2019 EXTERNAL SECTOR REPORT

ONLINE ANNEX 2.1. TECHNICAL NOTE

This annex discusses in detail the conceptual and empirical approach for assessing how the currency in which international trade is invoiced and the degree of integration into global value chains (GVCs) may alter the effect of exchange rate movements on traded prices, volumes, and the trade balance-to-GDP ratio. Section I presents the analysis of the implications of currency of invoicing, including the conceptual framework, the empirical approach and the key results. Section II explores the role of global value chains, by extending the framework of the first section.

CURRENCY INVOICING

A. Conceptual Framework

When prices are sticky, the invoicing currency of cross-border transactions has significant implications for external adjustment (i.e., how trade prices and volumes react to exchange rate movements). To illustrate this, consider a simple representation of trade flows— $T^a_{a\to b}$— which denotes the value of trade from country $\boldsymbol{a}$ to country $\boldsymbol{b}$**,** measured in country $\boldsymbol{a}$'s currency (superscript). Trade flows can be expressed in terms of prices and quantities:

$$T^a_{a\to b} = P^a_{a\to b} Q_{a\to b} \ .$$

Trade prices in the exporters' currency ($P^a_{a\to b}$) can be further decomposed into the exporter's marginal cost in its domestic currency ($MC^a_{a\to b}$) and the markup ($\mu_{a\to b}$):

$$P^a_{a\to b} = \mu_{a\to b} \cdot MC^a_{a\to b}.$$

Under sticky prices, quantities can be assumed to be a function of prices in the currency of the destination country (the importer)— that is, traded volumes are demand-determined—as well as some demand shock ($D_{a\to b}$):

$$Q_{a\to b} \equiv Q_{a\to b}\left(P^b_{a\to b}, D_{a\to b}\right).$$

In this setup, the effects of exchange rate changes on bilateral trade flows from $\boldsymbol{a}$ to $\boldsymbol{b}$ are driven (directly) by the exchange rate pass-through to prices in the exporter's currency ($P^a_{a\to b}$) and (indirectly) by the pass-through to prices in the importers currency ($P^b_{a\to b}$), with the latter affecting traded quantities.

The Mundell-Fleming Framework, PCP and LCP

Under the Mundell-Fleming framework, the most relevant exchange rate for trade between countries $\boldsymbol{a}$ and $\boldsymbol{b}$ would be their bilateral exchange rate (e_{ab}), as depicted in Figure 1, below. The reason is that the Mundell-Fleming framework does *not* allow for:

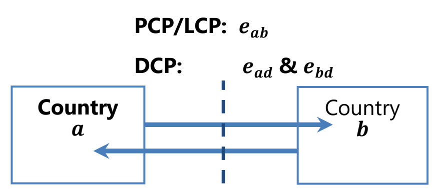
- ***Product market frictions,*** whereby exporters may charge different markups across destination markets (for example, due to strategic market complementarities). Hence, exporters' markups ($\mu_{a\to b}$) do not respond to exchange rate changes.

- ***Exporter's use of imported intermediate inputs or decreasing marginal returns to labor*****,** reflecting respectively**,** integration into GVCs and supply-side constraints (e.g. infrastructure bottlenecks). Therefore, exporters' marginal costs ($MC^a_{a\to b}$) do not respond to exchange rate fluctuations either.

If the exporters' mark-ups and marginal costs do not respond to exchange rate fluctuations, then the exchange rate pass-through to prices in the exporters' currency is zero, while the pass-through to prices in the importers' currency is one. These predictions are consistent with the producer currency pricing (PCP) paradigm, which assumes that international trade is invoiced in the currency of the exporter, and that prices in that currency are rigid. Furthermore, nominal depreciation increases the price of imports relative to exports, thus improving competitiveness.

An alternative international pricing framework developed by of Betts and Devereux (2000) and Devereux and Engel (2003)—in response to evidence against the law of one price that holds under PCP—assumes that prices are set and are rigid in the currency of the importer—so called local currency pricing (LCP). In this case, bilateral exchange rate movements should lead to a complete pass-through to prices in the exporters' currency ($P^{a}_{a\to b}$), and a zero pass-through to prices in the importers currency $(P^{b}_{a\to b})$. Hence, a nominal depreciation increases the prices of exports relative to imports, leading to a deterioration in competitiveness.

Figure 1. Conventional Trade



The Dominant Currency Pricing Framework

Recent empirical work raises questions about the validity of both PCP and LCP, showing that trade tends to be invoiced in a small number of "dominant currencies", with the U.S. dollar playing a prominent role (Goldberg and Tille, 2008 and Gopinath 2015); and that trade prices tend to be rigid in such currencies (Gopinath and Rigobon, 2008; and Fitzgerald and Haller, 2012). More recently, Casas et al (2017) and Boz et. al. (2018) show that, when prices are set in a third (dominant) currency (***$***), trade flows between countries $\boldsymbol{a}$ and $\boldsymbol{b}$ are also affected by exchange rates vis-à-vis the dominant currency ($e_{a\$}$ and $e_{b\$}$). They find that the exchange rate pass-through from the dominant currency to both export and import prices is high, while the pass-through of the bilateral (non-dominant) exchange rate is small, thus providing evidence against both PCP and LCP.[1] The authors also develop a model to explain these phenomena: the dominant currency pricing (DCP) framework.

Building on the approach proposed by Boz et. al. (2018) and Gopinath, et. al. (2018), the dominant role of the US dollar is explored by analyzing, at the country-pair level, the relationship of traded prices and quantities with the exchange rate vis-à-vis the trading partner (e_{ab}) and the US dollar ($e_{a\$}$).

The framework is extended to examine the implications of DCP for the exchange rate elasticity of the trade balance. To this end, trade prices and volumes are estimated from the perspective of both the exporter and the importer. On the export (import) side, the focus is on the effects of a depreciation of the

[1] These empirical exercises can be regarded as (indirect) tests for the presence of frictions which generate exchange rate sensitivity in mark-ups (such as strategic pricing complementarities faced by exporters in destination markets) or marginal costs (such as the use of imported inputs by exporting firms).

exporter's (importer's) currency on trade volumes and prices in the exporter's (importer's) currency. All these elements are necessary to compute the trade balance effect of a depreciation, for which a country-level perspective that accounts for the exporting and importing behavior of each economy is necessary.

Specifically, while the empirical estimation focuses on trade-flows between country-pairs ($T^a_{a\to b}$), the exchange rate effect on, say, country a's trade balance with any trading partner b is given by: $TB^a_{a\to b} = P^a_{a\to b}Q_{a\to b} - P^a_{b\to a}Q_{b\to a}$. Summing across all trade partners yields an expression for a's overall trade balance response:

$$TB_a = \sum_{j\neq a}\left[P^a_{a\to j}Q_{a\to j} - P^a_{j\to a}Q_{j\to a}\right].$$

This expression can be used to assess the impact of different exchange rate movements once the relevant price and volume elasticities vis-à-vis the bilateral and US dollar exchange rates are estimated. Finally, the country-level price and quantity elasticities are combined with measures of trade openness (X/Y and M/Y) to derive the response of the trade balance, as a share of output, which takes the following form:[2]

$$\frac{dTB_a}{Y_a} = \underbrace{\sum_{j\neq a}\left[\overbrace{\left(\frac{dP^A_{a\to j}}{de_{aj}} + \frac{dQ_{a\to j}}{de_{aj}}\right)}^{Bilateral\ ER\ elast.}de_{aj} + \overbrace{\left(\frac{dP^A_{a\to j}}{de_{a\$}} + \frac{dQ_{a\to j}}{de_{a\$}}\right)}^{USD\ ER\ elast.}de_{a\$}\right]\left(\frac{X_a}{Y_a}\right)}_{Export\ response} - \underbrace{\sum_{j\neq a}[\ldots]\left(\frac{M_a}{Y_a}\right)}_{\substack{Import\ response\\(similar\ expression)}},$$

where *X/Y* and *M/Y* denote export- and import-to-GDP ratios, respectively, and the last term on the right-hand side indicates a similar expression for imports to the one written in full for exports.

This general expression can be used for two thought experiments of interest:

- ***External adjustment.*** The relevant thought experiment from the perspective of closing a country's external imbalance is a movement of its exchange rate vis-à-vis all other currencies. In the example above, this would imply a shift in $\boldsymbol{a}$'s currency vis-à-vis all other currencies, including the US dollar (i.e., $de_{aj} = de_{a\$} = de$ for all $j \neq a$). The exchange rate between $\boldsymbol{a}$ and any other country would vary (in the same proportion), while exchange rates between any other two currencies would remain unchanged.

- ***Global US dollar shifts.*** If prices are set in US dollars, movements in the value of this currency vis-a-vis others would have implications for bilateral trade not only between the US and the rest of the world, but also among third-countries. These effects can be gauged by studying the responses of bilateral trade flows to movements in the exchange rate vis-à-vis the US, while other bilateral exchange rates remain unchanged (i.e., $de_{a\$} = de;\ de_{aj} = 0$ for all $j \neq \$$).

B. Empirical Estimation

Building on the empirical framework of Gopinath et. al. (2018), the following set of equations are estimated to obtain price and quantity elasticities for the expression above:

[2] This approach abstracts from the effect of exchange rate movements on output, as the latter is of second order importance for this analysis, for most countries.

$$\Delta_t \ln P^a_{a\to b} = \sum_l \beta_l^{PX}\Delta_{t-1}\ln e_{ab} + \sum_l \beta_l^{PX\$}\Delta_{t-1}\ln e_{a\$} + \Gamma^P \times Controls_{ab,t} + \varepsilon^P_{ab,t};$$

$$\Delta_t \ln P^b_{a\to b} = \sum_l \beta_l^{PM}\Delta_{t-1}\ln e_{ba,} + \sum_l \beta_l^{PM\$}\Delta_{t-1}\ln e_{b\$} + \Gamma^P \times Controls_{ab,t} + \varepsilon^P_{abt,};$$

$$\Delta_t \ln Q_{a\to b} = \sum_l \beta_l^{QX}\Delta_{t-1}\ln e_{ab} + \sum_l \beta_l^{QX\$}\Delta_{t-1}\ln e_{a\$} + \Gamma^Q \times Controls_{ab,t} + \varepsilon^Q_{ab,t};$$

$$\Delta_t \ln Q_{a\to b} = \sum_l \beta_l^{QM}\Delta_{t-1}\ln e_{ba} + \sum_l \beta_l^{QM\$}\Delta_{t-1}\ln e_{b\$} + \Gamma^Q \times Controls_{ab,t} + \varepsilon^Q_{ab,t};$$

where all variables are defined as in Section I.A Further, let $\Delta_{t-1}X_t = X_{t-l} - X_{t-l-1}$ for some variable X, and let ε denote the error term. In this baseline specification, each equation includes the following controls:[3]

- country-pair fixed effects to capture structural characteristics of any bilateral trade relationship, such as distance, common language, etc.
- time fixed effects to capture global shocks that can affect trade in any given year
- exporter's PPI growth to proxy for exporters' production costs
- importer's CPI and GDP growth to capture demand shocks.

To explore short and medium-run effects, 3 lags of all variables are included. Consequently, the short-run effect of exchange rates (e.g., depreciation vis-à-vis all other currencies) on the trade balance will be given by:

$$\frac{dT_a^{SR}}{Y_a} = de \times \frac{X_a}{Y_a}\left(\beta_0^{PX} + \beta_0^{PX\$} + \beta_0^{QX} + \beta_0^{QX\$}\right) - de \times \frac{M_a}{Y_a}\left(\beta_0^{PM} + \beta_0^{PM\$} + \beta_0^{QM} + \beta_0^{QM\$}\right).$$

Meanwhile, the sum of contemporaneous and lagged coefficients yields the trade balance response over the medium-run:

$$\frac{dT_a^{MR}}{Y_a} = de \times \frac{X_a}{Y_a}\left(\sum_{l=0..3}\left[\beta_l^{PX} + \beta_l^{PX\$} + \beta_l^{QX} + \beta_l^{QX\$}\right]\right) - de \times \frac{M_a}{Y_a}\left(\sum_{l=0..3}\left[\beta_l^{PM} + \beta_l^{PM\$} + \beta_l^{MX} + \beta_l^{QM\$}\right]\right).$$

And similar expressions can be obtained for the thought experiment of a global US dollar shift.

Data

Volumes and price indices for bilateral trade flows are obtained from the dataset in Boz and Cerutti (2017), also used in the Gopinath et al. (2018).[4] The dataset compiles COMTRADE data on bilateral trade at the commodity level, and constructs indices for changes in volumes and prices at the country-pair

[3] A number of robustness checks on the baseline specification are conducted below.

[4] Relative to Gopinath et al. (2018), the sample is restricted to the country-pairs, for which input-output data of WIOD 2016—used in the global value chains analysis of the next section—are available. The country sample is, thus, comprised of 37 countries compared to 55 economies in Gopinath et al. 2018).

level. Bilateral exchange rates are taken from the IMF International Financial Statistics Database. Data on real GDP, real domestic demand, CPI, PPI are taken from the World Economic Outlook Database.

C. Baseline Results

Results of the baseline specification are reported in Table 1. Columns 1 and 2 report exchange rate pass-through to prices quoted in exporter's and importer's currency, respectively. Columns 3 and 4 report export and import volume elasticities, respectively. Column 5 reports the effect of a 10 percent exchange rate depreciation vis-à-vis all currencies on the trade balance, expressed in percent of GDP, for an average country with 0.15 exports-to-GDP and imports-to-GDP ratios. The top section of the table reports the contemporaneous coefficients—the short-run effect—and the bottom section reports the sum of the contemporaneous and (three) lagged coefficients—which is dubbed the medium-run effect. Coefficients for the bilateral and US dollar exchange rates are reported separately. In addition, the sum of these two coefficients—what is called 'stand-alone' effect to differentiate from interaction terms later on—is reported and corresponds to the thought experiment of a depreciation vis-à-vis all trading partners.

The baseline results correspond to the trade-weighted regressions.[5] These provide indirect evidence on the role of the US dollar in trade invoicing. In particular:

- The US dollar exchange rate is found to be statistically and economically significant for traded prices and quantities in the short-run. The fact that the US dollar exchange is relevant after controlling for the bilateral exchange rate indicates that the US dollar is relevant for trade in country-pairs that do not include the US.

- The export and import price coefficients on the US dollar exchange rate are symmetric, as these refer to the same prices expressed, respectively, in the exporter and the importer's currency. Bilateral exchange rate coefficients, however, are higher for importer-currency prices than for exporter-currency prices—indicating the prevalence of producer currency pricing over local currency pricing for trade that is not invoiced in US dollars.

- While the importance of the US dollar remains over the medium-run, the estimates of exchange rate pass-through fall by about half, indicating that prices in the dominant currency start to adjust at longer horizons. For trade volume elasticities, the importance of the dollar in the medium-run is negligible.

When focusing on the thought experiment of a depreciation vis-à-vis all trading partners ('stand-alone' estimates), the findings are consistent with the dominant currency paradigm in the short-run, while the mechanisms of the standard the Mundell-Fleming framework seem to operate over the medium-run. Specifically:

[5] The weighted regression is chosen over the unweighted one as the baseline, because the former is likely more relevant to understand global phenomena.

- Exchange rate pass-through to trade prices from the importer and exporter perspective is high in the short-run (0.6-0.7), indicating little variation in the terms of trade.

- Quantities display an asymmetric response in the short-run. Imports fall in response to a depreciation (vis-à-vis all currencies), indicating expenditure-switching through imports.[6] This channel is primarily captured by the US dollar exchange rate, which displays a larger coefficient than the bilateral one (column 3). Exports do not react because, although the bilateral exchange rate depreciation would be expected to improve competitiveness and boost exports, trading partners face the same US dollar price and thus, do not change their demand for tradable goods.

Table 1. Currency of Invoicing—Baseline Specification

(weighted regression)

	Including USD exchange rate				
Dependent variable:	PX	PM	QX	QM	*TB/Y 5/*
	(1)	(2)	(3)	(4)	(5)
Short-run elasticty					
Bilateral ER (exporter) 1/	0.2050***		0.2877***		
	(0.0502)		(0.0471)		
USD ER (exporter) 2/	0.4255***		-0.2361***		
	(0.0333)		(0.0540)		
Bilateral ER (importer) 3/		0.3695***		-0.0516	
		(0.0527)		(0.0534)	
USD ER (importer) 4/		0.4255***		-0.2361***	
		(0.0333)		(0.0540)	
Stand-alone	**0.631*** **	**0.795*** **	**0.0516**	**-0.288*** **	**0.322*** **
	(0.0527)	**(0.0502)**	**(0.0534)**	**(0.0471)**	**(0.102)**
Long-run elasticty					
Bilateral ER (exporter) 1/	0.250***		0.450***		
	(0.0401)		(0.0761)		
USD ER (exporter) 2/	0.256***		-0.0186		
	(0.0671)		(0.111)		
Bilateral ER (importer) 3/		0.493***		-0.432***	
		(0.0532)		(0.0716)	
USD ER (importer) 4/		0.256***		-0.0186	
		(0.0671)		(0.111)	
Stand-alone	**0.507*** **	**0.750*** **	**0.432*** **	**-0.450*** **	**1.177*** **
	(0.0532)	**(0.0401)**	**(0.0716)**	**(0.0761)**	**(0.186)**
Observations	24,105	24,105	24,105	24,105	24,105
R-squared	0.268	0.401	0.267	0.267	0.574
Lags	3	3	3	3	3
Dyad FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES

Sources: Dataset from Gopinath and others (2018), Boz and others (forthcoming), WEO, and IMF staff estimates.
Note: *** p<0.01, ** p<0.05, * p<0.1. Standard errors clustered at the dyadic level in parentheses.
1/ Exporter depreciation vis-à-vis importer
2/ Exporter depreciation vis-à-vis USD
3/ Importer depreciation vis-à-vis exporter
4/ Importer depreciation vis-à-vis USD
5/ Assumed 10 % depreciation and 0.15 openness.

[6] Traditional expenditure-switching through imports refers to the mechanism whereby a nominal depreciation makes foreign goods more expensive and shifts consumption towards domestically produced goods. Expenditure-switching through exports, on the other hand, implies that a nominal depreciation should make domestically produced goods more competitive, thus boosting exports.

- While pass-through effects on prices fall somewhat in the medium-run—reflecting permanent level effects—the impact of a currency depreciation on quantities builds gradually over time.

- Furthermore, at longer horizons, the response of trade volumes is primarily driven by bilateral exchange rate movements. This finding suggests that, as traded prices in the invoiced currency start to adjust, the standard expenditure-switching mechanism through both exports and imports is re-established.

- Taking price and quantity effects together, a 10 percent depreciation vis-à-vis all trading partners is estimated to increase the trade balance—for a country with the average degree of trade-openness—by 0.3 percent in the short-run and 1.2 percent in the medium-run.

D. Heterogeneity

Direct Evidence

Following Boz et al. (2018), data on the share of invoicing in US dollars are used to examine cross-sectional differences in exchange rate pass-though and trade volume elasticities. The implications of dominant currency invoicing for external adjustment are directly explored by interacting the bilateral and US dollar exchange rates with the share of trade invoiced in US dollars. For the price and volume equations associated with trade flows from country $\boldsymbol{a}$ to $\boldsymbol{b}$, the relevant share of invoicing in US dollars is given by $S^{\$}_{a\to b}$, which is the GDP weighted average of: i) the share of country $\boldsymbol{a}$'s exports invoiced in US dollars and ii) the share of country $\boldsymbol{b}$'s imports invoiced in US dollars. The following set of equations are estimated:

$$\Delta_t \ln P^a_{a\to b} = \sum_l \beta^{PX}_l \Delta_{t-1} \ln e_{ab} + \sum_l \beta^{PX,S}_l \Delta_{t-1} \ln e_{ab} \cdot S^{\$}_{a\to b} + \sum_l \beta^{PX\$}_l \Delta_{t-1} \ln e_{a\$} + \sum_l \beta^{PX\$,S}_l \Delta_{t-1} \ln e_{a\$} \cdot S^{\$}_{a\to b} + \Gamma^{P} \times Controls_{ab,t} + \varepsilon^{P}_{ab,t};$$

$$\Delta_t \ln P^b_{a\to b} = \sum_l \beta^{PM}_l \Delta_{t-1} \ln e_{ba} + \sum_l \beta^{PM,S}_l \Delta_{t-1} \ln e_{ba} \cdot S^{\$}_{a\to b} + \sum_l \beta^{PM\$}_l \Delta_{t-1} \ln e_{b\$} + \sum_l \beta^{PM\$,S}_l \Delta_{t-1} \ln e_{b\$} \cdot S^{\$}_{a\to b} + \Gamma^{P} \times Controls_{ab,t} + \varepsilon^{P}_{ab,t};$$

$$\Delta_t \ln Q_{a\to b} = \sum_l \beta^{QX}_l \Delta_{t-1} \ln e_{ab} + \sum_l \beta^{QX,S}_l \Delta_{t-1} \ln e_{ab} \cdot S^{\$}_{a\to b} + \sum_l \beta^{QX\$}_l \Delta_{t-1} \ln e_{a\$} + \sum_l \beta^{QX\$,S}_l \Delta_{t-1} \ln e_{a\$} \cdot S^{\$}_{a\to b} + \Gamma^{Q} \times Controls_{ab,t} + \varepsilon^{Q}_{ab,t};$$

$$\Delta_t \ln Q_{a\to b} = \sum_l \beta^{QM}_l \Delta_{t-1} \ln e_{ba} + \sum_l \beta^{QM,S}_l \Delta_{t-1} \ln e_{ba} \cdot S^{\$}_{a\to b} + \sum_l \beta^{QM\$}_l \Delta_{t-1} \ln e_{b\$} + \sum_l \beta^{QM\$,S}_l \Delta_{t-1} \ln e_{b\$} \cdot S^{\$}_{a\to b} + \Gamma^{Q} \times Controls_{ab,t} + \varepsilon^{Q}_{ab,t};$$

where the variables are defined in Section I.B and Section I.D. Under this specification, the trade balance response of a hypothetical economy $\boldsymbol{a}$ which does not have any trade invoiced in US dollars would be given by the same equations as in the baseline specification. By contrast, if the share of trade invoiced in US dollars by economy $\boldsymbol{a}$ is, on average, $S_{a}^{\$}$, the short-run trade balance response would be given by:

$$\frac{dT_a^{SR}}{Y_a} = de \times \frac{X_a}{Y_a}\left(\beta_0^{PX} + \beta_0^{PX.S}\cdot S_a^{\$} + \beta_0^{PX\$} + +\beta_0^{PX\$,S}\cdot S_a^{\$} + \beta_0^{QX} + \beta_0^{QX,S}\cdot S_a^{\$} + \beta_0^{QX\$} + \beta_0^{QX\$,S}\cdot S_a^{\$}\right)$$

$$-de \times \frac{M_a}{Y_a}\left(\beta_0^{PM} + \beta_0^{PM,S}\cdot S_a^{\$} + \beta_0^{PM\$} + \beta_0^{PM\$,S}\cdot S_a^{\$} + \beta_0^{QM} + \beta_0^{QM,S}\cdot S_a^{\$} + \beta_0^{QM\$} + \beta_0^{QM\$,S}\cdot S_a^{\$}\right).$$

and the medium-run trade balance response would be given by the sum of these coefficients up to the third lag.

Table 2 reports the results. The figures in black correspond to estimates for a hypothetical country for which trade is not invoiced in US dollars. The figures in green report estimates for a country with a high share of trade invoiced in US dollars, corresponding to the 99th percentile of the distribution (or 0.96). The interaction terms (green coefficients) for pass-through and elasticity estimates represent the *additional* effect from having a high-share of trade invoiced in US dollars, whereas the "stand-alone" green coefficients capture the overall effect a depreciation in such an economy.

The results confirm that the short-run external adjustment process in countries with a large share of trade invoiced in USD conforms with the predictions of DCP.

- Combined pass-through estimates are high for prices of both exports and imports, due to the high coefficient on the US dollar exchange rate, amounting to about 0.8, compared to an estimate of 0.5-0.6 in economies that do not invoice in US dollars.

- Short-run trade volume elasticities in the economy that has a high US dollar invoicing are asymmetric—negligible for exports and -0.3 for imports. For the economy with no US dollar invoicing, export and import volume elasticities are more balanced at 0.1 and -0.2, respectively.

Despite the differences in the composition of external adjustment, the short-run trade balance response is very similar across countries with different degrees of invoicing in USD: a 10 percent depreciation is estimated to increase the trade-balance by about 0.25 percentage points of GDP. Over the medium run, exchange rate pass-through estimates, quantity elasticities and trade-balance effects are quantitively similar across countries with low and high US dollar invoicing. Taken together, these results lend further support to the notion that dominant currency pricing affects the composition of external adjustment mostly in the short-run.

Table 2. Currency of Invoicing—Direct Evidence

(weighted regression)

Dependent variable:	PX (1)	PM (2)	QX (3)	QM (4)	*TB/Y 5/* (5)
Short-run elasticty					
Bilateral ER (exporter) 1/	0.3160***		0.2163***		
	(0.0501)		(0.0557)		
USD ER (exporter) 2/	0.1645***		-0.0901		
	(0.0622)		(0.0677)		
Bilateral ER (exporter)*USD invoice share (99 pctile)	-0.2202**		0.0627		
	(0.0879)		(0.0972)		
USD ER (exporter)* USD invoice share (99 pctile)	0.5820***		-0.2557**		
	(0.1058)		(0.1122)		
Bilateral ER (importer) 3/		0.5195***		-0.1262**	
		(0.0520)		(0.0541)	
USD ER (importer) 4/		0.1645***		-0.0901	
		(0.0622)		(0.0677)	
Bilateral ER (importer)*USD invoice share (99 pctile)		-0.3618***		0.1930**	
		(0.0801)		(0.0779)	
USD ER (importer)*USD invoice share (99 pctile)		0.5820***		-0.2557**	
		(0.1058)		(0.1122)	
Stand-alone	**0.481*** **	**0.684*** **	**0.126** **	**-0.216*** **	**0.256**
	(0.0520)	**(0.0501)**	**(0.0541)**	**(0.0557)**	**(0.198)**
Stand-alone with USD invoice share at 99 pctile	**0.828*** **	**0.896*** **	**-0.0591**	**-0.277*** **	**0.276* **
	(0.0435)	**(0.0482)**	**(0.0495)**	**(0.0625)**	**(0.138)**
Long-run elasticty					
Bilateral ER (exporter) 1/	0.191***		0.497***		
	(0.0489)		(0.0695)		
USD ER (exporter) 2/	0.190***		-0.0408		
	(0.0680)		(0.0941)		
Bilateral ER (exporter)*USD invoice share (99 pctile)	-0.0524***		-0.000668***		
	(0.0483)		(0.0443)		
USD ER (exporter)* USD invoice share (99 pctile)	0.367***		-0.117		
	(0.0751)		(0.0952)		
Bilateral ER (importer) 3/		0.619***		-0.456***	
		(0.0504)		(0.0719)	
USD ER (importer) 4/		0.190***		-0.0408	
		(0.0680)		(0.0941)	
Bilateral ER (importer)*USD invoice share (99 pctile)		-0.315***		0.118***	
		(0.0652)		(0.0895)	
USD ER (importer)*USD invoice share (99 pctile)		0.367***		-0.117*	
		(0.0751)		(0.0952)	
Stand-alone	**0.381*** **	**0.809*** **	**0.456*** **	**-0.497*** **	**0.963*** **
	(0.0504)	**(0.0489)**	**(0.0719)**	**(0.0695)**	**(0.194)**
Stand-alone with USD invoice share at 99 pctile	**0.695*** **	**0.862*** **	**0.338*** **	**-0.496*** **	**1.228*** **
	(0.0513)	**(0.0483)**	**(0.0828)**	**(0.0589)**	**(0.210)**
Observations	21,173	21,173	21,173	21,173	21,173
R-squared	0.466	0.674	0.342	0.342	0.579
Lags	3	3	3	3	3
Dyad FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES

Sources: Datasets from Gopinath and others (2018), Boz and others (forthcoming), WEO, and IMF staff estimates.
Note: *** p<0.01, ** p<0.05, * p<0.1. Standard errors clustered at the dyadic level in parentheses.
1/ Exporter depreciation vis-à-vis importer
2/ Exporter depreciation vis-à-vis USD
3/ Importer depreciation vis-à-vis exporter
4/ Importer depreciation vis-à-vis USD
5/ Assumed 10 % depreciation and 0.15 openness.

Unweighted regressions and a wider country sample

An alternative way of assessing cross-country differences regarding the implications of DCP for external adjustment is by comparing the baseline estimations, where observations are trade-weighted, with those of an unweighted regression. The latter gives greater importance to small economies, where invoicing in US dollars tends to be more prevalent, and as such estimates are expected to provide stronger evidence in favor of DCP. The results of the unweighted regression are reported in Table 3. Exchange rate pass-through estimates are higher than in the weighted regression, owing to the larger coefficient on the US dollar exchange rate, at both short- and medium-term horizons. As in the weighted regression, trade volume responses are asymmetric in the short term—negligible for exports and negative for imports—but unlike the trade-weighted estimates, the asymmetry between export and import volume elasticities is still present over the medium term: the export quantities response is only one fourth of the import volume elasticity (in absolute value). Notwithstanding this asymmetry, the trade balance still improves over the medium run, and more so than in the short run.

Table 3. Currency of Invoicing—Unweighted Regression

(unweighted regression)

Dependent variable:	PX	PM	QX	QM	*TB/Y 5/*
	(1)	(2)	(3)	(4)	(5)
Short-run elasticity					
Bilateral ER (exporter) 1/	0.1954***		0.3135***		
	(0.0140)		(0.0374)		
USD ER (exporter) 2/	0.5573***		-0.2695***		
	(0.0198)		(0.0502)		
Bilateral ER (importer) 3/		0.2473***		-0.0440	
		(0.0143)		(0.0333)	
USD ER (importer) 4/		0.5573***		-0.2695***	
		(0.0198)		(0.0502)	
Stand-alone	**0.753*** **	**0.805*** **	**0.0440**	**-0.313*** **	**0.562*** **
	(0.0143)	**(0.0140)**	**(0.0333)**	**(0.0374)**	**(0.0897)**
Long-run elasticity					
Bilateral ER (exporter) 1/	0.256***		0.443***		
	(0.0274)		(0.0607)		
USD ER (exporter) 2/	0.481***		-0.304***		
	(0.0368)		(0.0870)		
Bilateral ER (importer) 3/		0.264***		-0.139**	
		(0.0243)		(0.0615)	
USD ER (importer) 4/		0.481***		-0.304***	
		(0.0368)		(0.0870)	
Stand-alone	**0.736*** **	**0.744*** **	**0.139** **	**-0.443*** **	**1.055*** **
	(0.0243)	**(0.0274)**	**(0.0615)**	**(0.0607)**	**(0.144)**
Observations	24,772	24,772	24,772	24,772	24,772
R-squared	0.532	0.586	0.149	0.149	0.328
Lags	3	3	3	3	3
Dyad FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES

Sources: Datasets from Gopinath and others (2018), Boz and others (forthcoming), WEO, and IMF staff estimates.
Note: *** p<0.01, ** p<0.05, * p<0.1. Standard errors clustered at the dyadic level in parentheses.
1/ Exporter depreciation vis-à-vis importer
2/ Exporter depreciation vis-à-vis USD
3/ Importer depreciation vis-à-vis exporter
4/ Importer depreciation vis-à-vis USD
5/ Assumed 10 % depreciation and 0.15 openness.

The estimates reported so far correspond to a country sample for which input-output data of WIOD 2016 are available, as the latter is necessary for the GVC analysis of the next section. For this reason, the estimates are somewhat different than those reported in Gopinath et al (2018). The differences are mainly driven by the change in the country sample, reflecting that the reduced sample has a larger share of advanced economies for which trade invoiced in US dollars is less prevalent.[7]

E. Identification

The exchange rate is an endogenous variable. Hence, a potential issue with the proposed specification is that some key omitted variables that determine traded prices and quantities may also impact the exchange rate. This issue is explored in this section.

The baseline specification aims at identifying the average effect of exchange rate variations on prices and quantities, without attempting to identify specific sources of shocks. With prices being sticky in US dollars, the effect of exchange rate changes on domestic currency prices is well identified. For quantities, however, possible omitted variable bias is a greater source of concern. In addition to including a rich set of controls in the baseline specification—and conducting additional robustness checks below—an instrumental variable (IV) estimation is explored as an attempt to establish a causal relationship from exchange rates movements to changes in trade prices and volumes. To the extent that differences between OLS and IV estimates are not (statistically) significant, the results would lend support to OLS estimates.

Construction of the exchange rate instrument

The instrumentation relies on the identification of high-frequency US monetary policy and risk-aversion shocks—obtained through a sign-restricted VAR. These types of shocks lead to global exchange rates movements that are likely exogenous to trade flows among non-US countries. Building on IMF (2014), a 3-variable VAR containing daily data for the US 10-yr bond yield (R_t), its stock market index (S_t), and its NEER (E_t) is estimated. The use of long-term yields captures monetary policy shocks under alternative regimes—namely, short-term interest rate changes, asset purchases and forward guidance. The reduced form system is given by:

$$R_{i,t} = \alpha_{i,0} + \alpha_{i,1}R_{i,t-1} + \alpha_{i,2}S_{i,t-1} + \alpha_{i,3}E_{i,t-1} + \varepsilon_{i,t}^{R};$$

$$S_{i,t} = \delta_{i,0} + \delta_{i,1}R_{i,t-1} + \delta_{i,2}S_{i,t-1} + \delta_{i,3}E_{i,t-1} + \varepsilon_{i,t}^{S};$$

$$E_{i,t} = \beta_{i,0} + \beta_{i,1}R_{i,t-1} + \beta_{i,2}S_{i,t-1} + \beta_{i,3}E_{i,t-1} + \varepsilon_{i,t}^{E};$$

where the reduced form shocks ($\varepsilon_t^{R/S/E}$) are a linear combination of the structural shocks ($\mu_t^{R/S/E}$), which are recovered through sign restrictions as summarized in the table below.

[7] Changes to the specification relative to the baseline results in the original paper also include (i) the inclusion of 3—rather than 2—lags; (ii) the inclusion of the importer's real GDP and CPI growth in the vector of controls.

Text Table 1.

Identifying assumptions

	10yr bond yield	Stock prices	NEER
MP tightening (or ↑ inflation)	+	-	+
Cyclical improvement	+	+	+
Risk-on (↓ risk aversion)	+	+	-

Source: IMF staff.

These restrictions are consistent with the notion that:

- A *cyclical improvement* increases stock prices, which is a proxy for demand conditions. This positive demand shock boosts inflationary pressures, leading to a tightening of monetary policy, raising long-term bond yields and appreciating the domestic currency.

- *A monetary contraction* increases (long-term) interest rates and stregthens the domestic currency (per the interest parity). However, stock prices fall, as the exogenous increase in interest rates lowers aggregate demand.

- *Lower risk-aversion* shifts investor demand towards riskier assets: stocks and foreign assets. Thus, stocks rise and capital outflows to other economies increase, with the latter leading to a depreciation the domestic currency. At the same time, demand for safe assets falls, leading to lower bond prices (higher yields).

The VAR is estimated with daily data—as the identifying assumptions are better suited for high frequencies—and the shocks are accumulated to annual shocks to match the frequency of the trade flows analysis.

The identified US monetary and risk-aversion shocks are used to instrument exchange rate movements, focusing on country-pairs that do not include the US as a trading partner. Further, because the shocks are common to all (non-US) country-pairs, cross-sectional variation for the instrument is obtained by interacting the shocks with a measure of FX intervention in each of the trading countries—importer (***b***) and exporter (***a***)—, which is denoted by $(FX_{a,t}, FX_{b,t})$. FX intervention is measured by the annual change in reserves as a share of GDP, and it proxies the country's degree of exchange rate management. Conceptually, exchange rates should fluctuate less in response to US monetary and risk-aversion shocks in countries that intervene more actively in their FX markets. Specifically, the set of instruments is given by

$$\left(\mu_t^R \cdot FX_{b,t} \;\;,\;\; \mu_t^E \cdot FX_{b,t} \;,\;\; \mu_t^R \cdot FX_{a,t} \;\;,\;\; \mu_t^E \cdot FX_{a,t}\right).$$

The 2SLS estimation is conducted for the specification with bilateral and USD exchange rates, instrumenting contemporaneous exchange rate movements. The sample includes data from the 1990s. Since the country sample includes a heterogenous group of countries— in terms of their invoicing in US dollars and tendency to intervene in FX markets—we examine exchange rate pass-through and trade volume elasticities for the whole country sample, and subsamples where the two, one or none of the trading partners is an advanced economy.

The results of the IV estimation are presented in Tables 4 and 5. The focus is on the AE-to-EM country grouping, for which the instrumentation performs particularly well (the instruments are valid for price and volume equations of both trade-weighted and unweighted regressions). [8]

Qualitatively, IV and OLS estimates are similar and support the predictions of the DCP framework. The coefficient on the US dollar exchange rate dominates that of the bilateral in the short-run for both price and volume equations. Relative to OLS estimates, US dollar exchange rate pass-though and trade volume elasticity estimates are somewhat larger with the IV approach, although the difference with the OLS estimates is not statistically significant.

Table 4. Exchange Rate Pass-Through into Trade Prices: AE-to-EM country pairs

Dependent variable:	PX		PM	
	OLS	IV	OLS	IV
	(1)	(2)	(3)	(4)
Short-run				
Bilateral ER (exporter) 1/	0.2009***	-0.2317		
	(0.0547)	(0.3183)		
USD ER (exporter) 2/	0.4151***	1.0466***		
	(0.0791)	(0.3633)		
Bilateral ER (importer) 3/			0.3840***	0.1851
			(0.0558)	(0.2207)
USD ER (importer) 4/			0.4151***	1.0466***
			(0.0791)	(0.3633)
Stand-alone	**0.616*** **	**0.815*** **	**0.799*** **	**1.232*** **
	(0.0558)	**(0.221)**	**(0.0547)**	**(0.318)**
Long-run				
Bilateral ER (exporter) 1/	0.192**	-0.145		
	(0.0899)	(0.326)		
USD ER (exporter) 2/	0.290***	0.790**		
	(0.107)	(0.344)		
Bilateral ER (importer) 3/			0.518***	0.355
			(0.0841)	(0.266)
USD ER (importer) 4/			0.290***	0.790**
			(0.107)	(0.344)
Stand-alone	**0.482*** **	**0.645** **	**0.808*** **	**1.145*** **
	(0.0841)	**(0.266)**	**(0.0899)**	**(0.326)**
Observations	8,238	8,238	8,238	8,238
R-squared	0.173	0.041	0.420	0.201
Lags	3	3	3	3
Dyad FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Underidentification test P-val		0.000		0.000
Kleibergen-Paap rk Wald F stat		77.060		77.060
Hansen J stat P-val		0.106		0.106

Sources: Datasets from Gopinath and others (2018), Boz and others (forthcoming), WEO, Haver Analytics, and IMF staff estimates.
Note: *** p<0.01, ** p<0.05, * p<0.1. Standard errors clustered at the dyadic level in parenthesis.
Excluded instruments: money and risk shocks interacted with FXI of reporter and partner countries)
1/ Exporter depreciation vis-à-vis importer
2/ Exporter depreciation vis-à-vis USD
3/ Importer depreciation vis-à-vis exporter
4/ Importer depreciation vis-à-vis USD

[8] In general, the proposed set of instruments is valid in regressions for country groupings that include advanced economies. This may be related to the high cross-sectional variation in FXI responses among AEs, or between AEs and EMs. In contrast, EMEs tend to use FXI similarly in response to common shocks, which may explain why, for the EM-to-EM country grouping, IV estimates are imprecise, and the instrument does not satisfy standard validity tests.

Table 5. Trade Volume Elasticities: AE-to-EM country pairs

Dependent variable:	QX		QM	
	OLS	IV	OLS	IV
	(1)	(2)	(3)	(4)
Short-run				
Bilateral ER (exporter) 1/	0.3118***	1.0240**		
	(0.0744)	(0.3985)		
USD ER (exporter) 2/	-0.2502**	-1.3022***		
	(0.1035)	(0.3857)		
Bilateral ER (importer) 3/			-0.0616	0.2781
			(0.0893)	(0.3213)
USD ER (importer) 4/			-0.2502**	-1.3021***
			(0.1035)	(0.3857)
Stand-alone	**0.0616**	**-0.278**	**-0.312*****	**-1.024****
	(0.0893)	**(0.321)**	**(0.0744)**	**(0.398)**
Long-run				
Bilateral ER (exporter) 1/	0.645***	1.199***		
	(0.111)	(0.400)		
USD ER (exporter) 2/	-0.192	-1.027***		
	(0.151)	(0.390)		
Bilateral ER (importer) 3/			-0.453***	-0.172
			(0.142)	(0.400)
USD ER (importer) 4/			-0.192	-1.027***
			(0.151)	(0.390)
Stand-alone	**0.453*****	**0.172**	**-0.645*****	**-1.199*****
	(0.142)	**(0.400)**	**(0.111)**	**(0.400)**
Observations	8,238	8,238	8,238	8,238
R-squared	0.311	0.071	0.311	0.071
Lags	3	3	3	3
Dyad FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Underidentification test P-val		0.000		0.000
Kleibergen-Paap rk Wald F stat		77.060		77.060
Hansen J stat P-val		0.503		0.503

Sources: Datasets from Gopinath and others (2018), Boz and others (forthcoming), WEO, Haver Analytics, and IMF staff estimates.
Note: *** p<0.01, ** p<0.05, * p<0.1. Standard errors clustered at the dyadic level in parenthesis.
Excluded instruments: money and risk shocks interacted with FXI of reporter and partner countries)
1/ Exporter depreciation vis-à-vis importer
2/ Exporter depreciation vis-à-vis USD
3/ Importer depreciation vis-à-vis exporter
4/ Importer depreciation vis-à-vis USD

GLOBAL VALUE CHAINS (GVC)

A. Conceptual Framework

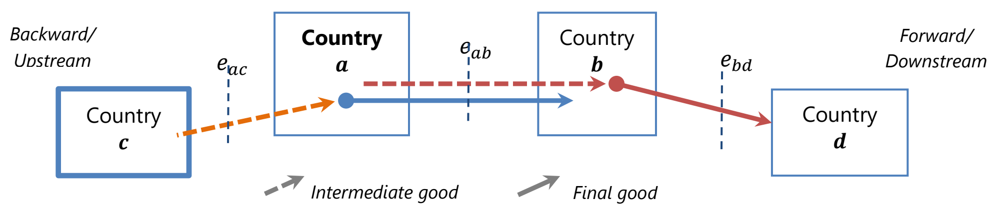
The analysis above is suitable to analyze trade in final goods or intermediate inputs used to produce goods consumed in the destination market. However, international trade has become more complex over time. In particular, integration into global value chains has brought greater trade in intermediate goods that are re-exported, making exchange rate movements vis-à-vis third-party countries relevant, because they influence trade with upstream suppliers (backward integration) or downstream buyers (forward integration).

In this section, the framework is extended to show how integration into GVCs can also alter the working of exchange rates. Initially, for expositional simplicity, dominant currency pricing is ignored (that is, producer or local currency pricing is assumed) which implies that only bilateral exchange rates are relevant. The inclusion of USD exchange rates is introduced later.

The framework focuses on the role of GVC integration through *backward linkages*—capturing how the use imported intermediate inputs turns exporters' marginal costs sensitive to exchange rates—and *forward linkages*—which capture demand and market structure aspects.[9] Although some of these features, alongside GVC integration, may determine the choice of currency of invoicing, the latter is taken as given for the purpose of this analysis.

Moving away from the example of conventional trade (Figure 1), consider an example of intermediate inputs that are traded beyond the immediate destination. That is, they are re-exported as a part of another product, as illustrated in Figure 2.

Figure 2. Example of Backward and Forward Linkages



Source: IMF staff

Backward integration (BWD). If exports from country $\boldsymbol{a}$ to $\boldsymbol{b}$ ($T^a_{a\to b}$) contain intermediate goods imported from country $\boldsymbol{c}$, 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 $\boldsymbol{a}$'s exchange rate vis-à-vis suppliers $\boldsymbol{c}$ (e_{ac}), as the latter would affect country $\boldsymbol{a}$'s marginal costs, $MC^a \equiv MC^a(e_{ac})$.[10] That is: $T^a_{a\to b} \equiv T^a_{a\to b}(e_{ab}; e_{ac})$. If substitutability between domestic and foreign intermediate goods is low, changes in e_{ac} would affect marginal costs proportionally to the imported intermediate good content.[11] With high substitutability, on the other hand, the impact on marginal costs would be low, as producers could substitute away or towards imported intermediate goods. Other things equal, a depreciation of currency $\boldsymbol{a}$ vis-à-vis all other currencies would have a positive effect on marginal costs and prices, and a negative (dampening) effect on quantities exported relative to the traditional ('standalone') effect.

Forward integration (FWD). If exports of intermediate goods from country $\boldsymbol{a}$ to $\boldsymbol{b}$ are re-exported to third countries ($\boldsymbol{d}$), trade flows form $\boldsymbol{a}$ to $\boldsymbol{b}$ will be affected by movements in the exchange rate of country

[9] The analysis is agnostic about the role played by other factors such as capacity constraints—which turn marginal costs sensitive to exchange rate movements (Goldberg and Hellerstein, 2008)—market structures that may affect price setting behavior (Amiti et. al., 2014), financial frictions, etc.

[10] In this simple example, it is assumed that country $\boldsymbol{a}$ only sources intermediate inputs from country $\boldsymbol{c}$, but not from countries $\boldsymbol{b}$ or $\boldsymbol{d}$. In the empirical specification, intermediate inputs from all partners are taken into account.

[11] Under strategic pricing complementarities, the effect could be more than proportional, as a producer of domestic intermediate goods could respond to higher prices of (competing) imported intermediate goods.

$\boldsymbol{b}$ vis-à-vis third countries (e_{bd} in this example)[12] as the latter will determine the demand for country $\boldsymbol{b}$'s exports and, consequently, for intermediate goods from country $\boldsymbol{a}$**.** This can be interpreted as a demand shock in this framework, $D \equiv D(e_{bd})$.[13] 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 flows from $\boldsymbol{a}$ to $\boldsymbol{b}$ that are used as intermediate inputs, and the share of output in $\boldsymbol{b}$ that is exported to $\boldsymbol{d}$ rather than consumed domestically. It is expected that a positive demand shock increases traded quantities and prices (for example, through higher markups set by producers).

Considering both backward and forward linkages, trade flows (prices and volumes) from country $\boldsymbol{a}$ to $\boldsymbol{b}$ can be generically characterized as:

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

These backward and forward integration terms can also be thought of as supply and demand shifters associated with upstream and downstream third-country exchange rate changes, respectively. The inclusion of these shifters in the empirical framework is key to disentangle the effect of different exchange rates, as bilateral and third-country exchange rates can be correlated.

Consider the thought experiment of a depreciation of country a's exchange rate vis-à-vis all other currencies ($de_{aj} = de, for\ all\ j$). In the presence of GVCs such exchange rate changes would operate on $\boldsymbol{a}$'s exports directly and through backward linkages as follows:

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

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

$$\frac{dT^a_{b \to a}}{de} = \underbrace{\frac{\partial f^a_{b \to a}(.)}{\partial e_{ab}}}_{\substack{stand-alone \\ bilateral}} + \underbrace{\frac{\partial f^a_{b \to a}(.)}{\partial D_{b \to a}} \frac{\partial D_{b \to a}(.)}{\partial e_{ac}}}_{\substack{BWD \\ bilateral}}.$$ [14]

The table below summarizes the sign of the expected effects of exchange rate depreciation vis-à-vis all other currencies, on prices and quantities:

[12] It is assumed that country $\boldsymbol{b}$ uses intermediate inputs from $\boldsymbol{a}$ only for its exports to $\boldsymbol{d}$. In the empirical specification, this assumption is relaxed, and reexporting to other countries, including country $\boldsymbol{a}$, is allowed.

[13] Demand shock could also be interpreted through the lenses of the responses of markups and marginal costs.

[14] Here and in what follows in Section II.A it is assumed that country $\boldsymbol{a}$ uses intermediate inputs from $\boldsymbol{b}$ to produce goods sold to $\boldsymbol{c}$.

Text Table 2. Effects of Depreciation vis-à-vis all other currencies under GVC integration

	Prices (in country a's currency)		Quantities	
	Stand-alone	BWD/FWD linkages	Stand-alone	BWD/FWD linkages
Exports $a \to b$	+	+ (BWD)	+	- (BWD)
Imports $b \to a$	+	+ (FWD)	-	+ (FWD)

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

Global Value Chains and Dominant Currency Pricing

Consider now a more general case that allows for bilateral trade between two countries to be priced in third country currencies (e.g., US dollar). The previous export equation for $T^a_{a\to b}$ can, thus, be written as:

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

And imports from $\boldsymbol{b}$ to $\boldsymbol{a}$ can be characterized similarly as:

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

In the presence of GVCs such exchange rate changes would operate on $\boldsymbol{a}$'s exports directly and through backward linkages as follows:

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

and they would affect imports directly and through forward linkages as shown below.

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

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

B. Empirical Approach

As discussed above, backward and forward participation can lead to additional channels through which exchange rate movements can affect trade flows. To assess this empirically, measures that capture the effect of exchange rates on marginal costs and the demand for imported intermediate inputs are constructed and used to augment the baseline specification.

Backward GVC linkages: supply-side shifters

For expositional simplicity, first consider the case where—due to backward integration—only bilateral exchange rate changes can affect exporters' marginal costs.

Marginal costs sensitivity to bilateral exchange rates

For an exporting country ($\boldsymbol{a}$), a backward GVC shifter is given by the weighted sum of all bilateral exchange rate movements relative to upstream suppliers, where the weight for each upstream trading partner is import content coming from that trading partner in country $\boldsymbol{a}$'s exports. The measures are computed at the country-sector level and later transformed to bilateral level using sectoral composition of bilateral trade flows. Moreover, country $\boldsymbol{a}$'s imported intermediate inputs comprise a direct and an indirect component: the former refers to intermediate inputs imported directly by each sector, while the latter captures intermediate inputs imported by domestic upstream sectors. The import content weight for each exporting country-sector ($\boldsymbol{as}$) is computed using global input-output tables (WIOD), and can be represented by the matrix $GVC_{a,t}^{bwd}$ below:

$$\boldsymbol{GVC}_{a,t}^{bwd} = \left(\boldsymbol{I}_S - \boldsymbol{A}_{a,t}\right)^{-1}\boldsymbol{M}_{a,t}.$$

where $\boldsymbol{GVC}_{a,t}^{bwd}$ is an $S \times C$ matrix, with S being the number of sectors in (the exporting) economy $\boldsymbol{a}$ and C is the number of its upstream trading partners. I_S is an $S \times S$ identity matrix; $\boldsymbol{A}_{a,t}$ is an $S \times S$ matrix, where each element $A_{a,t}^{sr}$ represents sector $\boldsymbol{s}$' expenditure share on inputs from *domestic* sector $\boldsymbol{r}$; and $\boldsymbol{M}_{a,t}$ is an $S \times C$ matrix, where each element $m_{a,t}^{sc}$ is sector $\boldsymbol{s}$' share of expenditures on intermediate inputs from country $\boldsymbol{c}$.[15]

The change in marginal costs of sector $\boldsymbol{s}$ in exporting economy $\boldsymbol{a}$ due to changes in ***bilateral*** exchange rates is given by the $\boldsymbol{s}$-*th* element of the $S \times 1$ vector $\Delta \ln \boldsymbol{MC}_{a,t}$, where

$$\Delta \ln \boldsymbol{MC}_{a,t} = \boldsymbol{GVC}_{a,t}^{bwd} \cdot \Delta \ln \boldsymbol{e}_{a,t}\ .$$

Here $\Delta \ln \boldsymbol{e}_{a,t}$ is a $C \times 1$ vector, where each element denotes the bilateral exchange rate movement of country $\boldsymbol{a}$*'s currency* vis-à-vis country $\boldsymbol{c}$*'s currency*, and a positive value represents a depreciation of country $\boldsymbol{a}$*'s currency*. Intuitively, $\Delta \ln \boldsymbol{MC}_{a,t}$ is positive when country $\boldsymbol{a}$ depreciates against its upstream suppliers, and its marginal costs increase.

The country-sector measures of marginal costs can be mapped into country-level bilateral measures, using data on the sectoral composition of trade between each country-pair. Specifically, let $\Delta \ln mc_{as,t}$ denote the $\boldsymbol{s}$-*th* element of $\Delta \ln \boldsymbol{MC}_{a,t}$. To gauge how bilateral exchange rates affect the marginal costs relevant to the exports of country $\boldsymbol{a}$ to country $\boldsymbol{b}$, a weighted average is computed across sectors and included in the regressions:

[15] Total expenditures include expenditures on domestic and imported intermediate inputs, labor, and others.

$$\Delta \ln MC^{bil.}_{a\to b,t} = \sum_{s} \left(\frac{X_{a,s\to b,t}}{\sum_s X_{a,s\to b,t}} \right) \times \Delta \ln mc^{bil.}_{as,t},$$

where $X_{a,s\to b,t}$ is the value of exports of country-sector ($\boldsymbol{as}$) to country $\boldsymbol{b}$.

Marginal costs sensitivity to the USD exchange rate

The measure proposed above assumes that exporting country $\boldsymbol{a}$'s marginal costs are only sensitive to changes in bilateral exchange rates vis-à-vis the trading partners from which it sources intermediate inputs ($\boldsymbol{c}$). However, if goods are priced in a dominant currency, like the US dollar, country $\boldsymbol{a}$'s marginal costs may also be sensitive to its exchange rate vis-à-vis the US dollar. Specifically:

$$\Delta \ln \boldsymbol{MC}^{US\$}_{a,t} = \boldsymbol{GVC}^{\boldsymbol{bwd}}_{\boldsymbol{a,t}} \times \Delta \ln e_{a\$,t},$$

where $\Delta \ln e_{a\$,t}$ is a scalar, corresponding to country $\boldsymbol{a}$'s bilateral exchange rate vis-a-vis the US dollar. The $\boldsymbol{s}$-*th* element of this vector is denoted by $\Delta \ln mc^{US\$}_{as,t}$ such that:

$$\Delta \ln MC^{US\$}_{a\to b,t} = \sum_{s} \left(\frac{X_{a,s\to b,t}}{\sum_s X_{a,s\to b,t}} \right) \times \ \Delta \ln mc^{US\$}_{as,t}.$$

This US dollar-based backward GVC shifter is also included in the regressions.

Forward GVC linkages: demand-side shifters

Demand sensitivity to bilateral exchange rates

Global value chain integration through forward linkages can be described as a situation where country $\boldsymbol{a}$ sells intermediate inputs to country $\boldsymbol{b}$, and $\boldsymbol{b}$ uses (some of) these inputs to produce (final) goods, which are re-exported to country $\boldsymbol{d}$ (see Section I). In this case, a depreciation of $\boldsymbol{a}$'s currency relative to $\boldsymbol{b}$'s *unambiguously* increases exports from $\boldsymbol{a}$ to $\boldsymbol{b}$, only if country $\boldsymbol{b}$'s currency also depreciates relative to country $\boldsymbol{d}$'s. To illustrate, assume that $\boldsymbol{b}$'s currency appreciates vis-à-vis the currencies of both $\boldsymbol{a}$ and $\boldsymbol{d}$. Hence $\boldsymbol{d}$'s (final-good) imports from $\boldsymbol{b}$ fall, inducing a decline in $\boldsymbol{b}$'s demand for intermediate inputs from $\boldsymbol{a}$, even as $\boldsymbol{a}$'s exports become more competitive in country $\boldsymbol{b}$.

The proposed measure of forward integration captures a change in importer's demand due to exchange rate fluctuations of downstream buyers. The forward GVC shifter considers the extent to which exports from country $\boldsymbol{a}$ (sector $\boldsymbol{s}$) to country $\boldsymbol{b}$ are used for re-exporting to other countries (calculated below), and $\boldsymbol{b}'s$ bilateral exchange rate movements vis-à-vis downstream importers ($\boldsymbol{d}$) (added later):

$$\widetilde{\boldsymbol{GVC}}^{fwd}_{ab,t} = \boldsymbol{x}^{\boldsymbol{I}}_{\boldsymbol{ab,t}} \left(\boldsymbol{I}_S - \widetilde{\boldsymbol{A}}_{\boldsymbol{b,t}} \right)^{-1} \boldsymbol{R}_{\boldsymbol{b,t}}.^{16}$$

where $\boldsymbol{x}^{\boldsymbol{I}}_{\boldsymbol{ab,t}}$ is an $S \times S$ matrix, in which each element $x^{I,sr}_{ab,t}$ reflects *exports from country-sector* ($\boldsymbol{as}$) *used as intermediate inputs by country-sector* ($\boldsymbol{br}$), *expressed as a share of total exports from country* $\boldsymbol{a}$ *to country* $\boldsymbol{b}$. $\widetilde{\boldsymbol{A}}_{\boldsymbol{b,t}}$ is an $S \times S$ matrix, with each element $\tilde{A}^{sr}_{b,t}$ representing the share of country-sector ($\boldsymbol{bs}$)'s

[16] Specifications that only consider the direct components of GVC integration assume that $\boldsymbol{A}_{a,t}=\boldsymbol{0}$ and $\widetilde{\boldsymbol{A}}_{\boldsymbol{b,t}}=\boldsymbol{0}$.

output that is used as intermediate inputs in country-sector ($\boldsymbol{br}$). $\boldsymbol{R_{b,t}}$ is an $S \times C$ matrix in which element $R_{b,t}^{sd}$ represents the share of gross output in country-sector ($\boldsymbol{bs}$) that is exported to country $\boldsymbol{d}$.

Hence, $\widetilde{\boldsymbol{GVC}}_{ab,t}^{fwd}$ is an $S \times C$ matrix, with each element $\widetilde{GVC}_{ab,t}^{fwd,sr}$ reflecting exports from country-sector (as) to country $\boldsymbol{b}$, which are reexported to country $\boldsymbol{d}$, expressed as a share of total exports from $\boldsymbol{a}$ to $\boldsymbol{b}$.

Let $\boldsymbol{GVC}_{ab,t}^{fwd}$ be a $1 \times C$ vector, obtained by summing across the rows of $\widetilde{\boldsymbol{GVC}}_{ab,t}^{fwd}$. The $\boldsymbol{d}^{\,th}$ element of $\boldsymbol{GVC}_{ab,t}^{fwd}$ corresponds to the share of exports from $\boldsymbol{a}$ to $\boldsymbol{b}$ that are reexported to country $\boldsymbol{d}$. The interaction of these reexported shares with country $\boldsymbol{b}$'s exchange rate movements vis-à-vis all its downstream buyers ($\boldsymbol{d}$) is denoted by $\left(\Delta \ln D_{ab,t}\right)$, and it captures exchange rate-induced demand shocks through forward linkages. Specifically:

$$\Delta \ln D_{ab,t}^{bil.} = \boldsymbol{GVC}_{ab,t}^{fwd} \cdot \Delta \ln \boldsymbol{e}_{b,t}.$$

Demand sensitivity to the USD exchange rate

The forward linkages demand shifter based on bilateral exchange rates assumes that importing country b's downstream demand is only sensitive to changes in its bilateral exchange rates vis-à-vis the trading partners that source intermediate inputs from it ($\boldsymbol{d}$).

As with the backward measure, a forward demand-shifter that responds to movements in the exchange rate vis-à-vis the USD is constructed and included in the regression, due to the large share of USD invoicing in international trade. This US dollar-based forward GVC shifter is given by:

$$\Delta \ln D_{a\to b,t}^{US\$} = \boldsymbol{GVC}_{ab,t}^{fwd} \times \Delta \ln e_{b\$,t}.$$

C. Econometric Specification

The bilateral and USD based GVC shifters are included in the baseline specification, as follows:

$$\Delta_t \ln P_{a\to b}^{a} = \sum_l \beta_l^{PX} \Delta_{t-1} \ln e_{ab} + \sum_l \beta_l^{PX\$} \Delta_{t-1} \ln e_{a\$} + \sum_l \gamma_l^{P} \Delta_{t-1} \ln MC_{a\to b,t}^{bil.} + \sum_l \gamma_l^{P\$} \Delta_{t-1} \ln MC_{a\to b,t}^{US\$} + \sum_l \delta_l^{P} \Delta_{t-1} \ln D_{a\to b,t}^{bil.} + \sum_l \delta_l^{P\$} \Delta_{t-1} \ln D_{a\to b,t}^{US\$} + \Gamma^{P} \times \, Controls_{ab,t} + \varepsilon_{ab,t}^{P};$$

$$\Delta_t \ln P_{a\to b}^{b} = \sum_l \beta_l^{PM} \Delta_{t-1} \ln e_{ba,} + \sum_l \beta_l^{PM\$} \Delta_{t-1} \ln e_{b\$} + \sum_l \gamma_l^{P} \Delta_{t-1} \ln MC_{a\to b,t}^{bil.} + \sum_l \gamma_l^{P\$} \Delta_{t-1} \ln MC_{a\to b,t}^{US\$} + \sum_l \delta_l^{P} \Delta_{t-1} \ln D_{a\to b,t}^{bil.} + \sum_l \delta_l^{P\$} \Delta_{t-1} \ln D_{a\to b,t}^{US\$} + \Gamma^{P} \times \, Controls_{ab,t} + \varepsilon_{abt,}^{P};$$

$$\Delta_t \ln Q_{a\to b} = \sum_l \beta_l^{QX} \Delta_{t-1} \ln e_{ab} + \sum_l \beta_l^{QX\$} \Delta_{t-1} \ln e_{a\$} + \sum_l \gamma_l^{Q} \Delta_{t-1} \ln MC_{a\to b,t}^{bil.} + \sum_l \gamma_l^{Q\$} \Delta_{t-1} \ln MC_{a\to b,t}^{US\$} + \sum_l \delta_l^{Q} \Delta_{t-1} \ln D_{a\to b,t}^{bil.} + \sum_l \delta_l^{Q\$} \Delta_{t-1} \ln D_{a\to b,t}^{US\$} + \Gamma^{Q} \times Controls_{ab,t} + \varepsilon_{ab,t}^{Q};$$

$$\Delta_t \ln Q_{a\to b} = \sum_l \beta_l^{QM} \Delta_{t-1} \ln e_{ba} + \sum_l \beta_l^{QM\$} \Delta_{t-1} \ln e_{b\$} + \sum_l \gamma_l^{Q} \Delta_{t-1} \ln MC_{a\to b,t}^{bil.} + \sum_l \gamma_l^{Q\$} \Delta_{t-1} \ln MC_{a\to b,t}^{US\$} + \sum_l \delta_l^{Q} \Delta_{t-1} \ln D_{a\to b,t}^{bil.} + \sum_l \delta_l^{Q\$} \Delta_{t-1} \ln D_{a\to b,t}^{US\$} + \Gamma^{\mathrm{Q}} \times Controls_{ab,t} + \varepsilon_{ab,t}^{Q}.$$

As before, the estimated equations include 3 lags for all variables. The effects on trade balance are calculated accordingly:[17]

$$\frac{dTB}{Y} = \frac{X}{Y}\left(de \times \left(\beta^{PX} + \beta^{QX} + \beta^{PX\$} + \beta^{QX\$}\right) + \Delta \ln MC(de)\ \left(\gamma^{P} + \gamma^{P\$} + \gamma^{Q\$} + \gamma^{Q\$}\right)\right) - \frac{M}{Y}\left(de \times \left(\beta^{PM} + \beta^{QM} + \beta^{PM\$} + \beta^{QM\$}\right) + \Delta \ln D(de)\left(\delta^{P} + \delta^{P\$} + \delta^{P\$} + \delta^{P\$}\right)\right).$$

Note that the effects on trade balance are estimated for some given level of GVC-induced shocks, $\Delta \ln MC(de)$ and $\Delta \ln D\,(de)$, that are functions of the size of exchange rate movements, as discussed above.

Data

In addition to the data used in section I, in this section bilateral GVC measures are constructed using WIOD 2016. This dataset is only available for 37 of the countries for which COMTRADE data on bilateral trade price and volumes are constructed by Boz and Cerutti (2017). In addition, WIOD 2016 is only available for the 2001-15 period. The aggregate measures of GVC integration are reported in Table 6.

[17] Note that the short-run response is obtained when contemporaneous β-coefficients are use and the medium-run response is calculated using the sum of the contemporaneous and three lags of the estimated β-coefficients.

Table 6. Global Value Chains. Aggregate Measures

	Backward integration (share of exports)		Forward integration (share of imports)	
	2001	2014	2001	2014
Australia	0.14	0.14	0.06	0.05
Austria	0.33	0.37	0.30	0.32
Belgium	0.37	0.43	0.35	0.32
Brazil	0.08	0.11	0.07	0.05
Canada	0.33	0.31	0.29	0.16
China	0.11	0.10	0.14	0.13
Czechia	0.35	0.47	0.26	0.55
Denmark	0.29	0.31	0.22	0.23
Estonia	0.29	0.46	0.17	0.38
Finland	0.24	0.33	0.39	0.27
France	0.27	0.31	0.25	0.21
Germany	0.23	0.28	0.30	0.39
Greece	0.16	0.16	0.02	0.03
Hungary	0.54	0.56	0.47	0.60
India	0.08	0.10	0.07	0.06
Indonesia	0.16	0.16	0.24	0.10
Ireland	0.41	0.46	0.43	0.27
Italy	0.17	0.23	0.21	0.28
Japan	0.06	0.12	0.08	0.11
Korea	0.20	0.24	0.32	0.33
Lithuania	0.23	0.28	0.14	0.20
Luxembourg	0.47	0.55	0.16	0.17
Mexico	0.39	0.41	0.33	0.37
Netherlands	0.28	0.42	0.19	0.23
Norway	0.22	0.25	0.10	0.13
Poland	0.27	0.38	0.17	0.30
Portugal	0.29	0.34	0.16	0.24
Romania	0.23	0.28	0.15	0.18
Russia	0.10	0.13	0.08	0.04
Slovakia	0.38	0.52	0.18	0.55
Slovenia	0.33	0.36	0.27	0.39
Spain	0.27	0.31	0.19	0.23
Sweden	0.29	0.31	0.40	0.32
Switzerland	0.30	0.32	0.21	0.25
Turkey	0.14	0.25	0.15	0.13
United Kingdom	0.20	0.24	0.16	0.14
United States	0.11	0.13	0.08	0.09

Sources: WIOD 2016, IMF staff calculations.

D. Main Results

Table 7 reports the results of the baseline regressions that include GVC-related demand and supply shifters. Every regression features bilateral and US dollar exchange rates, as well as forward and backward GVC measures, each computed with bilateral and US dollar exchange rates. For brevity, only the sum of bilateral and US dollar coefficients (i.e., combined effect that sheds light on the impact of a depreciation vis-à-vis all other currencies) is reported. Figures in black correspond to the stand-alone exchange rate elasticities; figures in blue report the differential effect from having an average degree of integration into GVCs; and figures in red correspond to the last two coefficients; that is, the overall exchange rate effect for a country with average GVC integration.

The coefficients on the GVC measures have the expected signs and, in most cases, they are economically and statistically significant. Backward GVC shifters, which can be thought of as marginal cost shocks, increase export prices and reduce export quantities. By contrast, forward GVC shifters increase import prices and quantities, as one might expect from a positive demand shock. The results imply that, for countries that are more integrated into GVCs through both backward and forward linkages, trade volume elasticities fall, whereas pass-through estimates increase.

Taken together, these estimates imply a dampening effect on the trade balance-to-GDP ratio, reflecting mainly the impact of GVC participation on the response of trade quantities, as the effect of GVCs on import and export prices tend to offset each other. Specifically, with an average degree of GVC integration the standalone import elasticity falls by about half, while the export elasticity declines by only a third, other things equal. Moreover, the dampening effect of GVC participation on trade volume elasticities is relevant in both the short and medium run, indicating that associated rigidities are somewhat persistent. For a country with an average degree of GVC participation and trade openness, the trade balance response (in percent of GDP) drops by about half in the short term and one third in the medium term, relative to a country with no GVC integration.

The inclusion of GVC shifters in the empirical framework leads to significant changes in the "stand-alone" estimates relative to the exchange rate elasticities of the baseline DCP model (Table 1). A comparison of Tables 1 and 7 indicates that including GVC-related shifters reduce the stand-alone pass-through estimates upwards and leads to somewhat higher trade volume elasticities. The coefficients on the US dollar exchange rate (not reported in the table) fall somewhat in absolute terms, but their sign and statistical significance remains broadly consistent with that of the baseline DCP estimation (Table 1). These results suggest that GVC integration explains part of the US dollar dominance, but the latter is a broader phenomenon (i.e., it is determined by other factors too).

Table 7. Global Value Chains. Baseline Results

(weighted regression)

Dependent variable:	PX	PM	QX	QM	TB/Y 1/
	(1)	(2)	(3)	(4)	
Short-run elasticty					
Stand-alone	0.571***	0.690***	0.130	-0.323***	0.500***
	(0.0798)	(0.0647)	(0.0904)	(0.0754)	(0.137)
GVC	0.192***	0.0643	-0.116	0.170***	-0.238**
(for average BWD and FWD level)	(0.0765)	(0.0458)	(0.0794)	(0.0591)	(0.100)
Stand-alone + GVC	0.763***	0.754***	0.0138	-0.153***	0.263***
	(0.0392)	(0.0377)	(0.0500)	(0.0499)	(0.102)
Long-run elasticty					
Stand-alone	0.531***	0.722***	0.533***	-0.583***	1.388***
	(0.0764)	(0.110)	(0.105)	(0.133)	(0.222)
GVC	0.183***	0.0225	-0.188*	0.299*	-0.490**
(for average BWD and FWD level)	(0.0654)	(0.115)	(0.112)	(0.162)	(0.206)
Stand-alone + GVC	0.714***	0.745***	0.345***	-0.284***	0.898***
	(0.0592)	(0.0672)	(0.0860)	(0.105)	(0.190)
Observations	18,708	18,708	18,708	18,708	18,708
R-squared	0.315	0.348	0.389	0.389	0.464
Lags	3	3	3	3	3
Dyad FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES

Sources: Datasets from Gopinath and others (2018), Boz and others (forthcoming), WEO, WIOD 2016, and IMF staff estimates.

Note: *** p<0.01, ** p<0.05, * p<0.1. Standard errors clustered at the dyadic level in parenthesis.

1/ Assumed 10 % depreciation and 0.15 openness.

E. Robustness

The results presented above hold qualitatively and quantitatively in a battery of robustness checks:

- Table 8 reports the same set of results as in Table 7 for the unweighted regressions.
- To address the issues of omitted import demand shocks that may be correlated with exchange rates, two more robustness checks were performed. Table 9 uses the importer's real domestic demand growth as a control instead of real GDP growth. Alternatively, a proxy for import demand shocks is constructed using estimated the fitted importer fixed effects from a regression of changes in trade volumes on importer and exporter fixed effects (Table 10).
- The exercise with only the direct component of GVC integration is reported in Table 11.
- Table 12 reports results when intra-Euro area trade is excluded.
- Table 13 shows results corresponding to a specification that models global factors more granularly by substituting the time fixed effects of the baseline specification with a vector of global controls—including global GDP growth, inflation, and real export shocks, as well as VIX and real oil prices.

Table 8. Global Value Chains. Unweighted Regressions

Dependent variable:	PX	PM	QX	QM	*TB/Y 1/*
	(1)	(2)	(3)	(4)	
Short-run elasticty					
Stand-alone	0.559***	0.698***	0.148***	-0.298***	0.460***
	(0.0282)	(0.0224)	(0.0533)	(0.0480)	(0.103)
GVC	0.181***	0.0928***	-0.170***	0.117**	-0.297***
(for average BWD and FWD level)	(0.0267)	(0.0236)	(0.0554)	(0.0565)	(0.112)
Stand-alone + GVC	0.741***	0.791***	-0.0211	-0.180***	0.163*
	(0.0226)	(0.0201)	(0.0454)	(0.0465)	(0.0913)
Long-run elasticty					
Stand-alone	0.666***	0.752***	0.416***	-0.420***	1.125***
	(0.0417)	(0.0414)	(0.0909)	(0.0883)	(0.177)
GVC	0.155***	0.0994***	-0.308***	0.138*	-0.585***
(for average BWD and FWD level)	(0.0369)	(0.0364)	(0.0801)	(0.0770)	(0.150)
Stand-alone + GVC	0.821***	0.851***	0.108	-0.281***	0.539***
	(0.0372)	(0.0363)	(0.0800)	(0.0792)	(0.156)
Observations	19,220	19,220	19,220	19,220	19,220
R-squared	0.270	0.279	0.205	0.205	0.233
Lags	3	3	3	3	3
Dyad FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES

Sources: Datasets from Gopinath and others (2018), Boz and others (forthcoming), WIOD 2016, WEO, and IMF staff estimates.

Note: *** p<0.01, ** p<0.05, * p<0.1. Standard errors clustered at the dyadic level in parenthesis.

1/ Assumed 10 % depreciation and 0.15 openness.

Table 9. Real Domestic Demand as a Demand Control

(weighted regression)

Dependent variable:	PX	PM	QX	QM	*TB/Y 1/*
	(1)	(2)	(3)	(4)	
Short-run elasticty					
Stand-alone	0.573***	0.686***	0.123	-0.211***	0.331**
	(0.0799)	(0.0684)	(0.0900)	(0.0713)	(0.132)
GVC	0.191**	0.0608	-0.100	0.188***	-0.238**
(for average BWD and FWD level)	(0.0770)	(0.0459)	(0.0785)	(0.0562)	(0.0976)
Stand-alone + GVC	0.763***	0.747***	0.0230	-0.0226	0.0935
	(0.0390)	(0.0394)	(0.0470)	(0.0469)	(0.0994)
Long-run elasticty					
Stand-alone	0.534***	0.730***	0.517***	-0.424***	1.117***
	(0.0756)	(0.118)	(0.104)	(0.141)	(0.225)
GVC	0.181***	0.0173	-0.193*	0.336**	-0.549***
(for average BWD and FWD level)	(0.0652)	(0.115)	(0.112)	(0.165)	(0.210)
Stand-alone + GVC	0.715***	0.747***	0.324***	-0.0873	0.568***
	(0.0579)	(0.0630)	(0.0862)	(0.106)	(0.203)
Observations	18,708	18,708	18,708	18,708	18,708
R-squared	0.316	0.349	0.402	0.402	0.479
Lags	3	3	3	3	3
Dyad FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES

Sources: Datasets from Gopinath and others (2018), Boz and others (forthcoming), WIOD 2016, WEO, and IMF staff estimates.
Note: *** p<0.01, ** p<0.05, * p<0.1. Standard errors clustered at the dyadic level in parenthesis.
1/ Assumed 10 % depreciation and 0.15 openness.

Table 10. Estimated Importer-time Fixed Effects as a Demand Control

(weighted regression)

Dependent variable:	PX	PM	QX	QM	*TB/Y 1/*
	(1)	(2)	(3)	(4)	
Short-run elasticty					
Stand-alone	0.572***	0.625***	0.113	-0.198***	0.388***
	(0.0707)	(0.0577)	(0.0762)	(0.0627)	(0.151)
GVC	0.187***	0.137***	-0.0892	0.0262	-0.0967
(for average BWD and FWD level)	(0.0674)	(0.0393)	(0.0621)	(0.0492)	(0.101)
Stand-alone + GVC	0.760***	0.762***	0.0239	-0.172***	0.291***
	(0.0362)	(0.0383)	(0.0464)	(0.0425)	(0.101)
Long-run elasticty					
Stand-alone	0.532***	0.727***	0.508***	-0.577***	1.335***
	(0.0751)	(0.0854)	(0.106)	(0.114)	(0.243)
GVC	0.199***	0.0617	-0.193	0.321**	-0.565***
(for average BWD and FWD level)	(0.0719)	(0.0768)	(0.134)	(0.109)	(0.213)
Stand-alone + GVC	0.730***	0.789***	0.315***	-0.256***	0.769***
	(0.0612)	(0.0604)	(0.0910)	(0.0973)	(0.206)
Observations	18,708	18,708	18,708	18,708	18,708
R-squared	0.351	0.382	0.450	0.450	0.473
Lags	3	3	3	3	3
Dyad FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES

Sources: Datasets from Gopinath and others (2018), Boz and others (forthcoming), WEO, WIOD 2016, and IMF staff estimates.
Note: *** p<0.01, ** p<0.05, * p<0.1. Standard errors clustered at the dyadic level in parenthesis.
1/ Assumed 10 % depreciation and 0.15 openness.

Table 11. Direct GVC Components Only

(weighted regression

Dependent variable:	PX	PM	QX	QM	*TB/Y 1/*
	(1)	(2)	(3)	(4)	
Short-run elasticty					
Stand-alone	0.586***	0.704***	0.110	-0.315***	0.462***
	(0.0696)	(0.0580)	(0.0810)	(0.0709)	(0.136)
GVC	0.186***	0.0471	-0.133**	0.144***	-0.208**
(for average BWD and FWD level)	(0.0602)	(0.0352)	(0.0641)	(0.0474)	(0.0900)
Stand-alone + GVC	0.772***	0.751***	-0.0227	-0.171***	0.254***
	(0.0395)	(0.0385)	(0.0476)	(0.0470)	(0.0944)
Long-run elasticty					
Stand-alone	0.551***	0.761***	0.497***	-0.563***	1.275***
	(0.0725)	(0.108)	(0.103)	(0.134)	(0.231)
GVC	0.176***	-0.0214	-0.192*	0.263	-0.387*
(for average BWD and FWD level)	(0.0614)	(0.123)	(0.115)	(0.177)	(0.213)
Stand-alone + GVC	0.726***	0.739***	0.305***	-0.300***	0.888***
	(0.0625)	(0.0713)	(0.0915)	(0.114)	(0.191)
Observations	18,708	18,708	18,708	18,708	18,708
R-squared	0.316	0.349	0.390	0.390	0.464
Lags	3	3	3	3	3
Dyad FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES

Sources: Datasets from Gopinath and others (2018), Boz and others (forthcoming), WEO, WIOD 2016, and IMF staff estimates.
Note: *** p<0.01, ** p<0.05, * p<0.1. Standard errors clustered at the dyadic level in parenthesis.
1/ Assumed 10 % depreciation and 0.15 openness.

Table 12. Excluding intra-Euro Area Trade

(weighted regression

Dependent variable:	PX	PM	QX	QM	*TB/Y 1/*
	(1)	(2)	(3)	(4)	
Short-run elasticty					
Stand-alone	0.601***	0.740***	0.151*	-0.340***	0.528***
	(0.0741)	(0.0701)	(0.0901)	(0.0829)	(0.137)
GVC	0.187**	0.0409	-0.125	0.198***	-0.265**
(for average BWD and FWD level)	(0.0761)	(0.0500)	(0.0854)	(0.0664)	(0.106)
Stand-alone + GVC	0.788***	0.781***	0.0258	-0.143***	0.263**
	(0.0412)	(0.0408)	(0.0508)	(0.0535)	(0.102)
Long-run elasticty					
Stand-alone	0.543***	0.743***	0.613***	-0.604***	1.526***
	(0.0803)	(0.116)	(0.114)	(0.140)	(0.232)
GVC	0.178**	0.00926	-0.257**	0.310*	-0.597***
(for average BWD and FWD level)	(0.0695)	(0.121)	(0.125)	(0.171)	(0.223)
Stand-alone + GVC	0.722***	0.752***	0.357***	-0.293***	0.929***
	(0.0597)	(0.0667)	(0.0892)	(0.105)	(0.194)
Observations	15,575	15,575	15,575	15,575	15,575
R-squared	0.330	0.364	0.383	0.383	0.458
Lags	3	3	3	3	3
Dyad FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES

Sources: Datasets from Gopinath and others (2018), Boz and others (forthcoming), WEO, WIOD 2016, and IMF staff estimates.
Note: *** p<0.01, ** p<0.05, * p<0.1. Standard errors clustered at the dyadic level in parenthesis.
1/ Assumed 10 % depreciation and 0.15 openness.

Table 13. Global Control Variables (removing time FE)

(world GDP growth, inflation, and real exports growth, real oil prices and VIX)

Dependent variable:	PX	PM	QX	QM	*TB/Y 1/*
	(1)	(2)	(3)	(4)	
Short-run elasticty					
Stand-alone	0.571***	0.690***	0.130	-0.323***	0.500***
	(0.0798)	(0.0647)	(0.0904)	(0.0754)	(0.137)
GVC	0.192**	0.0643	-0.116	0.170***	-0.238**
(for average BWD and FWD level)	(0.0765)	(0.0458)	(0.0794)	(0.0591)	(0.100)
Stand-alone + GVC	0.763***	0.754***	0.0138	-0.153***	0.263**
	(0.0392)	(0.0377)	(0.0500)	(0.0499)	(0.102)
Long-run elasticty					
Stand-alone	0.531***	0.722***	0.533***	-0.583***	1.388***
	(0.0764)	(0.110)	(0.105)	(0.133)	(0.222)
GVC	0.183**	0.0225	-0.188*	0.299*	-0.490*
(for average BWD and FWD level)	(0.0654)	(0.115)	(0.112)	(0.162)	(0.206)
Stand-alone + GVC	0.714***	0.745***	0.345***	-0.284***	0.898***
	(0.0592)	(0.0672)	(0.0860)	(0.105)	(0.190)
Observations	18,708	18,708	18,708	18,708	18,708
R-squared	0.315	0.348	0.389	0.389	0.464
Lags	3	3	3	3	3
Dyad FE	YES	YES	YES	YES	YES
Year FE	NO	NO	NO	NO	NO

Sources: Datasets from Gopinath and others (2018), Boz and others (forthcoming), WEO, WIOD 2016, and IMF staff estimates.

Note: *** p<0.01, ** p<0.05, * p<0.1. Standard errors clustered at the dyadic level in parenthesis.

1/ Assumed 10 % depreciation and 0.15 openness.

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