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Global Value Chains and the Exchange Rate Elasticity of Exports

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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.

CONTENTS

I. INTRODUCTION

In part of the economic literature, competitively valued exchange rates are seen as crucial to promote exports (Freund and Pierola, 2012, Di Nino *et al.* 2012, Eichengreen and Gupta, 2013, Nicita, 2013).[2] 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 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

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

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 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 highest 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 the role of GVCs in dampening the responsiveness of exports to a real depreciation is mainly due to backward linkages rather than other metrics such as the position of a country in the value chain. 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 (Bems and Johnson, 2013, and Bayoumi *et al.*, 2013), 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 *et al.*, 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 *et al.* (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 *et al.* (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 II provides some evidence of the average REER elasticity of total, goods and manufacturing exports, suggesting its decline over time. Section III 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.

II. 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 trade in value added from the OECD-WTO TiVA database used to undertake the main analysis in Section III.

A. 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[3] (total exports, goods plus services, from OECD-WTO TiVA, merchandise and manufacturing exports from UN-COMTRADE) and data on Real Effective Exchange Rates from the IMF Information Notice System (INS).[4] 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

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[3] 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.

[4] 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.

specific factor that might influence the results (e.g. changes in trade restrictiveness, the slowdown in global trade). The regression specification is as follows:

$$\Delta Exp_{it} = \alpha + \beta \Delta REER_{it} + \delta_i + \delta_t + \gamma Control_{it} + \varepsilon_{it} \tag{1}$$

where ΔExp_{it} denotes real (total, merchandise or manufacturing) export growth of country i at time t, $\Delta REER_{it}$ is the growth in the real effective exchange rate for country i at time t, δ_i and 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.[5] We estimate the regressions with standard errors clustered across cross-section (White cross-section covariance method).

B. 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).[6] 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

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[5] 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.

[6] 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.

level from the TiVA database in the analysis of next section. Finally, focusing on a narrower sector and (as done in Section III) 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.[7] 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.[8] 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.[9]

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[7] In a previous draft of this paper (Ahmed et at., 2015), we found a steeper fall in the REER elasticities across the two periods. That finding resulted from the use of a standard approximation method to compute the growth rate of exports (the percent change in nominal exports in U.S. dollars minus the percent change in the U.S. dollar exchange rate minus the percent change in the CPI), which however led to excessively high elasticities in the first period as several countries in the sample experienced high CPI inflation.

[8] 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.

[9] 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.

As common to this literature, results tend to be sensitive to the methodology through which real export series are obtained from nominal values.[10] 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 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.

C. 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-

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[10] 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.

year windows.[11] 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 *et al.*, 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 (2012) find 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 *et al.*, 2012), large exporters (Amiti *et al.*, 2014), and exporters of high quality goods (Chen and Juvenal, 2014) are more likely to absorb exchange rate movements in their mark-ups.[12] 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.

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

[12] 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.

III. 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.

A. Measures of GVC Integration

Figure 3 reproduces a schematic diagram developed by Koopman *et al.* (2010) of gross trade accounting.[13] 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 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).

GVC_Forward Linkages$_{i,k}$ = $IV_{i,k}/EXP_{i,k}$

GVC_Backward Linkages$_{i,k}$ = $FV_{i,k}/EXP_{i,k}$

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[13] Koopman *et al.* (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.

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$_{i,k}$).[14] 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

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

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.

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[14] Another index of position used in the literature is the so-called "upstreamness" (Fally *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.

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.[15] Consider backward 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.

B. 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

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

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 five years, we consider five-year average time series instead of annual time series in our panel regressions as well.[16] 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 *et al.*, 2013), and compare the estimates of the elasticity of value-added exports to these measures with our original estimates.

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 five-year averages[17]. The computed point estimates are consistent with previous results: The average GVC participation of

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[16] As discussed in the literature, there are also benefits to estimating regressions with data averaged for five-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, five-year average regressions provide a further robustness test of our results.

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

36.05 in the five-year average sample of the second panel of Table 2 predicts an elasticity of -0.87[18],

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. 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.

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 4 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 4

also provides the range of the impact of GVC backward and forward linkages using the estimates in

columns (3) and (4) of the second panel of Table 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

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[18] 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+0.006x36.05 = -0.87.

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

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 Johnosn, 2012, and Bayoumi *et al*., 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 total 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 *et al.* (2013): the REER in Tasks Value Added (a measure that is close to the value-added REER by Bems and Johnson, 2012) and the REER in Goods Value Added.[19]

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

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[19] In our regressions, we use the measures developed by Bayoumi *et al*. (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 *et al.* (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.

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.[20] 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.

IV. 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 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

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[20] 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.

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.

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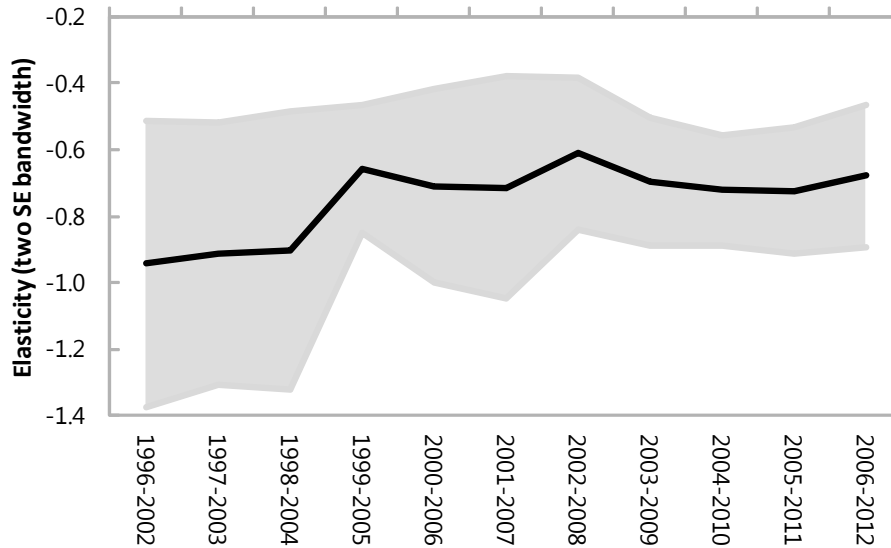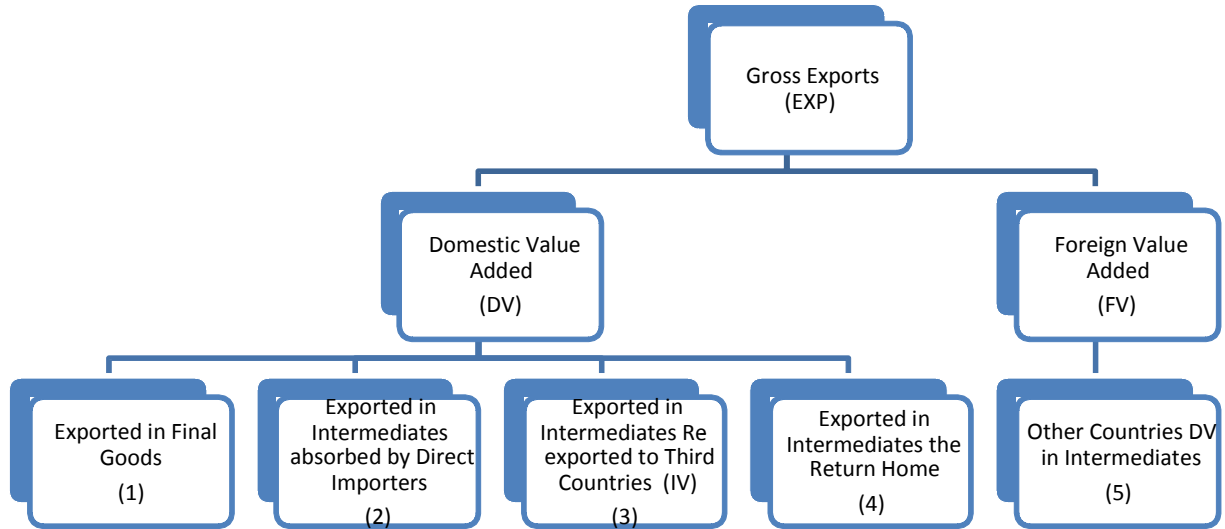
VI. FIGURES

Figure 1
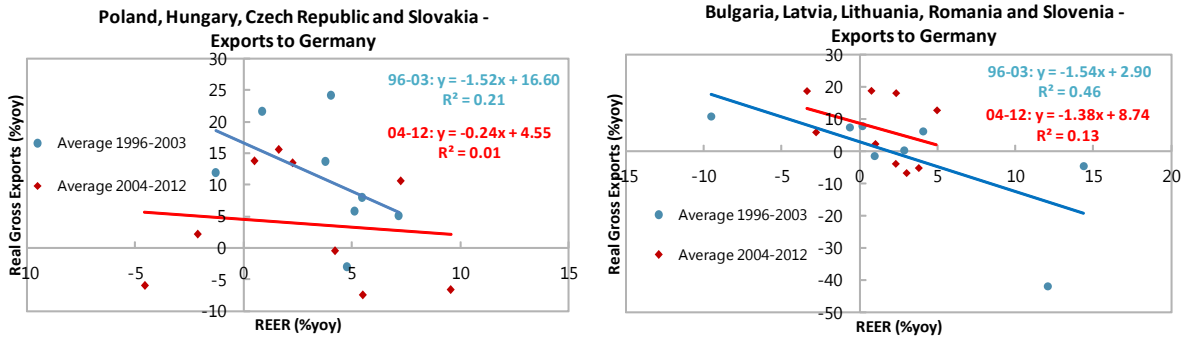
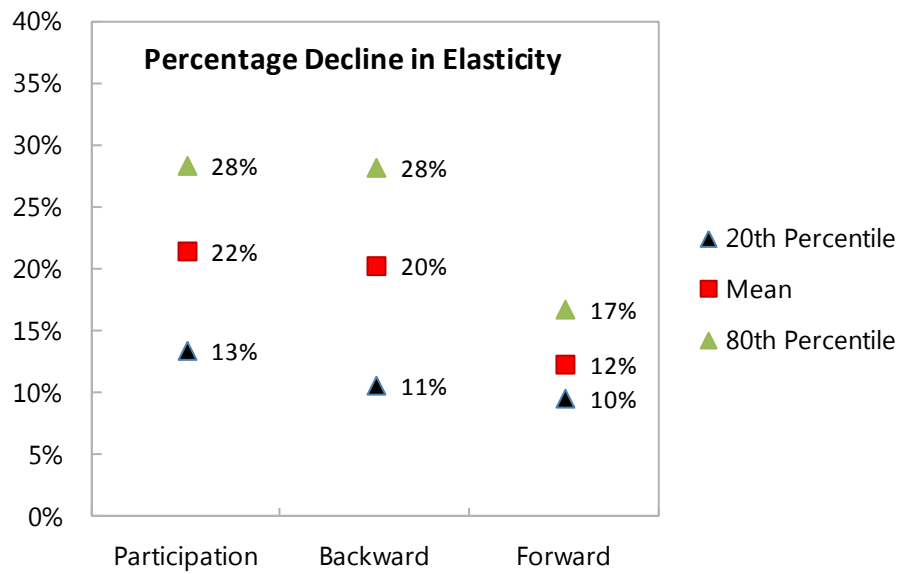Source: IMF, JP Morgan and National Sources.

Figure 2

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.

Figure 3

Source: Koopman *et al.* (2010)

Figure 4

VII. TABLES

Table 1

Dependent variable:	Panel A: Growth of Manufacturing Exports			Panel B: Growth of Total Exports of Goods			Panel C: Growth of Total 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
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.

Note: *** 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.

Table 2

Dependent variable:	Growth of Manufacturing Exports from COMTRADE			
	(1)	(2)	(3)	(4)
	Annual data			
Real Exchange Rate Change	**-0.832 *****	**-0.925 *****	**-1.016 *****	**-1.145 *****
	0.141	0.144	0.216	0.181
Real Exchange Rate Change interacted with Participation in GVCs		**0.003**	**0.008 ***	
		0.004	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
R-squared	0.573	0.574	0.583	0.579
	5 year average			
Real Exchange Rate Change	**-0.876 *****	**-1.106 *****	**-1.073 *****	**-1.204 *****
	0.117	0.067	0.132	0.129
Real Exchange Rate Change interacted with Participation in GVCs		**0.006 ***	**0.006 ****	
		0.004	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
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

Note: *** 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 grey shaded areas are jointly significant using Wald tests.

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

Table 3

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 Industriesin 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
R-squared	0.310	0.335	0.416	0.314

Note: *** 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.

Table 4

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

Note: *** indicates statistically significant 1%, ** indicates statisticlly 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.

VIII.   APPENDIX

Data Sources

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 *et al.* (2013)
REER in Tasks Value Added	Bayoumi *et al.* (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.