Have exports become less responsive to exchange rate movements?

The role of global value chains

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Abstract

This paper investigates how participation in global value chains affects the pass-through to export prices and the responsiveness of export volumes to changes in the exchange rate. We develop a partial equilibrium model of international trade with cross-border production and derive quantitative predictions for the role of precisely defined indices of global value chain participation for export elasticities. Using sectoral data, we then validate empirically our results and show that global value chain participation reduces the exchange rate pass-through to export prices and thereby lessens the responsiveness of export volumes.

Keyword:

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Non-technical summary

International trade today is characterised by global value chains. Firms use imported inputs to produce exports and export inputs that are processed by their trading partners and re-exported further. These goods and services either return back to the country of origin as final products or are designated for other final destination markets. In this paper we show in a partial equilibrium model of international trade that these different ways of participating in global value chains have different impacts on both the exchange rate pass-through to export prices and the price elasticity of exports. A greater share in total exports of foreign value added - or domestic value added that returns home - reduces the price elasticity of bilateral exports in our model, whereas a greater share of exports of inputs that are re-exported further should have little or no impact on the elasticities. Only a higher share of foreign value added should reduce the exchange rate pass-through to export prices.

To test the predictions from the model, we construct bilateral country-sector-by-destination indices of global value chain participation from global input-output tables, following Wang, Wei and Zhu (2013). Differently from the literature, we base these measures on currencies and not countries. This is important because it is arguably only supply chain links with countries of different currencies that will matter for the respective exchange rate elasticities.

With these new measures and a multi-country panel of sectors that cover 85% of world GDP from 1995-2009, we empirically test the model’s predictions. The empirical part strongly corroborate the theoretical results: a higher share of foreign value added (from the destination country with a different currency) as well as a greater share of exports that returns as imports weakens the responsiveness of exports to bilateral exchange rates. A higher share of exports of inputs that are re-exported further by the trading partner do not seem to change the price elasticity of exports nor the pass-through to export prices. These exports do however increase the responsiveness to the direct trading partner’s nominal effective exchange rate. Only a higher share of foreign value added reduces the exchange rate pass-through to export prices.

Our contribution to the literature is that we consider precisely defined bilateral indices of global value chain participation that capture all the important links embedded in global value chains. This allows us to distinguish between different production networks and their effects on the price elasticity of exports and the exchange rate pass-through to export prices.
1. Introduction

Much of international trade today is organised in global value chains. Firms import inputs and combine them with domestic factors of production to create exports of final products or refined inputs. A share of exports also consists of parts and components that are either used by the importer to produce domestic goods or services, or are used to produce exports to yet other destinations.

Firms that import a large share of inputs to produce exports might experience a lower exchange rate pass-through to their export prices, due to offsetting exchange rate effects on their marginal cost (as shown by Amiti, Itskhoki and Konings, 2014). Some of those imports however might be sourced from countries with the same currency and should thus not affect the trade elasticities. Moreover, if exports are re-exported further by the trading partner, export volumes should also be sensitive to the trading partners’ nominal effective exchange rate. Goods and services that are exported and ultimately re-imported back into the country of origin would also reduce the export elasticity between the two countries.

As complex production linkages have expanded globally over the past decades and with the formation of large currency areas such as the EMU, it is imperative to take into account both the details of global value chain participation as well as the movements in bilateral exchange rates when assessing the effect of global value chains on the price elasticity of exports and the exchange rate pass-through to export prices.

In this paper, we outline a partial equilibrium model of international trade with cross-border production. From the model, we derive a set of quantitative predictions on the impact of increasing integration in global value chains on the exchange rate pass-through to export prices, as well as its impact on the price elasticity of exports. Differently from much of the literature, we consider precisely defined bilateral indices of global value chain participation: foreign value added in exports that originate in destination countries with a different currency (foreign value added - FV), value added in exports that get re-exported by the trading partners (indirect value added - IV) and value added that get re-imported at a later stage (re-imported domestic value added - RDV).

As a first step, we run 10 000 simulations of the global input-output matrix in our theoretical model and estimate synthetic regressions based on the simulated data. The results suggest that FV and RDV should decrease the price elasticity of bilateral exports, whereas IV would
have only a negligible impact on the elasticities. For export prices, only FV should reduce the exchange rate pass-through.

We then take the results from the model to the data and empirically test the numerical predictions. First however, we specify indices of global value chains on the basis of currencies and not countries, which is usually the case in the literature on global value chains. With these new indices, we estimate equations for sectoral export volumes and export prices to destination-markets in a country-sector-to-destination-country level panel that cover 85% of world GDP from 1995-2009.

The empirical results corroborate the predictions from the simulations. A higher share of FV (from a country with a different currency) as well as RDV weakens the exchange rate responsiveness of exports. Higher share of IV do not seem to have any impact on bilateral export elasticity to exchange rates. However, it does seem that a higher IV with a trading partner increases the responsiveness to that trading partner’s nominal effective exchange rate. This is intuitive: it is the trading partners trading relationships that determine the demand for the IV exports. Thus, its nominal effective exchange rate will matter for those trade flows. For export prices, a higher FV reduces the exchange rate pass-through in line with the predictions of the model.

The outline of the paper is as follows: Section 2 gives a brief description of the literature related to this paper. Section 3 outlines the theoretical framework and numerical predictions of global value chain participation on the price elasticity of exports and exchange rate pass-through to export prices. Section 4 presents the main data sources and outlines the difference between our currency-based global value chain indices and those produced by Wang, Wei and Zhu (2013). Section 5 introduces the empirical specification and the results. Section 6 concludes.

2. Related literature

The responsiveness of trade volumes to movements in the exchange rate has recently been the focus of some debate. This perceived unresponsiveness of trade to exchange rate
movements has raised the question whether the price elasticity of exports has changed over time.¹

Arguments for a reduced exchange rate sensitivity of export volumes could relate to an increasing participation of firms in global value chains, which is associated with an increasing use of imported inputs in exports. In addition, the value of the domestic currency might not be what matters for the final destination of re-exports by trading partners.² For example, Ahmed, Appendino and Ruta (2015) find that participation in global value chains lowers the elasticity of manufacturing exports to the real effective exchange rate (REER) by 22 percent on average and by close to 30 percent for countries with the highest participation rates.

For Switzerland, Fauceglia, Lassmann, Shingal, and Wermelinger (2014), find that the decrease in relative prices of imported intermediate inputs may mitigate or even offset the negative effects of an exchange rate appreciation. Arbatli and Hong (2016) find that growing participation in global production chains and rising export complexity are important determinants of Singapore’s export elasticities. Imbs and Mejean (2017) confirm that trade elasticities can differ because of the specialization of consumption, of production, or because of international differences in sector-level trade elasticities.

Other factors that could reduce the responsiveness of exports to exchange rate movements relate to the increasing use of pricing-to-market strategies among large exporters that tend to keep their export prices stable and absorb any variability in the exchange rate in their mark-ups. Based on Belgian firm-product-level data, Amiti, Itskhoki and Konings (2014) find that import intensity and market share are key determinants of the exchange rate pass-through to export prices.

Although these studies have generally documented a lower exchange rate pass-through to export prices or export elasticity to the exchange rate from increasing global value chain participation, they have not taken into consideration the full set of global production linkages, nor the origin of foreign value added or the final destination of domestic value added in exports. Our contribution to the literature is that we consider precisely defined bilateral indices of global value chain participation that capture all the important links embedded in

global value chains and allow us to distinguish between different currency effects in the production network.

This paper therefore also adds one a critical dimension to the measurement of global value chains (pioneered by Wang, Wei and Zhu, 2013 and Koopman, Wang and Wei, 2014) when considering its effect on the price elasticity of exports and exchange rate pass-through to export prices.

3. Theoretical framework

How trade volumes react to movements in the exchange rate depends on two key elasticities: (i) the exchange rate pass-through; capturing the change in export price in response to an exchange rate movement, and (ii) the price elasticity of exports; that measures the change in export volumes following a price change in foreign currency. We argue that both elasticities are strongly impacted by participation in global value chains. First, as discussed in Amiti, Itskhoki and Konings (2014), firms importing a large share of inputs to produce exports experience a lower exchange rate pass-through, due to offsetting exchange rate effects on their marginal cost. However, some of those imports might be from countries with the same domestic currency (which should not affect the trade elasticities).

The reaction of exports to changes in the exchange rates is also a function of the final destination of exports, not just the first destination. Some exported inputs to a destination return to the country of origin as imports of final products. Others yet are re-exported to countries with different currencies. Hence, it is necessary to also take into account the finer details of global input-output linkages in order to fully account for the consequences of truly global production linkages for the responsiveness of export prices and export volumes to the exchange rate.

In the remainder of this section, we build a simple theoretical framework that illustrates how various global value chains flows impact both the exchange rate pass-through to export prices and the price elasticity of real exports. By taking into account firms’ engagement in global value chains both through imports and exports within a multi-country (multi-currency) world, we see our model as a first step toward the development of general equilibrium frameworks that can usefully be applied to the analysis of exchange rate movements. Moreover, our numerical exercise provides testable predictions that validate our modelling choices.
3.1 Production

Consider a stylized economy with three countries indexed by $k=1,2,3$. In each country, there is a representative firm producing with domestic labour and imported inputs according to a Cobb-Douglas technology:

$$Y_k = l_k^{\gamma_k} \times \prod_{k'=1}^{3} m_{k,k'}^{\alpha_{k,k'}} \quad \text{with} \quad \gamma_k + \sum_{k'=1}^{3} \alpha_{k,k'} = 1$$

where $\gamma_k$ is the labour share in production in country $k$ while $\alpha_{k,k'}$ is the share of output from country $k'$ in the total production of country $k$. Note that $Y_k$ is the gross output produced by country $k$ which is not equal to value added.

Let us denote by $\varepsilon_{i,j}$ the exchange rate faced by country $i$ vis-a-vis country $j$, that is: the units of country $i$ currency per unit of country $j$ currency. Firms are perfectly competitive, price at marginal cost and buy all their inputs in their domestic currency. In the absence of trade costs and taxes, standard cost minimization in each country leads to the following pricing system:

$$p_k = c_k \times w_k^{\gamma_k} \times \prod_{k'=1}^{3} (\varepsilon_{k,k'} p_{k'})^{\alpha_{k,k'}} \quad \text{for all } k$$

With $c_k$ a constant depending only on parameters. Taking the log and noting $k_k = \log(c_k)$ and $\Omega$ the cross-country input-output matrix of the economy (with $\Omega_{i,j} = \alpha_{i,j}$), country specific prices are the solution of:

$$\begin{pmatrix}
\log(p_1) \\
\log(p_2) \\
\log(p_3)
\end{pmatrix} = (I_3 - \Omega)^{-1} \begin{pmatrix}
k_1 + \gamma_1 \log(w_1) \\
k_2 + \gamma_2 \log(w_2) \\
k_3 + \gamma_3 \log(w_3)
\end{pmatrix} + (\Omega \circ \log(E)) \times \begin{pmatrix}1 \\ 1 \\ 1 \end{pmatrix}$$

One should keep in mind that with this definition, a 	extit{depreciation} of country $i$'s currency (compare to the one of country $j$) corresponds to an increase in $\varepsilon_{i,j}$ and a decrease in $\varepsilon_{j,i}$.

$^4$ $c_k$ is defined by:

$$c_k = \gamma_k^{\gamma_k} \prod_{k'} \alpha_{k,k'}^{\alpha_{k,k'}}$$
where $E$ is a 3-by-3 matrix of nominal exchange rate defined by $E_{i,j} = \varepsilon_{i,j}$, the symbol $\circ$ represents the element-wise (Hadamard) product and the log operator on $E$ is applied element-wise. As is usual in the global value chain literature, the Leontief inverse $(I_3 - \Omega)^{-1}$ captures all direct and indirect input-output linkages and naturally appears in the pricing equation. The price of a firm in country 1 hence depends on the price of its direct and indirect suppliers.

To illustrate the role of global value chains for both price and export sensitivity with respect to exchange rate changes, we consider a very simple input-output structure without domestic intermediates as follows:\(^5\)

$$
\Omega = \begin{pmatrix} 0 & \alpha_{1,2} & \alpha_{1,3} \\ \alpha_{2,1} & 0 & \alpha_{2,3} \\ \alpha_{3,1} & \alpha_{3,2} & 0 \end{pmatrix}
$$

In the simple case, it is useful to write a closed form solution for $\log(p_1)$ in order to gain intuition on the impact of different elements on firms' pricing behaviour:

$$
\log(p_1) = \lambda \times \left( (1 - \alpha_{3,2}\alpha_{2,3}) (k_1 + \gamma_1 \log(w_1) + \alpha_{1,2} \log(\varepsilon_{1,2}) + \alpha_{1,3} \log(\varepsilon_{1,3})) + (\alpha_{1,2} + \alpha_{1,3}\alpha_{2,3}) (k_2 + \gamma_2 \log(w_2) + \alpha_{2,1} \log(\varepsilon_{2,1}) + \alpha_{2,3} \log(\varepsilon_{2,3})) + (\alpha_{1,3} + \alpha_{1,2}\alpha_{2,3}) (k_3 + \gamma_3 \log(w_3) + \alpha_{3,1} \log(\varepsilon_{3,1}) + \alpha_{3,2} \log(\varepsilon_{3,2})) \right)
$$

With $\lambda = det(I_3 - \Omega)^{-1}$. Note that this expression of prices is independent of the demand side of the economy which will be described in the next section. From equation (3), one can easily compute several interesting elasticities. For example, one can investigate the effect of internal devaluations on prices by computing elasticities of prices with respect to changes in wage rates:

$$
\frac{\partial \log(p_1)}{\partial \log(w_1)} = \lambda \gamma_1 (1 - \alpha_{3,2}\alpha_{2,3}) , \quad \frac{\partial \log(p_1)}{\partial \log(w_2)} = \lambda \gamma_2 (\alpha_{1,2} + \alpha_{1,3}\alpha_{2,3}) , etc ...
$$

Furthermore, the exchange rate pass-through to export prices\(^6\) can also be computed from the above system. In order to do so, one must specify the exact currency movement for all country pairs. In order to gain intuition, we start with a particularly simple example and

\(^5\) This structure is also used for example in Duval et al (2016)

\(^6\) See for example Amiti, Itskhoki and Konings (2014) for both theoretical and empirical studies on this.
consider the case of depreciation in country 1 vis-à-vis the other two countries and assume that both countries do not alter the value of their own currency. In such a case, we have:

\[
\begin{align*}
1 &= \Delta \log(\varepsilon_{1,2}) = \Delta \log(\varepsilon_{1,3}) = -\Delta \log(\varepsilon_{2,1}) = -\Delta \log(\varepsilon_{3,1}) \\
0 &= \Delta \log(\varepsilon_{2,3}) = \Delta \log(\varepsilon_{3,2})
\end{align*}
\]  

(5)

Generally, a depreciation of country 1’s currency could also impact the wage rates in all countries. For simplicity, we abstract from these general equilibrium effects for now. Using the above result, we can compute the elasticity on country 1 price (in its domestic currency) with respect to a one percent depreciation of its own currency, everything else being constant:

\[
\Delta \log(p_1)_{1\% \text{ devaluation in 1}} = \lambda \left[ \alpha_{1,2} + \alpha_{1,3} - (\alpha_{1,2}\alpha_{2,1} + \alpha_{1,3}\alpha_{3,1}) - \alpha_{1,2}(\alpha_{2,3}\alpha_{3,1} + \alpha_{3,2}\alpha_{2,3}) - \alpha_{1,3}(\alpha_{3,2}\alpha_{2,1} + \alpha_{3,2}\alpha_{2,3}) \right]
\]

(6)

Equation (6) provides us with useful intuitions regarding the role of global value chains for the exchange rate pass through: as a first order effect, when devaluing its currency, country 1 makes its imports relatively more expensive which increases its price (in its own currency, but obviously not in foreign currency) as shown by the first term in the bracket, \(\alpha_{1,2} + \alpha_{1,3}\). Such an effect has been studied extensively and has been tested in the data for example in Amiti, Itskhoki and Konings (2014).

The importance of imported inputs for the pass-through could however be mitigated by the fact that some imported inputs are not entirely produced abroad, but are domestic value added that returns home as imports. Such value added comes from direct linkages (second term of the above equation, \((\alpha_{1,2}\alpha_{2,1} + \alpha_{1,3}\alpha_{3,1})\)) or indirectly through third country effects (third and fourth term). These terms, in turn, tend to reduce the first order increase due to the direct linkages. The key element of the above reasoning is the separation between gross flows and value added flows between countries. By considering gross trade flows instead of value added flows, other studies such as Amiti, Itskhoki and Konings (2014) face the risk of missing the full extent of cross-country linkages, which is an important feature of modern global production processes.

7 The consequence of depreciation on the labour market can be twofold: if there are some unemployed resources, depreciation can increase employment and output by stimulating foreign demand. If factors of production are fixed, it can increase wages. See Krugman and Taylor (1977) for a theoretical discussion of the possible contraction effects of devaluation.
Consider now a more general case. We denote by $\Delta$ the time difference of a given variable and use the fact that for all country pairs $\Delta \log(\varepsilon_{i,j}) = -\Delta \log(\varepsilon_{j,i})$. A total differentiation of the price equation (3) yields:

$$
\Delta \log(p_{1,t}) = \left[(1 - \alpha_{3,2}\alpha_{2,3})\alpha_{1,2} - (\alpha_{1,2} + \alpha_{1,3}\alpha_{3,2})\alpha_{2,1}\right] \lambda \Delta \log(\varepsilon_{1,2,t}) \\
+ \left[(1 - \alpha_{3,2}\alpha_{2,3})\alpha_{1,3} - (\alpha_{1,3} + \alpha_{1,2}\alpha_{2,3})\alpha_{3,1}\right] \lambda \Delta \log(\varepsilon_{1,3,t}) \\
+ \left[(\alpha_{1,2} + \alpha_{1,3}\alpha_{3,2})\alpha_{2,3} - (\alpha_{1,3} + \alpha_{1,2}\alpha_{2,3})\alpha_{3,2}\right] \lambda \Delta \log(\varepsilon_{2,3,t})
$$

(7)

where we assumed that changes in wage rates are not correlated with changes in the exchange rate so that the residual $u_{k,t}$ is orthogonal to other terms in the right hand side of the equation. The above expression then yields a simple, intuitive and testable prediction. The price change associated with a change in the exchange rate is increasing if the share of foreign value added in gross production increases (from countries vis-à-vis the currency depreciates). Moreover, the last term in the equation also shows that any change in the exchange rate between foreign countries also impacts domestic prices to the extent that some exports are domestic value added that return home as imports.

### 3.2 Demand

Goods produced in the home country can be sold to domestic and foreign consumers as final good as well as inputs. Demand stemming from consumers is derived from a reduced form utility function defined by:

$$
C_k = \prod_{k'=1}^{3} y_{k',k}^{\beta_{k,k'}} \quad \text{with} \quad \sum_{k'=1}^{3} \beta_{k,k'} = 1
$$

where $\beta_{k,k'}$ captures the share of country $k'$ in final consumption of country $k$ and $y_{k,k'}$ is the quantity of goods produced in $k'$ consumed in $k$.

In order to simplify the analysis and to avoid general equilibrium effects, there is an exogenous mass $L_k$ of agents in country $k$, all employed and earning an exogenous wage rate $w_k$. In what follows, we assume that the nominal wage is exogenously fixed and is not affected by exchange rate movements. It is important to note the partial equilibrium nature of

$$
u_{k,t} = (1 - \alpha_{3,2}\alpha_{2,3})\gamma_1 \Delta \log(w_{1,t}) + (\alpha_{1,2} + \alpha_{1,3}\alpha_{3,2})\gamma_2 \Delta \log(w_{2,t}) + (\alpha_{1,3} + \alpha_{1,2}\alpha_{2,3})\gamma_3 \Delta \log(w_{3,t})$$
this assumption: the wage is not determined by market clearing in the labour market and we do not model what happens to workers not employed by the domestic firm.\footnote{A simple micro-foundation of this would be to model an “outside good” sector producing using only labour and which would be freely traded across countries.} The Cobb-Douglas nature of aggregate preferences and the equality between labour payment and total spending imply that:

$$\varepsilon_{k',k} p_k y_{k',k} = \beta_{kt,k} w_{kt} L_{kt}, \quad \text{for all } k \text{ and } k'$$

Moreover, demand schedules coming from foreign firms are simply:

$$\varepsilon_{k',k} p_k m_{k',k} = \alpha_{kt,k} p_{kt} Y_{kt}, \quad \text{for all } k \text{ and } k'$$

As a reminder, in the equations above the exchange rate transforms country $k$ currency into country $k'$ currency. When country $k$’s currency depreciates vis-a-vis $k'$, $\varepsilon_{k',k}$ decreases so that the price of $k$-produced goods sold in $k$’s currency decreases, which increases the quantities exported.

### 3.3 Market clearing

Collecting sales across all agents and equating to production, we get the following market clearing conditions:

$$Y_k = \sum_{i=1}^{3} y_{k,i} + \sum_{i=1}^{3} m_{k,i}, \quad \text{for all } k \tag{10}$$

Replacing equations in Section 3.2 in the market clearing condition and using the fact that $\varepsilon_{i,j} = 1/\varepsilon_{j,i}$ we get the revenue system (in nominal terms for simplicity):

$$\begin{pmatrix} p_1 Y_1 \\ p_2 Y_2 \\ p_3 Y_3 \end{pmatrix} = \left[ I_3 - \Omega^T \circ E \right]^{-1} \left[ B^T \circ E \right] \begin{pmatrix} w_1 L_1 \\ w_2 L_2 \\ w_3 L_3 \end{pmatrix} = T \left[ B^T \circ E \right] \begin{pmatrix} w_1 L_1 \\ w_2 L_2 \\ w_3 L_3 \end{pmatrix} \tag{11}$$

where $B$ is a 3-by-3 matrix grouping the shares $\beta_{i,j}$ and we defined the matrix $T = \left( I_3 - \Omega^T \circ E \right)^{-1}$. Comparing to the pricing system, it is interesting to note that in the revenue system, the input-output matrix $\Omega$ is transposed, which stems from the fact that the
revenue of a given firm does depend on the revenue of its direct and indirect customers (whereas prices depend on a firm’s direct and indirect suppliers).

For given wages, the (partial) equilibrium is then defined by optimality of pricing (equation (2)) and market clearing conditions (equation (11)).

In order to illustrate the relationship between currency depreciation, exports and more specifically the impact of global value chains, let us consider a simple case in which consumers consume only domestic goods so that all trade happens in the intermediate good market. With this assumption, we have \( B = I_3 \) which leads to a simple expression for nominal gross output in country 1 (and similar equations follow for other countries):

\[
p_1 Y_1 = \mu \times \left( (1 - \alpha_3 \alpha_2) w_1 L_1 \right) + (\alpha_2 \epsilon_{1,2} - \alpha_2 \alpha_3 \epsilon_{3,2} \epsilon_{1,3}) w_2 L_2 + (\alpha_3 \epsilon_{1,3} - \alpha_2 \alpha_3 \epsilon_{2,3} \epsilon_{1,2}) w_3 L_3 \tag{12}\]

\[
p_2 Y_2 = \mu \times \left( \alpha_1 \epsilon_{2,1} - \alpha_1 \alpha_3 \epsilon_{3,1} \epsilon_{2,3} \right) w_1 L_1 + (1 - \alpha_1 \alpha_3) w_2 L_2 + (\alpha_3 \epsilon_{2,3} - \alpha_1 \alpha_2 \epsilon_{1,3} \epsilon_{2,1}) w_3 L_3 \tag{13}\]

\[
p_3 Y_3 = \mu \times \left( \alpha_1 \epsilon_{3,1} - \alpha_1 \alpha_2 \epsilon_{2,1} \epsilon_{3,2} \right) w_1 L_1 + (\alpha_2 \epsilon_{3,2} - \alpha_1 \alpha_2 \epsilon_{1,2} \epsilon_{3,1}) w_2 L_2 + (1 - \alpha_2 \alpha_1) w_3 L_3 \tag{14}\]

Where the constant \( \mu = det(T)^{-1} \) is invariant to changes in exchange rates as long as the no arbitrage condition between currencies is preserved. In this specific case of Cobb Douglas production function, the level of nominal gross output in each country is simply a function of the input-output matrix and the level of final nominal demand in each country. Hence, nominal exports from country 1 to country 2, which is proportional to nominal output in country 2 \( \text{Nominal Exports}_{1 \to 2} = \epsilon_{1,2} \alpha_{2,1} p_2 Y_2 \), does not depend on country 1’s price but is a function the whole network of input-output linkages as well as all pairwise exchange rates.

\[^{10}\text{In our special case of input-output linkages, we have:}\]

\[
\mu^{-1} = 1 - \alpha_{1,2} \alpha_{2,1} - \alpha_{1,3} \alpha_{3,1} - \alpha_{2,3} \alpha_{3,2} - \epsilon_{1,2} \epsilon_{2,3} \epsilon_{3,1} \alpha_{1,3} \alpha_{3,2} \alpha_{2,1} - \epsilon_{1,3} \epsilon_{3,2} \epsilon_{2,1} \alpha_{1,2} \alpha_{2,3} \alpha_{3,1}
\]
Finally, we can then get an expression of the relative change in real exports by simply:

\[
\frac{\Delta \text{Real Exports}_{1 \rightarrow 2}}{\text{Real Exports}_{1 \rightarrow 2}} = \frac{\Delta (\varepsilon_{1,2} \alpha_{2,1} p_2 Y_2) - \Delta p_1}{p_1}
\]

(15)

3.4 Quantitative explorations

In this section, we quantitatively investigate the consequences of a depreciation of country 1’s currency vis-à-vis other currencies and how global value chain participation impacts the exchange rate pass-through to export prices and the elasticity of real exports to changes in the exchange rate. In order to do so, we start by formally defining three indices of global value chain participation. We then calibrate the model to these structures, varying separately each of those indices and show numerically how those changes impact the trade elasticities.

3.4.1 Definition of indices

Following the literature on global value chains, we use the decompositions of trade flows from Wang, Wei and Zhu (2013)\(^{11}\), namely foreign value added (FV), intermediate value added (IV) and domestic value added exported that returns home (RDV) All the measures are expressed as ratio to gross exports.

The FV index measures the share of foreign value added in exports (the import content of exports) while the IV index measures the domestic value added that is exported and used by the direct trading partner for the production of their own exports to other countries.\(^{12}\) The third index, labelled RDV, captures the domestic value added exported abroad that then returns home where it is finally absorbed. Such an index is particularly interesting when studying the impact of currency movements on trade elasticities since it measures the value added in exports that is driven by domestic demand of the exporting country.

The general idea is to separate, in the expression of total trade flows, the embedded value added in exports by both origin and destination for final absorption. Let us consider gross

\(^{11}\) More precisely, we base our decomposition on equation 31 in Wang, Wei and Zhu (2013) for the case of three countries, two sectors per country and trade in both intermediate and final goods. In our empirical analysis, we then consider the general case as presented in equation 37.

\(^{12}\) In the global value chains literature, FV and IV are also considered measures of backward and forward participation in global value chains, respectively.
exports from any country \( i \) to another country \( j \) and let us denote by \( k \) the third country in the world. In our special case with three countries, only one sector per country and without trade in final goods, the expression simplifies to:

\[
E_{i \rightarrow j} = v_i \alpha_{i,j} T_j L_j + v_i \alpha_{i,j} T_j k L_k + v_i (T_{i,j} - 1) \alpha_{i,j} p_j Y_j + v_j T_j L_j + v_k T_k L_k + v_k T_k j L_k
\]

where \( T_{i,j} \) are elements of the matrix \( T \) and \( v_i \) is the value added share of gross output in country \( i \), which is simply equal to the share of labour in total costs and is defined by \( v_i = 1 - \sum_{k=1}^{3} \alpha_{i,k} \). \( E_{j \rightarrow \cdot} \) represents total gross exports from country \( j \), irrespective of the destination country and in country \( i \)'s currency. Note that as a result of our simplifying assumptions, the number of terms in this decomposition decreases from 16 in Wang, Wei and Zhu (2013) to only 8.\(^{13}\) Using this decomposition, the first term corresponds to the domestic value added exported from \( i \) to \( j \) and absorbed in \( j \). The domestic value added exported to \( j \) and then re-exported and absorbed in a third country (\( IV_{i \rightarrow j} \)) is defined by the second term. The foreign value added content of exports from \( i \) to \( j \) (\( FVA_{i \rightarrow j} \)) consists of the fifth and seventh term. Moreover, the domestic value added exported and then re-imported home for domestic absorption (\( RDV_{1 \rightarrow 2 \rightarrow 1} \)) consists of the third term. Finally, all other terms (fourth, sixth and eighth) are double counting (recall that there are no trade in final goods). Focusing on exports from country 1 to country 2, the indices are formally defined as:

\[
FVA_{1 \rightarrow 2} = \left( v_2 T_{2,1} \alpha_{2,1} \varepsilon_{1,2} w_2 L_2 + v_3 T_{3,1} \alpha_{2,1} \varepsilon_{1,2} w_2 L_2 \right) / E_{1 \rightarrow 2}
\]

\[
IV_{1 \rightarrow 2} = v_1 \alpha_{2,1} T_{2,3} \varepsilon_{2,3} w_3 L_3 / E_{1 \rightarrow 2}
\]

\[
RDV_{1 \rightarrow 2 \rightarrow 1} = v_1 \alpha_{2,1} T_{2,1} w_1 L_1 / E_{1 \rightarrow 2}
\]

### 3.4.2 Numerical exercise

In the remainder of this section, we will use our theoretical framework to perform comparative statics of the how the price elasticity of exports and exchange rate pass-through to export prices changes with the structure of global input-output linkages. To this end, we

\(^{13}\) The terms in our decomposition corresponds to, respectively T2, T3, T8, T10, T12, T13, T15 and T16 of equation 31 in WWZ. In their labelling, IV is T3+T4 and T5, FVA is T11+T12+T14, T15 and RDV is T6+T7+T8.
randomly create a sequence of 10,000 different configurations for the $\Omega$ matrix in the model outlined above. For each set of parameters, we simulate an exogenous decrease of country 1’s currency and compute the associated change in exports from country 1 to country 2. This allows us to have, for each configuration of the global input-output network, a value for the elasticity of exports to exchange rate and the exchange rate pass-through to export prices, as well as the value of our three indices: FV, IV and RDV. The simulated dataset is then used to assess the structural relationship between changes in the global value chain indices and the trade elasticities, and to produce numerical predictions.

For each value of the $\Omega$ matrix, we consider initially a perfectly symmetric world were exchange rates are all equal to $\varepsilon_{ij} = 1$ for all $(ij)$, $w_i = 1$ and $L_i = 100$ in all countries. From this point, we are interested in the impact of a depreciation of country 1’s currency. Hence, we exogenously increase $\varepsilon_{1,2}$ and $\varepsilon_{1,3}$ by 10 percent (taking into account that $\varepsilon_{i,j} = 1/\varepsilon_{j,i}$) and record the changes in real gross exports. We then compute the elasticities of real exports and export prices (in producer’s currency) with respect to the exchange rates as:

$$\eta_{\text{Export,Exchange rate}} = - \frac{\Delta \text{Real Exports}_{1 \rightarrow 2}}{\text{Real Exports}_{1 \rightarrow 2}} \frac{\Delta \varepsilon_{1,2}}{\varepsilon_{1,2}}$$

$$\eta_{\text{Export Price,Exchange rate}} = - \frac{\Delta p_1}{p_1} \frac{\Delta \varepsilon_{1,2}}{\varepsilon_{1,2}}$$

### 3.4.3 Numerical results

The simulated dataset consists of 10,000 observations indexed by $i$, each containing different values for the three global value chain indices and the associated price- and export elasticity of the exchange rate. To assess the influence of each index on the exchange rate elasticity, we perform the following regression:

$$\log(\eta_{\text{Export,Exchange rate},i}) = \alpha_1 + \beta_{FV} * FV_i + \beta_{IV} * IV_i + \beta_{RDV} * RDV_i + \varepsilon_{1,i}$$

$$\log(\eta_{\text{Price,Exchange rate},i}) = \alpha_2 + \delta_{FV} * FV_i + \delta_{IV} * IV_i + \delta_{RDV} * RDV_i + \varepsilon_{2,i}$$
Starting by examining the foreign value added in exports: an increase in $FV_{1 \rightarrow 2}$ is naturally associated with an increase in producer prices after a currency depreciation. As a result, an increase in $FV_{1 \rightarrow 2}$ is associated with a fall in the export elasticity of the exchange rate and a decrease in the exchange rate pass-through.

<table>
<thead>
<tr>
<th>Dependent variable:</th>
<th>Price elasticity of exports</th>
<th>Exchange rate pass-through to export prices</th>
</tr>
</thead>
<tbody>
<tr>
<td>FV</td>
<td>-0.13</td>
<td>0.12</td>
</tr>
<tr>
<td></td>
<td>(0.00)</td>
<td>(0.00)</td>
</tr>
<tr>
<td>RDV</td>
<td>-0.17</td>
<td>0.04</td>
</tr>
<tr>
<td></td>
<td>(0.00)</td>
<td>(0.00)</td>
</tr>
<tr>
<td>IV</td>
<td>-0.04</td>
<td>0.04</td>
</tr>
<tr>
<td></td>
<td>(0.00)</td>
<td>(0.00)</td>
</tr>
<tr>
<td>R²</td>
<td>0.99</td>
<td>0.99</td>
</tr>
<tr>
<td>N</td>
<td>10,000</td>
<td>10,000</td>
</tr>
</tbody>
</table>

*Note: standard errors in parentheses*

Regarding $IV_{1 \rightarrow 2}$, the association with the price elasticity of exports is about a third lower compared to the point estimate for $FV_{1 \rightarrow 2}$. Recall that $IV_{1 \rightarrow 2}$ measures the domestic value added exported from country 1 to country 2, which is used by country 2 to produce exports to country 3. From country 1’s perspective, these exports should not affect the upstream structure of the global value chain, and thus only have a limited impact on its price formation. Moreover, $IV_{1 \rightarrow 2}$ is also associated with a slight decrease in the export elasticity. This is due to the fact that we model the exchange rate depreciation of country 1’s currency vis-à-vis all countries in the world, and the value added used by country 2 to produce exports to 3 is also subject to the same gain than if they are absorbed in country 2 – with the only difference that the price of exports from 2 to 3 is made of a smaller share of country 1’s value added.

Finally, while an increase in $RDV_{1 \rightarrow 2 \rightarrow 1}$ has a limited impact on the price elasticity (once controlled for the effect going through $FV_{1 \rightarrow 2}$), it nevertheless strongly decreases the export elasticity to the exchange rate. This result is intuitive: exports to country 2 that are re-imported to country 1 do not benefit from a competitive edge when country 1’s currency depreciates.
One concern about the previous analysis could stem from the degree of correlation between various indices of global value chain participation, leading to issues of multicollinearity in the estimation. We recognise this and in order to assess its relevance, we compute the variance influence vector in the table below:

<table>
<thead>
<tr>
<th></th>
<th>Variance Influence Vector (VIF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FV</td>
<td>5.87</td>
</tr>
<tr>
<td>IV</td>
<td>4.95</td>
</tr>
<tr>
<td>RDV</td>
<td>2.00</td>
</tr>
<tr>
<td>Mean VIF</td>
<td>4.27</td>
</tr>
</tbody>
</table>

As argued initially by Mansfield and Helms (1982) or Alin (2010), a mean VIF close or above 10 raises some concerns regarding multicollinearity and the performance of estimation. In our case, a mean VIF below 5 is sufficiently low to be confident that such an issue does not affect significantly our point estimates.

### 3.4.4 Summary of testable predictions

The numerical exercise yields two main predictions that will later be tested in the data: first, an increase in both FV and RDV is strongly associated with a decrease in the elasticity of exports to exchange rates while the association with IV is negligible. Second, an increase in the FV index is associated with a higher price elasticity of exchange rate when the price is measured in domestic currency. Alternatively, when measuring prices in destination currency,
our result implies that an increase in FV is associated with lower price changes in response to exchange rate movements.

Finally, the setup developed in this paper assumes a fixed elasticity of substitution equal to one between domestic and foreign inputs in all production functions. Such a Cobb-Douglas framework has evidently an important impact on the value of the elasticity of exports volumes and export prices to exchange rate changes which might not be in line with empirical findings in all sectors or countries. However, it is important to note that our goal is not to recover the level of those elasticities, but rather to illustrate the impact of changes in global value chain participation. In other words, our analysis shows that for any fixed value of the sensitivity of exports volumes to changes in export prices, the participation in global value chain is a key element in the responsiveness of exports to movements in the exchange rate.

4. Data and methodology

4.1 Data

Before testing the predictions from the previous section, we must first construct a dataset that captures all the important links embedded in global value chains that allows us to distinguish between different currency effects in the production network. We utilise mainly two sources of data; (i) the World Input-Output Tables (WIOD) and (ii) a sectoral panel dataset from the Socio-Economic Accounts (SEA). These tables contain annual global input-output information for 35 sectors, comprising primary, durable and nondurable manufacturing as well as services sectors, including financial intermediation. The WIOD is available for 40 countries of which a majority is in the European Union, but also include countries in North America, South America and Asia, as well as rest of the world (constructed as one economy) from 1995 to 2011. These tables are both available in current (to 2011) and in previous years.

14 In general, this elasticity is a function of (i) the elasticity of substitution between domestic and foreign goods in both production and demand functions and (ii) the intertemporal elasticity of substitution governing intertemporal choices. In our static framework, the latter channel is not present.

15 While the focus of this paper is on export volumes, in the theoretical literature the effect of an exchange rate change on the trade balance is usually studied through the Marshall-Lerner condition which states that the sum of export and import elasticities of the exchange rate should be above unity in order for trade balance to improve upon currency depreciation. Our study shows that both elasticities are strongly impacted by countries’ participation in global value chains. Moreover, the empirical literature has expressed concerns regarding the validity of the Marshall-Lerner condition. See Rose (1991) or Auboin and Ruta (2012) for more on the topic.

16 www.wiod.org
Therefore, for each year a full country-sector input-output matrix of the dimension $1435 \times 1435$ is available and allows for the analysis of bilateral supply and use relationships between a sector in a specific country, as well as the sectors in the other 39 countries in the WIOD.

The Socio-Economic Accounts of the WIOD contain a multi-country panel of sector data on for example employment, capital stocks, gross output and value added at current and in previous years prices (up to 2009). The bilateral nominal exchange rates are provided by the WIOD whereas countries’ nominal effective exchange rates are obtained from the BIS. Together, these sources form the basis for the construction of bilateral trade flows, export prices, bilateral exchange rates and indices of global value chain participation.

Obtaining the real bilateral exports flows between a sector $s$ and its destination market $d$ from the WIOD is straightforward. They are calculated as the gross nominal flows from sector $s$ in country $o$ to other countries $d$ (where $o \neq d$). Sector-level export prices to a particular destination are computed by dividing for each year the global input-output tables in current prices with the same tables in previous year’s prices. Since the WIOD is expressed in US dollars, we convert them to local currencies with bilateral exchange rates. Thereafter, we consider export prices from sector $s$ in country $o$ to destination market $d$ (recall that $o \neq d$ so intra-country prices are not included) and we use them to deflate the corresponding gross export flows. In the following analysis these prices will be expressed in the destination markets currency.

### 4.2 Currency- and country-based indices of global value chains

We base our three indices (FV, IV and RDV) of global value chain participation on the value added decomposition of sectoral gross exports developed by Wang, Wei and Zhu (2013). Those measures need to be adapted however to be comparable to our predictions from Section 3. In the theoretical model each country has its own currency. Since reality is more complex with countries participating in currency unions (such as the EMU) or have currency pegs, we need to construct indices of global value chain participation that are based on currencies and not countries. One of our innovations compared to the literature on global value chains and its impact on trade elasticities therefore, is that we re-compute FV, IV and RDV on the basis of

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17 The 2016 release of the World Input-Output Tables contains information for 56 sectors in 43 countries annually from 2000-2014 in nominal values. However, these tables are not yet available in both current and previous year’s prices.
currencies. This is important because it is arguably only those trade flows in global value chains that vary with the bilateral exchange rate that will dampen the trade elasticities.

Starting with FV, our first measure of global value chain participation: in the literature, this measure would encapsulate all imports that are used to produce exports to a destination. However, the only imports used to produce exports that should matter for reducing the elasticity in the bilateral case is the imports that are priced in the same currency as the destination of the exports.

For example, consider a German firm that imports some of its components from the United States to produce exports there. In this case, increasing the share of imports would affect the German firm’s export and export price elasticities to the EUR/USD. However, inputs sourced from countries with the same currency as Germany should have no impact on the export elasticity to the United States. Moreover, imported inputs from countries with different currencies than the EUR or USD would have an ambiguous impact on the elasticities and would depend on the relative exchange rate movements of the three currencies.

Since we are interested in the precise impact of global value chains on the trade elasticities, we construct our bilateral index, $FV_{o \rightarrow d}$, by considering only value added that originated in a destination market $d$, that also have a different currency than $o$. If the destination market $d$ has the same currency as the origin, $FV_{s \rightarrow d} = 0$.

Our second currency-based index, IV, also differs from the corresponding country-based one. To illustrate this, we continue with the example of the German firm. It sells components to an assembly plant in Mexico, where they are processed and later exported to the United States as a finished product. In this case, our $IV_{o \rightarrow d}$ measure and the country-based index coincide. If all countries (origin, assembler and final destination) are within a currency area such as the EMU, however, the IV measure would not be counted at all.

If the final destination of exports is within the origin country’s currency area (Spain instead of the United States for example), we would consider that as domestic value added that returns “home” and would be counted as RDV. Therefore, all value added that goes through a trading partner with a different currency, but returns to a country with the same currency as the origin, will be counted as “returned domestic value added”, $RDV_{o \rightarrow d}$.

How do our currency-based indices differ from those computed on the basis of countries? Table 1 shows summary statistics for the various measures, computed over all country-sector
exports to destination markets, based on currencies and countries in 2005. As expected, the average of the currency-based IV is smaller than the one based on countries, whereas the RDV is larger. This is intuitive: by construction, some exports in IV will end up in RDV when we base the measures on currencies instead of countries. This is especially true since the inception of the euro in 1999. Our FV measure is also smaller on average when based on currencies, instead of countries.18

Table 1
Summary statistics of FV, IV and RDV based on currencies and countries

<table>
<thead>
<tr>
<th></th>
<th>based on currencies, 2005</th>
<th>based on countries, 2005</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>IV</td>
<td>RDV</td>
</tr>
<tr>
<td>average</td>
<td>16.0%</td>
<td>1.4%</td>
</tr>
<tr>
<td>max</td>
<td>93.8%</td>
<td>38.5%</td>
</tr>
<tr>
<td>min</td>
<td>0.0%</td>
<td>0.0%</td>
</tr>
</tbody>
</table>

Note: The ratios are based on nominal exports of goods and services, for each country-sector bilateral exports to a destination.

The indices values also vary across the distribution (see Figure 1). Notably, the IV measure based on countries is larger than the IV measure based on currencies, especially at very low percentiles. Conversely, the RDV measure based on currencies in the 95th percentile is much higher (almost 16% at the 99th percentile, compared to just over 6% for measures based on the countries).

Taking a time-series perspective on the three different indices, Figure 2 shows the median value from 2000-2009. All three indices based on currencies differ in their levels compared to the country-based indices, but also their evolution over time. This is unsurprising: since 1999 and over the 2000s, many countries in the sample joined the European Monetary Union (EMU).

That is also the point of our analysis: if one takes argument about global value chains and exchange rate elasticities seriously, one needs to jointly take into account all links in the global value chains and how they are affected by currency movements. As Figure 2 shows, it is not clear that the evolution is the same across the indices when they are based on currencies or countries. For example, on average, the FV and IV measures based on currencies declined

18 To be comparable to our FV measure; the FV based on countries only considers value added from the “direct importer”, which is T11 and T12 in Wang, Wei and Zhu’s (2013) terminology.
much more strongly during the Great Recession than the ones based on countries. The RDV index that also take into consideration value added that return to a country with the same currency has increased strongly.

**Figure 1**
Currency- and country-based GVC participation indices across percentiles, in 2005

(\% share of total gross exports)

Note: The ratios are based on nominal exports of goods and services and computed for each bilateral country-sector-to-destination exports.

**Figure 2**
Currency and country-based GVC participation indices over time

(Index: 2000=100)

Note: The ratios are based on nominal exports of goods and services and computed over each bilateral country-sector to country exports.
5. Empirical estimates of the role of global value chains

Armed with the multi-country-sector panel dataset and our currency-based indices of global value chain participation, we are ready to test the predictions from our theoretical model empirically. Although we have dealt with one important difference between the model and the data in terms of the construction of the global value chain indices, other differences remain.

First, in the model, the elasticity of substitution between domestic and foreign inputs is identical for all sectors and countries and does not vary over time. In the data, these elasticities will vary across sectors, countries and will not be fixed over time. Therefore our regressions will include sector-destination and time fixed effects in order to exploit only the within sector-destination variation.

Second, in our model, countries produce and consume the same goods for exports or for domestic consumption. This is not the case in the data and a sector’s output price will be different from its export price, as was shown in Section 4.1, which will be specific to each destination market. Therefore, we use bilateral export prices instead of using total output prices.

5.1 Specification

The following section will in more detail outline our empirical specification and the results from the estimation.

5.1.1 Exports regression

In equation (20), export volumes of sector \( i \) in country \( o \) to destination \( d \), \( \Delta \text{exp}_{sodt} \), depend on \( \text{exr}_{odt} \) (the bilateral exchange rate)\(^{19} \) and the import demand of the trading partner for the goods produced by sectors \( i \) in all countries, \( \Delta \text{demand}_{sdt} \). As in our numerical simulations of the theoretical model in Section 3, the bilateral exchange rate is interacted with \( f_{v_{sodt}}, r_{dv_{sodt}} \) and \( iv_{sodt} \) in order to test for the dampening effect of global value chain trade on the export elasticity and precisely disentangle how each index affects the elasticity.

\[
\Delta \text{exp}_{sodt} = \eta_t + \beta_d \Delta \text{demand}_{sdt} + \beta_{\text{exr}} \Delta \text{exr}_{odt} + \beta_{\text{exriv}} \Delta \text{exr}_{odt} v_{sodt} + \beta_{\text{exrrdv}} \Delta \text{exr}_{odt} r_{dv_{sodt}} + \beta_{\text{exrfv}} \Delta \text{exr}_{odt} f_{v_{sodt}} + \beta_{\text{neer}} \Delta \text{neer}_{dt} + \beta_{\text{neeriv}} \Delta \text{neer}_{dt} iv_{sodt} + \epsilon_{sodt} \quad (20)
\]

\(^{19}\) As in the theoretical model, \( \text{exr}_{idt} \) is defined as units of \( i \)’s currency in exchange of a unit of \( d \)’s currency, so that an increase in the variable corresponds to a depreciation of \( i \)’s currency relative to \( d \)’s currency.
According to the theoretical predictions, $\beta_{\text{exr}}$ should be positive and $\beta_{\text{exrrd}_d}$ and $\beta_{\text{exrf}_v}$ should be negative. This means that if a sector $s$ in country $o$ experiences currency depreciation with respect to the destination country $d$’s currency, it has a positive effect on sector $s$’ exports. However, the effect is smaller the more sector $s$ sources intermediate inputs from the destination market $d$ (a higher $f_{v_{sodt}}$) and the larger the share of value added which returns back home as imports (higher $r_{dvd_{sodt}}$). In line with the model predictions, the effect of intermediate exports, $w_{idt}$ on the bilateral exchange rate elasticity should instead be negligible. Intuitively, a larger share of intermediate exports should rather affect the exports elasticity to the destination country's exchange rate vis-à-vis all its trading partners. Therefore we expect $\beta_{\text{neer}}$ and $\beta_{\text{neeriv}}$ in Equation 1) to be positive.

5.1.2 Prices regression

In equation (21) $\Delta p_{sodt}$ is the price – expressed in destination’s currency – of total exports produced by sector $s$ in country $o$ and sold in destination $d$. Export prices are determined by the bilateral exchange rate as well as sector-specific domestic labour and capital costs $\Delta l_{sot}$ and $\Delta k_{sot}$.

$$\Delta p_{sodt} = \eta_t + \beta_{\text{exr}} \Delta exr_{odt} + \beta_{\text{exrf}_v} \Delta exr_{odt} f_{v_{sodt}} + \beta_l \Delta l_{sot} + \beta_k \Delta k_{sot} + \epsilon_{sodt}$$

The coefficient of interest in (21) is $\beta_{\text{exrf}_v}$, i.e. the coefficient of the interaction of exchange rate with $f_{v_{sodt}}$. Based on our theoretical analysis, we expect that an exchange rate depreciation (increase in $\Delta exr_{odt}$) would make sector $s$’ prices to destination $d$ cheaper. However, this decrease would be (partly) outweighed by the increasing costs of sector $s$ arising from intermediate inputs that originated in $d$. This decrease should be proportional to $f_{v_{sodt}}$. Therefore, we expect $\beta_{\text{exrf}_v}$ to be positive.

5.2 Results

To investigate the role of global value chains on export elasticity and export prices pass-through, we start with a plain pooled OLS regression and then we include different combinations of sector, origin, and destination and time effects.\textsuperscript{20}

\textsuperscript{20} Origin and destination country dummies take into account the formation of the euro currency union along the sample. Before the introduction of the euro, each country has a corresponding dummy. After that, a single dummy is created for all member of the currency area at each year.
5.2.1 Exports elasticities

Table 2 reports the results for the export regression (20). The pooled OLS regression reveals a dampening effect of FV on the bilateral exchange rate elasticity and the positive effect of IV on the elasticity of exports to partner’s NEER. When we exploit the within sector-destination (second column) or the sector-origin-destination (fourth column) variability and we control for common time effects, we obtain a negative and significant coefficient for the interaction terms of the bilateral exchange rate with FV and RDV and an insignificant effect of IV on the exchange rate elasticity.

Interestingly, the coefficient of the destination’s NEER vis-à-vis its trading partners is not significant, whereas its interaction with IV is positive and significant, meaning that sector’s exports are more sensitive to its destination market’s multilateral exchange rate the higher is the quantity of exports that are intermediated by the latter. The results are confirmed even when controlling for time-varying characteristics of countries/currencies with country-time dummies, although the interaction of IV with the NEER of the destination market becomes slightly insignificant, but remains of the correct sign.

Finally, we substitute sector-origin-destination fixed effects with sector-destination-year fixed-effects, in order to control for destination characteristics varying over sector and time which might affect export elasticities, such as demand conditions, trade costs or tariffs. Overall, the results are confirmed, even though to a lesser extent as regards the effect on FV on the bilateral exchange rate elasticity of exports.

In Figure 1 we saw that country-sectors are engaged differently in global value chains. Therefore any given sector’s exports would react differently to changes in exchange rates, depending on the specific nature of its participation in global value chains. Figure 3-5 plot the exchange rate elasticities computed at various percentile values of FV, RDV and IV to illustrate these heterogeneous impacts. We see that the dampening effect of FV and RDV on the bilateral exchange rate elasticity of exports starts to kick-in for sectors at the 25th percentile of FV and RDV shares i.e. at the corresponding value of 0.011 and 0.019, respectively. Sectors which have a very strong participation in global value chains (those at the 95th percentile or higher, or equivalently, with shares of FV and RDV bigger than 1.4 and 7.7), eventually see an adverse impact on exports from an exchange rate depreciation.

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21 These effects do not completely absorb the demand shifter variable and the destination’s NEER, as the variables are constructed using a country concept, whereas the fixed-effects are based on a currency concept.

22 The reader should remind that FV and RDV are bilateral measures considering the share of sector’s export of foreign value added and reimported value added from the specific destination country.
For FV, these sectors are mainly operating in the energy-related sectors (Coke, Refined Petroleum and Nuclear Fuel and Electricity, Gas and Water Supply) and are exporting from Central Eastern European countries to Russia, but also comprise Canadian transport equipment exporting to the United States. Sectors producing basic metals, rubber plastics and textile products and those sectors operating in supporting auxiliary activities and water transport are those among the highest percentiles of RDV.

As for the interactive effect of IV with the destination-markets nominal effective exchange rate, we can see that sectors within the 10th percentile of the IV distribution are insensitive to destination’s exchange rate movements. However, as the share of the intermediate inputs exported and used by the first destination to produce exports to other markets increases, the elasticity of sectors’ exports to NEER rises until it reaches a value of 0.09. The sectors located in this highest percentile of the IV distribution are basic metals, transport, mining and quarrying and financial intermediation.

Table 2
Export regression

<table>
<thead>
<tr>
<th>Dep. Variable</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Δexp</td>
<td>0.243***</td>
<td>0.179***</td>
<td>0.271**</td>
<td>0.216***</td>
<td>0.383***</td>
<td>0.153**</td>
</tr>
<tr>
<td>Δexp</td>
<td>0.015</td>
<td>0.062</td>
<td>0.126</td>
<td>0.059</td>
<td>0.131</td>
<td>0.065</td>
</tr>
<tr>
<td>Δdemand</td>
<td>0.521***</td>
<td>0.487***</td>
<td>0.485***</td>
<td>0.485***</td>
<td>0.480***</td>
<td>0.643***</td>
</tr>
<tr>
<td>Δdemand</td>
<td>0.007</td>
<td>0.017</td>
<td>0.018</td>
<td>0.018</td>
<td>0.019</td>
<td>0.036</td>
</tr>
<tr>
<td>Δexp x IV</td>
<td>-0.000</td>
<td>0.003</td>
<td>-0.001</td>
<td>0.002</td>
<td>-0.003</td>
<td>0.004</td>
</tr>
<tr>
<td>Δexp x IV</td>
<td>0.001</td>
<td>0.003</td>
<td>0.002</td>
<td>0.003</td>
<td>0.002</td>
<td>0.003</td>
</tr>
<tr>
<td>Δexp x RIV</td>
<td>-0.003</td>
<td>-0.019**</td>
<td>-0.010</td>
<td>-0.026**</td>
<td>-0.015*</td>
<td>-0.023**</td>
</tr>
<tr>
<td>Δexp x RIV</td>
<td>0.004</td>
<td>0.009</td>
<td>0.008</td>
<td>0.011</td>
<td>0.008</td>
<td>0.010</td>
</tr>
<tr>
<td>ΔneerD</td>
<td>0.205***</td>
<td>0.009</td>
<td>0.120</td>
<td>-0.008</td>
<td>0.176</td>
<td>1.298***</td>
</tr>
<tr>
<td>ΔneerD</td>
<td>0.021</td>
<td>0.072</td>
<td>0.125</td>
<td>0.069</td>
<td>0.127</td>
<td>0.413</td>
</tr>
<tr>
<td>ΔneerD x IV</td>
<td>0.003***</td>
<td>0.008**</td>
<td>0.004</td>
<td>0.008**</td>
<td>0.003</td>
<td>0.008**</td>
</tr>
<tr>
<td>ΔneerD x IV</td>
<td>0.001</td>
<td>0.003</td>
<td>0.003</td>
<td>0.004</td>
<td>0.003</td>
<td>0.004</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.010</td>
<td>0.018</td>
<td>0.038</td>
<td>0.058</td>
<td>0.075</td>
<td>0.093</td>
</tr>
<tr>
<td>FE</td>
<td>no</td>
<td>sector-destination</td>
<td>sector-destination</td>
<td>origin-sector-destination</td>
<td>origin-sector-destination</td>
<td>sector-destination</td>
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<tr>
<td>cluster dummies</td>
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<td>origin-year</td>
<td>origin-year</td>
<td>origin-year</td>
<td>origin-year</td>
<td>origin-year</td>
</tr>
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</table>

Notes: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Estimation results of equation 20) Observations are at sector-origin-destination-level.
**Figure 3**
Effect of FV on the bilateral exchange rate elasticity

*Source:* World Input-Output tables (2013 release), BIS and authors' calculations.
*Notes:* The Figure reports percentiles of FV with respective values in parenthesis on the x-axis and the corresponding exchange rate elasticity on the vertical axis. Elasticities are computed from the specification in column (4) of Table 2, including origin-sector-destination fixed effects and time dummies.

**Figure 4**
Effect of RDV on the bilateral exchange rate elasticity

*Source:* World Input-Output tables (2013 release), BIS and authors’ calculations.
*Notes:* The Figure reports percentiles of RDV with respective values in parenthesis on the x-axis and the corresponding exchange rate elasticity on the vertical axis. Elasticities are computed from the specification in column (4) of Table 2, including origin-sector-destination fixed effects and time dummies.
5.2.2 Price pass-through

Table 3 shows the regression results for equation (21). As with export volumes, we start with a pooled OLS regression featuring only the exchange rate changes and changes in capital and labour costs as regressors, in order to estimate the full pass-through of exchange rate into destination prices. A currency depreciation (appreciation) of 1% leads to a decrease (increase) in export prices of about 0.7%. The coefficient does not fall dramatically when adding sector-destination (column 2) or sector-origin-destination (column 3) fixed effects and time dummies.

We then add the interaction between exchange rates and FV. The presence of imported inputs decreases the pass-through, as the sign of the coefficient is positive and significant for at least the specifications including the time effects in Table 3. In particular, as Figure 7 points out, for sectors falling within the 50th percentile of the FV distribution, the exchange rate pass-through remains unchanged. However, as the share of foreign intermediate input in exports increases, the pass-through is reduced substantially, falling to a value of 0.39. Overall, these results are in line with those of Amiti, Itskhoki and Konings (2014) and Faucelgia, Lassmann, Shingal and Wermelinger (2014) who also find evidence of declining exchange rate pass-through when participation in global value chains increases.
Effect of FV on exchange rate pass-through

Table 3
Exchange rate pass-through on export prices

<table>
<thead>
<tr>
<th>Dep. Variable Δp</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
<th>(7)</th>
<th>(8)</th>
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</thead>
<tbody>
<tr>
<td>Δext</td>
<td>-0.741***</td>
<td>-0.702***</td>
<td>-0.725***</td>
<td>-0.718***</td>
<td>-0.943***</td>
<td>-0.739***</td>
<td>-0.946***</td>
<td>-0.385***</td>
</tr>
<tr>
<td>(0.001)</td>
<td>(0.025)</td>
<td>(0.035)</td>
<td>(0.035)</td>
<td>(0.036)</td>
<td>(0.013)</td>
<td>(0.036)</td>
<td>(0.013)</td>
<td>(0.049)</td>
</tr>
<tr>
<td>Δext × fV</td>
<td>0.111***</td>
<td>0.028</td>
<td>0.096***</td>
<td>0.027</td>
<td>-0.017</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(0.082)</td>
<td>(0.027)</td>
<td>(0.035)</td>
<td>(0.031)</td>
<td>(0.025)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Δcap</td>
<td>0.082***</td>
<td>0.079***</td>
<td>0.072***</td>
<td>0.075***</td>
<td>0.046***</td>
<td>0.071***</td>
<td>0.073***</td>
<td>0.055***</td>
</tr>
<tr>
<td>(0.000)</td>
<td>(0.007)</td>
<td>(0.007)</td>
<td>(0.007)</td>
<td>(0.005)</td>
<td>(0.007)</td>
<td>(0.005)</td>
<td>(0.005)</td>
<td>(0.006)</td>
</tr>
<tr>
<td>Δlab</td>
<td>0.351***</td>
<td>0.327***</td>
<td>0.267***</td>
<td>0.324***</td>
<td>0.078***</td>
<td>0.265***</td>
<td>0.084***</td>
<td>0.182***</td>
</tr>
<tr>
<td>(0.001)</td>
<td>(0.038)</td>
<td>(0.046)</td>
<td>(0.037)</td>
<td>(0.014)</td>
<td>(0.045)</td>
<td>(0.015)</td>
<td>(0.020)</td>
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</tr>
<tr>
<td>Observations</td>
<td>707,382</td>
<td>707,382</td>
<td>707,382</td>
<td>707,382</td>
<td>707,382</td>
<td>707,382</td>
<td>707,382</td>
<td>707,382</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.545</td>
<td>0.570</td>
<td>0.628</td>
<td>0.572</td>
<td>0.723</td>
<td>0.630</td>
<td>0.752</td>
<td>0.744</td>
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</table>

FE: no, cluster: no, dummies: no, sector-origin-destination-level.

Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Estimation results of equation (21). Observations are at sector-origin-destination-level.

6. Conclusions

The exchange rate pass-through to export prices and the responsiveness of export volumes to changes in the exchange rate constitute key elements in macroeconomics. Those elasticities, in turn, are impacted by international production interlinkages. In this paper, we develop and simulate a partial equilibrium, multi-country model of international production and exchange...
rate and derive simple predictions for the role of precisely defined indices of global value chain participation in shaping the relationship between exchange rate and exports. Those predictions are then validated empirically by using sectoral data. The results show that the export elasticity of exchange rate decreases with (i) the share of exports made of inputs bought in foreign currency due to a price effect and (ii) the share of exports that returns to the same currency area as the exporting country. Moreover, the share of exports used in the destination country in the production of goods further exported to a third currency zone makes bilateral trade flows sensitive to “second order” exchange rates.

In order to precisely assess the consequences of international input-output linkages on exchange rate elasticities, we emphasize the importance of defining indices of global value chain participation based on currencies rather than countries. In our sample, the share of domestic value added exported and further reimported tends to decrease over time when computed based on countries, whereas it actually increases when we compute it based on currencies. Similarly, the share of foreign value added in exports follows different dynamics when we take into account the fact that many countries share the same currency (in particular in the EMU).

Those elements are important since they imply that participation in global value chains as defined in the literature is not necessarily associated with a decrease in the reactivity of exports to exchange rates: if international linkages are regional and with countries sharing the same currency, they might not significantly lessen the reactivity of export to changes in exchange rates. Hence, future developments in international linkages might have different impact on export elasticities depending on the future scope of common currency areas.
References


Eichengreen, Barry, and Poonam Gupta. "The real exchange rate and export growth: are services different?." (2013).


