Advances

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Global value chains and the exchange rate elasticity of exports

DOI 10.1515/bejm-2015-0130
Previously published online June 22, 2016

Abstract: This paper analyzes how the formation of global value chains (GVCs) has affected the exchange rate elasticity of exports. Using a panel framework covering 46 countries over the period 1996–2012, we first find some suggestive evidence that the elasticity of real manufacturing exports to the real effective exchange rate (REER) has decreased over time. We then examine whether the formation of supply chains has affected this elasticity using different measures of GVC integration. Intuitively, as countries are more integrated in global production processes, a currency depreciation only improves competitiveness of a fraction of the value of final good exports. In line with this intuition, we find evidence that GVC participation reduces the REER elasticity of manufacturing exports by 22 percent, on average.

Keywords: export growth; global value chains; real exchange rate.

JEL classification: F14; F15; F31.

1 Introduction

In part of the economic literature, competitively valued exchange rates are seen as crucial to promote exports (Di Nino, Eichengreen, and Sbracia 2011; Freund and Pierola 2012; Nicita 2012; Eichengreen and Gupta 2013).[1] However, in the aftermath of the financial crisis, some episodes of large depreciations appeared to have had little impact on exports (e.g. Japan). This has led some observers to

1 See Auboin and Ruta (2013) for a review of the literature on exchange rates and international trade.

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question the effectiveness of lower exchange rates (Financial Times 2015). Are currency depreciations becoming less effective in boosting export growth? What affects the responsiveness of exports to exchange rate changes?

This paper addresses these questions in two steps. First, we explore how the average elasticity of exports to the real effective exchange rate (REER), a standard synthetic measure of the price competitiveness of countries, has changed over time and across countries and sectors. Second, we study how the formation of global value chains (GVCs) has affected this relationship. Figure 1 focuses on a sample of Central Eastern European countries and provides some suggestive preliminary evidence to motivate our analysis. The figure shows that those countries that joined the European Union in 2004 and are more tightly integrated in German supply chains (Poland, Hungary, Czech Republic and Slovakia) saw a much stronger flattening of the REER growth/export growth to Germany correlation than those that are more loosely integrated in German supply chains (Bulgaria, Latvia, Lithuania, Romania, and Slovenia). While other factors were certainly at play, this evidence suggests that cross-border production linkages may contribute to reducing the effectiveness of depreciations to boost exports.

In our empirical analysis, we use a panel framework covering 46 countries over the period 1996–2012 to formally investigate the questions above. The period of analysis and sample size are determined by the availability of value-added trade data from the OECD-WTO Trade in Value Added (TiVA) database used to assess the role of GVC integration. We focus on manufacturing exports because of the importance of cross-border linkages in this sector. Our evidence suggests that the average REER elasticity of exports has decreased over time. Specifically, the average REER elasticity of gross real exports fell in absolute value from 0.83 at the beginning of the period to 0.68 at the end of the period, though there is only weak evidence that the estimated change is statistically significant. We also show that this decline preceded the global financial crisis, suggesting that it is only in part driven by cyclical factors such as weak global demand. In short, the effectiveness

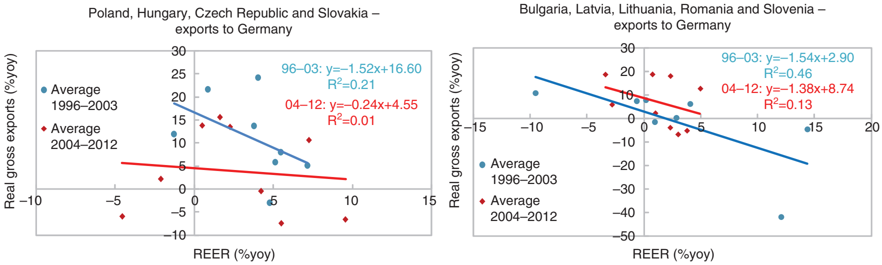

Figure 1: Exchange rate elasticity for selected Central Eastern European countries.
Source: IMF, JP Morgan and National Sources.

of exchange rate depreciations to boost manufacturing exports appears to have muted, although only slightly.

We next examine whether and how the formation of cross-border supply chains has affected the REER elasticity of exports. To understand the role of GVCs in the transmission of exchange rate changes, we need to decompose gross exports into their domestic and foreign value-added components, where the latter consists of the imported inputs embodied in exports. Cross-border production linkages are expected to lower the REER elasticity of (gross) exports for two reasons. First, an exchange rate depreciation improves the competitiveness of domestic value added in exports, but raises the cost of imported inputs. Second, as domestic value added embodied in exported intermediates can be further processed and exported to third countries, a depreciation makes downstream producers more competitive.

To capture these ideas in a simple way, we use two measures of GVC integration developed by Koopman et al. (2010). The first and main variable measures the participation of a country to cross-border production. Participation can take place through forward linkages (i.e. domestic value added exported in intermediates re-exported to third countries) and/or backward linkages (i.e. foreign value added embodied in gross exports; that is, the import content of exports). We expect higher GVC participation to lower the REER elasticity of exports because, as discussed above, both backward and forward linkages should mute the competitiveness gains of a depreciation. The second measure captures the position of a country in GVCs, whether upstream or downstream (i.e. whether the country enters GVCs predominantly through forward or backward linkages). Since the position variable measures the relative strength of backward and forward linkages, its impact on the REER elasticity of exports is in principle ambiguous.

We find evidence that the rise in GVC participation reduces the REER elasticity of exports by 22 percent, on average. For countries with high participation in supply chains (i.e. the 80th percentile of participation in GVCs in our dataset), this channel lowers the average exchange rate elasticity by close to 30 percent. Importantly, the finding that GVC participation reduces REER elasticity is quite robust and continues to hold when we use industry-level data which are less likely to suffer from endogeneity problems. We also find some evidence suggesting that both backward and forward GVC participation contribute to explain the lower elasticity of exports to REER changes but the first may have a larger impact. Intuitively, a depreciation of the real exchange rate only improves competitiveness of domestic value added embodied in final good exports. The larger an economy's import content of exports, the smaller the impact on export volumes of a depreciation.

As the above results illustrate, the decline of the REER elasticity of exports can be in part explained by the fact that REERs do not properly capture changes in price competitiveness in a world with GVCs. As Johnson (2014) puts it, countries ultimately produce and trade value added. Indeed, we show that, using measures of REER that correct for GVC participation developed in the literature (Bayoumi, Saito, and Turunen 2013; and Bems and Johnson 2015), we do not find any decreasing pattern of elasticity over time. Interestingly, we also find that the estimates of the elasticity of value-added exports to value-added measures of the REER are about 1/4 of our estimates in gross terms. While more work is needed in this area, this may indicate that the role of exchange rates in promoting export surges and in the macroeconomic adjustment process needs to be carefully re-evaluated in a world where GVCs are increasingly important.

This paper contributes to the empirical literature on the impact of exchange rates on export growth. This is an important question as the influential literature on the relationship between exchange rates and income growth (Hausmann, Pritchett, and Rodrik 2005; Eichengreen 2007; Rodrik 2008) emphasizes the role of export surges in the development process, the so called export-led growth. Some studies based on cross-country analysis stressed the role of the level of development and the composition of exports in explaining the impact of exchange rates on exports. Freund and Pierola (2012) find that depreciation stimulates manufacturing exports in developing countries, but not in developed countries. The results in Eichengreen and Gupta (2013) indicate that the effect of the real exchange rate is stronger for exports of services than for goods. We add to this literature by showing that the *nature* of trade, that is the extent to which countries are integrated in global production chains, also matters to explain the relationship between exchange rates and trade.

While we do not attempt to review the growing literature on this topic, it is worth stressing that a number of papers have looked at the role of cross-border production linkages in the transmission of exchange rate changes focusing on specific countries and/or episodes. Our results confirm in a cross section the recent findings by Amiti, Itskhoki, and Konings (2014) using disaggregated data for Belgian firms that the impact of a depreciation on export volumes is lower for exporters with higher import shares. Our results are also consistent with the recent work by Mattoo, Mishra, and Subramanian (2014) on the effect of China's exchange rate depreciation on exports of other developing countries in third markets. They find that this effect is substantially attenuated for products that rely more on foreign inputs, and hence have a lower content of Chinese domestic value added. Finally, Eichengreen and Tong (2015) find that two episodes of revaluation of the renminbi increased profits of firms exporting final goods to China, but not necessarily of firms that export intermediate goods for processing.

The rest of the paper is organized as follows: Section 2 provides some evidence of the average REER elasticity of total, goods and manufacturing exports, suggesting its decline over time. Section 3 focuses on the role of integration in GVCs and contains the main finding of the paper and a number of robustness tests. Concluding remarks follow.

2 The REER elasticity of exports

In this section, we investigate systematically the impact of real exchange rate changes on export volumes for a sample of 46 countries for the period 1996–2012. The choice of the period of analysis and sample of countries is determined by the availability of data on TiVA from the OECD-WTO TiVA database used to undertake the main analysis in Section 3.

2.1 Empirical strategy

To empirically test the relationship between exchange rates and exports, we exploit the variation across countries and over time to capture the marginal impact of real exchange rate changes on growth of export volumes, conditional on time/country fixed effects and other controls. The regression framework is based on the approach in the cross-country literature discussed in the Introduction, notably Freund and Pierola (2012) and Eichengreen and Gupta (2013).

We use a panel framework, where annual real export growth is expressed as a function of annual real exchange rate growth. We obtain export data from various sources[2] (total exports, goods plus services, from OECD-WTO TiVA, merchandise

2 In order to calculate annual real exports growth time series, we transform nominal USD exports annual time series to local currency using the nominal exchange rates and deflate by consumers price indices. Using CPI to deflate export values is common in the literature [this approach is used by both Freund and Pierola (2012) and Eichengreen and Gupta (2013), although they use US CPI as a deflator], but it is admittedly an approximation. Researchers have used this approach because export deflators may have two drawbacks. First, data tend to be noisy. Second, and more importantly for our analysis, if one is interested in manufacturing export volumes, relying on goods export deflators may have a compositional effect due to the high volatility of commodity prices. For these reasons, our main regressions report results using CPI; findings using different deflators are discussed in the corresponding sections.

and manufacturing exports from UN-COMTRADE) and data on REERs from the IMF information notice system (INS).[3] To control for country specific differences, we include cross section specific fixed effects. Similarly, we include time specific fixed effects to control for global demand and any other time specific factor that might influence the results (e.g. changes in trade restrictiveness, the slowdown in global trade). The regression specification is as follows:

$$\Delta \text{Exp}_{it} = \alpha + \beta \Delta \text{REER}_{it} + \delta_i + \delta_t + \gamma \text{Control}_{it} + \varepsilon_{it} \tag{1}$$

where ΔExp_{it} denotes real (total, merchandise or manufacturing) export growth of country *i* at time *t*, ΔREER_{it} is the growth in the REER for country *i* at time *t*, δ_i δ_t are country and time fixed effects, respectively. The coefficient β captures the effect of a depreciation on export growth. We also include in the regression a number of controls, Control_{it}, commonly used in the literature. Specifically, we control for initial conditions by including lagged GDP and use export-weighted GDP of the country's main trading partners which gives a sense of the demand for the country's exports in a particular year.[4] We estimate the regressions with standard errors clustered across cross-section (White cross-section covariance method).

2.2 REER elasticity of exports over time

Table 1 presents our results on the REER elasticity of exports in our sample. As the dependent variable, we use growth of (real) manufacturing exports (Panel A). For comparison, we also report regression results using as dependent variables growth of exports in goods (Panel B), and growth of total exports in goods and services (Panel C).[5] The reason to focus on manufacturing exports is threefold. First, manufacturing is the sector that has been mostly associated to the growth in cross-border supply chains that is at the heart of our explanation for the decline of the REER elasticity. Second, we can exploit the information on GVC integration at the sectoral and sub-sectoral level from the TiVA database in the

3 For countries where real effective exchange rate is not available in INS, we use data from JP Morgan and national sources. Unless otherwise stated, the data sources and country coverage are given in the Appendix.

4 In this specification, the country specific average growth rates should be captured by the country fixed effect. While not reported here, we also find that results are robust to alternative sets of controls, such as GDP in nominal US$ terms and GDP per capita.

5 We follow the literature here and focus first on gross exports. We turn to the impact of exchange rate changes on value-added exports in Table 4.

Table 1: The REER elasticity of exports.

Dependent variable	**Panel A: growth of manufacturing exports**			**Panel B: growth of exports of goods**			**Panel C: growth of exports of goods and services**		
	1996–2012	**1996–2003**	**2004–2012**	**1996–2012**	**1996–2003**	**2004–2012**	**1996–2012**	**1996–2003**	**2004–2012**
Real exchange rate change	**−0.832*****	**−0.882*****	**−0.683*****	**−0.886*****	**−0.939*****	**−0.708*****	**−0.875*****	**−0.910*****	**−0.775*****
	0.141	0.186	0.076	0.103	0.129	0.084	0.054	0.058	0.060
Lag real GDP	**−5.753**	**−6.568**	**−15.927****	**−3.832**	**−1.075**	**−18.674*****	**−5.391****	**−0.020**	**−17.582*****
	3.618	11.502	7.830	2.642	8.143	3.164	2.555	8.496	3.293
Foreign real GDP	**1.166****	**1.230**	**1.328*****	**1.288****	**0.776**	**1.536*****	**0.555***	**0.508**	**0.509**
	0.507	1.121	0.449	0.556	1.061	0.451	0.320	0.557	0.353
Time fixed effects	Y	Y	Y	Y	Y	Y	Y	Y	Y
Country fixed effects	Y	Y	Y	Y	Y	Y	Y	Y	Y
Number of observations	782	368	414	782	368	414	782	368	414
R-squared	0.573	0.492	0.703	0.667	0.606	0.796	0.783	0.728	0.869

Source: Exports of goods and services are from OECD-WTO TiVA processed by Duval et al. (2014), exports of goods and manufacturing exports from UN COMTRADE.

***Indicates statistically significant 1%, **indicates statistically significant at 5%, and *indicates statistically significant at 10%. Point estimates in bold letters and robust standard errors below.

Countries as in the Appendix. Number of observations correspond to a balanced annual panel.

analysis of next section. Finally, focusing on a narrower sector and (as done in Section 3) on subsectors is also a way of addressing the endogeneity problem of aggregate data, as export growth of narrower sectors is less likely to directly impact the value of the exchange rate.

Our findings indicate that the REER elasticity of manufacturing exports decreased over time, although slightly. Specifically, Panel A shows that this elasticity has declined from −0.88 for the period 1996–2003 to −0.68 for the period 2004–2012. Panels B also suggests a decreasing pattern using growth of real exports of goods. The elasticities are estimated to be −0.94 in the period 1996–2003 and −0.88 in the period 2004–2012. Finally, Panel C suggests a decline of the REER elasticity of total exports from −0.91 in the first period to −0.78 in the second period, respectively. Overall, the decline seems to be around 20 percent from 1996–2003 to 2004–2012, though there is only weak evidence that the estimated change is statistically significant.[6] Omitting potential outliers – i.e. countries that experienced financial crises or hyperinflations during the late 1990s, such as Bulgaria, Indonesia, Romania and Russia – does not affect the direction of these results, although as we increase the number of excluded countries the decline in the elasticity tends to narrow.[7] Since the sample covers the pre-Euro period, the decline in elasticity could be attributed to the change in the invoicing currency. An increasing number of importers and exporters were invoiced in Euros after the introduction of Eurozone (Ligthart and Werner 2012). To address this issue, in results not reported, we exclude euro area countries from our sample. The results do not change indicating that the formation of euro area is not driving the direction of our reported results in Table 1.

As common to this literature, results tend to be sensitive to the methodology through which real export series are obtained from nominal values.[8] In additional regressions not reported here, we find weaker results using total export volumes from World Economic Outlook (IMF) database, which do not rely on CPI to deflate

6 In results not reported here, we did some preliminary calculations for a formal structural break on the REER elasticity. We did not find statistical evidence of a break. However, there is weak evidence of a break in the early 2000s.

7 A trade-off underpins the optimal sample selection: while extreme values may be due to idiosyncratic macroeconomic developments and may widen artificially the reduction of REER elasticity, increasing the set of potential outliers comes at a cost as several of these countries, such as Indonesia, have seen a significant increase in GVC participation over the period.

8 Needless to say that the sample size and composition and the period of observation matter. Contemporaneous work by IMF (2015a) shows no statistically significant decline in the REER elasticity of total export volumes in a sample of more than 50 advanced and developing economies over the past three decades.

export values. Specifically, the point estimates of the elasticity are smaller and the decreasing pattern is less steep than in Table 1. Deflating the exports (goods and services, goods, and manufacturing) using wholesale price indices (WPI) rather than CPI, we find that the REER elasticity declines over time. However, the decline is less steep than the baseline (using CPI). Following Freund and Pierola (2012) and Eichengreen and Gupta (2013), we find that the REER elasticity of manufacturing exports are smaller than the ones reported in Table 1 when nominal exports are deflated with US CPI, but still show a declining pattern between the first and the second period. Finally, deflating manufacturing export values with export deflators of goods (in USD) available from WEO, we find that REER changes have no statistically significant impact on manufacturing export growth. As discussed in footnote 3, the lack of statistical significance in this case may be due to compositional effects, as available export deflators include highly volatile commodity prices.

2.3 Discussion

The REER elasticity of exports is clearly affected by a potentially large set of factors that can push it up or down over time. One concern is that the possible lower elasticity is exclusively driven by the global financial crisis. To have a better understanding of exactly when the sensitivity started decreasing for (manufacturing) exports, we run rolling regressions for the same specification using 7-year windows.[9] Figure 2 shows that the average REER elasticity has gradually decreased since mid-1990s and remained almost flat since early 2000s. Importantly, the observed decline in average REER elasticity of exports pre-dates the global financial crisis. The weak external demand associated to the crisis is, therefore, a factor among others at play. What can these factors be?

While not exhaustive or exclusive, we see four types of explanations for the lower REER elasticity of exports. First, the lower responsiveness of exports to real exchange rate changes may reflect the fact that trade growth has slowed down. Trade growth expanded in the 1990s as production fragmented internationally into GVCs and decreased in the 2000s as this process decelerated (Constantinescu, Mattoo, and Ruta 2015). Second, tariff barriers have declined faster in the 1990s relative to the 2000s and trade policy may have become progressively more responsive to real depreciations. Bown and Crowley (2013) find

9 For robustness, we also estimate regressions with smaller (5 and 6 years) and larger (8 years) windows and find similar results.

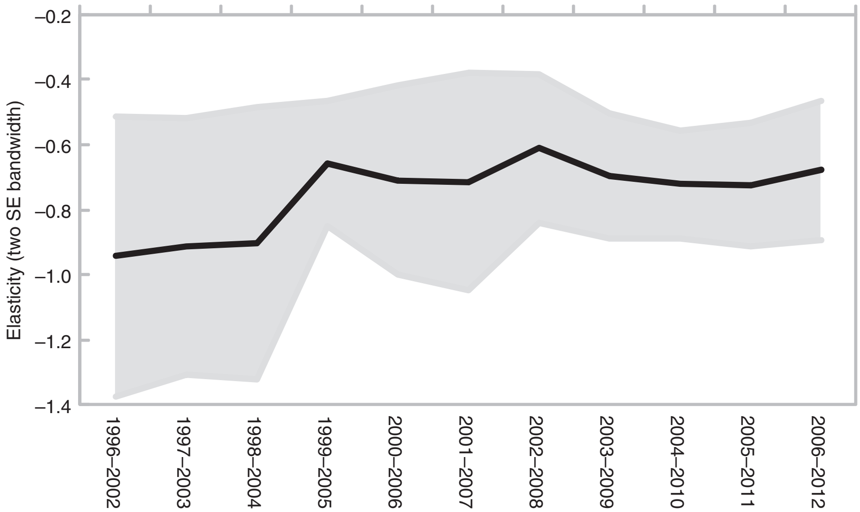

Figure 2: Exchange rate elasticity over time.
Note: These are the slopes on real effective exchange rate change elasticity of manufacturing exports estimated for the different samples in the horizontal axis using the regression framework discussed in empirical strategy.

evidence that temporary trade barriers such as anti-dumping and countervailing duties are set in response to currency movements by trading partners. Third, exchange rate pass-through may have decreased over time. Recent papers show that high performing firms (Berman, Martin, and Mayer 2012), large exporters (Amiti, Itskhoki, and Konings 2014), and exporters of high quality goods (Chen and Juvenal 2013) are more likely to absorb exchange rate movements in their mark-ups.[10] To the extent that these firms are increasingly more important in world trade, we should expect that export volumes respond less to currency depreciation.

In the next section, we investigate whether and how integration in GVCs affects the REER elasticity of exports. Specifically, we exploit the variation across countries and manufacturing subsectors of different measures of GVC integration to assess the impact that cross-border supply chains have on the relationship between exchange rates and trade.

10 Ree, Hong, and Choi (2015) show that the muted price and volume response of Japanese exports to the sustained weakness of the Yen may mask an expansion of the Japanese exporters' profits.

3 GVCs and the REER elasticity of exports

In this section, we first introduce the basic measures of GVC integration and then use these measures to empirically test the impact of GVCs on exchange rate elasticities.

4 Measures of GVC integration

Figure 3 reproduces a schematic diagram developed by Koopman et al. (2010) of gross trade accounting.[11] A country's gross exports can be decomposed into domestic value added (DV) – the domestic content in a country's gross exports – and foreign value added (FV) – the value added from foreign countries embodied in a country's gross exports. DV can be further divided into four components based on the next use or destination: (1) exported in final goods, (2) exported in intermediates, (3) exported in intermediates re-exported to third countries, and, (4) exported in intermediates that return home.

We follow Koopman et al. (2010) in using this decomposition to obtain several measures of integration in GVCs at the country-sector level. First, we define forward linkages (GVC_Forward Linkages$_{i,k}$) as the domestic content

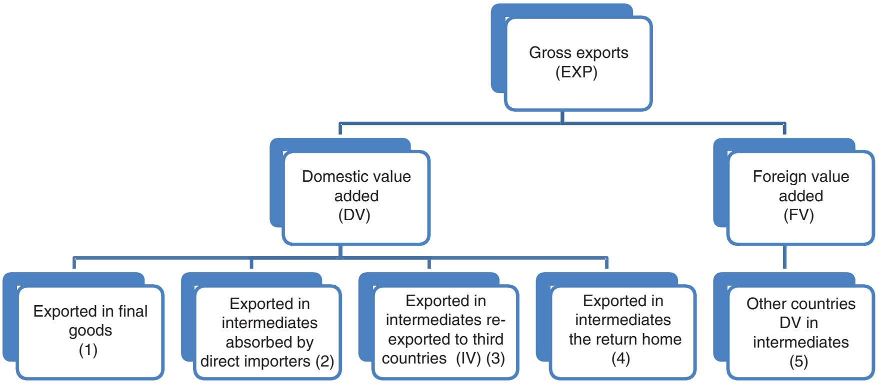

Figure 3: Decomposition of gross exports.
Source: Koopman et al. (2010).

11 Koopman, Wang, and Wei (2014) provide a further elaboration and present a more complex diagram. We present the simpler form of Koopman et al. (2010) as our data do not allow to capture these further complexities.

of a country-sector in third-country exports (i.e. the value of inputs produced domestically that are used in other countries' exports, $IV_{i,k}$) as a share of the country-sector's gross exports ($EXP_{i,k}$). Furthermore, we define the backward linkages (GVC_Backward Linkages$_{i,k}$) as the foreign content ($FV_{i,k}$) in a country-sector's gross exports (i.e. the import content of exports).

$$\text{GVC\_Forward Linkages}_{i,k} = IV_{i,k}/EXP_{i,k}$$

$$\text{GVC\_Backward Linkages}_{i,k} = FV_{i,k}/EXP_{i,k}$$

where subscripts i and k denote a country and sector, respectively.

Second, we define the participation index (GVC_Participation$_{i,k}$) as the sum of the foreign value added embodied in a country's exports and the indirect value-added exports expressed as a percentage of gross exports. This index gives a sense of how integrated a country is in GVCs, either via backward or forward linkages. Again, we can express this index at the country or the country-sector level. Formally, the participation index is given by

$$\text{GVC\_Participation}_{i,k} = IV_{i,k}/EXP_{i,k} + FV_{i,k}/EXP_{i,k}$$

Finally, we follow Koopman et al. (2010) in defining an index of position at the country or country-sector level (GVC_Position$_{i,k}$).[12] Two countries can have identical participation indices but they may participate in GVCs by specializing in activities upstream or downstream in the production process. If a country is upstream in the production process, it is likely that it has a high value of forward linkages relative to backward. On the other hand, if a country specializes in the last steps of production (downstream), it is likely to import a lot of intermediate goods and have high backward relative to forward linkages. The GVC position index is constructed in such a way that countries with high forward relative to backward linkages record a positive value and vice versa. Exactly the same logic applies to the country-sector level. Formally, we have

$$\text{GVC\_Position}_{i,k} = \ln(1+IV_{i,k}/EXP_{i,k}) - \ln(1+FV_{i,k}/EXP_{i,k})$$

Figure 4 reports the correlation between the participation and the position index (higher panels) and the backward and forward participation rate (lower panels) for the two periods 1996–2003 and 2004–2011, respectively. A few key facts stand out from these charts. First, the index of GVC participation tends to vary more across countries relative to the measure of GVC position (higher panels).

12 Another index of position used in the literature is the so-called "upstreamness" (Antràs et al. 2012), which captures distance to final demand. We use this alternative measure as a robustness test in the empirical analysis of the next subsection.

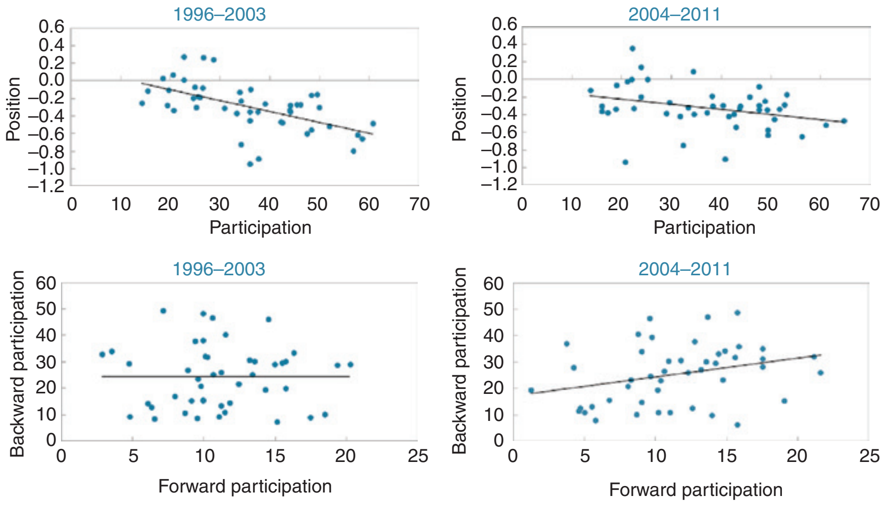

Figure 4: Global value chain measures over time.

This variability in participation is largely driven by backward participation more than forward participation (lower panels). Second, all the indices of GVC involvement tend to be relatively stable over time on average, with only few countries recording large changes. On average, the measures of GVC participation, backward and forward linkages increased over the period of analysis, while position decreased indicating that backward participation increased more than forward for the average country.

In the next subsection, we use these indices at the country and at the country-sector level to investigate how GVC integration affects the relationship between exchange rates and exports. Intuitively, as countries are more integrated in global production processes either through backward or forward linkages, a depreciation only improves the competitiveness of a fraction of the value of final goods exports. This simple observation has important implications that can be best understood by comparing the impact of a depreciation in a traditional model where production is entirely domestic with a setting characterized by cross-border input linkages.

Traditional macroeconomic models predict that a depreciation increases exports through an expenditure switching mechanism: foreign demand for domestically produced goods increases as the lower exchange rate makes them more competitive. GVCs complicate this simple mechanism.[13] Consider backward

13 For a formal analysis, see the recent work by Bems and Johnson (2015).

and forward linkages separately. In presence of backward linkages, a depreciation increases the cost of imported intermediate inputs used in final-good production, thus lowering the competitive gain. When a country exports intermediate goods (forward linkages), a depreciation also increases the competitiveness of downstream producers, which stimulates demand for their goods, and may counterbalance the expenditure-switching mechanism. Therefore, our conjecture is that backward and forward linkages are associated to a lower exchange rate elasticity of exports. We expect higher GVC participation to lower the REER elasticity of exports, while GVC position has in principle an ambiguous sign. The empirical model allows us to formally test these ideas and identify the key transmission channels in the data.

4.1 GVCs and REER elasticity

In order to test whether the integration in GVCs affects the REER elasticity of exports, we exploit the panel variation of the different GVC measures. Specifically, we use value-added exports data from the OECD-WTO TiVA database to build measures of GVC participation, backward and forward linkages, and GVC position for each country and, when available, for each manufacturing subsectors, from 1996 to 2012, using the definition provided in the previous subsection. As data are available only for selected years, we also rely on time-series constructed by Duval et al. (2014) interpolating the OECD-WTO data in some of our regressions.

The regressions reported in this section build on Equation (1) and can be grouped in three categories. First, we add to the regressions for manufacturing exports growth the interaction of the REER with the GVC variables. Since the underlying data used to construct GVC data is published approximately every 5 years, we consider 5-year average time series instead of annual time series in our panel regressions as well.[14] Second, we increase the cross-sectional variation of GVC measures considering manufacturing exports growth at the industry level and we interact the REER with GVC participation at the industry level. Finally, we consider value-added exports and alternative measures of REER that correct for the presence of GVCs, namely the REER in goods value added or REER in tasks value added (Bayoumi, Saito, and Turunen 2013), and compare the estimates

14 As discussed in the literature, there are also benefits to estimating regressions with data averaged for 5-year periods: lag structure becomes less important, outliers are less of a concern because they are averaged out, and, finally, unit roots in variables are less of an issue. In this sense, 5-year average regressions provide a further robustness test of our results.

of the elasticity of value-added exports to these measures with our original estimates.[15]

4.1.1 Manufacturing exports

Table 2 shows that, in line with our hypothesis, higher participation in GVCs is related to lower elasticity of manufacturing exports to REER. Columns (2) and (3) of Table 2 show that countries with higher participation in GVCs present a lower exchange rate elasticity of manufacturing exports both in the first panel for annual data and the second panel with the 5-year averages.[16] The computed point estimates are consistent with previous results: The average GVC participation of 36.05 in the 5-year average sample of the second panel of Table 2 predicts an elasticity of −0.87,[17] in line with the elasticity estimated in column (1) of Table 2.

Turning to the other measures of supply chain integration, we find that GVC position does not have an impact on the exchange rate elasticity. Specifically, column (3) of Table 2 shows that the elasticity of manufacturing exports to the REER does not change with GVC position in any of the two panels. Furthermore, the signs of the interaction term of GVC position and REER change vary from panel to panel. It is possible that the strong negative correlation between position and participation may explain this result –see the charts in the first row of Figure 4.

When we decompose GVC participation into backward and forward linkages, we find that both measures contribute to explain the lower elasticity of exports

15 Our results are robust to the following alternative specifications. First, we exclude Euro Area countries from our sample, and the broader messages still hold. Second, we include lags, and our results remain unchanged. Third, we divide countries into high and low position. We find that those with high position present a higher REER elasticity of exports than those with low position. This may suggest that backward linkages are more important that forward linkages. However, this is not our baseline as there is loss of cross country and time variation when we split the sample. Finally, we consider higher order polynomial terms to account for potential non-linearity. In some cases, the quadratic terms are statistically significant. However, this is not our baseline since high polynomials may aggravate the misspecification problem when we do not have any clear economic reason to include them and not sufficient data to precisely estimate the new parameters.

16 The main conclusions are robust when we use WPI, instead of CPI, as the deflator to compute real exports.

17 If we take the slope estimated for the REER in the first line of column (2) of the second panel of Table 2, –1.106, and, then correct it using the positive estimated slope on the interaction term for participation in GVCs, 0.006, and the average participation in GVCs, 36.05, we have $-1.106+0.006*36.05=-0.87$.

Table 2: GVCs and the REER elasticity of manufacturing exports.

Dependent variable	**Growth of manufacturing exports**			
	(1)	**(2)**	**(3)**	**(4)**
Annual data				
Real exchange rate change	**−0.832***** 0.141	**−0.925***** 0.144	**−1.016***** 0.216	**−1.145***** 0.181
Real exchange rate change interacted with participation in GVCs		**0.003** 0.004	**0.008*** 0.005	
Real exchange rate change interacted with position in GVCs			**0.331** 0.208	
Real exchange rate change interacted with backward participation in GVCs				**0.002** 0.004
Real exchange rate change interacted with forward participation in GVCs				**0.025**** 0.012
Number of observations	782	782	782	782
R-squared	0.573	0.574	0.583	0.579
5 Year average				
Real Exchange Rate Change	**−0.876***** 0.117	**−1.106***** 0.067	**−1.073***** 0.132	**−1.204***** 0.129
Real exchange rate change interacted with participation in GVCs		**0.006*** 0.004	**0.006**** 0.003	
Real exchange rate change interacted with position in GVCs			**−0.221** 0.167	
Real exchange rate change interacted with backward participation in GVCs				**0.010***** 0.003
Real exchange rate change interacted with forward participation in GVCs				**0.014*** 0.008
Number of Observations	184	184	184	184
R-squared	0.575	0.581	0.617	0.604
All Regressions				
Lag real GDP and Foreign real GDP	Y	Y	Y	Y
Time fixed effects	Y	Y	Y	Y
Country fixed effects	Y	Y	Y	Y

***Indicates statistically significant 1%, **indicates statistically significant at 5%, and *indicates statistically significant at 10%.
Point estimates in bold letters and robust standard errors below. The gray shaded areas are jointly significant using Wald tests.
Countries as in the Appendix. Number of observations correspond to a balanced annual panel.

to REER changes but the first may have a larger impact. Specifically, column (4) shows that introducing the interaction term of REER and backward and forward participation increases the estimate of the REER elasticity of manufacturing exports. Consistently with existing firm-level studies, column (4) of the second panel highlights that backward linkages (i.e. the import-content of exports) explain the variation of the elasticity with GVC participation more than forward linkages. The slope on the interaction of REER change and backward linkages is statistically more significant than the interaction with forward linkages in the same panel –see the discussion on Figure 5 below. The low variation across countries in the forward participation rate shown in Figure 4 may contribute to explain this finding. In addition, the positive correlation between backward and forward linkages variables, as in the charts in the second row of Figure 4, may bias point estimates due to collinearity.

We can also provide a back of the envelope quantification of the impact of GVC participation on the REER elasticity of exports. In the second panel of Table 2, we can see that a country with no participation in GVCs would have a REER elasticity of –1.1, therefore, on average, GVC participation reduces REER elasticity by approximately 22 percent (–1.11+0.87/–1.11). Figure 5 shows that if we did the same calculation with the 20th and 80th percentile of participation in GVCs, we would expect a reduction of REER elasticity between 13 percent and 28 percent, respectively. Similarly, Figure 5 also provides the range of the impact of GVC backward and forward linkages using the estimates in columns (3) and (4) of the second

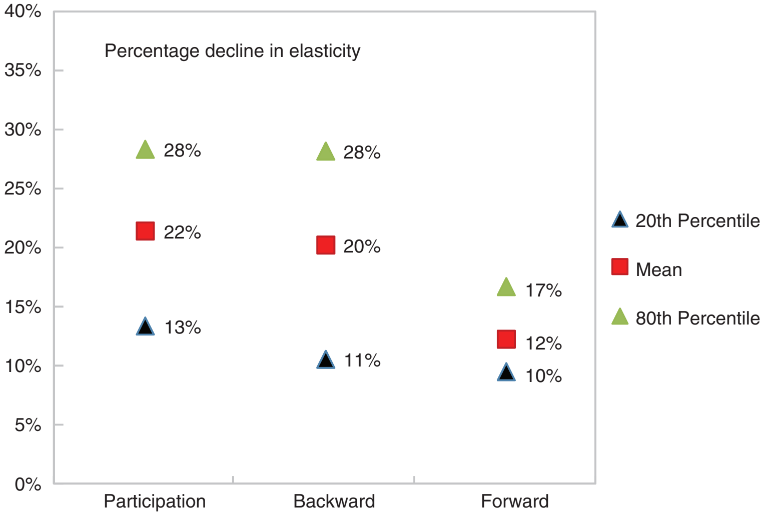

Figure 5: The decline in exchange rate elasticity due to global value chains.

panel of Table 2. Backward linkages' impact on REER elasticity is on average almost twice as much as forward linkages.

4.1.2 Sectoral analysis

We exploit sectoral variation in manufacturing exports and GVC participation in Table 3 and confirm our previous results. The first three columns show that, when we use exports growth at the industry level, the suggested decreasing evolution of elasticity over time is stronger than for total manufacturing exports: the elasticity for the first half of the sample (1996–2003) is higher than for the most recent years (2004–2011), though without statistical significance. The fourth column confirms that higher GVC participation reduces the REER elasticity of exports: for the average country-sector GVC participation of 4.5, the predicted elasticity is −0.99, close to the result in the first column of −1.0. The robustness of the main results using sectoral data can also be considered as evidence against endogeneity bias

Table 3: GVCs and the REER elasticity of manufacturing exports by industry.

Dependent variable	**Growth of manufacturing exports from COMTRADE by industry**			
	1996–2011	**1996–2003**	**2004–2011**	**1996–2011**
Real exchange rate change	**−1.003*** **	**−1.103*** **	**−0.681*** **	**−1.096*** **
	0.159	0.196	0.074	0.194
Real exchange rate change interacted with participation of industries in GVCs				**0.024** **
				0.011
Participation				**−0.835* **
				0.431
Lag real GDP	**−0.969**	**−2.747**	**−23.830*** **	**−0.557**
	4.154	13.844	4.822	4.085
Foreign real GDP	**1.067** **	**1.019**	**1.138*** **	**1.114*** **
	0.433	0.853	0.393	0.420
Time fixed effects	Y	Y	Y	Y
Country-industry fixed effects	Y	Y	Y	Y

***Indicates statistically significant 1%, **indicates statistically significant at 5%, and *indicates statistically significant at 10%.

Point estimates in bold letters and robust standard errors below.

Countries as in the Appendix. Number of observations correspond to a balanced annual panel.

Industries included basic metals, chemicals, electrical equipment, food, machinery, textiles, transport equipment and wood products.

Number of observations correspond to a balanced annual panel.

because it is unlikely that developments in a particular industry would have an impact on currency movements.

4.1.3 Value-added exports and exchange rates

A recent literature has developed measures of REER that correct for GVC participation, generally defined as value-added REER (Bems and Johnson 2012; Bayoumi, Saito, and Turunen 2013). We use these measures to estimate the elasticity of value-added exports to changes in value-added REER and compare these estimates with our estimates of the standard REER to gross exports. Specifically, the first row in Table 4 presents the same results as in Table 1 but for a shorter time series and less countries due to data availability. In the second line of Table 4, we regress value-added exports on the standard REER. In the last two rows, instead of using the standard REER and gross exports, we regress value-added exports on two measures of the REER corrected for GVC participation taken from Bayoumi, Saito, and Turunen (2013): the REER in Tasks Value Added (a measure that is

Table 4: The REER elasticity of exports for different REER measures.

Exports of goods and services				
Independent variable/ dependent variable	**1996–2011**	**1996–2003**	**2004–2011**	**2011–2004 minus 1996–2003**
Total exports/REER	−0.88***	−0.94***	−0.68***	0.25
Value added exports/REER	−0.75***	−0.81***	−0.58***	0.22
Value added exports/ REER in value added terms (tasks value added)	−0.20***	−0.17*	−0.25***	−0.08
Value added exports/ REER in value added terms (goods value added)	−0.27**	−0.23*	−0.32***	−0.09
Number of observations	624	312	312	

***Indicates statistically significant 1%, **indicates statistically significant at 5%, and *indicates statistically significant at 10%. Point estimates in bold letters and robust standard errors below. All Regressions include time FE, country FE, lag real GDP and foreign real GDP.

Countries include Australia, Austria, Belgium, Brazil, Canada, Chile, China, Denmark, Finland, France, Germany, Greece, Hungary, India, Indonesia, Ireland, Israel, Italy, Japan, Korea, Republic of, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Singapore, Slovakia, Slovenia, South Africa, Spain, Sweden, Switzerland, Thailand, Turkey, United Kingdom, United States. Number of observations correspond to a balanced annual panel.

close to the value-added REER by Bems and Johnson 2012) and the REER in goods value added.[18]

We establish two main results that corroborate the importance of GVC integration as a determinant of the suggested decline in the responsiveness of exports to real exchange rate changes. First, the value-added REER elasticity does not present the same decreasing pattern as the standard REER elasticity does. This result is independent of the specific measure of the value-added REER. Importantly, this finding suggests that the decrease in the REER elasticity is, at least in part, an optical illusion that results from the fact that REER and exports are measured in gross rather than value-added terms. Second, we can see that the elasticity in each of the two regressions in value-added terms is lower than the corresponding ones in the first row. This seems to indicate that the impact of a currency depreciation on exports is substantially less when measured in value-added terms.[19] There is one caveat to this second result that we need to bear in mind. The REER adjusted for value-added terms use GDP deflator whereas (gross) REER uses CPI deflator. One may argue that one of the reasons for the decline in elasticity is due to the different deflators. However, using the same gross REER, the first and second row of Table 4 show that the elasticity is indeed lower for value-added exports relative to gross exports, suggesting that different deflators are not a key determinant of our finding. That said, this issue could be delved deeper in future research.

5 Conclusion

This paper provides new evidence on the role of vertical integration in the transmission of exchange rate changes. Specifically, we find that GVC participation

18 In our regressions, we use the measures developed by Bayoumi, Saito, and Turunen (2013) which are publicly available. See IMF (2013) for a discussion and comparison of the different approaches used in the literature to obtain REER in value-added terms. Patel, Wang, and Wei (2014) develop a theoretical framework to compute REERs at the country-sector level. Assessing the impact on (value-added and gross) exports of these new REER measures at the country and sector levels would be a further refinement to the present analysis.

19 It could be argued that the value-added component of exports should be more responsive to REER changes but it may also be possible that complementarities between foreign and domestic value added explain the slightly lower responsiveness of domestic value-added exports to the REER. Similarly to the exercise in this section, the independent work in IMF (2015b) investigates the impact of value-added REER on value-added exports differentiating between sectors more integrated in GVCs, defined as GVC sectors, and sectors where GVCs are less relevant. Consistently with our results, they find that the competitive impact of a depreciation is stronger for the latter as they rely less on imported inputs.

lowers the elasticity of manufacturing exports to the REER by 22 percent on average and by close to 30 percent for countries with highest GVC participation. Consistently with this view, we find that the REER elasticity of manufacturing exports has slightly declined over time for our period of analysis. Moreover, when REER are corrected for GVC participation and exports are measured in value-added rather than gross terms, we find that the estimated REER elasticities of exports are substantially smaller and do not display any declining time pattern. These results contribute to the literature on the impact of exchange rates on export growth by showing in a cross section that the nature of trade, i.e. a country's involvement in global production processes, is a determinant of this relationship.

There are a number of reasons why these findings are relevant and more work in this area would be welcome. First, the impact of exchange rate depreciations on exports is at the core of the process of international adjustment and rebalancing. Countries that are more integrated in GVCs will see their exports react less to exchange rate depreciations than that predicted by models that do not properly account for the nature of their trade relations, leading to inaccurate policy predictions. Second, future research should explore alternative channels such as lags of depreciations due to GVC structure adjustment, including incorporating the fact that different industries may have different lag structure, or different pricing to market behavior depending on market power. Third, currency depreciations are often viewed as instrumental in stimulating exports and enhancing growth through this channel, particularly in developing countries. However, our results indicate that this mechanism may be less effective for countries that have a large import-content of exports, as currency depreciations only impact the domestic value added embodied in gross exports. More subtly, researchers interested in the trade-growth nexus may need to identify the impact that exchange rate changes have on the ability of countries to anchor to GVCs and hence to benefit from cross-border production linkages (e.g. knowledge spillovers), as GVC integration can itself be endogenous to the macroeconomic conditions of a country.

Acknowledgments: The authors are thankful to Jaebin Ahn, Tamim Bayoumi, Tiago Cavalcanti (the Editor), Ruo Chen, Cristina Constantinescu, Stephan Danninger, Mitali Das, Romain Duval, Caroline Freund, Poonam Gupta, Martin Kaufman, Subir Lall, Daniel Leigh, Nan Li, Weicheng Lian, Bill Maloney, Aaditya Mattoo, Gian Maria Milesi Ferretti, Coleman Nee, Denisse Pierola, Dulani Seneviratne, Gonzalo Varela, an anonymous referee and seminar participants at the IMF and the Fourth IMF/WB/WTO Trade Workshop for their helpful comments and suggestions, and Estefanía Fallas for her editorial assistance.

Appendix

Data sources

Variables	Source
Merchandise/manufacturing exports	UN COMTRADE
Total (goods plus services) exports	Duval et al. (2014) based on OECD-WTO TiVA database
Value-added exports	Duval et al. (2014) based on OECD-WTO TiVA database
Participation indices for manufacturing	Duval et al. (2014) based on OECD-WTO TiVA database
Position indices for manufacturing	Duval et al. (2014) based on OECD-WTO TiVA database
GDP in constant US dollar terms	World Development Indicators (WDI), World Bank
Real GDP growth of foreign countries weighted by export shares	IMF
Consumer price indices	IMF, National sources
Real effective exchange rate (REER)	IMF Information Notice System (INS), JP Morgan, National sources
Other exchange rates (e.g. versus USD)	IMF
REER in goods value added	Bayoumi, Saito, and Turunen (2013)
REER in tasks value added	Bayoumi, Saito, and Turunen (2013)

List of countries for tables 1 to 3

Australia, Austria, Belgium, Brazil, Bulgaria, Canada, Chile, China, Czech Republic, Denmark, Finland, France, Germany, Greece, Hong Kong, Hungary, India, Indonesia, Ireland, Israel, Italy, Japan, Korea, Republic of, Latvia, Luxembourg, Malaysia, Mexico, Netherlands, New Zealand, Norway, Philippines, Poland, Portugal, Romania, Russian Federation, Singapore, Slovakia, Slovenia, South Africa, Spain, Sweden, Switzerland, Thailand, Turkey, United Kingdom, United States.

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