Exchange Rates and Trade: Disconnected?*

Daniel Leigh
International Monetary Fund

Weicheng Lian
International Monetary Fund

Marcos Poplawski-Ribeiro
International Monetary Fund

Rachel Szymanski
International Monetary Fund

Viktor Tsyrennikov
International Monetary Fund

Hong Yang
International Monetary Fund

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Abstract

Do exchange rates and trade volume disconnect over time? This paper examines the exchange rate and trade nexus by analyzing exchange rate pass-through and the price elasticity of trade volumes separately. We find that both relationships are largely stable over time by looking at different types of analysis, including structural break tests, sector-level analysis, and episodes of large depreciations. We conclude, therefore, that exchange rates and trade are still strongly linked.

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Author's E-Mail Address: dleigh@imf.org; wlian@imf.org; mpoplawskiribeiro@imf.org; viktor.tsyrennikov@gmail.com; rszymanski@imf.org; hyang2@imf.org;

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I. Introduction

Recent exchange rate movements have been unusually large. The recovery since the global financial crisis of 2008 has been uneven and most of the world economies remain vulnerable. The uneven recovery—as well as the unconventional monetary policy response to the global financial crisis—has created large movements in the currencies of the biggest economies. On one hand, the U.S. dollar has appreciated by more than 10 percent in real effective terms since mid-2014.[1] On the other hand, the euro has depreciated by more than 10 percent since early 2014 and the yen has lost more than 30 percent of its value since mid-2012. The recent time paths of these currencies and their historic ranges are shown in Figure 1. Such movements, although not unprecedented, are well outside "normal" fluctuation ranges of these currencies.[2] Even for emerging market and developing economies (EMDEs), whose currencies typically fluctuate more than those of advanced economies (AEs), the recent movements have been unusually large. On one hand, the yuan and the rupee have appreciated substantially; and, on the other hand, the Brazilian real and the South African rand have depreciated largely, by more than 50 percent since mid-2012 up to the end of 2015. The aforementioned currency movements have substantial impact on trade competitiveness. However, there is little consensus on whether these changes necessarily imply large redistribution of trade flows in favor of depreciating currencies.[3]

Standard theoretical models predict that currency changes are passed through into relative prices. A depreciation reduces export prices in foreign currency and increases import prices in domestic currency which, in turn, leads to more exports and less imports. This creates the expenditure-switching effect of a currency depreciation (see Obstfeld and Rogoff, 2007). Basing his analysis on the above reasoning, Krugman (2015, 2016) predicts that the recent exchange rate movements will have a strong effect on trade. Others argue that there is a disconnect between exchange rates and trade. Recent studies by the OECD (Ollivaud, Rusticelli, and Schwellnus, 2015) and the World Bank (Ahmed, Appendino, and Ruta, 2015) have suggested that the increased participation in global value chains (GVCs) is a source of the apparent disconnect.

This is not the first time that the link between exchange rates and trade has been questioned. Claims like that have been made at least since the economist Fritz Machlup coined the phrase 'elasticity pessimism' back in 1950 (Machlup, 1950). Exchange rate disconnect gained most popularity in the late 1980s after the U.S. dollar depreciation failed to promote the U.S. trade

[1] Effective exchange rate refers to the exchange rate weighted by trade flows of a country's partners.

[2] Normal fluctuation range refers to the interval of exchange rate change that occurs with probability 90 percent.

[3] Although our sample period so far stops in the end of 2014 before the largest recent drop in commodity prices, we still capture the beginning of that movement—and its effects on exchange rates and trade—for some countries and currencies.

and after the yen appreciation caused by the Plaza Accord in 1985 had little initial effect on Japanese exports. Nonetheless, the U.S. and Japan trade balance have later adjusted in line with the predictions of conventional models (Krugman 1991). The key question, therefore, is whether this time is different and trade has become disconnected from exchange rates; possibly reflecting the changes in the organization of world trade since the trade liberalization that started in the 1990s.

Whether exchange rate and trade are disconnected is important for the formulation of economic policies. First, a disconnect between exchange rates and trade could weaken monetary policy by reducing its effect on trade balance. Second, exchange rates may become less effective in absorbing external shocks if trade does not improve in response to a weakened currency. Third, a disconnect between exchange rates and trade could slow down the resolution of global imbalances, as currencies of countries with large trade deficits could depreciate without triggering an improvement in trade balance.

The focus of this paper, therefore, is put equally on the relation between exchange rates and trade at the macroeconomic level and on the stability of that relationship over time. Our empirical specification separates the relation between exchange rate and trade into two: (i) the relation between exchange rates and trade prices (exchange rate pass-through), and (ii) the relation between trade prices and trade volumes (price elasticity of trade volumes). This approach allows us to control for factors that are specific to the above relationships. In addition, when estimating exchange rate pass-through we control for unit labor costs to reduce the bias caused by the Balassa-Samuelson-Baumol effect.[4] Given noisy trade data, in various exercises, we use panel regressions to check the stability of trade elasticities over time. Moreover, to shed light on the relationship between exchange rate and trade, we also study the role of initial (economic slack and financial) conditions in the responses of trade flows to exchange rate movements.

Importantly, our study is the most extensive to date in terms of country coverage. We estimate trade elasticities for 88 AEs and EMDEs for the period 1980–2014. Our dataset goes beyond core AEs typically examined in related studies and this is warranted by the growing importance of EMDEs in the world trade.[5] Given noisy trade data, individual trade elasticities are typically estimated imprecisely at the macro level. This calls for estimation of trade elasticities using the pooled data and it makes a large sample especially valuable.

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[4] This downward bias on the pass-through elasticity from the real effective exchange rate to trade prices reflects rising distribution and retail costs, owing to the increase in the costs of labor and rent internationally (Balassa-Samuelson effect) and domestically (Baumol effect) over time (see, e.g., Frankel, Parsley, and Wei, 2005).

[5] Much of the literature focuses on AEs. Notable exceptions include Bussière, Delle Chiaie, and Peltonen (2014) that estimates trade price equations for 40 economies, whereas Morin and Schwellnus (2014) estimate trade elasticities for 41 economies (most of them members of the OECD).

The main challenge of the analysis is the potential endogeneity and reverse causality that may exist between exchange rates and trade in the empirical exercises. We address it in several ways. First, to alleviate the reverse causality, we control for domestic and foreign demand, in particular separating different GDP components (Bussière et al., 2013). Second, we study export response using historical episodes with large currency depreciations that are more likely to be exogenous. Third, we analyze sector-level data given that exchange rate fluctuations are more likely to be exogenous from a perspective of individual sectors and country-level estimates may include a downward aggregation bias due to heterogeneity in the relationship between trade and exchange rate for different sectors (Mejean and Imbs, 2015). These alternative analyses reach similar conclusions, indicating the robustness of our results, and also uncover factors that may be restricting trade response to recent currency movements.

Our first finding is that, despite of noisy trade data, exchange rate pass-through coefficients and trade elasticities mostly fall within their theoretical bounds. That is, exchange pass-through coefficients are between 0 and 1 and trade price elasticities are negative. Importantly, our pooled estimates suggest that exchange rate and trade are connected. We estimate that a 10 percent depreciation improves domestic output by 1.5 percent. Most of the response of trade to the exchange rate movements materializes within the first year. Moreover, the relationship satisfies the Marshall-Lerner condition, which is a crucial condition for the analysis of macroeconomic policies in open economies.

The second finding is that trade elasticities are largely stable over time. Thus, exchange rate remains an effective policy tool. Stability of the strength of the relation between exchange rates and trade is further confirmed in the analysis of large exchange rate depreciation episodes as well as in the analysis based on sector-level data. The sector-level analysis also points to a limited impact of GVCs on trade elasticities.

The third finding is that initial (economic and financial) conditions play an important role in determining the response of trade flows to exchange rate movements in large depreciation episodes. *Relaxed* financial conditions and *larger* economic slack both strengthen export volumes' responses to exchange rates. Given that global business and financial cycles may strongly influence these conditions (Rey, 2015), particularly at the current juncture, such analysis may help us understand better the trade elasticities and their stability over time.

We also find that the choice of the deflator used to define export volume is critical in the analysis of trade elasticities and their stability. Ahmed, Appendino, and Ruta (2015) find declining exchange rate effects on export volumes by performing a similar analysis to ours but use the consumer price index (CPI) as the deflator to construct export volume. In contrast, we use export prices (coming from the World Economic Outlook database) as the deflator. We find that the results of Ahmed, Appendino, and Ruta (2015) crucially depend on using the CPI as the deflator.[6] However, as exchange rate pass-through into consumer prices is much weaker than into border prices,[7] the CPI-deflated trade volume is a biased measure of the true volume. Moreover, the CPI reflects prices of many non-traded goods and services which do not relate to the cost structure of exports.

The rest of the paper is structured as follows. Section II describes the estimation of trade elasticities at the macroeconomic level. Section III investigates large currency depreciation episodes, whereas Section IV performs the analysis based on sectoral data. Section V concludes and discusses the main policy implications of the paper.

II. ESTIMATION OF AGGREGATE TRADE ELASTICITIES

This section estimates standard trade relations at the aggregate (macroeconomic) level for both AEs and EMDEs. We estimate the relationship between exchange rate movements and relative export and import prices, respectively (exchange rate pass-through), and the relationship between export and import relative prices and trade volumes (price elasticity of trade). The estimated relations are dynamic and this allows us to distinguish between short and long-term effects of exchange rate movements on trade.

The theoretical framework underlying the analysis builds upon the pricing-to-market literature, *e.g.* in Krugman (1985 and 1986), Feenstra, Gagnon, and Knetter (1996), Campa and Goldberg (2005), Burstein and Gopinath (2014) among others. According to this framework, exporting firms maximize profits by choosing export prices while taking as given the demand for their products and their competitors' prices. Hence, exporters may incompletely pass exchange rate movements into export prices relative to their competitors' prices.[8] Product demand depends on the relative prices and on overall economic conditions in destination markets. Based on these assumptions, export prices relative to foreign prices depend on the real exchange rate and real production costs, while export quantities depend on these relative export prices as well as on foreign aggregate demand. The determinants of import prices and quantities can be derived analogously based on the observation that the price of each economy's imports is the price of its trading partners' exports expressed in domestic currency units.

The export price equation can be represented by the following supply function:

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[6] Appendix B discusses in detail the differences between our results and theirs.

[7] Here both the consumer price index and the border price are denominated in exporters' currency.

[8] It is assumed that domestic and foreign consumer markets are segmented. This implies that even adjusting for trade costs products can be priced differently in different geographical locations.

$$\frac{eP^X}{P^*} = S\left(\frac{ULC}{P}, \frac{eP}{P^*}\right), \tag{1}$$

where e is the nominal effective exchange rate (NEER); P^X is the price of exports in domestic currency; P^* is the foreign price level; P is the domestic price level; ULC is the nominal unit labor cost, so that ULC/P denotes the real unit labor cost; and eP/P^* denotes the real effective exchange rate (REER).

The export volume equation represents the demand side of the market and it can be represented by the following demand function:

$$X = D\left(\frac{eP^X}{P^*}, Y^*\right), \tag{2}$$

where eP^X/P^* is again the foreign-currency relative export price; and Y^* denotes the foreign aggregate demand.[9]

When estimating the exchange rate pass-through into relative export and import prices, we use the standard equations in the literature, e.g., Campa and Goldberg (2005) and Burnside and Gopinath (2014). Both real effective exchange rates and competitors' prices are based on producer prices, and we further control for unit labor costs in the regression to reduce bias caused by Balassa-Samuelson effects.[10] When estimating the price elasticity of trade volumes, we study how trade volume responds to relative trade prices, controlling for demands. As Bussière et al. (2013) show, GDP components are different in terms of import intensity, we separate GDP components in our equations to avoid potential bias caused by assuming homogeneous income elasticities of these components. Our main analysis uses panel regressions based on these standard trade equations to study the stability of trade elasticities over time.

Nevertheless, this type of macroeconomic-level estimation presents caveats that have been known at least since Orcutt (1950). As Orcutt (1950) explains, simultaneity and omitted-variables can lead to underestimation of trade price elasticities. First by not identifying properly trade demand and supply functions, the estimation of (1) and (2) provides a trade elasticity closer to zero than the true elasticity. That is why in our empirical strategy we estimate (1) and (2) independently, which allows us to control unit labor costs and foreign demands separately, helping in the identification of the trade elasticities.

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[9] The equations for imports are similar to (1) and (2). The import supply function is: $P^M / P = S\left(eP^* / P, Y\right)$; and the import demand function is: $M = D\left(P^M / P, Y\right)$.

[10] Notice that our focus in this paper is on the study of exchange rate pass-through to relative trade prices and not to CPI prices (Taylor, 2000). Some papers suggest a weaker pass-through to CPI, which is not necessarily against a stable pass-through to relative trade prices.

Second, additional variables excluded from any of the two equations—preference shocks, for example—may also lead to an omitted-variable bias. Third, the heterogeneity of demand elasticities across different goods could also bias the analysis against finding a strong effect of relative price changes on trade. This happens because price movements of price-inelastic goods have a disproportionate influence on movements of the aggregate trade prices (Imbs and Mejean, 2015). As a consequence, the estimate of trade elasticity over-weighs price-inelastic goods and is understated. As a consequence, the estimate of trade elasticity over-weighs price-inelastic goods and is understated.

Movements in domestic or foreign demand also complicate the estimation. Quantity and price of exports are generally negatively related. But a contraction in foreign demand causes a simultaneous decline in both quantity and price of exports, obscuring the conventional negative relation between the two. Similarly, a contraction in domestic demand imports causes a simultaneous decline in the quantity and price, affecting estimation of import-related elasticities. Our analysis addresses these sources of endogeneity by controlling for foreign and domestic output. But shifts in domestic and foreign preferences may still pose a problem.

To show that any remaining issues have limited influence in our findings, we re-estimate the trade elasticities using only episodes of large depreciations. Large depreciations are more likely to be exogenous to exports as such strong exchange rate movements are typically driven by factors other than exports.[11] We also re-estimate the trade elasticities using sectoral-level data. The benefit is that movements in exchange rates are unlikely to be affected materially by individual sectors.

A. Data

The analysis estimates the trade elasticities using annual data for 60 economies—23 AEs and 37 EMDEs in a panel set up as well as at the individual-economy level (see Tables 1 and 2 respectively). As mentioned before, this is a broader sample of economies than typically covered in related studies. The estimations focus on gross exports and imports, which include both goods and services, albeit some of the robustness checks are done for goods or manufactured goods only. Depending on data availability and the economy in question, the sample starts between 1980 and 1989 and ends in 2014.[12] When estimating trade elasticities for individual economies, the sample is restricted to those for which at least 25 years of

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[11] While we focus on large depreciations given the relevance in the current global economy conjuncture, our results are symmetric and robust to the identification of large appreciations (results not shown here, but available upon request).

[12] The sample further excludes a number of AEs with special circumstances, including Hong Kong SAR and Singapore, given these economies' significant entrepôt activity, and Ireland, given its special treatment of export sales (IMF, 2015a,b,c,d). To avoid unduly influencing the estimation results with developments in small or very low-income economies, it excludes economies with fewer than 1 million inhabitants as of 2010 or with an average per capita income (at purchasing-power parity) of less than $3,000 in 2014 prices.

annual data are available so that there are enough degrees of freedom to estimate the long-term relationship between exchange rate changes and trade for each of them.

The primary data sources for our analysis are the IMF's World Economic Outlook (WEO) database, Information Notice System (INS), and Global Assumption and Global Economic Environment databases; the Organisation for Economic Co-operation and Development's OECD Economic Outlook; and the U.S. Bureau of Labor Statistics. The data on global value chains comes from the Trade in Value Added (TiVA) database from the OECD–World Trade Organization (WTO). Table 3 describes all indicators used in the paper as well as their sources. In addition, Table A1 in the Appendix lists all countries used in the discussion of GVCs.

Main variables used in the analysis are defined as follows: the NEER and the consumer price index (CPI)-based REER are both taken from the IMF Information Notice System (INS). They are weighted average of trading partner bilateral exchange rates, with the weights based on gross exports. We construct producer price index (PPI)-based REER, as well as trade-weighted foreign producer prices, using the trade weights from the INS. Whenever the sample size is not a concern, we use PPI-based variables to limit the potential bias caused by Balassa-Samuelson-Baumol effects. The unit labor costs data of OECD countries come from OECD Statistics. For non-OECD economies, we construct the unit labor cost as the total wage bill divided by real GDP, with the total wage bill[13] and real GDP taken from the IMF's WEO database, Haver Analytics, the International Labor Organization, the IMF's International Financial Statistics, and the CEIC data.

B. Empirical Strategy

To estimate trade elasticities, the benchmark models are Autoregressive Distributed Lag (ARDL) models, which are widely used in the literature (Bussière, Delle Chiaie, and Peltonen, 2014 among others). The elasticities are initially estimated for individual economies separately. Because trade data is noisy and estimates for individual economies vary substantially, it is important to pool information to obtain precise and reliable numbers. We then analyze the stability of trade elasticities through panels.

The ARDL specifications for the four types of trade elasticities—which can be obtained by log-linearizing the abstract demand-supply system illustrated by Equations (1) and (2) for exports—are presented below. As the panel analysis will be the focus of the paper, the equations below refer to the analysis done for balanced-panels. Equations estimated for individual economies are similar:

- Exchange-rate pass-through to export prices in foreign currency:

[13] When unavailable, total wage bill data are constructed using the average wage rate and total employment.

$$\Delta \ln\left(\frac{eP^{\mathrm{X}}}{P^{*}}\right)_{it} = \mu_i + \tau_t + \rho\Delta \ln\left(\frac{eP^{\mathrm{X}}}{P^{*}}\right)_{i,t-1} + \sum_{j=0}^{2}\beta_j \Delta \ln\left(\frac{eP}{P^{*}}\right)_{i,t-j} + \sum_{j=0}^{2}\gamma_j \Delta \ln\left(\frac{ULC}{P}\right)_{i,t-j} + \varepsilon_{it}, \quad (3)$$

- The price elasticity of export volumes in foreign currency:

$$\Delta \ln X_{it} = \mu_i + \tau_t + \rho\Delta \ln X_{i,t-1} + \sum_{j=0}^{2}\beta_j \Delta \ln\left(\frac{eP^{\mathrm{X}}}{P^{*}}\right)_{i,t-j} + \gamma\Delta \ln Y_{it}^{*} + \lambda\left(\Delta \ln Y^{*} \times gfc\right)_{it} + \varepsilon_{it}, \quad (4)$$

- Exchange-rate pass-through to import prices in local currency:

$$\Delta \ln\left(\frac{P^{\mathrm{M}}}{P}\right)_{it} = \mu_i + \tau_t + \rho\Delta \ln\left(\frac{P^{\mathrm{M}}}{P}\right)_{i,t-1} + \sum_{j=0}^{2}\beta_j \Delta \ln\left(\frac{eP}{P^{*}}\right)_{i,t-j} + \Delta \ln Y_{it} + \varepsilon_{it}, \quad (5)$$

- The price elasticity of import volumes in local currency:

$$\Delta \ln M_{it} = \mu_i + \tau_t + \rho\Delta \ln M_{i,t-1} + \sum_{j=0}^{2}\beta_j \Delta \ln\left(\frac{eP}{P^{*}}\right)_{i,t-j} + \delta\Delta \ln X_{it} + \gamma\Delta \ln DD_{it} + \lambda\left(\Delta \ln Y \times gfc\right)_{it} + \varepsilon_{it}, \quad (6)$$

where the subscript *i* in the equations above denotes country *i*, the subscript *t* denotes the *t-th* year of the sample, and ε_{it} is an I.I.D. error term. Beyond the variables already described in Equations (1) and (2), Specifications (3) to (6) also include the following additional variables:

- country- and time-fixed effects (μ_i and τ_t, respectively) to take into account differences in countries' normal growth rates and global shocks;[14]
- lags (*j=1,2)* of real exchange rate $\left(eP/P^{*}\right)_{i,t-j}$ and real unit labor costs $\left(ULC/P\right)_{i,t-j}$ because firms adjust slowly and costs pass-through into prices gradually;
- interaction terms of a global financial crisis dummy (*gfc*) with proxies for changes in (domestic or external) demand in (4) and (6) to address the possibility that trade volumes may respond unusually strongly to demand during the crisis (see Bussière et al., 2013);
- measures of export and domestic demands in (6) proxied by output minus exports—to account for the possibility that marginal import propensities of these categories are different (see, for example, Morin and Schwellnus, 2014).[15]

[14] For the single-economy estimations, we replace the time-fixed effects by: (i) a time *trend* to account for differences in countries' growth rates and for global shocks; (ii) an indicator of global financial crisis, *gfc*, because it affects credit availability that trade depends strongly on; and (iii) *fuel* and *non-fuel* commodity prices to control for shifts in global commodity prices.

[15] Note that the estimates are robust to the inclusion of (external and domestic) output growth in the single-economy estimations of (3) and (5), respectively.

In each of the four specifications, equations (3) to (6), the long-term elasticity is estimated as $\sum_{j=0}^{2}\beta_j / (1-\rho)$. Using only two lags in the analysis is a conventional choice for annual data. We conduct the panel cointegration tests of Pedroni (2004) and find no evidence of cointegration between variables. For the single economy estimations, we perform the Dickey-Fuller cointegration test. If that test does not reject cointegration between the variables for a particular economy, Equations (3) to (6) are re-estimated in the error-correction form that includes the residual from the estimated cointegration relation using ordinary least squares (OLS). The share of economies for which there is no evidence of cointegration is 57 percent for export price equation (3), 50 percent for export volume equation (4), 56 percent for import price equation (5), and 54 percent for import volume equation (6), respectively.

C. Individual Economies Estimations

To investigate whether exchange rate and trade are connected in our sample, we further estimate the relationship between exchange rate and trade for *individual economies*. The specifications of regressions for individual economy estimates are similar to equations (3) to (6), with two differences. First, time fixed effects are replaced with a linear trend and a global financial crisis dummy.[16] In the case of exchange rate pass-through to trade prices, we further control for commodity and non-commodity prices. Second, if co-integration exists among regression variables, we estimate the ARDL in level rather than in first differences.

Regarding the long-term pass-through elasticities, as Figure 2 (panel 1) displays, virtually the estimates for all the economies considered have the expected sign and typically lie in the [0,1] interval.[17] In turn, the average pass-through elasticities reported in the first two columns of Table 4 imply that, on average, a 10 percent real effective currency depreciation reduces export prices in foreign currency by 5.5 percent and increases import prices by 6.1 percent.[18] The results in the row "One-Year Effects" of Table 4 also indicate that most of the long-term effects on trade prices materialize within one year.

In turn, Figure 2 (panel 2) suggests that the price-to-volume elasticities for most individual economies have the expected negative sign. The average estimates for the country sample (mean group estimator), reported in the third and fourth columns of Table 4 further suggest that, on average, a 10 percent rise in export and import prices reduces the level of both export

[16] One if the year is 2008 or 2009, and zero otherwise.

[17] It is interesting to note that economies with stronger exchange rate pass-through to export prices in foreign currency tend to have weaker pass-through to domestic import prices, a pattern that also emerges from the findings of Bussière, Delle Chiaie, and Peltonen (2014).

[18] The corresponding response of export prices in *domestic* currency to a real effective currency depreciation of 10 percent would be a rise of 4.5 percent (–10 × (0.552 – 1)).

and import volumes by about 3 percent in the long term.[19] The "One-Year Effect" rows in that table further indicate that most of the long-term effects on trade volumes materialize within one year. Finally, the last column of Table 4 further evinces that the Marshall-Lerner condition—the condition that checks whether an exchange rate depreciation will cause a nominal balance of trade improvement—holds under imperfect pass-through.[20]

The individual-economy estimates vary substantially as panel 2 of Figure 2 shows. Even if we restrict the analysis to economies with a relatively long sample (> 25 years) and exploit co-integration relationships among variables, such large differences appear to come from data noise, the challenges of identifying the effects of trade prices on volumes mentioned above, and the downward bias caused by the aggregate elasticities (Imbs and Mejean, 2015). The true effects are likely to be stronger than suggested by the cross-country averages reported in the third and fourth columns of Table 4.[21]

D. Disconnect or Stability over Time?

This section investigates whether the relationship between exchange rate movements and trade—either long-term effects or transmission lags—has weakened over time.

The stability of trade elasticities has been investigated by previous studies and little consensus has been found. Goldstein and Kahn (1985) provide a comprehensive literature review on early studies. Otani, Shiratsuka, and Shirota (2001) find that exchange rate pass-through into import prices declines in Japan in the 1990s compared with in the 1980s. Frankel, Parsley and Wei (2012) find a downward trend in the pass-through into import prices in developing countries. In contrast, Campa and Goldberg (2008) find that the pass-through may have declined at the level of import prices, but the result is inconclusive over types of goods and countries. While most of the literature studies exchange rate pass-through, Ahmed, Appendino, and Ruta (2015) analyze the relationship between exchange rate and export volume. They find that it has been weaker in the recent decade. Those authors examine the relationship for 46 economies covered by the OECD TIVA database in the period between 1995 and 2012. They attribute the weakening to the expansion of the global value chains (GVCs).[22]

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[19] While we present the results with the mean-group estimation in Table 4, the results using the panel estimation (pooled mean group) are similar (not shown here, but available upon request), indicating the robustness of the elasticities estimated.

[20] For a derivation of the Marshall-Lerner condition under incomplete pass-through see Annex 3.3 of IMF (2015e)

[21] For a broader discussion of the role of foreign and domestic output in driving trade, including during the post-crisis decline in global trade, see IMF (2010) and Hoekman (2015).

[22] Frankel, Parsley, and Wei (2012) and Gust, Leduc, and Vigfusson (2010) provide evidence on the declining exchange rate pass-through to import prices over time. Shifts in the invoice currency chosen by economies are also likely to play a role (see Gopinath, Itskhoki, and Rigobon 2010).

We find that the result in Ahmed, Appendino, and Ruta (2015) depends critically on the use of CPI as to deflate nominal exports and the sample with strong presence of inflation outliers.[23] Baring the methodological weaknesses, it is important to note that there is no consensus about whether GVCs could have substantial impact on the relationship between exchange rate and trade. On the one hand, during the past several decades, international trade has been increasingly organized within GVCs, with different stages of production distributed across different economies. Such changes may weaken the relationship. Figure 3 suggests that the share of foreign value added (FVA) in gross exports has gradually risen from a cross-country average of about 15 percent of gross exports in the 1970s to about 25 percent in 2013.[24] The average share of exports consisting of intermediate inputs used by trading partners for production of their exports has also gradually increased from 20 percent to 24 percent of gross exports during 1995–2009. On the other hand, the changes in various measures of GVC participation do not appear to be substantial. This raises doubts about the size of GVCs' impact on the relationship between exchange rate and trade. At the same time, other developments in world trade could have strengthened the effects of exchange rate movements on trade such as the several waves of trade liberalization.[25]

Therefore, to analyze the behavior of the elasticities over time, the analysis estimates the four trade elasticities discussed above for successive 10-year rolling intervals. The analysis is based on the panel (pooled mean group) estimation approach that combines data for multiple economies for the four trade elasticities, as specified in Equations (3) to (6). The full sample includes the 88 AEs and EMDEs listed in Table 2. Again, given the lack of evidence of cointegration for the panel of economies considered (as assessed based on the panel cointegration tests in Pedroni 2004), the specification is estimated in first differences. Because some regions are more likely to have experienced greater structural change than others, the analysis investigates the evolution of trade elasticities both for the global sample and for separate regions. In particular, since the rise of GVCs has been particularly noticeable in a number of Asian and European economies, rolling regression results are provided separately for these two regions. To avoid changes in sample composition over time, the sample includes only economies for which data for the entire 1990–2014 period are

[23] For more details see Appendix B.

[24] Figure 3 also suggests that for some economies, such as Hungary, Romania, Mexico, Thailand, and Ireland, the increase has been greater than 20 percentage points. Moreover, some evidence indicates that the rise of GVCs measured along this dimension has slowed in recent years. Indeed, Constantinescu, Mattoo, and Ruta (2015) find that the slower pace of GVC-expansion has contributed to the global trade slowdown observed since the global financial crisis.

[25] The findings of the recent literature further suggest that, for economies that have become more deeply involved in GVCs, trade in GVC-related products may have become less strongly responsive to exchange rate changes. Cheng et al. (2015), for example, find that a real appreciation of a country's currency not only reduces its exports of domestic value added, but also lowers its imports of FVA (in contrast to the traditional rise in imports following currency appreciation). This latter result is consistent with the notion that GVC-related domestic and FVA are complements in production. In addition, the analysis finds that the magnitudes of import and export elasticities depend on the size of a country's contribution to GVCs—smaller domestic contribution of value added tends to dampen the response to exchange rate changes (see also IMF 2015a, 2015b, 2015c).

available. Based on this data availability, the first 10-year interval used for estimation is 1990–1999 and the last is 2005–14.[26]

The results displayed in Figure 4 suggest that exchange rates have not generally become disconnected from trade. The elasticity of imports with respect to import prices shows some weakening toward the end of the sample in some of the regions. However, because there is no sign of weakening in the responsiveness of exports to relative export prices (there is even a mild strengthening in some subsamples), or in the effects of exchange rates on trade prices, the evidence regarding the implications of the rise of GVCs remains inconclusive.[27] Given that the rise of GVCs has generally been only gradual and even appears to have decelerated recently (Figure 3), this inconclusive evidence is perhaps not surprising.

We also perform structural-break tests to analyze stability of trade elasticities between the 1990–2001 and the 2002–2014 samples. The results, displayed in Table 5, confirm our finding of broad stability. The tests fail to reject the null of no change in most cases. Similarly inconclusive results emerge when the tests are repeated for countries with larger increase in terms of integration into GVCs, and the data samples used elsewhere, including the 46 economies included in the analysis of Ahmed, Appendino, and Ruta (2015).

III. Analysis of Large Currency Depreciations Episodes

This section focuses on the evidence of the effects of large and sudden depreciations on trade. During such episodes exchange rate fluctuations are likely to include a larger exogenous component than during normal times. At the same time, because in practice there are various adjustment costs that may hamper response of exports to exchange rate changes, businesses and consumers are likely to respond quicker if the relative prices change by a lot. In such episodes exchange rate changes are likely to be the major factor influencing agents' decisions. In addition, it is unlikely that foreign demands and preference shocks change abruptly and simultaneously. Demand curve should be relatively stable as compared to the fundamentals of the economy in question minimizing the bias in our implied price elasticities that measure slope of the demand curve. That is by focusing on large depreciation episodes we not only limit the likelihood that reverse causality effects are in play, but also increase chances that trade response will not be muted by other developments in the economy and that the response will be more immediate.

[26] So far, we perform the panel estimations for the rolling regressions attributing an equal weight for all economies in the sample. This is mainly due to the sample size constraint for every individual economy, which makes it difficult to estimate the rolling regression for every single economy and perform a weighted average for the full sample.

[27] The finding of broad stability in exchange rate pass-through over time is consistent with the findings of Bussière, Delle Chiaie, and Peltonen (2014), who test stability in exchange rate pass-through coefficients for the period 1990–2011 for 40 AEs and EMDEs.

A study of trade dynamics following such relatively extreme events allows the analysis to provide better estimates of export elasticities.[28] To a certain extent, this has been exploited by a relatively seasoned literature from the 1990s and early 2000s (see Borensztein and De Gregorio, 1989; Frankel and Rose, 1996; Goldfajn and Valdés, 1999; and Milesi-Ferretti and Razin, 2000). Such literature has, indeed, found significant effects of large currency depreciations (currency crises) on CPI inflation and the current account. More recently, IMF (2015e) and de Gregorio (2016) have revisited that methodology.[29] With a slightly different identification approach from us, De Gregorio (2016) examines data for a large sample of countries dating back to the early seventies. Likes us, he confirms that the large devaluations are not unprecedented this time around either in terms of magnitude or duration. In turn, different from us, he investigates the exchange rate pass-through to CPI inflation rather than relative export prices, and the current account rather than export volumes. In that analysis, he finds that the pass-through from exchange rate to CPI inflation have been somewhat lower than in previous episodes and that the current account adjustment has been more limited than in the past.

Besides of focusing in relative export prices and volumes, our analysis further zooms in episodes of large exchange rate depreciation not associated with banking crises. That is because such banking crises can have additional confounding effects on trade.[30] But, in a number of cases, these episodes coincide with currency crises. Currency crises do not pose a problem because, as mentioned above, we only include episodes when a banking sector remained functional implying that financing sources of exporters remained intact. Thus, in most of these scenarios depreciations are driven by loss of confidence rather than by domestic fundamentals that are more stable. That is corroborated by an interesting speech from the governor of the Reserve Bank of New Zealand in 2000 stating that fundamentals certainly cannot constitute the whole explanation of the 44 percent depreciation of the NZD against the USD between 1997 and 2000.[31]

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[28] It is important to note that the above arguments do not necessarily suggest that the relation between exchange rate changes and trade are non-linear and that trade is likely to respond only during large exchange rate moves. It is rather that the response of trade cannot be identified with the same confidence when the observed changes are small. For similar reasons our analysis focuses only on exports – various domestic developments that affect imports are likely to coincide with large exchange rate depreciations.

[29] Joy et al. (2015) also investigate currency and banking crises, but those authors are more interested in the determinants of those crises rather than on their effects on trade.

[30] Although this episode-based approach addresses some of the problems associated with the macro-level approach of estimating the effects of exchange rates on trade, it is subject to the criticism that large depreciation episodes could be triggered by a policy response to unusually weak export performance in the context of an unsustainable balance of payments deficit. In that case, the episodes would tend to be associated with unusually weak export growth, biasing the analysis against finding that currency depreciation causes a rise in exports.

[31] Donald Brash's speech "The fall of the New Zealand dollar - why has it happened, and what does it mean?" of October 5, 2000 addressed to the American Chamber of Commerce can be accessed at http://www.bis.org/review/r001012b.pdf.

A. Methodology

We identify large exchange rate depreciation episodes using two criteria. The first criterion identifies a large depreciation as an unusually sharp nominal depreciation of the currency vis-à-vis the U.S. dollar with a numerical threshold set at the 90th percentile of all annual depreciations in the sample. The second criterion prevents the same large exchange rate depreciation episode from being captured more than once. It requires the change in the depreciation rate compared with the previous year to be unusually large (greater than the 90th percentile of all changes). Because exchange rates tend to be more volatile in EMDEs than in AEs, both thresholds are defined separately for the two groups of economies. For the first criterion, the threshold for AEs is a depreciation of 13 percent vis-à-vis the dollar, whereas for EMDEs, the threshold is 20 percent. For the second criterion, the AE and EMDE thresholds are both about 13 percentage points.

To ensure that the results are not unduly influenced by high-inflation episodes,[32] the analysis considers only large exchange rate depreciations that occur when the inflation rate is less than 30 percent annually. In addition, the analysis focuses on episodes not associated with banking crises to avoid confounding factors associated with credit supply disruptions. In particular, large exchange rate depreciation episodes occurring within three years of a banking crisis based on the updated version of Laeven and Valencia's (2013) dataset are discarded.

Applying the methodology as explained above to all economies that have data on export volumes and prices during 1980–2014 yields 66 large exchange rate depreciation episodes. As reported in Table 6, about one-quarter (17) of these large exchange rate depreciations occurred in AEs.[33] They include, for example, European economies affected by the 1992 European Exchange Rate Mechanism crisis. The remaining episodes occurred in EMDEs and include, for example, the devaluation of the Chinese yuan in 1994 and the large depreciation of the Venezuelan bolívar in 2002.

The methodology is standard and follows Cerra and Saxena (2008) and Romer and Romer (2010) among others. The average responses of export prices and export volumes to a large depreciation are estimated separately using panel data analysis. We use an autoregressive distributed lags (ARDL) model in first differences. The estimated lagged impacts of an episode of large exchange rate depreciation are then cumulated to obtain the dynamic impact on the level of export prices and export volumes. For export prices, the estimated equation has the change in the log of export prices in foreign currency as the dependent variable. The explanatory variables are the current and lagged values of the dummy variable indicating an episode of large exchange rate depreciation. Including lags allows for a delayed impact of a

[32] These exchange rate movements would be most likely endogenous.

[33] The baseline results for the effects of large exchange rate depreciation episodes are compared with the results based on the following three alternative approaches (i) local projection methods; (ii) thresholds based on real effective exchange rate depreciations; and (iii) using Laeven and Valencia's (2013) currency crisis episodes. In each case, the results are similar to the baseline results.

large depreciation. In addition, the approach controls for lags of the change in the log of export prices in foreign currency, to distinguish the effect of a large depreciation from the delayed impact of past export price changes. The estimated equations are:

$$\Delta \ln\left(\frac{eP}{P^*}\right)_{it} = \mu_i + \tau_t + \rho\Delta\ln\left(\frac{eP}{P^*}\right)_{i,t-1} + \sum_{j=0}^{2}\beta_j shock_{i,t-j} + \varepsilon_{it}, \quad (7)$$

$$\Delta \ln\left(\frac{eP^{X}}{P^*}\right)_{it} = \mu_i + \tau_t + \rho\Delta\ln\left(\frac{eP^{X}}{P^*}\right)_{i,t-1} + \sum_{j=0}^{2}\beta_j shock_{i,t-j} + \sum_{j=0}^{2}\gamma_j \Delta\ln\left(\frac{ULC}{P}\right)_{i,t-j} + \varepsilon_{it}, \quad (8)$$

$$\Delta \ln X_{it} = \mu_i + \tau_t + \rho\Delta\ln X_{i,t-1} + \sum_{j=0}^{2}\beta_j shock_{i,t-j} + \gamma\Delta\ln Y_{it}^* + \varepsilon_{it}, \quad (9)$$

in which again the subscript *i* denotes the *i-th* country and the subscript *t* denotes the *t-th* year; and *shock* is the dummy variable, indicating the occurrence of a large depreciation. We include country- and time dummies (μ_i and τ_t) to account for country fixed effects and common time trends, respectively.

B. What happens to Exports after a Large Exchange Rate Depreciation

The results suggest that large depreciations substantially boost exports. As shown by the solid line in the first panel of Figure 5, during the identified depreciation episodes the real effective exchange rate declines on average 25 percent over five years. Export prices in foreign currency fall by about 10 percent, with much of the adjustment occurring in the first year (solid line in the mid-panel of Figure 5). The implied pass-through of the real exchange rate into export prices relative is thus about 0.4, similar to the estimate based on the trade equations at macro level. The solid line in the right panel of Figure 5 evinces, in turn, that export volumes rise more gradually, by about 10 percent over five years.[34] This response suggests the average price elasticity of exports of about –0.7, which is higher in absolute value than the elasticity of –0.3 estimated using the trade equations at macro-level and closer to the estimated value using sectoral data. This higher estimated price elasticity likely reflects the stronger identification based on large exchange rate depreciation episodes. All the results are statistically significant at conventional levels.[35]

[34] Consistent with this result, Alessandria, Pratap, and Yue (2013) find that exports rise gradually following a large depreciation, based on data for 11 emerging market economies.

[35] These results are robust to the use of a number of alternative specifications and methodologies to estimate the impulse responses or to identify the large exchange rate movements available upon request.

C. Large Depreciations and Disconnect

To shed further light on whether the links between exchange rates and trade have weakened over time, we calculate the effects of large exchange rate depreciations on exports for the first and second halves of the sample. This serves as another robustness check of stability of trade elasticities.

Of the 66 episodes of large currency depreciation in the sample, half (33) occurred in 1997 or earlier, and the other half occurred in more recent years. The analysis indicates that export prices and volumes responded similarly during the two time samples, in line with the results for rolling regressions (Figure 4) and structural break tests (Table 5) of the previous section. That is, again, we find no evidence of a weakening in the effects of exchange rates over time (Figure 6). We also do not find evidence that response lags have lengthened. This is consistent with the view that trade and exchange rates have remained connected.

D. The Role of Initial Conditions

We further investigate whether export dynamics following large depreciations differ depending on initial economic conditions. When there is more economic slack and more spare capacity in the economy, there could be better possibilities for production and exports to expand following a rise in foreign demand associated with exchange rate depreciation. Intuitively, this is because the volume of exports sold depends not only on the strength of demand, but also on an economy's ability to adjust production in response to stronger demand. After all, while an individual firm can readily expand its export production by purchasing more inputs, a national economy has to either utilize unemployed resources or move resources following the exchange rate depreciation.[36]

We define the degree of economic slack by looking at de-meaned real GDP growth in the year preceding the episode of large exchange rate depreciation.[37] Low growth (economic slack) is then defined as de-meaned growth of less than the median for the 66 episodes (the median is near zero).

The results suggest that, for the subsample of episodes with larger initial slack in the economy, the export gain is larger than in the full-sample baseline by an additional 7 percentage points after five years (long-dashed lines in Figure 6).[38] While this result is not surprising from a theoretical viewpoint, it has not been highlighted in related studies. The exchange rate also tends to depreciate by more and in a more persistent manner than in the

[36] For a similar intuition for the boost on domestic production given spare capacity and fiscal stimulus see Baum, Poplawski-Ribeiro, and Weber (2012).

[37] The results are broadly similar when the definition of economic slack is based on the output gap in the year preceding the large exchange rate depreciation.

[38] To ease comparability of the estimation results for the two groups, the estimated impulse responses are scaled to ensure that the first-year impact on the real exchange rate is exactly the same.

baseline, arguably providing exporters with stronger incentives to cut export prices than in the baseline.

We also look whether the boost to exports associated with a large exchange rate depreciation depend on the health of the exporting economy's financial sector. In principle, banking crises can depress exports by reducing the availability of credit needed to support export production.[39] This drop in credit availability could offset export gains due to the currency depreciation. We apply the same criteria used in the previous subsections but here do not exclude banking crises, identifying 57 episodes, which are not the same as those included in the baseline analysis. These new episodes include, for example, the large exchange rate depreciations in Finland and Sweden in 1993; Thailand and Korea in 1997 and 1998, respectively; Russia in 1998; Brazil in 1999; and Argentina in 2002.[40]

The results, displayed in Figure 7, suggest that the boost to exports is indeed weaker when exchange rate depreciation is associated with a banking crisis (short-dashed lines in Figure 7). In this case export prices decline by less, suggesting an average elasticity of export prices to the real effective exchange rate of 0.25, about half of the baseline estimate. The response of real exports is near zero. These results are consistent with the view that the credit constraint that exporting firms face when a country's financial sector is weak limits their ability to borrow and increases their exporting capacity when the currency depreciates. At the same time, banking crises result in a wide range of outcomes, as discussed in the literature (see, for example, IMF, 2010). For a number of the episodes associated with banking crises analyzed here, exports effect was positive—for example, for the large depreciations of Argentina (2002), Brazil (1999), Russia (1998), and Sweden (1993).[41]

Overall, the results based on the analysis of traditional trade equations and large exchange rate depreciation episodes suggest that trade responds substantially to the exchange rate according to the historical evidence and that the conventional expenditure-switching effects apply. The rise in exports associated with exchange rate depreciation is likely to be largest when there is slack in the economy and when the financial sector is operating normally.

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[39] Ronci (2004) analyzes the effect of constrained trade finance on trade flows in countries undergoing financial and balance of payments crises and concludes that constrained trade finance depresses both export and import volumes in the short term. Dell'Ariccia, Detragiache, and Rajan (2005) and Iacovone and Zavacka (2009) find that banking crises have a detrimental effect on real activity in sectors more dependent on external finance, which includes export oriented sectors. Kiendrebeogo (2013) investigates whether banking crises are associated with declines in bilateral exports, by estimating a gravity model using a sample of advanced economies and developing countries for the period 1988–2010. The results suggest that banking-crisis-hit countries experience lower levels of bilateral exports, with exports of manufactured goods falling particularly strongly. More generally, for an analysis of the evolution of trade following large depreciations associated with financial crises, see IMF (2010).

[40] The list of episodes is available upon request. The results for such analysis are also robust to controlling for the occurrence of banking crises in trading partners in the estimated equations.

[41] For additional analysis of the effects of the 2002 Argentina episode, see Calvo, Izquierdo, and Talvi 2006. For the 1998 Russia episode, see Chiodo and Owyang 2002. For the 1993 Sweden episode, see Jonung 2010.

Our analysis of the effects of initial conditions has implications for the lack of trade response to the recent large depreciations. Because economies still face difficulties recovering from the global financial crisis and, so, they operate below their potential levels trade is expected to respond less vigorously than in normal times. As the world economy recovers from the crisis we expect large trade re-distribution to occur.

IV. Sectoral Level Analysis

The analysis of sectoral data robustifies our estimates of trade elasticities. Similarly to the analysis of large depreciation episodes, exchange rate movements are more likely to be exogenous to individual sectors. In addition, sectoral analysis allows us to decrease downward "heterogeneity bias" that could appear in the form of disconnect between exchange rates and trade.

Since Machlup (1950) and Orcutt (1950), the literature on estimation of trade elasticities has argued that elasticities estimated at the macro level may be biased downward. This downward bias has been recently emphasized again by Imbs and Mejean (2015). They show that with "well-behaved" residuals, a regression of aggregate imports on aggregate price of imports implies an estimate equal to a weighted average of microeconomic elasticities. With the sector-level heterogeneity in price elasticity of trade volume, the estimate is biased downward as the aggregate price changes are largely accounted for by products with low elasticity.[42] In this case residuals correlate systematically with explanatory variables leading to the classic heterogeneity bias as defined, for instance, by Pesaran and Smith (1995).

Sector-level data allows estimating trade relations with heterogeneous trade elasticities, and, in this way, avoiding the downward heterogeneity bias. Trade elasticities that are estimated at sector level are also less subject to reverse causality, as sector demand shifts have less impact on the aggregate exchange rate. Even if the reverse causality is not solved completely, size of the bias would depend on sector's weight in overall trade. Thus, it is possible to detect its presence via an interaction term between exchange rate and sector's export share.

Sector level data could also help understand an apparent lack of relation between trade elasticities and countries' participation in global value chains (GVCs). GVC measures have a rich variation at the country and sector level. So, by using sector level data we can analyze how they affect exchange rate pass-through (see Amiti, Itskhoki, Konings, 2014) and, hence, how exchange rate movements affect trade volume.

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[42] Imbs and Mejean (2015) explain why price changes may be larger for products with inelastic demand. First, under imperfect competition firms that face highly elastic demand may choose to limit impact of cost shocks, stabilizing prices and letting markups vary instead. Second, tariffs are unlikely to create large distortions for products with inelastic demand and this prompts policymakers to impose higher taxes in them which amplify price fluctuations.

But the use of disaggregated data may also come at a cost. As Russell and Hummels (2013) point out, noise in measures of trade prices at the sector level biases price elasticity of trade volume—one of the two components of the overall elasticity—towards one. For this reason, in this section we estimate the effects of exchange rate movements on trade volumes directly—the so-called reduced form estimation of trade elasticities—rather than estimating the pass-through- and price-to-volume elasticities separately.

A. Data

Our main dataset is based on UN ComTrade database. To include GVC measures into our regression analysis, we employ data from the OECD TiVA database, which covers 46 countries and restricts our sample to the years between 1995 and 2011.

The main challenge in assembling the sector-level dataset is to construct effective exchange rates that vary with sectors' destination profiles and price deflators to derive sectoral level trade volumes from trade values. The UN Comtrade provides export and import U.S. dollar values, and export and import quantities that allow us constructing product unit values. We aggregate each product unit value into one of 18 sector prices using the HS 2002 6-digit product classification based on the OECD Inter-Country Input-Output (ICIO) classification.

Importantly, we construct import and export prices at the sector level as GEKS indexes (Ivancic, Diewert, and Fox (2011) and De Haan and van der Grient (2011)). The GEKS index has two advantages over the Fisher chain index which it is based on. First, it uses bilateral information between any two periods, which is useful as trade data at the product level often have gaps, creating issues for the construction of the Fisher chain index. Second, it avoids chain drift, which arises when a selection of goods used to compute an index changes significantly over time. Appendix C provides a detailed description of the index construction.[43]

For the calculation of the sector level exchange rate, we use the Tornqvist method (Kee and Tang, 2016). Its most important feature is that it uses only exporting destination countries for which exports were made in two consecutive years. The method helps, therefore, to avoid compositional bias. Mathematically, for the country pair i, j and sector k, the sector level exchange rate change from year $t-1$ to year t is defined as:

$$\ln(ER^i_{k,t}) - \ln(ER^i_{k,t-1}) = \sum_{j \in I^i_{kt} \cap I^i_{kt-1}} \frac{1}{2}\left(s^i_{j,k,t} + s^i_{j,k,t-1}\right)\left(\ln\left(ER^i_{j,t}\right) - \ln\left(ER^i_{j,t-1}\right)\right)$$

[43] It turns out, that our results do not depend on whether the GEKS or the Fisher index is used. We take this fact as pointing to high consistency of our data.

where I_{kt}^{i} is the set of countries that import from the sector k of country i in year t; $s_{j,k,t}^{i}$ is the country j's share in the exports of sector k of country i; $\ln(ER_{j,t}^{i}) - \ln(ER_{j,t-1}^{i})$ is the change of the bilateral exchange rate between country i and j from year $t-1$ to t.

To insure robustness of our results we exclude observations with GEKS index changes above 90th percentile and below the 10th percentile of the distribution of price changes in the same industry and in the same year.

B. Sectoral Level Estimations

We follow Campa and Goldberg (2005) in constructing macro-level variables that may influence exchange rate pass-through and the effects of exchange rate movements on trade volumes. We then estimate the trade elasticities at sectoral level as follows:

$$\Delta\ln\left(\frac{eP^{X}}{P^{*}}\right)_{ikt} = \alpha_{ik} + \eta_{t} + \gamma_{k}\Delta\ln\left(\frac{eP}{P^{*}}\right)_{it} + \vec{\phi}\,\Delta\ln\left(\frac{eP}{P^{*}}\right)_{ikt} \times \vec{Z}_{ikt} + \beta\,\Delta\ln\left(\frac{ULC}{P^{*}}\right)_{it} + \nu_{ikt}, \qquad (10)$$

$$\Delta\ln X_{ikt} = \alpha_{ik} + \eta_{t} + \gamma_{k}\Delta\ln\left(\frac{eP}{P^{*}}\right)_{ikt} + \vec{\phi}\,\Delta\ln\left(\frac{eP}{P^{*}}\right)_{ikt} \times \vec{Z}_{ikt} + \beta\,\Delta\ln Y_{it}^{*} + \nu_{ikt}, \qquad (11)$$

$$\Delta\ln\left(\frac{eP^{M}}{P}\right)_{ikt} = \alpha_{ik} + \eta_{t} + \gamma_{k}\Delta\ln\left(\frac{eP}{P^{*}}\right)_{it} + \vec{\phi}\,\Delta\ln\left(\frac{eP}{P^{*}}\right)_{it} \times \vec{Z}_{ikt} + \beta\,\Delta\ln Y_{it} + \nu_{ikt}, \qquad (12)$$

$$\Delta\ln M_{ikt} = \alpha_{ik} + \eta_{t} + \gamma_{k}\Delta\ln\left(\frac{eP}{P^{*}}\right)_{it} + \vec{\phi}\,\Delta\ln\left(\frac{eP}{P^{*}}\right)_{it} \times \vec{Z}_{ikt} + \beta\,\Delta\ln Y_{it} + \nu_{ikt}, \qquad (13)$$

where α_{ik} denotes the country-industry fixed effects; and η_{t} denotes the time fixed-effects; the real effective exchange rate's coefficient γ_{k} is allowed to differ across industries.

The variables contained in the vector $\vec{Z}_{ikt}$ in the equations above follow the methodology used by Campa and Goldberg (2005). That includes money growth rate, GDP growth, and inflation, as well as some GVC measures. It also includes a period dummy to detect any instability of trade elasticity over time. That dummy assumes value equal to 1 for the years since 2002 and zero otherwise. The variables in that vector $\vec{Z}_{ikt}$ are all demeaned and normalized such that its standard deviation is equal to one. Finally, the vector also contains GVC measures that will be tested to check whether a larger integration to GVC has caused an exchange rate disconnect. Here, we follow the standard practice in the literature, and use *foreign value added share in exports* (*xfva_x*) as our GVC measure. This GVC measure is constructed both at the country-sector level as well as at the sector level only.

Each interaction term serves a specific role. The interaction between exchange rate and the time dummy is designed to mimic the Chow test. The interactions with the GVC variables are designed to uncover effect of those variables on the potential disconnect between exchange rates and trade.

The interaction term with macroeconomic variables follow, in turn, Campa and Goldberg (2005). As those authors discuss, macroeconomic variables may explain cross-country differences in exchange rate pass-through rates and, hence, should be controlled for if one explores the impact of GVCs on trade elasticities. This may be the case for the relative stability of local monetary policy (see Devereux and Engel, 2001) If exporters set their prices in the currency of the country that has the most stable monetary policies, import prices in local currency terms should be more stable in countries with more stable monetary policy. All else equal exchange rate pass through should be higher for countries with more volatile monetary policy. Country size may be another important factor in ranking pass-through elasticities of countries. Exchange rate pass-through may be higher if the exporters are large in number relative to the presence of local competitors. One approximation to this notion is that pass-through elasticities might be inversely related to country real GDP. An alternative approach would be to also consider measures of sector-specific openness for countries.

Finally, regarding the other controls, we assume that foreign and domestic demands have the same impact across industries. This is true if the following two assumptions are satisfied. First, consumers must have homothetic utility functions, or equivalently, their demands for final goods must be linear in income. Second, firms must have homothetic production functions, or equivalently their demands for intermediate goods must be proportional to firm's total output. We assume rather than verify that the conditions are met as is typically done in the literature.

C. Results

Tables 7 and 8 present the results of the sectoral analyses with the interaction terms for export and import prices (Table 7) and export and import volumes (Table 8). As the coefficient for the interaction term of the exchange rate with the dummy period conveys, the claim that exchange rate and trade have become disconnected over time is again rejected in our sectoral analysis. For trade prices that interaction term is not significant particularly when we include all other relevant interaction terms in Table 7 (Column 3). For the estimations of export volume, the interaction terms indicates that if anything the volume elasticity has increased in the more recent period since 2002. For import volumes, as already highlighted in the aggregate estimations of Section II, there is an indication of a marginal decline on its elasticity.

In turn, the interaction terms of our GVC measures (*foreign value added*) are significant in some of the estimations of Tables 7 and 8. In Table 7, either the country-industry share of FVA on gross export, or its world average are statistically significant and with a negative sign for import prices. So, they suggest a marginal reduction in the pass-through to import prices. Yet, the values of the coefficient are very small, indicating a small economic significance for those GVC variables. In Table 8, the interaction terms of GVC variables with exchange rates are significant for both export and import volumes. This suggests that the integration into GVC does have a dampening effect in the volume elasticities.

Overall, the main findings of this section are that: (i) exchange rate movements have significant effects on trade volumes at the sector level; (ii) the strength of the relation between exchange rates and trade appears to have not declined over time, and (iii) GVC's impact on trade elasticities is insignificant (at least economically) in most of the cases investigated.

V. CONCLUSION

This paper indicates that exchange rate movements tend to have strong effects on exports and imports and there has been no disconnect between that trade and exchange rate over time. There is little sign of a general weakening in the responsiveness of exports to relative export prices or in the effects of exchange rates on trade prices. Our finding of no disconnect is robust to estimating the elasticities using large depreciation episodes and using sectoral level data. The lack of disconnect despite of the increase in production fragmentation across the world is due to the fact that such global-value-chain-related trade has increased only gradually through the decades, and the bulk of global trade still consists of conventional trade.

Therefore, based on our estimates at macro level, we find that a 10 percent real effective depreciation in an economy's currency is associated with, on average, a 1.5 percent of GDP rise in real net exports, with substantial cross-country variation around this average. Foreign and domestic aggregate demand, indeed, play robust roles in driving exports and imports, a link that has featured prominently in the policy debate on the postcrisis decline in global trade.

These findings suggest thus that recent exchange rate movements, including the U.S. dollar's appreciation could result in a substantial redistribution of real net exports across economies.[44] With regard to direct effects on trade, the real effective exchange rate movements observed since January 2013 point to a redistribution of real net exports, from the United States and economies whose currencies move with the dollar, to the euro area, to Japan, and to economies whose currencies move with the euro and the yen. As our analysis of large currency depreciation further evinces, among economies experiencing currency depreciation, the rise in exports is likely to be greatest for those with slack in the domestic economy and with financial systems operating normally.

In interpreting these results, it is further worth noting that the macroeconomic relevance of trade elasticities depends on the shares of exports and imports in GDP, both of which have risen in recent decades, reflecting the process of trade globalization (Figure 8). On their own,

[44] Overall outcomes for trade will reflect not only the direct effect of exchange rates on trade, but also shifts in the underlying fundamentals driving exchange rates themselves.

the increases in these trade ratios imply larger effects of exchange rate movement on total imports and exports in percentage points of GDP. Therefore, even a decline in trade elasticities could, in the context of rising import and export ratios, be consistent with exchange rate movements having equally important if not greater macroeconomic implications for trade than before.

Policy views based on the traditional relationship between exchange rates and trade are thus still tenable. The results confirm that exchange rate changes have strong effects on export and import prices, with implications for inflation dynamics and the transmission of monetary policy changes. Economies in which the rise of global value chains has weakened the effects of exchange rates on trade may have less scope for expenditure switching, and larger changes in exchange rates may be required for the resolution of trade imbalances. In general, however, the role of flexible exchange rates in facilitating the resolution of trade imbalances remains significant.

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TABLES AND FIGURES

Table 1 Economies Included in the Panel Estimation of Trade Elasticities

Albania, Algeria, Argentina, Australia, Austria, Bangladesh, Belgium, Bolivia, Brazil, Bulgaria, Cambodia, Canada, Chile, China, Colombia, Republic of Congo, Costa Rica, Côte d'Ivoire, Croatia, Czech Republic, Denmark, Dominican Republic, Ecuador, Egypt, El Salvador, Estonia, Finland, France, Germany, Ghana, Greece, Guatemala, Honduras, Hungary, India, Indonesia, Iran, Israel, Italy, Japan, Jordan, Kenya, Korea, Kuwait, Kyrgyz Republic, Latvia, Lebanon, Libya, FYR Macedonia, Malaysia, Mexico, Morocco, Netherlands, New Zealand, Nicaragua, Nigeria, Norway, Oman, Pakistan, Paraguay, Peru, Philippines, Poland, Portugal, Romania, Russia, Saudi Arabia, Slovak Republic, Slovenia, South Africa, Spain, Sri Lanka, Sweden, Switzerland, Syria, Taiwan Province of China, Thailand, Trinidad and Tobago, Tunisia, Turkey, Ukraine, United Arab Emirates, United Kingdom, United States, Uruguay, Venezuela, Yemen, Zambia

Table 2. Economies Included in the Individual Estimation of Trade Elasticities

Advanced Economies	Emerging Market Economies
Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Israel, Italy, Japan, Korea, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Taiwan Province of China, United Kingdom, United States	Algeria*, Argentina, Bangladesh, Bolivia*, Bulgaria, Chile*, China, Colombia*, Republic of Congo*, Costa Rica, Côte d'Ivoire*, Egypt, El Salvador, Guatemala, Honduras, Hungary, India, Indonesia, Islamic Republic of Iran*, Jordan, Kenya, Kuwait*, Malaysia, Mexico, Morocco, Nigeria*, Pakistan, Paraguay*, Philippines, Saudi Arabia*, South Africa*, Sri Lanka, Thailand, Trinidad and Tobago*, Tunisia, United Arab Emirates, Venezuela*

* Denotes commodity exporters, that is, economies for which primary products constitute the main source of export earnings, exceeding 50 percent of total exports, on average, between 2009 and 2013.

Table 3. Data Sources

Indicator	**Source**
Export Prices	IMF staff calculations using export value divided by export volume
Export Volume	IMF, World Economic Outlook database
Export Value	IMF, World Economic Outlook database
Import Prices	IMF staff calculations using import value divided by import volume
Import Volume	IMF, World Economic Outlook database
Import Value	IMF, World Economic Outlook database
International Commodity Price Index	IMF, Global Assumptions database
International Energy Price Index	IMF, Global Assumptions database
Nominal Effective Exchange Rate	IMF, Information Notice System
Nominal GDP	IMF, World Economic Outlook database
Real Effective Exchange Rate	IMF, Information Notice System
Real GDP	IMF, World Economic Outlook database
Trade-Weighted Foreign CPI	IMF staff calculations
Trade-Weighted Foreign Demand	IMF, Global Economic Environment database
Trade-Weighted Foreign PPI	IMF staff calculations
Unit Labor Cost[1]	Organisation for Economic Co-operation and Development, *OECD Economic Outlook*; U.S. Bureau of Labor Statistics; and IMF staff calculations
Indicators Used for Global Value Chain Analysis	
Backward Participation	Organisation for Economic Co-operation and Development–World Trade Organization, Trade in Value Added database
Forward Participation	Organisation for Economic Co-operation and Development–World Trade Organization, Trade in Value Added database

Note: CPI = consumer price index; PPI = producer price index.
[1]IMF staff calculations use data from Haver Analytics; International Labor Organization; IMF, World Economic Outlook database; and IMF, International Financial Statistics.

Table 4. Exchange Rate Pass-Through and Price Elasticities

	Exchange Rate Pass-Through		Price Elasticity of Volumes		Marshall-Lerner Condition Satisfied?[1]
	Export prices	Import prices	Exports	Imports	
Based on Producer Price Index[2]					
Long-Term	0.552	–0.605	–0.321	–0.298	Yes
One-Year Effect	0.625	–0.580	–0.260	–0.258	Yes
Based on Consumer Price Index[3]					
Long-Term	0.457	–0.608	–0.328	–0.333	Yes
One-Year Effect	0.599	–0.546	–0.200	–0.200	Yes
Memorandum					
Non–Commodity Exporters[4]					
Long-Term Elasticity[2]	0.571	–0.582	–0.461	–0.272	Yes

Source: IMF staff estimates.
Note: Table reports simple average of individual economy estimates for 60 economies during 1980–2014.

[1]The formula for the Marshall-Lerner condition adjusted for imperfect pass-through is (–*ERPT* of P^X) (1 + price elasticity of X) + (*ERPT* of P^M) (1 + price elasticity of M) + 1 > 0, in which X denotes exports,
M denotes imports, and P^X and P^M denote the prices of exports and imports, respectively (Annex 3.3).

[2] Estimates based on producer price index–based real effective exchange rate and export and import prices relative to foreign and domestic producer prices, respectively.

[3] Estimates based on consumer price index–based real effective exchange rate and export and import prices relative to foreign and domestic consumer prices, respectively.

[4] Excludes economies for which primary products constitute the main source of export earnings, exceeding 50 percent of total exports, on average, between 2009 and 2013.

Table 5. Trade Elasticities over Time: Stability Tests

	Full	1990–2001	2002–2014	Statistical Significance of the Difference between the Two Periods [1]
	1. Pass-Through into Export Prices			
By Region				
All Countries	0.569***	0.557***	0.457***	
Asia	0.429***	0.419***	0.346***	
Europe	0.658***	0.647***	0.687***	
By Integration into Global Value Chains				
Countries with Larger Increase	0.572***	0.560***	0.548***	
Countries with Smaller Increase	0.684***	0.608***	0.609***	
	2. Pass-Through into Import Prices			
By Region				
All Countries	-0.612***	-0.549***	-0.632***	
Asia	-0.671***	-0.684***	-0.668***	
Europe	-0.553***	-0.528***	-0.587***	
By Integration into Global Value Chains				
Countries with Larger Increase	-0.621***	-0.545***	-0.618***	
Countries with Smaller Increase	-0.650***	-0.511***	-0.720***	**
	3. Price Elasticities of Exports			
By Region				
All Countries	-0.207***	-0.147***	-0.255***	*
Asia	-0.329***	-0.265***	-0.489***	**
Europe	-0.281***	-0.303**	-0.375***	
By Integration into Global Value Chains				
Countries with Larger Increase	-0.305***	-0.343**	-0.373***	
Countries with Smaller Increase	-0.402***	-0.225	-0.566***	*
	4. Price Elasticities of Imports			
By Region				
All Countries	-0.433***	-0.452***	-0.335***	
Asia	-0.436***	-0.566***	-0.233	
Europe	-0.470***	-0.484***	-0.446***	
By Integration into Global Value Chains				
Countries with Larger Increase	-0.521***	-0.658***	-0.271**	**
Countries with Smaller Increase	-0.467***	-0.455***	-0.420***	

Source: IMF staff estimates.
[1] Blank space in this column indicates no statistically significant difference.
*$p < 0.1$; **$p < 0.05$; ***$p < 0.01$.

Table 6. Large Exchange Rate Depreciations Not Associated with Banking Crises

Country	Year
Advanced Economies	
Australia	1985
Greece	1991, 1993, 2000
Iceland	1989, 1993, 2001
Ireland	1993
Israel	1989
Italy	1993
Korea	2008
New Zealand	1998, 2000
Portugal	1993
Spain	1993, 1997
United Kingdom	1993
Emerging Market and Developing Economies	
Belarus	2009
China	1994
Comoros	1994
Ethiopia	1993
The Gambia	1987
Ghana	2000, 2009, 2014
Guinea	2005
Haiti	2003
Honduras	1990
Iran, Islamic Republic of	1985, 1989, 1993, 2000, 2002, 2012
Kazakhstan	1999
Kiribati	1985
Libya	2002, 1998
Madagascar	2004
Malawi	1992, 1994, 1998, 2003, 2012
Mozambique	2000
Nepal	1992
Nigeria	1999
Pakistan	2009
Papua New Guinea	1995, 1998
Paraguay	1987, 1989, 2002
Poland	2009
Rwanda	1991
Solomon Islands	1998, 2002
South Africa	1984
Syria	1988
Trinidad and Tobago	1986, 1993
Turkmenistan	2008
Venezuela	1987, 2002, 2009
Zambia	2009

Sources: Laeven and Valencia 2013; and authors' estimates.

Table 7. Sectoral Level Analysis on Export and Import Prices

Variable	Export prices			Import prices		
	Model (1)	Model (2)	Model (3)	Model (1)	Model (2)	Model (3)
Exchange rate 1/	0.360***	0.297***	0.402***	-0.717***	-0.633***	-0.685***
	(0.04)	(0.05)	(0.066)	(0.026)	(0.048)	(0.062)
Exchange rate*period	0.079	0.279***	0.027	-0.109***	-0.018	-0.060
	(0.042)	(0.075)	(0.104)	(0.03)	(0.071)	(0.098)
Exchange rate*money growth			-0.077			0.005
			(0.08)			(0.004)
Exchange rate*real GDP			0.006			0.014***
			(0.015)			(0.005)
Exchange rate*inflation			-0.435***			0.023*
			(0.079)			(0.013)
Exchange rate*country-industry FVA share in gross exports		-0.020	-0.027		0.012***	0.013***
		(0.035)	(0.042)		(0.005)	(0.006)
Exchange rate*world industry FVA share in gross exports		-0.274***	0.043		0.030***	0.035***
		(0.099)	(0.13)		(0.009)	(0.01)
Exchange rate*industry share in exports		0.038	0.038		0.009	0.006
		(0.03)	(0.031)		(0.004)	(0.005)

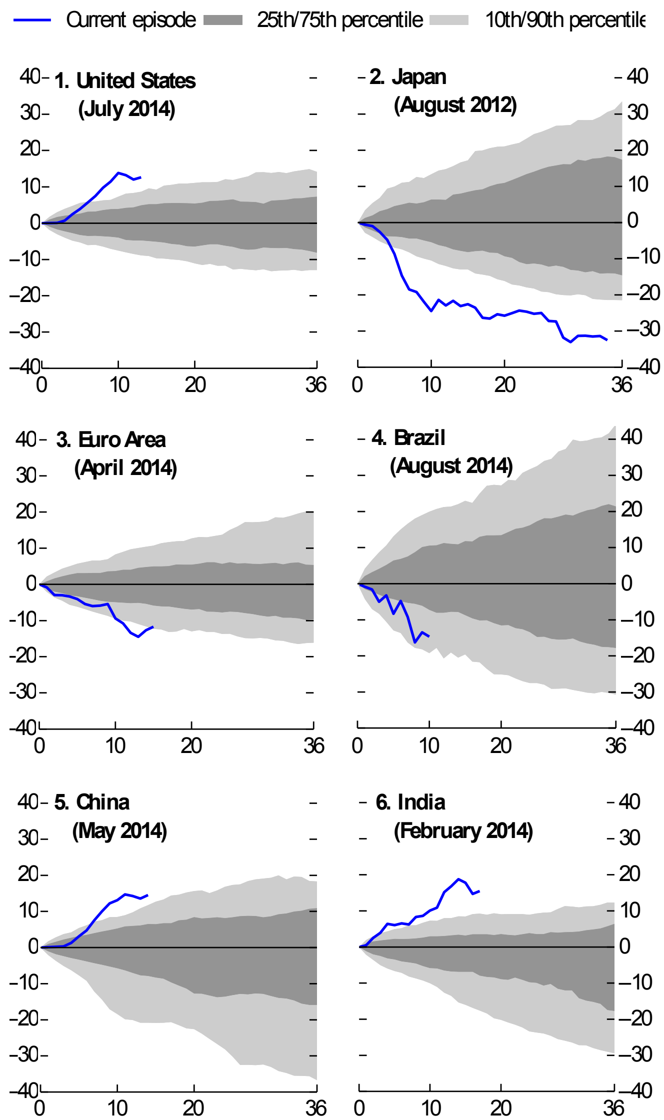
Significance at *** p<0.01, ** p<0.05, * p<0.1; standard errors in parenthesis.

Table 8. Sectoral Level Analysis on Export and Import Volumes

Variable	Export volume			Import volume		
	Model (1)	Model (2)	Model (3)	Model (1)	Model (2)	Model (3)
Exchange rate 1/	-0.244***	0.217	0.221	1.147***	1.423***	1.829***
	(0.124)	(0.152)	(0.184)	(0.107)	(0.147)	(0.178)
Exchange rate*period	-0.552***	-0.949***	-0.786***	-0.826***	-1.634***	-1.604***
	(0.133)	(0.227)	(0.277)	(0.111)	(0.226)	(0.276)
Exchange rate*money growth			-1.246***			0.289
			(0.253)			(0.245)
Exchange rate*real GDP			-0.098			-0.183***
			(0.051)			(0.048)
Exchange rate*inflation			1.552***			1.777***
			(0.389)			(0.305)
Exchange rate*country-industry FVA share in gross exports		0.320***	0.197**		0.026	0.143
		(0.094)	(0.104)		(0.081)	(0.091)
Exchange rate*world industry FVA share in gross exports		0.379	0.368		1.427***	1.286***
		(0.298)	(0.377)		(0.281)	(0.328)
Exchange rate*industry share in exports		0.051	-0.013		0.090	0.191**
		(0.096)	(0.103)		(0.097)	(0.104)

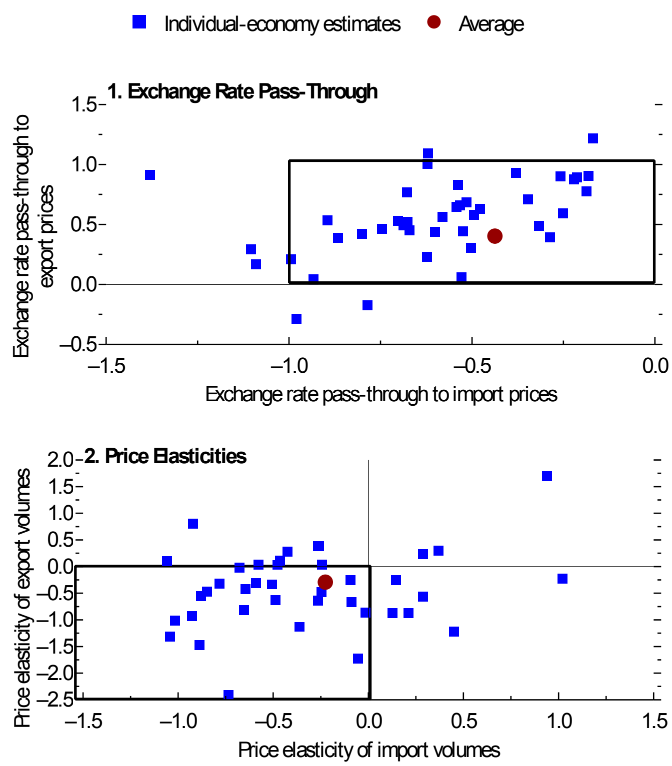
Significance at *** p<0.01, ** p<0.05, * p<0.1; standard errors in parenthesis.

Figure 1. Recent Exchange Rate Movements in Historical Perspective



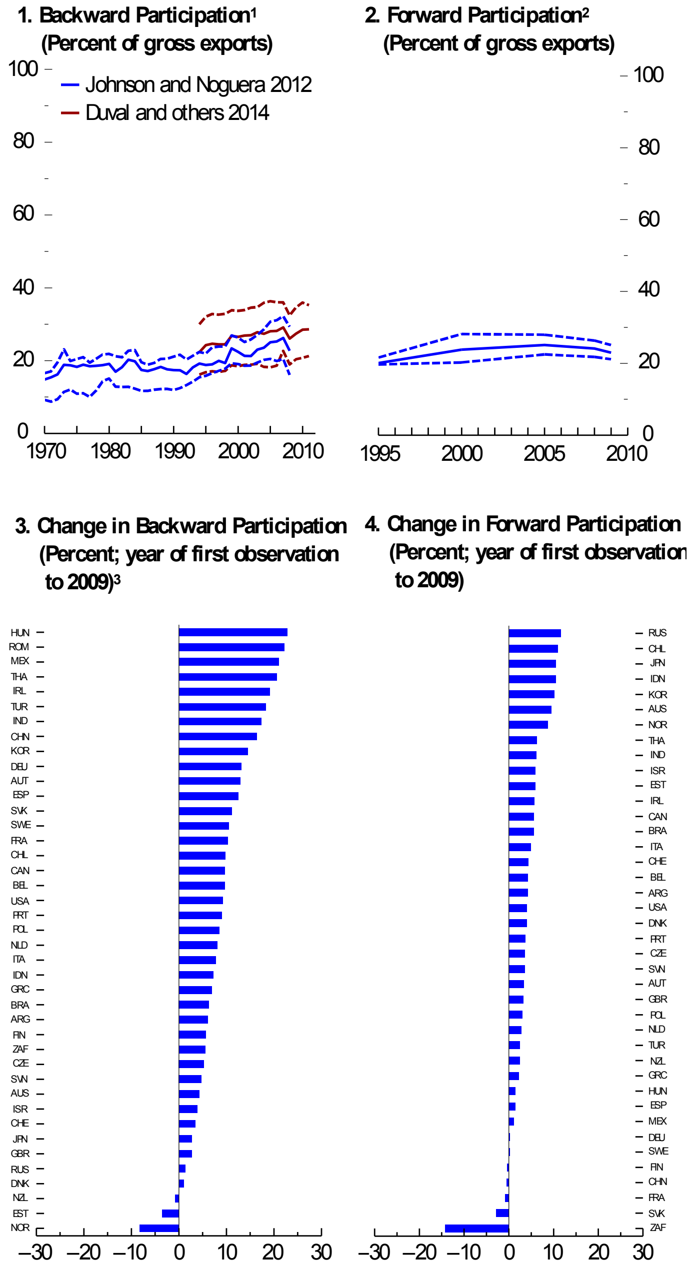
Source: IMF, Information Notice System.
Note: Figure reports historical fluctuation bands for level of CPI-based real effective exchange rate based on all 36-month-long evolutions since January 1980. Confidence band at month *t* is based on all historical evolutions up to month *t*. Blue lines indicate most recent exchange rate paths of appreciation or depreciation that have no interruptions of more than three months. Dates in parentheses mark the starting point for the current episode in each panel. Last observation reported is June 2015.

Figure 2. Long-Term Exchange Rate Pass-Through and Price Elasticities



Source: IMF staff estimates.
Note: Estimates based on annual data for 60 advanced and emerging market and developing economies from 1980 to 2014. Boxes indicate the expected sign and, in the case of exchange rate pass-through, the expected size of the estimates.

Figure 3. Evolution of Global Value Chains



Sources: Duval and others 2014; Johnson and Noguera 2012; and Organisation for Economic Co-operation and Development.

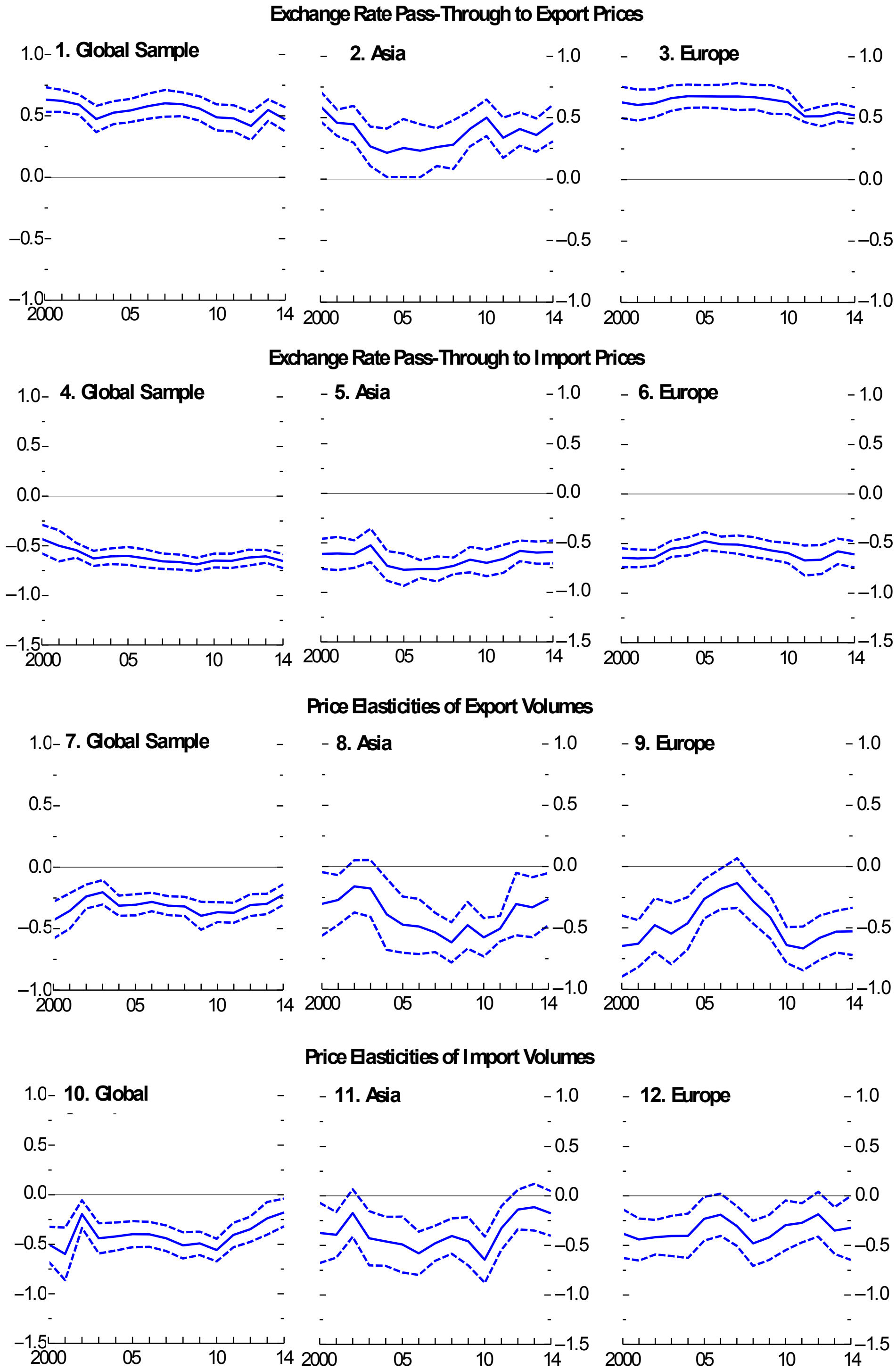
Note: Data labels in the figure use International Organization for Standardization (ISO) country codes.

[1] Share of foreign value added in gross exports. Solid lines denote the average. Dashed lines denote 25th and 75th percentiles.

[2] Intermediate goods used by trading partners for production of their exports as a share of gross exports.

[3] Based on Johnson and Noguera 2012.

Figure 4. Trade Elasticities over Time in Different Regions
(Ten-year rolling windows ending in year t)



Source: IMF staff estimates.
Note: Figure is based on panel estimates using producer price index–based real effective exchange rate and export and import prices relative to foreign and domestic producer prices, respectively. Full sample spans 88 advanced and emerging market and developing economies from 1990 to 2014. Dashed lines denote 90 percent confidence intervals.

Figure 5. Export Dynamics Following Large Exchange Rate Depreciations
(Percent; years on x-axis)

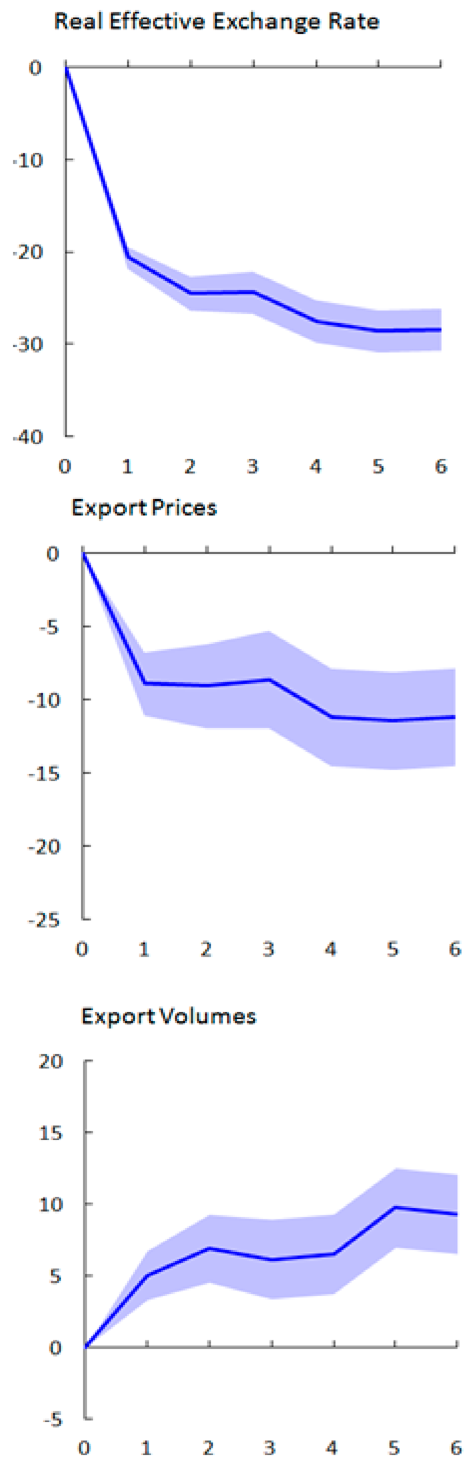
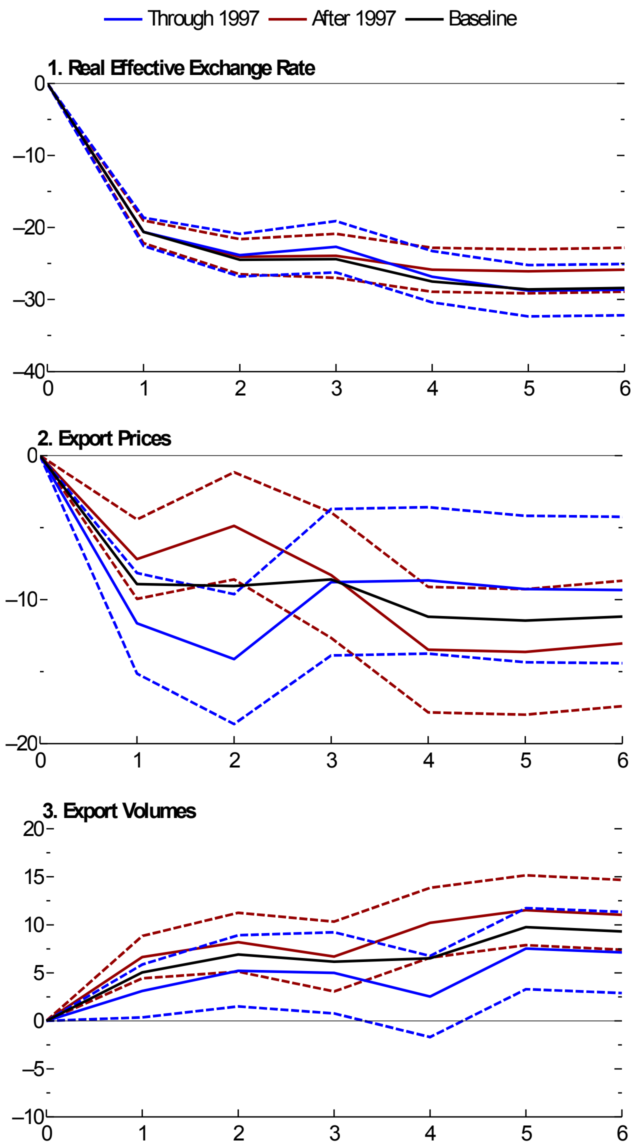


Figure 6. Export Dynamics Following Large Exchange Rate Depreciations: Through and After 1997
(Percent; years on x-axis)



Source: IMF staff estimates.
Note: Dashed lines denote 90 percent confidence intervals.

Figure 7. Large Exchange Rate Depreciations: The Role of Initial Conditions
(Percent; years on x-axis)

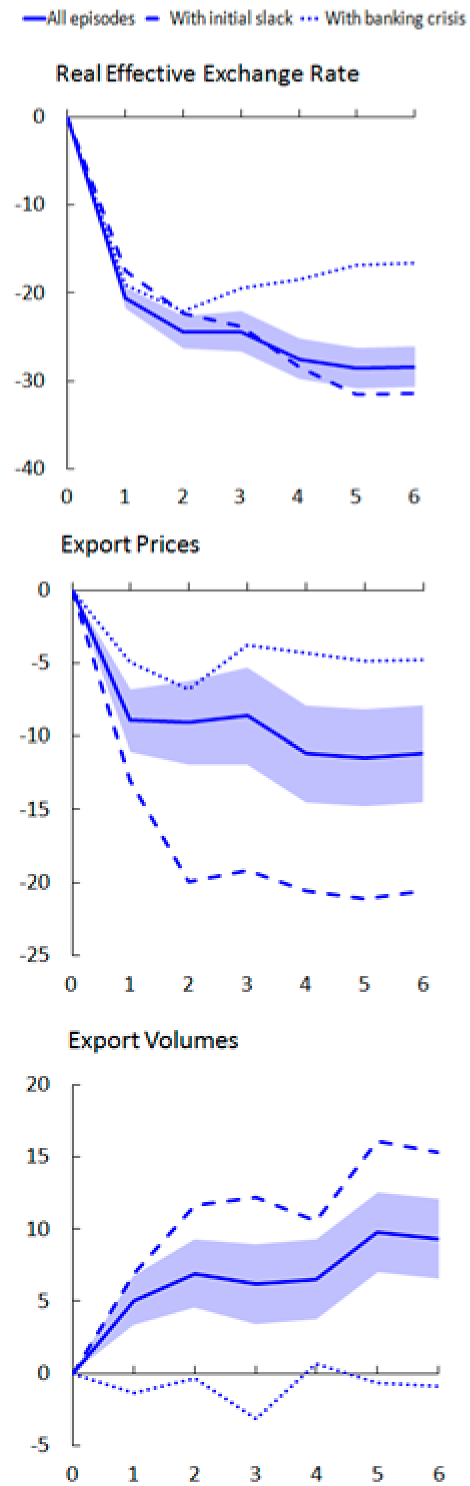
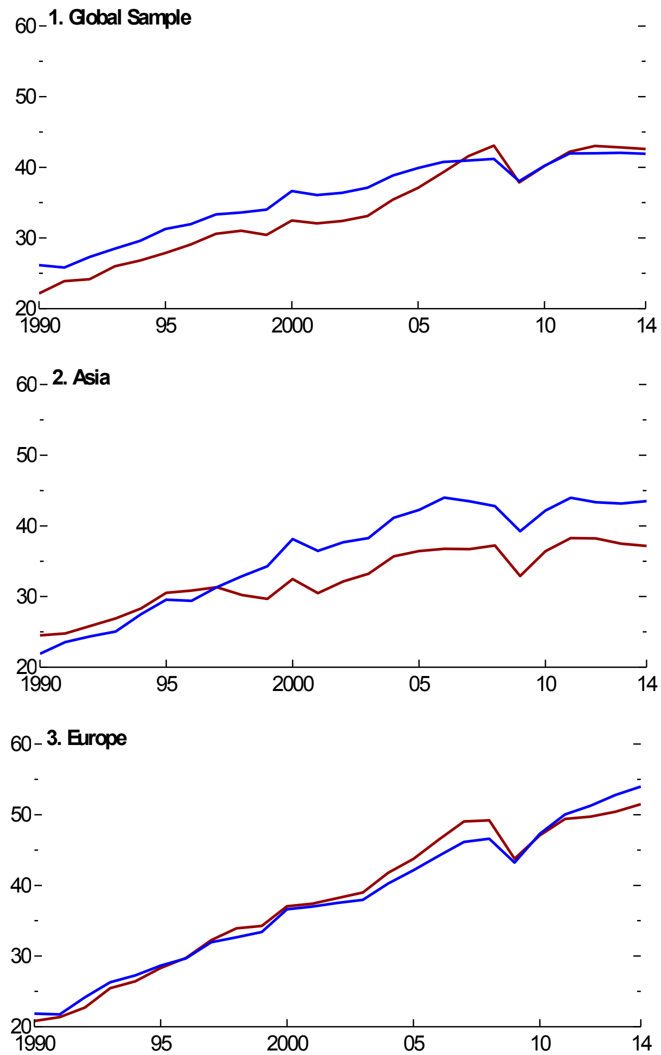


Figure 8. Ratios of Exports and Imports to GDP, 1990–2014
(Percent)



Source: IMF staff calculations.
Note: Figure presents simple averages of economies in the sample.

Appendix

A. Country Samples

Table A1. Economies Covered in the Trade in Value Added Database

Argentina, Australia, Austria, Belgium, Bulgaria, Brazil, Brunei Darussalam, Cambodia, Canada, Chile, China, Colombia, Costa Rica, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hong Kong SAR, Hungary, Iceland, Indonesia, India, Ireland, Israel, Italy, Japan, Korea, Latvia, Lithuania, Luxembourg, Malaysia, Malta, Mexico, Netherlands, New Zealand, Norway, Philippines, Poland, Portugal, Russia, Saudi Arabia, Singapore, Slovak Republic, Slovenia, South Africa, Spain, Sweden, Switzerland, Taiwan Province of China, Thailand, Tunisia, Turkey, United Kingdom, United States, Vietnam

Note: The Trade in Value Added database is from the Organisation for Economic Cooperation and Development and World Trade Organization.

Table A2. Economies Covered in the Sector-Level Analysis

Advanced economies	Emerging economies
Australia, Austria, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Italy, Japan, Korea, Latvia, Lithuania, Netherlands, New Zealand, Norway, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, United Kingdom, United States	Algeria, Argentina, Bolivia, Brazil, Chile, China, Colombia, Costa Rica, Croatia, Ecuador, Egypt, Guatemala, Hungary, India, Indonesia, Macedonia, FYR, Madagascar, Malaysia, Mauritius, Mexico, Morocco, Nicaragua, Oman, Paraguay, Peru, Romania, South Africa, Thailand, Trinidad and Tobago, Tunisia, Turkey, Uruguay, Venezuela

B. Robustness Test: Exchange Rate to Export Volume Elasticity

In this section we perform robustness tests on the estimations of our trade elasticities, checking how our results compare with a specification estimating the reduced form effect of exchange rate to export volumes, which is typically used in the literature (e.g., Ahmed, Appendino, and Ruta, 2015). We estimate the following equation in a panel setup:

$$\Delta X_{i,t} = \mu_i + \tau_t + \beta \, \Delta\left(\frac{eP}{P^*}\right)_{it} + \gamma \, \Delta Y^*_{i,t} + \delta \, Y_{i,t-1} + \varepsilon_{i,t}, \qquad (14)$$

where ΔX is the growth rate of either total real exports, real goods exports, or real manufacturing exports;[45] $\mu_i + \tau_t$ $\mu_i + \tau_t$ are country- and time-fixed effects, respectively; $\frac{eP}{P^*}$ denotes a country's REER (here CPI-based); $\Delta Y^*_{i,t}$ is the growth rate of foreign (trading partner) GDP; and Y is the (log) level of a country's real GDP in U.S. dollars.

Table 3 reports the results of estimating (14)[46] For this analysis, we use the same period and country sample as in Ahmed, Appendino, and Ruta (2015), with 46 economies spanning from 1996 to 2012. To test the robustness of our finds in terms of stability, we also split that sample into two halves as those authors (1996-2003 and 2004-2012).4-2012).

Using that database and specification, we are able to closely replicate the findings of the literature. For total exports, we obtain a decline in the elasticity (β) between the two subsamples from –1.2 to –0.7 and, for manufacturing exports from –1.3 to –0.6. We further investigate the robustness of these findings along three simple dimensions. First, we check whether outliers are driving the results. This is particularly the case since the period sample includes a number of financial crises and hyperinflations, including Bulgaria in 1997 and Russia in 1999, among others. Since these episodes all occur in the early part of the sample, 1996-2003, they complicate the comparison of trade elasticities in this period and the later period, 2004-2012. Excluding the crises is thus warranted. Such episodes can also be caused by factors with an independent effect on trade, providing another reason for their exclusion.

The second row in Table 3 shows that re-estimating (14) while excluding the thirteen datapoints with CPI inflation in excess of 30 percent noticeably reduces the estimated decline in β. For example, for total exports, the decline is now from –0.8 to –0.7 (instead of from –

[45] We use three different specifications, one for each type of export product used in the left-hand side of (14).

[46] Data for total exports and goods exports come from WEO. Data for manufacturing exports come from COMTRADE. Table 7 only reports the estimate of β from (14). The estimates of the other coefficients are available upon request and similar to those obtained in the literature.

1.2 to –0.7), while, for manufacturing exports, it is from –0.7 to –0.6 (instead of from –1.3 to –0.6). The estimated decline in β is now inside one standard error of the estimate (0.1).

In order to control for potential outliers, we additionally apply the robust regression approach to estimate (14). This econometric technique downweights observations with larger absolute residuals using iterative weighted least squares (Andersen, 2008). The results displayed in the rows (3) in Table 3 underscore the fragility of the baseline results in Table 3 (rows (1)). For total exports, the estimated elasticity β remains around –0.7 in the two subsamples in that table. For manufacturing exports, the point estimate of β now rises in absolute value from –0.6 to –0.7, although this change is again within one standard error of the estimate.

A second dimension of robustness test performed to estimate (14) was to use the log of first-difference to calculate the growth rates of the variables, such as in (14), instead of percentage changes. Using percentage changes to calculate the growth rate of the variables introduces an asymmetry between increases and decreases—percentage increases are unbounded, whereas percentage decreases are bounded by -100 percent.

The results of estimating the reduced-form elasticity using this growth rate calculation are displayed in Rows (4) in Table 3. Using the log first difference approach noticeably reduces the estimated decline in β. For example, for total exports, the decline is now from –0.8 to –0.6 (instead of from –1.2 to –0.7). For manufacturing exports, the decline in the estimate of β is now from –0.8 to –0.7, which is within one standard error of the estimate. This finding relates to the role of outliers, since taking log differences dampens the role of extreme values. The log difference specification is standard and consistent with the assumed log-linear model specification, so we maintain it for the remaining robustness checks.

In line with (4) and (6) to deflate export values and obtain the export volumes in . The CPI reflects prices of many non-traded goods and services which do not relate to the cost structure of exports. Also, in the baseline specification of (14), the numerator of the REER variable on the right-hand side and in the denominator as the deflator of nominal exports on the left-hand side, implying a spurious strengthening of the negative co-movement between trade volumes and the (CPI-based) REER. This issue holds in general and particularly in the context of spikes in the CPI associated with high-inflation episodes.[47]

When we deflate total exports using the deflator for total exports of goods and services, and deflate goods and manufacturing exports using the deflator for goods exports from WEO, the absolute size of the estimates of β decline (Rows 5 of Table 3). This result reflects the

[47] More generally, the dynamics of export prices (especially of manufacturing goods) and the CPI are quite different. Even for an economy such as the United States with low inflation, the average difference in the growth rate of the CPI and the export deflator for goods over the period 1980-2014 is about 2.5 percentage points per year. So deflating exports with the CPI would imply a substantial difference in real export dynamics. A useful benchmark reference here is the OECD Economics Department working paper by Morin and Schwellnus 2014, which estimates trade elasticities based on export volumes for both AEs and EMDEs.

removal of the spurious correlation already mentioned. The estimated drop in β is also less apparent. For total exports, the elasticity estimate is now unchanged at –0.2 across the two time subsamples, while the point estimates of β for goods and manufacturing exports actually rise slightly (again within one standard error of the estimate).

We also conduct an additional robustness check, removing the initial domestic GDP control from (14). This has little effect on our finding that the drop in β over time is fragile. The conclusion is also not affected by expanding the sample from the 46 economies to the 88 economies included in Section II.D (see Table A3), or by expanding the time sample to span 1990-2014, instead of 1996-2012. Overall, the analysis in this section confirms the results of no disconnect over time for the trade elasticities at macro level even at its reduced-form.

Table B1. Elasticity of Total Exports to the Real Effective Exchange Rate: Robustness Analysis

Elasticity of Total Exports to the Real Effective Exchange Rate

	Full sample	1996–2003	2004–2012
(1) Baseline	-1.046***	-1.245***	-0.664***
(2) As (1) but inflation < 30%	-0.776***	-0.822***	-0.664***
(3) As (1) but without outliers (robust regression) 1/	-0.714***	-0.749***	-0.653***
(4) Log linear specification 2/	-0.734***	-0.780***	-0.633***
(5) As (4) but real exports defined using export prices (not CPI)	-0.180***	-0.196**	-0.174***
(6) As (5) but no domestic real GDP control	-0.177***	-0.186**	-0.176***

Elasticity of Goods Exports to the Real Effective Exchange Rate

	Full sample	1996–2003	2004–2012
(1) Baseline	-1.182***	-1.440***	-0.622***
(2) As (1) but inflation < 30%	-0.765***	-0.804***	-0.622***
(3) As (1) but without outliers (robust regression) 1/	-0.688***	-0.856***	-0.626***
(4) Log linear specification 2/	-0.814***	-0.861***	-0.674***
(5) As (4) but real exports defined using export prices (not CPI)	-0.157*	-0.146	-0.169***
(6) As (5) but no domestic real GDP control	-0.156**	-0.130	-0.192***

Elasticity of Manufacturing Exports to the Real Effective Exchange Rate

	Full sample	1996–2003	2004–2012
(1) Baseline	-1.081***	-1.294***	-0.592***
(2) As (1) but inflation < 30%	-0.671***	-0.651***	-0.592***
(3) As (1) but without outliers (robust regression) 1/	-0.691***	-0.592***	-0.653***
(4) Log linear specification /2	-0.746***	-0.765***	-0.663***
(5) As (4) but real exports defined using export prices (not CPI)	-0.0899	-0.0377	-0.166*
(6) As (5) but no domestic real GDP control	-0.0870	-0.0160	-0.191**

*p < 0.1; ** p < 0.05; *** p < 0.01.

1/ Robust regression downweights observations with larger absolute residuals using iterative weighted least squares (Andersen, 2008).

2/ Growth rates computed as log first differences.

C. Construction of the GEKS Indices

We construct country-sector level export and import price indexes for 18 tradable sectors using UN Comtrade data at the annual frequency. The 18 sectors are defined in the text. We adopt a method proposed by Ivancic et al. (2011), which is an adapted version of the multilateral GEKS approach. The GEKS index has two properties: (1) it makes maximum use of all possible matches between any two periods, and (2) it has no chain drift.

To construct a price index for sector i from the prices of products $n \in i$, for the period 0 to M, we construct a GEKS price index, denoted as $GEKS_{0,t}$, with $t \in \{0, \ldots, M\}$. Hereafter, without confusion, we omit i for simplicity. The construction consists of two steps. First, we obtain sector i -- GEKS price indexes for any two adjacent periods $\tau - 1$ and τ, denoted as $GEKS_{\tau-1,\tau}$. Second, we calculate $GEKS_{0,t}$ using all $GEKS_{\tau-1,\tau}$ for τ = 1, …, t.

The details are as follows: in the first step, $GEKS_{\tau-1,\tau}$ is the geometric average of the ratios of bilateral Fisher indexes (defined below):

$$(1) \qquad GEKS_{\tau-1,\tau} = \prod_{l=0}^{M} (P^F_{\tau-1,l}/P^F_{\tau,l})^{1/M} = \prod_{l=0}^{M} (P^F_{\tau-1,l} \cdot P^F_{l,\tau})^{1/M}$$

where M + 1 is the number of years, and $P^F_{\tau,l}$ denotes the Fisher index between period τ and l.

In the second step, the GEKS index between time 0 and time t is defined as

$$(2) \qquad GEKS_{0,t} = \prod_{\tau=1}^{t} (GEKS_{\tau-1,\tau})$$

To construct the bilateral Fisher indices, $P_{Fj,k}$ is defined as:

$$P^F_{j,k} = \sqrt{P^L_{j,k} * P^P_{j,k}}$$

$$P^L_{j,k} = \frac{\sum_n (P_{n,k} \cdot Q_{n,j})}{\sum_n (P_{n,j} \cdot Q_{n,j})}$$

$$P^P_{j,k} = \frac{\sum_n (P_{n,k} \cdot Q_{n,k})}{\sum_n (P_{n,j} \cdot Q_{n,k})}$$

where $P^L_{j,k}$ is the Laspeyres price index, and $P^P_{j,k}$ the Paasche price index of sector i. Accordingly, the summation in these indexes is carried over products in sector i, with $P_{n,t}$ indicating the price, and $Q_{n,t}$ the quatity of product n in year t. Products are defined at the HS 2002 6-digit level.