Trade Balances and Global Value Chains: is there a link?

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Abstract

This paper assesses whether and how the participation to Global Value Chains (GVCs) contributes to trade imbalances. We test empirically the relationship between GVCs participation and a country's net export for 42 countries in the period 2000-2014, using the World Input - Output Database (WIOD) on international production linkages. We find that trade balance is positively associated with countries' involvement in GVCs, but the trade balance worsens the higher the offshoring to lower-income countries, while it improves the higher the offshoring to higher-income countries. This asymmetry suggests that when countries offshore to higher-income partners the gains in competitiveness overcome the potentially negative effect of larger imports of intermediate inputs.
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1. Introduction

Intermediate goods account for the large majority of international trade flows and most analyses suggest that Global Value Chains (GVCs) are responsible for at least half and possibly two thirds of world trade (WTO, 2019; World Bank 2020). The rapid increase of international trade in intermediate and semi-finished goods in the past twenty years gave rise to an extensive literature trying to understand how the shift from trade in final goods to this 'vertical trade' affected the trade patterns and specialization of countries (Deardorff, 2001; Hummels et al., 2001; Yi, 2003; Jones et al., 2005; Baldwin and Lopez-Gonzalez, 2013). The growing relevance of trade in intermediate goods is directly related to the expansion of international fragmentation of production (IFP), or the development of international production chains stretching across different countries, where the various production phases

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and the creation of value added for a given final good is taking place in different locations. This phenomenon, initially studied especially for the US, has become increasingly relevant also for the European Union (EU), for East Asia and other areas of the world.

International fragmentation of production and the high share of intermediate goods on overall trade flows led scholars to partially revise the traditional measures of trade flows across countries and the related indexes of comparative advantage (Deardorff, 2005; Baldone et al., 2007; Stehrer, 2012; Koopman et al., 2014), while generally less attention was devoted to the implications of this type of trade for countries' trade balances. The macroeconomic effects of the participation to GVCs started to be discussed more recently in the international economics literature (Feenstra, 2010), also stimulated by the widening trade imbalances and sharp trade fluctuations registered before and during the global financial crisis of 2008 (Levchenko et al., 2010; Gopinath and Neiman, 2014). In the decade following the financial crisis and the subsequent macroeconomic corrections, a partial rebalancing was observed in many countries (e.g. in the U.S. and China), and in many EU countries trade balances have been improving (e.g. Italy and Poland). Given the persistence of many other imbalances, in a medium-term perspective it is important to understand their determinants (Cheung et al., 2012; Afonso and Jalles, 2019). Trade balances in fact are still at the center of many economic policy debates, as the trade tensions between the U.S. and China clearly display.

In this work, we want to focus on the structural components of trade balances. Specifically, we aim to understand how the extent and form of participation of a country in the global value chain might affect the amount of its exports and imports in the medium term.

The issue is also relevant for the European countries. EU Member States appear differentiated in their external position (Guerrieri and Esposito, 2012; Belke and Dreger, 2013). As EU countries were affected by the financial crisis, it became apparent that one of the dimensions of the EU problems was the persistent difference in its members' trade balances. These differences shrunk after the crisis, but not completely. While there can be a number of standard macroeconomic reasons

for these imbalances (Obstfeld and Rogoff, 1998), from asymmetric shocks to fiscal policies to international capital flows, the debate highlighted also the role of the different evolution of competitiveness among EU members in producing this result (Baldwin and Giavazzi, 2015). This became a reason of concern as the correction of this divergence could not rely on adjustments in the external value of the euro. In order to understand this phenomenon and design the appropriate policy measures, not only domestic variables (such as the wage trend or the public expenditure changes) need to be considered, but the new vertical specialization of EU is an additional structural factor to be taken into account, and the evolution of the trade balance should be assessed accordingly (Landesmann and Stllinger, 2019).

In this paper, we explore the possible relationship between the trade imbalances and the participation to GVCs, and we investigate empirically whether a country's involvement in GVCs is a potential medium-term determinant of its trade balance, along with the other structural medium-term determinants already highlighted by the macroeconomic literature. There are several channels potentially linking GVCs to trade balances, that we conceptually explore in the next section. First of all, an accounting channel is at work since GVC participation generates trade in intermediate goods crossing the border several times. GVCs are also likely to enhance a country's competitiveness, by allowing to either a reduction in costs or an increase in quality of goods. An income channel is also likely be at work since GVCs affect income distribution both within and between countries.

We compute an indicator of a country's participation in the GVCs, the share of foreign value added in a country's gross export, recently proposed by Koopman et al. (2014), by using the last release of the World Input - Output Database (WIOD). In order to explore the relationship between participation in the GVCs and the trade balance, we then employ an empirical model of medium-term determinants of the external balance along the lines of Chinn and Prasad (2003), recently applied to the crisis context by Lane and Milesi-Ferretti (2012), and the lines suggested by the IMF methodology for the External Balance Assessment procedure (Phillips et al., 2013).

We make two main contributions to the extant literature, in particular to Brumm

et al. (2019), the closest contribution to our work. First, we split the GVC participation index of each country by groups of partners to which a country offshores, where groups are formed according to the partner's product quality. Such splitting, together with disentangling the exports and imports component in the trade account, aims to better investigate the channels through which GVC participation affects the external position. Second, we focus on the sample of EU countries — which fits well with the country coverage of WIOD — and investigate the relative role of intra-EU vs. extra-EU value chains, both pooling all trade partners and by type of partner (lower- vs higher-quality).

Our results show that the involvement of a country in GVCs is on average positively associated to its trade balance. However, the sign of the relationship crucially depends on the partners in the production process. The trade balance worsens the higher the backward participation in the GVCs of lower-income/lower-product quality countries, i.e. the larger the use of lower-quality inputs. This evidence suggests that when countries import lower-quality inputs, the negative accounting relationship between importing intermediate inputs and the trade balance is not compensated by the potentially positive effect of gaining competitiveness through more efficient production processes thanks to GVCs. On the other hand, the higher the amount of inputs from higher-income/higher-product quality countries the more the trade balance improves, suggesting that incorporating higher-quality imported inputs into production allows the competitiveness channel to prevail. This result is made clearer when carrying out our analysis by focusing on exports and imports separately. GVCs do positively affect both exports and imports, but offshoring to higher-income partners affects exports more than imports, while the opposite occurs when offshoring to lower-income countries takes place. Lastly, probably owing to the features of the data we use, the aggregate results are mainly driven by the group of countries belonging to the EU. By focusing on the latter, we show that intra-EU partners in the GVC are not more relevant than extra-EU partners. However, splitting by the type of partner reveals some interesting heterogeneity: while offshoring to lower product-quality partners has similar effects irrespective of EU vs. non-EU location, the positive effect of high product-quality partners is much

larger for non-EU partners. This could be explained by the higher competitive-enhancing effect generated by importing high-technology intermediate goods from more technologically advanced countries (e.g. the US and Japan).

The structure of the paper is as follows: the next section gives some theoretical insights, based on the existing literature, on the channels behind the relationship between GVCs and trade balances, motivating our analysis; Section 3 illustrates some descriptive evidence of countries' involvement in GVCs and trade balances; in Section 4 we present the empirical framework for the estimation of the relationship between GVCs and trade balances, while Section 5 reports the main results, further explorations on the potential channels and some sensitivity analysis; Section 6 concludes.

2. Theoretical framework

Countries' external imbalances have generally been explained by the 'traditional' macroeconomic factors, i.e. by countries' differences in their macroeconomic fundamentals, in line with the intertemporal approach to current account determination (Obstfeld and Rogoff, 1998). However, these explanations are only part of the story, and also structural components might play a relevant role, affecting production efficiency and competitiveness (Collignon, 2013; Punnose and Peersman, 2013), and giving rise to different responses across countries (Afonso and Jalles, 2019).

Our analysis moves from these considerations, looking at one specific feature of the international trade linkages of countries, i.e. their involvement in the international fragmentation of production and in GVCs, which impacts directly on countries' trade flows and competitiveness. We therefore anticipate that countries' involvement in GVCs should be assessed as a potential medium-term determinant contributing to their trade balance.

There is no clear *a priori* prediction of the sign of the effect of GVC participation on a country's trade balance, as the trade flows generated by this organization of production affect simultaneously different aspects of an economic system. First of all, there can be an *accounting effect*, because a higher share of imported intermediates in exports means that the country imports more relative to its exports; besides

this, there is a potential re-importing channel which is the one that motivated the distinction between trade flows in gross terms and in value added terms (Yi, 2003; Johnson and Noguera, 2012; Koopman et al., 2014; Nagengast and Stehrer, 2016). Considering a specific country pair in the global value chain, exporting intermediate and semi-finished goods and re-importing finished and assembled goods can give rise to a trade deficit (both in gross terms and in value added terms, but with different magnitudes) for the country in the upstream part of the international production chain, while it can originate a trade surplus for downstream countries. In this case, the sign of the effect differs according to the position of countries in the international production chain.

Secondly, if this international reorganization of production allows countries to improve their competitiveness and to gain access (even indirectly) to new export markets, the *competitiveness effect* on trade balances can be positive for all countries involved. This competitiveness channel can develop along different lines. Higher competitiveness through international fragmentation of production can be reached through cost and, therefore, price reduction (Deardorff, 2001); it can arise through technological improvements or factors' productivity enhancement (Grossman and Rossi-Hansberg, 2008; Jabbour, 2010; Schwörer, 2013; Halpern et al., 2015) and through the quality of intermediate inputs and components from abroad incorporated in a country's final product. Several recent contributions have highlighted the link between the quality of inputs and the quality of output and the role of non-price competitiveness in countries' external performance (Verhoogen, 2008; Kugler and Verhoogen, 2012).

Finally, a country's involvement and position in the global value chain can also be related to its external position through *income effects*. International fragmentation of production can affect both the within and between countries' income distribution depending on a country's position in the global value chain and the tasks offshored (Grossman and Rossi-Hansberg, 2008; Costinot et al., 2013, 2014; Timmer et al., 2013, 2014; Lin et al., 2018), with ambiguous consequences on the trade balance.

The sign and magnitude of the effects of international fragmentation of production on a country's medium-term external position are thus open to empirical

investigation, as we do here, contributing to three main streams of literature.

Our analysis contributes to the stream of literature recently emerged on measures of countries' involvement in the global value chain (Koopman et. al., 2014; Timmer et al., 2014, 2015) by looking at their relationship with the aggregate external position. The contributions belonging to this already large stream of literature provide new sophisticated indicators, new data and conceptual categories on the international fragmentation of production, showing several stylized facts on trade specialization patterns highlighting the difference in gross and net terms, factor income shares' dynamics and patterns across countries, and patterns of foreign and domestic value added content in gross export and production (Daudin et al., 2011; Antras et al., 2012; Johnson and Noguera, 2012; Stehrer, 2012; Timmer et al., 2013). In particular, some recent contributions investigate the relationship between integration into international supply chains and the exchange rate (Johnson, 2014; Bems, 2014; Bems and Johnson,2017; De Soyeres, et al., 2018), arguing that in presence of GVCs the relevant exchange rates are not only those of the immediate trade partners. Our work also expands the literature on medium-term determinants of external imbalances, by investigating the role of a country's participation in GVCs as a potential determinant of its external position.

To the best of our knowledge, the closest contribution to our work is Brumm et al. (2019). The authors use WIOD data (first release) to investigate the relationship between international fragmentation of production and current account for a group of 29 countries for the period 1995-2011. They find a positive relationship between GVC participation and the current account for the whole sample. By using the new release of WIOD data for 42 countries for the period 2000-2014, we extend the country coverage and we include more recent years. Beyond that, as highlighted in the Introduction, we extend their work along two main directions. Firstly, we try to go a step further in exploring the channels through which the average effect occurs. We investigate the potential role of the 'type' of partner in GVC relationships, by splitting the partners where a country off-shores into two groups according to their product quality level. We also decompose the net external position in its export and import components. Secondly, in addition to analysing the aggregate relationship

between GVCs and a country's external position, for EU countries, we investigate the relative role of intra-EU vs. extra-EU partners, also by partner type.

In order to better identify those channels, we focus on backward participation in GVC, following Koopman et al. (2014) definition. In other words, we consider how much foreign value added embodied in intermediate inputs a country imports to be able to produce and eventually export goods that are final or closer to the final production stage, as this type of participation allows to clearly identify specific effects on inward and outward trade flows. We are aware that this is a partial measure of GVC participation, as to fully measure GVC participation one should also consider forward participation, that is export of domestic value added in intermediate goods to be embodied in downstream production phases in other countries. But forward participation *per se* has a positive accounting effect on the trade balance, which could confound the identification of the positive competition channel we are most interested in. For this reason, we consider backward participation only, differently from Brumm et al. (2019).

Last but not least our paper contributes to the fast-growing literature on non-price competitiveness and the role of quality in international trade (among others, Hallak, 2006; Verhoogen, 2008; Crozet et al., 2012; Feenstra and Romalis, 2014), explicitly considering the role of input quality in assessing the effects of a country's participation in international fragmentation of production.

3. Trade balances and Global Value Chains

As mentioned, in the last two decades there have been large shifts in the trade balance of many countries. Figure 1, Panel (a), shows the widening and then the relative reduction of the U.S. trade deficit, with a (only partial) symmetry in the (larger) widening and reduction of the Chinese trade surplus. In the EU, we observe the nearly continuous improvement of the trade balance of Germany, but also of the Czech Republic and Poland, while Italy's trend is more unstable (Figure 1, Panel (b)). Some of the observed changes in trend appear related to the economic cycle (for example, the effect of the global financial crisis of 2008 is clearly visible), but this is not the whole story. The goal of this paper is to relate part of these imbalances

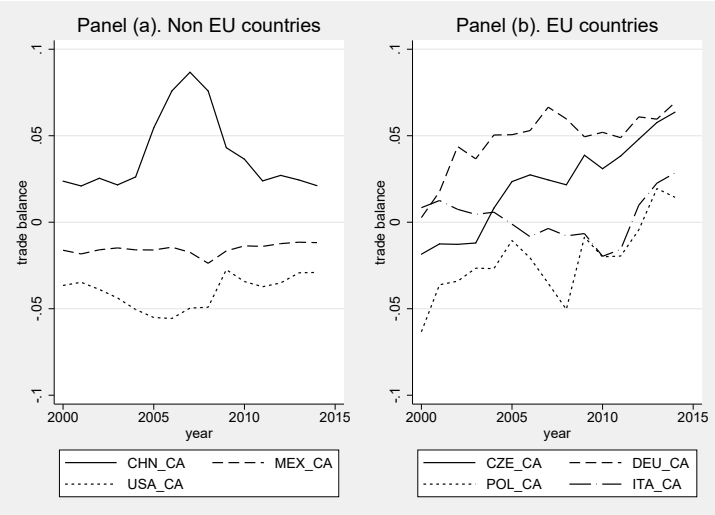
to participation to GVCs.

All countries considered in our sample are involved in global or regional value chains, but with remarkably different roles and positions. To assess this participation, we build one of the indices developed to this aim, the share of foreign value added on the value of gross exports. The data used to build our measure of GVC participation come from WIOD dataset (second release, 2016). The database is built on national accounts statistics, national input-output tables and national supply-use tables for 43 countries for the period 2000-2014, including all twenty-eight members of the European Union (as of July 1, 2013) and fifteen other major economies (the list of countries is reported in Section 8.1). As described in detail by Timmer et al. (2016), these countries have been selected aiming at higher data quality, at the same time obtaining a large coverage of the world economy. Countries in WIOD cover more than 85 per cent of world GDP (at current exchange rates). The dataset include a category, called the 'rest of the world' region, estimated to capture the remaining part of the world economy.

[1] In particular, the database provides domestic and international input-output flows for two-digit industries. Since its release, WIOD dataset has been used intensively in the economic analysis of GVCs, as it was built also with this specific purpose. In our analysis, the choice of relying on WIOD data is motivated by the rationale behind the construction of the World Input Output tables in the WIOD data, i.e. the consistency with the System of National Accounts, and therefore with its concepts and accounting identities, together with consistency over time. This makes WIOD the best choice for the purpose of this paper. Indeed, exploring the relationship between GVC participation and a country's current account, given the macroeconomic framework, clearly requires reliable GVC data consistent with reliable national accounting statistics. This comes at the cost of a smaller number of countries and a shorter time interval with respect to other datasets (like Eora),

[1] As reported by Timmer et al. (2016), in 2014, 54% of global imports consisted of trade between WIOD countries, 21% were WIOD countries' imports from rest-of-the-world, 16% were WIOD exports to rest-of-the-world and 9% was trade between countries in the rest-of-the-world region (Timmer et al., 2016). For a detailed description of the dataset, see Stehrer et al. (2014) and Timmer et al. (2016).

Figure 1: Trade balance in % of GDP for selected Non-Eu and EU countries, 2000-2017



Source: our elaborations on World Bank WDI database.

providing Inter-Country Input Output tables for a larger set of countries, in particular low-income countries, but missing the consistency with national aggregates and across time periods.

It is also worth noting, beyond data issues, that there are other reasons to exclude low-income countries from the analysis of the relationship between current account and GVC participation. As underlined also by Lane and Milesi-Ferretti (2012) in low income countries there are other factors, depending on institutional and policy agreements, typically playing a relevant role in their current accounts, like for instance, external aid, debt reduction or forgiveness agreements. The role of those factors, according to the authors, makes quite difficult and probably meaningless to quantify the relative role of standard macroeconomics and structural determinants of the current account for these countries. Additionally, for many less developed countries, participation to GVCs is often limited to providing raw materials and commodities (see for example by Foster-McGregor et al, 2015, and Smeets, 2021), and this reduces the role of the channels we are focusing on in this paper. This type of forward GVC participation based on commodities generates mainly exports, embodying very low values of foreign value added, with more direct effects on the trade balance.

The availability of inter-country input - output tables allowing to separate the use of domestic and imported intermediate inputs in production makes it possible to compute the domestic and foreign contribution to value added in final goods (see Koopman et al., 2014). According to Johnson (2014) and Bems (2014) trade flows measured in gross and value added terms could be differently related to the external position of a country. Following this intuition, by using the WIOD database and following Koopman's methodology, we decomposed domestic and foreign value added in countries' gross exports to obtain the aggregate measures of foreign shares of value-added incorporated in country s gross exports:

$$\mathsf{FVA_i} = \mathsf{FV_i}/\mathsf{E_{i*}} \tag{1}$$

where $\mathsf{FV_i}$ is the foreign value-added incorporated in country i gross exports ($\mathsf{E_{i*}}$).[2] The values of this indicator are reported in Table 1 below.

The foreign value added content of gross exports (FVA) shows high variations across countries, both in terms of the absolute level and in terms of change over time. On average, smaller countries tend to be more open, also with respect to GVC participation. All EU countries display a relatively high level of participation in GVCs compared to other areas of the world, and an increase of the index over time (with the only exception of Cyprus), confirming the growing involvement of EU members in GVCs worldwide (Zhou et al., 2019). For some countries - such as Greece or Italy - the increase is remarkable, for others is quite small (like Sweden). In other areas of the world we also observe sizable increases of the FVA index (e.g. Japan, Korea, USA), but there are also countries displaying a reduction (like Canada, and more remarkably China). In particular, it is worth noting that, according to the ranking in terms of FVA in 2014, countries in the top three quartiles belong mostly to the EU (with only 5 exceptions, including Turkey and Switzerland), suggesting that the ratio of GVCs trade over total trade is larger in EU countries, as highlighted by recent IMF analyses (IMF, 2019). It is also worth noting that the FVA originating in the Rest of the World aggregate is about one forth.

[2]For the derivation of the index, see Appendix 9.1.

Table 1: Measures of participation in Global Value Chains

Country	Foreign Value Added 2000	Foreign Value Added 2014
Luxemburg	0.5527	0.6594
Malta	0.5750	0.6526
Hungary	0.4766	0.5170
Ireland	0.4062	0.4914
Slovakia	0.3822	0.4793
Czech Rep.	0.3132	0.4564
Belgium	0.3719	0.4561
Estonia	0.3545	0.4335
Taiwan	0.3749	0.4142
Bulgaria	0.3118	0.3815
Denmark	0.3104	0.3734
Slovenia	0.3293	0.3724
Netherlands	0.2550	0.3603
Austria	0.2844	0.3583
Lithuania	0.2303	0.3565
Finland	0.2590	0.3487
Korea	0.2977	0.3479
Mexico	0.3244	0.3329
Portugal	0.2778	0.3106
Latvia	0.2387	0.3090
Spain	0.2553	0.3085
Poland	0.2456	0.3069
Greece	0.1896	0.3036
Sweden	0.2799	0.2850
Turkey	0.1615	0.2840
Cyprus	0.3247	0.2799
France	0.2373	0.2724
Croatia	0.2434	0.2724
Germany	0.2202	0.2674
Romania	0.2498	0.2662
Italy	0.1904	0.2604
Switzerland	0.2293	0.2531
Canada	0.2808	0.2380
Japan	0.0934	0.2326
India	0.1313	0.2061
UK	0.1755	0.1895
Indonesia	0.1832	0.1714
Norway	0.1313	0.1678
China	0.1641	0.1591
Australia	0.1502	0.1402
Brasil	0.1162	0.1278
USA	0.0976	0.1214
Russia	0.0934	0.0750
Rest of the World	0.2617	0.2479

Notes. The Foreign Value Added in a country's export as a share of export is computed as in Koopmans et al. (2014); for each year, countries are ordered in terms of the fva index in 2014.

Source: Our elaborations on the WIOD database.

We report in Table 2 also our second main variable of interest, countries' trade balances. As mentioned, comparing the initial and final years of our observation period, we see a general improvement in the trade balances of EU countries, while we can find some case of (not severe) deterioration in some other countries, both developed (e.g. Canada and Japan) and developing (e.g India and Indonesia). There is no clear pattern immediately emerging for the whole countries' sample.

Table 2: Trade balance (goods and services)

Country	Trade balance (goods and services)	
	2000	2014
Luxembourg	0.2502	0.3241
Ireland	0.1384	0.1802
Malta	-0.0719	0.1194
Switzerland	0.0613	0.1169
Netherlands	0.0653	0.1110
Norway	0.1681	0.0900
Slovenia	-0.0367	0.0740
Denmark	0.0671	0.0696
Germany	0.0027	0.0692
Russia	0.2003	0.0641
Hungary	-0.0364	0.0638
Czech Rep.	-0.0185	0.0636
Korea	0.0207	0.0525
Sweden	0.0587	0.0431
Estonia	-0.0324	0.0356
Slovakia	-0.0257	0.0343
Austria	0.0133	0.0327
Italy	0.0084	0.0285
Spain	-0.0301	0.0243
China	0.0238	0.0211
Lithuania	-0.0618	0.0208
Croatia	-0.0305	0.0192
Cyprus	0.0243	0.0177
Poland	-0.0633	0.0144
Belgium	0.0264	0.0063
Portugal	-0.1104	0.0019
Australia	-0.0216	-0.0043
Romania	-0.0528	-0.0044
Indonesia	0.1052	-0.0075
Finland	0.0918	-0.0093
Bulgaria	-0.0535	-0.0094
Canada	0.0562	-0.0098
France	0.0133	-0.0115
Mexico	-0.0162	-0.0118
Latvia	-0.0799	-0.0145
UK	-0.0184	-0.0161
Greece	-0.1098	-0.0240
Japan	0.0143	-0.0247
Brasil	-0.0226	-0.0266
USA	-0.0365	-0.0290
India	-0.0091	-0.0299
Turkey	-0.0310	-0.0389

Notes. For each year, countries are ordered in terms of the value of the trade balance in 2014.
Source: World Bank (WDI).

Given the evidence of these strong and often growing international production linkages, we can certainly expect they affect import and export flows of countries and their trade balances. This is why we proceed to analyze the relationship between a country's external position and GVC indicators.

4. The empirical framework.

4.1. Variables and strategy

As a first step, we consider a standard empirical model of external balance determination. The following empirical specification is considered

$$\mathsf{TB}_{\mathsf{it}} = a_0 + a_2 \mathsf{X}_{\mathsf{it}} + u_{it} \tag{2}$$

where the dependent variable $\mathsf{TB}_{\mathsf{it}}$ is the country i's current account balance in goods and services (Trade Balance) at time t expressed as the ratio to GDP; X_{it} is a vector of explanatory variables as listed here below; u_{it} is an error term. The current account is highly correlated with the current account balance in goods and services, but for our purposes, considering trade in goods and services provides a better indicator of a country's external position since we are focusing on channels related to the real sector of the economy. Therefore, we follow Schmitz and von Hagen (2011), and use the trade balance to study the relationship between GVC participation and external position imbalances.

In the spirit of the literature on medium-term current account determination (Chinn and Prasad, 2003; Ca' Zorzi, Chudik, Dieppe, 2012; Lane and Milesi-Ferretti, 2012; Phillips et al., 2013; Brumm et al., 2019) we consider the following potential determinants of current accounts.[3] [4].

We include the main macroeconomic fundamentals. The real GDP's growth rate, capturing catching-up factors, is usually ex- pected to have a negative sign, since the higher the real GDP growth, the higher the income expected in the future, and the higher the current consumption. Income per capita (in natural log- arithm), measured as GDP in purchasing power standard (PPS) per inhabitant, again cap-

[3]In particular, we employ the specification in Lane and Milesi-Ferretti (2012) with only small differences (for instance, in place of the variable *aging speed* which is available only every five-years interval, we include *public expenditure on health services*, borrowed from Phillips et al. (2013)). We nonetheless made a robustness check by including some other control variables used in the EBA procedure (Phillips et al., 2013) and in Brumm et al. (2019), chosen in order not to reduce too much the number of observations and the sample of countries. Our results, available upon request, are robust to the inclusion of the following variables: private credit, output gap, labour productivity interacted with capital openness. We also performed a sensitivity test, following the methodology in Cinelli and Hazlett (2020) for potential omitted variables bias.

[4]Fuels comprise the commodities in Standard International Trade Classification (SITC) Section 3 (mineral fuels, lubricants and related materials)

turing catching-up factors, is expected to have a positive relationship with the CA balance since the higher the in- come per capita, the lower the income expected in the catching-up process, the lower the current consumption. The net foreign assets (expressed as a share of GDP, and lagged one year), according to the theory should have a positive sign, since the steady-state cur- rent account balance should be proportional to the equilibrium net foreign asset position in a growing economy. We include demographic variables, i.e. the population growth rate and the old-age dependency. The former is expected to have a negative sign as a positive demographic trend tends to increase aggregate consumption in the short run. The old-age dependency ratio included is the ratio of people older than 65 years over the population aged between 15 and 64, the sign of which is also ex- pected to be negative since a country with a relatively high share of a economically dependent population is expected to have a lower level of national savings, and therefore a lower CA balance. As for policy variables, we consider the fiscal balance and the public expenditure on health services, both as a share of GDP. Ac- cording to the twin-deficit hypothesis, a departure from the Ri- cardian equivalence is possible and predicts a positive relationship between government budget balances and current account in the medium term, (see for instance (Normandin, 1999)). Public expenditure on health is a protection policy which may influence the national saving rate; the expected sign is negative since it should reduce households' precautionary saving. We also include some variables capturing other countries' char- acteristics like natural resources endowments and size. The energy products balance (values of net export of energy products 4 as a share of GDP) is included to control for the specific nature of oil trade; it is expected to have a positive relationship with the CA balance, since countries with natural resources wealth are likely to save more as a consequences of the exhaustible nature of this en- dowment; we allow this variable to play a different role for Russia and Norway. Total population, as a proxy of a country's size, is in- cluded to control for a country's openness; as documented by the trade literature, smaller countries are more opened, i.e. the stock of population is negatively related with a country's openness; at the same time, size can reasonably be considered exogenous with respect to its external position (differently from

a openness index). We include the terms of trade (in natural logarithm) in order to capture the effects of changes in world market prices for a coun- try's exports or imports. Finally we include two dummy variables. A crisis dummy variable, to capture the effects of the financial and economic crisis, for years 2007, 2008 and 2009, is expected to have a positive sign, since it captures the disruption in access to capital markets. A dummy variable for a number of economies that are relatively small and have 'financial center' characteristics, namely Netherlands, Switzerland and Luxembourg in our sample, is included to control for potential measurement errors.

As a second step, we include in the model the FVA index defined in equation (1) to check the relationship between a country's trade balance over GDP and its involvement in the global value chain, and whether such a relationship is robust to the inclusion of all the regressors usually considered as the main determinants of external imbalances listed above. We then run the following regression

$$\mathsf{TB}_{\mathsf{it}} = a_0 + a_1 \mathsf{FVA}_{\mathsf{it}} + a_2 \mathsf{X}_{\mathsf{it}} + u_{it} \tag{3}$$

where $\mathsf{FVA}_{\mathsf{it}}$ is our measure of international fragmentation of production at time t and all the other variables have already been defined.

As anticipated, we have no a priori on the sign for the IFP variable, as a country's participation in the global value chain could have different effects on the trade balance. In particular, we have mentioned i) an accounting effect (importing and re-importing effect, whose sign typically depends on the position of the country in the GVC), ii) the competitiveness-enhancing effect, potentially positively related with the trade balance, and iii) the income channel, with ambiguous effects on the trade balance depending on consequences of IFP on the type of tasks kept domestic and the general equilibrium effects on total production and factors' returns. We expect all these channels to act simultaneously on the trade balance. For instance, importing higher quality inputs is likely to affect the trade balance in the same year; similarly, importing cheaper inputs is likely to reduce production costs in the same year. It is worth noting that by introducing in our empirical model the income per capita not only we do consider one of the main determinants of the trade balance,

but we also control for one potential channel linking the IFP to the trade balance, mentioned above (the income channel).[5]

Going a step further, should a competitiveness channel be at work, then the characteristics of the partner in GVC could also matter. To investigate this aspect, we split the partners of a country in its international vertical relationships according to their average product quality. The higher the partners' average product quality, the higher the quality of imported intermediate inputs, and therefore the higher the quality of final goods produced by a country (Kugler and Verhoogen, 2012), which should in turn positively affect its competitiveness. We therefore expect that for 'higher quality partners' the competitiveness channel should prevail on the accounting channel.

We proxy the product quality of the partners with income per capita, following previous contributions reporting that income per capita is positively related with the quality of goods produced, consumed and exported by a country (Verhoogen, 2008). We distinguish between two groups of countries, lower- and higher- product quality, taking the median value of the GDP per capita in PPP in 1998. This way, we build three new variables on the basis of the type of partners in the GVC: FVALI, i.e. offshoring to lower-income partners; FVAHI, i.e. offshoring to higher-income partners; FVAresI which represents the offshoring to a group of partners that is residual, and cannot be classified, in the ranking. We report in the Appendix 8.1 the list of countries belonging to each group. It is worth underlining that the only aim of splitting partners by income groups is to proxy for the product quality to single out a potential channel through which GVC may affect the trade balance, i.e. the competitiveness channel. What we need is a 'relative' measure of product quality within the sample of partners, not an absolute one, which we cannot capture also because of the composition of the WIOD sample. The trade flows with countries not included in the dataset are collapsed in the rest of the world (RoW) aggregate mentioned in Section 3.[6] In the average relationship estimated in the model in

[5] We prefer to exclude REER since it should be conceptually estimated in a separated regression with the same determinants, as argued in the EBA-IMF methodology (Phillips, S. et al., 2013).

[6] On average across years and countries, FVA from partners which are not included in the sample (i.e. FVA from RoW in WIOD) is 22% of total FVA of a country export. Therefore, the residual

equation (3), the FVA from RoW is included in the aggregate index FVA. In the partners' splitting in the model in equation (4) below, we control for FVA from RoW in the regression by including it in a residual category, FVAresI, since we cannot have the income/quality level of RoW. This implies that in our regressions we control for the FVA originating in the partner-countries not included in the sample.

We therefore estimate the following model:

$$\mathsf{TB}_{\mathsf{it}} = a_0 + a_1\mathsf{FVALI}_{\mathsf{it}} + a_2\mathsf{FVAHI}_{\mathsf{it}} + a_3\mathsf{FVAresI}_{\mathsf{it}} + a_4\mathsf{X}_{\mathsf{it}} + u_{it} \tag{4}$$

where $\mathsf{FVALI}_{\mathsf{it}}$, $\mathsf{FVAHI}_{\mathsf{it}}$ and $\mathsf{FVAresI}_{\mathsf{it}}$ are our measure of international fragmentation of production by partner group at time t and all the other variables have already been defined.

In the third step, we estimate the models described above but with export and import, separately, as dependent variables. Since the involvement of a country in the GVC is intrinsically affecting both its export and import activities, to have a deeper understanding of the relationship between GVC participation and trade balance, we decompose the latter in its export and import components. We therefore firstly estimate the model in equation (3), replacing on the left-hand-side trade balance with export and import over GDP (two separate regressions). Secondly, we split partners as in the model in equation (4) in order to check the potentially heterogeneous relationship between our indicators and aggregate exports and imports, since, as we stated above, we expect that the accounting channel (acting through imports) may prevail for lower-income/lower-quality imported inputs while the competitiveness one (acting through exports) may prevail for higher-income/higher-quality imported inputs. As mentioned above, importing from lower-income/lower-quality partners may positively affect a country's competitiveness by reducing production costs, this positively affecting its export and therefore its trade balance. On the other hand, it allows to produce lower-cost goods for domestic consumption. Therefore, importing from lower-income/lower-quality partners may be negatively related with the trade

category is not so big on average, but it could clearly play a different role for different groups of countries.

balance if the accounting channel prevails over the competitiveness one. We also expect that the higher the income/quality of the intermediate goods, the higher the quality and the complexity of the final products (Verhoogen, 2008, Kugler and Verhoogen, 2012). The higher the quality and complexity of the good (the higher the segment of the market where a country competes), the more likely intermediate inputs are to be (re)imported for the final good to be produced and exported from the home country instead of using third countries as export platforms, since more control on the production process is needed and more complex tasks are used (Keller and Yeaple, 2009; Elms and Low, 2013). Therefore, we expect to find a larger positive relationship between a country's trade balance and importing from higher income/quality partners, because higher-quality goods are more likely to be re-exported from the home country.

4.2. Data and methodology

Initially, we estimate the model in equation (2) and (3) by using OLS. We then follow Phillips et al. (2013) and Cubeddu et al. (2019), i.e. the methodology in the External Balance Assessment (EBA) procedure used by IMF, and Brumm et al. (2019) in using pooled GLS with a panel-wide AR(1) correction in all the other models. As trade balance data display strong autocorrelation, it is important to take it into account in the estimation. We also follow the literature (Lane and Milesi-Ferretti, 2012; Phillips et al., 2013; Brumm et al., 2019) in expressing all the variables, except for the Net Foreign Asset position and the terms of trade, in relative terms with respect to the average value computed on the sample's countries (weights are the country's GDP on total GDP). The reason of this is that a country's trade balance should be affected by the above variables to the extent that they differ from the other countries. We do the same for our main explanatory variable, i.e. the FVA index. As explained by Phillips et al. (2013) this is also a way to take into account the role of a country's economic size in mediating external shocks. Moreover, in considering all variables in relative terms with respect to the average

value, we somehow capture specific time varying factors common to all countries.[7]

This strategy therefore does not allow us to tackle neither endogeneity caused by country-time and country varying factors nor a potential reverse causality issue, which might arise in this macroeconomic-general equilibrium framework. We share this shortcoming with almost all the literature focusing on the determinants of CA imbalances. In our case, the reverse causality concern is probably less severe due to the nature of our main variables of interest, i.e. it is more reasonable to think that the trade balance is affected by a country's participation in the global value chain than the other way round, after controlling for all the factors listed above.[8] In our framework, an Instrumental Variables (IV) strategy is very difficult to implement. Since our dependent variable is the trade balance and our main explanatory variable of interest is an IFP index, even if one accomplishes the very hard task of finding an exogenous shock impacting on IFP, i.e. an 'instrumental variable', the exclusion restriction assumption would require that the only way this variable affects the trade account is through IFP. However, owing to the macroeconomic nature of the problem, the several channels of influence involved, and general equilibrium effects, this assumption is very unlikely to hold.[9]

We use two sources of data. As mentioned, our measures of international fragmentation of production are based on the last release of the WIOD database. As for the macroeconomic variables needed to estimate a model of trade balance deter-

[7]The EBA procedure does not include country fixed effects, arguing that country dummies would not provide an economic explanation of observed CAs and might pick up the uncaptured effects of sustained distortions on the CA (Phillips et al., 2013). On the other hand, it is worth underlining that we do not have enough time variation in our main explanatory variables to include country fixed effects (country fixed effects explain most of the variation in the FVA index, with a R-squared of .93)

[8]Moreover, it is also worth mentioning that the literature on international knowledge flows which looks at the effects of some indicators of import on productivity or innovation performance at the country level does not usually address causality issues.

[9]We performed nonetheless two robustness checks, which might partly shed light on the endogeneity issue. First, we estimated a dynamic version of the model in equation (3) by including the lagged dependent variable among the regressors. This test is in the spirit of the Granger causality test proposed in Granger (1969). The coefficient of FVA is lower than in our main specification as in column 4, Table 3, but still statistically significant (0.05 at the 1% level). Secondly, to explore reverse causality, we estimated the model in equation (3) by including the lagged (and therefore predetermined) value of our main explanatory variable, i.e. FVA. The coefficient of the one period lagged FVA is 0.23 statistically significant at the 1% level and very similar to our baseline estimates.

mination, we rely on World Development Indicators dataset from the World Bank and on the dataset 'The External Wealth of Nations Mark II' provided by Lane and Milesi-Ferretti (2017) for the Net Foreign Asset position. A Table with the description of the variables and main sources is provided in Table 15 in the Appendix. Our sample is driven by the WIOD sample of 42 countries for the period 2000-2014, for which we can build the IFP index.[10]

5. Results

5.1. Main results on the relationship between international fragmentation of production and trade account.

In column (1) and (2) of Table 3 below, we analyze the main macroeconomic determinants of the trade balances in goods and services, by carrying out the estimation of the model in equation (2) by OLS (column 1) and GLS (column 2). We rely on GLS as our preferred specification, but the comparison between results in columns 1 and 2 show that signs are consistent for most variables.[11]

[10] WIOD sample is 43 countries because it includes Taiwan, for which we do not have data for the macroeconomic variables. Taiwan is nonetheless included among the partners. The first release of WIOD data covered the period 1995-2011, but merging the two releases of the WIOD data in order to extend the time interval back to 1995 is not recommended, for differences in the methodology and in the sectoral aggregation.

[11] Population growth, fiscal balance and public expenditure on health turn to be negative but not statistically significant in the GLS model; Russia and Norway dummy, net fuel trade and its interaction with the dummy change sign in the GLS model in column 2.

Table 3: Trade balance and GVC participation (FVA)

VARIABLES	(1) TB	(2) TB	(3) TB	(4) TB
GDP growth rate	-0.203**	-0.188***	-0.336***	-0.205***
	(0.092)	(0.039)	(0.081)	(0.040)
GDP per capita	0.041***	0.041***	0.052***	0.047***
	(0.009)	(0.013)	(0.008)	(0.012)
Age dep. ratio	-0.334***	-0.156*	-0.152**	-0.152*
	(0.066)	(0.094)	(0.059)	(0.085)
Population, total	0.000**	0.000	0.000***	0.000**
	(0.000)	(0.000)	(0.000)	(0.000)
Population growth	1.026**	-0.126	1.044***	-0.016
	(0.403)	(0.302)	(0.352)	(0.302)
Fiscal balance	0.165**	-0.049	0.079	-0.051
	(0.076)	(0.043)	(0.066)	(0.044)
Public expenditure on health	0.568**	-0.372	-0.196	-0.342
	(0.240)	(0.290)	(0.217)	(0.276)
Terms of trade	-0.060***	-0.023	-0.072***	-0.019
	(0.018)	(0.019)	(0.015)	(0.019)
Net foreign assets (lagged)	0.004	0.008	-0.000	0.006
	(0.006)	(0.006)	(0.005)	(0.005)
Crisis dummy	-0.018***	-0.004	-0.017***	-0.003
	(0.005)	(0.002)	(0.005)	(0.002)
Financial center dummy	0.113***	0.109***	0.082***	0.093***
	(0.012)	(0.020)	(0.010)	(0.018)
Net fuel trade (Nft)	-0.134	0.210**	0.663***	0.340***
	(0.115)	(0.100)	(0.117)	(0.103)
Nft×(Russia-Norway)	-0.028	0.750***	-0.597	0.675***
	(0.429)	(0.211)	(0.376)	(0.214)
Russia-Norway dummy	0.135	-0.085**	0.146**	-0.066
	(0.083)	(0.041)	(0.073)	(0.041)
Foreign Value Added (FVA)			0.288***	0.183***
			(0.022)	(0.035)
Method	OLS	GLS	OLS	GLS
Observations	565	565	565	565
R-squared	0.564		0.669	
Number of countries	42	42	42	42

Significance level: * p-value<0.10; ** p-value<0.05; *** p-value<0.01.

Our results in column 2 show that age dependency ratio and GDP growth rate are significantly and negatively related to countries' TB, while income per capita, net oil balance and its interaction with oil countries dummy are positively related to the TB. The financial center dummy also shows a positive, statistically significant, coefficient.[12] The other variables are not statistically significant in our sample.

[12]The oil countries dummy has instead a negative statistically significant coefficient.

With only few exceptions, our results are generally in line with what is found by the previous literature (Lane and Milesi-Ferretti, 2012; Phillips, et al., 2013; Brumm et al., 2019) and they fit well a catching up explanation of external imbalances (Obstefeld and Rogoff, 1998).

In column (3) and (4) we show the estimates of the model in equation (3), where we also include among the trade balance determinants our main variable of interest, i.e. the FVA index in equation (1). Again, we implement both OLS and GLS estimations for comparison with previous results. The coefficient of the FVA index is positive and statistically significant at the 1% level. The OLS estimated coefficient in column (3) is 0.29, which falls to 0.18 in our preferred GLS estimate in column (4).[13]

In particular, in the GLS estimates, a one standard deviation (one-SD for brevity) increase in the FVA index (that is 0.12 points) is associated with a 2.2 percentage points (pp) increase in the trade balance as a percentage of GDP. The relationship is robust to the inclusion of all the medium-term determinants of TB considered in the literature listed in the previous section. This suggests that GVC participation is playing a distinct role with respect to those factors. This result is in line with Brumm et al. (2019), which find a positive relationship between CA and GVC participation for a sample of 29 countries for the period 1995-2011, by using the

[13]In order to assess the sensitivity of our estimates to omitted variables bias (OVB) we have computed some statistics suggested in Cinelli and Hazlett (2020). This has been implemented using the Stata package `sensemakr`, see Cinelli et al. (2020). In particular, we have computed the Robustness Value (RV), which tells us what percentage of the residual variance of the treatment (FVA) and the outcome (current account) the omitted unobserved factor should explain to make the estimated coefficient of the treatment (FVA) null. RV is 0.24 meaning that the unobservable to produce this result should explain 24% of residual FVA and current account variance. This is a sizeable percentage for an omitted variable. We also reported the Partial R2 of the treatment (FVA) on the outcome, which gives us some information on the "worse case scenario." The computed Partial R2 is 0.426 that indicates that even if the omitted variable explains 100% of the residual variation in the outcome, it should explain at least 42.6% of the residual variation in the treatment to bring down the estimated effect to zero. Also in this case the percentage is quite high. Given that our specification follows quite closely past published work and is theory-based, in particular Lane and Milesi-Ferretti (2012), we mantain that we are unlikely to have omitted such important confounders from our baseline model.

first release of the WIOD data.[14]

Here, by including income per capita among the regressors, we control for potential income channels through which GVC participation may affect the TB. This result therefore suggests that across all countries and all potential partners in a GVC relationship, the competitiveness channel prevails over a potential negative impact of the accounting channel. This means that on average, global value chains generate a larger exported value than imported value. GVCs' participation allows producing goods at a lower cost or of higher quality, therefore increasing net exports with respect to countries with lower participation in a GVC. It also suggests that countries involved in GVCs generally re-export a larger value than the goods that they have imported.

5.2. Dissecting the relationship: the role of partners in GVCs.

In Table 4 below, we explore the potential channels behind this average result, by splitting the partners in the GVC relationship according to their income level i.e. estimating the model in equation (4) (column (2)), and by decomposing the TB in its export and import components (columns (3)-(6)). In column (1) of Table 4, we report the same estimation as in column (4) of Table 3 for comparison, i.e. the average aggregate relationship.

[14] In their main analysis, Brumm et al. (2019) use other measures of GVC participation, i.e. backward (forward) participation, the ratio of gross imported (exported) intermediates to gross output, and the sum of the two. As robustness, they show also the results obtained by employing the index FVA computed by the OECD (TiVA data), which corresponds to the numerator of our index FVA. They obtain a coefficient of 0.13 for their measure of backward participation in the main analysis (column 4, Table A.2) and a coefficient of 0.05 for the FVA index (column 3, Table A.4) versus the coefficient of 0.18 in our sample. Beyond the fact that the indexes are not exactly comparable, we expect them to find a lower effect than us since we include all EU countries, while they have only a subset of them, missing in particular Baltic countries and several EU-Eastern countries. The two samples are instead almost overlapping for non-EU countries. Since we find a much larger effect for EU than for non-EU countries, as discussed in Section 5.3, and since non-EU countries represent a larger share of their sample, it is not surprising that they find a smaller effect.

Table 4: Trade balance, Export and Import and GVC (FVA) by group of partners

VARIABLES	(1) TB	(2) TB	(3) EXP	(4) EXP	(5) IMP	(6) IMP
GDP growth rate	-0.205***	-0.212***	0.216***	0.198***	0.413***	0.404***
	(0.040)	(0.037)	(0.072)	(0.067)	(0.068)	(0.067)
GDP per capita	0.047***	0.027**	0.107***	0.065***	0.069***	0.048**
	(0.012)	(0.012)	(0.025)	(0.024)	(0.022)	(0.022)
Age dep. ratio	-0.152*	-0.066	-0.147	0.032	-0.004	0.090
	(0.085)	(0.084)	(0.188)	(0.182)	(0.161)	(0.159)
Population, total	0.000**	0.000	0.000	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Population growth	-0.016	-0.304	-0.192	-0.782	0.001	-0.420
	(0.302)	(0.291)	(0.565)	(0.537)	(0.530)	(0.525)
Fiscal balance	-0.051	-0.029	-0.267***	-0.215***	-0.217***	-0.183**
	(0.044)	(0.042)	(0.081)	(0.076)	(0.076)	(0.075)
Public expenditure on health	-0.342	-0.645**	-1.924***	-2.531***	-1.605***	-1.944***
	(0.276)	(0.269)	(0.555)	(0.531)	(0.502)	(0.498)
Terms of trade	-0.019	-0.039**	0.034	-0.018	0.063*	0.031
	(0.019)	(0.018)	(0.037)	(0.036)	(0.034)	(0.034)
Net foreign assets (lagged)	0.006	0.004	-0.015	-0.021**	-0.022**	-0.024**
	(0.005)	(0.005)	(0.010)	(0.010)	(0.010)	(0.009)
Crisis dummy	-0.003	-0.003	-0.009*	-0.008**	-0.005	-0.006
	(0.002)	(0.002)	(0.004)	(0.004)	(0.004)	(0.004)
Financial center dummy	0.093***	0.066***	0.306***	0.252***	0.198***	0.175***
	(0.018)	(0.018)	(0.041)	(0.041)	(0.035)	(0.035)
Net fuel trade (Nft)	0.340***	0.273***	-0.391**	-0.508***	-0.732***	-0.798***
	(0.103)	(0.098)	(0.193)	(0.182)	(0.181)	(0.177)
Nft×(Russia-Norway)	0.675***	0.755***	2.048***	2.181***	1.338***	1.400***
	(0.214)	(0.203)	(0.393)	(0.369)	(0.372)	(0.364)
Russia-Norway dummy	-0.066	-0.074*	-0.053	-0.062	0.031	0.025
	(0.041)	(0.039)	(0.079)	(0.075)	(0.073)	(0.071)
FVA from LI partners		-0.469***		1.131***		1.661***
		(0.131)		(0.260)		(0.243)
FVA from HI partners		0.380***		2.436***		2.100***
		(0.044)		(0.095)		(0.084)
FVA from other partners		-0.136		1.043***		1.258***
		(0.084)		(0.159)		(0.153)
Foreign Value Added (FVA)	0.183***		1.984***		1.894***	
	(0.035)		(0.076)		(0.066)	
Method	GLS	GLS	GLS	GLS	GLS	GLS
Observations	565	565	565	565	565	565
Number of countries	42	42	42	42	42	42

Significance level: * p-value<0.10; ** p-value<0.05; *** p-value<0.01.

In column (2) our variables of interest are FVA from lower-income partners and FVA from higher-income partners, their coefficients capturing the relationship with the trade balance when offshoring to lower-income partners / higher-income partners

with respect to using inputs produced domestically. The GVC indexes turn out to be statistically significant, at the 1% level, with a negative sign and a positive sign for offshoring to lower-income and to higher-income partners, respectively.

As mentioned before, several channels may link GVC participation to a country's TB, namely the accounting (importing and re-importing) channel, potentially negatively related with the trade balance, the competitiveness-enhancing channel, which can be further decomposed in terms of cost/efficiency competitiveness and quality/non-price competitiveness, all potentially positively related with the trade balance, and finally the income channel. The negative sign of offshoring to lower-income countries may be capturing the fact that when countries offshore towards these destinations the accounting channel overcomes the competitiveness one, the latter being weakened by a lower quality of final goods incorporating lower-quality inputs (Kugler-Verhoogen, 2012). The opposite happens when countries offshore to higher-income partners. In this case the competitiveness channel prevails.

We then turn to look separately at exports and imports. Columns (3) and (5) show that the FVA index is positively related with both export and import. The slightly larger magnitude of the export coefficient (2 versus 1.9) explains the positive average relationship with the TB as shown in column (1). As commented before, we can interpret this as the competitive channel prevailing on average over the accounting one.

In columns (4) and (6), we consider the role of the partners' split by income group with respect to export (column 4) and import (column 6), respectively. Results show that both offshoring to lower-income partners (FVALI) and offshoring to higer-income partners (FVAHI) are positively related (significant at the 1% level) with export, but the size of the coefficients is significantly different. The coefficient of offshoring to lower-income partners is half than that of offshoring to higher-income partners, 1.1 versus 2.4. This suggests that in both cases there is a competitiveness effect in being involved in GVC relationships, i.e. there is an increase in competitiveness and therefore in exports, but this effect is much larger when offshoring to higher-income partners than to lower-income ones. We could also speculate that this evidence may capture cost versus quality competitiveness. Offshoring to lower-

income partners raises exports by allowing for lower production costs, while offshoring to higher-income partners increases exports by producing higher quality goods through higher quality inputs. Moreover, offshoring to lower income partners may allow to save costs to produce standardized lower-quality goods which are more likely to be either directly re-exported from third countries or used domestically. On the other hand, offshoring to higher-income partners does also increase imports, but less than exports. Therefore, the use of high-quality intermediate inputs does significantly improve the competitiveness of a country, either by incorporating high quality inputs into final goods and this way improving the quality of final goods, or by increasing the efficiency in the production of the final goods. We think that it is more likely that high quality intermediate inputs are used to produce final goods sold directly from the home country.

Turning the attention on imports, results show again that both offshoring to lower-income partners and offshoring to higher-income partners are positively related (significant at the 1% level) with imports, but the difference in the size of the coefficients is not statistically significant. Intuitively, the accounting channel works similarly when importing from higher-income or lower-income partners.

Due to the different coefficients of export and imports (columns (4) and (5)), the net effect is negative when offshoring to lower-income partners and positive when offshoring to higher income partners. It means that the lower-quality imported intermediates that we observe increasing domestic imports are possibly mostly used to produced lower-quality final goods for domestic consumption.

5.3. Differences between EU and non-EU countries

In this section we explore the relationship between participation in GVCs and a country's external position focusing on EU countries, mainly motivated by the country coverage of WIOD. In EU countries the weight of GVCs trade is higher than in larger economies like the U.S., China or Japan, where traditional trade still dominates (IMF, 2019). Both the deep integration process that accompanied the introduction of the single European currency and the enlargement of the EU to the Central and Eastern European Countries (CEECs) gave rise to extensive intra-European production chains. We first allow for heterogeneous effects by non-EU and

EU countries. Then, we focus on EU and investigate the relative role of intra-EU vs. extra-EU value chains, both pooling all trade partners and by type of partner (lower- vs higher-quality).

We proceed in exploring the relationships as in the model in equation (3) and (4) but by interacting our main variables of interest with a EU dummy. Therefore, we estimate the following two specifications:

$$\mathsf{TB}_{\mathsf{it}} = a_0 + a_1\mathsf{FVA}_{\mathsf{it}} + a_2\mathsf{FVA}_{\mathsf{it}} * \mathsf{EU} + a_3\mathsf{EU} + a_2\mathsf{X}_{\mathsf{it}} + u_{it} \tag{5}$$

and

$$\begin{aligned}\mathsf{TB}_{\mathsf{it}} = a_0 + a_1\mathsf{FVALI}_{\mathsf{it}} + a_2\mathsf{FVAHI}_{\mathsf{it}} + \\ a_3\mathsf{FVAresI}_{\mathsf{it}} + a_4\mathsf{FVALI}_{\mathsf{it}} * \mathsf{EU} + a_5\mathsf{FVAHI}_{\mathsf{it}} * \mathsf{EU} + \\ a_6\mathsf{FVAresI}_{\mathsf{it}} * \mathsf{EU} + a_7\mathsf{EU} + a_8\mathsf{X}_{\mathsf{it}} + u_{it}\end{aligned} \tag{6}$$

where $\mathsf{FVALI}_{\mathsf{it}}$, $\mathsf{FVAHI}_{\mathsf{it}}$ and $\mathsf{FVAresI}_{\mathsf{it}}$ are our measure of international fragmentation of production by partner group at time t, EU is a dummy variable for belonging to EU and all the other variables have already been defined.

Results are reported in Table 5, where in column (1) are reported the results of the estimate of the model in equation (5) and in column (2) those of the model in equation (6).

Table 5: Trade balance and GVC (FVA) in EU and non-EU countries

VARIABLES	(1) TB	(2) TB
GDP growth rate	-0.206***	-0.213***
	(0.040)	(0.038)
GDP per capita	0.048***	0.029***
	(0.012)	(0.011)
Age dep. ratio	-0.187**	-0.045
	(0.092)	(0.085)
Population, total	0.000*	0.000
	(0.000)	(0.000)
Population growth	0.014	-0.398
	(0.303)	(0.292)
Fiscal balance	-0.040	-0.014
	(0.044)	(0.042)
Public expenditure on health	-0.385	-0.678***
	(0.275)	(0.257)
Terms of trade	-0.039*	-0.038*
	(0.020)	(0.020)
Net foreign assets (lagged)	0.007	0.003
	(0.006)	(0.005)
Crisis dummy	-0.003	-0.003
	(0.002)	(0.002)
Financial center dummy	0.091***	0.069***
	(0.018)	(0.017)
Net fuel trade (Nft)	0.360***	0.348***
	(0.103)	(0.098)
Nft×(Russia-Norway)	0.643***	0.673***
	(0.215)	(0.206)
Russia-Norway dummy	-0.071*	-0.077*
	(0.041)	(0.039)
EU dummy	-0.001	-0.015
	(0.013)	(0.012)
FVA from LI partners		-0.757
		(0.533)
FVA from HI partners		0.042
		(0.116)
FVA from other partners		0.375
		(0.230)
FVA from LI partners×EU		0.327
		(0.537)
FVA from HI partners×EU		0.411***
		(0.118)
FVA from other partners×EU		-0.563**
		(0.242)
Foreign Value Added (FVA)	0.002	
	(0.089)	
FVA×EU	0.204**	
	(0.094)	
Method	GLS	GLS
Observations	565	565
Number of countries	42	42

Significance level: * p-value<0.10; ** p-value<0.05; *** p-value<0.01.

For the sake of clarity, in Table 6 we summarize the relevant coefficients for EU and non-EU [15]

Table 6: Trade balance and GVC (FVA) in EU and non-EU countries

	EU	**not EU**
All partners	0.206***	0.002
	(0.041)	(0.089)
FVALI	-0.430***	-0.757
	(0.125)	(0.533)
FVAHI	0.453***	0.042
	(0.047)	(0.116)

Significance level: * p-value<0.10; ** p-value<0.05; *** p-value<0.01.

As for the aggregate relationship, results show that the positive coefficient emerging by the general estimates in Table 3 is mainly driven by the EU group of countries, whose coefficient is 0.2 (statistically significant at the 1% level). The relationship between FVA and TB for non-EU countries is positive, but not statistically significant. When splitting the partners by income group, we see that that the signs are consistent with the expected ones reported for the sample including all countries in Table 4: negative and positive when offshoring to LI and HI countries, respectively, both for EU and non-EU countries. But in the case of non-EU partners the estimates are not statistically significant. In the case of the EU countries, the estimates are very close to the ones obtained on the whole sample reported in Table 4 (-0.43 and +0.45, for offshoring to LI and HI countries, respectively, both significant at the 1% level). This shows that also the results obtained on the whole sample splitting by group of partner are mainly driven by EU countries. The WIOD sample composition may play a role in these results, as EU countries are over-represented in WIOD sample (28 out of 42), this possibly implying that our results may not be fully representative of the whole population of non-EU countries. Moreover the dataset does not allow to take into full account the non-EU countries' bilateral trade links when splitting the partners by income group, due to the larger weight for these countries of FVA from the RoW included in the residual category. Nonetheless,

[15] The excluded category is non-EU; therefore the coefficient for non-EU is the one of the FVA index not interacted, while the coefficient for the EU is the sum of the interacted one and the not interacted one.

this evidence may also suggest that GVC participation is more significantly related with a country's TB in very integrated markets. And that the effect is larger for EU countries because GVC trade is more relevant than traditional trade, differently from larger non-EU countries, as also shown in Table 1. This would deserve further investigation when comparable data for more non-EU countries become available. Given the higher coverage of our data to EU countries, we take a further look into the EU by making an attempt at disentangling regional chains from global chains. To this end, we first estimate the model in equation (3) on the sub-sample of the 28 EU countries to assess the role of participation in GVCs for the EU. As a second step, we split the partners into two groups, intra-EU partner and extra-EU partners, and we estimate the following model:

$$\mathsf{TB}_{\mathsf{it}} = a_0 + a_1 \mathsf{FVAintraEU}_{\mathsf{it}} + a_2 \mathsf{FVAextraEU}_{\mathsf{it}} + a_3 \mathsf{X}_{\mathsf{it}} + u_{it} \tag{7}$$

where $\mathsf{FVAintraEU}_{\mathsf{it}}$ and $\mathsf{FVAextraEU}_{\mathsf{it}}$ are our measures of international fragmentation of production by partner group, the FVA from EU countries and the FVA from non-EU countries, respectively, at time t, and all the other variables are as defined above.

As a third step we split both EU and non-EU partners by income group, following the same strategy we implemented on the whole sample:

$$\begin{aligned}\mathsf{TB}_{\mathsf{it}} =& a_0 + a_1 \mathsf{FVALIintraEU}_{\mathsf{it}} + a_2 \mathsf{FVAHIintraEU}_{\mathsf{it}} + \\ & a_2 \mathsf{FVALIextraEU}_{\mathsf{it}} + a_3 \mathsf{FVAHIextraEU}_{\mathsf{it}} + a_4 \mathsf{FVAreslextraEU}_{\mathsf{it}} + a_5 \mathsf{X}_{\mathsf{it}} + u_{it}\end{aligned} \tag{8}$$

Results are reported in Table 7 below. Column 1 shows the estimations for the main specification (model in equation (3)), column 2 those for the split of intra-EU and extra-EU partners as in the model in equation (7) and column 3 the further split as in the model in equation (8).[16]

[16] We also carried out the analysis by exploring another dimension of countries' heterogeneity,

i.e. by country size, proxied by its population. Results, available upon request, show that the larger the country, the lower the positive relationship between GVC participation and the TB. This is not surprising since for larger countries the role of GVC trade is less relevant that that of total trade, in particular including commodities, which are likely to affect the current account to a larger extent.

Table 7: Trade balance and GVC (FVA) in EU countries

	(1)	(2)	(3)
VARIABLES	TB	TB	TB
GDP growth rate	-0.245***	-0.245***	-0.263***
	(0.047)	(0.047)	(0.045)
GDP per capita	0.115***	0.115***	0.068***
	(0.016)	(0.016)	(0.016)
Age dep. ratio	-0.369***	-0.368***	-0.104
	(0.137)	(0.136)	(0.124)
Population, total	-0.000***	-0.000***	-0.000***
	(0.000)	(0.000)	(0.000)
Population growth	-0.538	-0.540	-0.845**
	(0.352)	(0.353)	(0.337)
Fiscal balance	-0.049	-0.049	0.007
	(0.051)	(0.051)	(0.049)
Public expenditure on health	-0.386	-0.386	-0.527*
	(0.326)	(0.326)	(0.296)
Terms of trade	0.031	0.031	0.019
	(0.044)	(0.045)	(0.041)
Net foreign assets (lagged)	0.010	0.010	0.003
	(0.006)	(0.006)	(0.006)
Crisis dummy	-0.007**	-0.007**	-0.007**
	(0.003)	(0.003)	(0.003)
Financial center dummy	0.068***	0.068***	0.054***
	(0.021)	(0.021)	(0.018)
Net fuel trade (Nft)	0.231*	0.232*	0.227**
	(0.122)	(0.122)	(0.115)
FVA from EU LI partners			-0.268
			(0.236)
FVA from EU HI partners			0.161***
			(0.060)
FVA from non-EU LI partners			-0.268*
			(0.159)
FVA from non-EU HI partners			0.820***
			(0.119)
FVA from other partners			-0.230**
			(0.092)
FVA from intraEU partners		0.116*	
		(0.060)	
FVA from extraEU partners		0.113*	
		(0.067)	
Foreign Value Added (FVA)	0.114**		
	(0.045)		
Method	GLS	GLS	GLS
Observations	387	387	387
Number of countries	33 28	28	28

Significance level: * p-value<0.10; ** p-value<0.05; *** p-value<0.01.

Results in column 1 show that the FVA is positively and significantly (5%) associated with the TB in EU countries with a coefficient slightly smaller than in the whole sample (0.11 vs 0.18). Column 2 shows that the positive relationship is equally driven by intra-EU and extra-EU partners, suggesting that with respect to the trade balance the role played by the so called 'factory Europe' is not more important than that played by external partners. Turning the attention to lower vs higher income partners, we see that both within and outside EU relationships exhibit the expected signs, i.e. a negative and a positive sign respectively. Interestingly enough, while the negative coefficients of FVA from LI countries are similar in intra-EU and extra-EU relationships (-0.27, not significant in intra-EU and significant at the 10% level for extra-EU), the positive coefficients of FVA from HI countries is of a bigger magnitude in extra-EU than in intra-EU relationships (0.82 vs 0.16 both statistically significant at the 1% level). This suggests that non-EU technologically advanced partners such as US, Canada and Japan play a relevant role in EU countries' competitiveness.

5.4. Robustness

5.4.1. Alternative index of fragmentation

We replicate the analysis above by using as a proxy of participation to GVC a variation of the index that has become standard in the literature, the 'offshoring' index.[17] The aggregate offshoring index is given by the following expression:

$$OFFIND_{it} = \frac{\sum_j \sum_s import^i_{js}}{\sum_j input^i_j} \tag{9}$$

where i is the reporting country, t is time, s is the partner from which a country imports intermediate goods, j is a country's intermediate goods sector.

Estimates, reported in Tables 8 and 9 in the Appendix, show that our results are robust to econometric specifications using this second index of Offshoring.

[17] This index, originally introduced by Feenstra and Hanson (1996), has subsequently improved thanks to the use of input - output tables for imports. We take the aggregate measure by summing up across sectors and across partners, so that our numerator is the sum of the value of all intermediate goods imported by all intermediate goods' sectors of country i from all sectors of all partners' countries s (including the Rest of the World aggregate), while the denominator is the total value of all intermediate inputs used in production in all sectors of country i.

5.4.2. Alternative countries' split

We also consider an alternative 'direct' measure of a country's product quality provided by Hallak and Schott (2011), the 'normalized quality index', and we rank the partners according to this index in 1998, i.e. in a pre-sample year to reduce potential endogeneity issues. As underlined by Hallak and Schott (2011), the overlapping in the countries' rankings based on their normalized quality index and on the income per capita is only partial, and therefore it makes sense to use both indicators.[18] Results, reported in Table 10 in the Appendix, confirm what we obtained with the split by income group.

5.4.3. Euro area countries in place of EU countries

EU countries are also largely overlapping with the sample of Euro area countries. We therefore cannot disentangle the role of belonging to an integrated market from that of belonging to a monetary union. We replicate the analysis of the models in equations (5) and (6), but considering a Euro area dummy. Results, reported in Table 11 and Table 12 in the Appendix, are in line with those obtained for EU versus non-EU countries, confirming that we cannot disentangle between the effect of the two.[19] Interestingly enough, the coefficient of sourcing inputs from higher income partners (FVA from HI) of non-EU countries is much larger than that of non-Euro countries, i.e. 0.27 statistically significant at the 1% level vs 0.04, not statistically significant, respectively. This difference is likely to be driven by the Eastern countries, which belong to the complementary group in the Euro vs non-Euro split and for which the positive effect of buying inputs from higher-income countries is higher.

[18] Another reason why we choose to rely on both rankings is that in both cases some countries are excluded from the partners classifications, and enter a residual group, because there is no perfect overlap with the WIOD data (see Appendix 8.1). By using two indicators, we are more comfortable in claiming that results do not depend on the residual group.

[19] Latvia and Lithuania are not included among Euro area countries since they entered only in 2014, which is the last year in our sample. EU countries which are not Euro countries in our sample are therefore Bulgaria, Czech Republic, Hungary, Latvia, Croatia, Lithuania, Polonia, Romania, Denmark, Sweden, United Kingdom.

6. Conclusion

In this paper, we make a first attempt to explore the potential relationship between trade imbalances and the phenomenon of the international fragmentation of production. We rely on an indicator of countries' involvement in international fragmentation of production and in global value chains, the share of foreign value added in gross exports, computed from the last release of the WIOD database. We use this indicator to test empirically this relationship for a sample of 42 countries, both developed and developing economies, in the period 2000-2014. In order to investigate the channels behind the relationship we carry out our analysis by splitting the trade partners of a country according to their product quality and by focusing on exports and imports separately. We also focus on EU countries, by distinguishing between regional and global value chains for EU countries, both on aggregate and splitting the partners by income level.

Our results show that, on average, international fragmentation of production is positively and significantly associated with countries' trade balance. Further investigations show that the trade balance worsens the higher the offshoring to lower-income/lower-product quality countries, and improves the higher the offshoring to higher-income/higher-product quality countries. In particular, international fragmentation of production increases both exports and imports, but the net positive effect emerges when offshoring to higher-income/higher-product quality countries. This result suggests that in the latter case the negative mechanical relationship between importing intermediate inputs and the trade balance overcomes the potentially higher competitiveness induced by offshoring. Interestingly enough, regional and global value chains play a similar role for EU countries. In particular, offshoring to higher-income non-EU partners increases EU competitiveness.

Our results are robust to the inclusion of standard medium-term current account determinants, to using different indicators of international fragmentation of production, and to classifications of partner countries based on different countries' product quality indexes.

From a policy perspective, we could conclude that what is relevant for the sign of the overall GVC involvement and trade balance relationship is the ability of a

country to enhance its competitiveness through offshoring by 'selecting' the right partners. The latter is in turn likely related to the reasons for offshoring, i.e. learning from partners, importing technology and knowledge versus pure cost saving. It is worth noting though that our analysis, despite highlighting some robust associations, still remains of a descriptive nature. Additional investigations are needed to assess the causal nature of these relationships, and the overall welfare effects of offshoring, as the effects on a country's external position are only one aspect of this complex phenomenon.

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8. Appendix

8.1. Partners' classifications

List of partners in WIOD data: Austria, Australia, Belgium, Bulgaria, Brazil, Canada, China, Cyprus, Croatia, Czech Rep., Germany, Denmark, Estonia, Greece, Spain, Finland, France, Hungary, Indonesia, Ireland, India, Italy, Japan, Korea, Lithuania, Luxembourg, Latvia, Malta, Mexico, Netherlands, Norway, Poland, Portugal, Romania, Russia, Sweden, Slovenia, Slovakia, Switzerland, Turkey, Taiwan, United Kingdom, United States and Rest of the World (43, plus RoW; 28 EU).

List of countries by group when the classification is on the basis of their gdp per capita. We build the groups of countries on the basis of the median value in 1998.

- Higher-income countries: Austria, Australia, Belgium, Canada, Luxembourg, Netherlands, Sweden, Denmark, Spain, Finland, France, UK, Italy, Germany, Ireland, Japan, USA, Cyprus, Taiwan, Switzerland.
- Lower-income countries: Bulgaria, Czech Rep., Croatia, Hungary, Estonia, Lithuania, Latvia, Poland, Portugal, Greece, Romania, Slovakia, Slovenia, Turkey, Brazil, Mexico, India, China, Korea, Indonesia, Malta.
- Residual group: 'Rest of the World', Russia, Norway.

Russia and Norway are excluded because the role of oil in their economy may be misleading in the attribution to an income group. It is worth noting that Taiwan is included among the partners, since we have information of its GVCs involvement because Taiwan is included in WIOD.

List of EU countries by income group

- Higher-income countries: Austria, Belgium, Luxembourg, Netherlands, Sweden, Denmark, Spain, Finland, France, UK, Italy, Germany, Ireland, Cyprus.
- Lower-income countries: Bulgaria, Czech Rep., Croatia, Hungary, Estonia, Lithuania, Latvia, Poland, Portugal, Greece, Romania, Slovakia, Slovenia, Malta.

List of non-EU countries by income group

- Higher-income countries: Australia, Canada, Japan, USA, Taiwan, Switzerland.
- Lower-income countries: Turkey, Brazil, Mexico, India, China, Korea, Indonesia.
- Residual group: 'Rest of the World', Russia, Norway.

List of countries by group when the classification is on the basis of the 'normalized quality index' provided by Hallak and Schott (2011). We build the groups of countries on the basis of the median value in 1998.

- Higher-quality countries: Austria, Belgium, Netherlands, Sweden, Denmark, Finland, France, United Kingdom, Italy, Germany, Ireland, Japan, Korea, Hungary, Switzerland.
- Lower-quality countries: Canada, Australia, Poland, Portugal, Romania, Turkey, Brazil, Mexico, India, Indonesia, China, Greece, Spain, Taiwan.
- Residual group: RoW, Luxembourg, United States, Bulgaria, Czech Rep., Estonia, Lithuania, Latvia, Slovakia, Slovenia, Croatia, Cyprus, Russia, Malta, Norway.

The residual group is larger due to the low overlapping between the countries for which Hallak and Schott (2011) provide the quality index and WIOD data.

8.2. Robustness checks

Table 8: Trade balance, Export and Import and GVC (Offhsoring)

VARIABLES	(1) TB	(2) TB	(3) EXP	(4) EXP	(5) IMP	(6) IMP
GDP growth rate	-0.216***	-0.214***	0.107	0.103	0.308***	0.310***
	(0.039)	(0.037)	(0.067)	(0.065)	(0.070)	(0.069)
GDP per capita	0.043***	0.024**	0.087***	0.059**	0.056***	0.047**
	(0.012)	(0.012)	(0.024)	(0.023)	(0.019)	(0.019)
Age dep. ratio	-0.123	-0.053	-0.033	0.052	0.174	0.184
	(0.089)	(0.084)	(0.179)	(0.171)	(0.135)	(0.130)
Population, total	0.000**	0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Population growth	-0.039	-0.222	0.099	-0.275	0.402	0.058
	(0.297)	(0.288)	(0.521)	(0.512)	(0.516)	(0.516)
Fiscal balance	-0.044	-0.019	-0.164**	-0.125*	-0.118	-0.099
	(0.043)	(0.041)	(0.074)	(0.072)	(0.077)	(0.076)
Public expenditure on health	-0.364	-0.674**	-1.733***	-2.218***	-1.774***	-1.975***
	(0.279)	(0.270)	(0.517)	(0.506)	(0.454)	(0.447)
Terms of trade	-0.023	-0.029	-0.054	-0.072**	0.005	-0.011
	(0.019)	(0.018)	(0.034)	(0.033)	(0.031)	(0.030)
Net foreign assets (lagged)	0.008	0.004	-0.000	-0.005	-0.000	-0.002
	(0.005)	(0.005)	(0.010)	(0.009)	(0.009)	(0.009)
Crisis dummy	-0.003	-0.002	-0.008**	-0.008*	-0.005	-0.006
	(0.002)	(0.002)	(0.004)	(0.004)	(0.004)	(0.004)
Financial center dummy	0.086***	0.059***	0.238***	0.201***	0.116***	0.114***
	(0.019)	(0.019)	(0.040)	(0.039)	(0.029)	(0.028)
Net fuel trade (Nft)	0.338***	0.247**	-0.440**	-0.576***	-0.915***	-0.948***
	(0.101)	(0.097)	(0.177)	(0.174)	(0.174)	(0.173)
Nft×(Russia-Norway)	0.632***	0.700***	1.668***	1.734***	0.912**	0.895**
	(0.210)	(0.201)	(0.362)	(0.353)	(0.373)	(0.370)
Russia-Norway dummy	-0.069*	-0.069*	-0.099	-0.094	0.012	0.013
	(0.041)	(0.039)	(0.074)	(0.071)	(0.070)	(0.069)
Off to LI partners		-0.536***		1.749***		2.427***
		(0.120)		(0.227)		(0.197)
Off to HI partners		0.391***		2.401***		2.058***
		(0.043)		(0.087)		(0.065)
Off to other partners		0.003		1.301***		1.297***
		(0.090)		(0.166)		(0.152)
Offshoring (Off)	0.202***		2.111***		2.005***	
	(0.036)		(0.073)		(0.055)	
Method	GLS	GLS	GLS	GLS	GLS	GLS
Observations	565	565	565	565	565	565
Number of countries	42	42	42	42	42	42

Significance level: * p-value<0.10; ** p-value<0.05; *** p-value<0.01.

Table 9: Trade balance and GVC (Offshoring) in EU and non-EU countries

VARIABLES	(1) TB	(2) TB
GDP growth rate	-0.218***	-0.211***
	(0.040)	(0.038)
GDP per capita	0.044***	0.027**
	(0.011)	(0.011)
Age dep. ratio	-0.163*	-0.070
	(0.090)	(0.085)
Population, total	0.000*	-0.000
	(0.000)	(0.000)
Population growth	0.120	-0.226
	(0.300)	(0.290)
Fiscal balance	-0.024	0.004
	(0.044)	(0.042)
Public expenditure on health	-0.326	-0.681***
	(0.268)	(0.256)
Terms of trade	-0.046**	-0.042**
	(0.019)	(0.018)
Net foreign assets (lagged)	0.008	0.004
	(0.005)	(0.005)
Crisis dummy	-0.003	-0.002
	(0.002)	(0.002)
Financial center dummy	0.086***	0.061***
	(0.017)	(0.016)
Net fuel trade (Nft)	0.388***	0.315***
	(0.102)	(0.098)
Nft×(Russia-Norway)	0.625***	0.698***
	(0.214)	(0.204)
Russia-Norway dummy	-0.074*	-0.074*
	(0.041)	(0.039)
EU dummy	-0.011	-0.017
	(0.013)	(0.012)
Off to LI partners		-1.331**
		(0.607)
Off to HI partners		-0.019
		(0.114)
Off to other partners		0.213
		(0.256)
Off to LI partners × EU		0.873
		(0.604)
Off to HI partners × EU		0.474***
		(0.115)
Off to other partners × EU		-0.237
		(0.267)
Offshoring (Off)	-0.099	
	(0.107)	
Offshoring × EU	0.349***	
	(0.108)	
Method	GLS	GLS
Observations	565	565
Number of countries	42	42

Significance level: * p-value<0.10; ** p-value<0.05; *** p-value<0.01.

Table 10: Trade balance, Export and Import and GVC (FVA) by group of partners (quality index)

VARIABLES	(1) TB	(2) TB	(3) EXP	(4) EXP	(5) IMP	(6) IMP
GDP growth rate	-0.205***	-0.206***	0.216***	0.217***	0.413***	0.413***
	(0.040)	(0.039)	(0.072)	(0.068)	(0.068)	(0.067)
GDP per capita	0.047***	0.042***	0.107***	0.091***	0.069***	0.058***
	(0.012)	(0.012)	(0.025)	(0.024)	(0.022)	(0.021)
Age dep. ratio	-0.152*	-0.151*	-0.147	-0.224	-0.004	-0.050
	(0.085)	(0.086)	(0.188)	(0.182)	(0.161)	(0.153)
Population, total	0.000**	0.000*	0.000	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Population growth	-0.016	0.007	-0.192	-0.181	0.001	0.011
	(0.302)	(0.298)	(0.565)	(0.540)	(0.530)	(0.520)
Fiscal balance	-0.051	-0.051	-0.267***	-0.251***	-0.217***	-0.209***
	(0.044)	(0.043)	(0.081)	(0.076)	(0.076)	(0.075)
Public expenditure on health	-0.342	-0.418	-1.924***	-2.231***	-1.605***	-1.876***
	(0.276)	(0.277)	(0.555)	(0.532)	(0.502)	(0.486)
Terms of trade	-0.019	-0.030	0.034	-0.016	0.063*	0.033
	(0.019)	(0.019)	(0.037)	(0.036)	(0.034)	(0.033)
Net foreign assets (lagged)	0.006	0.007	-0.015	-0.013	-0.022**	-0.019**
	(0.005)	(0.005)	(0.010)	(0.010)	(0.010)	(0.009)
Crisis dummy	-0.003	-0.002	-0.009*	-0.007	-0.005	-0.004
	(0.002)	(0.002)	(0.004)	(0.004)	(0.004)	(0.004)
Financial center dummy	0.093***	0.079***	0.306***	0.248***	0.198***	0.155***
	(0.018)	(0.019)	(0.041)	(0.041)	(0.035)	(0.034)
Net fuel trade (Nft)	0.340***	0.307***	-0.391**	-0.502***	-0.732***	-0.807***
	(0.103)	(0.101)	(0.193)	(0.184)	(0.181)	(0.177)
Nft×(Russia-Norway)	0.675***	0.723***	2.048***	2.214***	1.338***	1.430***
	(0.214)	(0.210)	(0.393)	(0.374)	(0.372)	(0.365)
Russia-Norway dummy	-0.066	-0.072*	-0.053	-0.078	0.031	0.016
	(0.041)	(0.040)	(0.079)	(0.076)	(0.073)	(0.071)
FVA from LQ partners		-0.306**		0.606**		0.965***
		(0.135)		(0.259)		(0.236)
FVA from HQ partners		0.303***		2.585***		2.320***
		(0.054)		(0.111)		(0.095)
FVA from other partners (Q)		0.152**		1.615***		1.619***
		(0.062)		(0.119)		(0.110)
Foreign Value Added (FVA)	0.183***		1.984***		1.894***	
	(0.035)		(0.076)		(0.066)	
Method	GLS	GLS	GLS	GLS	GLS	GLS
Observations	565	565	565	565	565	565
Number of countryid	42	42	42	42	42	42

Significance level: * p-value<0.10; ** p-value<0.05; *** p-value<0.01.

Table 11: TB and GVC (FVA) in Euro and non-Euro countries

VARIABLES	(1) TB	(2) TB
GDP growth rate	-0.200***	-0.212***
	(0.039)	(0.038)
GDP per capita	0.042***	0.028**
	(0.012)	(0.011)
Age dep. ratio	-0.104	-0.045
	(0.087)	(0.081)
Population, total	0.000*	0.000
	(0.000)	(0.000)
Population growth	-0.090	-0.284
	(0.300)	(0.294)
Fiscal balance	-0.038	-0.017
	(0.044)	(0.043)
Public expenditure on health	-0.384	-0.615**
	(0.274)	(0.261)
Terms of trade	-0.031	-0.052***
	(0.019)	(0.018)
Net foreign assets (lagged)	0.005	0.001
	(0.005)	(0.005)
Crisis dummy	-0.003	-0.003
	(0.002)	(0.002)
Financial center dummy	0.087***	0.062***
	(0.018)	(0.017)
Net fuel trade (Nft)	0.364***	0.310***
	(0.102)	(0.100)
Nft×(Russia-Norway)	0.632***	0.720***
	(0.213)	(0.208)
Russia-Norway dummy	-0.072*	-0.080**
	(0.041)	(0.039)
Euro	-0.016	-0.018
	(0.013)	(0.011)
FVA from LI partners		-0.524**
		(0.264)
FVA from HI partners		0.274***
		(0.077)
FVA from other partners		-0.146
		(0.112)
FVA from LI partners×EURO		0.163
		(0.290)
FVA from HI partners×EURO		0.187**
		(0.089)
FVA from other partners× EURO		0.042
		(0.161)
Foreign Value Added (FVA)	0.054	
	(0.052)	
FVA×EURO	0.218***	
	(0.070)	
Method	GLS	GLS
Observations	565	565
Number of countries	42	42

Significance level: * p-value<0.10; ** p-value<0.05; *** p-value<0.01.

Table 12: Trade balance and GVC (FVA) in Euro and non-Euro countries

	Euro	**not-Euro**
All partners	0.272***	0.054
	(0.048)	(0.052)
FVALI	-0.360***	-0.524**
	(0.140)	(0.264)
FVAHI	0.461***	0.274***
	(0.051)	(0.077)

Significance level: * p-value<0.10; ** p-value<0.05; *** p-value<0.01.

Table 13: Cross-correlation table

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
CA (goods and ser.) (1)	1.00														
GDP growth rate (2)	-0.11	1.00													
	(0.01)														
GDP per capita (3)	0.46	-0.44	1.00												
	(0.00)	(0.00)													
Age dep. ratio (4)	-0.05	-0.45	0.54	1.00											
	(0.24)	(0.00)	(0.00)												
Population, total (5)	-0.07	0.47	-0.64	-0.52	1.00										
	(0.11)	(0.00)	(0.00)	(0.00)											
Population growth (6)	0.38	0.02	0.19	-0.44	0.17	1.00									
	(0.00)	(0.64)	(0.00)	(0.00)	(0.00)										
Fiscal balance (7)	0.35	0.25	0.18	-0.13	0.01	0.22	1.00								
	(0.00)	(0.00)	(0.00)	(0.00)	(0.86)	(0.00)									
Public expenditure on health (8)	0.16	-0.47	0.73	0.68	-0.47	-0.02	-0.07	1.00							
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.67)	(0.09)								
Terms of trade (9)	-0.03	0.05	-0.01	-0.12	-0.13	0.07	0.25	-0.07	1.00						
	(0.51)	(0.27)	(0.82)	(0.01)	(0.00)	(0.11)	(0.00)	(0.12)							
Net foreign assets (lagged) (10)	0.44	0.07	0.32	0.08	0.14	0.25	0.37	0.16	-0.01	1.00					
	(0.00)	(0.08)	(0.00)	(0.07)	(0.00)	(0.00)	(0.00)	(0.00)	(0.88)						
Net fuel trade (Nft) (11)	0.29	0.01	0.15	-0.08	-0.03	0.13	0.59	0.08	0.58	0.28	1.00				
	(0.00)	(0.81)	(0.00)	(0.06)	(0.44)	(0.00)	(0.00)	(0.05)	(0.00)	(0.00)					
Nft×Russia-Norway (12)	0.30	0.02	0.12	-0.03	-0.03	0.01	0.60	-0.00	0.44	0.27	0.89	1.00			
	(0.00)	(0.60)	(0.00)	(0.52)	(0.53)	(0.90)	(0.00)	(0.99)	(0.00)	(0.00)	(0.00)				
Russia-Norway dummy (13)	0.30	0.03	0.10	-0.03	-0.02	-0.01	0.57	-0.02	0.44	0.26	0.88	0.99	1.00		
	(0.00)	(0.50)	(0.01)	(0.44)	(0.61)	(0.84)	(0.00)	(0.69)	(0.00)	(0.00)	(0.00)	(0.00)			
Financial center dummy (14)	0.52	-0.06	0.37	0.03	-0.09	0.21	0.13	-0.03	-0.10	0.45	-0.06	-0.06	-0.06	1.00	
	(0.00)	(0.13)	(0.00)	(0.41)	(0.03)	(0.00)	(0.00)	(0.45)	(0.02)	(0.00)	(0.18)	(0.13)	(0.12)		
Foreign Value Added (FVA) (15)	0.28	-0.06	0.21	0.13	-0.33	-0.05	-0.15	0.13	-0.27	-0.04	-0.48	-0.33	-0.34	0.23	1.00
	(0.00)	(0.17)	(0.00)	(0.00)	(0.00)	(0.26)	(0.00)	(0.00)	(0.00)	(0.34)	(0.00)	(0.00)	(0.00)	(0.00)	

Table 14: Descriptives

Variable	Obs	Mean	Std. Dev.	Min	Max
Current account in goods and services (GDP share)	565	0.01	0.07	-0.20	0.33
GDP growth	565	0.02	0.03	-0.14	0.14
GDP per capita (ln)	565	10.22	0.59	7.93	11.49
Age dep. ratio (old, share of working age pop.)	565	0.21	0.06	0.07	0.41
Population (millions)	565	102.84	271.55	0.39	1364.27
Pop. growth	565	0.00	0.00	-0.03	0.02
Fiscal balance (GDP share)	565	-0.01	0.04	-0.31	0.20
Public expenditure on health (GDP share)	565	0.05	0.01	0.00	0.09
Term of trade (ln)	565	4.60	0.16	3.91	5.31
Net foreign assets position (GDP share)	565	-0.22	0.50	-1.46	2.62
Net fuel balance (GDP share)	565	-0.01	0.05	-0.12	0.24
Foreign value added (share of exports)	565	0.29	0.12	0.05	0.68

Table 15: Variables and sources

N.	Indicator	Source
1	Current account in goods and services: net exports of goods and services (over GDP)	World Bank, World Development Indicators (WDI)
2	GDP converted to international dollars using PPP rates (constant 2011 international $)	World Bank (WDI)
3	GDP (current US $)	World Bank (WDI)
4	Fiscal Balance: government revenue minus expenses (over GDP)	World Bank (WDI) and OECD for China
5	Public expenditure on health (over GDP)	World Bank (WDI)
6	Population	World Bank (WDI)
7	Population growth rate	World Bank (WDI)
8	Age dependency ratio, old (as a share of working-age population)	World Bank (WDI)
9	Net fuel trade (over GDP)	World Bank (WDI)
10	Term of trade index (2000100)	World Bank (WDI)
11	Net Foreign Assets position (over GDP)	Lane and Milesi-Ferretti (2017)
12	Foreign Value Added in a country exports (over exports)	WIOD.org (Timmer et al., 2015)
13	Offshoring index	WIOD.org (Timmer et al., 2015)

9. On-line Appendix

9.1. The Foreign Value Added in a country's export

Here we describe the parts of the Inter-Country Input-Output model of Koopmans et al. (2014) that we have used to compute the foreign value-added embodied in a country's exports.

Assume a G-country world, in which each country produces goods in N differentiated sectors. Goods in each sector might be consumed directly or used as intermediate input. Each country can also export both intermediate and final goods.

All gross output produced by country s must be used as either an intermediate good or a final good at home or in other countries,

$$\mathbf{X}_s = \mathbf{A}_{ss}\mathbf{X}_s + \mathbf{A}_{sr}\mathbf{X}_r + \mathbf{Y}_{ss} + \mathbf{Y}_{rs} \quad r, s = 1, ..., G \; r \neq s \tag{10}$$

where $\mathbf{X}_s$ is the $N \times 1$ gross output vector of country s, $\mathbf{Y}_{sr}$ is the $N \times 1$ final demand vector that represent demand in country r for final goods produced in s and $\mathbf{A}_{sr}$ is the $N \times N$ Input-Output coefficient matrix, showing the use in r of intermediate goods produced in s. The G-country production and trade system can be written as Inter-Country Input-Output model in block matrix notation

$$\begin{bmatrix} \mathbf{X}_1 \\ \mathbf{X}_2 \\ \vdots \\ \mathbf{X}_G \end{bmatrix} = \begin{bmatrix} \mathbf{A}_{11} & \mathbf{A}_{12} & ... & \mathbf{A}_{1G} \\ \mathbf{A}_{21} & \mathbf{A}_{22} & ... & \mathbf{A}_{2G} \\ \vdots & \vdots & \ddots & \vdots \\ \mathbf{A}_{G1} & \mathbf{A}_{G2} & ... & \mathbf{A}_{GG} \end{bmatrix} \begin{bmatrix} \mathbf{X}_1 \\ \mathbf{X}_2 \\ \vdots \\ \mathbf{X}_G \end{bmatrix} + \begin{bmatrix} \mathbf{Y}_{11} + \mathbf{Y}_{12} + ... + \mathbf{Y}_{1G} \\ \mathbf{Y}_{21} + \mathbf{Y}_{22} + ... + \mathbf{Y}_{2G} \\ \vdots \\ \mathbf{Y}_{G1} + \mathbf{Y}_{G2} + ... + \mathbf{Y}_{GG} \end{bmatrix} \tag{11}$$

and rearranging

$$\begin{bmatrix} \mathbf{X}_1 \\ \mathbf{X}_2 \\ \vdots \\ \mathbf{X}_G \end{bmatrix} = \begin{bmatrix} \mathbf{1} - \mathbf{A}_{11} & -\mathbf{A}_{12} & ... & -\mathbf{A}_{1G} \\ -\mathbf{A}_{21} & \mathbf{1} - \mathbf{A}_{22} & ... & -\mathbf{A}_{2G} \\ \vdots & \vdots & \ddots & \vdots \\ -\mathbf{A}_{G1} & -\mathbf{A}_{G2} & ... & \mathbf{1} - \mathbf{A}_{GG} \end{bmatrix}^{-1} \begin{bmatrix} \sum_r^G \mathbf{Y}_{1r} \\ \sum_r^G \mathbf{Y}_{2r} \\ \vdots \\ \sum_r^G \mathbf{Y}_{Gr} \end{bmatrix} = \begin{bmatrix} \mathbf{B}_{11} & \mathbf{B}_{12} & ... & \mathbf{B}_{1G} \\ \mathbf{B}_{21} & \mathbf{B}_{22} & ... & \mathbf{B}_{2G} \\ \vdots & \vdots & \ddots & \vdots \\ \mathbf{B}_{G1} & \mathbf{B}_{G2} & ... & \mathbf{B}_{GG} \end{bmatrix} \begin{bmatrix} \mathbf{Y}_1 \\ \mathbf{Y}_2 \\ \vdots \\ \mathbf{Y}_G \end{bmatrix} \tag{12}$$

where $\mathbf{B}_{sr}$ denotes the $N \times N$ block Leontief inverse matrix, which is the total requirement matrix that gives the amount of gross output produced in country s for one-unit increase in final demand in country r, $\mathbf{Y}_s = \sum_r^G \mathbf{Y}_{sr}$ is the $N \times 1$ vector that gives the global use of s's final products. This system can be also expressed as:

$$\mathbf{X} = (\mathbf{I} - \mathbf{A})^{-1}\mathbf{Y} = \mathbf{B}\mathbf{Y} \tag{13}$$

where $\mathbf{X}$ and $\mathbf{Y}$ are $GN \times 1$ vectors, and $\mathbf{A}$ and $\mathbf{B}$ as $GN \times GN$ matrices.

Having defined the Leontief inverse matrix, we turn to show how domestic and foreign contents of gross exports are computed. Let $\mathbf{V}_s$ be the $1 \times N$ direct value-added coefficient vector. Each element of $\mathbf{V}_s$ gives the share of direct domestic value added in total output. This is equal to one minus the intermediate input share from all countries (including domestically produced intermediates):

$$\mathbf{V}_s \equiv \mathbf{u}(\mathbf{I} - \sum_r \mathbf{A}_{rs}) \tag{14}$$

where $\mathbf{u}$ is a $1 \times N$ unity vector. To be consistent with the Inter-Country model, we define $\mathbf{V}$ the $G \times GN$ matrix of direct domestic value added for all countries,

$$\mathbf{V} \equiv \begin{bmatrix} \mathbf{V}_1 & \mathbf{0} & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{V}_2 & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \ddots & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{V}_G \end{bmatrix} \tag{15}$$

As in Koopman et al. (2014), combining $\mathbf{V}$ with Leontief inverse matrix $\mathbf{B}$ produces the $G \times GN$ value-added share ($\mathbf{VB}$) matrix, $\mathbf{VB}$ is our basic measure of value-added shares by source of production:

$$\mathbf{VB} = \begin{bmatrix} \mathbf{V}_1\mathbf{B}_{11} & \mathbf{V}_1\mathbf{B}_{12} & ... & \mathbf{V}_1\mathbf{B}_{1G} \\ \mathbf{V}_2\mathbf{B}_{21} & \mathbf{V}_2\mathbf{B}_{22} & ... & \mathbf{V}_2\mathbf{B}_{2G} \\ \vdots & \vdots & \ddots & \vdots \\ \mathbf{V}_G\mathbf{B}_{G1} & \mathbf{V}_G\mathbf{B}_{G2} & ... & \mathbf{V}_G\mathbf{B}_{GG} \end{bmatrix} \tag{16}$$

Within $\mathbf{VB}$, each element $\mathbf{V}_s\mathbf{B}_{sr}$ is a $1 \times N$ vector. Vectors on the diagonal denote domestic value-added share of domestically produced N products. The out-diagonal vectors along columns denote instead the foreign country's value-added shares in the same domestically produced N products. Each of the first N columns in the $\mathbf{VB}$ matrix includes all value added components, domestic and foreign, needed to produce one additional unit of domestic product at home.

Because all value added must be either domestic or foreign, the sum along each column is unity.

The $\mathbf{VB}$ matrix contains all the information to separate domestic and imported content shares in each country's gross exports at the sectoral level.

Let $\mathbf{E}_{sr}$be the $N \times 1$ vector of gross exports from s to r. For consistency with the Inter-Country Input-Output model we also define

$$E_{s*} = \sum_{r \neq s}^{G} \mathbf{E}_{sr} = \sum_{r \neq s}^{G} (\mathbf{A}_{sr}\mathbf{X}_r + \mathbf{Y}_{sr}) \;\; r, s = 1...G \tag{17}$$

$$\mathbf{E} = \begin{bmatrix} \mathbf{u}E_{1*} & \mathbf{0} & ... & \mathbf{0} \\ \mathbf{0} & \mathbf{u}E_{2*} & ... & \mathbf{0} \\ \vdots & \vdots & \ddots & \vdots \\ \mathbf{0} & \mathbf{0} & ... & \mathbf{u}E_{G*} \end{bmatrix} = \begin{bmatrix} \mathbf{E}_{1*} & \mathbf{0} & ... & \mathbf{0} \\ \mathbf{0} & \mathbf{E}_{2*} & ... & \mathbf{0} \\ \vdots & \vdots & \ddots & \vdots \\ \mathbf{0} & \mathbf{0} & ... & \mathbf{E}_{G*} \end{bmatrix} \tag{18}$$

where $\mathbf{E}$ is a $GN \times G$ export matrix and each element $\mathbf{E}_{s*} = \mathbf{u}E_{s*}$ is a $N \times 1$

vector given by the product of the unity $N \times 1$ vector $\mathbf{u}$ and the scalar E_{s*}.

The combination of value added share matrix $\mathbf{VB}$ and the export matrix $\mathbf{E}$ produces a $G \times G$ matrix ($\mathbf{VBE}$) that represents the aggregate measures of value-added by origin in countries gross exports

$$\mathbf{VBE} = \begin{bmatrix} \mathbf{V}_1\mathbf{B}_{11}\mathbf{E}_{1*} & \mathbf{V}_1\mathbf{B}_{12}\mathbf{E}_{2*} & ... & \mathbf{V}_1\mathbf{B}_{1G}\mathbf{E}_{G*} \\ \mathbf{V}_2\mathbf{B}_{21}\mathbf{E}_{1*} & \mathbf{V}_2\mathbf{B}_{22}\mathbf{E}_{2*} & ... & \mathbf{V}_2\mathbf{B}_{2G}\mathbf{E}_{G*} \\ \vdots & \vdots & \ddots & \vdots \\ \mathbf{V}_G\mathbf{B}_{G1}\mathbf{E}_{1*} & \mathbf{V}_G\mathbf{B}_{G2}\mathbf{E}_{2*} & ... & \mathbf{V}_G\mathbf{B}_{GG}\mathbf{E}_{G*} \end{bmatrix} \tag{19}$$

Diagonal elements of $\mathbf{VBE}$ define the domestic value-added in each countrys gross exports. Off-diagonal elements along each column give the foreign value-added embodied in each countrys exports by origin. Therefore, gross exports of country s can be decomposed into two components: domestic value-added content of gross exports (DV_s) and foreign value-added content of gross exports (FV_s) as follows

$$\mathbf{DV} = \begin{bmatrix} DV_1 \\ DV_2 \\ \vdots \\ DV_G \end{bmatrix} = \begin{bmatrix} \mathbf{V}_1\mathbf{B}_{11}\mathbf{E}_{1*} \\ \mathbf{V}_2\mathbf{B}_{22}\mathbf{E}_{2*} \\ \vdots \\ \mathbf{V}_G\mathbf{B}_{GG}\mathbf{E}_{G*} \end{bmatrix} \tag{20}$$

$$\mathbf{FV} = \begin{bmatrix} FV_1 \\ FV_2 \\ \vdots \\ FV_G \end{bmatrix} = \begin{bmatrix} \sum_{r \neq 1} \mathbf{V}_r\mathbf{B}_{r1}\mathbf{E}_{1*} \\ \sum_{r \neq 2} \mathbf{V}_r\mathbf{B}_{r2}\mathbf{E}_{2*} \\ \vdots \\ \sum_{r \neq G} \mathbf{V}_r\mathbf{B}_{rG}\mathbf{E}_{G*} \end{bmatrix} \tag{21}$$

$\mathbf{FV}$ and $\mathbf{DV}$ are both $G \times 1$ vectors. Elements of $\mathbf{FV}$ are the result of the sum of out-diagonal elements along each column of $\mathbf{VBE}$.

It holds that for the generic country s

$$E_{s*} = \mathbf{V}_s\mathbf{B}_{ss}\mathbf{E}_{s*} + \sum_{r \neq s} \mathbf{V}_r\mathbf{B}_{rs}\mathbf{E}_{s*} \tag{22}$$

Therefore we can easily derive the aggregate measures of domestic and foreign shares of value-added incorporated in country s gross exports as

$$dva_s = DV_s / E_{s*} \tag{23}$$

$$FVA_s = FV_s / E_{s*} \tag{24}$$

Note that measures indicated here as DV are instead denoted in Koopmans et al. (2014) as DC standing for domestic content of gross export; measures indicated here as FV are instead labeled in Koopmans et al. (2014) as VS standing for the foreign content of gross exports. VS indeed corresponds to the index proposed by Hummels et al. (2001) for measuring vertical specialization.