CHAPTER 2

EXCHANGE RATES AND EXTERNAL ADJUSTMENT

There is an ongoing debate about the role of exchange rates in facilitating external adjustment. This chapter explores how certain aspects of international trade, namely dominant currency pricing and international integration through global value chains, shape the working of exchange rates to induce external adjustment. The analysis suggests that the widespread use of the US dollar in trade pricing alters the short-term response of trade flows to exchange rate movements, with export volumes responding timidly to an exchange rate depreciation, while most of the adjustment takes place through import volumes. A more balanced adjustment process, through both export and import volumes, reemerges over the medium term. Meanwhile, greater integration into global value chains reduces the exchange rate elasticity of gross trade volumes, both in the short and medium term, but the associated increase in gross trade flows largely offsets this effect in most cases. Overall, the results suggest that while these features of international trade affect the composition and timing of the external adjustment process, for most countries, there remain benefits of exchange rate flexibility, especially in the medium term. With more muted effects of exchange rates on trade flows in the short term, complementary policies may be needed in some cases to support exchange rate flexibility and facilitate external rebalancing.

Introduction

The notion that exchange rates play a key role in external adjustment has been at the core of modern conventional wisdom. Since the collapse of the Bretton Woods system, academic and policy analysis has been guided by the Mundell-Fleming framework, whereby exchange rate movements cause changes in relative prices, affecting demand and supply of tradable goods, thus inducing adjustment of export and import volumes. Through expenditure-switching effects, whereby export and import volumes respond to changes in prices of tradable goods relative to nontradable goods, the exchange rate provides a key adjustment mechanism for external rebalancing.

There is an ongoing debate, however, about whether increased complexities of international trade and finance have affected how exchange rates operate. Particular attention has been given to two features of international trade:

- *The dominant role of certain currencies in the invoicing of trade*, which challenges the Mundell-Fleming paradigm, at least in the short term, as the response of domestic prices of internationally traded goods and trade volumes to exchange rate movements depend on the currency in which trade is invoiced.[1] Movements of the exchange rate have different effects if prices are set and sticky in the currency of the producer, as assumed in the Mundell-Fleming framework, or in other currencies.[2]
- *The growing importance of global value chains*, whereby countries' cross-border transactions increasingly entail importing intermediate goods, adding some value, and reexporting them. Greater foreign-value-added content may also entail lower sensitivity of gross trade flows to exchange rate movements in part because trade prices and marginal costs move in tandem.[3,4] Integration into international supply chains also means that upstream and downstream third-party exchange rate movements can affect a country's gross trade flows.

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[1]The terms "pricing" and "invoicing" are used interchangeably throughout the discussion. The key notion underlying both terms relates to prices being sticky in the currency in which they are priced and generally invoiced.

[2]See a fuller discussion in Gopinath (2015); Casas and others (2017); Boz, Gopinath, and Plagborg-Møller (2018); and Gopinath and others (2018).

[3]See related work in, among others, Amiti, Itskhoki, and Konings (2014); Bems (2014); Borin and Mancini (2019); Chapter 3 of the IMF's October 2015 *World Economic Outlook*; Cheng and others (2015); Bems and Johnson (2017); Leigh and others (2017); Bayoumi and others (2018); and De Soyres and others (2018).

[4]Low substitutability between domestic and foreign intermediate goods—due, for example, to difficulties in rearranging production—may also play a role in reducing overall gross trade elasticities.

This chapter sheds light on the empirical importance of the mechanisms whereby invoicing of trade in a dominant currency and integration into global value chains affect the external adjustment process. The relevance of these features, and how they shape the adjustment process, is assessed by studying the response of trade prices and quantities to exchange rate movements, in a panel setting encompassing bilateral *manufacturing trade* among 37 advanced and emerging market economies. The analysis uses newly constructed data on bilateral prices and quantities (from Boz and others (forthcoming) and novel measures of value-chain-related exchange rate shocks. Because these features relate to nominal and real rigidities that may play different roles at different time horizons, special attention is given to their importance in the short versus medium term. Some caveats are worth highlighting. While this work sheds light on the relevance of these specific features in shaping manufacturing trade elasticities, other relevant aspects and country-specific factors, like the role of services trade and balance sheet vulnerabilities, are not considered. In addition, the analysis takes as given the invoicing of trade and global value chain integration, recognizing that these two features are dependent on each other, as well as on other country-specific factors.[5] The rest of the discussion is organized as follows: the second section, "Currency of Trade Invoicing," presents empirical evidence and discusses the implications of the dominant role of the US dollar in trade invoicing. The third section, "Global Value Chains," studies the role of global value chains in shaping trade elasticities. The last two sections, "Conclusions and Policy Implications" and "Future Considerations," conclude with policy implications and considerations for future research. Further details on the empirical analysis can be found in Online Annex 2.1.

Currency of Trade Invoicing

The currency of trade invoicing has bearing on the external adjustment process. With stickiness in nominal prices, the currency of invoicing plays a key role in determining the degree of exchange rate pass-through (that is, how exchange rate changes translate into changes of prices in domestic currency) and the associated response of trade volumes. Trade flows between two countries will respond to changes in their bilateral exchange rate if transactions between them are priced in the currency of either trading partner. If trade is priced in third-country currencies, however, movements of exchange rates vis-à-vis those third-country currencies become relevant, and possibly more important than bilateral exchange rates. Therefore, how exchange rates facilitate external adjustment much depends on the price setting mechanism of internationally traded goods:

- *When prices are set in the currency of the producer*—as the Mundell-Fleming framework assumes—exchange rate depreciation entails an increase in country *a*'s import prices, measured in domestic currency, inducing lower import demand (Table 2.1). The depreciation also entails a fall in the prices faced by its trading partners in their respective domestic currencies, inducing higher demand for country *a*'s exports. Overall, there is a balanced response, involving import and export volumes, to the exchange rate.
- *When prices are set in a third country's ("dominant") currency*, country *a*'s depreciation entails a similar increase in import prices in domestic currency and thus lower import demand. However, local currency prices faced by trading partners are unchanged as their exchange rates vis-à-vis the dominant do not change. Thus, trading partners' demand for country *a*'s exports and, correspondingly, country *a*'s export volumes do not respond to the currency depreciation.[6] The result is an *unbalanced response* in trade volumes.

Major currencies, and the US dollar in particular, play a dominant role in pricing of international trade. For most countries, the share of exports and imports

Table 2.1. Short-Term Effect on (*a*–*b*) Country Pair Trade Flow of Country *a*'s Depreciation (Vis-à-Vis All Currencies)—An Example[1]

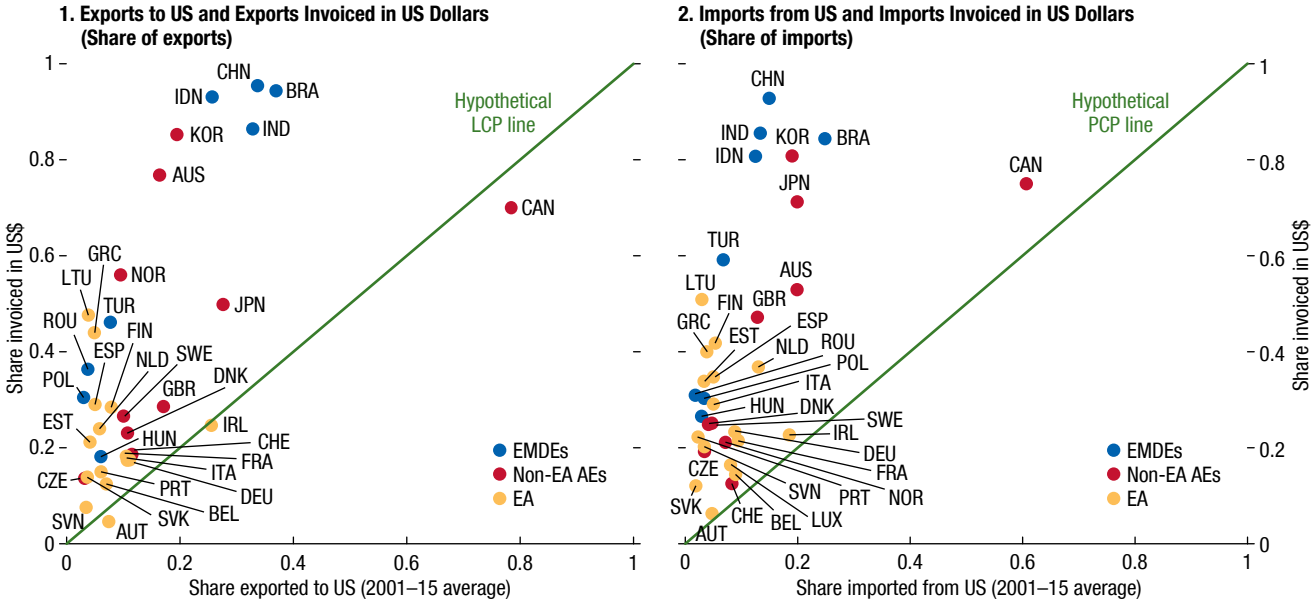
	Destination Price	Producer Currency Pricing	Dominant Currency Pricing
Exports ($a \rightarrow b$)	P^b	$P^b\downarrow$; $Q_{a\rightarrow b}\uparrow$	$\overline{P^b}$; $\overline{Q_{a\rightarrow b}}$
Imports ($a \leftarrow b$)	P^a	$P^a\uparrow$; $Q_{a\leftarrow b}\downarrow$	$P^a\uparrow$; $Q_{a\leftarrow b}\downarrow$

Source: IMF staff calculations.
[1]Under local currency pricing—not illustrated in the table—destination prices do not vary with exchange rate movements.

[5]The existence of global value chains and trade in intermediate inputs is one reason for exporters to invoice in a dominant currency. Determinants of invoicing currencies may also include market structure features and capacity constraints. See related discussion in Casas and others (2017) and Boz, Gopinath, and Plagborg-Møller (2018).

[6]In this example, and because prices are sticky in the currency in which trade is invoiced, trade volumes are demand-determined.

Figure 2.1. Trade with United States and US Dollar Invoicing



Sources: Gopinath (2015); World Input-Output Database 2016; and IMF staff calculations.
Note: AEs = advanced economies; EA = euro area; EMDEs = emerging market and developing economies; LCP = local currency pricing; PCP = producer currency pricing. Data labels use International Organization for Standardization (ISO) country codes.

invoiced in US dollars is significantly greater than the corresponding share of exports to and imports from the United States, respectively. This indicates that the US dollar plays a dominant role in trade invoicing—that is, it is used in the pricing of trade between country pairs that do not include the United States (Figure 2.1). This pattern is particularly marked in emerging market and developing economies, although it is also visible in key advanced economies (for example, Australia, Japan, Korea). The euro is also used significantly in international trade, although its role is considerably narrower than that of the US dollar.[7] Similarly, partial data indicate that invoicing in other major currencies (for example, British pounds, yen, swiss francs, and renminbi) is significant only in cross-border transactions involving the economies that issue those currencies.

The empirical relevance of invoicing currencies and their implications for external adjustment are explored in an econometric specification that models bilateral trade flows. Building on Gopinath (2015) and Boz, Gopinath, and Plagborg-Møller (2018), the role of the US dollar in trade pricing is studied in a panel setting that models prices and quantities of bilateral manufacturing trade among 37 advanced and emerging market economies during 1990–14.[8] The framework is extended to disentangle price and quantity responses to bilateral and US dollar exchange rates, from both the exporter's and importer's perspective, which allows for computation of the trade balance response.[9] A depreciation vis-à-vis the US dollar implies that the currencies of both the country of interest and its trading partners depreciate vis-à-vis the US dollar (the exchange rate between the country of interest and non-US trading partners remains unchanged). A bilateral depreciation implies a movement vis-à-vis a trading partner only (the exchange rates between the country of interest and other trading partners remain unchanged). The case of a country's depreciation vis-à-vis all (US dollar and other) currencies is analyzed separately below. Contemporaneous and lagged effects (up to three years)

[7]Boz, Gopinath, and Plagborg-Møller (2018) documents that the US dollar dominates over the euro as an invoicing currency, as the former has greater explanatory power in estimations of exchange rate pass-through and trade volume elasticities.

[8]The sample is smaller than the one used in Boz, Gopinath, and Plagborg-Møller (2018) primarily because it is restricted to countries with data on global-value-chain-related trade, an aspect explored later in the chapter. The country sample is still representative of the global economy, accounting for about 85 percent of world GDP.

[9]On the exporter (importer) side, the focus is on depreciations of the exporter's (importer's) currency and their effects on trade volumes and prices expressed in the exporter's (importer's) domestic currency.

are explored to shed light on short- and medium-term dynamics. See Online Annex 2.1 for further details.[10]

The empirical evidence on exchange rate pass-through confirms the importance of the US dollar, especially in the short term. Specifically:[11]

- *In the short term (same year as the shock)*, the exchange rate vis-à-vis the US dollar is a statistically and economically important driver of trade prices in domestic currency (that is, exchange rate pass-through) even after controlling for the bilateral exchange rate (Figure 2.2, panel 1). This reflects the fact that the US dollar is used for trade pricing in a significant number of bilateral transactions that do not involve the United States. Moreover, the average effect of the US dollar exchange rate is higher than that of the bilateral exchange rate for trade prices expressed in both the exporter's and importer's currency, suggesting also that the US dollar is used more than the individual currencies of the respective trading partners (that is, it plays a dominant role). Specifically, while a 1 percent change in the bilateral exchange rate leads to only a 0.2 percent change in trade prices in the exporter's currency, on average, a 1 percent variation in the exchange rate vis-à-vis the US dollar is associated with a 0.45 percent change in those prices. Results from an importer perspective are also consistent with a dominant role of the US dollar.[12] Moreover, results on the dominance of the US dollar are starker in unweighted regressions (shown in Online Annex 2.1), which give equal weights to large and small economies and, thus, represent more closely the prevailing patterns in the latter group, where US dollar invoicing is more pervasive.
- *In the medium term (three years after the shock)*, when US dollar prices are more flexible, the relative importance of the exchange rate vis-à-vis the US dollar diminishes, whereas the bilateral exchange rate plays a relatively greater role in affecting trade prices in domestic currency. For example, the average US dollar pass-through to export prices falls from 0.45 in the short term (same year) to 0.25 in the medium term (three-year horizon), whereas the pass-through from the bilateral exchange rate rises slightly from 0.2 to 0.25. The reduced importance of the US dollar exchange rate over the medium term is also visible from an importer's perspective.[13]
- Direct evidence examining the link between exchange rate pass-through and the observed degree of trade invoiced in US dollars for a subset of countries corroborates the dominance of the US dollar in the short term (Figure 2.2, panel 2). For example, in countries with high US dollar invoicing, pass-through from bilateral exchange rates to export-currency prices averages 0.1 compared with 0.7 from the US dollar exchange rate. The order of magnitude of these estimates changes to 0.3 and 0.2, respectively, for countries with low US dollar invoicing. Over the medium term, the effects of US dollar invoicing are visible, but less pronounced.

The dominant role of the US dollar affects the response of export and import volumes to exchange rate movements (Figure 2.3). For countries other than the United States:[14]

- *In the short term*, bilateral export volumes respond positively to a bilateral exchange rate depreciation (that is, an appreciation of the trading partners' currency alone). However, bilateral exports respond negatively to a depreciation only vis-à-vis the US

[10]The econometric approach aims at identifying average effects of exchange rate variations on prices and quantities without attempting to identify specific sources of shocks, as done in other studies. With prices being sticky in US dollars, the effect of exchange rate changes on domestic currency prices is well identified. For quantities, omitted variable bias is a greater source of concern, although a rich set of controls, and robustness checks—including various measures of import demand and unit labor costs, among others—lend support to the baseline results. See Online Annex 2.1 for further details.

[11]Estimates differ somewhat in magnitude from those reported in Gopinath and others (2018) due to the smaller country sample, although results are qualitatively consistent.

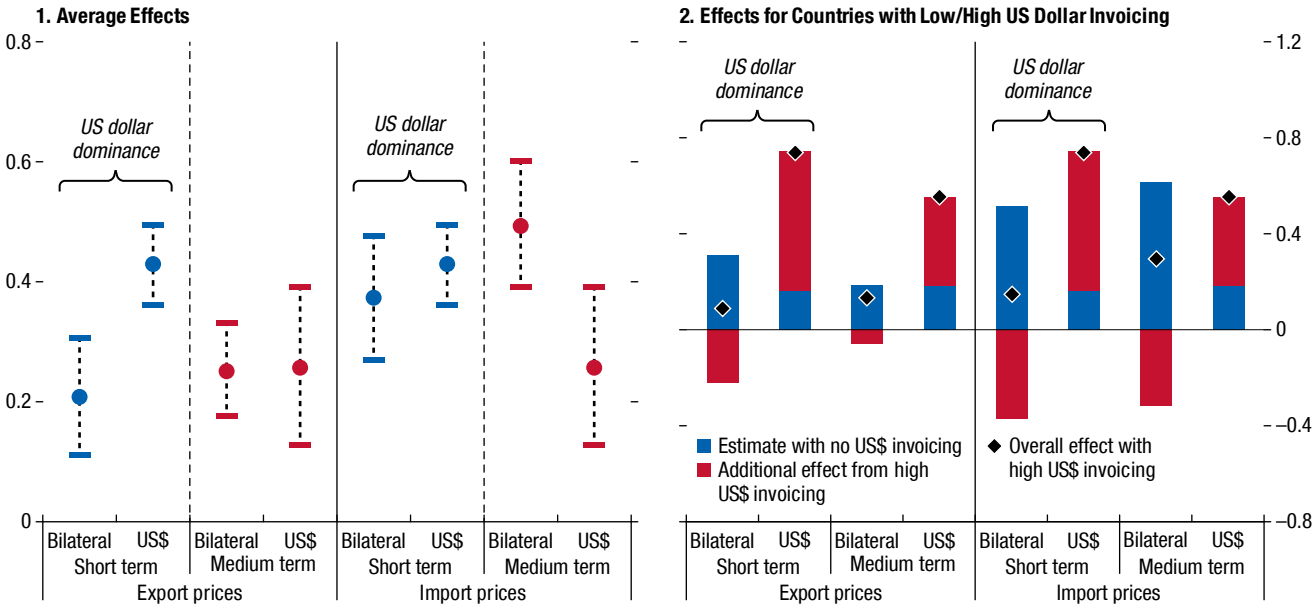
[12]Pass-through from a depreciation vis-à-vis the US dollar is broadly the same for prices in the exporter's and the importer's currency. In contrast, depreciations vis-à-vis the trading partner only—captured by changes in the bilateral exchange rate—have a lower pass-through into exporter-currency prices (when the exporter's currency depreciates) than the pass-through into importer-currency prices (when the importer's currency depreciates). These results are consistent with the prevalence of producer currency pricing over local currency pricing in trade that is not invoiced in US dollars.

[13]As before, while the pass-through from changes in the exchange rate vis-à-vis the US dollar are symmetric for prices in the currency of the exporter and the importer, the pass-through from changes in bilateral exchange rates is higher for prices in the importer's currency than for prices in the exporter's currency (consistent with the prevalence of producer currency pricing in trade not invoiced in US dollars). A possible explanation is that prices adjust more quickly than wages. As prices become flexible over the medium term while wages continue to be sticky, price and quantity outcomes resemble the case of producer currency pricing.

[14]For the United States, a depreciation of the US dollar entails limited effects through imports as prices in US dollars remain largely unchanged, while exports increase on account of higher demand from the rest of the world (as their prices in local currency of trading partners fall).

Figure 2.2. Exchange Rate Pass-Through from Bilateral and US Dollar Exchange Rates[1]

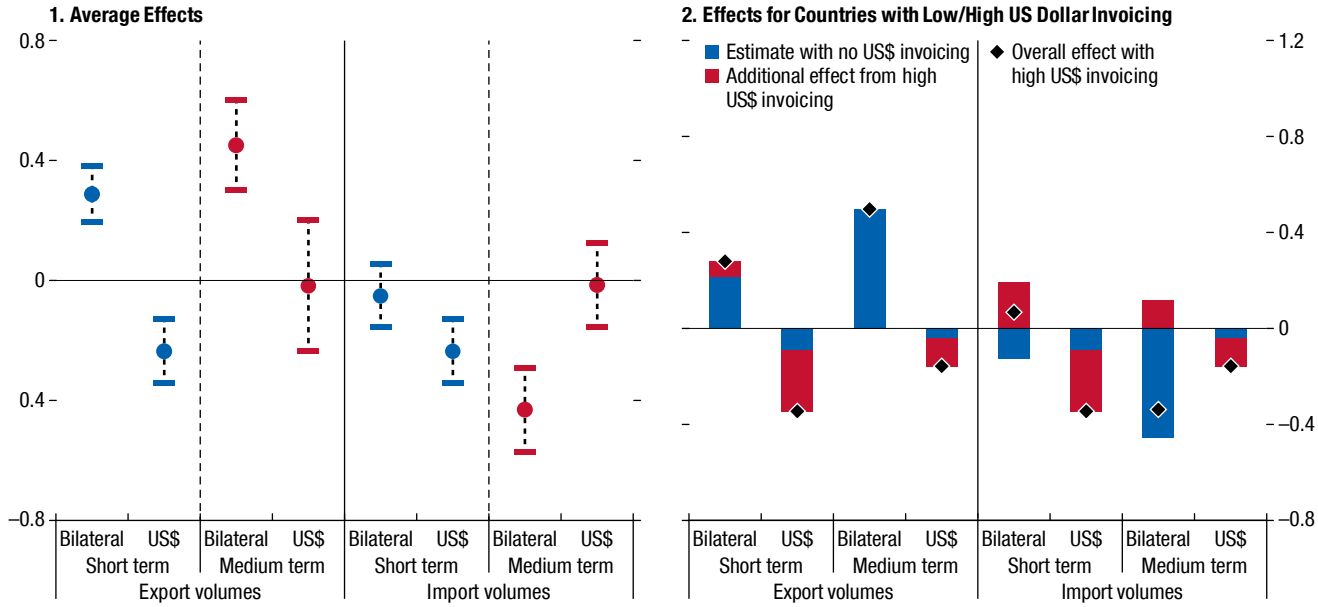
(Weighted regressions)



Sources: IMF staff estimates based on data sets from Gopinath and others (2018) and Boz and others (forthcoming).
[1]An increase in either exchange rate implies a depreciation of the domestic currency of the exporter, for export prices (trade prices in the exporter's currency), and a depreciation of the domestic currency of the importer for import prices (trade prices in the importer's currency). Panel 1 reports point estimates and 95 percent confidence bands. See Online Annex 2.1 for details on methodology and country sample.

Figure 2.3. Estimated Trade Volume Elasticities to Bilateral and US Dollar Exchange Rates[1]

(Weighted regressions)



Sources: IMF staff estimates based on data sets from Gopinath and others (2018) and Boz and others (forthcoming).
[1]An increase in either exchange rate implies a depreciation of the domestic currency of the exporter, for export volumes, and a depreciation of the domestic currency of the importer, for import volumes. Panel 1 reports point estimates and 95 percent confidence bands. See Online Annex 2.1 for details on methodology and country sample.

Table 2.2. Short-Term Effects of a 10 Percent Depreciation vis-à-vis All Other Currencies[1]

	Prices (Percent)		Volumes (Percent)		Trade Balance (Percent of GDP)[2]
	Exports	Imports	Exports	Imports	
Indirect Estimation (Average effect)	6.31***	7.95***	0.516	–2.88***	0.322***
Direct Estimation[3]					
Low US Dollar Invoicing	4.81***	6.84***	1.26***	–2.16***	0.256
High US Dollar Invoicing	8.28***	8.96***	–0.59	–2.77***	0.276*

Notes: *** p < 0.01, ** p < 0.05, * p < 0.1.
[1] Combined effects of bilateral and US dollar exchange rates are reported.
[2] Trade balance response refers to overall effect through prices and quantities, expressed in percent of GDP (for the median trade openness ratio).
[3] Estimation taking into account observed US dollar invoicing shares. Low (high) US dollar invoicing corresponds to 0 and the 99th percentile of the distribution.

dollar (that is, when trading partners also depreciate vis-à-vis the US dollar), as the latter implies that the (non-US) trading partner faces higher trade prices in domestic currency and, thus, lowers its demand for imports. This result is also consistent with studies linking shifts in global trade volumes to global shift in the US dollar vis-à-vis all currencies (see further discussion in Box 2.1). Import volumes, in contrast, respond limitedly to a bilateral depreciation (that is, an appreciation of the trading partner alone), as import prices remain largely unchanged, while more pronouncedly to a depreciation vis-à-vis the US dollar, as the latter entails an increase in import prices in the importer's currency.

- *In the medium term*, as prices in the currency of invoicing adjust, both export and import volumes display greater sensitivity to bilateral exchange rate movements, while the effect of the US dollar exchange rate becomes economically and statistically insignificant.
- Direct evidence of the influence of US dollar invoicing on trade volume elasticities corroborates the results on the dominant role of the US dollar in the short term (Figure 2.3, panel 2).

Overall, the composition of the external adjustment process is influenced by the dominance of the US dollar, in the near term. The empirical evidence (Table 2.2) indicates that the response of the trade balance to a depreciation of a country's currency vis-à-vis all others is limited in the near term, mostly reflecting subdued responses from trade volumes, especially exports. US dollar invoicing contributes to the latter, altering the export/import and price/quantity composition of the adjustment process. Specifically, US dollar invoicing is associated with:

- *Unbalanced volume responses.* While import volumes fall in response to the depreciation, irrespective of the extent of US dollar invoicing, export volumes react less with greater US dollar invoicing. As discussed above, the latter reflects that local currency prices faced by trading partners are unchanged—as their exchange rates vis-à-vis the US dollar do not vary—and so are their demand for imports.
- *Greater (and more symmetric) price responses.* Prices in the exporter's and importer's currency react similarly under high US dollar invoicing, in comparison with a more asymmetric response under low US dollar invoicing (the latter being consistent with producer currency pricing).
- *Taking these results on prices and quantities together*, in the short term, US dollar invoicing alters the price/quantity composition of external adjustment, with higher US dollar invoicing levels leading to

Table 2.3. Medium-Term Effects of a 10 Percent Depreciation vis-à-vis All Other Currencies[1]

	Prices (Percent)		Volumes (Percent)		Trade Balance (Percent of GDP)[2]
	Exports	Imports	Exports	Imports	
Indirect Estimation (Average effect)	5.07***	7.50***	4.32***	–4.50***	1.177***
Direct Estimation[3]					
Low US Dollar Invoicing	3.81***	8.09***	4.56***	–4.97***	0.963***
High US Dollar Invoicing	6.95***	8.62***	3.38***	–4.96***	1.228***

Notes: *** p < 0.01, ** p < 0.05, * p < 0.1.
[1] Combined effects of bilateral and US dollar exchange rates are reported.
[2] Trade balance response refers to overall effect through prices and quantities, expressed in percent of GDP (for the median trade openness ratio).
[3] Estimation taking into account observed US dollar invoicing shares. Low (high) US dollar invoicing corresponds to 0 and the 99th percentile of the distribution.

less adjustment through export quantities and more adjustment through prices (and, thus, markups).

Over the medium term, the influence of the dominant currency is more muted. Consistent with greater price flexibility at longer horizons, the evidence points to less influence of US dollar invoicing over the medium term, with more symmetric export and import volume responses and greater asymmetry between export and import prices (Table 2.3). That is, the conventional expenditure-switching mechanism through both exports and imports reemerges in the medium term.

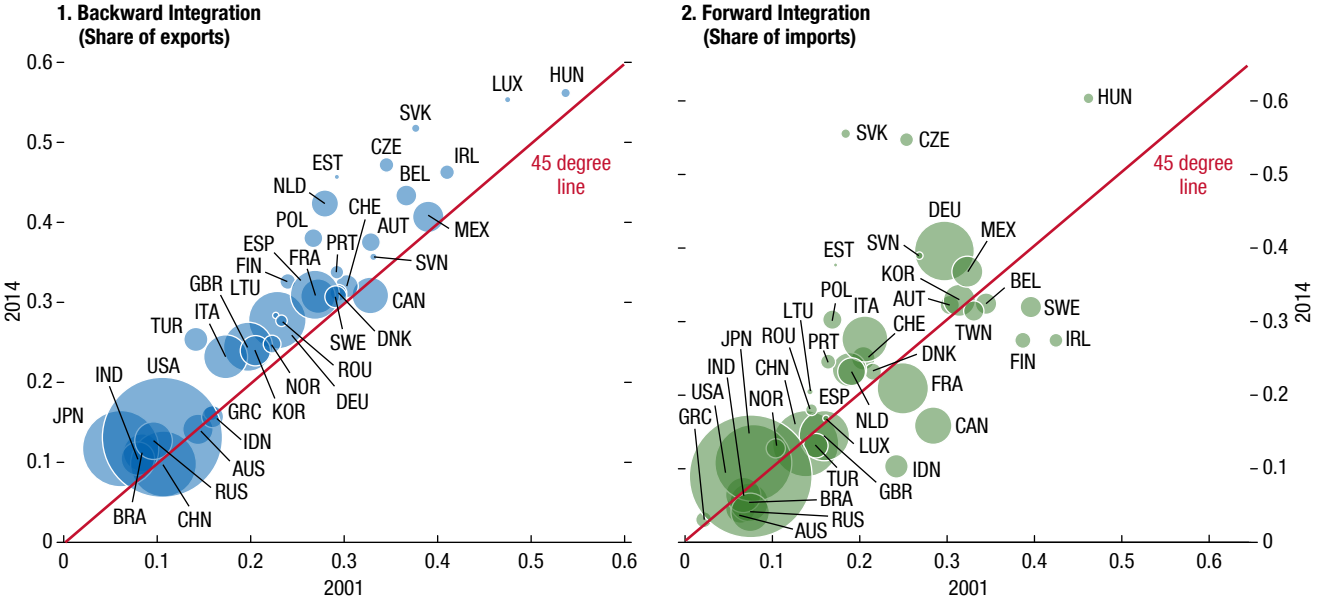
Global Value Chains

This section explores how integration into international supply chains can influence the workings of exchange rates.

- A country's degree of integration into global value chains affects how gross trade flows respond to different exchange rates. Greater integration into value chains entails a larger extent of trade in intermediate goods that are reexported (after adding some domestic value). This has two direct implications (see a fuller discussion on the economics of global supply chains in Box 2.2).
- Exchange rates beyond those of the immediate trading partners become relevant, as currency shifts of upstream suppliers (backward integration) and downstream buyers (forward integration) affect the whole supply chain.
- Shifts in the value of a country's currency may have more muted effects on its gross trade flows. A depreciation of a country's currency, for example, would have more muted effects on its exports volumes as the latter include imported intermediate goods (backward participation) and, thus, the depreciation would raise export prices (in local currency) but also production costs. In addition, demand for intermediate goods from foreign downstream buyers (forward integration) may respond less to the exchange rate depreciation if demand for intermediate goods is inelastic due to adjustment costs in production.

Most economies have become increasingly integrated into global value chains, although differences across countries are large. This process of integration started before the sample period considered in the analysis (see, for example, Johnson and Noguera 2014, 2017; and Duval and others 2014, 2016) and continued through the 2000s, although at a slower pace, leading to sizable differences across countries (Figure 2.4). While

Figure 2.4. Integration into Global Value Chains, 2001–14
(Manufacturing, trade-weighted average across trading partners)



Sources: World Input-Output Database; and IMF staff calculations.
Note: Data labels in the figure use International Organization for Standardization (ISO) country codes.

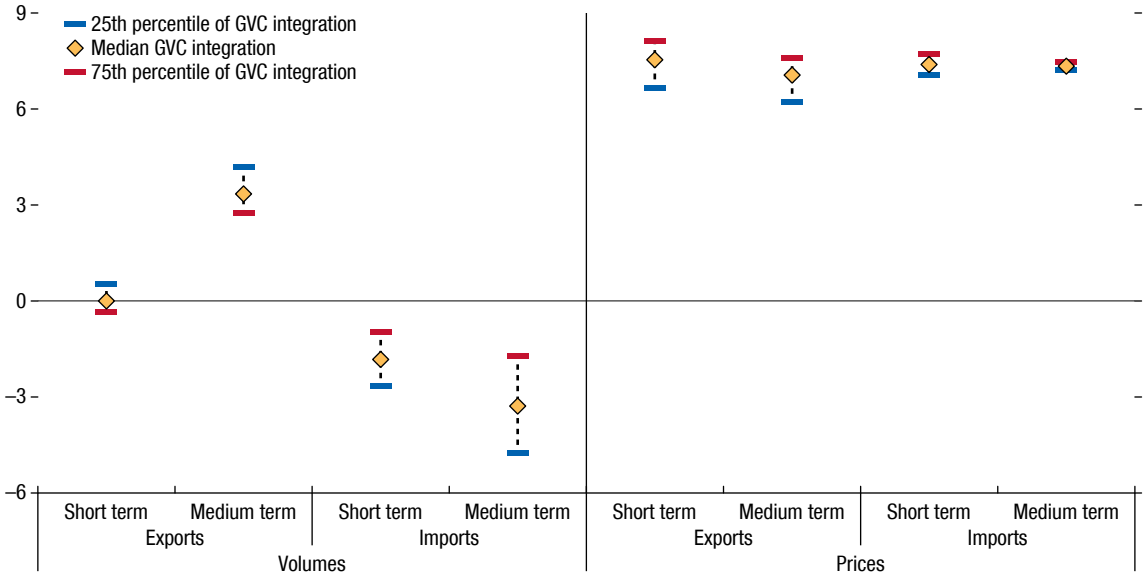
a considerable share of today's global trade remains non-value-chain-related, the degree of integration through value chains is significant in some cases, especially in small economies where, for example, the import content of exports (backward integration) can reach one-third to one-half.[15] This is the case, for example, in economies such as Belgium, the Czech Republic, Hungary, and the Slovak Republic, which are heavily integrated into European value chains. In contrast, for large systemic economies (for example, China, Japan, United States) traditional trade still dominates.

The influence of global value chain integration on the external adjustment process can be explored by extending the empirical framework used to study the role of dominant currencies. Specifically, the framework is modified to study how traditional trade elasticities are affected by the impact of third-country exchange rates on both marginal costs (backward integration) and the demand for intermediate inputs (forward integration). Data on domestic and imported intermediate inputs from the 2016 World Input-Output Database, available for 2001–14, are matched with the bilateral trade data from Boz and others (forthcoming) to measure the importance of global value chain linkages among country-pairs, decomposing corresponding prices and quantities. The extended framework takes into account the role of dominant currency invoicing in intermediate goods trade by building measures of global value chain integration with bilateral and US dollar exchange rates (see Box 2.3). While integration into global value chains is one of the determinants of US dollar invoicing, the framework allows for these effects to operate independently.

Greater global value chain integration dampens gross trade volume elasticities. Consistent with the theory and previous country-specific studies, results indicate that, for a given degree of trade openness (that is, exports- or imports-to-GDP ratio), greater global value chain integration dampens the exchange

[15]Measures of global-value-chain-related trade considered in this analysis focus on manufacturing goods that cross international borders (as an intermediate good or embedded in a final good) at least twice and, thus, form an international value chain. Other, less stringent definitions (for example, Organisation for Economic Co-operation and Development 2018) focus on all cross-border transactions in intermediate goods and services and, thus, imply higher levels of value-chain-related trade.

Figure 2.5. Trade Flow Responses and Global Value Chain Integration[1]
(Response to a 10 percent depreciation vis-à-vis all currencies, weighted regression)



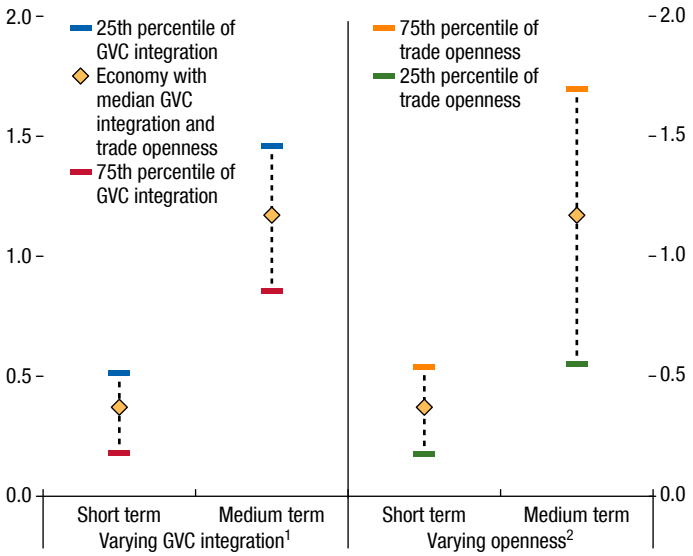
Sources: Boz and Cerutti (forthcoming); Gopinath (2015); World Input-Output Database 2016; and IMF staff estimates.
Note: GVC = global value chain.
[1]Openness for the median economy.

rate elasticity of gross trade volumes, lowering the response of both exports and imports through backward and forward linkages (see Figure 2.5 and Box 2.2). This dampening effect is not only relevant in the short term but also in the medium term, pointing to, among other things, persistent rigidities in production due to international value chain integration (see Box 2.4 for further analysis on the importance of production rigidities). For example, while the medium-term exchange rate elasticity of export volumes for a country with a low degree of integration into global value chains (25th percentile of the distribution, both backward and forward) is about 0.45, this elasticity drops to 0.3 for a country in the 75th percentile. Similarly, import volume elasticities are considerably different between the two cases, at –0.5 and –0.25 for countries with a low and high degree of integration, respectively. Meanwhile, greater global value chain integration leads to somewhat higher exchange rate pass-through to both export and import prices reflecting, respectively, the greater sensitivity of marginal costs and input demand to exchange rate changes, although the effects are small in general. The results indicate that the dominant role of the US dollar is partly related to exporters' use of imported intermediate goods (that is, linked to global-value-chain trade) but also goes beyond, as the patterns of exchange rate pass-through and effects on volumes remain significant even after including global value chain measures in the framework.[16]

The sensitivity of the trade balance to exchange rates falls with greater global value chain integration. Combining the estimated impact on prices and quantities, the results indicate that, for a given level of trade openness, greater global value chain participation entails a more muted response of the trade balance to the exchange rate both in the short and medium term (Figure 2.6). Conversely, for a given level of global value chain integration, greater trade openness increases the overall responsiveness of the trade balance in terms of percentage points of GDP.

Greater integration into global value chains is associated with higher trade openness. While disentangling the share of trade that is created by participating in global value chains is empirically challenging, greater integration into value chains is generally associated with larger trade flows, as moving toward the use of

Figure 2.6. Influence of Global Value Chain and Trade Openness on Trade Balance Response to Exchange Rate
(Response to a 10 percent depreciation vis-à-vis all currencies)



Source: IMF staff estimates.
Note: GVC = global value chain.
[1]Openness fixed at the level of the median economy.
[2]Backward and forward GVC integration fixed at the level of the median economy.

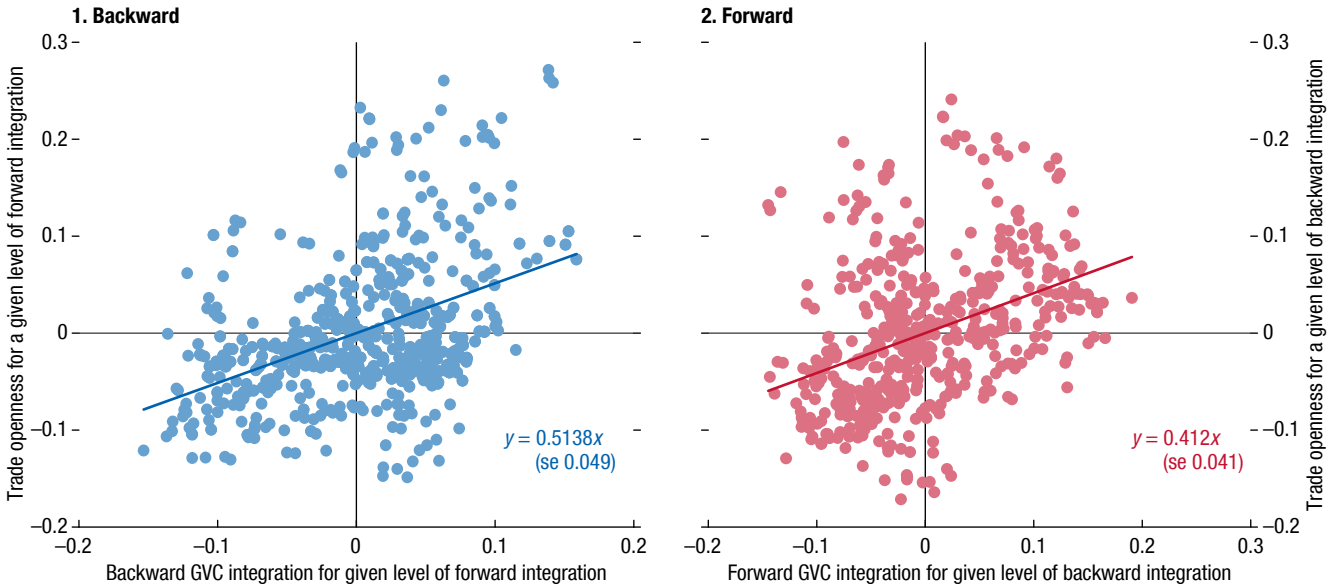
imported intermediate inputs frees domestic factors of production, which can be used to produce and export other goods and services. Such positive relationship between global value chain integration and trade openness is strong in the data (Figure 2.7).

Taking into account the degree of both global value chain integration and trade openness, trade balance elasticities appear to be different across countries but broadly stable over time. The distribution of medium-term trade balance elasticities resulting from the analysis displays significant variance, indicating considerable heterogeneity across countries although, for most cases, estimated responses are economically meaningful (Figure 2.8, panel 1). For the average country (in terms of global value chain integration and trade openness), a 10 percent depreciation is estimated to lead to an increase in the trade balance of about 1 percentage point of GDP.[17] Moreover, such estimates do not appear to have changed much since early 2001, mainly as the effect of increasing global value chain integration has been largely offset by the

[16]See further discussion in the Online Annex 2.1.

[17]This magnitude is broadly consistent with previous estimates in the literature (although considerably lower than estimates of tariff elasticities. See, for example, Head and Mayer (2014).

Figure 2.7. Partial Correlation between Trade Openness and Backward/Forward Global Value Chain Integration



Sources: World Input-Output Database; and IMF staff calculations.
Note: GVC = global value chain; se = standard error.

accompanying increase in trade openness (Figure 2.8, panel 2).[18]

Conclusions and Policy Implications

The increasing complexity of international trade requires a granular analysis of cross-country linkages and exchange rates to understand the dynamics of external adjustment. As countries price their trade in currencies other than those of immediate trading partners or become more integrated into global value chains, the set of exchange rates that can impact a country's external position becomes more difficult to identify and the composition and dynamics of external adjustment change. Where dominant currency invoicing is pervasive, traditional metrics of effective exchange rates—which focus on currencies of trading partners rather than invoicing currencies—may be less informative to understand *short-term* adjustment dynamics, although they remain relevant to shed light on *medium-term* dynamics. Thus, competitiveness metrics that take invoicing currencies into account would complement traditional metrics well. Similarly, with high integration into global value chains, exchange rates vis-à-vis immediate trading partners become less relevant, while other downstream and upstream exchange rates become more relevant. In addition, the traditional view that a country competes with trading partners may not fully reflect value chain complementarities, especially if supply chains are rigid as suggested by the data. Thus, taking into account input linkages would be a valuable refinement to existing effective exchange rates measures, particularly for some small economies that are highly integrated into global value chains.[19] Given that data limitations remain an obstacle in many cases, improved data collection efforts are essential.[20]

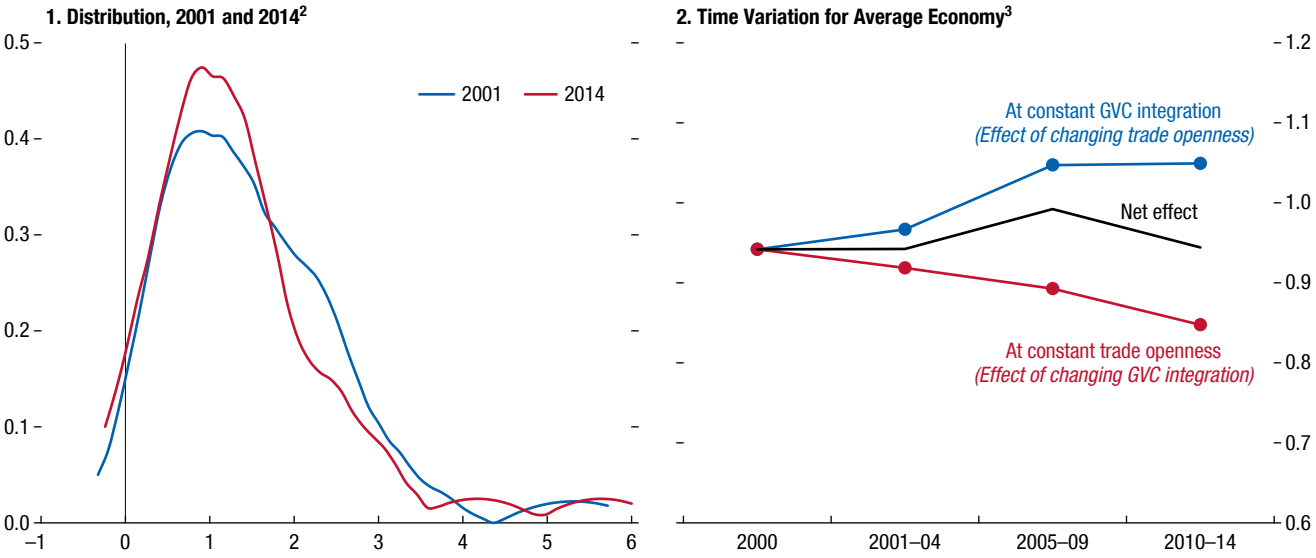
Exchange rate flexibility may need to be supported with other policies. The findings suggest that exchange rate changes have muted effects on the trade balance in the short term, including because of the limited response of export volumes. Thus, where external

[18]Although trade openness has increased over time, the calculations of the trade-balance effect assume constant GDP, as the impact of exchange rate changes through trade flows should be of second order importance for most countries. Modeling how trade flows changes affect GDP is beyond the scope of the analysis.

[19]See Bems and Johnson (2017) for details on constructing value-added real effective exchange rate measures.

[20]A Working Group on Balance of Payments Statistics Relevant for Global Value Chain Analysis was formed in 2017 to advance the collection and compilation of related statistics.

Figure 2.8. Trade Balance Response—Distribution and Variation over Time, 2000–14[1]
(Response to a 10 percent depreciation vis-à-vis all currencies, percent of GDP)



Source: IMF staff estimations.
Notes: GVC = global value chain.
[1]Cross-section and time series differences are based on varying degrees of global value chain integration and trade openness.
[2]Density of estimated medium-term trade balance responses to a 10 percent depreciation vis-à-vis all currencies across all countries in the sample.
[3]Estimated trade balance elasticity for the average economy in the sample, allowing for changes in GVC integration or trade openness, one at a time, or both (net effect).

deficits are excessive, achieving meaningful near-term external adjustment may require larger exchange rate movements—which may have adverse balance sheet effects and feed into inflation—and/or tighter macroeconomic policies. Even in cases with no evident external imbalances, weak near-term buffering effects of exchange rates suggest that other policy tools may be needed to achieve full employment in the event of a negative shock.

Exchange rate mechanisms can be strengthened with structural policies. Price stickiness in dominant currencies partly reflects frictions that limit exporters' responses to exchange rate movements, including capacity constraints. For example, firms may choose to price trade and maintain those prices in US dollars despite exchange rate movements when capacity constraints prevent them from reaping the benefits of expanding sales by lowering US dollar prices.[21] Thus, the benefits of exchange rate flexibility could be bolstered by macroeconomic and structural policies that alleviate such capacity constraints, including through improved access to credit and transportation infrastructure.

Overall, exchange rate flexibility remains key to facilitating external adjustment. While the analysis indicates that the features of international trade studied in this chapter may affect the composition and strength of exchange rate effects in the short term, it also indicates that the conventional exchange rate mechanisms are present in the medium term. Thus, while other temporary policies may be needed to support exchange rate flexibility in the near term, these should not be thought of as substitutes for exchange rate flexibility, which remains a key mechanism to facilitate durable external adjustment.

Future Considerations

Understanding the choice of invoicing currencies and the associated price stickiness, as well as the intrinsic rigidities of global value chains, is key to the design of policy responses. The analysis in this chapter considered currency of invoicing and global value chain

[21]See, for example, Casas and others (2017). In some cases, the weak export response may reflect exchange rate uncertainties and associated adjustment costs from irreversibility.

participation as exogenous features of international trade. Pricing strategies likely depend on the extent of integration into global value chains, and both these features of international trade reflect multilayered decisions shaped by numerous country features, including expectations about exchange rate policies. A deeper analysis of the factors that shape these decisions is necessary for a fuller view on optimal policy design.

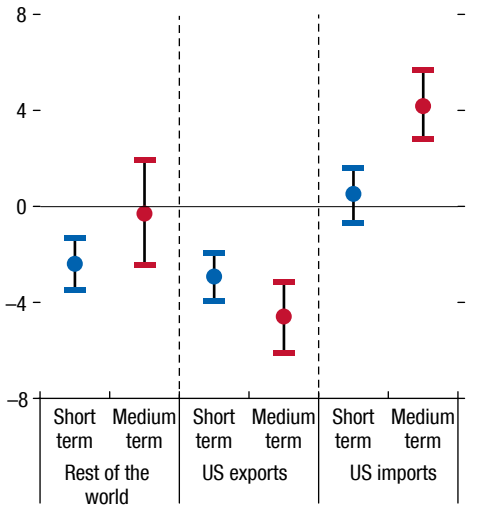
Other country characteristics and fundamentals can have bearing on how exchange rates affect the external adjustment process. Understanding whether the chapter's findings on manufacturing trade apply to services trade (such as tourism)—which relies more on nontradable inputs—is essential to a fuller picture of the process of external adjustment for some countries. In addition, external balance sheet vulnerabilities mentioned earlier can also play a role in shaping the workings of exchange rates in the adjustment process. Further efforts are necessary to integrate empirically these additional trade and financial features.

Box 2.1. US Dollar Shifts and Global Trade

The widespread use of the US dollar in trade invoicing implies that *global* movements in the value of US dollar (vis-à-vis all other currencies) may have short-term implications for global trade.[1] This box discusses the estimated short-term effects of a strengthening of the US dollar on global trade implied by the empirical results presented in the main text (see Figure 2.1.1).[2]

- *United States:* Because a large share of exports and imports are priced in US dollars, an appreciation of the US dollar vis-à-vis other currencies can affect export and import volumes asymmetrically, in the short term. Since the price of imports US consumers face is largely unchanged, so will be import demand. Export volumes, on the other hand, tend to contract in response to the appreciation of the US dollar as the rest of world faces higher domestic prices of tradable goods and thus demands fewer imports.
- *Other countries:* With the US dollar's dominant role in global trade invoicing, a depreciation of other currencies vis-à-vis the US dollar increases local currency prices of goods traded between country pairs excluding the United States. As a result, import demand contracts and, thus, trade volumes among countries in the rest of the world contract.

Figure 2.1.1. Trade Volume Responses to a 10 Percent Appreciation of the US Dollar[1]
(Weighted regression)



Sources: Data sets from Gopinath and others (2018) and Boz and others (forthcoming); and IMF staff estimates.
[1]Point estimates and 95 percent confidence bands are reported. See online Technical Appendix for details.

Over time, the adjustment in the United States becomes more balanced (with both export and import volumes reacting to exchange rate movements) and the effects on the rest of the world fade away, consistent with greater flexibility in trade prices.

The authors of this box are Gustavo Adler, Carolina Osorio Buitron, and Sergii Meleshchuk.

[1]See also Boz, Gopinath, and Plagborg-Møller (2018).

[2]This exercise sheds light on, among other things, the spillovers of US monetary policy through trade.

Box 2.2. The Economics of Global Value Chains: A Simple Example

Traditional trade: Historically, international trade has been dominated by the exchange of final goods or intermediate goods used for producing final goods consumed domestically. In this context, the most relevant exchange rate for trade flows between two countries, *a* and *b*—if priced in the currency of either country—was their bilateral exchange rate (e^{ab}).[1] Thus, bilateral exports and imports could be characterized simply as $T_{a\to b} = f[e^{ab}]$ and $T_{b\to a} = f[e^{ab}]$, respectively (Figure 2.2.1).

Global value chains: Over time, international trade has become more complex, with integration into global value chains entailing more trade in intermediate goods that are reexported, thus increasing the relevance of exchange rate movements vis-à-vis third-party countries. As shown in Figure 2.2.2, these third-country exchange rates can influence trade either through upstream suppliers (backward integration) or downstream buyers (forward integration):

- *Backward integration (BWD):* If exports from country *a* to country *b* ($T^a_{a\to b}$) contain intermediate goods imported from country *c*, the former bilateral trade flow would be affected not only by movements in the corresponding bilateral exchange rate (e_{ab}) but also by movements in *a*'s exchange rate vis-à-vis suppliers *c* (e_{ac}), as the latter would act as a supply shock by affecting country *a*'s marginal costs, $MC^a \equiv MC^a(e_{ac})$. That is: $T^a_{a\to b} \equiv T^a_{a\to b}(e_{ab}; e_{ac})$. If substitutability between domestic and foreign intermediate inputs is low, changes in e_{ac} would affect marginal costs in proportion to the imported intermediate input content. The higher the substitutability, however, the lower the impact of e_{ac} movements on marginal costs, as producers would substitute away from or toward imported intermediate goods. All else equal, backward global value chain integration implies that a depreciation of currency *a* vis-à-vis all other currencies would increase marginal costs and dampen the effect on export quantities relative to the traditional ("stand-alone") effect.
- *Forward integration (FWD):* If intermediate good exports from country *a* to *b* are reexported to third countries (*d*), trade flows from *a* to *b* will also be affected by movements in the exchange rate of country *b* vis-à-vis third countries (e_{bd}) as the latter will determine the demand for country *b*'s exports and, consequently, for intermediate goods from country *a*. This can be interpreted as a demand shock, $D \equiv D(e_{bd})$. Hence, $T^a_{a\to b} \equiv T^a_{a\to b}(e_{ab}; e_{ac}; e_{bd})$. The relevance of e_{bd} depends on the elasticity of substitution of final demand, the share of intermediate inputs in trade flows from *a* to *b*, and the share of output in *b* that is exported to *d* rather than consumed domestically.

Considering both backward and forward linkages, trade flows (prices and volumes) can be generically characterized as:

$$T^a_{a\to b} \equiv f^a_{a\to b}\left[\underbrace{e_{ab}}_{stand\text{-}alone}, \underbrace{MC^a_{a\to b}(e_{ac})}_{BWD}, \underbrace{D(e_{bd})}_{FWD}\right]$$

These backward and forward integration terms can also be thought of as supply and demand shifters

The authors of this box are Gustavo Adler, Carolina Osorio Buitron, and Sergii Meleshchuk.

[1]This example starts with local/producer currency pricing for simplicity. Below, it is extended to the case of a dominant currency (for example, US dollar) in trade invoicing.

Figure 2.2.1. Traditional Trade

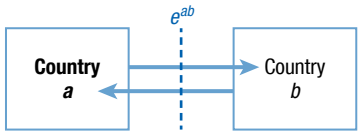
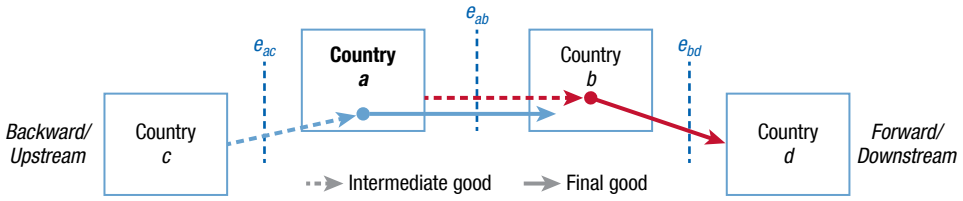


Figure 2.2.2. Example of Backward and Forward Linkages



Box 2.2 *(continued)*

Table 2.2.1. Effects of a Depreciation vis-à-vis All Other Currencies under Global Value Chain Integration

	Prices (in country *a*'s currency)		Quantities	
	Stand-alone	BWD/FWD Linkages	Stand-alone	BWD/FWD Linkages
Exports ($a \rightarrow b$)	+	+ (BWD)	+	– (BWD)
Imports ($b \rightarrow a$)	+	+ (FWD)	–	+ (FWD)

Source: IMF staff.

Note: BWD = backward integration; FWD = forward integration. Stand-alone denotes effects on prices for a combination of producer and consumer currency pricing.

associated with upstream and downstream third-country exchange rate changes, respectively. The inclusion of these shifters in the empirical framework is key to disentangling the effect of different exchange rates, as bilateral and third-country exchange rates can be correlated.

Global value chain and exchange rate effects: In the presence of global value chains, a depreciation of country *a*'s exchange rate vis-à-vis all other currencies ($de_{aj} = de \text{ for all } j$) would operate on *a*'s exports directly and through backward linkages as follows:

$$\frac{dT^a_{a\rightarrow b}}{de} = \underbrace{\frac{\partial f^a_{a\rightarrow b}(.)}{\partial e_{ab}}}_{\substack{stand-alone\\ bilateral}} + \underbrace{\frac{\partial f^a_{a\rightarrow b}(.)}{\partial MC^a_{a\rightarrow b}}\frac{\partial MC^a_{a\rightarrow b}(.)}{\partial e_{ac}}}_{\substack{BWD\\ bilateral}}$$

and it would affect imports directly and through forward linkages as follows:

$$\frac{dT^a_{b\rightarrow a}}{de} = \underbrace{\frac{\partial f^a_{b\rightarrow a}(.)}{\partial e_{ab}}}_{\substack{stand-alone\\ bilateral}} + \underbrace{\frac{\partial f^a_{b\rightarrow a}(.)}{\partial D_{b\rightarrow a}}\frac{\partial D_{b\rightarrow a}(.)}{\partial e_{ac}}}_{\substack{FWD\\ bilateral}}$$

The expected effects of an exchange rate depreciation vis-à-vis all other currencies are described in Table 2.2.1.

Combining global value chain and dominant currency pricing: In the more general case that allows for bilateral trade between two countries to be priced in third-country currencies (for example, US dollars), the *export equation* for $T^a_{a\rightarrow b}$ can be written as follows:

$$T^a_{a\rightarrow b} = f^a_{a\rightarrow b}\left[e_{ab}, e_{a\$}, MC^a_{a\rightarrow b}(e_{ac}, e_{a\$}), D_{a\rightarrow b}(e_{bd}, e_{b\$})\right]$$

while imports from *b* to *a* can be characterized, similarly, as:

$$T^a_{b\rightarrow a} = f^a_{b\rightarrow a}\left[e_{ab}, e_{a\$}, MC^b_{b\rightarrow a}(e_{bd}, e_{b\$}), D_{b\rightarrow a}(e_{ac}, e_{a\$})\right]$$

Thus, exchange rate changes would operate on *a*'s exports both directly and through backward linkages as follows:

$$\frac{dT^a_{a\rightarrow b}}{de} = \underbrace{\frac{\partial f^a_{a\rightarrow b}(\cdot)}{\partial e_{ab}}}_{\substack{stand-alone\\ bilateral}} + \underbrace{\frac{\partial f^a_{a\rightarrow b}(\cdot)}{\partial e_{a\$}}}_{\substack{stand-alone\\ vis-à-vis\ USD}} +$$

$$\underbrace{\frac{\partial f^a_{a\rightarrow b}(.)}{\partial MC^a_{a\rightarrow b}}\frac{\partial MC^a_{a\rightarrow b}(.)}{\partial e_{ac}}}_{\substack{BWD\\ bilateral}} + \underbrace{\frac{\partial f^a_{a\rightarrow b}(.)}{\partial MC^a_{a\rightarrow b}}\frac{\partial MC^a_{a\rightarrow b}(.)}{\partial e_{a\$}}}_{\substack{BWD\\ vis-à-vis\ USD}}$$

and affect *a*'s imports directly and through forward linkages as shown below.

$$\frac{dT^a_{b\rightarrow a}}{de} = \underbrace{\frac{\partial f^a_{a\rightarrow b}(\cdot)}{\partial e_{ab}}}_{\substack{stand-alone\\ bilateral}} + \underbrace{\frac{\partial f^a_{b\rightarrow a}(\cdot)}{\partial e_{a\$}}}_{\substack{stand-alone\\ vis-à-vis\ USD}} +$$

$$\underbrace{\frac{\partial f^a_{b\rightarrow a}(.)}{\partial D_{b\rightarrow a}}\frac{\partial D_{b\rightarrow a}(.)}{\partial e_{ac}}}_{\substack{FWD\\ bilateral}} + \underbrace{\frac{\partial f^a_{b\rightarrow a}(.)}{\partial D_{b\rightarrow a}}\frac{\partial D_{b\rightarrow a}(.)}{\partial e_{a\$}}}_{\substack{FWD\\ vis-à-vis\ USD}}$$

These equations take into account stand-alone as well as backward and forward exchange rate effects, both for movements vis-à-vis the bilateral currency and the US dollar.

Box 2.3. Measuring Global-Value-Chain-Related Exchange Rate Shocks at the Bilateral Level

The chapter's analysis is based on novel measures of exchange-rate-driven supply and demand shocks (or "shifters") that arise from upstream and downstream exchange rate movements, respectively. These capture how upstream and downstream changes in exchange rates affect marginal costs and demand, respectively. This box explains how these bilateral country pair ($a \rightarrow b$) exchange rate measures are constructed.

- *A backward (supply) shifter* can be constructed as the weighted sum of exchange rate movements of exporter a vis-à-vis its upstream suppliers. The weight for each upstream supplier c, denoted by $\omega^{B}_{a\rightarrow b,c}$, corresponds to the import content from c in exports from a to b:

$$\Delta \ln MC_{a\rightarrow b} = \sum_{c} \omega^{B}_{a\rightarrow b,c} \cdot \Delta \ln e_{ac}.$$

- *A forward (demand) shifter* is the weighted sum of exchange rate movements of importer b vis-à-vis its downstream buyers. The weight for each downstream buyer d, denoted by $\omega^{F}_{a\rightarrow b,d}$, corresponds to the exports from a to b, that are reexported to d:

$$\Delta \ln D_{a\rightarrow b} = \sum_{d} \omega^{F}_{a\rightarrow b,d} \cdot \Delta \ln e_{bd}.$$

The sums of the backward and forward weights, $\sum_{c} \omega^{B}_{a\rightarrow b,c}$ and $\sum_{d} \omega^{F}_{a\rightarrow b,d}$, reflect the import content of exports and the reexported content of exports from a to b, respectively.

Each measure has a *direct component* that measures production inputs directly imported, as well as an *indirect component* that captures the import content of intermediate inputs supplied by the domestic economy.

The analysis focuses on the period 2001–14 and 37 countries for which data from both sources are available. Data on domestic and imported intermediate inputs come from the 2016 World Input-Output Database.[1] Bilateral price and quantity indices come from Boz and Cerutti (forthcoming).

The authors of this box are Gustavo Adler, Carolina Osorio Buitron, and Sergii Meleshchuk.

[1]See a detailed description of the data set in Timmer and others (2015).

Box 2.4. How Inflexible Are Global Supply Chains?

The rise of global value chains has been one of the most notable changes in the world economy over the past few decades, bringing myriad transformations and complicating macroeconomic analysis. An important aspect for assessing the impact of such supply chains is how easily they can reconfigure in response to changes in prices. The impact of trade barriers is more destructive if supply chains are inflexible, as inflexibility makes it more difficult to reconfigure them. This box reports estimates of the degree of flexibility using annual data on trade in goods and services for 59 countries over a period of 21 years (Bayoumi, Barkema, and Cerdeiro, forthcoming).

An illustration: How changes in competitiveness translate into changes in the demand for domestic goods (and thus into output) depends on the relative responsiveness of production and consumption to real exchange rates (Bems and Johnson 2017). Consider, for example, the case of a Korean firm that produces flat screens that a Chinese firm adds to computers exported to the United States. How much does a depreciation in the won (vis-à-vis all currencies) matter for the Korean firm's exports of flat screens? Two polar cases can be considered:

- *Inflexible supply chains:* Assume that the response of the Chinese firm to changes in the price of the flat screen is small relative to the equivalent response of US buyers to changes in the price of the computer. In this case, it is the demand for Chinese computers in the United States that determines the demand for Korean flat screens given that Chinese producers will use similar amounts of Korean flat screens in each computer irrespective of the price. Indeed, if production is fully inflexible (the "Leontief" production function case) all that matters is the price of the entire Chinese computer in the US market, and *the fact that the won is now cheaper will matter only in proportion to the Korean flat screen's contribution to the total value of the final good*. This is often dubbed "trade in goods" given that it is the cost of the entire good (the computer) that matters.
- *Flexible supply chains:* If the Chinese producer responds as much to changes in the price of the flat screen as US consumers do to changes in computer prices, the intermediate production process is simply an illusion. As shown more generally in Bems and Johnson (2017), the flat screens discussed above can be thought of as being directly exported from Korea to the United States. This is often termed "trade in tasks," on the logic that a good can be seen as an amalgam of components ("tasks"). Crucially for the purpose of the analysis here, because the Korean flat screens are treated as a direct export from Korea to the United States, the value of the won is in fact all that matters for the demand for flat screens, implying also that the value of the renminbi is entirely inconsequential. Note that while the existence of global value chains mutes the impact on gross trade, the impact on output rose through the 2008 financial crisis before falling modestly afterward (in line with the path of correctly measured openness).

Empirical investigation: The illustration above shows how, depending on the degree of supply chain flexibility, the foreign and domestic components of a country's gross exports will be sensitive to different exchange rates. If we let FVA_{it} and DVA_{it} denote, respectively, foreign and domestic components embedded in country i's exports to final demand at time t, then the following specifications that relate relative price changes to the demand for value added can help elucidate the flexible or inflexible nature of global supply chains:

$$FVA_{it} = \eta + \alpha REER^{*}_{it} + \beta dva_{it} \times REER_{it} + \gamma dva_{it} \times REER^{*}_{it} + \delta X_{it} + \varepsilon_{it}, \quad (1)$$

$$DVA_{it} = \eta + \alpha REER_{it} + \beta fva_{it} \times REER^{*}_{it} + \gamma fva_{it} \times REER_{it} + \delta X_{it} + \varepsilon_{it}, \quad (2)$$

where $REER$ denotes country i's real effective exchange rate; $REER^{*}$ denotes the real effective exchange rate of country i's intermediate-import partners; dva (fva) is the share of domestic (foreign) value added in country i's gross exports to final demand; and X is a vector of controls.[1] Because it is possible that global supply chains are less flexible over short horizons than over longer time periods, and the response to changes in

The authors of this box are Jelle Barkema, Tamim Bayoumi, and Diego Cerdeiro.

[1]See Bayoumi and others (forthcoming) for details on the construction of the data set. Note also that the same notation is used across equations (1) and (2) for expositional simplicity given the discussion that follows. The coefficients need not be similar across the two equations: while foreign value added is by definition global-supply-chain trade (insofar as it measures exports of intermediates that are further processed to be reexported), domestic value-added exports include also exports that are not part of a multicountry supply chain.

Box 2.4 *(continued)*

Table 2.4.1. Testing the Degree of Flexibility of Global Supply Chains

	(1)	(2)	(3)	(4)	(5)	(6)
	Foreign Value Added (FVA)			Domestic Value Added (DVA)		
	Theory		Empirics	Theory		Empirics
	Flexible supply chains	*Inflexible supply chains*		*Flexible supply chains*	*Inflexible supply chains*	
Long Term						
Importing Partners' EER	–A	–B	–2.252 (–5.45)***			
Own EER × DVA Share	0	–B	–0.607 (–4.60)***			
Importing Partners' EER × DVA	0	+B	1.295 (5.07)***			
Own EER				–A	–B	–0.750 (–6.34)***
Importing Partners' EER × FVA				0	–B	–0.435 (–0.75)
Own EER × FVA Share				0	+B	1.381 (2.31)**
Short Term						
Error Correction Term			–0.202 (–7.10)***			–0.155 (–6.49)***
Importing Partners' EER	–a	–b	–0.640 (–2.94)***			
Own EER × DVA Share	0	–b	–0.477 (–4.43)***			
Importing Partners' EER × DVA	0	+b	0.677 (5.56)***			
Own EER				–a	–b	–0.297 (–1.54)
Importing Partners' EER × FVA				0	+b	–0.719 (–1.01)
Own EER × FVA Share				0	+b	0.757 (1.05)
Number of observations			1,116			1,116

Source: IMF staff calculations.

Note: EER = effective exchange rate; t statistics in parentheses; * p < 0.1 ** p < 0.05 *** p < 0.01. Controls: foreign demand, oil price, non-oil commodity prices.

relative prices might not be homogeneous across countries over short horizons, (1) and (2) are estimated as error-correction models with short-term heterogeneous coefficients (Pesaran, Shin, and Smith 1999).

The crucial test here is the value of the beta and gamma coefficients. If value chains are flexible (trade in tasks) then beta and gamma should both be zero—only the alpha coefficients on the foreign or domestic exchange rate should matter.

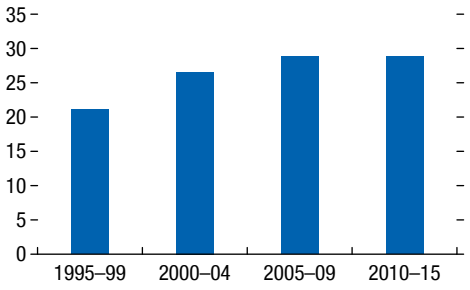
By contrast, if the value chain is inflexible (trade in goods) then both the foreign and domestic exchange rate matter. In the above equation, if the supply chain is fully inflexible then beta will be equal to minus gamma and to alpha. There are also intermediate possibilities in which beta is still different from zero but smaller (in absolute value) than alpha—in which case the production chain is partly flexible.

Results: The top part of Table 2.4.1 shows the resulting long-term coefficient estimates, whereas the bottom half presents the estimates associated with the short-term dynamics. To facilitate the interpretation of the results, the table also displays the expected coefficients if supply chains were flexible [columns (1) and (4)] and inflexible [columns (2) and (5)].

The evidence in Table 2.4.1 overwhelmingly rejects the hypothesis that global supply chains are flexible in the short term. In both the foreign- and domestic-value-added equations, the estimated

Box 2.4 *(continued)*

Figure 2.4.1. Foreign to Domestic Value Added
(World, five-year averages, percent)



Source: Organisation for Economic Co-operation and Development, Inter-Country Input-Output Tables.

coefficients on beta (gamma) are significantly negative (positive). For foreign value added, the beta and gamma coefficients are approximately equal and opposite, and sizable compared with the (absolute) value of alpha. The point estimate suggests that this ratio is about two-thirds over the entire 1995–2015 sample and hence that supply chains are quite inflexible in the short term (see Bayoumi and others, forthcoming, for a full derivation). The equivalent coefficients for domestic value added point to a similar qualitative result, although they are less precisely estimated.

Moreover, short-term responses of supply chains appear to have become increasingly inflexible over time. Reestimating the model for 2000–15 (that is, removing the first five years of the sample) reveals that production linkages might be fully inflexible in the short term. In particular, the hypotheses that alpha, beta, and gamma are all equal in absolute terms cannot be rejected in either the foreign- or the domestic-value-added equations. This suggests that the observed rising share of foreign inputs in international trade (Figure 2.4.1) is due to the development of increasingly complex production chains that involve increasingly specialized inputs.

Such short-term effects last for some time. The estimated half-life for transition from the short- to long-term relationships is about three to five years, and closing three-quarters of any short-term deviation requires six to nine years. In all, the estimated speed of adjustment suggests that the short-term coefficients remain relevant for horizons of five years. Strikingly, supply chains also remain somewhat inflexible in the long term. In particular, while the longer horizon leads to larger elasticities overall (that is, estimated coefficients tend to be larger in absolute value), complementarities in production persist. All long-term point estimates have the expected sign, and the fact that some of the beta and gamma terms are significant in both equations reveals a degree of inflexibility in production even over long horizons.

Overall, the results suggest that supply chains are pretty inflexible, implying larger disruptions from trade barriers and also adding to the costs of recreating them once lost. The results also have implications for competitiveness calculations: there is a greater role for final destinations—countries that consume final goods—in competitiveness compared with existing practice (see Bayoumi and others 2018).

References

Amiti, Mary, Oleg Itskhoki, and Jozef Konings. 2014. "Importers, Exporters, and Exchange Rate Disconnect." *American Economic Review* 104 (7): 1942–978.

Bayoumi, Tamim, Maximiliano Appendino, Jelle Barkema, and Diego A. Cerdeiro. 2018. "Measuring Competitiveness in a World of Global Value Chains." IMF Working Paper 18/229, International Monetary Fund, Washington, DC.

Bayoumi, Tamim, Jelle Barkema, and Diego A. Cerdeiro. Forthcoming. "The Inflexible Structure of Global Supply Chains." IMF Working Paper, International Monetary Fund, Washington, DC.

Bayoumi, Tamim, Mika Saito, and Jarkko Turunen. 2013. "Measuring Competitiveness: Trade in Goods or Tasks?" IMF Working Paper 13/100, International Monetary Fund, Washington, DC.

Bems, Rudolfs. 2014. "Intermediate Inputs, External Rebalancing, and Relative Price Adjustment." *Journal of International Economics* 94 (2): 248–62.

Bems, Rudolfs, and Robert C. Johnson. 2017. "Demand for Value Added and Value-Added Exchange Rates." *American Economic Journal: Macroeconomics* 9 (4): 45–90.

Borin, Alessandro, and Michele Mancini. 2019. "Measuring What Matters in Global Value Chains and Value-Added Trade." Policy Research Working Paper Series 8804, World Bank, Washington, DC.

Boz, Emine, Eugenio Cerutti, and Evgenia Pugacheva. Forthcoming. "Dissecting the Global Trade Slowdown: A New Database." IMF Working Paper, International Monetary Fund, Washington, DC.

Boz, Emine, Gita Gopinath, and Mikkel Plagborg-Møller. 2018. "Global Trade and the Dollar." VOX, CEPR Policy Portal, Center for Economic and Policy Research, Washington, DC.

Casas, Camila, J. Federico Diez, Gita Gopinath, and Pierre-Olivier Gourinchas. 2017. "Dominant Currency Paradigm: A New Model for Small Open Economies." IMF Working Paper 17/264, International Monetary Fund, Washington, DC.

Cheng, C. Kevin, Sidra Rehman, Dulani Seneviratne, and Shiny Zhang. 2015. "Reaping the Benefits from Global Value Chains." IMF Working Paper 15/204, International Monetary Fund, Washington, DC.

De Soyres, Francois, Erik Frohm, Vanessa Gunnella, and Elena Pavlova. 2018. "Bought, Sold, and Bought Again: The Impact of Complex Value Chains on Export Elasticities." Policy Research Working Paper 8535, World Bank, Washington, DC.

Duval, Romain, Kevin Cheng, Kum Hwa Oh, Richa Saraf, and Dulani Seneviratne. 2014. "Trade Integration and Business Cycle Synchronization: A Reappraisal with Focus on Asia." IMF Working Paper 14/52, International Monetary Fund, Washington, DC.

Duval, Romain, Nan Li, Richa Saraf, and Dulani Seneviratne. 2016. "Value-Added Trade and Business Cycle Synchronization." *Journal of International Economics* 99 (C): 251–62.

Goldberg, Pinelopi Koujianou, and Rebecca Hellerstein. 2008. "A Structural Approach to Explaining Incomplete Exchange Rate Pass-Through and Pricing-to-Market." *American Economic Review* 98 (2): 423–29.

Gopinath, Gita. "The International Price System." 2015. NBER Working Paper 21646, National Bureau of Economic Research, Cambridge, MA.

———, Emine Boz, Camila Casas, Federico J. Dıez, Pierre-Olivier Gourinchas, and Mikkel Plagborg-Møller. 2018. "Dominant Currency Paradigm." CREI Lectures in Macroeconomics 2018, Centre de Recerca en Economia Internacional, Barcelona.

Head, Keith, and Thierry Mayer. 2014. "Gravity Equations: Workhorse, Toolkit, and Cookbook." In *Handbook of International Economics* 4:131–95.

Johnson, Robert C., and Guillermo Noguera. 2014. "Fragmentation in Trade Value Added over Four Decades." NBER Working Paper 19186, National Bureau of Economic Research, Cambridge, MA.

———, 2017. "A Portrait of Trade in Value-Added over Four Decades." *Review of Economics and Statistics* 99 (5): 896–911.

Leigh, Daniel, Weicheng Lian, Marcos Poplawski-Ribeiro, Rachel Szymanski, Viktor Tsyrennikov, and Hong Yang. 2017. "Exchange Rates and Trade: A Disconnect?" IMF Working Paper 17/58, International Monetary Fund, Washington, DC.

Pesaran, M. H., Y. Shin and R. P. Smith. 1999. "Pooled Mean Group Estimation of Dynamic Heterogeneous Panels," *Journal of the American Statistical Association* 94 (446): 621–34.

Organisation for Economic Co-operation and Development (OECD). 2018. "Trade Policy Implications of Global Value Chains." OECD Trade Policy Brief, Paris.

Timmer, Marcel P., Erik Dietzenbacher, Bart Los, Robert Stehrer, and Gaaitzen J. de Vries. 2015. "An Illustrated User Guide to the World Input–Output Database: The Case of Global Automotive Production." *Review of International Economics* (23): 575–605.