign footprint (2)
Distance	-0.747***	-0.624***
	(0.0347)	(0.0322)
Contiguity	0.327***	0.300***
	(0.104)	(0.0893)
Language	0.509**	0.316
	(0.211)	(0.192)
Common Legal Origin	0.156***	0.0903*
	(0.0576)	(0.0519)
FDI stock		0.116***
		(0.0118)
Observations	9,381	9,381
R-squared	0.933	0.940
Absorber-Year FE	YES	YES
Originator-Year FE	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: The panel includes annual observations over the period 2000-2011. The models include robust variance estimates yielding heteroscedasticity-consistent standard errors, while distance is used as a clustering variable. 'Foreign footprint' refers to bilateral import content of exports at a country pair level.

5.1 Central and eastern European countries – empirical case study

In this subsection we zoom in on CEEC. Given their rapid economic transition, supported by foreign direct investment inflows and trade integration,[10] they constitute an interesting case to analyse. The broad geographical patterns of gross exports, gross imports and inward FDI stocks in the region are relatively similar and clearly dominated by other EU countries (see Annex Chart E.6). These similarities suggest that there is a link between FDI providers and the geography of supply chains, serving either the investors' home market or other markets, or a combination of both.

Compared to their economic size, CEEC are among the largest recipients of FDI worldwide. On average, the stock of inward FDI in 2008 amounted to about 40% of the region's GDP, compared to just above 30% in the rest of EU and 20% in emerging market economies. The significant inflows of FDI to the region reflected both the mergers and acquisitions related to the large-scale privatisation programmes in earlier years of economic transition and 'greenfield' FDI later on. According to Jimborean and Kelber (2017), both types of foreign investment had common drivers, including progress with structural and institutional reforms, falling risk premia, lower labour costs and increasing trade openness. As the EU membership negotiations of CEEC started and

[10] Kaminsky and Ng (2005) identify production sharing as the driving force behind trade integration of CEEC.

countries' prospects of the Single Market participation became more tangible, FDI inflows increased significantly.[11]

Turning to trade, for most CEEC the bulk of foreign value added originates in other EU countries, while the contribution of individual economies, notably Russia, is also relevant for some. Looking at the geographic composition of their forward linkages indicates that proximity has been a key element shaping countries' participation in cross-border production sharing.[12]

Taking a sectorial view, the manufacturing sector clearly dominates the region's export structure, accounting for about 75% of gross exports, compared to a global average of around 65%.[13] For the region as a whole, its share has been gradually increasing since the mid-1990s, while the share of services hovered around 20% of gross exports. This picture changes dramatically when considering the respective contribution of manufacturing and services exports in terms of value added. Interestingly, the respective share of both sectors is broadly comparable at around 45%. This comparison reveals that the dominance of the manufacturing sector in CEEC reflects both its high import-intensity[14] and its reliance on domestic inputs purchased from the services sector. A similar contrast between gross and value added exports can also be observed when looking at sector-level concentration measures, such as the Herfindal-Hirschman Index (see Annex Chart E.4). For a number of individual service sectors the value added exports significantly exceeds the gross export volume. This reflects fragmentation of production within a country, as some traditionally "non-tradable" sectors become *de facto* exporters by supplying inputs to export industries.[15] The import-content of exports also reveals a clear sector bias of the geographic "footprint" (see Annex Charts E.1 and E.2). Indeed, the domestic-to-foreign content ratio strongly varies between sectors, depending on the complexity of the goods produced: whereas some sectors' exports predominantly consist of domestic value added, others are largely exporting goods assembled from foreign inputs. Furthermore, the origin of those foreign inputs varies, suggesting different geographic patterns of cross-border value chains at sectorial level.

In order to empirically asses the specificity of CEEC we augment our baseline gravity model with time invariant CEEC-exporter and CEEC-importer dummies that are respectively interacted with traditional gravity variables (Equation 4). This allows us to observe whether the nature of trade

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11 For an empirical investigation of determinants of FDI in CEEC, see, among others, Bevan and Estrin (2004).

12 Taking the example of Slovakia, the largest part of its forward linkages - equivalent to about 2.5% of its GDP in 2008 - was channelled via Germany. Moreover, the neighbouring Visegrad countries constitute an increasingly important conduit for the Slovak exporters - about 1.5% of Slovak GDP was processed and exported via the Czech Republic and 0.5% through Hungary and Poland respectively – emphasising the growing prevalence of regional production networks. The downstream importance of Germany and the increasing establishment of joint CEEC' production platforms around the "German-Central European Supply Chain" (see IMF, 2013), is visible also in other CEEC countries.

13 This share even rises to above 80% for the Czech Republic, Slovakia and Slovenia.

14 A stronger reliance of the manufacturing sector on foreign inputs also affects GVC-metrics. For instance, the manufacturing sector in the region is positioned more "downstream", or closer to the final consumer compared to the service sector, which is positioned more "upstream". Annex E presents a more detailed sector-level perspective on domestic and foreign value added in CEEC.

15 Such indirect exports challenge the traditional distinction between tradable and non-tradable sectors, in particular when the export-orientation of an economy exposes domestic non-exporters to foreign demand shocks. While the presence of export industries may potentially create beneficial cluster effects, the indirect links may however imply an alignment on the risks to foreign shocks faced by direct exporters. This has indeed been visible when the 2009 trade collapse propagated to indirect exporters, dragging down their exported value added (see Nagengast and Stehrer, 2015).

flows originating in, or directed to the region differs from bilateral trade flows involving other countries in our sample. It also allows us to detect asymmetries in trade cost elasticities depending on whether a CEEC is exporter or importer.

$$\ln X_{ijt} = \delta_0 + \delta_1 \ln dist_{ij} + \delta_2 \ln dist_{ij} \times D_{i,CEEC} + \delta_3 \ln dist_{ij} \times D_{j,CEEC} + \delta_4 contig_{ij} + \delta_5 contig_{ij} \times D_{i,CEEC} + \delta_6 contig_{ij} \times D_{j,CEEC} + \delta_7 cl_{ij} + \delta_8 comleg_{ij} + \delta_9 D_{i,CEEC} + \delta_{10} D_{j,CEEC} + \varphi_{it} + \varphi_{jt} + \epsilon_{ijt} \quad (4)$$

The singular role of CEEC relative to other countries in our sample, as regards their participation in supply chains, clearly transpires (see Table 6). The elasticities with respect to trade costs are significantly different for the distance variable (less so for contiguity) and indeed higher for CEEC regardless of the final or intermediate nature of the products traded. This points to a particularly strong regional orientation of the production networks involving CEEC. Furthermore, there are asymmetries in trade cost elasticities depending on whether trade flows originate in CEEC, or are directed to them. Indeed, CEEC exports appear more sensitive to trade costs and proximity than imports, as reflected in the consistently higher coefficient on the CEEC exporter interaction term. In the case of final products, this points to foreign firms seeking market access to CEEC in view of taking advantage of their convergence process and potential. In the case of intermediate goods, it confirms that the region constitutes a privileged location of assembling activities in view of supplying nearby markets. We also estimate a gravity model for bilateral import content of exports and a set of traditional gravity variables and absorber-year and originator-year fixed effects, adding interaction terms in order to capture CEEC country-specificities (Equation 5). The additional effect of CEEC on respective gravity variable is broadly similar compared to specification using gross export variables.

$$\ln VAiX^i_{ot} = \delta_0 + \delta_1 \ln dist_{io} + \delta_2 \ln dist_{io} \times D_{i,CEEC} + \delta_3 \ln dist_{io} \times D_{o,CEEC} + \delta_4 contig_{io} + \delta_5 contig_{io} \times D_{i,CEEC} + \delta_6 contig_{io} \times D_{o,CEEC} + \delta_7 cl_{io} + \delta_8 cl_{io} \times D_{i,CEEC} + \delta_9 cl_{io} \times D_{o,CEEC} + \delta_8 comleg_{io} + \delta_9 comleg_{io} \times D_{i,CEEC} + \delta_{10} comleg_{io} \times D_{o,CEEC} + \delta_9 D_{i,CEEC} + \delta_{10} D_{o,CEEC} + \varphi_{it} + \varphi_{ot} + \epsilon_{iot} \quad (5)$$

Table 6. Trade and foreign footprint in CEEC

	Distance		Contiguity		Language		Legal Origin	
	x $CEEC_{exp}$	x $CEEC_{imp}$	x $CEEC_{exp}$	x $CEEC_{imp}$	x $CEEC_{exp}$	x $CEEC_{imp}$	x $CEEC_{exp}$	x $CEEC_{imp}$
Gross Exports	**-0.37**	**-0.35**	**0.35**	0.17	**0.79**	-0.50	**-0.40**	0.19
Final	**-0.41**	**-0.37**	0.13	0.22	**1.04**	**-0.65**	**-0.22**	-0.01
Intermediate	**-0.38**	**-0.35**	**0.41**	0.19	**0.74**	-0.54	**-0.45**	0.20
Consumed	**-0.39**	**-0.35**	**0.41**	0.20	**0.64**	-0.47	**-0.44**	0.20
Exported further	**-0.40**	**-0.34**	**0.48**	0.21	**0.95**	**-0.64**	**-0.43**	0.16
Shipped back	**-0.76**	**-0.77**	**0.57**	0.40	0.45	0.40	**-0.35**	-0.31
	x $CEEC_{abs}$	x $CEEC_{ori}$	x $CEEC_{abs}$	x $CEEC_{ori}$	x $CEEC_{abs}$	x $CEEC_{ori}$	x $CEEC_{abs}$	x $CEEC_{ori}$
'Foreign footprint'	**-0.20**	**-0.20**	**0.26**	**0.46**	-0.30	**0.60**	0.08	**-0.25**

Note: Elasticities for respective interaction terms of the gravity variables and CEEC dummies obtained by two specifications of a gravity model are reported. Bold figures reflect statistical significance at 10% level. Further estimation details are reported in Annex Table C.3. 'Foreign footprint' refers to bilateral import content of exports.

Finally, we modify our FDI-augmented gravity model by including CEEC-dummies and interaction terms with the FDI stock for both, gross exports and imports. This allows us to identify possible differences in the relationship of the bilateral FDI stock and GVC-related trade for CEEC relative to other countries in our sample. We are also interested to see whether the relationship varies, depending on whether CEEC are recipients or providers of direct investment (see Equations 6 and 7).

$$\ln X_{ijt} = \delta_0 + \delta_1 \ln dist_{ij} + \delta_2 contig_{ij} + \delta_3 cl_{ij} + \delta_4 comleg_{ij} + \delta_5 \ln FDI_{jit} + \delta_6 \ln FDI_{jit} \times D_{i,CEEC} + \delta_7 \ln FDI_{jit} \times D_{j,CEEC} + \delta_8 D_{i,CEEC} + \delta_9 D_{j,CEEC} + \varphi_{it} + \varphi_{jt} + \epsilon_{ijt} \quad (6),$$

$$\ln M_{ijt} = \delta_0 + \delta_1 \ln dist_{ij} + \delta_2 contig_{ij} + \delta_3 cl_{ij} + \delta_4 comleg_{ij} + \delta_5 \ln FDI_{jit} + \delta_6 \ln FDI_{jit} \times D_{i,CEEC} + \delta_7 \ln FDI_{jit} \times D_{j,CEEC} + \delta_8 D_{i,CEEC} + \delta_9 D_{j,CEEC} + \varphi_{it} + \varphi_{jt} + \epsilon_{ijt} \quad (7).$$

While the baseline result of a positive relationship between bilateral trade and FDI stock holds (see Tables 7 and 8), we also find that this correlation is stronger when a CEEC stands on the recipient side of the investment relationship. In contrast, the coefficient on the FDI stock interacted with a CEEC FDI-provider dummy, is not significantly different from zero, possibly reflecting the relatively low, albeit steadily growing foreign investment activity by CEEC. The higher elasticity observed in the case of intermediate goods, specifically for the export equation (see Table 7) underlines the strong link between foreign investment and cross-border production sharing.

Table 7. Bilateral exports and the CEEC-interaction terms

	Gross exports	Final goods	Intermediate goods	Intermediate goods, which are processed and…		
				… consumed	… exported further	… shipped back
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
Distance	-0.714***	-0.658***	-0.736***	-0.737***	-0.724***	-1.552***
	(0.0403)	(0.0445)	(0.0401)	(0.0412)	(0.0427)	(0.0758)
Contiguity	0.267***	0.312***	0.268***	0.269***	0.212**	0.472**
	(0.0937)	(0.104)	(0.0954)	(0.0948)	(0.0986)	(0.187)
Language	0.586***	0.468**	0.630***	0.637***	0.588***	1.140***
	(0.186)	(0.217)	(0.187)	(0.188)	(0.187)	(0.425)
Common Legal Origin	0.231***	0.223***	0.235***	0.234***	0.213***	0.453***
	(0.0611)	(0.0677)	(0.0608)	(0.0609)	(0.0629)	(0.129)
FDI stock	0.123***	0.132***	0.125***	0.123***	0.134***	0.232***
	(0.0136)	(0.0148)	(0.0142)	(0.0143)	(0.0151)	(0.0265)
FDI stock x CEEC $_{FDI\ recipient}$	0.0876***	0.0748***	0.0936***	0.0953***	0.0854***	0.207***
	(0.0154)	(0.0163)	(0.0159)	(0.0157)	(0.0166)	(0.0296)
FDI stock x CEEC $_{FDI\ provider}$	0.0356	0.0437	0.0320	0.0342	0.0299	0.0453
	(0.0291)	(0.0331)	(0.0281)	(0.0280)	(0.0291)	(0.0556)
Observations	9,381	9,381	9,381	9,381	9,381	9,381
R-squared	0.933	0.928	0.927	0.929	0.918	0.909
Exporter-Year FE	YES	YES	YES	YES	YES	YES
Importer-Year FE	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: The panel includes annual observations over the period 2000-2011. The CEEC dummies are included in the estimation, but not reported. The models include robust variance estimates yielding heteroscedasticity-consistent standard errors, while distance is used as a clustering variable.

Table 8. Bilateral imports and the CEEC-interaction terms

	Gross imports	Final goods	Intermediate goods	Intermediate goods, which are processed and…		
				… consumed	… exported further	… shipped back
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
Distance	-0.758***	-0.719***	-0.780***	-0.771***	-0.781***	-1.557***
	(0.0402)	(0.0444)	(0.0406)	(0.0408)	(0.0454)	(0.0754)
Contiguity	0.266***	0.257***	0.281***	0.291***	0.188*	0.483**
	(0.0929)	(0.0990)	(0.0945)	(0.0935)	(0.0989)	(0.189)
Language	0.472**	0.498*	0.461**	0.463**	0.421*	0.986**
	(0.235)	(0.266)	(0.226)	(0.231)	(0.233)	(0.440)
Common Legal Origin	0.225***	0.264***	0.223***	0.222***	0.227***	0.468***
	(0.0680)	(0.0758)	(0.0666)	(0.0668)	(0.0702)	(0.131)
FDI stock	0.104***	0.0897***	0.114***	0.111***	0.122***	0.241***
	(0.0143)	(0.0155)	(0.0153)	(0.0152)	(0.0171)	(0.0277)
FDI stock x CEEC $_{FDI\ recipient}$	0.101***	0.112***	0.103***	0.104***	0.110***	0.192***
	(0.0159)	(0.0174)	(0.0163)	(0.0160)	(0.0174)	(0.0297)
FDI stock x CEEC $_{FDI\ provider}$	0.0435	0.0486	0.0352	0.0420	0.0187	0.0629
	(0.0293)	(0.0330)	(0.0285)	(0.0283)	(0.0290)	(0.0546)
Observations	9,381	9,381	9,381	9,381	9,381	9,381
R-squared	0.930	0.926	0.923	0.925	0.913	0.925
Exporter-Year FE	YES	YES	YES	YES	YES	YES
Importer-Year FE	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Note: The panel includes annual observations over the period 2000-2011. The CEEC dummies are included in the estimation, but not reported. The models include robust variance estimates yielding heteroscedasticity-consistent standard errors, while distance is used as a clustering variable.

We have shown above that bilateral FDI stock is positively associated with the bilateral foreign footprint. As the largest export sectors in the region typically also have the largest foreign footprint, we investigate whether we can identify relation between the sectorial foreign footprint and sectorial FDI stock. This would be consistent with vertical motives of FDI, such as assembly-activities of imported inputs, which notably take place within multinational enterprises. Using the available data for the CEEC region we focus on the 14 manufacturing sub-sectors and regress the sectorial import-content of exports on the FDI stock in that sector (Table 9).[16] We include sector-year fixed effects and exporter-year fixed effects to account for unobserved heterogeneity over time at sectorial level and country level respectively. The foreign footprint enters the regression in two forms, either as a share of total gross exports (columns 1 and 2) or in levels in logarithmic transformation (columns 3 and 4). Likewise, the sectorial FDI stock is expressed either as a share of the total FDI stock in all manufacturing sectors or in log-levels.

[16] A bilateral geographical breakdown of the FDI stock is not available at the sector level.

Table 9. Import-content of exports and FDI stock at sector level

'Foreign footprint'	share in gross exports		log-levels	
	(1)	(2)	(3)	(4)
Sectors' FDI (share in total FDI)	0.247***		0.068***	
	(0.0319)		(0.00397)	
Sectors' FDI (log-level)		2.007***		0.495***
		(0.190)		(0.0221)
Observations	1,649	1,552	1,636	1,548
R-squared	0.725	0.764	0.845	0.889
Exporter-Year FE	YES	YES	YES	YES
Sector-Year FE	YES	YES	YES	YES

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Note: The panel includes annual observations over the period 1995-2011. The sample is restricted to CEEC countries and 14 manufacturing sectors.

The results reveal a positive correlation between the FDI stock and the import-content of exports across manufacturing sectors. Separately, we also find that the sectorial distribution of the FDI stock in the manufacturing sectors leaves an imprint on the composition of the export basket and the overall industrial structure.[17] We interpret this result as an indication that foreign investors are shaping the production processes in CEEC (as reflected in the sector-specific "footprint") and by extension also the industrial structure of exporting countries. This confirms earlier findings showing that FDI has contributed to restructuring of the export sector in the region (see Damijan et al., 2013).

6 Conclusions

Cross-border production sharing has become the norm nowadays and a growing share of firms participates in global value chains. The implications of this fragmented production mode have sparked a growing interest by academics and policy-makers alike. In this paper, we have investigated determinants behind countries' participation in international production chains, focussing in particular on how foreign investors shape the host countries' export structure and their degree of GVC-participation. We construct a new dataset, combining GVC-participation metrics and bilateral and sectorial FDI stocks. Using an augmented gravity model framework, we show that traditional gravity variables play a significant role in explaining GVC-related bilateral trade, as well as the bilateral import-content of exports. We also find some evidence that cooperation costs – measured by linguistic and geographical proximity – seem more relevant for trade that reflects production sharing. Further, we find a significant positive relationship between the bilateral FDI stock and bilateral trade in both final and intermediate products. This association also holds for the bilateral import-content of exports (the 'foreign footprint'), which is positively related to the origin of foreign investment. In our view, the trade-generating effect of FDI primarily relates to intra-firm trade. Overall, our results indicate that foreign investors play an active role in shaping host

[17] This is tested by regressing sector-level exports on the FDI stock in the sector (not reported here; available upon request).

economies' export structure and their participation in international production networks. Policies to attract foreign investors would thus constitute an indirect way to deepen a country's GVC-participation.

Our paper also includes a case study on CEEC. Due to their trade openness and the massive inflow of foreign investment in the past two decades this region constitutes an interesting case to study the interaction of GVC participation and foreign direct investment. In terms of production sharing, the CEEC region is among the most interconnected worldwide and at the same time features the largest FDI stock relative to economic output. We show that GVC-participation of CEEC has a strong regional, EU-centred, focus and that the largest export sectors are the most import-intensive. Using a gravity model, we show that CEEC trade is generally more sensitive to trade costs than trade of other countries in our sample. We also find that bilateral FDI are positively associated with the bilateral foreign footprint in CEEC. Zooming in on the manufacturing sector and its 14 subsectors in CEEC, we show that the sectorial FDI stock could be positively associated with import-content of exports of particular sub-sector and its share in the country's gross exports basket.

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Annex A: Sample specifications

Annex Table A.1. Country sample

World	a+b+c	40	
EU	a = a1 +a2	27	
- CEEC	a1	10	Bulgaria, Czech Republic, Estonia, Hungary, Lithuania, Latvia, Poland, Romania, Slovakia, Slovenia
- other EU	a2	17	Austria, Belgium, Cyprus, Germany, Denmark, Spain, Finland, France, United Kingdom, Greece, Ireland, Italy, Luxembourg, Malta, Netherlands, Portugal, Sweden
EMEs	b	9	Brazil, China, Indonesia, India, South Korea, Mexico, Russia, Taiwan, Turkey
Advanced	c	4	Australia, Canada, Japan, USA

Source: WIOD, UNCTAD.

Annex Table A.2. Sector sample

Mining and Quarrying	C	
Manufacturing	15t16	Food, Beverages and Tobacco
	17t18	Textiles and Textile Products
	19	Leather, Leather and Footwear
	20	Wood and Products of Wood and Cork
	21t22	Pulp, Paper, Paper , Printing and Publishing
	23	Coke, Refined Petroleum and Nuclear Fuel
	24	Chemicals and Chemical Products
	25	Rubber and Plastics
	26	Other Non-Metallic Mineral
	27t28	Basic Metals and Fabricated Metal
	29	Machinery, Nec
	30t33	Electrical and Optical Equipment
	34t35	Transport Equipment
	36t37	Manufacturing, Nec; Recycling
Electricity, Gas and Water Supply	E	
Construction	F	
Services	50	Sale, Maintenance and Repair of Motor Vehicles and Motorcycles; Retail Sale of Fuel
	51	Wholesale Trade and Commission Trade, Except of Motor Vehicles and Motorcycles
	52	Retail Trade, Except of Motor Vehicles and Motorcycles; Repair of Household Goods
	H	Hotels and Restaurants
	60	Inland Transport
	61	Water Transport
	62	Air Transport
	63	Other Supporting and Auxiliary Transport Activities; Activities of Travel Agencies
	64	Post and Telecommunications
	J	Financial Intermediation
	70	Real Estate Activities
	71t74	Renting of M&Eq and Other Business Activities
	L	Public Admin and Defence; Compulsory Social Security
	M	Education
	N	Health and Social Work
	O	Other Community, Social and Personal Services
	P	Private Households with Employed Persons

Annex B. Derivation of global value chain metrics

We derive global value chain metrics from the World Input Output Database (Timmer, 2012; Dietzenbacher et al., 2013), which contains annual international sector-by-sector input-output tables over the period 1995 to 2011. It covers 40 countries and a Rest-of-the-World aggregate as well as 35 sectors (see Annex A). Global value chain metrics are derived from both gross exports and final expenditure (for a detailed discussion see Stehrer, 2013).

B.1 Decomposition of gross exports

Gross exports typically contain a mix of goods and services at all stages of their respective value chains: some are final and thus ready for consumption, some only need "finishing touches" (e.g. assembling, packaging), while others still need to be processed many times over before becoming final and hence have a long way ahead (e.g. raw materials). As such, gross exports represent a snapshot of a simultaneous "forward move" along many different parallel value chains. GVC-metrics derived from such a snapshot can thus focus either on the origin or on the destination of the gross exports, respectively.

The first approach takes an "upstream" or "backward" perspective. It essentially consists in disassembling gross exports into their smallest parts and tracing each component back to its country and sector of origin. The bilateral gross exports of country i to country j can hence be split into the domestic value added embedded in exports ($DVAiX$) and the foreign value added embedded in exports ($FVAiX$), i.e. the import-content, respectively. In matrix notation, this can be expressed as follows:

$$\boldsymbol{e_j^i} = \underbrace{\boldsymbol{v^i L e_j^i}}_{\text{(DVAiX)}} + \underbrace{\textstyle\sum_{\boldsymbol{k \neq i}} \boldsymbol{v^k L e_j^i}}_{\text{(FVAiX)}} \qquad \text{(B.1)},$$

where $\boldsymbol{e_j^i}$ is a vector of dimension $ms \times 1$, which contains the gross bilateral exports at sector-level of country i to country j (m and s refer to the number of countries and sectors, respectively)[18]. Pre-multiplying this vector by the $ms \times ms$ total requirements matrix $\boldsymbol{L}$ (also known as the Leontief inverse), yields a column vector of the gross output per country and sector required to produce exports. Further pre-multiplication by $\boldsymbol{v^i}$, a $1 \times ms$ vector containing value added coefficients of country i's sectors, returns the value added generated during this process in this country ($DVAiX_i$,). Likewise, pre-multiplication by the $1 \times ms$ vector $\boldsymbol{v^k}$, which contains the value added coefficients of all industries in the upstream country k yields the value added generated in country *k* entering the production process abroad $FVAiX_{ik}$.[19]

The second perspective (Koopman et al., 2010) focuses on the destination of value added and thus takes a "downstream" or "forward" perspective on traded value added. Whereas for final goods the obvious destination is country j, there are different options for intermediate goods, after having

[18] The remaining entries of the vector are set to zero.

[19] These decompositions can easily be refined at the sector-level by arranging the vectors accordingly.

been processed in country j. Once processed, intermediate goods exports can be organised according to the country they will be sold to next.[20] There are three possible cases: goods can remain in country j; they can be exported further to a third country l; they can be shipped back to their country of origin. Equation 2 below disentangles the $s \times 1$ gross exports vector, $\boldsymbol{e_j^i}$, according to these uses (final and prospective destination of intermediaries):[21]

$$\boldsymbol{e_j^i} = \underbrace{\boldsymbol{f_j^i}}_{(1)} + \underbrace{\boldsymbol{A_{ij}X_j^j}}_{(2)} + \underbrace{\boldsymbol{\sum_{k \neq j,i} A_{ij}X_k^j}}_{(3)} + \underbrace{\boldsymbol{A_{ij}X_i^j}}_{(4)}, \qquad \text{(B.2)},$$

where $\boldsymbol{f_j^i}$ stands for exports of final goods/services from country i to country j, $\boldsymbol{A_{ij}}$ is the $s \times s$ sub-matrix of technical (input-output) coefficients (specifying in which proportion inputs from country i enter country j's production process), and $\boldsymbol{X^j}$ is the gross output of country j ($\boldsymbol{X_j^j}$ is thus country j's gross output used domestically, while $\boldsymbol{X_k^i}$ and $\boldsymbol{X_i^j}$ represent the gross output (i.e. gross exports) shipped to a third country k or back to country i, respectively). The sum of terms 2-4 corresponds to all intermediate goods and services exported from country i to of country j ($\boldsymbol{A_{ij}X^j}$).

Each of the four components in Equation 2 contains domestic and foreign value added, respectively. The domestic share of value added that can be retrieved by pre-multiplying the four terms by the $s \times s$ Leontieff sub-matrix for country i (this corresponds to country i's the diagonal block of the inter-country Leontief-matrix), yielding gross output, and the $s \times 1$ vector containing the value added coefficients of the s industries in country i.

$$\boldsymbol{e_j^i} = \underbrace{\boldsymbol{v^i L_{ii} f_j^i}}_{(1)} + \underbrace{\boldsymbol{v^i L_{ii} A_{ij} X_j^j}}_{(2)} + \underbrace{\boldsymbol{v^i L_{ii} \sum_{k \neq j,i} A_{ij} X_k^j}}_{(3)} + \underbrace{\boldsymbol{v^i L_{ii} A_{ij} X_i^j}}_{(4)} + \underbrace{FVAiX_j^i}_{(5)} \qquad \text{(B.3)}$$

The terms (1) to (4) jointly represent the domestic value embedded in exports and correspond to the first term on the right-hand side of Equation B.1. The remainder, i.e. the foreign value added embedded in each of the four terms in Equation B.2, is encapsulated in the import-content term $\mathrm{FVAiX_j^i}$, which represents the upstream/backward links country i draws upon in order to supply country j. Terms (1) and (2) are actual exports from country i to country j, which are either absorbed or remain in j after the first round of processing. Flows captured in the terms (3) and (4), in contrast, only remain in country j for one round of processing, before crossing borders again. They correspond to the vertical specialisation measures (VS1) introduced by Hummels et al. (2001).

B.2 Value added exports

The second concept is based on trade in value added (Johnson and Noguera, 2012), and establishes a direct link between the country where value-added originates ("value added exporter") and the country where it is absorbed ("value added importer"). Trade in intermediaries and multiple counting is thus corrected for. However, the itinerary through which value added

[20] This occurs either in final or in intermediate form and is assumed to be a final destination for the exported goods. This is a necessary simplification, as otherwise it would give rise to an infinite process.

[21] Note that the dimensionality changes from ms to s.

travels is effectively lost and replaced by an artificial bilateral originator-absorber link. Value added exports from country i to country j are given by the following equation:

$$\boldsymbol{VAX}_{\boldsymbol{j}}^{\boldsymbol{i}} = \boldsymbol{v}^{\boldsymbol{i}}\boldsymbol{L}\boldsymbol{f}_{\boldsymbol{j}}, \qquad \text{(B.4)},$$

where $\boldsymbol{f}_{\boldsymbol{j}}$ is a $ms \times 1$ vector of final demand (from all destinations[22]) in country j. $\boldsymbol{L}$ and $\boldsymbol{v}^{\boldsymbol{i}}$ are defined as in equation B.1. The value added trade-concept thus traces back the contribution of country i to country j's final demand, irrespective of the countries through which it is transferred there. Accordingly, Noguera (2012) refers to these contributions as "output transfers". Gross and value added export would be equivalent if only final goods were traded.

[22] This can be seen by re-writing $\boldsymbol{f}_{\boldsymbol{d}} = \sum \boldsymbol{f}_{\boldsymbol{d}}^{\boldsymbol{l}}$, where $\boldsymbol{f}_{\boldsymbol{d}}^{\boldsymbol{l}}$ is the a $mn \times 1$ column vector containing goods and services finalised in country l (country i and country j would be special cases) and absorbed in country j, and zeros otherwise.

Annex C. Gravity models estimation results

Based on the decomposition of Koopman et al. (2010), described in Equation B.3, we iterate through the following alternative dependent variables: (1) total gross exports (E_ij); (2) gross exports of final (consumer) goods (Y_ij); (3) gross exports of intermediate goods (A_ijX_j); (4) gross exports of intermediate goods, which remain in the country after going through the production process (A_ijX_jj); (5) gross exports of intermediate goods, which are embedded in country j's exports to country k (A_ijX_jk); (6) gross exports of intermediate goods, which are embedded in country j's exports to country i (A_ijX_ji), i.e. "re-imports".[23] The respective trade flow variables enter the model in logarithmic transformation.

We regress exports from country i to country j in year t, X_{ijt}, on the bilateral distance (ln_dist), contiguity (contig), a common language index (cl)[24] and common legal origin (comleg) (Equation C.1, Table C.1), using the ordinary least squares (OLS) estimator. The setup includes exporter-year (φ_{it}) and importer-year (φ_{jt}) fixed effects, that account for unobservable factors affecting trade at the level of the exporter and importer, respectively, in a given year. This specification ensures that the model captures multilateral resistance terms and is consistent with theoretical derivation of the standard gravity equation provided by Anderson and van Wincoop (2003).

$$\ln X_{ijt} = \delta_0 + \delta_1 \ln dist_{ij} + \delta_2 contig_{ij} + \delta_3 cl_{ij} + \delta_4 comleg_{ij} + \varphi_{it} + \varphi_{jt} + \epsilon_{ijt} \quad \text{(C.1)}$$

In the model, we also use the bilateral import-content of gross exports, measured as the value added of country o (the originator) embedded in the total gross exports of country i (the exporter), $VAiX_o^i$ (where $o \neq i$) (see Equation C.2, Table C.1). Essentially, this can be thought of as the value added generated in country o "exported" by country i.[25] Note that, as discussed above, the bilateral import-content from country o does not necessarily need to have been imported directly in full and may have entered country i embedded in the imports from third countries.

$$\ln VAiX_{o_t}^i = \delta_0 + \delta_1 \ln dist_{io} + \delta_2 contig_{io} + \delta_3 cl_{io} + \delta_4 comleg_{io} + \varphi_{it} + \varphi_{ot} + \epsilon_{iot} \quad \text{(C.2)}$$

[23] Note that all trade flows considered (1-6) contain both domestic and foreign value added and that trade flows (4-6) are subsets of intermediate trade (3).

[24] The common language index takes into account the linguistic proximity of two languages, even if they are formally distinct. All other things equal, a higher linguistic similarity should facilitate cooperation via lower interpretation and communication costs.

[25] In other words, it is a backward (upstream) link of country i to country o, or, equivalently, the forward (downstream) link of country o via country i.

Annex Table C.1. Baseline gravity model, OLS

VARIABLES	(1) ln_E_ij	(2) ln_Y_ij	(3) ln_A_ijX_j	(4) ln_A_ijX_jj	(5) ln_A_ijX_jk	(6) ln_A_ijX_ji	(7) ln_VAiX_io
ln_dist	-1.055***	-1.003***	-1.096***	-1.091***	-1.107***	-2.234***	-0.834***
	(0.0513)	(0.0551)	(0.0524)	(0.0533)	(0.0526)	(0.103)	(0.0346)
contig	0.216	0.259	0.207	0.208	0.129	0.360	0.252**
	(0.150)	(0.161)	(0.152)	(0.152)	(0.155)	(0.308)	(0.118)
cl	0.674***	0.538**	0.723***	0.709***	0.718***	1.318***	0.637***
	(0.240)	(0.255)	(0.246)	(0.249)	(0.242)	(0.496)	(0.181)
comleg	0.301***	0.336***	0.296***	0.297***	0.291***	0.583***	0.185***
	(0.0658)	(0.0696)	(0.0672)	(0.0683)	(0.0672)	(0.135)	(0.0460)
Observations	26,514	26,506	26,514	26,514	26,514	26,508	26,520
R-squared	0.900	0.894	0.890	0.891	0.885	0.882	0.924
Exporter-Year FE	YES	YES	YES	YES	YES	YES	YES
Importer-Year FE	YES	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Note: The panel includes annual observations for 40 countries over the period 1995-2011. The models include robust variance estimates yielding heteroscedasticity-consistent standard errors, while distance is used as a clustering variable.

We also estimate the model including exporter- and importer-GDP in view of testing how countries' respective economic size – as proxies for supply and demand capacity – affects bilateral trade (Equation C.3, Table C.2). In order to remain consistent with theory and account for the multilateral resistance terms, the pair-specific variables – distance, contiguity, language proximity and common legal origin – are corrected,[26] following the method proposed by (Baier and Bergstrand, 2009) that relies on a Taylor series approximation of the multilateral resistance terms and essentially consists in weighting the bilateral variables.[27] The specification also includes year-fixed effects.

$$\ln X_{ijt} = \delta_0 + \beta_1 \ln GDP_i + \beta_2 \ln GDP_j + \delta_1 \ln dist^*_{ij} + \delta_2 contig^*_{ij} + \delta_3 cl^*_{ij} + \delta_4 comleg^*_{ij} + \varphi_t + \epsilon_{ijt} \quad \text{(C.3)}$$

$$\ln VAiX^i_{o_t} = \delta_0 + \beta_1 \ln GDP_i + \beta_2 \ln GDP_o + \delta_1 \ln dist^*_{io} + \delta_2 contig^*_{io} + \delta_3 cl^*_{io} + \delta_4 comleg^*_{io} + \varphi_t + \epsilon_{iot} \quad \text{(C.4)}$$

[26] Restricting the potential determinants of bilateral trade flows to country- and pair-specific variables of the two countries involved only, would disregard the fact that countries (generally) have more than one bilateral trade partner and that other bilateral trade relationships may create or divert trade – failure to do so would yield a "naïve" version of the gravity model with omitted variable and award the "gold medal" of gravity model errors (Baldwin and Taglioni, 2006).

[27] Specifically, the transformation for the bilateral distance is given by $\ln dist^*_{ij} = \left[\frac{1}{N}\left(\sum_{j=1}^{N} \ln dist_{ij}\right) + \frac{1}{N}\left(\sum_{i=1}^{N} \ln dist_{ij}\right) - \frac{1}{N^2}\left(\sum_{i=1}^{N}\sum_{j=1}^{N} \ln dist_{ij}\right)\right]$. The transformation for contiguity is similar.

Annex Table C.2. GDP-weighted gravity model, OLS

VARIABLES	(1) ln_E_ij	(2) ln_Y_ij	(3) ln_A_ijX_j	(4) ln_A_ijX_jj	(5) ln_A_ijX_jk	(6) ln_A_ijX_ji	(7) ln_VAiX_io
ln_gdp_i	0.807***	0.835***	0.799***	0.790***	0.807***	1.528***	0.598***
	(0.0153)	(0.0168)	(0.0156)	(0.0153)	(0.0186)	(0.0282)	(0.0135)
ln_gdp_j	0.720***	0.725***	0.718***	0.770***	0.570***	0.564***	0.826***
	(0.0148)	(0.0162)	(0.0154)	(0.0153)	(0.0176)	(0.0285)	(0.0138)
ln_dist_star	-1.103***	-1.057***	-1.143***	-1.134***	-1.165***	-2.333***	-0.876***
	(0.0802)	(0.0872)	(0.0808)	(0.0785)	(0.0931)	(0.163)	(0.0692)
contig_star	0.175	0.211	0.168	0.172	0.0793	0.274	0.217
	(0.198)	(0.209)	(0.201)	(0.195)	(0.239)	(0.406)	(0.192)
cl_star	0.670**	0.536	0.722**	0.707**	0.718*	1.309*	0.637**
	(0.331)	(0.358)	(0.332)	(0.320)	(0.396)	(0.674)	(0.324)
comleg_star	0.290***	0.322***	0.284***	0.287***	0.276**	0.558**	0.174*
	(0.108)	(0.115)	(0.109)	(0.104)	(0.129)	(0.219)	(0.101)
Constant	122.7***	115.5***	127.1***	125.2***	130.0***	260.1***	94.46***
	(10.27)	(11.19)	(10.35)	(10.04)	(11.93)	(20.93)	(8.922)
Observations	26,514	26,506	26,514	26,514	26,514	26,508	26,520
R-squared	0.761	0.722	0.750	0.767	0.658	0.688	0.773
Year FE	YES	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Note: The panel includes annual observations for 40 countries over the period 1995-2011. The models include robust variance estimates yielding heteroscedasticity-consistent standard errors, while distance is used as a clustering variable.

Annex Table C.3. Gravity models for exports with interaction terms for CEEC, OLS

VARIABLES	(1) ln_E_ij	(2) ln_Y_ij	(3) ln_A_ijX_j	(4) ln_A_ijX_jj	(5) ln_A_ijX_jk	(6) ln_A_ijX_ji	(X) ln_VAiXio
ln_dist	-0.833***	-0.761***	-0.868***	-0.861***	-0.877***	-1.762***	-0.714***
	(0.0511)	(0.0537)	(0.0534)	(0.0547)	(0.0533)	(0.104)	(0.0345)
ln_dist_ceec_i	-0.365***	-0.405***	-0.384***	-0.389***	-0.401***	-0.755***	-0.196***
	(0.0572)	(0.0613)	(0.0583)	(0.0588)	(0.0591)	(0.0963)	(0.0353)
ln_dist_ceec_j	-0.349***	-0.371***	-0.350***	-0.350***	-0.340***	-0.769***	-0.196***
	(0.0510)	(0.0533)	(0.0548)	(0.0552)	(0.0554)	(0.0986)	(0.0361)
contig	0.00709	0.113	-0.0334	-0.0355	-0.145	-0.0344	-0.0235
	(0.161)	(0.174)	(0.162)	(0.163)	(0.158)	(0.337)	(0.125)
contig_ceec_i	0.350**	0.126	0.411**	0.409**	0.476***	0.565*	0.260*
	(0.178)	(0.204)	(0.174)	(0.175)	(0.176)	(0.339)	(0.140)
contig_ceec_j	0.168	0.217	0.191	0.199	0.214	0.399	0.460***
	(0.178)	(0.211)	(0.173)	(0.173)	(0.178)	(0.335)	(0.137)
cl	0.731***	0.575**	0.812***	0.804***	0.787***	1.407**	0.659***
	(0.265)	(0.290)	(0.268)	(0.272)	(0.264)	(0.560)	(0.198)
cl_ceec_i	0.792**	1.039***	0.740**	0.639*	0.953***	0.454	-0.302
	(0.340)	(0.398)	(0.347)	(0.351)	(0.348)	(0.522)	(0.254)
cl_ceec_j	-0.497	-0.645*	-0.536	-0.465	-0.640*	0.388	0.599**
	(0.342)	(0.365)	(0.358)	(0.363)	(0.360)	(0.528)	(0.237)
comleg	0.210***	0.242***	0.211***	0.210***	0.207***	0.446***	0.141***
	(0.0760)	(0.0789)	(0.0784)	(0.0796)	(0.0782)	(0.158)	(0.0533)
comleg_ceec_i	-0.398***	-0.223*	-0.448***	-0.441***	-0.425***	-0.354*	0.0829
	(0.120)	(0.132)	(0.132)	(0.133)	(0.135)	(0.195)	(0.0916)
comleg_ceec_j	0.185	-0.0146	0.195	0.197	0.157	-0.313	-0.252***
	(0.124)	(0.126)	(0.134)	(0.134)	(0.137)	(0.197)	(0.0883)
Observations	26,514	26,506	26,514	26,514	26,514	26,508	26,520
R-squared	0.910	0.904	0.901	0.901	0.896	0.897	0.931
Exporter-Year FE	YES	YES	YES	YES	YES	YES	YES
Importer-Year FE	YES	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Note: The panel includes annual observations for 40 countries over the period 1995-2011. The models include robust variance estimates yielding heteroscedasticity-consistent standard errors, while distance is used as a clustering variable. The ceec_i and ceec_j suffixes indicate that the variable is interacted with a CEE exporter dummy and a CEE importer dummy respectively.

Annex Table C.4. CEEC: Gross exports by product category and origin
as percentage of gross exports and GDP; 2008

	Gross Exports					Gross Exports		Forward link (as % of GDP)
	Final goods	Intermediate goods				Domestic value added	Foreign value added	
			consumed	exported further	shipped back			
	a	b	c	d	e	f	g	h
Bulgaria	31.8	68.2	47.1	21.0	0.1	56.1	43.9	6.9
Czech Republic	37.6	62.4	39.2	22.6	0.7	54.5	45.5	9.3
Estonia	29.5	70.5	49.0	21.3	0.2	62.3	37.7	7.6
Hungary	38.7	61.3	39.3	21.6	0.4	51.9	48.1	8.6
Lithuania	30.2	69.8	50.0	19.5	0.3	60.2	39.8	5.9
Latvia	31.2	68.8	48.1	20.4	0.3	71.1	28.9	5.3
Poland	39.7	60.3	38.8	20.9	0.6	67.4	32.6	5.9
Romania	32.3	67.7	46.7	20.6	0.3	72.0	28.0	4.5
Slovakia	38.3	61.7	38.3	22.9	0.4	53.4	46.6	9.8
Slovenia	40.0	60.0	39.4	20.5	0.1	58.8	41.2	7.4
Memo items								
EU	37.8	62.2	42.4	18.4	1.4	68.5	31.5	5.3
World	32.9	67.1	48.4	16.3	2.3	73.7	26.3	3.9

Source: WIOD, authors' calculations.

Annex D. Robustness test: Poisson Pseudo-Maximum Likelihood Estimator

The empirical analysis presented in this paper is based on gravity models estimated by ordinary least squares (OLS). However, Santos Silva and Tenreyro (2006) show that the parameters of log-linearized models (such as the gravity equation) estimated by OLS may under certain circumstances be biased and inconsistent. To surmount this problem, they propose a non-linear Poisson Pseudo-Maximum Likelihood (PPML) estimator. In order to test the robustness of our results obtained with OLS, we re-estimate the regressions with the PPML estimator. Overall, the estimates are broadly comparable in sign and statistical significance, hence supporting our conclusions (see Annex Table D.1).[28]

Annex Table D.1. FDI-augmented gravity models for exports; PPML

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	E_ij	Y_ij	A_ijX_j	A_ijX_jj	A_ijX_jk	A_ijX_ji
ln_dist	-0.499***	-0.508***	-0.504***	-0.497***	-0.463***	-0.976***
	(0.0309)	(0.0358)	(0.0311)	(0.0315)	(0.0371)	(0.0699)
contig	0.424***	0.444***	0.407***	0.417***	0.285***	0.581***
	(0.0813)	(0.0861)	(0.0868)	(0.0853)	(0.0948)	(0.171)
cl	-0.00455	-0.359*	0.162	0.149	0.355*	-0.502
	(0.169)	(0.194)	(0.170)	(0.168)	(0.185)	(0.387)
comleg	0.230***	0.288***	0.214***	0.175***	0.204***	0.854***
	(0.0636)	(0.0700)	(0.0641)	(0.0658)	(0.0684)	(0.142)
lnfdi_ji	0.145***	0.134***	0.148***	0.147***	0.152***	0.416***
	(0.0214)	(0.0249)	(0.0201)	(0.0209)	(0.0211)	(0.0485)
Observations	9,381	9,381	9,381	9,381	9,381	9,381
R-squared	0.928	0.931	0.925	0.931	0.856	0.983
Exporter-Year FE	YES	YES	YES	YES	YES	YES
Importer-Year FE	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Note: The panel includes annual observations over the period 1995-2011. The models include robust variance estimates yielding heteroscedasticity-consistent standard errors, while distance is used as a clustering variable.

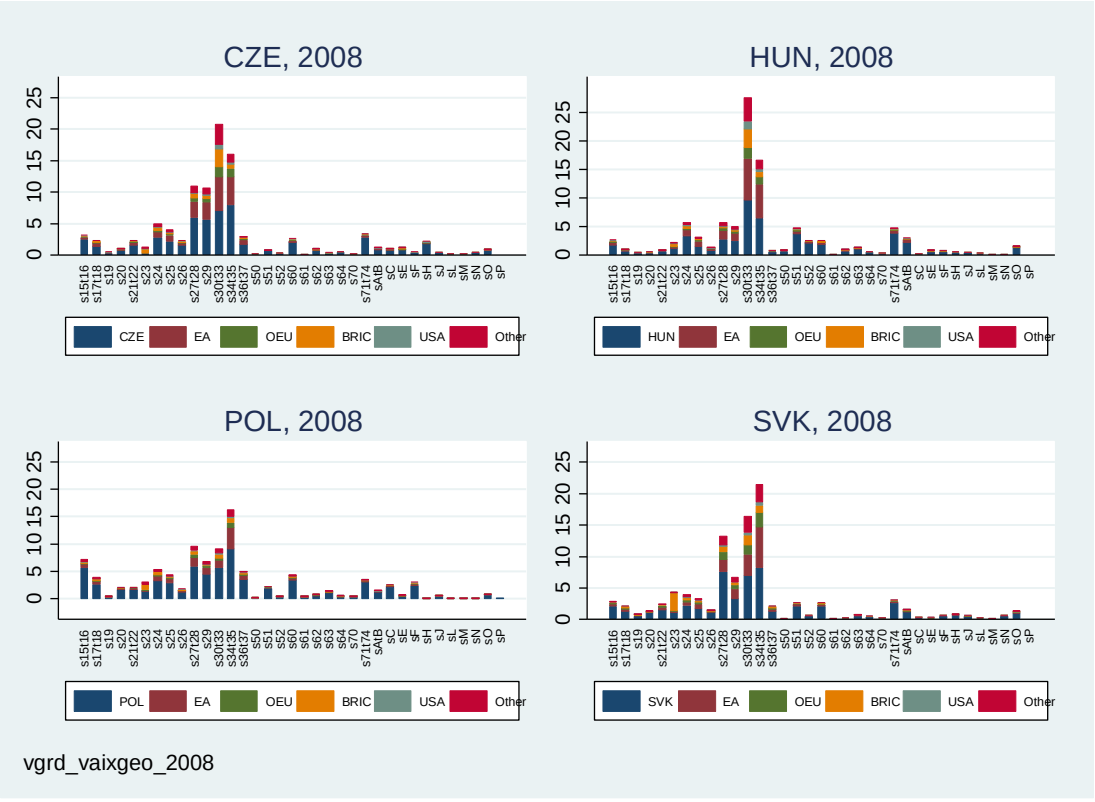
[28] Further estimation results using PPML are available upon request.

Annex E. CEEC: stylized facts on sectors and production sharing

In this annex we analyse how the sectorial composition of CEEC exports affects countries' participation in GVCs. CEEC exports are generally highly concentrated in a few sectors. In the Czech Republic, Hungary and Slovakia, for example, "Electrical and optical equipment" (sector 30t33) and "Transport Equipment" (sector 34t35) jointly account for more than a third of gross exports. In the other CEEC, the export basket is somewhat more dispersed (see Annex Charts E.1 and E.2), even though in some countries individual sectors may account for a large export share, e.g. "Coke, Refined Petroleum and Nuclear fuel" (23) in Lithuania and Bulgaria, or "Basic Metals and Fabricated Metals" (27t28) in Bulgaria.

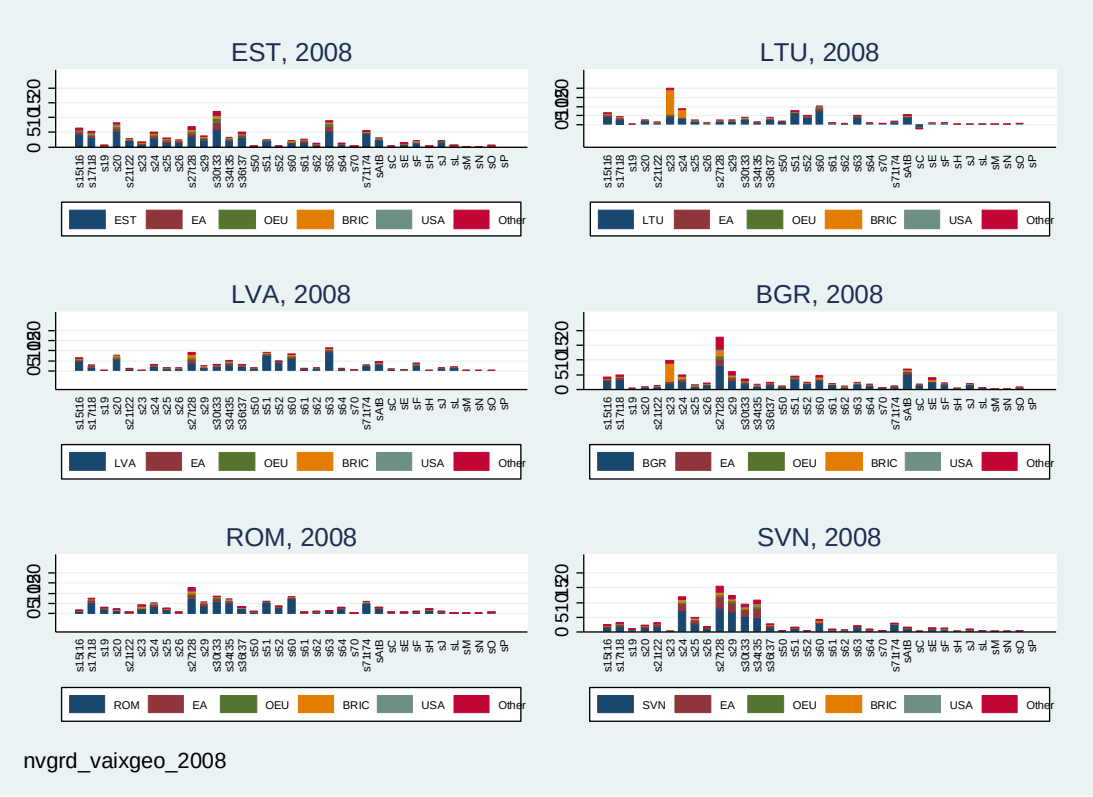
The stacked colour blocks composing the individual bars (Annex Chart E.1) provide information on the geographic "footprint", i.e. the distribution of the origin of the value added embedded in exported products. The part contributed by firms in the exporting country (i.e. the domestic value added embedded in exports, *DVAiX*) is represented by the blue segment, while the other colours represent the value added share generated in other countries or groups of countries (i.e. the foreign value added embedded in exports, *FVAiX*).

Annex Chart E.1. Exports shares and composition of value added
as percentage of gross exports; 2008



Source: WIOD, authors' calculations.
Note: For sector codes see Annex Table A.1.

Annex Chart E.2. Exports share and composition of value added
as percentage of gross exports; 2008

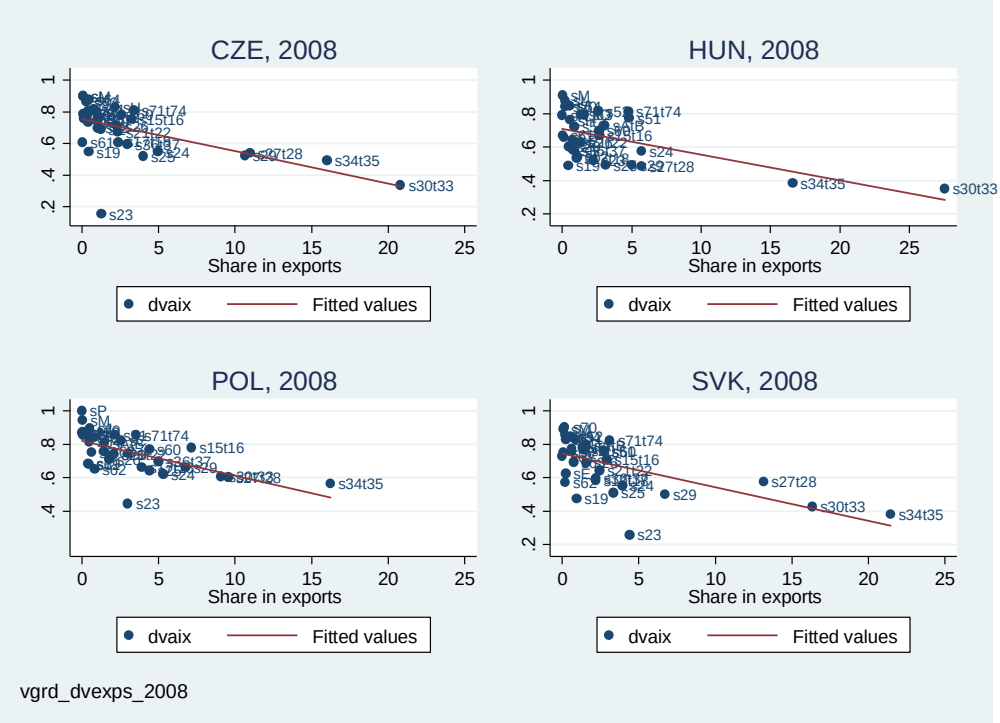


Source: WIOD, authors' calculations.
Note: For sector codes see Annex Table A.1.

The sector-specificity of the geographical "footprint" clearly emerges. Indeed, the domestic-to-foreign content ratio strongly varies from one sector to another, depending on the complexity of the goods it produces: whereas some sectors' exports predominantly consist of domestic value added (e.g. "Food, Beverages and Tobacco", 15t16), others are largely made up of foreign inputs. Likewise, the distribution of the origin of the foreign inputs is uneven across sectors and supports the view of a sector-specific geography of value chains: whereas inputs originating in EU countries account for the bulk of exports of "Transport Equipment" (sector 34t35), inputs sourced from the BRIC countries appear to be more concentrated in "Electrical and optical equipment" (30t33). Furthermore, it is striking that the largest export categories generally feature the strongest foreign import-content. footprint and contain relatively low shares of domestic value added (blue segment), i.e. the more export-oriented a sector, the higher is its import-content.

We document a negative relationship between a sector's share in the export basket and the domestic value added contained in exports for the Visegrad countries (see Annex Chart E.3). It is particularly pronounced for the Czech Republic and Hungary and clearly illustrates the "assembled in" versus "made in" dichotomy.

Annex Chart E.3. Value added and gross exports shares by sectors
In % of total value added; in % of gross exports; 2008



Source: WIOD, authors' calculations.
Note: For sector codes see Annex Table A.1.

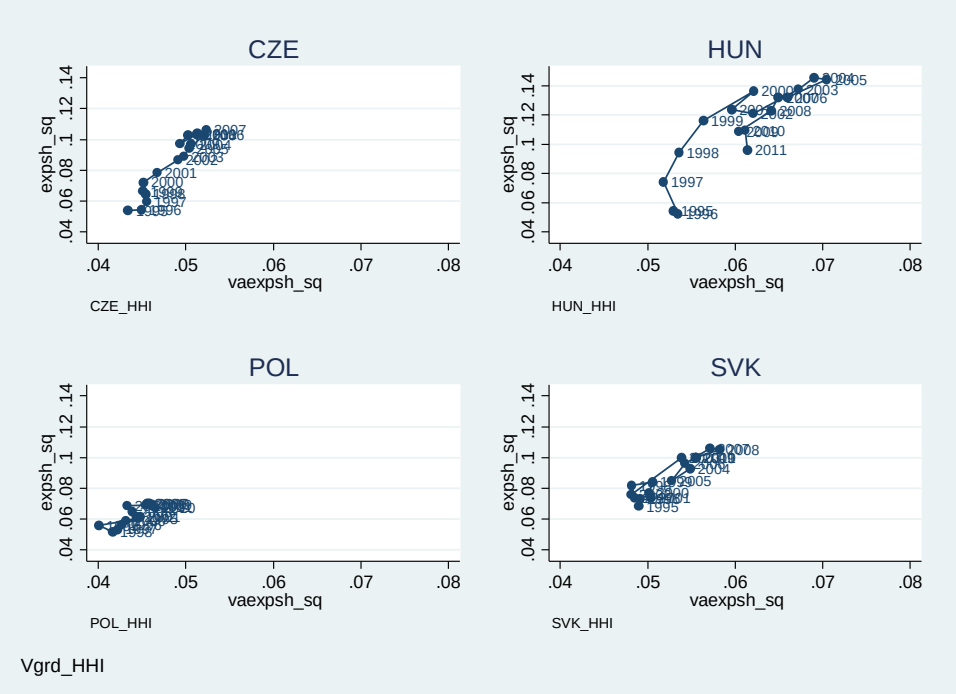
The concentration of gross exports has clearly risen over time in several CEEC – specifically in the Czech Republic, Hungary, and Slovakia – under the dominance of the automotive and electronics sectors. In comparison, the concentration of value added exports is generally lower and its changes over time have been less pronounced. This implies that the gross export structure only partially reflects of the structure of trade revenue generation (see Annex Chart E.4).[29]

The export concentration, measured by the Herfindal-Hirschmann index, is a gross rather than a value added phenomenon, reflecting the uneven reliance on imported inputs across sectors (Annex Chart E.4). Given that foreign input-reliance is first and foremost a characteristic of manufacturing sectors, the manufacturing share in gross exports is significantly higher in gross than in value added exports. The converse is accordingly true for services. It may also occur that more value added generated by a particular sector is consumed abroad than was actually exported directly by it. This is a reflection of the fragmentation of production at the domestic level, as some traditionally "non-tradable" sectors become *de facto* exporters by supplying inputs to export industries. To approximate the indirect dependence of a sector on foreign demand we compare sector's value added exports and gross exports (see Annex Chart E.5), the so-called VAX ratio (Johnson and Noguera, 2012). A positive value of the VAX-ratio indicates that a sector's exported value added exceeds its gross exports, and vice versa. These indirect exports of value added challenge the

[29] The divergence in the concentration for gross exports and value added also reflects the structural changes that occurred over time, notably the complexification or quality upgrade of the production processes of many manufacturing sectors, for which sourcing inputs abroad constitutes a necessity.

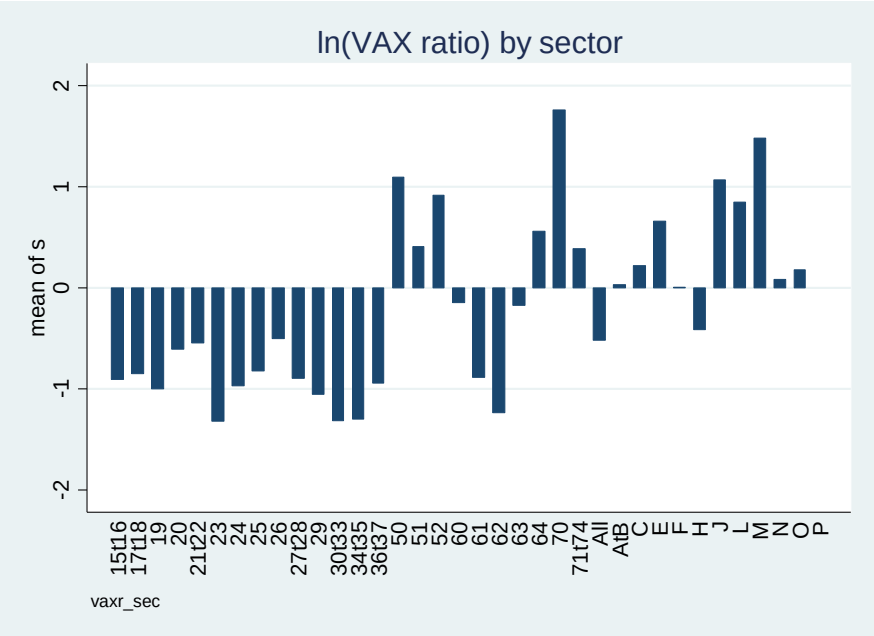
traditional distinction between tradable and non-tradable sectors, in particular when the export-orientation of an economy exposes domestic non-exporters to foreign demand shocks. While the presence of export industries may potentially bring about advantageous cluster effects, the indirect links may also imply an alignment on the risks to foreign shocks faced by direct exporters. This has indeed been visible with the propagation of the 2009 trade collapse to indirect exporters, dragging down their exported value added (Nagengast and Stehrer, 2015).

Annex Chart E.4. Gross exports and value added concentration
(Herfindal-Hirschman index)



Source: WIOD, authors' calculations.
Note: The Herfindal-Hirschmann index is defined as follows : $HHI = \sum_{i=1}^{S} s_i^2$, where s_i is the share of sector i in the export basket, and $S = 35$, and is thus bound between $1/S$ and 1, where a higher value indicates that exports are concentrated in fewer sectors.

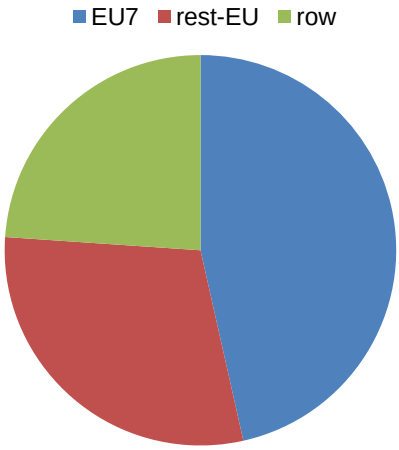
Annex Chart E.5. CEEC VAX-ratio
2008



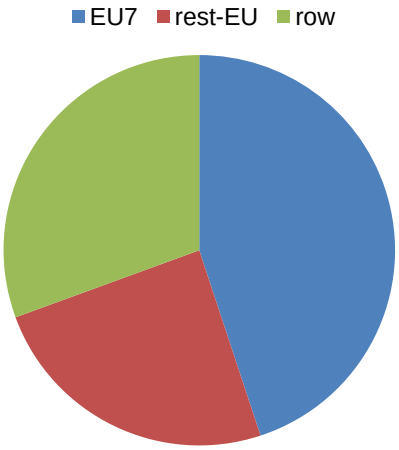
Source: WIOD, authors' calculations.
Note: The VAX ratio is the ratio between value added exports and gross exports. Expressed in logs, a positive value indicates that a sector transfers more value added abroad than it exports directly.
See Table A.1 for sector notation.

Annex Chart E.6. Central and eastern European countries…

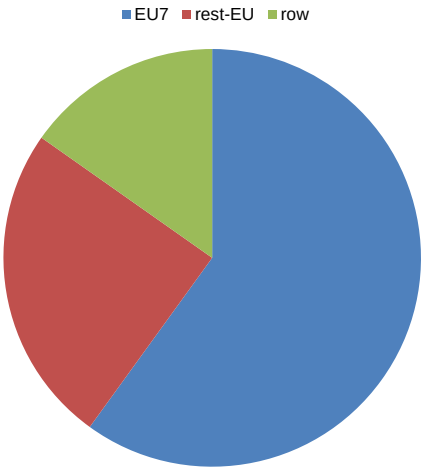
export to…



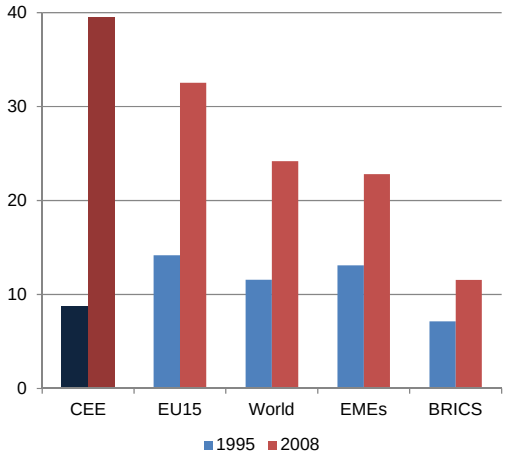
import from…



receive FDI from…

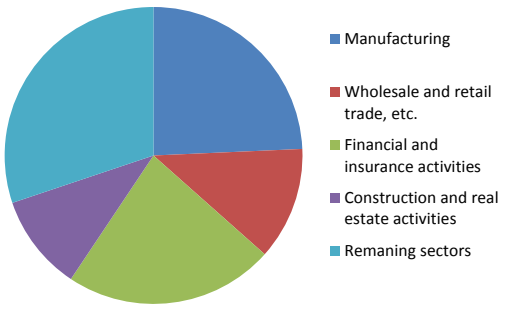


…and belong to the largest recipient of FDI.

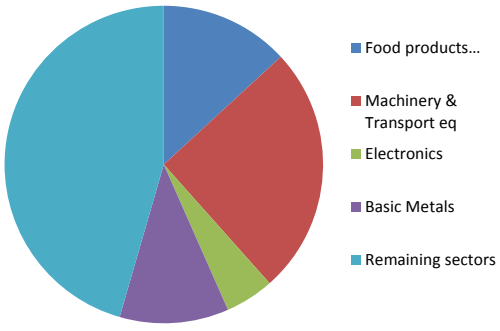


Source: WIOD, UNCTAD, IMF DOTS, wiiw FDI database and authors' calculations. Note: Pie charts refer to the year 2008. The bottom right charts shows inward FDI as percentage of regional nominal GDP.

Total FDI stock by sector



FDI stock in manufacturing



Source: wiiw FDI database. Note: 2012 for SVK; NACE 2; NACE 1 for BGR and HRV. Data for 2013.

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