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Global Value Chains and External Adjustment: Do Exchange Rates Still Matter?

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Global Value Chains and External Adjustment: Do Exchange Rates Still Matter?*

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Abstract

The paper explores how international integration through global value chains shapes the working of exchange rates to induce external adjustment both in the short and medium run. The analysis indicates that greater integration into international value chains reduces the exchange rate elasticity of *gross* trade volumes. This result holds both in the short and medium term, pointing to the rigidity of value chains. At the same time, greater value chain integration is associated with larger gross trade flows, relative to GDP, which tends to amplify the effect of exchange rate movements. Overall, combining these two results suggests that, for most countries, integration into global value chains does not materially alter the working of exchange rates and the benefits of exchange rate flexibility in facilitating external adjustment remain.

Keywords: inflation targeting, foreign exchange intervention, exchange rate

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I. 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 —the responses of both export and import volumes to changes in the price of tradable goods relative to nontradable goods—the nominal exchange rate provides a key adjustment mechanism for external rebalancing.

There is an ongoing debate, however, about the whether and how increased complexities of international trade have altered the way exchange rates operate and their impact on external balances. The growing importance of *global value chains (GVC)*, whereby countries' cross-border transactions increasingly entail importing intermediate goods, adding some value, and reexporting them, has drawn particular attention. Integration into GVCs can affect the expenditure switching mechanism in various ways. The use of imported intermediate inputs in exports (backward GVC integration) is one of the underlying forces behind the use of a dominant currency—the US dollar—in international trade invoicing, and the high degree of stickiness of trade prices in such currency (Gopinath, et al., Forthcoming). As shown by (Gopinath, et al., Forthcoming) and IMF, 2019), under dominant currency pricing, expenditure switching through exports is muted in the short-term. Moreover, backward GVC integration, can lower the sensitivity of gross export flows to exchange rate movements, because it causes trade prices and marginal costs to move in tandem.[1, 2] More generally, GVC integration means that exchange rate movements among upstream suppliers and downstream buyers can affect a country's gross trade flows through backward and forward linkages, respectively.

This paper sheds light on the empirical importance of the mechanisms whereby integration into GVCs affects the external adjustment process. The relevance of this feature, and how it shapes 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 (Gopinath, et al., Forthcoming)), as well as novel measures of international value-chain-related exchange rate shocks vis-à-vis both upstream and downstream trading partners (and the dominant currency). The latter is one of the main contributions of this paper. Because the rigidities associated with GVCs may play different roles

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[1] See related work in, among others, (Amiti, Itskhoki, & Konings, 2014); (Bems, Intermediate inputs, external rebalancing and relative price adjustment, 2014); (Borin & Mancini, 2019); Chapter 3 of (IMF, 2015); (Cheng, Rehman, Seneviratne, & Zhang, 2015); (Bems & Johnson, Demand for Value Added and Value-Added Exchange Rates, 2015); (Leigh, et al., 2017); (Bayoumi, Appendino, Barkema, & Cerdeiro, 2018); (de Soyres, Frohm, Gunnella, & Pavlova, 2018).

[2] 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.

at different time horizons, special attention is given to their importance in the short versus medium term.

The results indicate that, for a given level of trade openness, countries which use imported intermediate inputs intensively and those which re-export a large share of imports have, respectively, lower export and import volume elasticities.

Consider the case of a unilateral depreciation. Through the traditional expenditure switching channel, this shock improves competitiveness and boosts exports. However, with backward GVC integration, the depreciation also raises exporters' marginal costs, reducing competitiveness and the export volume response, *relative to the* "*traditional"* channel. On the import side, the depreciation traditionally shift's demand away from imports and towards domestically produced goods. With GVC integration through forward linkages, however, the weaker currency also enhances the competitiveness of re-exported goods—increasing the demand for imported inputs needed to produce them, thereby dampening the import volume response relative to the *traditional case*. Hence, a GVC-related exchange rate shock through backward linkages is akin to a supply shifter, because it affects exporters' marginal costs of production. And a GVC-related exchange rate shock through forward linkages operates as a demand shifter, because it affects the competitiveness of imports that are re-exported to downstream buyers.

At the same time, the results suggest that greater GVC integration goes hand in hand with greater trade openness, and the latter amplifies the effects of exchange rate movements on the trade balance *as a share of GDP*, largely offsetting the dampening GVC effect on trade volumes. Taking these two related aspects together, the data corroborates that increased integration into GVCs has not materially altered the working of exchange rates in facilitating external adjustment.

The paper builds on several strands of literature. First, it draws from a vast literature on exchange rate pass-through (see (Burstein & Gopinath, 2014) for a comprehensive review). Following (Gopinath, et al., Forthcoming), exchange rate pass-through and trade elasticities are estimated at the country-pair level for both the bilateral and dollar exchange rates. The focus on bilateral trade flows mitigates aggregation biases associated with weighted effective exchange rate measures, as noted by (Spilimbergo & Vamvakidis, 2003) and (Mayer & Steingress, 2019). Similar to (Bussière, Gaulier, & Steingress, 2016), the framework allows for exchange rate pass-through and trade volume elasticities to vary across countries, albeit with a different methodology: while the authors conduct country-by-country estimates, this paper relies on panel estimates and cross-sectional differences in elasticity estimates are solely driven by countries' degree of integration in trade and GVCs.

Second, the paper is related to the growing literature on the effects of exchange rate movements on trade volumes and prices in presence of global value chains. Following (Amiti, Itskhoki, & Konings, 2014), our analysis explores how exchange rates vis-à-vis upstream suppliers affect export prices to downstream buyers through input-output linkages. In addition, our paper also explores how exchange rate vis-à-vis downstream buyers can affect the demand on imports from upstream suppliers, in spirit of (de Soyres, Frohm, Gunnella, & Pavlova, 2018). The measures of forward and backward participation in GVCs developed in this paper are specifically tailored to take into account exchange rate movements relative to downstream buyers and upstream providers using World Input-Output Database (see (Timmer, Dietzenbacher, Los, Stehrer, & Vries, 2015) for detailed description). The findings of the paper supplement the evidence from (Ahmed, Appendino, & Ruta, 2017), (Fauceglia, Lassmann, Shingal, & Wermelinger, 2014), and (Ollivaud, Rusticelli, & Schwellnus, 2015), and (Cheng, Hong, Seneviratne, & van Elkan, 2016) which document the dampening effect of GVC participation on exchange rate trade elasticities. The paper also contributes to the literature by studying the importance of GVCs in the context of dominant currency pricing.

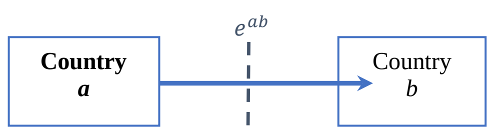
The rest of the discussion is organized as follows: Section II presents the conceptual framework on the economics of global value chains and why they may affect trade elasticities. Section III presents the empirical analysis. Section IV concludes with a discussion on considerations for future work.

II. Conceptual framework

A. Traditional vs GVC-related Trade

Historically, international trade was 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}, measured in units of currency a per unit of currency b).[3] Thus, bilateral exports from country a to country b could be characterized simply as $T_{a \to b} = f[e^{ab}]$. Correspondingly, trade flows in the opposite direction, that is, exports from b to a can be characterized as $T_{b \to a} = f[e^{ab}]$ (not shown in Figure 1).

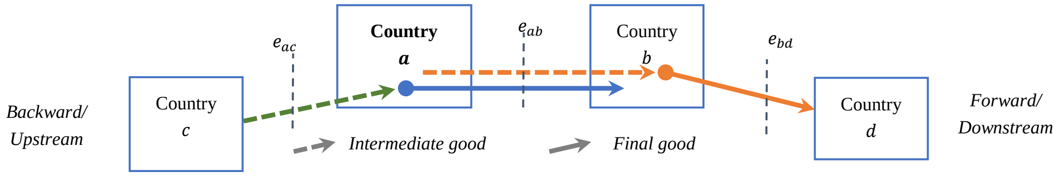
Figure 1. Traditional Trade



However, over time, international trade has become more complex, with integration into GVCs 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, these third-country exchange rates can influence trade either through upstream suppliers (backward integration) or downstream buyers (forward integration):

[3] 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. Example of Backward and Forward Linkages



Backward integration (BWD): If exports from country a to country b ($T^a_{a\to b}$) contain intermediate goods imported from a country c, the bilateral trade flow $T^a_{a\to b}$ would be affected by movements in the bilateral exchange rate (e_{ab}) as well as movements in the exporter (a)'s exchange rate vis-à-vis its upstream supplier c (e_{ac}). In this context, movements in e_{ac} would act as a supply shock by affecting country a's marginal costs, $MC^a(e_{ac})$. 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 imported intermediate goods produced in countries with stronger currencies. All else equal, backward GVC 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 a third country (d), trade flows from a *to* b will also be affected by movements in the exchange rate of the importer, country b, vis-à-vis the downstream buyer country d (e_{bd}). Movements in this exchange rate will determine the demand for country b's exports and, consequently, for the intermediate goods needed to produce them, which are supplied by country a. This can be interpreted as a demand shock, $D(e_{bd})$. Hence, $T^a_{a\to b} \equiv T^a_{a\to b}(e_{ab}; e_{ac}; e_{bd})$. The relevance of the forward exchange rate 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:

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

where BWD represents the backward GVC-supply shifter associated with exchange rates vis-a-vis upstream suppliers, and FWD represents the forward GVC-demand shifter associated with exchange rates vis-à-vis downstream buyers. 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.

Consider the thought experiment of a country a's external adjustment through a depreciation it currency vis-à-vis all others ($de_{aj} = de \; for \; all \; j$). If integrated into GVCs, such GVCs, depreciation would operate on 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 it would affect imports directly and through forward linkages as follows:

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

with the expected effects described in Table 1:

Table 1. Effects of a 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 denotes effects on prices for a combination of producer and consumer currency pricing.

B. Computing backward (supply) and forward (demand) shifters

The conceptual example above can be extended to multiple trading partners and currencies. Specifically, we construct two 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.

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. 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 $GVC^{bwd}_{a,t}$ below:

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

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 $\boldsymbol{c}$.[4]

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:

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

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

Forward GVC linkages: demand-side shifters

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

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

countries (calculated below), and $\boldsymbol{b}'s$ bilateral exchange rate movements vis-à-vis downstream importers (***d***) (added later):

$$\widetilde{\boldsymbol{GVC}}_{ab,t}^{fwd} = \boldsymbol{x}_{\boldsymbol{ab,t}}^{\boldsymbol{I}}\left(\boldsymbol{I}_S - \widetilde{\boldsymbol{A}}_{\boldsymbol{b,t}}\right)^{-1}\boldsymbol{R}_{\boldsymbol{b,t}}.$$ [5]

where $\boldsymbol{x}_{\boldsymbol{ab,t}}^{\boldsymbol{I}}$ is an $S \times S$ matrix, in which each element $x_{ab,t}^{I,sr}$ 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 ***a*** to country ***b***; $\widetilde{\boldsymbol{A}}_{\boldsymbol{b,t}}$ is an $S \times S$ matrix, with each element $\tilde{A}_{b,t}^{sr}$ representing the share of country-sector ($\boldsymbol{bs}$)'s output that is used as intermediate inputs in country-sector ($\boldsymbol{br}$); $\boldsymbol{R}_{\boldsymbol{b,t}}$ 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 ***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 ***b***, which are reexported to country ***d***, expressed as a share of total exports from ***a*** to ***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 ***a*** to ***b*** that are reexported to country ***d***. The interaction of these reexported shares with country ***b***'s exchange rate movements vis-à-vis all its downstream buyers (***d***) is denoted by $\left(\Delta \ln D_{ab,t}\right)$, and it captures exchange rate-induced demand shocks through forward linkages. Specifically:

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

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 (***d***).

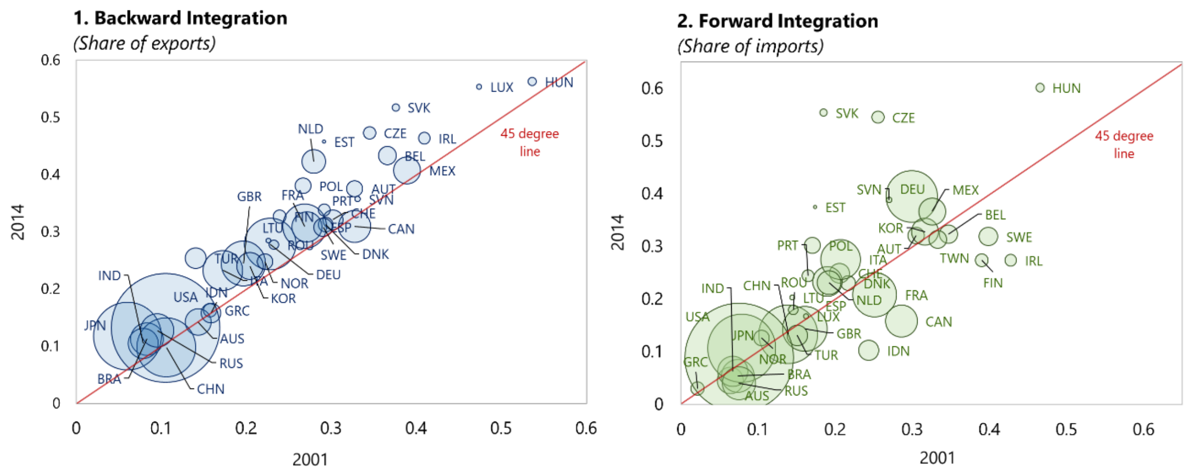
C. GVC integration: Stylized facts

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 & Noguera, Fragmentation and Trade in Value Added Over Four Decades, 2012), (Johnson & Noguera, A Portrait of Trade in Value Added over Four Decades, 2017); and (Duval, Cheng, Oh, Saraf, & Seneviratne, 2014) (Duval, Li, Saraf, & Seneviratne, 2016)) and continued through the 2000s, although at a slower pace, leading to sizable differences across countries (Figure 3). While 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

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

content of exports (backward integration) can reach one-third to one-half.[6] 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.[7]

Figure 3. Integration into Global Value Chains, 2001–14
(Manufacturing, trade-weighted average across trading partners)



Sources: (Timmer, Dietzenbacher, Los, Stehrer, & Vries, 2015); and IMF staff calculations.
Note: Data labels in the figure use International Organization for Standardization (ISO) country codes.

III. Econometric Analysis

A. Baseline Specification

The empirical investigation entails estimating exchange rate pass-through and trade volume elasticities in a panel setting at the country-pair level, taking the existing GVC links as given.[8] In order to derive a trade balance elasticity, the focus is on exchange rate movements associated with a depreciation of both, the currency of the exporter and the currency of the importer. Further, to gauge short-term and medium-term exchange rate effects, contemporaneous and lagged regressors are included in the specification, as follows:

[6] 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, (OECD, 2018)) focus on all cross-border transactions in intermediate goods and services and, thus, imply higher levels of value-chain-related trade.

[7] See country-specific values in Appendix Table A.1.

[8] Exchange rate movements could induce relocation of production over sufficiently long horizons. The evidence presented below, however, suggests that value chains are quite rigid over the horizon of the analysis (0-3 years).

$$\Delta_t \ln P^a_{a\to b} = \sum_l \beta_l^{PX} \Delta_{t-l} \ln e_{ab} + \sum_l \gamma_l^P \Delta_{t-l} \ln MC^{bil.}_{a\to b,t} + \sum_l \delta_l^P \Delta_{t-l} \ln D^{bil.}_{a\to b,t}$$
$$+\Gamma^P \times \; Controls_{ab,t} + \varepsilon^P_{ab,t};$$

$$\Delta_t \ln P^b_{a\to b} = \sum_l \beta_l^{PM} \Delta_{t-l} \ln e_{ba,} + \sum_l \gamma_l^P \Delta_{t-l} \ln MC^{bil.}_{a\to b,t} + \sum_l \delta_l^P \Delta_{t-l} \ln D^{bil.}_{a\to b,t}$$
$$+\Gamma^P \times \; Controls_{ab,t} + \varepsilon^P_{abt,};$$

$$\Delta_t \ln Q_{a\to b} = \sum_l \beta_l^{QX} \Delta_{t-l} \ln e_{ab} + \sum_l \gamma_l^Q \Delta_{t-l} \ln MC^{bil.}_{a\to b,t} + \sum_l \delta_l^Q \Delta_{t-l} \ln D^{bil.}_{a\to b,t}$$
$$+\Gamma^Q \times Controls_{ab,t} + \varepsilon^Q_{ab,t};$$

$$\Delta_t \ln Q_{a\to b} = \sum_l \beta_l^{QM} \Delta_{t-l} \ln e_{ba} + \sum_l \gamma_l^Q \Delta_{t-l} \ln MC^{bil.}_{a\to b,t} + \sum_l \delta_l^Q \Delta_{t-l} \ln D^{bil.}_{a\to b,t}$$
$$+\Gamma^Q \; \times Controls_{ab,t} + \varepsilon^Q_{ab,t}.$$

where $\Delta_{t-1} \ln e_{ba}$ denotes the change in the log of the bilateral nominal exchange rate; $\ln MC^{bil.}_{a\to b,t}$ is the bilateral metric of backward integration; and $\ln D^{bil.}_{a\to b,t}$ is the bilateral measure of forward integration. Controls include (i) country-pair fixed effects to capture structural characteristics of any bilateral trade relationship, such as distance, common language, etc.; (ii) time fixed effects to capture global shocks that can affect trade in any given year; (iii) exporter's PPI growth to proxy for exporters' production costs; and (iv) importer's CPI and GDP growth to capture, respectively, the exporter's competitor prices and demand shocks.

The estimated exchange rate pass-through and trade volume elasticities are used to calculate the effect of exchange rate changes on the trade balance (as share of GDP), which can be written generically as:

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

The "stand-alone" short-run response to a unit exchange rate movement ($de = 1$) is captured by the contemporaneous β-coefficients, whereas the medium-run response is given by the sum of the contemporaneous and three lags of these β-coefficients. For each country i at every point in time t, the indirect effects of exchange rate movements through GVCs on the *exports side* are given by the γ-coefficients interacted with *i*'s degree of backward GVC integration ($\Delta \ln MC_{it}$). While on the *imports side*, the indirect effects through GVCs are given by the δ-coefficients, interacted with *i*'s degree of forward GVC integration ($\Delta \ln D_{it}$). As with the stand-alone exchange rate responses, indirect effects through GVCs can be computed for both the short-term—using the contemporaneous coefficients— and the medium-term— using the sum of the contemporaneous and three-lags of the relevant coefficients.

Bilateral GVC measures are constructed using WIOD 2016 from (Timmer, Dietzenbacher, Los, Stehrer, & Vries, 2015). Bilateral trade price and volumes are constructed by (Boz, Cerutti, & Pugacheva, Forthcoming; Gopinath, et al., Forthcoming) using COMTRADE data. The overlap between the two sources of data covers trade and GVC linkages among 37 economies over the period 2000-14.

The results of the baseline estimation are reported in Table 22. The table reports the short-run and medium-run effects of standalone exchange rate movements as well as exchange rate induced GVC-induced shifters on prices, quantities, and trade balance. The row 'stand-alone' indicates the effect for an economy without integration into GVCs; while the row 'GVC' reports the additional effect for an economy with the average degree of integration.

The results indicate that, in absence of GVC integration, an exchange rate depreciation increases export and import prices in the short run (indicating that some trade prices are set in foreign currency, as further discussed below), while increasing export volumes and contracting import volumes. This is consistent with the standard expenditure-switching channel. Taking into account the average degree of trade openness (last column), these results imply a small improvement in the trade balance in response to a depreciation in the short run, The same qualitative effects are observed over the medium term, although effects on quantities and the trade balance are larger, pointing to the gradual buildup of the exchange rate effects over time

Table 2. Baseline specification
(weighted regression)

Dependent variable:	PX	PM	QX	QM	*TB/Y 1/*
	(1)	(2)	(3)	(4)	
Short-run elasticty					
Stand-alone	0.4416***	0.5584***	0.2112***	-0.2112***	0.458***
	(0.0640)	(0.0640)	(0.0658)	(0.0658)	(0.135)
GVC	0.277***	0.149***	-0.176**	0.09531*	-0.215**
(for average BWD and FWD level)	(0.0658)	(0.0476)	(0.0723)	(0.0535)	(0.0999)
Stand-alone + GVC	0.719***	0.708***	0.0350	-0.116**	0.243**
	(0.0337)	(0.0396)	(0.0399)	(0.0491)	(0.100)
Long-run elasticty					
Stand-alone	0.400***	0.600***	0.561***	-0.561***	1.382***
	(0.0802)	(0.0802)	(0.106)	(0.106)	(0.214)
GVC	0.251***	0.0832	-0.183*	0.329**	-0.518***
(for average BWD and FWD level)	(0.0736)	(0.0936)	(0.102)	(0.140)	(0.195)
Stand-alone + GVC	0.650***	0.683***	0.378***	-0.232**	0.865***
	(0.0537)	(0.0662)	(0.0887)	(0.0925)	(0.180)
Observations	18,708	18,708	18,708	18,708	18,708
R-squared	0.308	0.341	0.385	0.385	0.462
Lags	3	3	3	3	3
Dyad FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES

Sources: Datasets from Boz and Cerutti (2017), 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 percent depreciation and 0.15 openness

Participation in GVCs alters the response of prices and quantities to the exchange rate, amplifying the effects on prices and dampening the response on quantitates.

- *Prices.* A depreciation of the exporter's currency leads to an additional increase in export prices, with an increase of 0.277 in the short run elasticity for a country with average degree of backward integration, and of 0.255 in the medium run elasticity. These additional effects are sizable in comparison to the stand-alone effects (of 0.442 and 0.400, respectively). This amplification effect on prices is also visible in import prices.
- *Quantities.* While GVC integration tends to amplify the effect of exchange rates on prices, results point to a significant dampening effect on quantities. In the short-run, while the elasticity of export (import) volumes is about 0.211 (-0.211) for an economy without not GVC linkages, the elasticity is significantly smaller in absolute value for an economy with the average degree of GVC integration, with an export (import) volume elasticity of about 0.04 (-0.12). Importantly, this dampening effect is still significant in the medium-run, indicating that rigidities in global value chains can be quite persistent.

Taken together, results indicate that, for an economy with an average degree of trade openness, greater integration into GVCs implies a lower sensitivity of the trade balance to the exchange rate, both in the short and medium run.

B. GVC Integration and Dominant Currency Pricing

The previous section abstracted from trade pricing in third-party (dominant) currencies for expositional simplicity. In this section, the framework is extended to account for pricing in a dominant currency (the US dollar) in bilateral trade flows, when countries are integrated into GVCs. This is done in two steps. First, following (Gopinath, et al., Forthcoming), exchange rates vis-à-vis the trading partner as well as the US dollar are included in the regression. Second, since goods can be priced in the dominant currency, the sensitivity to exchange rates vis-à-vis the US dollar through GVC linkages is also explored. Thus, measures of GVC backward-supply and forward-demand shifters *vis-à-vis the US dollar* are also constructed and included in the regressions. Specifically, for backward linkages the following marginal cost shifter is computed as:

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

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 $\Delta \ln mc_{as,t}^{US\$}$ such that:

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

Similarly, a forward-demand-shifter that captures movements in the exchange rate vis-à-vis the USD is constructed as:

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

Using the previous general notation, the *export equation* for a bilateral trade relationship $T_{a\to b}^{a}$ can, thus, be written as follows to take into account dominant currency pricing:

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

while imports from b to a can be characterized as:

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

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

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

and, similarly, affect a's imports directly and through forward linkages:

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

Similarly, the econometric specification can be refined to include both bilateral and USD-based GVC shifters, as follows:

$$\Delta_t \ln P^a_{a\to b} = \sum_l \beta^{PX}_l \Delta_{t-l} \ln e_{ab} + \sum_l \beta^{PX\$}_l \Delta_{t-l} \ln e_{a\$} + \sum_l \gamma^P_l \Delta_{t-l} \ln MC^{bil.}_{a\to b,t} + \sum_l \gamma^{P\$}_l \Delta_{t-l} \ln MC^{US\$}_{a\to b,t} + \sum_l \delta^P_l \Delta_{t-l} \ln D^{bil.}_{a\to b,t} + \sum_l \delta^{P\$}_l \Delta_{t-l} \ln D^{US\$}_{a\to b,t} + \Gamma^P \times Controls_{ab,t} + \varepsilon^P_{ab,t};$$

$$\Delta_t \ln P^b_{a\to b} = \sum_l \beta^{PM}_l \Delta_{t-l} \ln e_{ba,} + \sum_l \beta^{PM\$}_l \Delta_{t-l} \ln e_{b\$} + \sum_l \gamma^P_l \Delta_{t-l} \ln MC^{bil.}_{a\to b,t} + \sum_l \gamma^{P\$}_l \Delta_{t-l} \ln MC^{US\$}_{a\to b,t} + \sum_l \delta^P_l \Delta_{t-l} \ln D^{bil.}_{a\to b,t} + \sum_l \delta^{P\$}_l \Delta_{t-l} \ln D^{US\$}_{a\to b,t} + \Gamma^P \times Controls_{ab,t} + \varepsilon^P_{abt,};$$

$$\Delta_t \ln Q_{a\to b} = \sum_l \beta^{QX}_l \Delta_{t-l} \ln e_{ab} + \sum_l \beta^{QX\$}_l \Delta_{t-l} \ln e_{a\$} + \sum_l \gamma^Q_l \Delta_{t-l} \ln MC^{bil.}_{a\to b,t} + \sum_l \gamma^{Q\$}_l \Delta_{t-l} \ln MC^{US\$}_{a\to b,t} + \sum_l \delta^Q_l \Delta_{t-l} \ln D^{bil.}_{a\to b,t} + \sum_l \delta^{Q\$}_l \Delta_{t-l} \ln D^{US\$}_{a\to b,t} + \Gamma^Q \times Controls_{ab,t} + \varepsilon^Q_{ab,t};$$

$$\Delta_t \ln Q_{a\to b} = \sum_l \beta^{QM}_l \Delta_{t-l} \ln e_{ba} + \sum_l \beta^{QM\$}_l \Delta_{t-l} \ln e_{b\$} + \sum_l \gamma^Q_l \Delta_{t-l} \ln MC^{bil.}_{a\to b,t} + \sum_l \gamma^{Q\$}_l \Delta_{t-l} \ln MC^{US\$}_{a\to b,t} + \sum_l \delta^Q_l \Delta_{t-l} \ln D^{bil.}_{a\to b,t} + \sum_l \delta^{Q\$}_l \Delta_{t-l} \ln D^{US\$}_{a\to b,t} + \Gamma^Q \times Controls_{ab,t} + \varepsilon^Q_{ab,t}.$$

And the effects on the trade balance can be calculated accordingly as:

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

An important consideration is that the use of imported intermediate inputs is one of the potential determinants of dominant currency pricing (Gopinath, et al., Forthcoming). Thus, these two features should not be regarded as independent from each other.

Table 4 reports the results of the refined specification including 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 for an economy with the average degree of GVC integration. Figures. in red correspond to the sum of the last two coefficients, that is, the overall exchange rate effect for a country with an average degree GVC integration.

Results are broadly consistent with those presented before, with the coefficients on the GVC measures displaying expected signs and, in most cases, being economically and statistically significant. As before, backward integration increases export prices and reduce export quantities. Forward integration increases import prices and quantities. As before, 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 low substitutability in international supply chains among downstream and upstream trading partners. 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[9].

[9] The inclusion of GVC shifters in the empirical framework leads to significant changes in the "stand-alone" estimates relative to estimates from a model that does not include them. Including GVC-related shifters reduces the stand-alone pass-through estimates and leads to somewhat higher trade volume elasticities. In addition, relative to the model without GVC shifters, the coefficients on the US dollar exchange rate (not reported in the table) are lower absolute terms, but their sign and statistical significance remains unchanged. These results suggest that GVC integration explains part of the US dollar dominance, although the latter phenomenon is determined by other factors too.

Table 4. Global Value Chains with dollar dominance
(weighted regression)

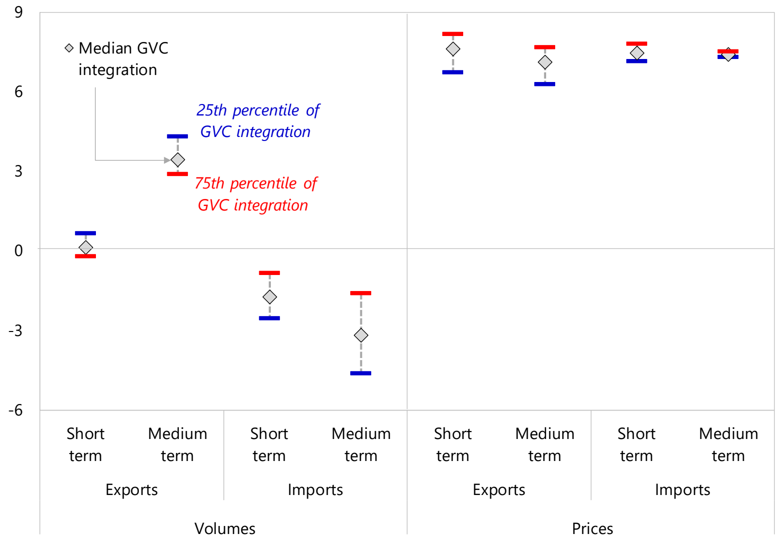
Dependent variable:	PX	PM	QX	QM	*TB/Y 1/*
	(1)	(2)	(3)	(4)	
Short-run elasticty					
Stand-alone	0.571***	0.690***	0.130	-0.323***	0.500***
	(0.0798)	(0.0647)	(0.0904)	(0.0754)	(0.137)
GVC	0.192***	0.0643	-0.116	0.170***	-0.238**
(for average BWD and FWD level)	(0.0765)	(0.0458)	(0.0794)	(0.0591)	(0.100)
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 (Boz, Cerutti, & Pugacheva, Forthcoming), WEO, (Timmer, Dietzenbacher, Los, Stehrer, & Vries, 2015), 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 percent depreciation and average openness.

Figure 4 helps to visualize the relevance of the degree of GVC integration by reporting the effects on quantities and prices for different levels of integration (percentiles 25, 50 and 75), keeping the degree of trade openness constant. As shown, economies at the 25th and 75th percentiles of the distribution of GVC integration measures display materially different responses to exchange rates, both in prices (with greater integration amplifying such effects) and quantities (greater integration playing a dampening effect). This is not only the case in the short run but also in the medium run.

Figure 4. Trade Flow Responses and GVC Integration

(Response to a 10 percent depreciation vis-à-vis all currencies, weighted regression)



Sources: IMF staff estimates, (Boz, Cerutti, & Pugacheva, Forthcoming), (Timmer, Dietzenbacher, Los, Stehrer, & Vries, 2015), and (Gopinath, The International Price System, 2015).

C. Robustness

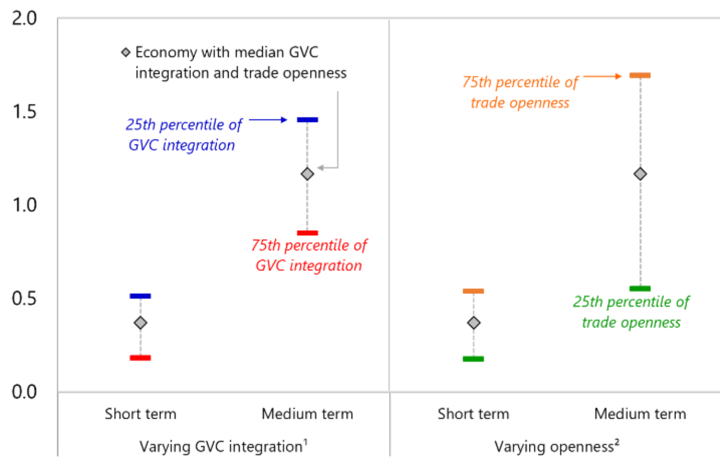
The results presented above hold qualitatively and quantitatively in a battery of robustness checks:

- Appendix Table A.2 reports the same set of results as in Table 3 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: Appendix Table A.3 includes the importer's real domestic demand growth as control, instead of real GDP growth. Alternatively, a proxy for import demand shocks is constructed using estimated importer fixed effects from a regression of changes in trade volumes on importer and exporter fixed effects (Appendix Table A.4).
- The exercise with only the direct component of GVC integration is reported in Appendix Table A.5.
- Appendix Table A.6 reports results when intra-Euro Area trade is excluded, given the lack of bilateral nominal exchange rate movements.
- Appendix Table A.7 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.
- A proxy for export supply shocks is constructed using estimated exporter fixed effects from a regression of changes in trade volumes on importer and exporter fixed effects (Appendix Table A.8).

D. GVC integration and Trade Openness

A discussed above, combining the estimated impact on prices and quantities, the results indicate that, for a given level of trade openness, greater GVC participation entails a more muted response of the trade balance to the exchange rate both in the short and medium term. Conversely, for a given level of integration, greater trade openness increases the overall responsiveness of the trade balance in terms of percentage points of GDP (Figure 5). Thus, understanding the link between the two is key to assess the overall influence of GVC integration on the effect of exchanges rates on the trade balance.

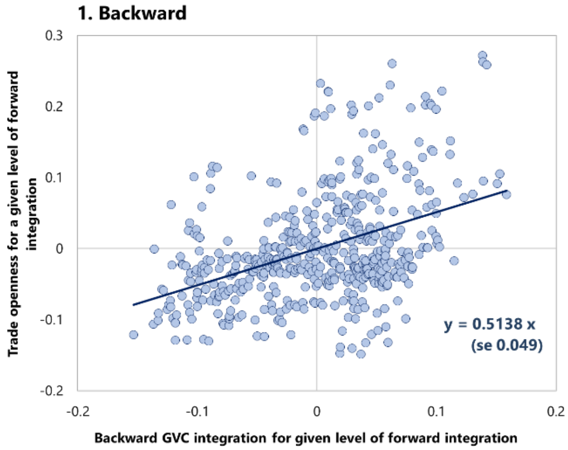
Figure 5. Influence of Global Value Chain and Trade Openness on Trade Balance Response to Exchange Rate
(Response to a 10 percent depreciation vis-à-vis all currencies)

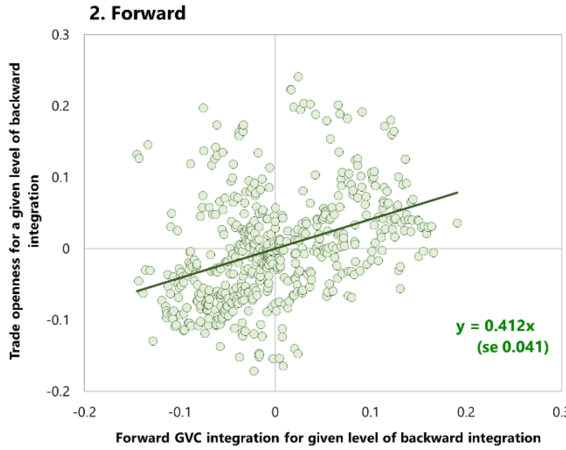


Source: Authors' estimates.
Note: GVC = global value chain.
[1]Openness fixed at the level of the median economy.
[2]Backward and forward global value chain integration fixed at the level of the median economy.

While disentangling the share of trade that is created by participating in global value chains is empirically challenging, the empirical evidence indicates that greater integration into value chains is strongly associated with larger trade flows (Figure 6). Intuitively, this pattern reflects the fact that moving toward the use of imported intermediate inputs frees domestic factors of production, which can be used to produce and export other goods and services.

Figure 6. Partial Correlation between Trade Openness and Global Value Chain Integration



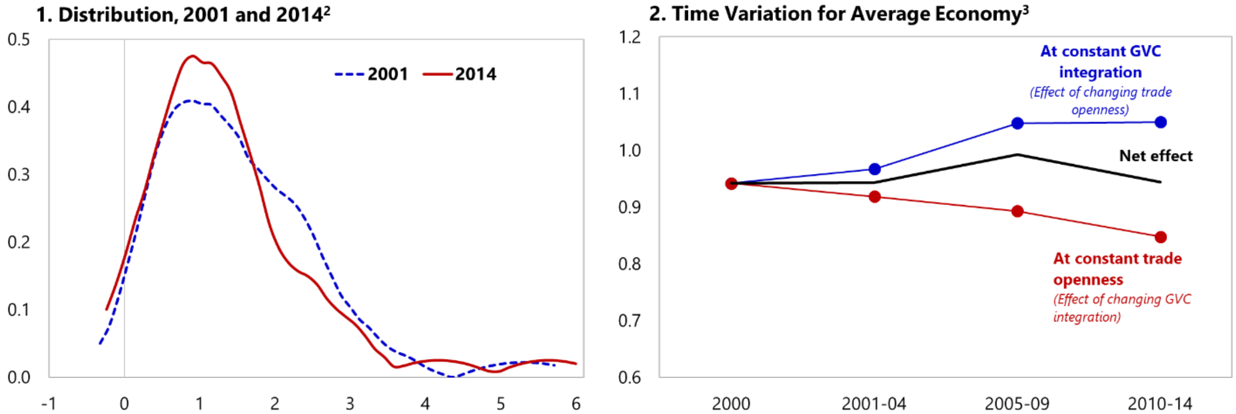


Sources: World Input-Output Database; and authors' calculations.
Note: GVC = global value chain; se = standard error.

Taking into account both the degree of both GVC integration and trade openness, trade balance elasticities appear to be different across countries but broadly stable over time. As shown in Figure 7, panel 1, 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. 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. This magnitude is broadly consistent with previous estimates in the literature (although considerably lower than estimates of tariff elasticities. [10] 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 accompanying increase in trade openness (Figure 7, panel 2).[11]

[10] See, for example, (Head & Mayer, 2014).
[11] 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.

Figure 7. 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: Authors' 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 global value chain integration or trade openness, one at a time, or both (net effect).

IV. Conclusions

With the increasing complexity of international trade, understanding how exchange rates operate and facilitate external adjustment requires a more granular and sophisticated analysis of cross-border linkages. In particular, as countries become more integrated into global value chains, the set of exchange rates that can impact a country's external balance becomes wider and more difficult to identify, and the composition and dynamics of external adjustment may change. The paper shed light on some of these key aspects. The findings indicate that greater integration into international value chains reduces the exchange rate elasticity of *gross* trade volumes, and this holds both in the short- and medium-term. At the same time, greater value chain integration is associated with larger gross trade flows, which tends to amplify the effect of exchange rates on the trade balance. Overall, the results suggest that greater integration into global value chains has not materially altered the working of exchange rates and the benefits of exchange rate flexibility in facilitating external adjustment remain.

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Appendix

Table A.1. 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: (Timmer, Dietzenbacher, Los, Stehrer, & Vries, 2015), IMF staff calculations.

Table A.2. 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 (Boz, Cerutti, & Pugacheva, Forthcoming), (Timmer, Dietzenbacher, Los, Stehrer, & Vries, 2015), 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 A.3. 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 (Boz, Cerutti, & Pugacheva, Forthcoming), (Timmer, Dietzenbacher, Los, Stehrer, & Vries, 2015), 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 A.4. 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 (Boz, Cerutti, & Pugacheva, Forthcoming), (Timmer, Dietzenbacher, Los, Stehrer, & Vries, 2015), 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 A.5. 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 (Boz, Cerutti, & Pugacheva, Forthcoming), (Timmer, Dietzenbacher, Los, Stehrer, & Vries, 2015), 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 A.6: 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 (Boz, Cerutti, & Pugacheva, Forthcoming), (Timmer, Dietzenbacher, Los, Stehrer, & Vries, 2015), 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 A.7. 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 (Boz, Cerutti, & Pugacheva, Forthcoming), (Timmer, Dietzenbacher, Los, Stehrer, & Vries, 2015), 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 A.8. Exporter-time estimated FE as supply control

Dependent variable:	PX	PM	QX	QM	*TB/Y 1/*
	(1)	(2)	(3)	(4)	
Short-run elasticty					
Stand-alone	0.617***	0.681***	0.0758	-0.310***	0.483***
	(0.0845)	(0.0629)	(0.0814)	(0.0719)	(0.140)
GVC	0.186**	0.0667	-0.0620	0.162***	-0.158**
(for average BWD and FWD level)	(0.0662)	(0.0432)	(0.0683)	(0.0518)	(0.100)
Stand-alone + GVC	0.803***	0.747***	0.0138	-0.147***	0.325*
	(0.0382)	(0.0368)	(0.0408)	(0.0492)	(0.106)
Long-run elasticty					
Stand-alone	0.664***	0.704***	0.396***	-0.537***	1.340***
	(0.0642)	(0.103)	(0.0778)	(0.124)	(0.176)
GVC	0.161***	0.0404	-0.182	0.254**	-0.473**
(for average BWD and FWD level)	(0.0650)	(0.114)	(0.0961)	(0.168)	(0.196)
Stand-alone + GVC	0.825***	0.744***	0.214**	-0.283	0.867***
	(0.0543)	(0.0636)	(0.0845)	(0.103)	(0.184)
Observations	19,182	19,182	19,182	19,182	19,182
R-squared	0.343	0.374	0.442	0.442	0.482
Lags	3	3	3	3	3
Dyad FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES

Sources: Datasets from (Boz, Cerutti, & Pugacheva, Forthcoming), (Timmer, Dietzenbacher, Los, Stehrer, & Vries, 2015), 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.