CHAPTER 3

# EXCHANGE RATES AND TRADE FLOWS: DISCONNECTED?

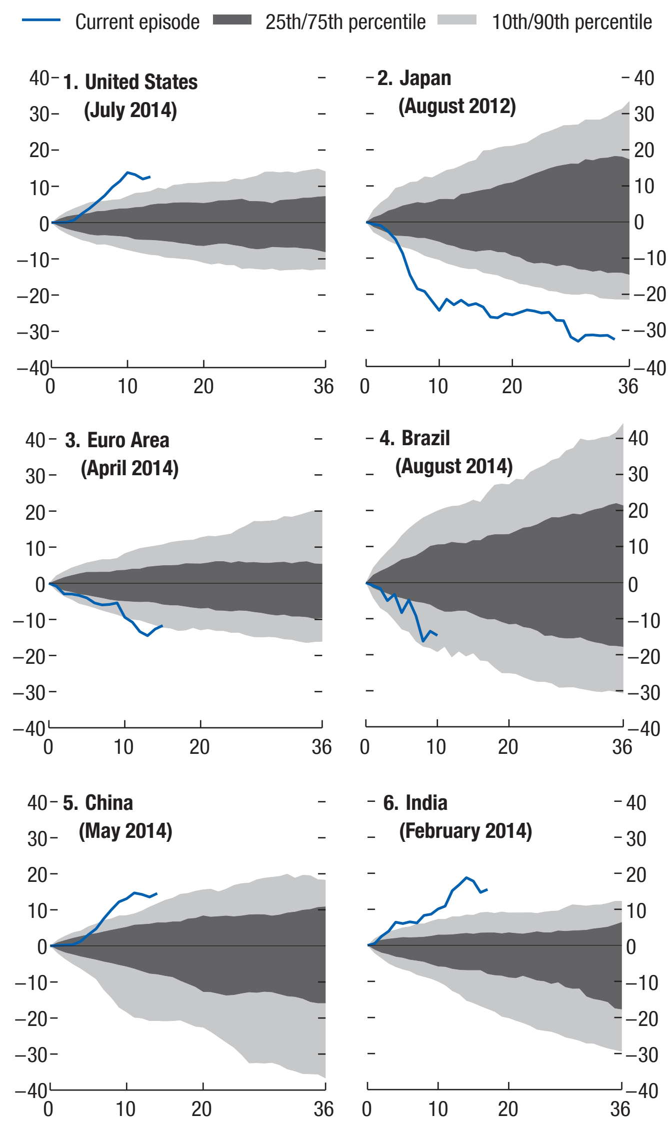
*Recent exchange rate movements have been unusually large, triggering a debate regarding their likely effects on trade. Historical experience in advanced and emerging market and developing economies suggests that exchange rate movements typically have sizable effects on export and import volumes. A 10 percent real effective depreciation in an economy's currency is associated with a rise in real net exports of, on average, 1.5 percent of GDP, with substantial cross-country variation around this average. Although these effects fully materialize over a number of years, much of the adjustment occurs in the first year. The boost to exports associated with currency depreciation is found to be largest in countries with initial economic slack and with domestic financial systems that are operating normally. Some evidence suggests that the rise of global value chains has weakened the relationship between exchange rates and trade in intermediate products used as inputs into other economies' exports. However, the bulk of global trade still consists of conventional trade, and there is little evidence of a general trend toward disconnect between exchange rates and total exports and imports.*

## Introduction

Recent exchange rate movements have been unusually large. The U.S. dollar has appreciated by more than 10 percent in real effective terms since mid-2014. The euro has depreciated by more than 10 percent since early 2014 and the yen by more than 30 percent since mid-2012 (Figure 3.1).[1] Such movements, although not unprecedented, are well outside these currencies' normal fluctuation ranges. Even for emerging market and developing economies, whose currencies typically fluctuate more than those of advanced economies, the recent movements have been unusually large.

**Figure 3.1. Recent Exchange Rate Movements in Historical Perspective**
*(Percent; months on x-axis)*

Major currencies have seen large movements in recent years in real effective terms that are unusual compared with historical experience.




Source: IMF, Information Notice System.
Note: Figure reports historical fluctuation bands for level of consumer price index–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.

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[1]Based on consumer price index–based real effective exchange rate data ending in June 2015.

There is little consensus, however, on the likely effects of these large exchange rate movements on trade—exports and imports—and, therefore, on economic activity. Some have predicted strong effects, based on conventional economic models (Krugman 2015, for example). Others have pointed to the limited changes in trade balances in some economies following recent exchange rate movements—in Japan, in particular—implying an apparent disconnect between exchange rates and trade. It has also been suggested that the increasing participation of firms in global value chains has reduced the relevance of exchange rate movements for trade flows, as in recent studies conducted at the Organisation for Economic Co-operation and Development (Ollivaud, Rusticelli, and Schwellnus 2015) and the World Bank (Ahmed, Appendino, and Ruta 2015).[2]

This is not the first time that the conventional wisdom regarding the link between exchange rates and trade has been questioned. In the late 1980s, for example, the U.S. dollar depreciated, and the yen appreciated sharply after the 1985 Plaza Accord, but trade volumes were slow to adjust, leading some commentators to suggest a disconnect between exchange rates and trade. By the early 1990s, however, U.S. and Japanese trade balances had adjusted, after some lags, largely in line with the predictions of conventional models.[3] A key question is whether this time is different, reflecting the changing structure of world trade since the 1990s, or whether, once lags have played out, the apparent disconnect between exchange rates and trade will once again dissipate.

A disconnect between exchange rates and trade would have profound policy implications. It could, in particular, weaken a key channel for the transmission of monetary policy by reducing the boost to exports that comes with exchange rate depreciation when monetary policy eases. It could also complicate the resolution of trade imbalances (that is, when exports exceed imports, or vice versa) via the adjustment of relative trade prices.

To contribute to the debate on the likely effects of recent currency movements and to assess whether trade flows are becoming disconnected from exchange rates, this chapter focuses on the following questions:

- Based on historical experience, how does trade typically evolve following real exchange rate movements? In particular, to what extent do exchange rate changes pass through to the relative prices of exports and imports, and how strongly do trade flows respond following these trade price changes? How quickly do the adjustments occur?
- Is there evidence of a disconnect between exchange rates and trade over time? In particular, has the changing structure of global trade, with increasing participation in global value chains, weakened the relationship between exchange rates and trade? Have either the long-term effects or the speed of transmission of exchange rate movements declined over time, making them less relevant for overall trade?

To address these questions, the chapter starts by investigating the relationship between exchange rate changes and trade in advanced and emerging market and developing economies over the past three decades. The growing importance of emerging market and developing economies in world trade warrants this broad coverage, which goes beyond the group of economies typically examined in related studies.[4] The approach employs both standard trade equations and an analysis of historical cases of large exchange rate movements. The chapter then assesses whether the rise of global value chains, also referred to as the international fragmentation of production, has weakened the link between exchange rates and trade. Finally, it investigates more generally whether there is evidence of disconnect over time by estimating the relationship between exchange rates and trade in different historical periods.

The analysis focuses narrowly on the direct effect of exchange rate changes on trade. Although the trade channel is a critical channel for the transmission of exchange rate changes to an economy, this partial equilibrium focus on direct effects has limitations. By definition, it ignores the general equilibrium effects of exchange rate changes on overall economic activity, which involve not just the effects on trade, but also those operating through other variables, including inflation expectations, interest rates, and domes-

[2]As explained in the discussion that follows, during the past several decades, international trade has increasingly been organized within so-called global value chains, with different stages of production located across different economies.

[3]See Krugman 1991 for a discussion of this episode.

[4]Much of the related literature focuses on advanced economies, with a number of exceptions, including Bussière, Delle Chiaie, and Peltonen 2014, which estimates trade price equations for 40 economies, and Morin and Schwellnus 2014.

tic demand.[5] Through the effects on these variables, trade is also affected indirectly. The narrow focus also abstracts from the fact that the underlying drivers of an exchange rate change also matter for trade and economic activity outcomes. The main reason that these outcomes can differ is that the indirect effects of exchange rate changes can differ, depending on the driver. Consider, for example, the exchange rate changes during the past year or so. As discussed in the April 2015 *World Economic Outlook* (WEO), these changes have been partly driven by surprises in the relative strength of domestic demand, with countries with stronger domestic demand experiencing appreciation. Compare this with another example, in which the exchange rate change is not driven by domestic demand, but reflects an unexpected shift in investor preferences for U.S.-dollar-denominated assets. The behavior of domestic demand in the two examples would clearly be different, with implications for the overall outcome for trade.

The chapter's main findings are as follows:

- Trade tends to respond strongly to exchange rate movements. A depreciation in an economy's currency is typically associated with lower export prices paid by foreigners and higher domestic import prices, and these price changes, in turn, lead to a rise in exports and a decline in imports.[6] Reflecting these channels, a 10 percent real effective exchange rate depreciation implies, on average, a 1.5 percent of GDP increase in real net exports. The figures around this average response vary widely across economies (from 0.5 percent to 3.1 percent). It takes a number of years for the effects to fully materialize, but much of the adjustment occurs in the first year. The export increase associated with currency depreciation is typically stronger when the domestic economy is experiencing more slack, but weaker when a country's financial system is weak, as in the context of a banking crisis.
- The rise of global value chains has weakened the relationship between exchange rates and trade for some economies and products, but little evidence shows that it has led to a disconnect between exchange rates and trade in general. In particular, for economies that have become more deeply involved in global value chains, trade in intermediate products used as inputs into other economies' exports has become less responsive to exchange rate changes. However, the relative pace of expansion of global-value-chain-related trade has decelerated in recent years, and the bulk of global trade still consists of conventional trade.
- More generally, the notion of a disconnect between exchange rates, trade prices, and gross export and import volumes finds little support in the data. The estimated links have not generally weakened over time. A key exception to this pattern is Japan, which displays some evidence of disconnect, with weaker-than-expected export growth despite substantial exchange rate depreciation, although this weak export growth reflects a number of Japan-specific factors.[7]

## From Exchange Rates to Trade: Historical Evidence

A natural benchmark for assessing the implications of recent exchange rate movements is the historical relationship between exchange rates and trade. Standard theoretical models predict that currency depreciation will reduce the prices of exports in foreign currency and increase the prices of imports in domestic currency, which will lead to more exports and less imports.[8] These theoretical predictions guide the statistical analysis in this chapter.

This section starts by examining the historical evidence on the connection between exchange rates, trade prices, and trade volumes for a large group of economies. It estimates export and import price and volume equations for 60 individual economies—23 advanced and 37 emerging market and developing economies—for the past three decades. This is a broader sample of economies than is typically covered in related studies.[9]

[5]For an example of a general equilibrium assessment of the effects of exchange rate movements, see Scenario Box 2 in the April 2015 *World Economic Outlook*, which uses the IMF's G20 Model to explore the potential macroeconomic impact of real exchange rate changes from August 2014 to February 2015 based on shocks that represent changes in investor preferences for U.S.-dollar-denominated assets.

[6]There is little evidence of asymmetry—exchange rate appreciations and depreciations tend to have opposite effects, but of a similar absolute size.

[7]These factors include, in particular, the acceleration in production offshoring since the global financial crisis and the 2011 earthquake.

[8]The response of trade volumes to relative trade prices relates to the expenditure-switching effect discussed, for example, in Obstfeld and Rogoff 2007.

[9]Related studies also tend to focus on either the effect of exchange rates on relative trade prices or the effect of relative trade prices on volumes. In contrast, the analysis here focuses on both parts of the

To contribute more directly to the debate on the recent large exchange rate changes, the section also presents evidence on trade dynamics following unusually large exchange rate movements. The focus is on the evolution of export prices and volumes following large and sudden currency depreciations in both advanced and emerging market and developing economies.

## Revisiting Trade Elasticities

To inform the assessment of the likely impact of the recent large exchange rate movements on trade, this subsection estimates standard trade elasticities (that is, how responsive trade variables are to changes in other variables) for both advanced and emerging market and developing economies. In particular, it focuses on estimating four elasticities: the relationship between exchange rate movements and export and import prices, respectively (exchange rate pass-through), and the relationship between these export and import prices and trade volumes (price elasticity), based on standard trade equations. The emphasis is on long-term effects of exchange rate movements, although the discussion also touches on how much of these long-term effects materialize in the near term.

The theoretical framework underlying the analysis comes from the pricing-to-market literature, as described in Krugman 1986, Feenstra, Gagnon, and Knetter 1996, Campa and Goldberg 2005, Burstein and Gopinath 2014, and others. In this framework, exporting firms maximize profits by choosing export prices subject to the demand for their products in foreign markets, taking into account their competitors' prices.[10] Product demand depends on the prices of exports relative to the prices of competing products as well as on overall demand 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 multiplied by the bilateral exchange rate.[11]

The analysis estimates the four trade elasticities at the individual-economy level using annual data for 60 economies. Depending on data availability and the economy in question, the sample starts between 1980 and 1989 and ends in 2014. To permit the long-term relationship between exchange rate changes and trade to be estimated, the sample is restricted to economies for which at least 25 years of annual data are available.[12] The analysis focuses on gross exports and imports, which include both goods and services (Annex 3.1 reports the sources of the data used). The econometric specifications employed are standard and yield estimates of the relationship between exchange rates and trade prices and between trade prices and trade volumes.[13]

exchange rate transmission process, thus providing a more comprehensive assessment.

[10]This literature assumes market segmentation between domestic and foreign purchasers.

[11]In this framework, the export price equation reflects optimal pricing decisions of suppliers and can be written as $eP^X/P^* = S(ULC/P, eP/P^*)$, in which $e$ is the nominal exchange rate, $P^X$ is the price of exports in domestic currency, $P^*$ is the foreign price level, $P$ is the domestic price level, $ULC/P$ denotes the real unit labor cost, and $eP/P^*$ denotes the real effective exchange rate. The export volume equation represents the demand side of the market and can be written as $X = D(eP^X/P^*, Y^*)$, in which $eP^X/P^*$ is the relative export price in foreign currency already mentioned and $Y^*$ denotes foreign aggregate demand. On the import side, the relative prices of imports are a function of the real exchange rate and domestic aggregate demand, $P^M/P = S(eP^*/P, Y)$, in which $Y$ denotes domestic aggregate demand, and import volumes are a function of this relative price and domestic aggregate demand, $M = D(P^M/P, Y)$.

[12]The sample excludes a number of advanced economies with special circumstances, including Hong Kong SAR and Singapore, given these economies' significant entrepôt activity, and Ireland, given its special treatment of export sales (April 2015 WEO). To avoid unduly influencing the estimation results with developments in small or very low-income economies, it also 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.

[13]The analysis is based on log-linear specifications for the four trade equations. For each equation, the analysis checks whether the variables included are cointegrated based on a Dickey-Fuller test, in which case the equations are estimated in levels. For example, for export prices, the specification estimated in levels for each economy is

$$\ln\left(\frac{eP^X}{P^*}\right)_t = \alpha + \beta \ln\left(\frac{eP}{P^*}\right)_t + \gamma \ln\left(\frac{ULC}{P}\right)_t + \varepsilon_t,$$

in which the subscript $t$ denotes the $t$th year; $\left(\frac{eP^X}{P^*}\right)$ denotes the relative price of exports in foreign currency ($e$ is the nominal effective exchange rate; $P^X$ is the price of exports in domestic currency; and $P^*$ is the foreign, trade-weighted producer price index [PPI]); and $\left(\frac{eP}{P^*}\right)$ is the PPI-based real effective exchange rate. The PPI represents the relative price of goods and services produced at home and abroad more precisely than does the consumer price index (CPI). Nevertheless, as reported later, the results are similar when all the

A number of issues complicate the estimation of trade elasticities and can bias the analysis against finding any effect of exchange rate movements on trade. Different economic developments can lead to different joint evolutions of trade prices and quantities, complicating the estimation of the causal effects of trade prices on quantities. The main potential source of this simultaneity problem is the movement in either domestic or foreign demand. For example, a contraction in foreign demand can cause a simultaneous decline in both the quantity and the price of exports, obscuring the conventional positive effect of a drop in export prices on export demand. And when domestic demand growth is weak, reducing imports, the price of imports may also fall, obscuring the positive effect of lower import prices on imports. The analysis addresses this source of endogeneity by controlling for foreign and domestic output.[14] This leaves shifts in the composition of demand or in the propensity to import for a given composition of demand. The analysis attempts to control for shifts in composition by including nonexports and exports together in the import equation, but controlling for shifts in import propensities is challenging. Overall, because of these remaining sources of bias, weak or perversely signed estimation results could still arise, although they do not necessarily imply that trade is unresponsive to changes in trade prices.[15]

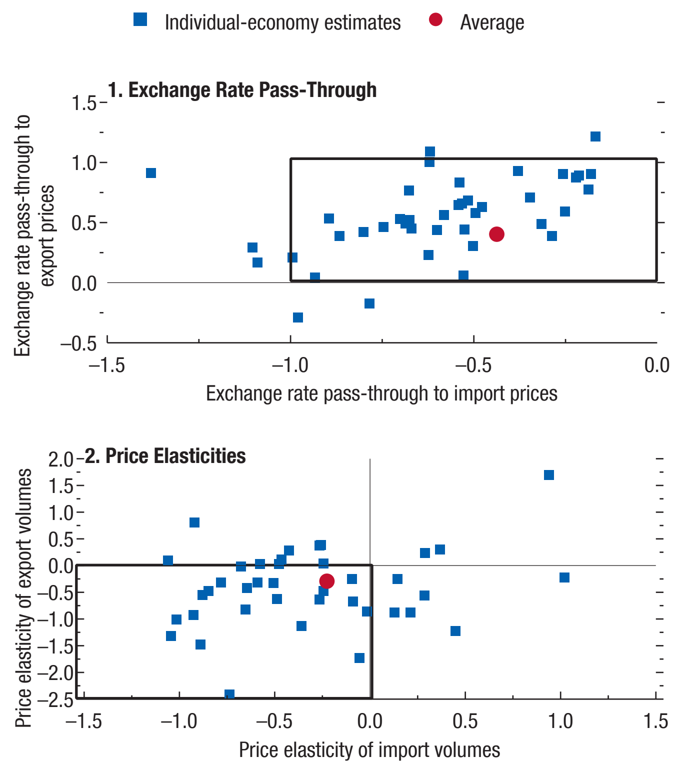
*P* and *P** terms in the equation are replaced with the domestic and foreign CPI. The estimate for β provides the long-term effect of the exchange rate on export prices. Short-term effects are obtained by estimating, in a second step, the equation in error correction form, as explained in Annex 3.2. The equations for estimating the other elasticities are set up analogously, as also explained in Annex 3.2.

[14]Moreover, all equations also include a time trend to account for secular trends in the variables and a dummy variable (which equals 1 during 2008–09) to account for the global financial crisis and the interaction of this crisis dummy with the measure of foreign output in the export volume equation and with the measure of domestic output in the import volume equation, respectively. These interaction terms address the notion that trade responded unusually strongly to demand during the crisis (see, for example, Bussière and others 2013). In addition, to control for shifts in global commodity prices, which can affect exporting firms' costs, the equations for export and import prices control for the (log) indices of international fuel and nonfuel commodity prices. To ensure the results are not driven by periods of high inflation (such episodes can be caused by factors that have an independent effect on trade), the sample excludes years in which CPI inflation exceeds 30 percent. As a further precaution against outliers, observations with Cook's distance greater than $4/N$, where $N$ is the sample size, are discarded.

[15]A large literature that goes back to Orcutt (1950) explains how simultaneity and omitted-variable issues can lead to considerable underestimation of trade price elasticities. Another issue that biases the analysis against finding a strong effect of trade price changes on trade is that of heterogeneous elasticities across different goods. Different goods have different price elasticities, but movements in aggregate trade prices may be dominated by movements in the relative prices of price-inelastic goods. This dominance would dampen estimated price effects on trade flows. In fact, micro-level estimates of trade elasticities tend to be somewhat larger than those based on aggregate data, as discussed by Feenstra and others (2014) and Imbs and Mejean (2015).

**Figure 3.2. Long-Term Exchange Rate Pass-Through and Price Elasticities**

The estimated effects of exchange rate movements on trade prices and volumes have the expected sign for most of the economies considered.




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.

## *Results: From Exchange Rates to Trade Prices*

The analysis suggests that exchange rate movements typically have substantial effects on trade prices, with the estimates of long-term pass-through elasticities having the expected sign for virtually all the economies considered (Figure 3.2). The estimates of exchange rate pass-through typically lie, as would be expected, in the 0–1 interval. The results imply that, on average, a 10 percent real effective currency depreciation increases import prices by 6.1 percent and reduces export prices

**Table 3.1. 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* | | | | | |
| Noncommodity 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.

in foreign currency by 5.5 percent (Table 3.1).[16] The estimation results are broadly in line with existing studies for major economies.[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). The results also indicate that most of the long-term effects on trade prices materialize within one year.[18]

[16]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)).

[17]For example, the results are strongly correlated with those reported in a recent study by Bussière, Delle Chiaie, and Peltonen (2014), who report pass-through elasticities for 40 economies (Annex Figure 3.2.1).

[18]The estimates of pass-through to trade prices also have implications for the estimated effect of a change in the exchange rate on the terms of trade (the price of exports relative to imports), which have implications for domestic demand. The baseline long-term pass-through estimates reported in Table 3.1 are 0.55 for export prices in foreign currency and –0.61 for import prices in domestic currency. So a 1 percent appreciation in a country's currency lowers the domestic prices of its imports by 0.61 percent and raises the foreign-currency price of exports by 0.55 percent. This means that the domestic-currency price of exports falls by 0.45 percent (0.55 – 1) and the terms of trade improve by 0.16 percent (–0.45 – (–0.61)) following a 1 percent appreciation. This is well below the full pass-through case in which a 1 percent appreciation translates into a 1 percent improvement in the terms of trade.

### *Results: From Trade Prices to Trade Volumes*

The analysis suggests that trade price movements typically have the expected effects on export and import volumes, with most individual-economy estimates having the conventional (negative) sign (Figure 3.2, panel 2). On average, the estimated price elasticities of volumes suggest that a 10 percent rise in export and import prices reduces the level of both export and import volumes by about 3 percent in the long term (Table 3.1). The results also indicate that most of the long-term effects on trade volumes materialize within one year.

At the same time, numerous individual-economy estimates have counterintuitive (positive) signs. Given the challenges already mentioned of identifying the effects of trade prices on volumes, these exceptions are not surprising, and the true effects are likely to be stronger than suggested by the cross-country averages reported in Table 3.1. Also, the sample includes a range of economies, including some for whom fuel and nonfuel primary products constitute the main source of export earnings (exceeding 50 percent of total exports). To investigate whether these primary-product exporters have a strong influence on the estimation results, the analysis is repeated while excluding them from the sample. The results are similar to the baseline, suggesting that these economies are not driving the results (Table 3.1).

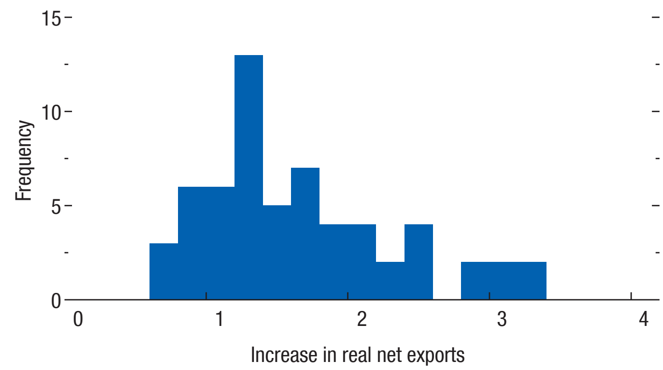
Meanwhile, the effects of shifts in foreign and domestic aggregate demand on export and import volumes have the expected positive sign for all economies in the sample (Annex Figure 3.2.2). On average, a 1 percent increase in trading-partner aggregate demand is associated with a 2.3 percent increase in exports. A 1 percent increase in domestic aggregate demand is associated with a 1.4 percent increase in imports.[19] These results confirm that shifts in relative demand have a strong bearing on trade, a link that has featured prominently in the policy debate on the postcrisis decline in global trade.[20]

### *Overall Effect on Net Exports*

What do the estimates for price and volume elasticities imply for the overall effect of exchange rate movements on net exports? To answer this question, the analysis combines the average estimates for the four elasticities reported in Table 3.1, which are more reliable than the individual-economy estimates, with economy-specific shares of imports and exports in real GDP.[21] The results suggest that a 10 percent real effective depreciation in an economy's currency is associated with a rise in real net exports of, on average, 1.5 percent of GDP, with substantial cross-country variation around this average (Figure 3.3). Given the wide range of GDP shares of exports and imports across economies, this implied effect of a real effective depreciation of 10 percent ranges from 0.5 percent of GDP to 3.1 percent of GDP. Although it takes a number of years for these effects to fully materialize, much of the adjustment occurs in the first year, as mentioned.[22]

**Figure 3.3. Effect of a 10 Percent Real Effective Depreciation on Real Net Exports**
*(Percent of GDP)*

A 10 percent real effective depreciation in an economy's currency is associated with a rise in real net exports of, on average, 1.5 percent of GDP, with substantial cross-country variation around this average.




Source: IMF staff calculations.
Note: Figure shows long-term effect on level of real net exports in percent of GDP based on country-specific import- and export-to-GDP ratios and the average producer price index–based trade elasticities reported in Table 3.1 for the 60 economies in the sample.

## Insights from Large Exchange Rate Depreciation Episodes

To contribute more directly to the debate about the effects of the recent large exchange rate changes, this subsection presents evidence of the effects of large and sudden depreciations. In a number of cases, these episodes coincide with currency crisis episodes identified in the literature. A study of trade dynamics following such relatively extreme events allows the analysis to provide better estimates of export elasticities. (The exercise is less able to identify import elasticities because various domestic developments that affect imports coincide with large exchange rate depreciations.) The analysis focuses on large exchange rate depreciation episodes not associated with banking crises, given that such crises can have additional confounding effects on trade. Overall, large exchange rate depreciation episodes are likely to include a larger exogenous component than more normal exchange rate

[19]As mentioned, the equation estimated for import volumes decomposes the effects of aggregate demand into exports and domestic demand for domestic goods. The estimated elasticities for these two components of aggregate demand are both 0.7, consistent with a combined aggregate demand elasticity of 1.4.

[20]For a broader discussion of the role of foreign and domestic output in driving trade, including during the postcrisis decline in global trade, see Chapter 4 of the October 2010 WEO and Hoekman 2015.

[21]The effect of a real exchange rate movement on real net exports as a percentage of GDP is defined as $\eta P^X \eta^X (X/Y) - \eta P^M \eta^M (M/Y)$, in which $\eta P^X$ and $\eta^X$ denote the exchange rate pass-through to export prices and the price elasticity of exports, respectively, and $\eta P^M$ and $\eta^M$ denote the exchange rate pass-through to import prices and the price elasticity of imports, respectively. Given the focus on the effects of exchange rate movements since 2012, the shares of exports and imports in GDP ($X/Y$ and $M/Y$, respectively) as of 2012 are used in the calculation. Combining the estimates in the first row of Table 3.1 with the sample averages for exports and imports in percent of GDP as of 2012 (42 and 41 percent of GDP, respectively) yields an estimated rise in net exports of 1.47 percent of GDP following a real effective depreciation of 10 percent.

[22]Similarly, the estimates indicate that the Marshall-Lerner condition holds, so that a currency depreciation improves the nominal trade balance. Note that, in the presence of imperfect pass-through, the Marshall-Lerner condition is ($-ERPT$ of $P^X$) (1 + price elasticity of $X$) + ($ERPT$ of $P^M$) (1 + price elasticity of $M$) + 1 > 0, in which $ERPT$ denotes exchange rate pass-through, as explained in Annex 3.3. The Marshall-Lerner condition computed here is based on the cross-country average of estimates reported in Table 3.1. The condition also holds for much—though not all—of the sample, when individual-economy elasticity estimates, rather than the sample averages, are used in the calculation.

fluctuations and are more appropriate for estimating the relationship between exchange rates and trade.[23]

### *Identifying Large Exchange Rate Depreciation Episodes*

The analysis identifies large exchange rate depreciation episodes using a statistical approach similar to those employed in the literature. The approach is based on two criteria. The first criterion identifies a large depreciation as an unusually sharp nominal depreciation of the currency against the U.S. dollar. This identification approach is based on a numerical threshold set at the 90th percentile of all annual depreciations in the sample.[24] 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 emerging market and developing economies than in advanced economies, both thresholds are defined separately for the two groups of economies. For the first criterion, the threshold for advanced economies is a depreciation of 13 percent against the dollar, whereas for emerging market and developing economies, the threshold is 20 percent. For the second criterion, both thresholds are about 13 percentage points.

To ensure that the results are not unduly influenced by high-inflation episodes, the analysis considers only large exchange rate depreciations that occur when the inflation rate is less than 30 percent. 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 Laeven and Valencia's (2013) data set are discarded. The effects of large depreciations associated with banking crises are considered separately later in the chapter.

[23]Although this episode-based approach addresses some of the problems associated with the conventional 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.

[24]This approach of identifying large exchange rate depreciation episodes based on statistical thresholds is similar to that of Laeven and Valencia (2013), who in turn build on the approach of Frankel and Rose (1996).

Applying this strategy to all economies that have data on export volumes and prices during 1980–2014 yields 66 large exchange rate depreciation episodes.[25] As reported in Annex Table 3.4.1, about one-quarter (17) of these large exchange rate depreciations occurred in advanced economies. They include, for example, European economies affected by the 1992 European Exchange Rate Mechanism crisis. The remaining episodes occurred in emerging market and developing economies and include, for example, the devaluation of the Chinese yuan in 1994 and the large depreciation of the Venezuelan bolívar in 2002.[26]

### *What Happens to Exports after a Large Exchange Rate Depreciation?*

Now that large exchange rate depreciation episodes have been identified, this subsection uses statistical techniques to assess the relationship between exchange rates and export prices and export volumes. The methodology is standard and follows Cerra and Saxena 2008 and Romer and Romer 2010, among others. In particular, the average responses of export prices and export volumes to a large depreciation are estimated separately using panel data analysis.[27]

[25]For the purpose of the panel estimation conducted in this subsection, the sample includes all economies that have data on export volumes and prices during 1980–2014. Thus, 158 economies are included in the sample. For a number of the 158 economies, no large exchange rate depreciation episodes are identified, and the data for these economies serve to estimate the dynamic structure of the equations. Note that, in contrast, for the individual-economy estimates reported earlier in the chapter, the sample includes only the 60 economies with at least 25 years of data on relative trade prices and volumes.

[26]A number of well-known large exchange rate depreciation episodes were associated with banking crises and are therefore not included in the baseline sample for analysis, for example, Mexico in 1994, Russia in 1998, Argentina in 2002, and Finland and Sweden in the early 1990s.

[27]The estimated equation makes use of an autoregressive distributed lags 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 on the left-hand side. On the right-hand side, 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 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 that of normal dynamics. The equation estimated for export prices is

$$y_{it} = \alpha + \Sigma_{j=1}^{2} \beta_j y_{i,t-j} + \Sigma_{s=0}^{2} \beta_s S_{i,t-s} + \mu_i + \lambda_t + \upsilon_{it},$$

in which the subscript $i$ denotes the $i$th country and the subscript $t$ denotes the $t$th year; $y$ is the log change in export prices in foreign

The results suggest that large depreciations substantially boost exports. By definition, the episodes studied are associated with large depreciations, and the results indicate that these depreciations average 25 percent in real effective terms over five years (Figure 3.4). Export prices in foreign currency fall by about 10 percent, with much of the adjustment occurring in the first year. The implied pass-through elasticity of export prices relative to the real exchange rate is thus about 0.4, similar to the estimate based on trade equations already noted.

Export volumes rise more gradually, by about 10 percent over five years.[28] This response indicates an average price elasticity of exports of about –0.7, which is stronger than the elasticity of –0.3 estimated using the traditional trade equations discussed earlier. This stronger estimated price elasticity could reflect the clearer identification strategy based on large exchange rate depreciation episodes. All the results are statistically significant at conventional levels.[29]

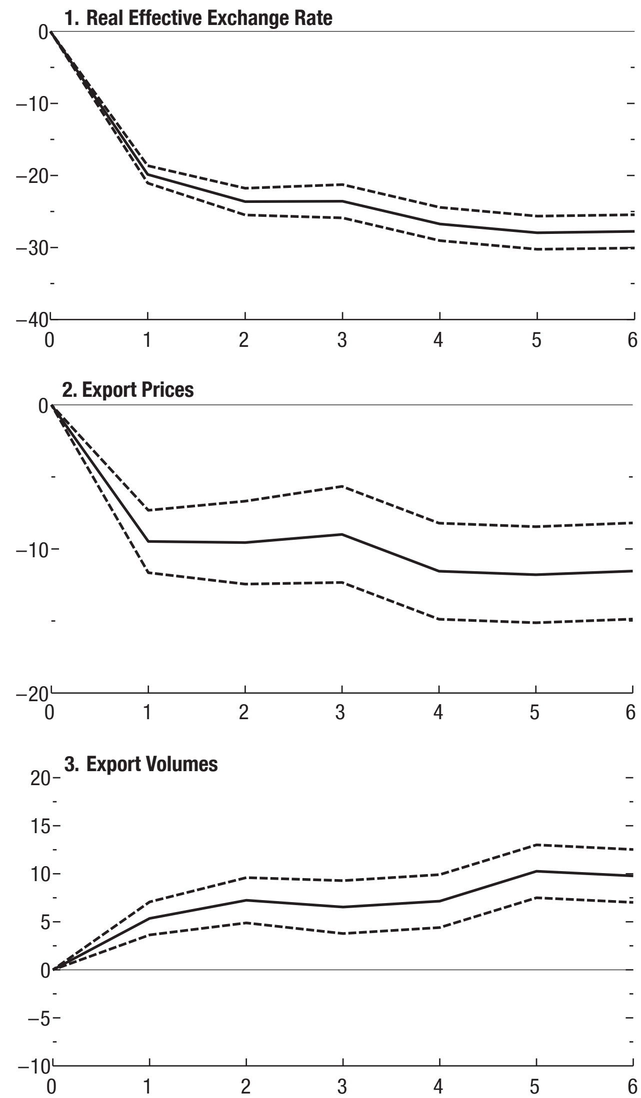
### *Do Initial Economic Conditions Matter?*

Do export dynamics following large depreciations differ depending on initial economic conditions? When there is more economic slack and a greater degree of spare capacity in the economy, there could be more scope 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 from nontraded into traded goods production. Economies may vary in the speed of their ability to reallocate resources in this way, although this issue would be less salient in the presence of economic slack.

To investigate this possibility, the analysis divides the 66 identified episodes of depreciation in half according to the degree of economic slack in the year preceding

**Figure 3.4. Export Dynamics Following Large Exchange Rate Depreciations**
*(Percent; years on x-axis)*

Large exchange rate depreciations are associated with a substantial decline in export prices in foreign currency and a rise in export volumes.




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

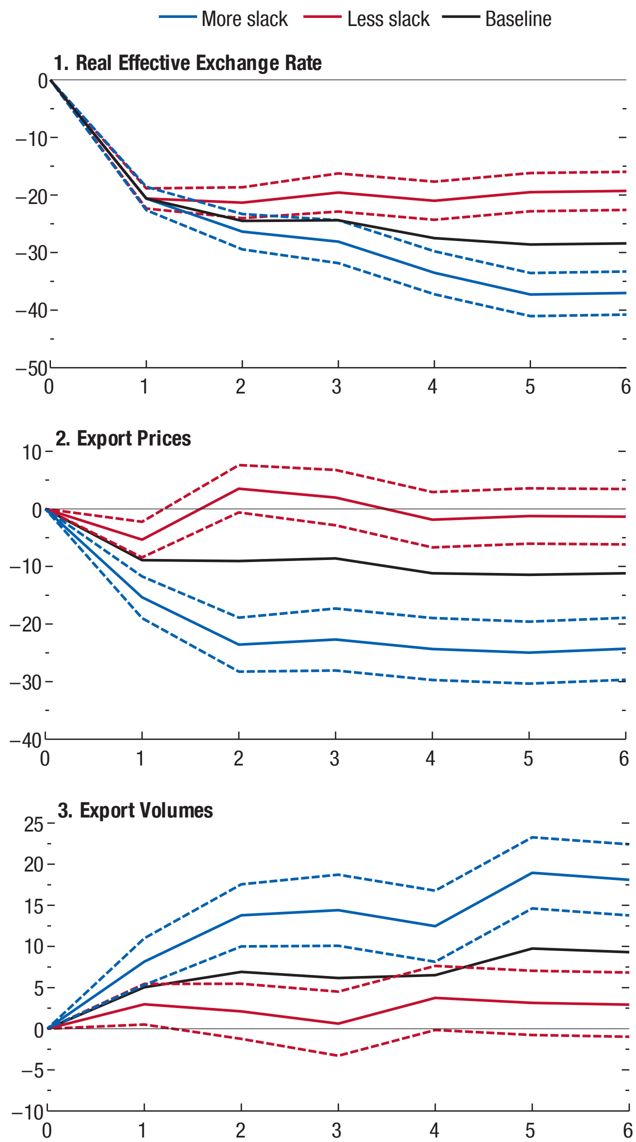
currency, $y = \Delta \ln\left(\frac{eP^X}{P^*}\right)$, in which $P^*$ is the foreign (trade-weighted) consumer price index; and $S$ is the dummy variable indicating the occurrence of a large depreciation. The approach includes a full set of country dummies ($\mu_i$) to take into account differences in countries' normal growth rates. The estimated equation also includes a full set of time dummies ($\lambda_t$) to take into account global shocks such as shifts in oil prices or global business cycles. For the real effective exchange rate (*REER*) and for export volumes, the dependent variable is replaced with $y = \Delta \ln(REER)$ and $y = \Delta \ln(X)$, respectively. For the study of export volumes, the analysis also controls for changes in foreign demand, proxied by trading-partner GDP growth.

[28]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.

[29]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, as explained in Annex 3.4.

**Figure 3.5. Export Dynamics Following Large Exchange Rate Depreciations: The Role of Initial Economic Slack**
*(Percent; years on x-axis)*

The export increase associated with large currency depreciations is typically stronger when there is more economic slack in the domestic economy.




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

the exchange rate depreciation.[30] The results suggest that, for the subsample of episodes with less economic slack, the impact of the depreciation on exports is still positive but close to zero (Figure 3.5).[31] By contrast, for the subsample with more 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). While this result is not surprising from an analytical 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 baseline, arguably providing exporters with stronger incentives to cut export prices than in the baseline.

### *Is the Behavior of Exports Different after Large Depreciations Associated with Banking Crises?*

Does 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 expand export production.[32] This drop in credit availability could offset the export gains due to the currency depreciation.

To shed light on this question, the analysis in this subsection focuses on large exchange rate depreciation episodes associated with banking crises. In particular, it applies the same criteria used in the previous subsections, identifying 57 episodes in which a

[30]The degree of economic slack is defined here based on real GDP growth in the year preceding the episode of large exchange rate depreciation, as explained in Annex 3.4. 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.

[31]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. Such rescaling is performed in all later comparisons of large exchange rate depreciation episodes.

[32]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 Chapter 4 of the October 2010 WEO.

banking crisis (again, based on the data set of Laeven and Valencia 2013) occurred in the three-year period before or after the large exchange rate depreciation (see Annex Table 3.4.2). By definition, these 57 episodes are not the same set as those included in the baseline analysis. They 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.

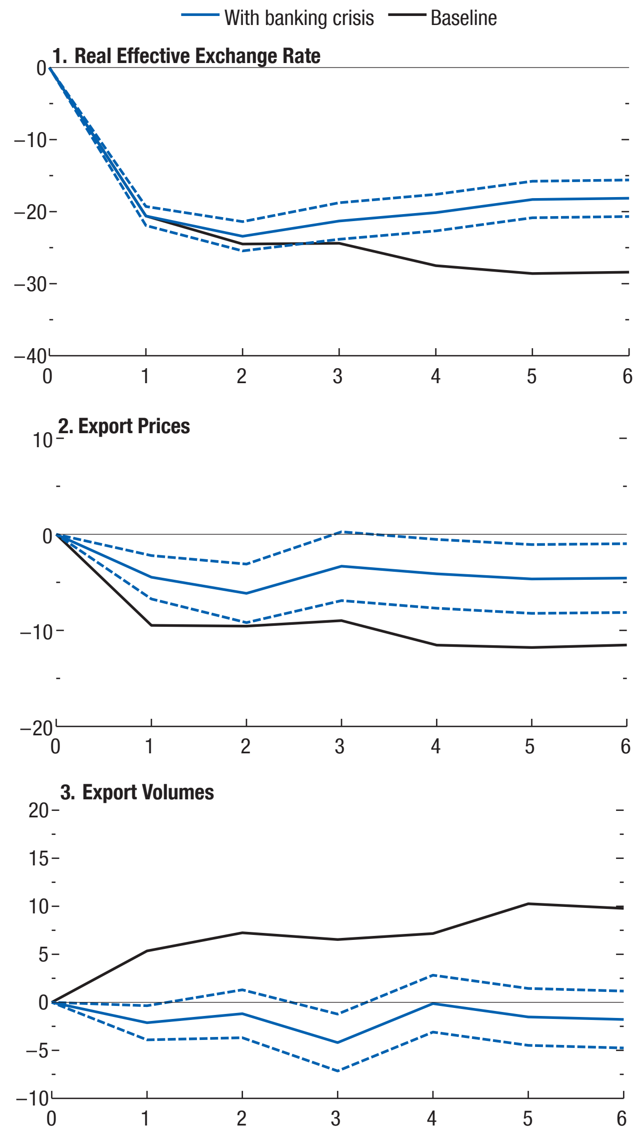
The results suggest that the boost to exports is indeed weaker when an exchange rate depreciation is associated with a banking crisis (Figure 3.6). In particular, export prices decline by less, suggesting an average elasticity of export prices to the real effective exchange rate of 0.25, about half that observed in the baseline case. The response of real exports is near zero. These results are consistent with the view that the credit constraint 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.[33]

At the same time, banking crises result in a wide range of outcomes, as discussed in the literature (see Chapter 4 of the October 2009 WEO, for example). For a number of the episodes associated with banking crises analyzed here, exports outperformed the near-zero average effect—for example, for the large depreciations of Argentina (2002), Brazil (1999), Russia (1998), and Sweden (1993), for which the estimated effect on exports is positive.[34]

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.

**Figure 3.6. Export Dynamics Following Large Exchange Rate Depreciations Associated with Banking Crises**
*(Percent; years on x-axis)*

The export increase associated with a large currency depreciation is typically smaller when a country's financial system is weak, as in the context of a banking crisis.




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

[33]These results are robust to controlling for the occurrence of banking crises in trading partners in the estimated equations.

[34]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.

## Disconnect or Stability?

The analysis so far has assumed that the historical relationship between exchange rates and trade has been stable over time and thus provides an appropriate benchmark for assessing the implications of the recent exchange rate movements. This section investigates whether this assumption is warranted or whether trade and exchange rates have become disconnected. It starts by investigating the role of the rise of global value chains, with the associated international fragmentation of production, in reducing the links between exchange rates and trade—an issue that has featured prominently in the recent policy debate on disconnect. It then investigates more generally whether the relationship between exchange rates and trade flows—either measured using the traditional trade equations or based on large exchange rate depreciation episodes—has weakened.

### Disconnect and the Rise of Global Value Chains

Gross trade flows can be decomposed into trade related to global value chains (trade in intermediate goods that serve as inputs into other economies' exports) and other trade. This section begins with a brief overview of the rise of global value chains during the past several decades. Then it explains why trade related to global value chains could respond more weakly than traditional trade to exchange rate changes and assesses the evidence.[35]

#### *The Rise of Global Value Chains*

During the past several decades, international trade has been increasingly organized within so-called global value chains, with different stages of production distributed across different economies. Production fragmentation has grown as economies increasingly specialize in adding value at some stage of production rather than producing entire final products. Exports of domestic value added have gradually declined as a fraction of gross exports, while the share of exports consisting of imported intermediate products, that is, foreign value added, has increased. At the same time, the share of intermediate goods in total exports is rising, while the share of final products is declining. As a result, export competitiveness is determined not only by the exchange rate and price level of the export destination economy, but also by the exchange rate and price level of the economy at the end of the production chain.

Participation in global value chains is measured along two dimensions: backward (import) links with previous production stages and forward (export) links with subsequent production stages.

- *Backward participation*. As global value chains have become more prevalent, the share of gross exports consisting of inputs imported from abroad has increased. Hence, the share of foreign value added 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 (Figure 3.7). However, for some economies, such as Hungary, Romania, Mexico, Thailand, and Ireland, the increase has been greater than 20 percentage points, substantially larger than the cross-country average. Some evidence indicates that the rise of global value chains measured along this dimension has slowed in recent years. Indeed, Constantinescu, Mattoo, and Ruta (2015) find that the slower pace of global value chain expansion has contributed to the global trade slowdown observed since the global financial crisis.
- *Forward participation*. With the rise of global value chains, the share of exports consisting of intermediate inputs used by trading partners for production of their exports has increased. The share has increased gradually, to 24 percent from 20 percent of gross exports, on average, during the period 1995–2009 (Figure 3.7). Russia, Chile, Indonesia, Japan, and Korea have seen the largest rises.

These two measures could be used to assess a country's relative position in global value chains. Economies toward the end (downstream) of production chains are more likely to have strong backward but weak forward links. Those closer to the origin (upstream) of production chains are more likely to have strong forward but weak backward links.

#### *Global Value Chain Participation and Trade Elasticities*

What effect does increased participation in global value chains have on the responsiveness of trade to exchange rates?

- *Exchange rate pass-through*. If the share of foreign value added in exports is large, a currency

[35]The extent to which the rise of global value chains matters for the relationship between exchange rates and trade depends on the share of the related trade in gross trade flows and on the degree to which the related trade responds differently to exchange rate fluctuations.

depreciation can substantially increase the cost of an economy's imported inputs if the input composition remains unchanged.[36] This higher cost may then be passed on to the next production stage. Hence, foreign-currency export prices might not decline as much as in the conventional case of no foreign-value-added content, implying a weaker exchange rate pass-through to export prices.[37] The likely impact of the rise of global value chains on pass-through to import prices is less clear.

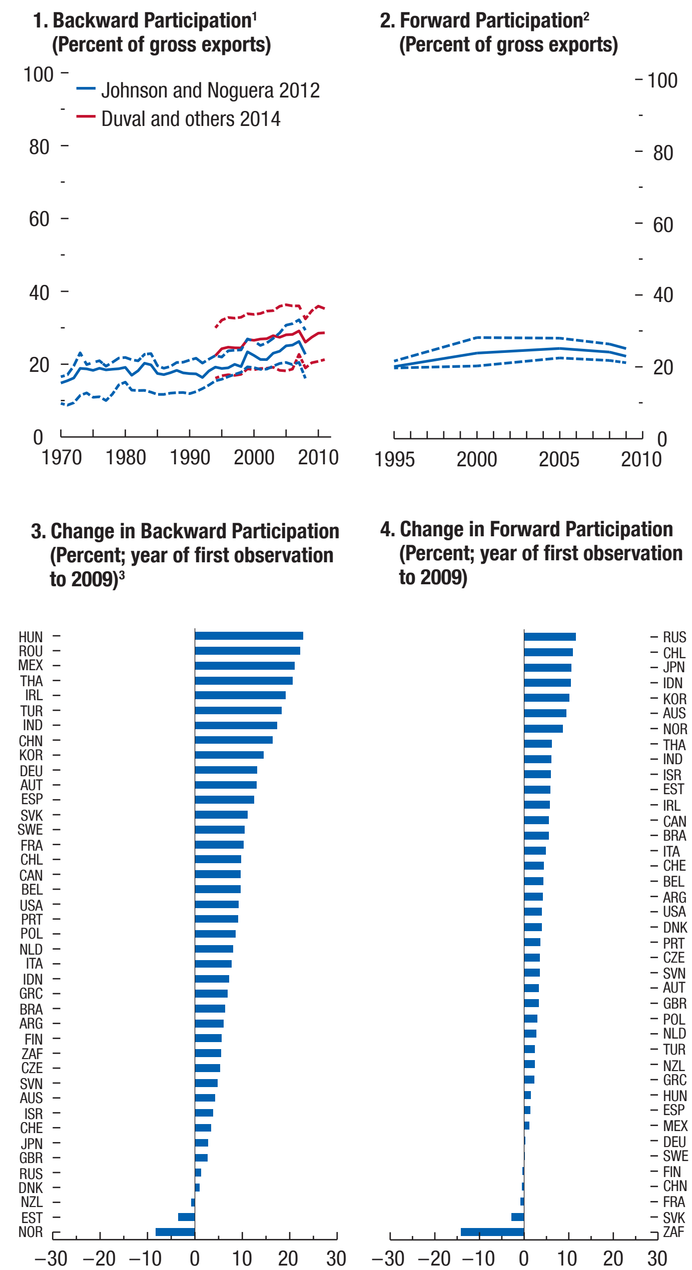
- *Price elasticities*. Demand for an economy's exports ultimately depends on the demand conditions and the price competitiveness of the finished product in the final destination market. With production increasingly fragmented across international borders, however, the final buyers at the end of an economy's production chain may not be among the economy's direct trading partners. This lack of direct connection complicates the estimation of the traditional trade relationship discussed earlier in the chapter. In particular, it could lead to "measurement error" in the sense that export prices become a weaker signal of true price competitiveness, and this measurement error could bias estimates of the effect of export prices on export demand toward zero. An analogous argument applies to the relationship between import prices and imports, since imports increasingly reflect developments in exports. An increase in import prices resulting from an exchange rate depreciation could coincide with lower export prices and stronger demand for exports and, therefore, a rise in import demand. The rise in the price of imports could then be associated with a perverse increase in imports despite higher import prices, counter to the traditional expenditure-switching logic. Overall, estimated export and import price elasticities could be smaller the more an economy participates in global value chains. The same reasoning also applies to the estimated effect of exchange rate movements on net exports.

[36]However, the composition of inputs might not remain unchanged, because foreign importers of intermediates can, at least in principle, substitute among a variety of suppliers to minimize production costs.

[37]At the same time a large fraction of trade in value added is within the same firm rather than between different firms. When a country's currency depreciates and export profits increase, firms may change export prices to shift some of their profits to foreign affiliates. Such transfer pricing behavior could alter pass-through to export prices, thus confounding the effect on pass-through attributable to global value chains.

## Figure 3.7. Evolution of Global Value Chains

Participation in global value chains has generally risen gradually, with substantial changes in some countries.




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.

In general, increased participation in global value chains could lower the effects of exchange movements on trade prices and of trade prices on trade volumes. At the same time, although trade related to global value chains has grown in recent decades, the bulk of global trade still consists of conventional trade. In addition, as already mentioned, the average increase in the share of foreign value added in exports has generally been gradual and has recently slowed. Thus, the rising share of foreign value added is unlikely to have dramatically reduced the responsiveness of gross exports and imports to exchange rates for most countries. The overall evidence regarding a rising disconnect between exchange rates and trade, which reflects not only the rise of global value chains but also other factors, is assessed later in the chapter. That analysis does not suggest a general weakening of the relationship between exchange rates, trade prices, and total trade volumes.

However, beyond the implications of global value chains for the relationship between overall gross trade flows and exchange rates, increased participation in value chains may have a bearing on the relationship between exchange rates and trade in global-value-chain-related goods. Box 3.1 assesses the evidence. In particular, it estimates the relationship between trade in global-value-chain-related goods and real effective exchange rates. It finds that a real appreciation of a country's currency not only reduces its exports of domestic value added, but also lowers its imports of foreign value added (in contrast to the traditional rise in imports following currency appreciation). This latter result is consistent with the notion that global-value-chain-related domestic and foreign value added are complements in production.[38] So producing and exporting less domestic value added would also reduce the derived demand for imported foreign value added. In addition, the analysis finds that the magnitudes of import and export elasticities depend on the size of a country's contribution to global value chains—smaller domestic contribution of value added tends to dampen the response to exchange rate changes (see Cheng and others, forthcoming; and IMF 2015a, 2015b, 2015c).[39]

Finally, the rise of global value chains has implications for competitiveness assessments. As already mentioned, in a value chain, the cost of producing an economy's goods as well the demand for them can depend on the exchange rates of economies that are not among the economy's direct trading partners. Thus, the real effective exchange rate relevant for competitiveness assessments not only needs to include the country's direct trading partners but must also take into account all participants in the value chain, including the final consumers. Such a measure, the so-called value-added real effective exchange rate, is described in Box 3.2. This measure depends on the final destinations of exported domestic value added, and it accounts for product substitutability in demand and production. As Box 3.2 reports, a number of economically important differences arise between value-added real effective exchange rates and conventional real effective exchange rates. However, overall, the two measures are strongly correlated, in part because the vast majority of trade does not consist of global-value-chain-related trade.[40]

Overall, the evidence suggests that, for economies that have become more deeply involved in global value chains, trade in global-value-chain-related products has become less strongly responsive to exchange rate changes. At the same time, although global-value-chain-related trade has gradually increased through the decades, the relative pace of its expansion appears to have decelerated in recent years, and the bulk of global trade still consists of conventional trade. The rise of global value chains is thus unlikely to have

[38]It is important to keep a macroeconomic perspective on this issue. Input substitution for product categories or some industries may rise. Generally, however, once a firm arranges production processes with a foreign supplier, it may well continue working with the supplier for some time to recoup sunk costs of moving production abroad. A generally low degree of substitutability between domestic and foreign input suppliers could thus be expected.

[39]Consistent with this result, Ahmed, Appendino, and Ruta (2015) find that the response of gross exports of manufactured goods to real exchange rate movements is weaker in economies with a higher share of foreign value added in gross exports, and Ollivaud, Rusticelli, and Schwellnus (2015) find that the elasticity of the terms of trade to the exchange rate is weaker in such economies. In related work based on firm-level data, Amiti, Itskhoki, and Konings (2014) find that import-intensive exporters have significantly lower exchange rate pass-through to their (foreign currency) export prices. Eichengreen and Tong (2015) find that renminbi appreciation has a positive effect on the stock market valuation of firms in sectors exporting final goods to China, with a negligible effect on those providing inputs for China's processing exports. The IMF (2015d) provides additional evidence, using data for Singapore, that products that have a higher foreign-value-added share respond more weakly to relative export prices.

[40]This observation also suggests that biases in estimated value-added trade relations due to incorrect use of standard real effective exchange rates could be small. The same implication applies to the estimation of gross trade relations based on value-added real effective exchange rates.

dramatically altered the responsiveness of gross exports and imports to exchange rates. This notion is further investigated in the next subsection.

## Disconnect over Time?

This subsection investigates more generally whether the relationship between exchange rate movements and trade—either long-term effects or transmission lags—has weakened over time. Numerous developments beyond the rise of global value chains could, in principle, have altered the effects of exchange rate movements. Some, such as the liberalization of trade flows and increased international competition associated with globalization, may have increased the responsiveness of trade to exchange rates. Others, such as the rise of pricing to market among several emerging markets and the moderation and stabilization of inflation in some economies, may have reduced the effects of changes in exchange rates on trade prices.[41] The question is whether, taken together, these developments have led to a disconnect.

### *Stability Tests*

To check whether the estimated links between exchange rates and trade have weakened, the analysis reestimates the four trade elasticities already discussed for successive 10-year rolling intervals. The first 10-year interval used for estimation is 1990–99 and the last is 2005–14. Since a period of 10 years provides insufficient data to estimate the elasticities for individual economies (based on annual data), the analysis is based on a panel estimation approach that combines data for multiple economies.[42]

Given that some regions are likely to have experienced greater structural change than others, the analysis investigates the evolution of trade elasticities for a global sample and for separate regions. In particular, because the rise of global value chains has been particularly noticeable in a number of Asian and European economies, rolling regression results are provided separately for these two regions.

The results suggest that exchange rates have not generally become disconnected from trade (Figure 3.8). The elasticity of imports with respect to import prices shows some weakening toward the end of the sample in some of the regions, which is consistent with the view that imports are increasingly responsive to export developments, as in global value chains. 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 global value chains remains inconclusive. Given that the rise of global value chains has generally been only gradual and appears to have decelerated recently, this inconclusive evidence is perhaps not surprising.[43]

Structural-break tests for a number of different samples confirm this finding of broad stability in total trade elasticities over time. When the sample used for the estimation of the panel regressions is divided into two halves—years through 2001 and years since 2002—a structural-break test fails to reject the null hypothesis of no change in the trade elasticities across the two time periods in most cases (Annex Table 3.5.1). The tests are conducted for the geographical groups included in Figure 3.8, as well as for a sample of economies that increased their participation in global value chains particularly strongly (those with a rise during 1995–2009 in the share of foreign value added in gross exports that is greater than the cross-country median), and for those economies that

[41]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).

[42]For each region, the analysis is based on the estimation of a multieconomy panel for the four trade equations already discussed. 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. For example, for export prices, the specification estimated is as follows (the other equations are set up analogously):

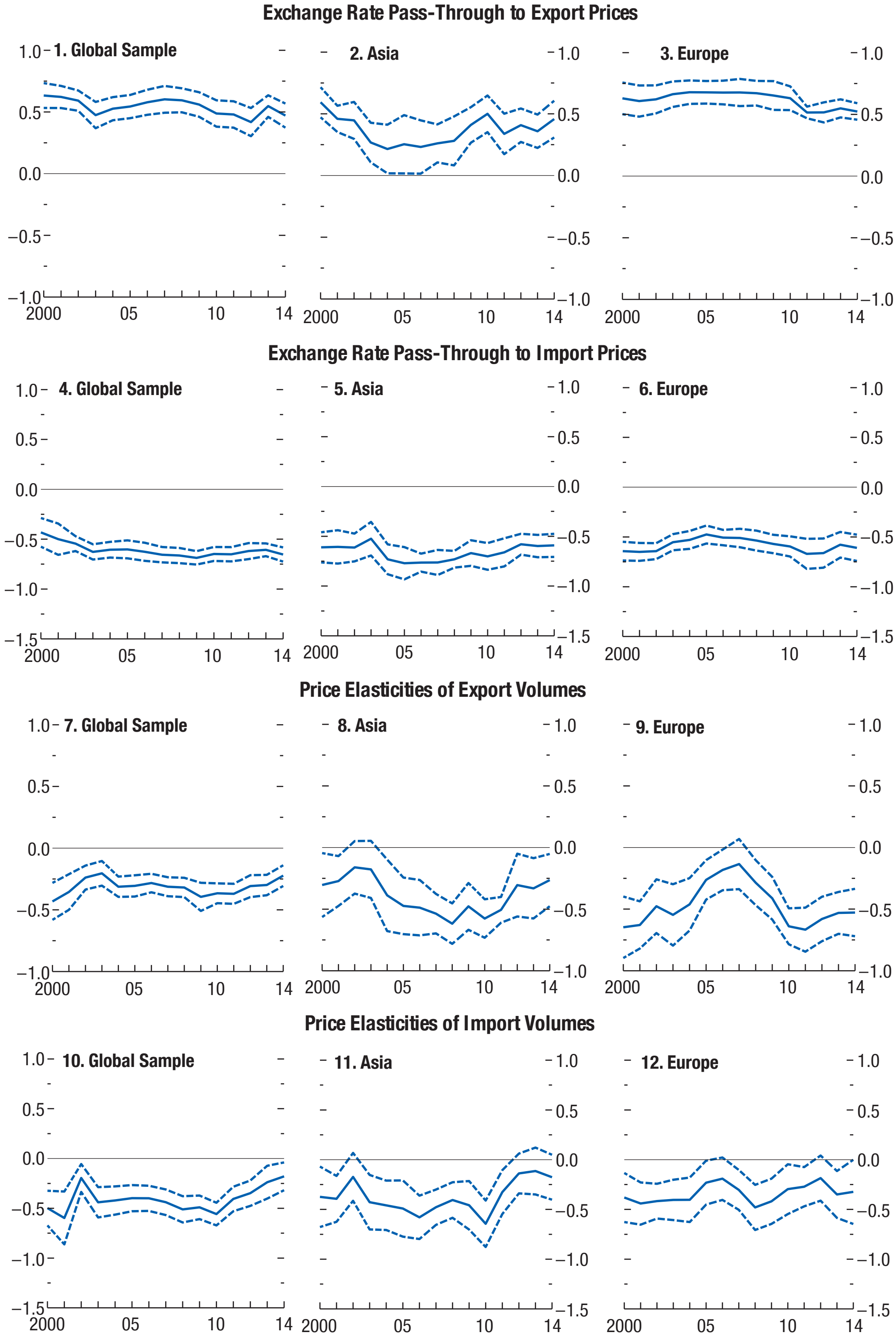
$$\Delta \ln\left(\frac{eP^X}{P^*}\right)_{it} = \alpha + \rho\, \Delta \ln\left(\frac{eP^X}{P^*}\right)_{i,t-1} + \Sigma_{j=0}^{2}\, \beta_j\, \Delta \ln\left(\frac{eP}{P^*}\right)_{i,t-j} + \Sigma_{j=0}^{2}\, \gamma_j\, \Delta \ln\left(\frac{ULC}{P}\right)_{i,t-j} + \mu_i + \lambda_t + \upsilon_{it},$$

in which the subscript $i$ denotes the $i$th country and the subscript $t$ denotes the $t$th year. As before, the estimated effects in years $t + j$, for $j = 0$, 1, and 2, are then based on the estimates of the $\beta_j$ coefficients. Long-term effects are estimated as $\Sigma_{j=0}^{2}\, \beta_j/(1 - \rho)$. The estimated equation also includes a full set of time dummies ($\lambda_t$) to take account of global shocks such as shifts in commodity prices. To avoid changes in its composition over time, the sample includes only economies for which at least 20 years of data are available. Based on data availability, the full sample includes 88 advanced and emerging market and developing economies. They are listed in Annex Table 3.1.4.

[43]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 advanced and emerging market and developing economies.

**Figure 3.8. Trade Elasticities over Time in Different Regions**
*(Ten-year rolling windows ending in year t)*

There is little evidence of a general trend toward disconnect between exchange rates, trade prices, and total trade volumes.




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.

increased their participation less strongly (those with a rise in the foreign-value-added share that is less than the cross-country median).

Similarly inconclusive results emerge when the tests are repeated for data samples used elsewhere, as in the 46 economies included in the analysis of Ahmed, Appendino, and Ruta 2015 (Annex 3.5). Additional analysis suggests that evidence regarding a lengthening of transmission lags is also limited. A lengthening in lags would imply a divergence between long-term effects and shorter-term effects, but there is little evidence of such a divergence.

In interpreting these results, it is also 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 3.9). On their own, 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 or even greater macroeconomic implications for trade than before.

### *Effects of Large Exchange Rate Depreciations over Time*

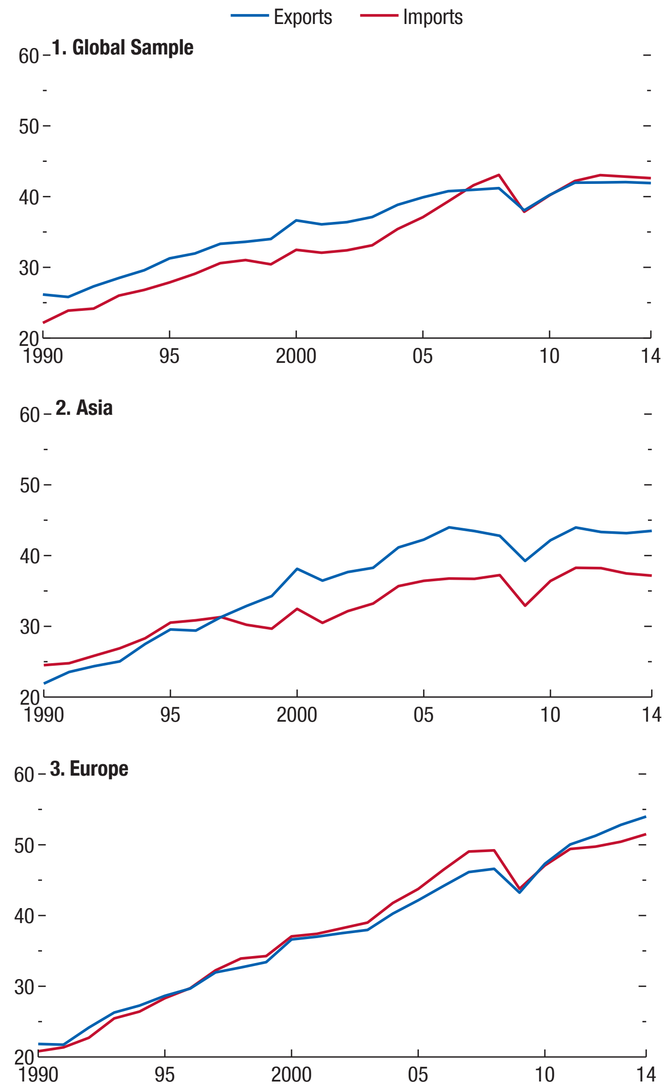
To shed more light on whether the links between exchange rates and trade have weakened, the analysis reconsiders the effects of large exchange rate depreciations on exports in the first and second halves of the sample. Of the 66 episodes of large currency depreciation in the sample, half (33) occurred in 1997 or earlier, and the other half occurred in more recent years.

Analysis of these two time samples indicates little evidence of a weakening in the effects of exchange rates over time (Figure 3.10). The analysis indicates that export prices and volumes responded similarly during the two time samples. Little evidence emerges of either weakened long-term responses or lengthened lags.

Overall, the results are consistent with the view that trade and exchange rates have remained connected. It is worth recalling that the view that exchange rates are becoming disconnected from trade has been partly motivated by Japan's recent experience; despite a sharp depreciation of the yen, export growth has failed to accelerate as expected. As discussed in Box 3.3, this experience reflects a number of Japan-specific factors that have partly offset the positive impact of yen depreciation on exports and that do not necessarily apply elsewhere.

**Figure 3.9. Ratios of Exports and Imports to GDP, 1990–2014**
*(Percent)*

Exports and imports have been rising as a share of GDP, increasing the macroeconomic relevance of exchange rate movements, for a given set of trade elasticities.



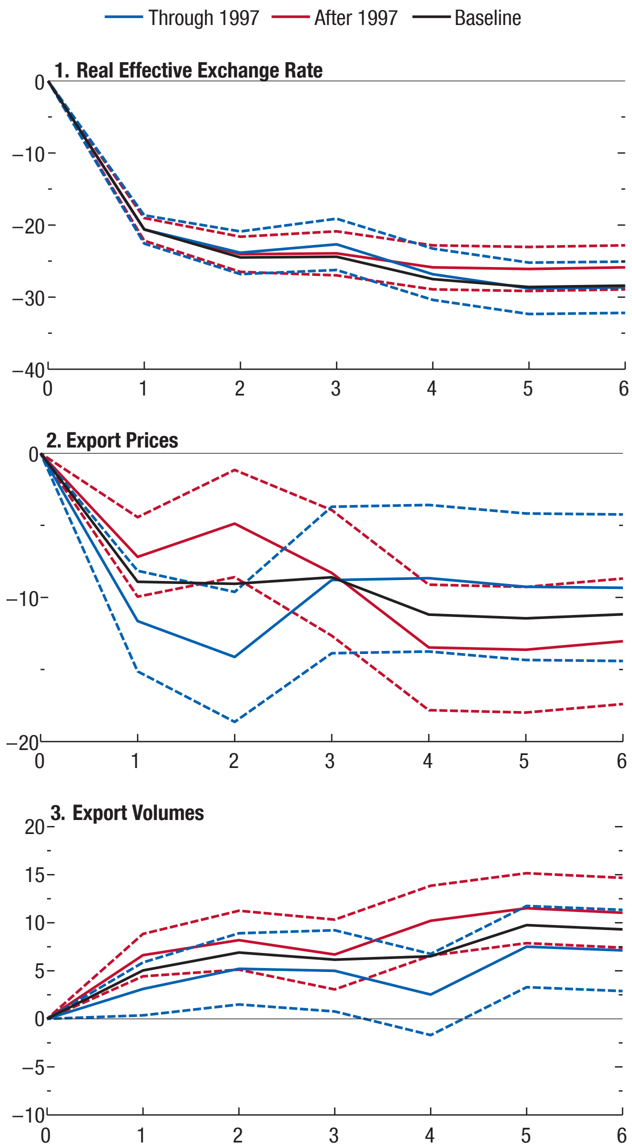

Source: IMF staff calculations.
Note: Figure presents simple averages of economies in the sample.

## Implications for the Outlook

The analysis in this chapter suggests that exchange rate movements tend to have strong effects on exports and imports. Based on the chapter's estimates, 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. It takes a number of years for the effects to fully materialize, but

**Figure 3.10. Export Dynamics Following Large Exchange Rate Depreciations: Through and After 1997**
*(Percent; years on x-axis)*

Export prices and volumes display similar dynamics during the period through 1997 and in the period thereafter.




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

much of the adjustment occurs in the first year. The analysis also indicates that foreign and domestic aggregate demand 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 results suggest that recent exchange rate movements, including the U.S. dollar's appreciation of more than 10 percent in real effective terms during the past year, would result in a substantial redistribution of real net exports across economies. As discussed in Chapter 1, recent exchange rate movements have reflected variations in underlying fundamentals, such as expected demand growth at home and in trading partners, declines in commodity prices, and a variety of country-specific shocks. 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. With regard to direct effects on trade, the real effective exchange rate movements 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 (Figure 3.11).[44] 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.

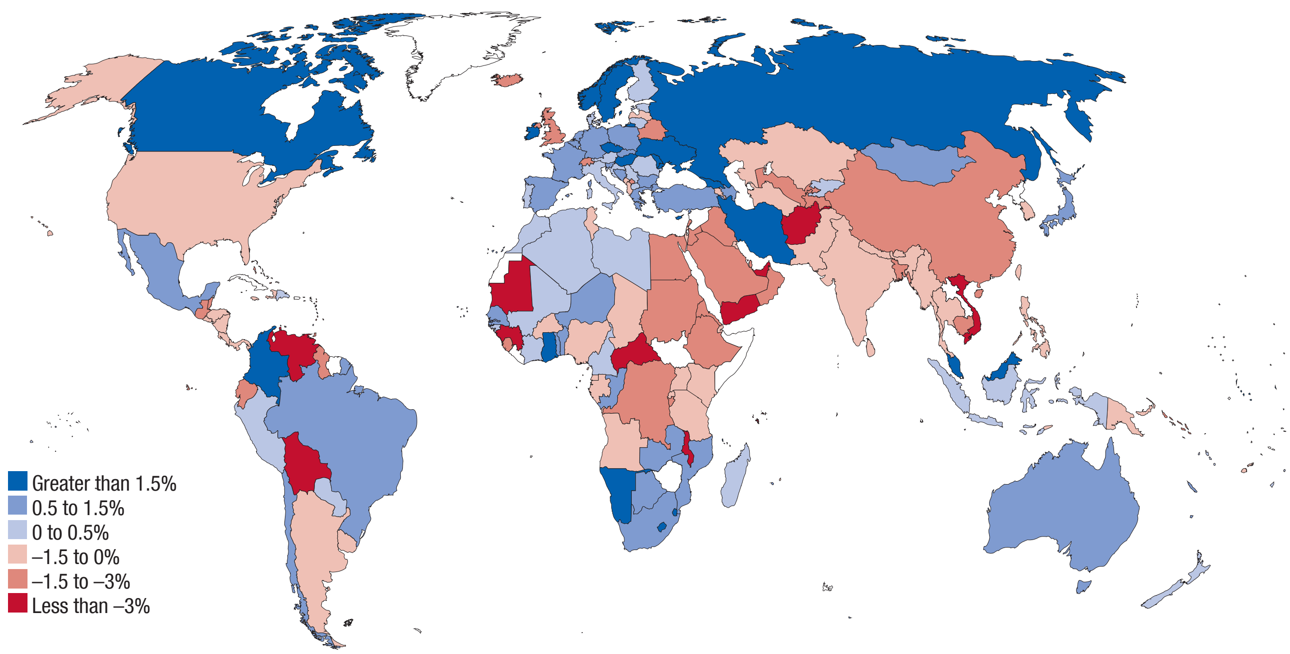
The chapter also finds that there is little evidence of a trend toward disconnect between exchange rates, trade prices, and trade volumes over time. Some evidence indicates that the rise of global value chains has weakened the relationship between exchange rates and trade in intermediate products used as inputs into other economies' exports. However, global-value-chain-related trade has increased only gradually through the decades, and the bulk of global trade still consists of conventional trade. There is also 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. Overall, the evidence regarding a general disconnect between exchange rates and overall trade remains inconclusive.

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

[44]The illustrative calculation reported in Figure 3.11 is based solely on changes in real effective exchange rates from January 2013 to June 2015. The calculation is based on CPI-based real effective exchange rates because they are available for more economies than are PPI-based ones. It applies the average estimates of CPI-based trade elasticities reported in Table 3.1 to all economies.

**Figure 3.11. Illustrative Effect of Real Effective Exchange Rate Movements since January 2013 on Real Net Exports**
*(Percent of GDP)*

Exchange rate movements since January 2013 imply a substantial redistribution of real net exports across economies.




Source: IMF staff calculations.
Note: The illustrative effects of consumer price index (CPI)–based real effective exchange rate movements from January 2013 to June 2015 on real net exports in percent of GDP are based on the average CPI-based estimates of the exchange rate pass-through into export and import prices and the price elasticity of exports and imports reported in Table 3.1. These average estimates are applied to all economies. Country-specific shares of exports and imports in GDP used in the calculation are from 2012.

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 strong.

## Annex 3.1. Data

### Data Sources

The primary data sources for this chapter 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 analysis performed in "Disconnect and the Rise of Global Value Chains" also uses the Trade in Value Added database from the OECD–World Trade Organization.[45] Annex Table 3.1.1 describes all indicators used in the chapter as well as their sources. Annex Tables 3.1.2 and 3.1.3 list all countries used in the estimation of trade elasticities (individual economy and panel, respectively), and Annex Table 3.1.4 lists those used in the analysis of global value chains.

### Data Definitions

The nominal exchange rate used throughout the chapter is the nominal effective exchange rate taken from the INS. It is a weighted average of trading-partner bilateral nominal exchange rates, with the weights based on gross exports. The consumer price

[45]The WEO list of 37 advanced economies is used as the basis for the analysis in this chapter. The maximum data range available spans 1960–2014, with data for 2014 preliminary. Data limitations constrain the sample size in a number of cases, as noted in the chapter text.

## Annex Table 3.1.1. 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 Labour Organization; IMF, World Economic Outlook database; and IMF, International Financial Statistics.

## Annex Table 3.1.2. Economies Included in 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, 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 constituted the main source of export earnings, exceeding 50 percent of total exports, on average, between 2009 and 2013.

## Annex Table 3.1.3. 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 Co-operation and Development and World Trade Organization.

## Annex Table 3.1.4. Economies Included in the Rolling Regressions

| |
|---|
| 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 |

index (CPI)–based real effective exchange rate also comes from the INS. The producer price index (PPI)–based real effective exchange rate, as well as the CPI-based and PPI-based trade-weighted foreign producer prices, are constructed as trade-weighted indices, with the weights from the INS. The unit labor cost data come from OECD Statistics and, in case of missing observations, are supplemented using IMF staff calculations. For non-OECD economies, the unit labor cost is constructed as the total wage bill divided by real GDP. The total wage bill and real GDP are taken from the IMF's WEO database, Haver Analytics, the International Labour Organization, the IMF's *International Financial Statistics*, and CEIC. When unavailable, total wage bill data are constructed using the average wage rate and total employment.

## Annex 3.2. Estimation of Trade Elasticities

### Trade Equations Estimated for Individual Economies

The analysis is based on log-linear specifications for the four trade equations. For each equation, the analysis checks whether the variables included are cointegrated based on a Dickey-Fuller test, in which case the equations are estimated using ordinary least squares in levels. Otherwise, they are estimated in first differences.

In level terms, the four trade equations estimated are as follows. For export prices, the specification is

$$\ln\left(\frac{eP^{X}}{P^{*}}\right)_t = \alpha + \beta \ln\left(\frac{eP}{P^{*}}\right)_t + \gamma \ln\left(\frac{ULC}{P}\right)_t + \varepsilon_t,$$

in which the subscript $t$ denotes the $t$th year, $\left(\frac{eP^{X}}{P^{*}}\right)$ denotes the relative price of exports in foreign currency ($e$ is the nominal effective exchange rate, $P^{X}$ is the price of exports in domestic currency, and $P^{*}$ is the foreign-trade-weighted producer price index [PPI]), and $\left(\frac{eP}{P^{*}}\right)$ is the PPI-based real effective exchange rate. $ULC$ is unit labor costs.

For export volumes, the specification is

$$\ln X_t = \alpha + \beta \ln\left(\frac{eP^{X}}{P^{*}}\right)_t + \gamma \ln Y^{*}_t + \varepsilon_t,$$

in which $X$ denotes export volume and $Y^{*}$ denotes foreign real GDP (in trade-weighted terms).[46]

[46]The estimates for the export price equation are also robust to the inclusion of a foreign demand control on its specification.

For import prices, the specification is

$$\ln\left(\frac{P^{M}}{P}\right)_t = \alpha + \beta \ln\left(\frac{eP}{P^{*}}\right)_t + \gamma \ln Y_t + \varepsilon_t,$$

in which $Y$ denotes domestic real GDP.

For import volumes, the specification is

$$\ln M_t = \alpha + \beta \ln\left(\frac{P^{M}}{P}\right)_t + \gamma \ln(DD_t) + \delta \ln(X_t) + \varepsilon_t,$$

in which $DD$ denotes domestic demand for domestic goods ($Y - X$).

All equations also include a time trend and a dummy variable (which equals 1 during 2008–09) to account for the global financial crisis, and the interaction of this crisis dummy with the measure of foreign output for the export equation and with the measure of domestic output for the import equation. These interaction terms address the notion that trade responded unusually strongly to demand during the crisis (see, for example, Bussière and others 2013). In addition, to control for shifts in global commodity prices, which can affect exporting firms' costs, the equations for export and import prices control for the (log) indices of international fuel and nonfuel commodity prices. The estimates for the export price equation are also similar when trading-partner real GDP growth is used as an additional control.

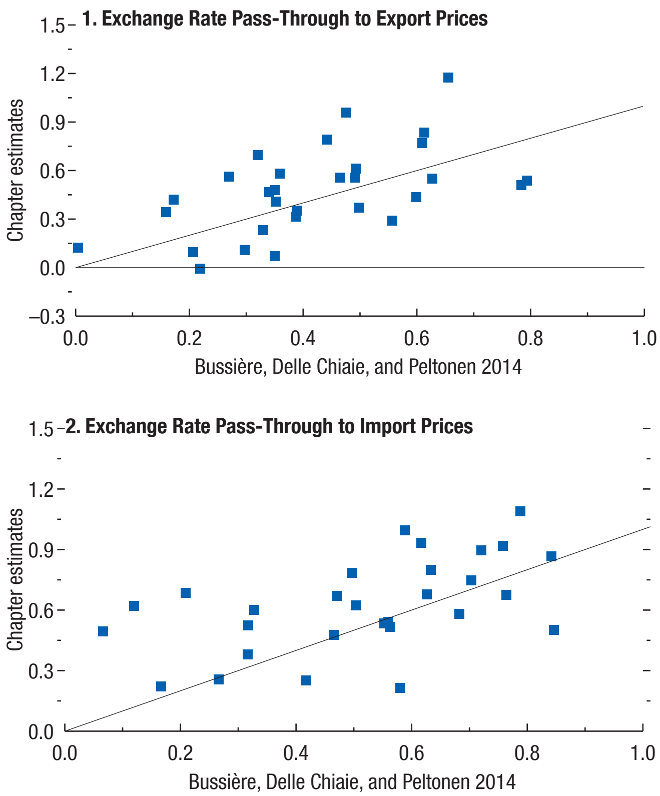
In each case, the estimate for $\beta$ indicates the estimated long-term effect. Short-term effects are obtained by estimating, in a second step, the equation in error correction form. For example, for export prices, this equation is

$$\Delta\ln\left(\frac{eP^{X}}{P^{*}}\right)_t = \alpha + \rho\, \Delta\ln\left(\frac{eP^{X}}{P^{*}}\right)_{t-1} + \Sigma_{j=0}^{2} \beta_j\, \Delta\ln\left(\frac{eP}{P^{*}}\right)_{t-j} + \Sigma_{j=0}^{2} \gamma_j\, \Delta\ln\left(\frac{ULC}{P}\right)_{t-j} + \varphi EC_t + \varepsilon_t,$$

in which $EC$ denotes the error correction term (residual from the levels equation). Here, the estimate of $\beta_0$ indicates the estimated adjustment in relative export prices after one year.

In the case in which there is no evidence of cointegration, the relevant equation is estimated in first differences, which is identical to the error correction case but without the $EC$ term. In that case, long-term effects are estimated as $\Sigma_{j=0}^{2} \beta_j/(1 - \rho)$. The share of economies for which no evidence of cointegration is found is 57 percent for export prices, 50 percent for export volumes, 56 percent for import prices, and 54

**Annex Figure 3.2.1. Exchange Rate Pass-Through Estimates: Comparison with Bussière, Delle Chiaie, and Peltonen 2014**




Sources: Bussière, Delle Chiaie, and Peltonen 2014; and IMF staff estimates.
Note: For consistency with Bussière, Delle Chiaie, and Peltonen 2014, chapter estimates refer to pass-through of exchange rate depreciation to export and import prices in domestic currency.

percent for import volumes. The use of two lags in the analysis is a conventional choice.

## Additional Country-by-Country Estimation Results

See Annex Figures 3.2.1 and 3.2.2 for additional country-by-country estimation results discussed in the text.

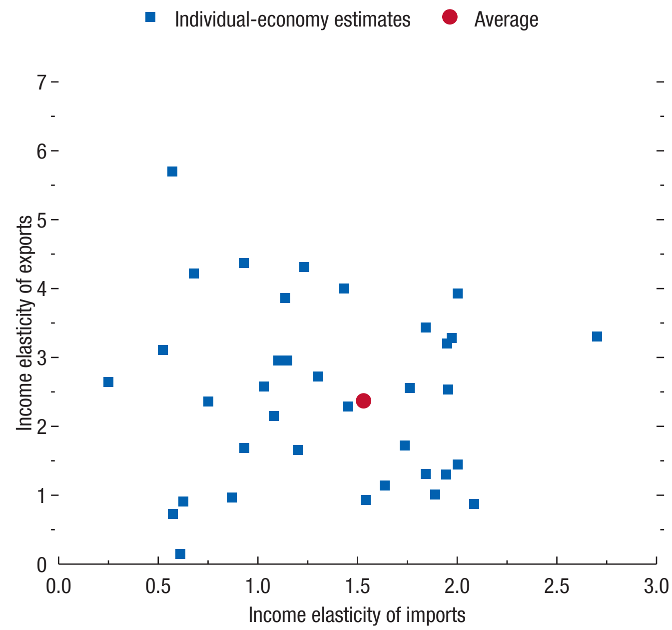
## Annex 3.3. Derivation of the Marshall-Lerner Condition under Incomplete Pass-Through

The nominal trade balance $TB$ is defined as

$$TB = \frac{\widetilde{P^X}X}{e} - P^M M,$$

in which $\widetilde{P^X}$ denotes export prices in foreign currency, $X$ denotes export volumes, $e$ denotes the nominal effective exchange rate, $P^M$ denotes import prices in home currency, and $M$ denotes import volumes.

**Annex Figure 3.2.2. Income Elasticities of Imports and Exports**




Source: IMF staff estimates.

The impact of the nominal effective exchange rate on the trade balance is

$$\frac{\partial TB}{\partial e} = -\frac{\widetilde{P^X}X}{e^2} + \frac{X}{e}\frac{\partial \widetilde{P^X}}{\partial e} + \frac{\widetilde{P^X}}{e}\frac{\partial X}{\partial \widetilde{P^X}}\frac{\partial \widetilde{P^X}}{\partial e} - M\frac{\partial P^M}{\partial e} - P^M\frac{\partial M}{\partial P^M}\frac{\partial P^M}{\partial e}. \quad \text{(A3.3.1)}$$

Exchange rate pass-through to trade prices ($ERPT^X$ and $ERPT^M$) and price elasticities of trade volumes ($\eta^X$ and $\eta^M$) are defined as

$$ERPT^X = \frac{e}{\widetilde{P^X}}\frac{\partial \widetilde{P^X}}{\partial e},$$

$$\eta^X = \frac{\widetilde{P^X}}{X}\frac{\partial X}{\partial \widetilde{P^X}},$$

$$ERPT^M = \frac{e}{P^M}\frac{\partial P^M}{\partial e},$$

$$\eta^M = \frac{P^M}{M}\frac{\partial M}{\partial P^M}.$$

Substituting these in equation (A3.3.1) gives

$$\frac{\partial TB}{\partial e} = -\frac{\widetilde{P^X}X}{e^2}\left(-1 + ERPT^X + ERPT^X \times \eta^X\right) - \frac{P^M M}{e}\left(ERPT^M + ERPT^M \times \eta^M\right).$$

In equilibrium, $\frac{\widetilde{P^X}X}{e} = P^M M$.

The Marshall-Lerner condition under incomplete pass-through is thus

$$ERPT^X(1 - |\eta^X|) - ERPT^M(1 - |\eta^M|) < 1.$$

Note that when the pass-through is complete, $ERPT^X = 1$ and $ERPT^M = -1$. Then, the Marshall-Lerner condition is

$$|\eta^X| + |\eta^M| > 1.$$

## Annex 3.4. Analysis of Large Exchange Rate Depreciation Episodes

### List of Episodes

Annex Table 3.4.1 lists the 66 baseline large exchange rate depreciation episodes used in the subsection "Insights from Large Exchange Rate Depreciation Episodes." Annex Table 3.4.2 lists the additional 57 large exchange rate depreciation episodes that are associated with banking crises.

### Robustness Analysis

The baseline results for the effects of large exchange rate depreciation episodes are compared with the results based on the following three alternative approaches. In each case, the results are similar to the baseline results.

- *Alternative 1: Local projections method*. In this exercise, the local projections method is used to estimate the relationship between a large exchange rate depreciation and trade. As in Chapter 2, the methodology used is the one first set out in Jordà 2005 and developed further in Teulings and Zubanov 2014. This method provides a flexible alternative to traditional vector autoregression (VAR) techniques. Unlike a VAR, local projections are robust to misspecification of the data-generating process. (If the VAR is misspecified, this specification error will be compounded at each horizon of the impulse response.) The method uses separate regressions for the variable of interest (the real effective exchange rate, export prices, or export volumes) at different horizons. The sequence of coefficient estimates for the various horizons provides a nonparametric estimate of the impulse response function. The estimated specification is as follows:

$$y_{i,t+h} = \alpha_i^h + \gamma_t^h + \beta_{i,1}^h S_{i,t} + \sum_{j=1}^{p} \beta_{i,2}^h S_{i,t-j} + \sum_{j=0}^{h-1} \beta_{i,3}^h S_{i,t+h-j} + \sum_{j=1}^{p} \beta_{i,4}^h y_{i,t-j} + \varepsilon_{i,t}^h,$$

in which $i$ subscripts denote countries; $t$ and $j$ subscripts denote years; $h$ superscripts denote the horizon in years of the projection after time $t$; $p$ denotes the number of lags included; $y$ denotes the growth rate of the variable of interest; and $S$ is the event indicator dummy, which in this chapter indicates the start of a large exchange rate depreciation. Regressions include country fixed effects, $\alpha_i^h$,

**Annex Table 3.4.1. 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 | 1985, 1989, 1993, 2000, 2002, 2012 |
| Kazakhstan | 1999 |
| Kiribati | 1985 |
| Libya | 1998, 2002 |
| 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 IMF staff estimates.

**Annex Table 3.4.2. Large Exchange Rate Depreciations Associated with Banking Crises**

| Country | Year |
|---|---|
| **Advanced Economies** | |
| Finland | 1993 |
| Iceland | 2008 |
| Japan | 1996 |
| Korea | 1998, 2001 |
| Norway | 1993 |
| Sweden | 1993, 2009 |
| **Emerging Market and Developing Economies** | |
| Albania | 1997 |
| Algeria | 1988, 1991, 1994 |
| Argentina | 2002 |
| Burkina Faso | 1994 |
| Brazil | 1999, 2001 |
| Cameroon | 1994 |
| Central African Republic | 1994 |
| Chile | 1985 |
| Colombia | 1997 |
| Costa Rica | 1991 |
| Côte d'Ivoire | 1994 |
| Dominican Republic | 2003 |
| Equatorial Guinea | 1994 |
| Ghana | 1993 |
| Guinea-Bissau | 1994 |
| Haiti | 1992 |
| India | 1991 |
| Indonesia | 1997 |
| Kazakhstan | 2009 |
| Madagascar | 1987, 1991, 1997 |
| Malaysia | 1998 |
| Mali | 1994 |
| Mongolia | 2009 |
| Nigeria | 1991, 2009 |
| Paraguay | 1998 |
| Philippines | 1983, 1998 |
| Russia | 1998, 2009 |
| São Tomé and Príncipe | 2001 |
| Senegal | 1994 |
| Sierra Leone | 1995 |
| Tanzania | 1984, 1987, 1992 |
| Thailand | 1997 |
| Uganda | 1991, 1993 |
| Ukraine | 1998, 2009, 2014 |
| Uruguay | 2002 |
| Zambia | 1998 |

Sources: Laeven and Valencia 2013; and IMF staff estimates.

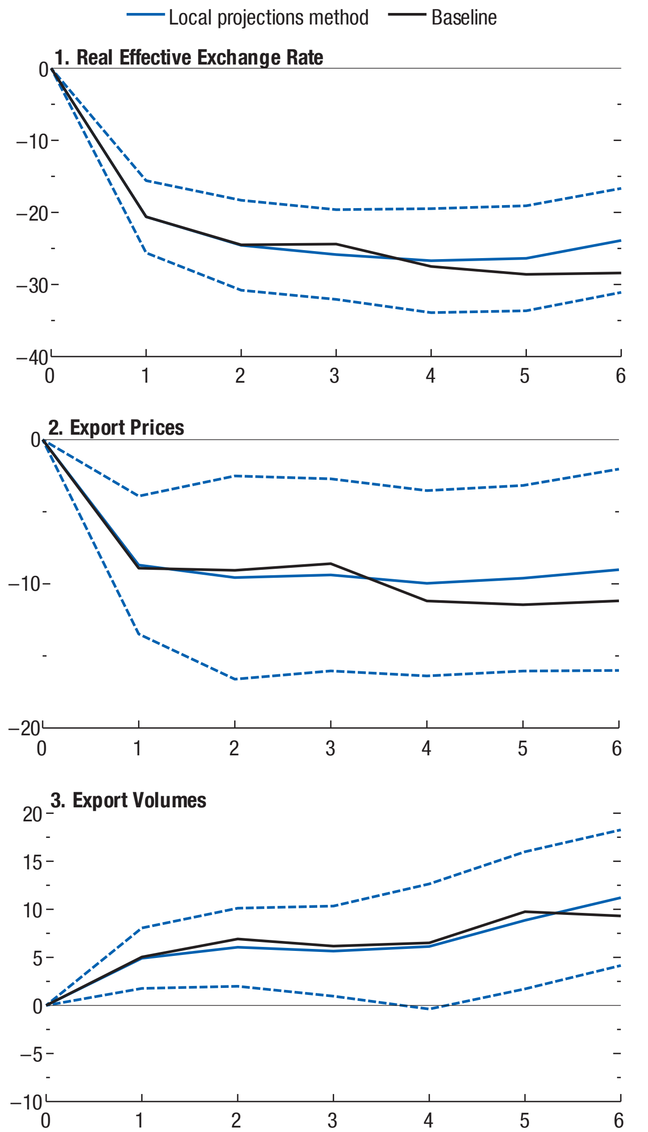
and time fixed effects, $\gamma_t^h$, to control for economic developments facing a particular country in a given year. Annex Figure 3.4.1 reports the estimation results based on this approach, which are similar to the baseline provided in Figure 3.4.

- *Alternative 2: Thresholds based on real effective exchange rate depreciations*. In this alternative, large exchange rate depreciation episodes are identified based on numeric thresholds taken from the statistical distribution of the depreciation rate of the real effective exchange rate, rather than of the currency vis-à-vis the U.S. dollar. Using this identification strategy, large exchange rate depreciation episodes for advanced economies require two criteria: (1) a real effective depreciation of at least 6 percent (the 90th percentile of all annual depreciation rates) and (2) a change in the real effective depreciation that is at least 7 percentage points greater than that in the previous year (the 90th percentile of all changes in annual depreciation rates). For emerging market and developing economies, the definition requires the same two criteria, but with different threshold values: (1) a real effective depreciation of at least 10 percent and (2) a change in the real effective depreciation that is at least 12 percentage points higher than that in the previous year. Annex Figure 3.4.2 reports the results of this robustness test.
- *Alternative 3: Using Laeven and Valencia currency crisis episodes.* The analysis is repeated based on the currency crisis episodes identified in Laeven and Valencia 2013. Annex Figure 3.4.3 reports the results of this robustness test.

The analysis in "Do Initial Economic Conditions Matter?" uses unusually low growth in the year before the episode to measure initial economic slack. Growth is defined as de-meaned real GDP growth (for each economy, growth minus the economy's mean growth rate). Low growth is then defined as de-meaned growth of less than the median for the 66 episodes (the median is near zero). As a robustness check, the analysis is repeated with economic slack defined based on the output gap one year before the episode. The source of the output gap data is the World Economic Outlook database. When this series is missing, it is replaced with an output gap computed based on the Hodrick-Prescott filter applied to real GDP with a smoothing parameter of 100. Episodes associated with economic slack are those having an output gap that is less than the median for the 66 episodes (the median is near zero). Annex Figure 3.4.4 reports the estimation results for this robustness test. The results for trade volumes continue to show that exports rise more strongly when there is more economic slack. The results for export prices, however, show no statistically distinguishable difference between the two sets of initial economic conditions.

**Annex Figure 3.4.1. Export Dynamics Following Large Exchange Rate Depreciations**

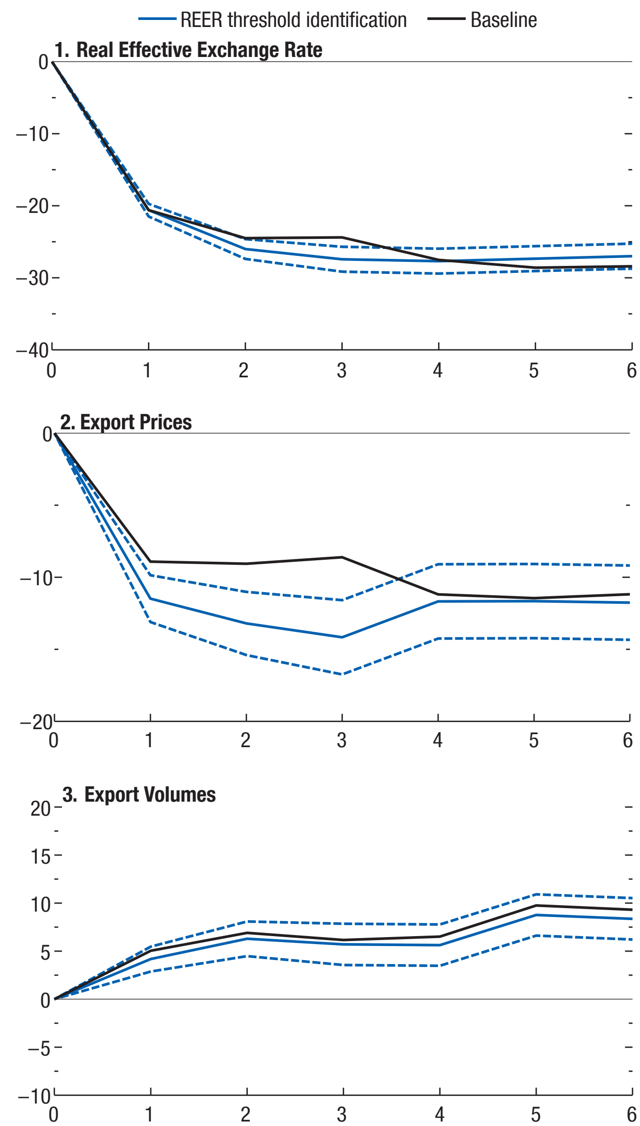
*(Percent; years on x-axis)*




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

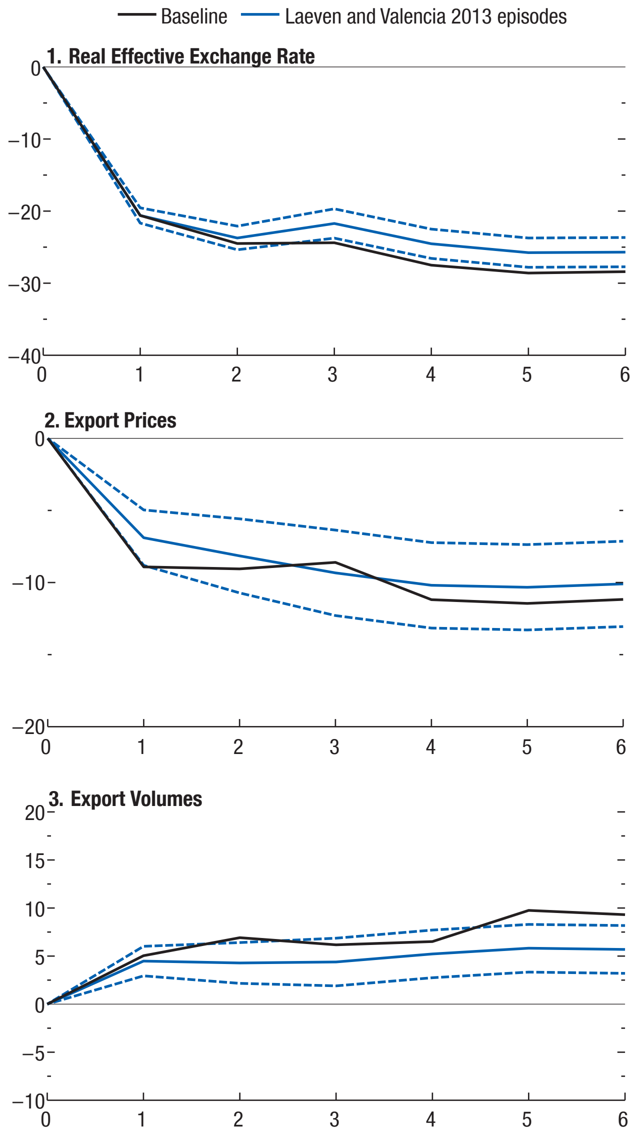
**Annex Figure 3.4.2. Export Dynamics Following Large Exchange Rate Depreciations Identified Based on the Real Effective Exchange Rate**

*(Percent; years on x-axis)*



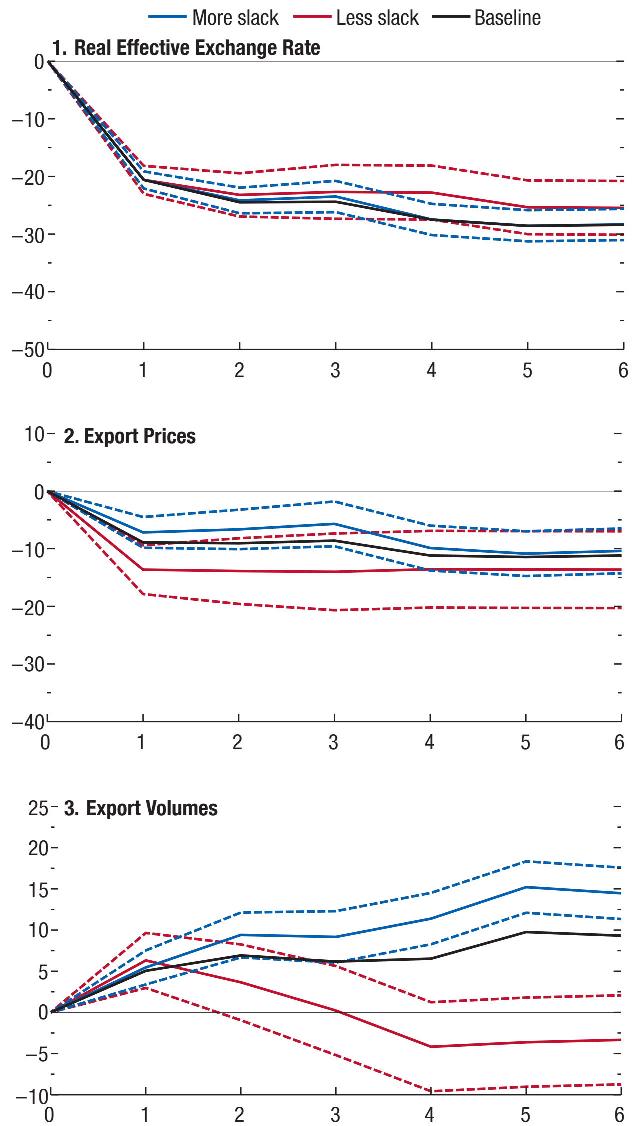

Source: IMF staff estimates.
Note: Dashed lines denote 90 percent confidence intervals. REER = real effective exchange rate.

**Annex Figure 3.4.3. Export Dynamics Following Laeven and Valencia 2013 Currency Crises**
*(Percent; years on x-axis)*




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

**Annex Figure 3.4.4. Export Dynamics Following Large Exchange Rate Depreciations: Role of Initial Output Gap**
*(Percent; years on x-axis)*




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

## Annex 3.5. Trade Elasticities over Time: Stability Tests

The analysis in "Stability Tests" estimates the four long-term trade elasticities for successive 10-year rolling intervals (Figure 3.8) and finds limited evidence of a decline in trade elasticities over time.

Structural-break tests confirm this finding of broad stability (Annex Table 3.5.1). The tests divide the sample used for the estimation of the panel regressions into two halves—years through 2001 and years since 2002—and test the null hypothesis of no change in the trade elasticities across the two time periods. The tests are conducted for the geographical groups included in Figure 3.8, as well as for a sample of economies that increased their participation in global value chains particularly strongly (those with a rise during 1995–2009 in the share of foreign value added in gross exports that is greater than the cross-country median), and for those economies that increased their participation less strongly (those with a rise in the foreign-value-added share that is less than the cross-country median).

As Annex Table 3.5.1 reports, the tests fail to reject the null of no change in most cases. Similarly inconclusive results emerge when the tests are repeated for data samples used elsewhere, as in the 46 economies included in the analysis of Ahmed, Appendino, and Ruta 2015. That study finds that the responsiveness of exports to the real effective exchange rate dropped substantially between 1996–2003 and 2004–12. When the analysis is repeated for this sample of 46 economies, but export volumes are constructed by deflating nominal exports using export prices rather than the consumer price index (CPI)—as in that study—there is little evidence of a decline in export elasticities. (The CPI reflects the prices of many nontraded goods and services and increases on average at a considerably higher rate than export prices.) The same applies if outlier observations, including those associated with spikes in CPI inflation, are removed from the sample.

### Annex Table 3.5.1. Trade Elasticities over Time: Stability Tests

| | Full | 1990–2001 | 2002–14 | Statistical Significance of the Difference between the Two Periods[1] |
|---|---|---|---|---|
| | **1. Pass-Through to 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 to 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*** | |

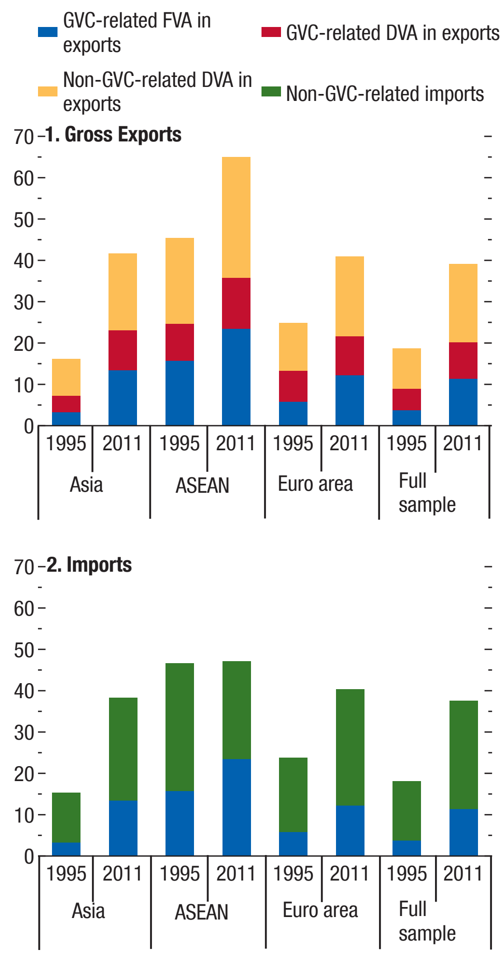
Source: IMF staff estimates.
[1]Blank space in this column indicates no statistically significant difference.
*$p < .1$; **$p < .05$; ***$p < .01$.

## Box 3.1. The Relationship between Exchange Rates and Global-Value-Chain-Related Trade

Global value chains have increased in prominence in global production and trade. About one-third of world trade consists of intermediate products for subsequent reexport in a transformed state. This process contrasts with the traditional view of international trade, in which goods are produced in their entirety within a single country and shipped as final goods to export markets. Given that within a global value chain, imports are inputs into the production of exports, and imports (which represent foreign value added) are complements in production with domestic value added, global-value-chain-related trade may respond differently than trade in final goods to exchange rate changes. Using a recently released data set on trade in value added, this box assesses how global value chains affect the responses of different types of exports and imports and the overall trade balance to changes in exchange rates.[1] Moreover, this approach isolates the impact of exchange rate changes on domestic value added, the concept that determines GDP and competitiveness, and one that is of ultimate concern to policymakers.

Before turning to the main question at hand, exploring the trade data is useful. As shown in Figure 3.1.1, gross exports comprise exports produced within a global value chain as well as other, non–global value chain exports. Gross global value chain exports can, in turn, be divided into domestic-value-added and foreign-value-added components, both of which are subsequently exported as inputs into the next stage of the supply chain. In contrast, non–global value chain exports consist primarily of domestic value added. Therefore, gross exports consist of both domestic value added and foreign value added. Gross imports encompass global-value-chain-related imports—which is the foreign-value-added component of global-value-chain-related exports—and non-global-value-chain-related imports. Since foreign value added in global value chain exports appears in both gross imports and exports, it has no impact on the size of the trade balance. It is apparent that global-value-chain-related gross exports (the sum of domestic value added in global value chains and foreign value added) grew substantially as a share of GDP in all

**Figure 3.1.1. Decomposition of Gross Exports and Imports, 1995 versus 2011**
*(Percent of GDP)*




Sources: Organisation for Economic Co-operation and Development–World Trade Organization Trade in Value Added database; and IMF staff calculations.
Note: ASEAN = Association of Southeast Asian Nations; DVA = domestic value added; FVA = foreign value added; GVC = global value chain.

The authors of this box are Kevin Cheng and Rachel van Elkan, based on Cheng and others, forthcoming.

[1]The analysis is based on the Organisation for Economic Co-operation and Development–World Trade Organization Trade in Value Added database, which covers 57 countries, for the years 1995, 2000, 2005, and 2008–09. The periodic data are transformed to annual frequency, as discussed in Cheng and others, forthcoming.

## Box 3.1 (continued)

regions during 1995–2011, and especially in member countries of the Association of Southeast Asian Nations. Nonetheless, non-global-value-chain-related exports remain, on average, about two-thirds of world total exported domestic value added.

### *The Exchange Rate Response of Global-Value-Chain-Related Trade*

A panel framework with time and country fixed effects is used to estimate the responsiveness of global-value-chain-related export and import volumes to changes in real effective exchange rates (REERs).[2] A term for the interaction between the REER and the share of foreign value added in gross global-value-chain-related exports is also included to capture the dampening effect arising from a larger foreign-value-added share. The interpretation of this term and its corresponding coefficient is discussed later in this box.[3]

[2]The regressions are estimated using ordinary least squares. All variables are expressed in natural logarithm levels. Value-added trade weights are used to aggregate bilateral real exchange rates, and the consumer price index (CPI) is used to deflate nominal exchange rates. Real trade volumes are obtained by deflating nominal volumes by the CPI. Controls include own and partner country demand and others specified in the note to Table 3.1.1. Note that in the global value chain import equation, partner—rather than domestic—demand is used as a regressor to account for the fact that the imports are intended for reexport and hence depend on external demand conditions.

[3]Inclusion of this interaction term is grounded in a theoretical model, available in Cheng and others, forthcoming.

The main findings of the analysis reported in Table 3.1.1 are as follows:

- A real appreciation not only reduces exports of domestic value added (a conventional result), but also lowers imports of foreign value added (contrary to the traditional view). This latter result is consistent with the notion that global-value-chain-related domestic value added and foreign value added are complements in production, so producing and exporting less domestic value added also reduces the derived demand for imported foreign value added.
- A larger foreign-value-added share in gross global-value-chain-related exports tends to dampen the response of domestic value added and foreign value added to REER changes. This finding is shown by the positive coefficients on the interaction between REER and the foreign-value-added share in the second row of Table 3.1.1. Intuitively, this result is consistent with the notion that when a country's own domestic-value-added contribution in gross global value chain exports is relatively small, a change in its REER will have only a modest effect on the competitiveness of the entire supply chain, thereby muting the domestic-value-added and foreign-value-added responses to a change in the country's own REER.

The dampening effect on global value chain import and export elasticities from an increase in the foreign-value-added share is illustrated in Figure 3.1.2. When the foreign-value-added share is very small (corresponding to a large domestic-value-

**Table 3.1.1. Responses of Global-Value-Chain-Related Trade to the Real Effective Exchange Rate**

| | (1) | (2) |
|---|---|---|
| Variables | Imports (FVA) | Exports (DVA) |
| Lagged Log (REER-Value-Added-Based) | –1.390*** | –1.670*** |
| | (–2.822) | (–3.527) |
| Lagged Log (REER) x Lagged (FVA/DVA + FVA) | 0.027*** | 0.026*** |
| | (3.166) | (3.330) |
| Lagged Log (Demand) | 1.108*** | 0.758*** |
| | (5.961) | (4.470) |
| Time Fixed Effects | Yes | Yes |
| Country Fixed Effects | Yes | Yes |
| Additional Controls | Yes | Yes |
| Clustering | Country level | Country level |
| Number of Observations | 699 | 699 |
| $R^2$ | 0.733 | 0.681 |

Source: IMF staff calculations.

Note: Specifications – $\log(\mathit{Exports\ [Imports]\ volume})_{c,t} = \alpha t + \alpha c + \alpha_1 \log(\mathit{REER})_{c,t-1} + \alpha_2 \text{interaction term} + \alpha_3 \log(\mathit{Demand})_{c[w],t-1} + \alpha \log(\mathit{Controls})_{c,t} + \varepsilon_t$. Additional controls included in the specifications are log of real stock of foreign direct investment, foreign-value-added share, tariffs, and output gap. Demand is proxied by GDP. DVA = domestic value added; FVA = foreign value added; GVC = global value chain; REER = real effective exchange rate. Robust *t*-statistics in parentheses.

***$p < .01$.

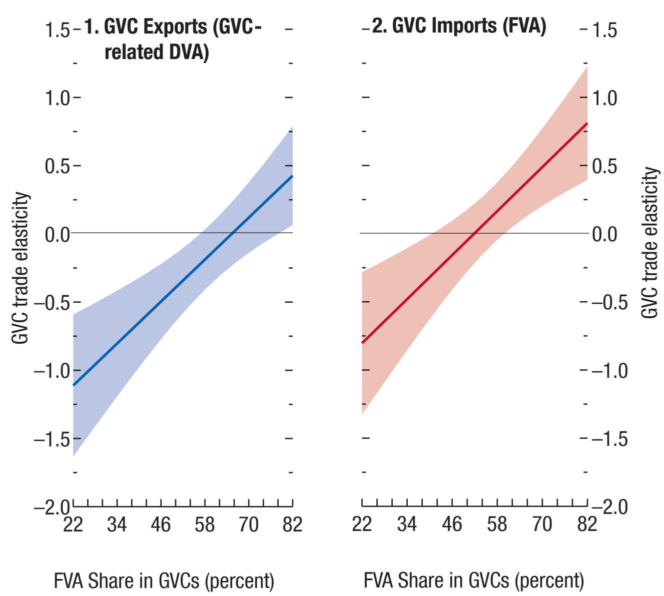
## Box 3.1 *(continued)*

added contribution), the spillover from a country's exchange rate depreciation onto the competitiveness of the entire supply chain is correspondingly large. Therefore, the elasticities are negative and close to the "own effect" coefficients of row 1 of Table 3.1.1, causing both global-value-chain-related domestic value added and global-value-chain-related foreign value added to increase. As the foreign-value-added share rises—corresponding to a smaller own domestic-value-added contribution to the global value chain—the spillover benefit from an own depreciation on the competitiveness of the entire supply chain (second row in the table) declines, resulting in smaller (negative) global value chain trade elasticities. When the foreign-value-added share rises to 50–60 percent, the competitiveness benefit for the entire supply chain from an own depreciation is neutralized by the corresponding relative appreciation in global value chain partners' REERs, leading to zero import and export elasticities. With even larger foreign-value-added shares, import and export elasticities can become positive, although the relevance of the positive REER elasticity for global value chain trade appears to be limited in practice.[4]

Overall, it is worth recalling that although global value chain trade has grown considerably in recent decades, conventional trade remains important—if not dominant—at the global level. As additional analysis confirms, even for countries in the sample with the smallest domestic-value-added contributions and the largest global value chain trade shares, a depreciation is found to improve the real trade balance.

[4]The positive REER is irrelevant for two reasons. First, the estimated export elasticities corresponding to foreign-value-added shares of 50–80 percent lie within the 90 percent confidence interval spanning zero, suggesting that the elasticities are not statistically distinguishable from zero. For import elasticities, the corresponding foreign-value-added share range is 38–62 percent, but above this range, a positive elasticity cannot be rejected. Second, the maximum foreign-value-added contribution to global-value-chain-related gross exports for any country in the data set is less than 80 percent, with the average foreign-value-added share about 50–60 percent. Thus, most countries operate in the range in which global value chain elasticities are about zero.

**Figure 3.1.2. Global Value Chain Trade Elasticities**




Source: Cheng and others, forthcoming.
Note: Shaded areas denote 90 percent confidence intervals. DVA = domestic value added; FVA = foreign value added; GVC = global value chain.

## Box 3.2. Measuring Real Effective Exchange Rates and Competitiveness: The Role of Global Value Chains

The real effective exchange rate (REER) is a widely used demand-based indicator of competitiveness.[1] Standard theory postulates that countries produce differentiated products and compete with one another to sell their products on world markets, and demand for products responds to relative prices. The rise of global value chains poses a challenge to this conventional view as countries increasingly specialize in adding value to a particular state of production rather than producing entire finished products. This practice means that countries compete to supply value added, rather than supply gross exports, to world markets.

This box, therefore, discusses two main questions related to the increased role of global value chains in international trade:

- How does the rise of global value chains affect the measurement of competitiveness and REERs?
- How do these new measures of competitiveness and REERs differ from the conventional measures?

The rise of global value chains requires a rethinking of the relationship between exchange rates and competitiveness. Consider, for example, the effect of a yuan depreciation on China's Asian trading partners. According to the conventional view, yuan depreciation unambiguously increases demand for Chinese goods and lowers demand for goods produced elsewhere in Asia. As a result, depreciations are beggar-thy-neighbor. When trade in inputs and specialization in stages of production are prevalent, this conventional view becomes incomplete. Because production in China is linked to its Asian supply chain partners, the yuan depreciation can make the supply chain's final product more competitive, stimulating demand for value added at each stage of production. This outcome counterbalances the conventional beggar-thy-neighbor channel. Which channel dominates is ultimately an empirical matter.

Bems and Johnson (2015) present a model framework that extends the conventional demand-side analysis to include supply-side linkages. The extended framework incorporates two key features pertaining to global value chains. First, by modeling intermediate production inputs, the framework distinguishes between gross and value-added concepts in trade (in terms of both quantities and prices). Second, there are two distinct margins of substitution (with potentially differing elasticities): substitution in final demand and substitution in production (between value added and intermediate inputs or across inputs). The latter captures substitution in supply chains.

The extended framework alters the conventional link between exchange rates and competitiveness in three important ways: different weights, different price indices, and country-specific trade elasticities.

### *Different Weights*

The weights used in the construction of these new REER measures of Bems and Johnson (2015) depend on both input-output linkages and relative elasticities in production versus consumption. In contrast, conventional REER weights are constructed using gross trade flows. Accounting for input-output linkages and differences in elasticities can significantly alter REER weights. Bilateral weights can even become negative, if competitiveness gains for supply chain partners outweigh the beggar-thy-neighbor effects (as in the yuan depreciation example earlier).

Figure 3.2.1 illustrates this general result by comparing REER weights that trading partners assign to China and Germany. The figure includes three sets of weights for each country: conventional consumer price index (CPI)–based REER weights; input-output REER (IOREER) weights, which account for both input-output linkages and the variation in elasticities; and the intermediate case of value-added REER (VAREER) weights that impose equal elasticities in production and consumption.[2]

Consistent with standard intuition, neighboring countries that trade a great deal with China, such as Korea, Japan, and Malaysia, attach the largest weights to China in the conventional CPI-based REER indices.[3] Relative to this benchmark, countries that are integrated into the supply chains with China and "Factory Asia" put less weight on China in the newly proposed REER indices. VAREER weights are reduced for China's supply chain partners because value-added trade flows, on which the VAREER is based, eliminate

The authors of this box are Rudolfs Bems and Marcos Poplawski-Ribeiro.

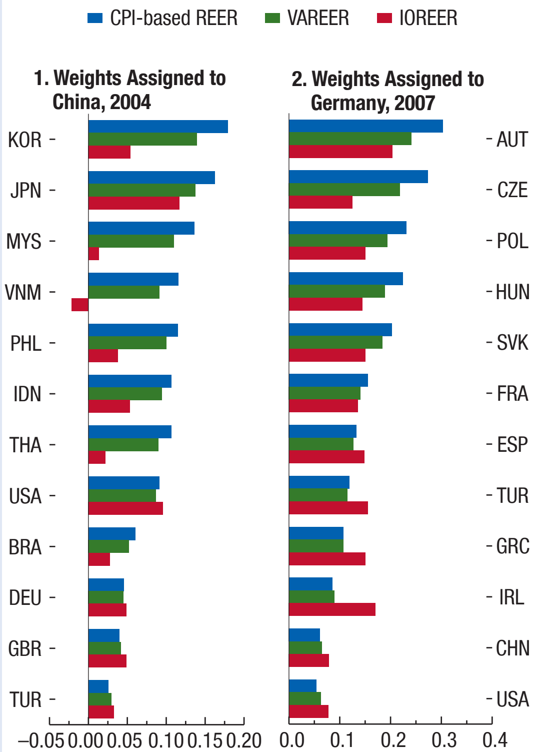
[1]Competitiveness for the purposes of this box is defined as a change in demand for a country's output induced by changes in international relative prices.

[2]For VAREER weights Bems and Johnson (2015) show that value-added trade flow data are sufficient for the weight construction.

[3]These large weights reflect the fact that in conventional macroeconomic analysis, large bilateral gross trade flows signify intense head-to-head competition.

## Box 3.2 *(continued)*

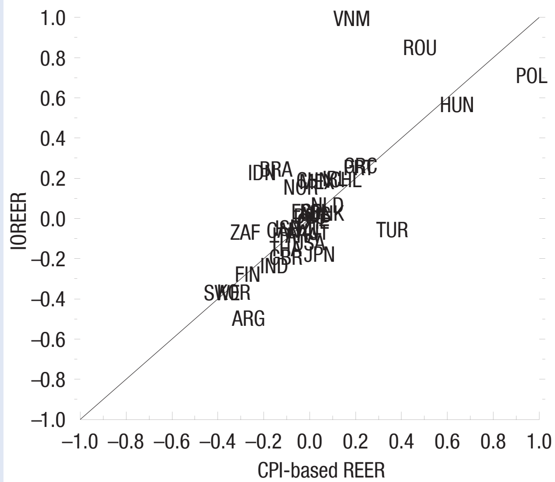
### Figure 3.2.1. Real Effective Exchange Rate Weights Assigned to China and Germany




Sources: Bems and Johnson 2015; and IMF staff calculations.
Note: CPI = consumer price index; IO = input-output; REER = real effective exchange rate; VA = value added. Data labels in the figure use International Organization for Standardization (ISO) country codes.

### Figure 3.2.2. Comparison of Conventional and Input-Output Real Effective Exchange Rates

*(Log changes, 1990–2009)*




Sources: Bems and Johnson 2015; and IMF staff calculations.
Note: CPI = consumer price index; IO = input-output; and REER = real effective exchange rate. Data labels in the figure use International Organization for Standardization (ISO) country codes.

"round-tripping," which is more prevalent within the region. These weight shifts are further amplified when production elasticities are relatively low, as captured by the IOREER index. This is the case because low production elasticities emphasize the role of substitution in final demand, as opposed to the within-region substitution in supply chains. For some countries, weights attached to China fall dramatically, with an offsetting rise in weights elsewhere. For Vietnam, a decline in Chinese prices actually raises Vietnamese competitiveness in the IOREER case, as captured by Vietnam's negative IOREER weight.[4]

The basic insights from the Chinese example carry over to the case of Germany, reported in panel 2 of Figure 3.2.1. Conventional REER weights are largest for Germany's regional trading partners. The VAREER and IOREER weights, relative to the conventional ones, fall the most for the European Union accession countries (the Czech Republic and Poland, for example) because of supply chain linkages. The magnitudes of the weight changes can be substantial. For example, moving from the conventional REER to the IOREER roughly halves the weight that the Czech Republic attaches to Germany.

#### *Different Price Indices*

By distinguishing between gross flows and value added, the model framework provides clear guidance on how to combine REER weights and prices to measure competitiveness, where prices need to be measured using GDP deflators. Figure 3.2.2 reports REER changes during the 1990–2009 period, constructed

[4]Bems and Johnson (2015) find that the total weight attached by a typical Asian country to its Asian partners is 15 percentage points lower in the IOREER index than in a conventional CPI-based REER index.

## Box 3.2 *(continued)*

using historical input-output data and observed price changes for the period. IOREER indices can differ substantially from conventional (CPI-based) REER indices, both because of differences in weights and because of different measures of price changes.[5] However, over this long horizon (19 years), the bulk of the divergence between the two REER indices reflects persistent differences in the two price measures (CPI and GDP deflators). At the same time, the two measures of the REER are strongly correlated, partly because the vast majority of trade does not consist of global-value-chain-related trade.[6] This observation also implies that biases in estimated value-added trade relations due to incorrectly using standard REERs are likely to be small.

### *Country-Specific Trade Elasticities*

Conventional measures of competitiveness rely on a universal trade elasticity that translates effective price developments into changes in economic activity and hence competitiveness. In contrast, with two distinct margins of substitution—final demand and production—trade elasticities in the extended framework are country specific. If production is less responsive to price changes than is final demand,[7] countries that are more involved in global value chains (for example, China), and hence trade more in intermediate inputs, will in the aggregate exhibit lower trade elasticities than countries that trade more in final consumption goods (for example, the United States). In the latter case, the more price-sensitive final demand is weighted more heavily in the aggregate trade elasticity. One implication is that with country-specific aggregate trade elasticities, the REER index alone is an incomplete statistic for measuring competitiveness.[8]

Overall, global value chains change the measurement of competitiveness and REERs. Relative to the conventional benchmark, global value chains change both the weights and the prices that are used in the construction of REER indices. Global value chains can allow countries to benefit from improvements in the competitiveness of supply chain partners, which can counteract the standard beggar-thy-neighbor channel.

What do these findings mean for the relationship between trade and exchange rate movements? On the one hand, if production is less sensitive to relative price changes than is final demand, aggregate trade elasticities should be lower in countries that are more integrated in global value chains. On the other hand, if consumption is less price sensitive than is production, then countries that are more integrated into global value chains should exhibit higher aggregate trade elasticities.

[5]Bems and Johnson (2015) further show that value-added exchange rates capture competitiveness developments missed by conventional indices in important episodes.

[6]A regression of the IOREER measure on the CPI-based REER yields a slope coefficient of 0.89 that is statistically significant at the 1 percent level.

[7]For example, in the case of the so-called Leontief production function, in which there is no substitutability between production factors.

[8]Furthermore, with the worldwide rise of global value chains, value-added trade elasticities should decrease for the average country over time. For a more in-depth discussion of the role of value-added elasticities in the measurement of competitiveness, see Bems and Johnson 2015.

## Box 3.3. Japanese Exports: What's the Holdup?

After rebounding from collapse during the global financial crisis, real goods exports from Japan have remained broadly flat during the past few years despite a sharp depreciation of the yen since late 2012. Following aggressive monetary easing by the Bank of Japan, the yen has depreciated by about 35 percent in real effective terms during that period. This depreciation has come after a sharp yen appreciation from 2008 to 2011. So what explains the subdued recovery of Japanese exports? This box focuses on three interconnected explanations: lower pass-through from exchange rates to export prices, offshoring of production, and deeper involvement in global value chains.

### *A Sluggish Export Recovery*

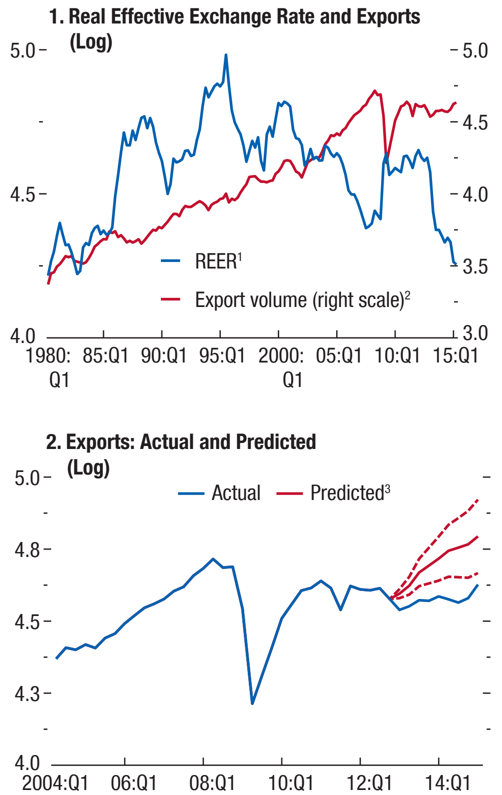
The recent pace of export recovery in Japan is much slower than could be expected based on the usual response of exports to external demand and the exchange rate. Exports are currently some 20 percent below the level predicted by a standard export demand equation estimated for the pre-Abenomics period (Figure 3.3.1).[1]

### *Lower Pass-Through to Export Prices*

Japanese exporters have long demonstrated pricing-to-market behavior by maintaining the stability of their export prices in overseas markets and absorbing exchange rate fluctuations through profit margins. This practice results in limited exchange rate pass-through to export prices. Since the onset of yen depreciation in 2012, export prices in yen have risen sharply, and Japanese exporters' profit margins have surged by some 20 percent (Figure 3.3.2, panel 1).[2] (Exporters also experienced a sizable compression in profit margins during the sharp yen appreciation from 2008 to 2011 and have been rebuilding margins since.)

Incomplete exchange rate pass-through to export prices has been prevalent in Japan for some time, but evidence indicates that exchange rate pass-through has recently declined further (Figure 3.3.2, panel 2).

**Figure 3.3.1. Japan: Exchange Rate and Exports**




Sources: IMF, Information Notice System; and IMF staff calculations.
[1]REER denotes consumer price index–based real effective exchange rate.
[2]Goods exports.
[3]Out-of-sample prediction for third quarter of 2012 through first quarter of 2015 based on export demand equation estimated through third quarter of 2012. Dashed lines indicate 90 percent confidence intervals.

The authors of this box are Nan Li and Joong Shik Kang.

[1]The export demand equation is based on an error correction model specification and is estimated on data from the first quarter of 1980 through the third quarter of 2012:

$$\Delta \ln EX_t = c + \Sigma_{i=1}^{4} \beta_{1i} \Delta \ln EX_{t-i} + \Sigma_{i=1}^{4} \beta_{2i} \Delta \ln REER_{t-i} + \Sigma_{i=1}^{4} \beta_{3i} \Delta \ln D_{t-i} - \gamma(\ln EX_{t-1} - \alpha_1 \ln REER_{t-1} - \alpha_2 \ln D_{t-1}) + \varepsilon_t,$$

in which *EX* denotes the export volume, *REER* denotes the real effective exchange rate, and *D* is foreign demand—measured by the weighted average of trading partners' real GDP. The specification also includes dummy variables for the crisis (taking a value of 1 from the third quarter of 2008 through the first quarter of 2009) and for the 2011 earthquake (taking a value of 1 in the first and second quarters of 2011).

[2]Exporters' profit margins are proxied by 1 minus the ratio of the input cost to the export price.

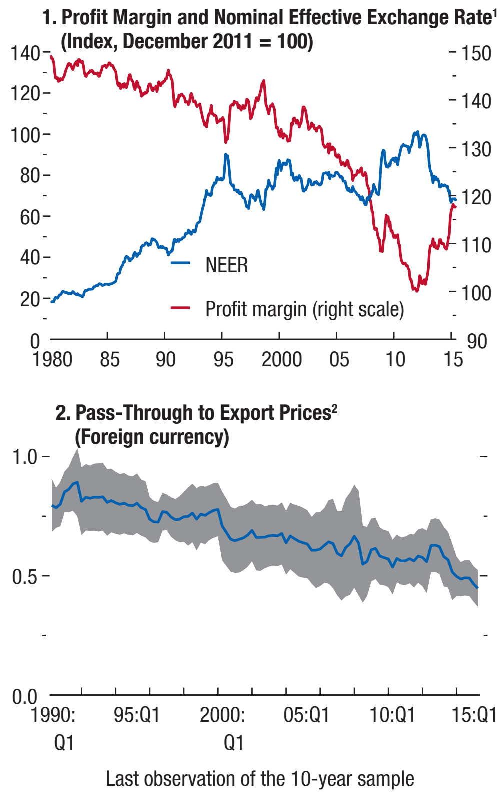
## Box 3.3 *(continued)*

Analysis based on rolling regressions suggests that exchange rate pass-through has declined from near 85 percent during the 1980s to about 50 percent in recent years (Figure 3.3.2). In other words, a 10 percent yen depreciation reduced export prices by about 8.5 percent in the 1980s, but now reduces them by only 5 percent.[3] This observation suggests that if the pass-through had remained at the level of the 1980s, foreign export prices would have fallen by almost 30 percent since 2012, compared with the actual decline of 17 percent. Based on the estimated price elasticity of exports, this larger decline, in turn, could have boosted exports by an additional 6 percent.[4] Note, however, that in the medium term, exchange rate pass-through is likely to increase. Ree, Hong, and Choi (2015) find that exchange rate pass-through to export prices occurs over about five years in Japan, albeit not to a full extent, which would imply stronger export growth in the future.

### *Production Offshoring*

During the past two decades, Japanese firms have expanded abroad to exploit labor cost differentials and rising demand in host countries. The pace of offshoring has accelerated since the global financial crisis, arguably as a reflection of the sharp appreciation of the yen in 2008–11 and uncertainty about the energy supply after the 2011 earthquake (Figure 3.3.3). Overseas investment by Japanese subsidiaries now accounts for about 25 percent of total manufacturing investment. Overseas sales—the sum of exports and sales by Japanese subsidiaries—have risen by more than 60 percent in value since 2011, which is much faster than the growth rate for domestic exports (14 percent), and now account for about 60 percent of total sales (Kang and Piao 2015). This trend increase in investment and sales overseas suggests that intrafirm trade has become much more important. This finding could help explain the decline in exchange rate pass-through, given that intrafirm transactions are less subject to the impact of exchange rate fluctuations.[5]

**Figure 3.3.2. Exchange Rate, Profits, and Pass-Through**




Sources: Haver Analytics; and IMF staff calculations.
Note: NEER = nominal effective exchange rate.
[1]Exporters' profit margins are proxied by 1 minus the ratio of the input cost to the export price normalized to 100 for December 2011.
[2]Estimated percent change in export prices in foreign currency resulting from a 1 percent nominal effective appreciation.

[3]The analysis is based on rolling regressions using the following specification and 10-year rolling windows with quarterly data, starting with the window beginning in the first quarter of 1980 and ending in the fourth quarter of 1989:

$$\Delta \ln P^X_t = \alpha + \Sigma^4_{i=0}\, \beta_i\, \Delta \ln NEER_{t-i} + \Sigma^4_{i=0}\, \gamma_i\, \Delta \ln C_{t-i} + \Sigma^4_{i=0}\, \delta_i\, \Delta \ln CP_{t-i}, \quad (3.3.1)$$

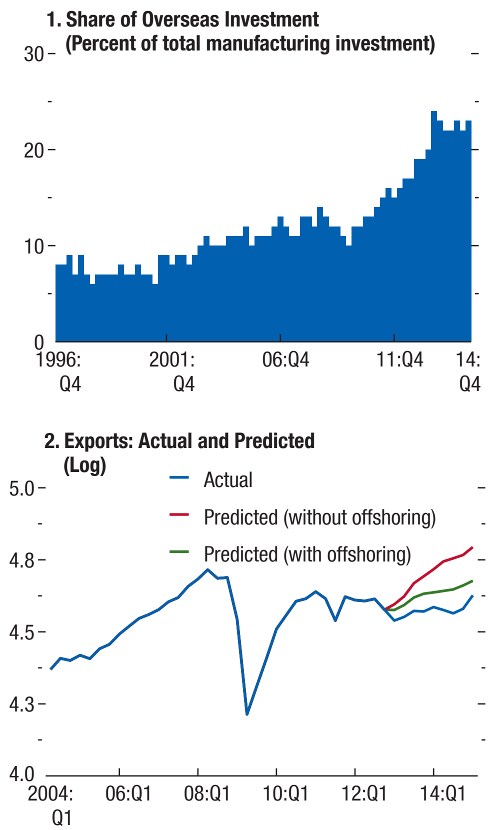
in which $P^X_t$ stands for the export price index in foreign currency, $C_t$ is the input cost index, and $CP_t$ is the competitors' price index, which is proxied by trading partners' GDP deflator. The sum of the coefficients on the exchange rate, $\Sigma^4_{i=0}\, \beta_i$, corresponds to the pass-through rate of the nominal effective exchange rate (*NEER*) to export prices in the destination country after one year. Using the consumer price index and import price index as alternative proxies for $CP_t$ and including more lags in the regression yield similar results.

[4]The estimated one-year elasticity of exports to foreign export prices used here is 0.5 and is obtained by reestimating the exports equation while substituting export prices for the *REER* terms.

[5]There is evidence that Japanese intrafirm trade is largely concentrated in the main exporting industries, such as trans-

## Box 3.3 *(continued)*

**Figure 3.3.3. Offshoring and Exports**




Sources: Haver Analytics; and IMF staff calculations.

To what extent does Japan's lackluster export performance reflect this shift toward offshoring? To address this question, the export model estimated is augmented to control for the degree of offshoring, proxied by the share of overseas investment in total investment in Japan's manufacturing sector. The resulting out-of-sample forecasts come much closer to tracking the observed flat performance of Japan's exports since 2012 (Figure 3.3.3, panel 2). This result is consistent with the view that increases in production offshoring have decreased domestic exports, offsetting the positive impact of the yen depreciation on exports.

### *Deeper Involvement in Global Value Chains*

Japanese exports are dominated by high-value-added products: electrical machinery, transportation equipment, and machinery, accounting for more than 60 percent of exports. These sectors are specialized, are not easily substitutable, and are tightly connected to global value chains.

During the past two decades, Japan has been increasingly involved in global value chains. According to the Organisation for Economic Co-operation and Development–World Trade Organization Trade in Value Added (TiVA) database, foreign value added as a percentage of Japan's gross exports (backward participation) increased between 1995 and 2009 from 6 percent to 11 percent (Figure 3.7). Meanwhile, Japan has also become a more important intermediate-input supplier for other countries' exports: domestically produced inputs used in third countries' exports (forward participation) rose from 22 percent to 33 percent during the same period. This places Japan among the countries experiencing the largest increase in the forward-participation rate. In addition, compared with other non-commodity-exporting countries, Japan is more specialized in sectors at the beginning of a value chain that are more intensive in research and design, as shown by the TiVA data. As Japan becomes more heavily involved in global value chains and as global value chains become ever more complex, exchange rate depreciation could be expected to play a less important role in boosting export growth of such global-value-chain-related goods.

Overall, the response of exports to the yen depreciation has been weaker than expected as a result of a number of Japan-specific factors. In particular, this weak response largely reflects the acceleration in production offshoring since the global financial crisis. It also reflects deeper involvement of Japanese production and trade in global value chains and a decline in the strength of the short-term exchange rate pass-through.

portation equipment and electrical machinery, which have been the most active in expanding overseas and accounted for almost three-quarters of total overseas investment as of 2014. This type of intrafirm trade involves exports of parts and components from Japanese parent firms to their foreign affiliates. The products produced or assembled by foreign affiliates in these industries are either sold in local markets or shipped to unrelated buyers in third-country markets. Therefore, the offshored production or sales by Japanese firms has increasingly become a "substitute" for domestic production or exports.

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