Real Exchange Rate and External Balance: How Important Are Price Deflators?*

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Abstract

This paper contrasts real effective exchange rate (REER) measures based on different deflators (consumer price index, GDP deflator, and unit labor cost) and discusses potential implications for the link—or lack thereof—between the REER and the external balance. We begin by comparing the evolution of different measures of REERs to confirm that the choice of deflator plays a significant role in REER movements. A subsequent empirical investigation based on 35 developed and emerging market economies over 1995 to 2017 yields comprehensive and robust evidence that only the REER deflated by unit labor cost exhibits contemporaneous patterns consistent with the expenditure-switching mechanism. Finally, we show that a standard open-economy model with nominal rigidities and trade in intermediate goods is able to generate qualitatively these aforementioned patterns.

JEL Codes: F31; F32; F41

Key Words: Real exchange rate; External balance; Expenditure switching; Deflators

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1 Introduction

Real exchange rate movements facilitate external balance adjustments. This notion is grounded on the central tenet of the Keynesian approach to international macroeconomics: namely, the expenditure-switching mechanism (for instance, Engel (2003), Obstfeld and Rogoff (2001), Obstfeld (2001)). The theoretical link goes in two stages: a depreciating nominal exchange rate triggers changes in relative prices, making foreign goods comparably more expensive. This, in turn, prompts consumers to switch their expenditure away from foreign goods towards home goods, thereby improving the country's external balance. Most of the recent discussion in the literature centered around the first stage: whether exchange rate pass-through is complete due to producer currency pricing (PCP) or incomplete due to local currency pricing (LCP). While these assumptions have important and distinct implications on optimal monetary policy (Devereux and Engel (2007); Obstfeld and Rogoff (2001)), both sides of the debate implicitly agree on the second stage that changes in relative prices ultimately lead to external balance adjustments.

This paper investigates the second stage—the link between real exchange rates and external balances—, with a particular focus on how the empirical relationship depends on the choice of price deflator and how this may affect economic analyses and subsequent policy discussions.

Our starting point is to acknowledge that real exchange rates are not directly observable. The real exchange rate is a useful concept that allows for a comparison of the value of goods across economies and time by adjusting for differences in prices. The calculation amounts to deflating nominal exchange rates by local prices. Candidates for local prices range across the consumer price index (CPI), the GDP deflator, and unit labor cost (ULC), among others. The decision to choose one measure over the other may depend crucially on the researcher's ultimate question, although often it also relies on data availability. Most importantly, we believe, there is no definite answer to the choice of deflator that is most appropriate for detecting the expenditure-switching mechanism empirically.

In this paper, we show that the choice of deflator matters for assessing the relationship between real exchange rates and external balances. In particular, the only real exchange rate measure that shows a pattern that is comprehensively and robustly consistent with the expenditure-switching mechanism is the one that makes use of ULC, measured in effective terms, (henceforth, REER-ULC). Specifically, applying an error correction model (ECM) to both quarterly and annual data covering 35 economies over a period of around two decades, we find that the REER-ULC exhibits a negative and statistically significant correlation with the external balance (expressed as the ratio of the current account or trade balance to GDP), while real exchange rate measures deflated by the CPI or the GDP deflator (henceforth, REER-CPI and REER-GDP, respectively) tend to have a positive or statistically insignificant correlation with the external balance.

We rationalize these empirical findings by introducing a simple variant of the workhorse model in open macroeconomics Gali and Monacelli (2005), including trade in intermediate goods à la Obstfeld (2001) and Devereux and Engel (2007). Such a model can generate a qualitatively identical pattern to that uncovered in the empirics in response to productivity shocks, i.e. a negative correlation between external balances and REER-ULC but a positive or insignificant correlation between external balances and REER-CPI or REER-GDP. The main elements in the model necessary to deliver such predictions include sticky wage and final goods price, trade in intermediate goods, and flexible intermediate goods price. In a nutshell, to the extent that prices are relatively more flexible in tradable goods than in nontradable goods, sticky wages imply a full pass-through in unit labor cost in response to labor productivity shocks, which triggers the expenditure-switching mechanism in tradable goods via price adjustments. However, since nontradable goods prices do not respond as much, there will be a delayed adjustment in CPI or GDP deflator. As a result, for a given change in nominal exchange rate in response to productivity shocks, external balance adjustments due to expenditure-switching are matched more closely with the movement in REER-ULC than that with REER-CPI or REER-GDP.

The model and empirics clarify how the expenditure-switching mechanism operates through different price deflators. The absence of a significant negative correlation between external balances and CPI-based real exchange rate—the most widely used measure of the RER—is actually a natural result from nominal rigidity and intermediate goods trade, and the model highlights that it should not be used as evidence against the presence of the expenditure-switching mechanism. Importantly, our findings do not necessarily indicate the merit of a certain measure of REER over others.

Our work contributes to a large literature that aims at analyzing the relationship between real exchange rates and external balances. The main mechanism directly linking real exchange rates and external balances is expenditure-switching: the change in the composition between the demand for domestic products and foreign products in response to changes in relative prices. It has been examined using different theoretical assumptions, for instance, producer currency pricing in Obstfeld and Rogoff (2005), local currency pricing in Devereux (2000) or Chari, Kehoe and McGrattan (2002) among many others. Empirically, the link between the real exchange rate and external balances has been investigated for different sets of countries and time periods. For instance, Gervais, Schembri and Suchanek (2016) document that real exchange rate adjustment has contributed significantly to current account adjustment towards its long-run equilibrium, using a large set of emerging-market economies over the period 1975 to 2008. Arghyrou and Chortareas (2008), focusing on EU countries from 1970s to 2000s, find a sizable and often non-linear relationship between real exchange rate and current account. In particular, we note that both studies find an insignificant role of CPI-based REER measure in current account adjustment in the short run, consistent with our findings. Applying an event study approach, Freund and Warnock (2007) and Leigh et al. (2015) find that the external balance is negatively correlated with real exchange rates. Our approach complements this literature by exploring the relationship between external balance and real exchange rate beyond the use of CPI-based real exchange rate which is the default in most papers, and incorporating other cost-side deflators such as unit labor cost and other demand-side deflators such as GDP deflator.

Our paper is also closely related to the literature investigating the construction of REER and its implications. Chinn (2006) distinguishes between different types of REERs and highlights that commonly used indices may be inadequate to address certain research questions. Closest to our aim here is probably Bayoumi, Harmsen and Turunen (2011) and Comunale and Hessel (2014), who take the Euro area as a particular case to examine the link of different types of REERs with exports. Both papers call for caution when using standard measures of real effective exchange rates. Differently from our paper and related studies focusing on deflators, there is an emerging literature that focuses exclusively on the weights used in REER calculation, reflecting the growing relevance of value-added trade measures. Bems and Johnson (2015) incorporate trade in intermediates in the calculation of weights, Bayoumi, Saito and Turunen (2013) adjust weights to account for imported inputs, and Patel, Wang and Wei (2014) introduce sector-specific elasticities to replace the assumption of a single aggregate elasticity to better capture industry heterogeneity.

Lastly, this paper is also related to existing papers on nominal exchange rate responses and pass-through to various shocks (e.g. Cunningham et al. (2017), Forbes, Hjortsoe and Nenova (2018)). We extend this literature by analyzing the relationship between various real exchange rates and the external balance while emphasizing the interactions between nominal rigidities and shocks.

The paper is organized as follows: Section 2 presents and discusses the data, and Section 3 reports our empirical investigation. Section 4 lays out a standard open-economy model that generates the patterns uncovered in Section 3. Section 5 offers concluding remarks.

2 Data

We construct a balanced panel of 35 economies including major advanced and emerging economies covering 2000Q1-2017Q4. We also supplement the quarterly panel with an annual sample, which dates back to 1995, to explore a longer time period and additional robustness checks. Details on the dataset are provided in the Appendix A.1.

The real effective exchange rate (REER) is constructed following the conventional methodology in the literature. Specifically, we compile bilateral nominal exchange rates and price indices to calculate bilateral real exchange rates, and then take the weighted average for each country, where the weight is calculated from bilateral trade data as in Bayoumi, Lee and Jayanthi (2005):[1]

$$REER_i = \Pi_{j \neq i} \Big(\frac{P_i S_{ij}}{P_j} \Big)^{\lambda_{ij}}$$

where λ_{ij} represents the weight of j in trade with i and S_{ij} is the bilateral nominal exchange rate between i and j. As such, an increase in REER measure corresponds to an appreciation in the home currency. We consider three different types of price indices—consumer price index (CPI), GDP deflator, and unit labor cost (ULC)— to deflate nominal exchange rates, yielding three distinct REER measures: REER-CPI, REER-GDP, and REER-ULC. Table 1 reports summary statistics. A standard set of unit root and cointegration tests suggests the presence of a cointegrating relationship

[1] The weights are calculated using Global System, which uses data on trade flows. In the calculation, three types of trade categories are included: commodities, manufacture goods and services (represented by trade in tourism).

The overall weight is the weighted average of the three: $\lambda_{ij} = \alpha_M \lambda_{ij}^M + \alpha_C \lambda_{ij}^C + \alpha_T \lambda_{ij}^T$, which are based on the trade data between 2004 to 2006. IMF's official REER series (available from the International Finance Statistics database) follow this methodology since 2005. Investigating the role of REER weights is also highly relevant but beyond the scope of the current paper. Interested readers are referred to Bems and Johnson (2015) and Bayoumi, Saito and Turunen (2013).

between non-stationary REER and external balance measures.[2]

For the choice of deflator to matter it is necessary that (i) deflators have a non-negligible contribution for the variation in REERs and (ii) their movement is substantially different from one another. To check the first condition, we decompose the variance of real exchange rates into the variance of relative prices, nominal exchange rate, and a covariance term:[3]

$$\begin{aligned} Var(\ln REER) &= Var(\ln NEER + \ln P/P^*) \\ &= Var(\ln NEER) + Var(\ln P/P^*) + 2Cov(\ln NEER, \ln P/P^*) \end{aligned}$$

The variance decomposition results provided in Table A3 in the online appendix show that relative prices can account for around 10-20 percent of variation in annual growth in REER and substantially larger portions of the quarterly growth in REER, lending support to the idea that the choice of deflator may not be innocuous.

To illustrate the second condition, we plot REER measures using different relative price deflators for a selected group of countries along with their current account relative to GDP (Figure 1). Although all the REER measures tend to move in tandem, there is a noticeable difference in the magnitude of fluctuation, with REER-ULC often being most volatile. Moreover, fluctuations in current account balance appear to be most closely mirrored by those in REER-ULC, not only for southern euro area countries well covered in existing studies on their run-up to the crisis but also for other major current account surplus and deficit countries such as China, Korea, and the U.S. Taken together, they point to a potentially important role of deflators in analyzing the relationship between real exchange rates and external balances.[4]

3 Empirical Evidence

3.1 Econometric Specification

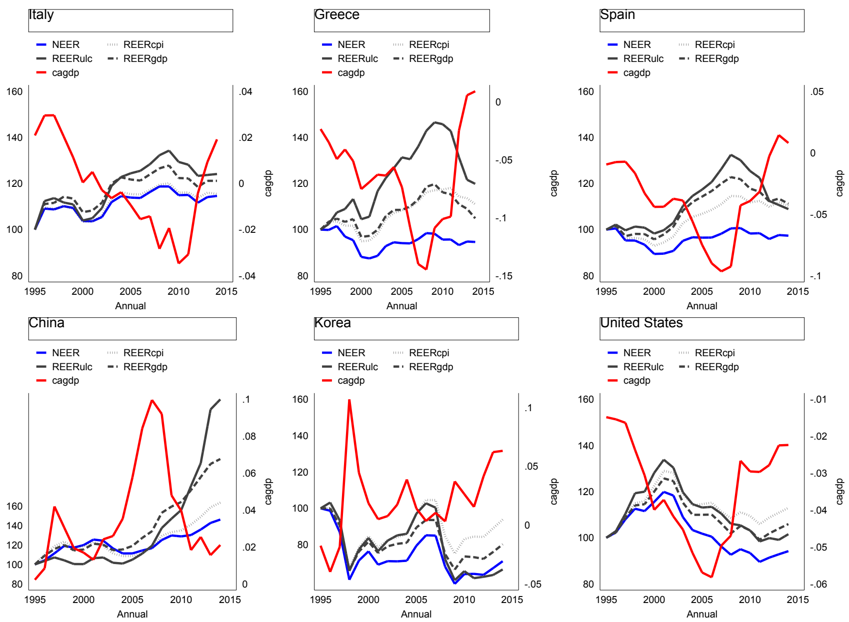
Our baseline approach to estimating the short-run relationship between external balance and real effective exchange rate is to use a single-equation error correction model (ECM), given that the variables of interest appear non-stationary and cointegrated as discussed in Section 2. To the extent that non-stationary variables have a co-integrating relationship, an error correction model is expected to deliver more efficient estimation results than other types of dynamic estimators. Our key empirical specification is:

[2] According to p-values reported in Table A1 in the online appendix, unit root test results are somewhat mixed. Most tests tend to reject the hypothesis that all the panels contain a unit root at least for one variable. On the other hand, the hypothesis that all the panels are stationary is strongly rejected for all the variables. These suggest that the variables likely contain a unit root in some countries but are stationary in other countries. Henceforth, we take a conservative stance that all the panels contain a unit root in these variables. A set of subsequent cointegration tests reported in Table A2 in the online appendix strongly suggest that REER measures are cointegrated with current account-to-GDP ratio.

[3] This decomposition is done using the change in each variable as we state above their levels are not stationary.

[4] A substantial difference between REER measures deflated by CPI and GDP-deflator is also highlighted in Bems and Johnson (2015).

Figure 1: REERs and External Balance



Note: This figure plots the current account in percent of GDP, NEER, and REERs based on CPI, ULC, and GDP deflators for Italy, Greece, Spain, China, Korea, and United States. The time series span from 1995 to 2015.

$$\begin{aligned}\Delta Y_{it} \quad &= \eta\Big(Y_{it-1} - \beta \ln REER_{it-1} - \beta_1 \ln GDP_{it-1} - \beta_2 \ln GDP^*_{it-1}\Big) \\ &+\gamma\Delta \ln REER_{it} + \gamma_1 \Delta \ln GDP_{it} + \gamma_2 \Delta \ln GDP^*_{it} + \alpha_i + \epsilon_{it}\end{aligned} \tag{1}$$

where Y denotes the external balance measured as current account balance or trade balance in percent of GDP.[5] GDP and GDP^* stand for the home country real GDP and weighted rest-of-world real GDP (same weights as REER), capturing the income effect on domestic and foreign demand conditions, respectively.

In the baseline model specified above, we assume homogeneity in all the coefficients across countries, while country-specific time invariant factors are absorbed by country fixed effects, α_i. As alternatives to this dynamic fixed effects (DFE) estimator, we also consider an estimator that allows for heterogeneous short-run dynamics but common long-run relationship—i.e., the pooled mean-group (PMG) estimator—or one that assumes heterogeneity in both the short- and long-run relationship—i.e., the mean-group (MG) estimator.

A legitimate concern about the single-equation error correction model is a potential endogeneity bias driven by the reverse causality from external balance to real effective exchange rate: improvement (deterioration) in external balance likely leads to currency appreciation (depreciation). Without correcting for such upward bias, the estimation coefficient can be seen at best as reflecting correlation rather than causality. We will keep this in mind, and consider its implications explicitly when

[5] In the paper, our baseline external balance measure is the current account balance, but results with alternative external balance measures are also reported for robustness.

discussing the estimation results.

3.2 Baseline Results

Table 2 reports the baseline results from the ECM dynamic fixed effects estimation using quarterly data. Columns 1-3 correspond to the estimation results when the deflator used to construct the REER measure in the regression is ULC, CPI, and GDP deflator, respectively. The top three rows summarize the long-run coefficient estimates, while the bottom panel shows the short-run coefficient estimates. The error-correction term that captures the speed of adjustment (*Error Correction Coef* (η) in the bottom panel) is estimated to be within $(-1, 0)$ and statistically significant across all columns irrespective of deflators, confirming the cointegrating relationship among the variables.

In the present context, the estimated coefficient of particular interest is the short-run REER coefficient (*ln REER* in the bottom panel). It is estimated to be negative and statistically significant for REER-ULC, but negative and insignificant or positive and insignificant for REER-CPI and REER-GDP, respectively. Since the expenditure switching mechanism would predict a negative coefficient—implying that REER depreciation (appreciation) is associated with current account balance improvement (deterioration)—, one interpretation of our estimates is that only the ULC-based REER measure is consistent with the expenditure-switching mechanism. The magnitude of the estimated short-run REER-ULC coefficient of -0.048 lies at the lower end of the elasticity range typically assumed across countries in IMF (2018). Most interestingly, such a stark contrast in the estimated coefficients across columns 1-3 from different REER measures is found only in the short-run REER coefficient and mostly absent in other short-run and long-run coefficients.

As for the long-run REER coefficients (*ln REER* in the top panel), they are estimated to be positive across all deflators, although statistically insignificant, potentially suggesting the long-run equilibrium relationship that strong (weak) external balance leads to REER appreciation (depreciation). Likewise, the income effect captured by measures of domestic and foreign demand is such that the long-run foreign demand coefficient (*ln* GDP^* in the top panel) is estimated to be positive and statistically significant across all columns, while the long-run domestic demand coefficient estimate (*ln GDP* in the top panel) is negative irrespective of deflators, which is consistent with the intuition that strong foreign (domestic) demand would boost (shrink) external balance. By contrast, short-run foreign and domestic demand coefficients (*ln* GDP^* and *ln* GDP^* in the bottom panel) are somewhat less precisely estimated with counter-intuitive signs.[6] We see these results as consistent with the previous literature (e.g., Arghyrou and Chortareas (2008)) that relative incomes have played a more prominent role in long-run current account determination, while REERs have been more relevant for short-run CA determination.

In the rest of the paper, we focus exclusively on the short-run REER coefficients because we are interested in the expenditure-switching mechanism and the Keynesian models that appeal to it, and less on structural factors driving real exchange rates and external balances.

Beyond the baseline specification, we first attempt to account for potential heterogeneity in the

[6] Although there also appears slight difference in the estimated coefficients of the short-run demand variables across columns, this is not so stark as the one for the short-run REER variable, a fact that is consistent throughout the battery of regression results reported in the paper and its online appendix.

coefficients across countries. Specifically, we apply the pooled mean-group and mean-group ECM estimators instead of the dynamic fixed effects estimator, which allows the coefficients of short-run variables only or both short-run and long-run variables to vary across countries. Table 3 summarizes the PMG and MG estimation results across three different REER measures. Clearly, estimation results from both the PMG and MG estimators are very similar to those from the DFE estimator reported in Table 2. REER-ULC always yields negative and statistically significant coefficient estimates of the short-run REER variable, while none of those from REER-CPI and REER-GDP is statistically significant, most of which are even positively signed. Moreover, such a stark contrast is not seen in other variables. At the bottom of Table 3, the p-values from the Hausman test indicate that the dynamic fixed effects estimator should be preferred to the pooled mean-group or mean-group estimator in terms of efficiency. For this reason, tables henceforth report the estimation results from the dynamic fixed effects only.[7]

We also allow for richer short-run dynamics by including additional lags of the short-run REER variable in the estimating equation whereby the selection of lags exactly follows Rose and Yellen (1989). Table 4 reports the coefficient estimates of the contemporaneous and lagged short-run REER variables for REER-ULC (top panel), REER-CPI (middle panel), and REER-GDP (bottom panel). Irrespective of the additional lags included, REER-ULC always yields negative and statistically significant estimates on the contemporaneous term and insignificant estimates on all the lagged terms. By contrast, all the coefficient estimates with REER-CPI or REER-GDP— contemporaneous and lagged—are statistically insignificant, confirming the robustness of the main finding to richer dynamic specifications. These are also consistent with Rose and Yellen (1989) that there is no evidence for the J-curve.

Instead of using the current account balance, we re-run our baseline regressions using the trade balance as a measure of external balance. Table 5 reports the baseline estimation results using trade balance-to-GDP ratio as dependent variable. These are qualitatively identical to those using the current account-to-GDP ratio in Table 2.

We further investigate whether our findings are driven by particular sample periods. It would be possible that the elasticity estimated in the baseline regression is due to that real exchange rates and external balance simultaneously respond to global factors, such as global risk or change in dominant currencies. In that case, the negative elasticity may not be a good indicator for expenditure switching. To address this concern, we add time (quarter) fixed effects to control for any time-specific factors to the baseline specification. From Table A4 in the online appendix, it is evident that the main finding earlier that only REER-ULC yields negative and statistically significant coefficient estimates on the short-run REER variable continues to hold after controlling for quarter-specific shocks.

Next, we check whether the exchange rate regime matters by separately estimating the relationship for countries with floating exchange regime and those with fixed exchange rate regime.[8] With floating exchange rate, even prices are sticky, depreciation or appreciation allows real exchange

[7]The extent to which the REER-CPI and the REER-ULC are correlated in each country differs substantially, but still our broad qualitative results hold even when looking at samples excluding countries with above median levels of this correlation or vise-versa.

[8]The classification of floating and fixed exchange rate regimes is based on Shambaugh (2004).

rate to adjust in response to shocks, hence triggers expenditure switching. Therefore, it would be useful to check whether the baseline results are largely driven by observations under floating exchange regime. Table A5 in the online appendix summarizes the ECM estimation results for floating exchange rate regime countries (columns 1-3) and fixed exchange rate regime countries (columns 4-6), confirming that qualitatively identical patterns are found in both floating and fixed exchange rate regime countries.

3.3 Robustness Checks

3.3.1 Annual Frequency Data

We now turn to the annual frequency version of our dataset for additional robustness checks. In addition to allowing to explore a longer time-series at the cost of losing higher-frequency dynamics, annual frequency data offer a broader set of feasible robustness checks because some of the necessary data series are available only at annual frequency. As such, the first part of this section will basically repeat all the ECM estimation procedures applied to the quarterly data above, while the latter part considers potential factors behind the results. To save space, we report all the robustness checks results discussed in this section in the online appendix.

As in Table 2 from the quarterly data, the top three rows in Table A6 in the online appendix summarize the long-run coefficient estimates, while the bottom panel shows the short-run coefficient estimates including the error-correction term that captures the speed of adjustment. Columns 1-3 correspond to the estimation results when the deflator used to construct the REER measure in the regression is ULC, CPI, and GDP deflator, respectively. The estimate of the short-run REER coefficient (*ln REER* in the bottom panel), our key interest, shows similar results to those from the quarterly data in that only the ULC based REER measure is consistent with the expenditure-switching mechanism. Specifically, it is estimated to be negative and statistically significant for REER-ULC, but positive and insignificant for REER-CPI and REER-GDP. Again, such a stark contrast in the estimated coefficients across columns 1-3 from different REER measures is found only in the short-run REER coefficient and mostly absent in other short-run and long-run coefficients.

As we did for the quarterly data in the previous section, we apply the pooled mean-group and mean-group ECM estimators to the annual frequency data, and confirm that the overall estimation results from both the PMG and MG estimators are similar to those from the DFE estimator reported. According to p-values from Hausman test statistics provided at the bottom of Table A7 in the online appendix, the dynamic fixed effects estimator should be preferred to the pooled mean-group or mean-group estimator in terms of efficiencies. We repeat additional robustness checks that we performed with the quarterly data. Table A8 in the online appendix reports the ECM dynamic fixed effects estimation results with year fixed effects. Our main finding that only REER-ULC yields negative and statistically significant coefficient estimates on the short-run REER variable continues to hold after controlling for year-specific shocks. To check if the finding is driven by exchange rate regimes, we report the ECM estimation results from annual data separately for flexible regime countries (columns 1-3) and for fixed regime countries (columns 4-6) in Table A9 in the online appendix. It confirms that such patterns are found in both exchange rate regime countries.

Replacing current account-to-GDP ratio with trade balance-to-GDP ratio as an external balance measure hardly affects the main result (Table A10 in the online appendix).

3.3.2 Additional Robustness Checks

So far, we have confirmed that our main finding also holds with data at annual frequency. One immediate concern from our baseline specification is whether the results are driven by a potential endogeneity bias. We argue that as far as the role of price deflator is concerned, the reverse causality concern would not overturn the results. First, the main direct channel through which the external balance affects real exchange rate is via its effects on nominal exchange rate, which is common in all the REER measures. Therefore, this should not affect our results on the difference in the coefficient estimates across different REER measures. Even if we believe external balances affect prices on top of its effects on nominal exchange rate, it is hard to come up with a particular mechanism that would induce a relatively more severe upward bias for CPI- or GDP-deflators than ULC-deflators. We take a similar stance on the potential omitted variable bias in that it should not affect our results on the difference in the coefficient estimates across different REER measures.

Nevertheless, we check a few of the most likely sources of omitted variable bias, and we start by commodity terms of trade. Intuitively, a collapse in commodity prices would result in a direct price effect, boosting (worsening) external balances in commodity importers (exporters). At the same time, it is expected to strengthen (weaken) currencies in commodity importers (exporters). As a result, omitting this variable may lead to an upward bias in the estimated coefficients on short-run REER variables. Table A11 in the online appendix confirms that our main finding is not driven by omitted variable bias caused by not controlling for commodity terms of trade[9]. In fact, compared to the baseline estimation results reported in Table A6, the coefficient estimate on REER-ULC becomes more negative, while that on REER-CPI or REER-GDP becomes even more positive, supporting our claim that a potential upward bias, if any, should be more severe for REER-ULC, and hence work against finding the pattern we uncover.

Another concern related to omitted variable bias is that the cost of other inputs, such as capital and/or intermediate inputs might well be part of the error term, which thus is likely to be correlated with labor costs as other inputs are substitutes or complements of labor. While we note that under the standard Cobb-Douglas production function assumption, ULC is equal to total production cost with a constant wedge such that they share the same dynamics after taking a log-transformation. We also acknowledge that Cobb-Douglas function might not be a good approximation for the aggregate production function in reality. For instance, as documented by Karabarbounis and Neiman (2014), the labor share is declining globally as opposed to the prediction from a Cobb-Douglas function that labor shares would be constant. Although it is difficult to obtain data on other costs of inputs, we try to address the problem by controlling for the cost of capital. To this end, we employ

[9] Data is available at the annual frequency from the IMF's EBA dataset. Commodity terms of trade are calculated as the ratio of a geometric weighted average price of the main commodity exports to a geometric weighted average price of main commodity imports. The commodity categories included are food, fuels, agricultural raw materials, metals, gold, and beverages, measured against the advanced economies manufacturing goods prices from the World Economic Outlook. These relative commodity prices of six categories are weighted by the time average of export and import shares of each commodity category in total trade (exports and imports of goods and services).

the data constructed by Karabarbounis and Neiman (2014) which covers the labor and capital share to output in a large panel of countries as far as back to 1970s (data availability varies with respect to countries). We calculate the ratio of total cost (labor and capital) to labor cost by $(capital\ share + labor\ share)/labor\ share$ and add that as an additional control to our baseline regression using REER-ULC. As shown in the last column of Table A11 in the online appendix, the negative correlation between REER-ULC and external balance is hardly affected, which helps to ease the concern about omitting other types of input costs. Including additional control variables such as trade openness, financial openness, or GDP per capita does not change the result in a significant way (Tables A12 and A13 in the online appendix).

Alternatively, one may suspect that the inherent difference in the composition of goods covered by each deflator is driving the empirical patterns. Such difference could be in terms of domestic and imported goods, final and intermediate goods, or tradable and non-tradable goods. For one thing, imported goods are included in CPI and in GDP deflator (negatively), while ULC covers only domestically produced goods. Moreover, with the development of global value chains, intermediate goods have become more prominent in international trade (and hence in external balances). The prices of intermediates are likely better covered in ULC than CPI or GDP deflator. Similarly, CPI and GDP deflators tend to cover non-tradable goods more broadly, whereas ULC tends to reflect mostly tradable goods.

Given such heterogeneity in the composition of goods across price indices, we aggregate sector-level ULC and GDP deflators in tradable sectors, thereby constructing an alternative set of REER measures covering tradable sectors only.[10] The results summarized in Table A14 in the online appendix suggest that the composition alone could not explain the empirical patterns. The REER measure using tradable GDP deflator still shows no significant short-run relationship with the external balance (columns (2)), whereas that using tradable ULC continues to show statistically significant and negative relationship (columns (1)). In column (3) and (4), we explicitly account for the relative price in tradable and nontradable sector, which yields qualitatively identical results.

Although we have used the ratio of current account (or trade balance) to GDP following the literature, Alessandria and Choi (2019) propose a novel decomposition and approximation of the external-balance-to-GDP ratio. Specifically, trade-to-GDP ratio can be decomposed into trade-balance-to-gross-trade ratio and gross-trade-to-GDP ratio, where the former can be, using first-order Taylor expansion, directly linked to the demand equation derived from the classic Armington model. In this context, we confirm that the alternative measure of external balance, namely, trade-balance-to-gross-trade ratio, can deliver our baseline finding (Table A15 in the online appendix).

Similarly, we address potential concerns about GDP as a proxy for total demand. Recalling that total domestic absorption in each country is essentially total consumption and investment, we replace home and rest-of-world GDP with total consumption and investment, which does not overturn the results (Table A16 in the online appendix).

We further investigate whether our findings have anything to do with the growing role of global value chains (GVCs) in international trade. Considering that export and import are comprised

[10] More details can be found in Mano (2017).

of both domestic value-added and foreign value-added contents, we break down the trade balance into a traditional trade component (i.e., domestic value-added in export less foreign value-added in import) and another pertaining to GVC-related trade (i.e., foreign value-added in export less domestic value-added in import) using the OECD TiVA dataset. The last three columns in Table A17 in the online appendix confirm that our baseline findings with trade balance-to-GDP ratio also hold in the sample observations restricted by the data availability in the OECD TiVA dataset. A separate regression of the two above-mentioned components is reported in columns (1)-(6): the first three columns are regression results of the first component (traditional trade balance) and next three columns are regression results of the second component (GVC-related trade balance). They indicate that our main results are driven by traditional trade balance, and no such pattern is observed in GVCs type of trade balance.

Lastly, although our REER measurements strictly follow the methodology of IMF's REER-CPI, it would be useful to double check our results using REER data from other sources. Among several potential options such as those from the Feds, BIS, OECD, and ECB, we select the European Commission's dataset which contains REERs based on ULC for the aggregate economy, ULC of manufactures, Harmonized Index of Consumer Price and GDP deflator. The dataset covers mainly EU28 countries plus Australia, Brazil, Canada, China, Hong Kong, Japan, Korea, Mexico, New Zealand, Norway, Russia, Switzerland, Turkey, and the U.S. (42 countries in total) from 1994 to 2017. We apply the baseline error correction model estimation to the new data, and the results that are summarized in Table A18 in the online appendix look remarkably similar to those from our self-constructed data.

Overall, our main finding that only the REER deflated by ULC is consistent with the expenditure-switching mechanism is shown to be extremely robust across empirical specifications as well as sample countries and periods. Beyond the compositional difference across price indices, there must be something else that could generate an environment in which REER-ULC moves differently from other REER measures, and thereby better reflect the relative price of goods that are relevant for external balance adjustments. We now turn to a model that can generate qualitatively identical patterns to this empirical evidence, shedding light on a rationale for our main findings.

4 Model

In this section, we show that a simple variant of a standard workhorse of the macro-international literature can generate the seemingly puzzling results of the previous section. In particular, we find that the simulated data from a version of the two-country New Keynesian model of Gali and Monacelli (2005) where only intermediates can be traded internationally, exhibit a negative contemporaneous correlation between external balance and REER-ULC but insignificant correlations with other REERs. Lagged correlations in the simulated data are also qualitatively similar to those uncovered in section 3. Crucial to these findings is the ability of the model to generate a large and immediate pass-through of productivity shocks to unit labor costs but low pass-through to final goods prices, and hence to CPI or the deflator, due to rigidities in nominal wages and prices of final goods.[11]

Because the model is standard, we sketch here its main features and direct the reader to Online Appendix B for the full details. The model includes nominal wage and price rigidities *a la* Calvo as in Ferrero (2015), trade in intermediate goods in the spirit of Obstfeld (2001) and Devereux and Engel (2007), and non-tradable final goods. The model features two countries, home and foreign. In each country, households set wages for differentiated labor, which is supplied to a labor union where composite labor is assembled and in turn provided to an intermediate producer. There is a positive probability that households cannot change wages in each period. The final producer uses intermediate inputs from both countries to produce final goods and sells them in the domestic market. When setting the final goods price, the producer is also subject to a positive probability that she will not be able to change it.

We simulate the model for 4000 periods allowing for both productivity and monetary policy shocks, and then compute the correlation, both contemporaneously and lagged, between RERs and external balance in the second half of the sample. In order to make these calculations comparable with the empirical results, we regress the ratio of trade balance-to-GDP on the logarithm of each RER controlling for the home and foreign GDP. The results are presented in Figure 2.

The simulated contemporaneous elasticity with respect to the RER-ULC is significant and negative, whereas the RER-CPI and RER-GDP's counterparts are insignificant, exactly matching our empirical findings. We also calculate lagged correlations, which are potentially interesting given the model's staggered price adjustment. Figure 2 shows that the trade elasticities with respect to all RERs become insignificant after one year. As most households get the chance to reset wages after one year, both wage and ULC increase leading to a decline in the competitiveness of home's intermediate goods, and deteriorating the trade balance. Thus, after the first year the trade balance is not significantly correlated with lagged RERs.

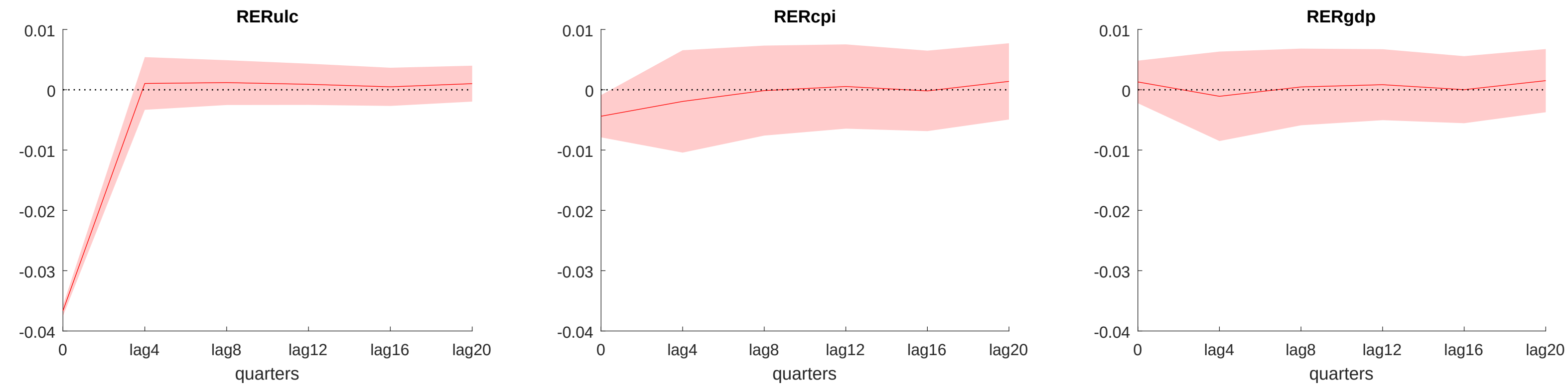
5 Conclusion

This paper investigates the role of price deflators in the empirical relationship between real exchange rate and external balance. We document a strong negative correlation between real exchange rate deflated by unit labor cost and external balance and the absence of a significant relationship with those based on CPI or GDP deflator. Using a large sample of 35 major economies covering almost two decades, we estimate these correlations using an error correction model and check the robustness of this finding using different regression specifications, subsample of countries and time periods. Motivated by the empirical findings, we lay out a two-country open economy model with both wage and final goods' price rigidities as well as trade in intermediate goods to rationalize the evolution of different real exchange rates and external balance.

The key insight lies in the dual-role of nominal rigidity on unit labor cost (as the factor cost), which is closely related to the trade in intermediate goods, and on CPI (as the final price), which is

[11] Although we adopt a two-country open economy model, a small economy model *a la* Schmitt-Grohé and Uribe (2003) would generate qualitatively similar implications because the mechanism for reproducing the key result lies in *home* responses, not in the responses of *foreign*

Figure 2: Contemporaneous and Lagged Elasticity of Current Account to RER



Note: This figure plots the elasticity of the current-account-to-GDP ratio to different RERs using model-simulated data. It shows the coefficient of ULC-, CPI-, and GDP deflator based RERs, left-to-right respectively, from regressing current-account-to-GDP ratio on each $\ln RER$ controlling for $\ln GDP$. Solid red lines denote point estimates and the light red band is the 95% confidence interval.

linked to domestic transactions in final goods. As the shocks hit, wage rigidity prevents wages from offsetting the shocks, thereby allowing full pass-through to the real exchange rate based on unit labor cost; on the contrary, price rigidity prevents the pass-through to CPI completely, and partially mutes the response in GDP deflator. As a result, when the expenditure-switching mechanism takes place, the relative price of intermediate goods governed by the real exchange rate based on unit labor cost is strongly related to movements in the external balance, while the lack of change in CPI and GDP deflator disconnects their corresponding real exchange rates from the changes in the external balance. Our baseline simulation demonstrates that the model can match well with the empirical patterns.

These results suggest that the choice of price deflators matters in assessing the relationship between the real exchange rate and the external balance, and warrant strong caution in interpreting observed empirical patterns. Our findings also stress that the absence of negative correlation between real exchanges rates and external balances should not be simply taken as evidence against the presence of the expenditure-switching mechanism and might even have bearing on the international elasticity puzzle.

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Table 1: Summary Statistics

Variable	Mean	Std. Dev.	Min.	Max.	N
Quarterly Sample					
REER-CPI	4.7142	0.1914	4.1189	5.5815	2520
REER-ULC	4.7307	0.2731	3.8518	6.2001	2520
REER-GDP	4.7284	0.2198	3.9739	5.8874	2520
NEER	4.6323	0.1697	3.5867	5.0639	2520
CA/GDP	0.0001	0.0603	-0.2712	0.1951	2520
TB/GDP	0.0171	0.0622	-0.2436	0.4123	2520
export/GDP	0.4309	0.2402	0.0217	1.2774	2520
import/GDP	0.4138	0.2253	0.0221	1.0875	2520
Annual Sample					
REER-CPI	4.6974	0.245	4.0196	5.3899	805
REER-ULC	4.7146	0.281	3.7388	5.7082	805
REER-GDP	4.7167	0.2574	3.8413	5.5803	805
NEER	4.4528	0.6047	1.4336	5.2167	805
CA/GDP	-0.001	0.0563	-0.2432	0.1804	805
TB/GDP	0.0139	0.0614	-0.207	0.3293	805
export/GDP	0.3802	0.2407	0.0009	1.2466	805
import/GDP	0.3626	0.2204	0.0008	0.9976	805

Note: This table reports the summary statistics for main variables in our sample, covering 35 countries over the period 2000Q1 to 2017Q4 for the quarterly sample and 1995 to 2017 for the annual sample. The top and bottom panel refer to the quarterly sample and the annual sample, respectively. All variables are expressed in log-terms except the ratios to GDP.

Table 2: Baseline Specification with Quarterly Data

Dependent variable: CA/GDP	(1) ULC	(2) CPI	(3) GDP
Long-run			
ln GDP	-0.037	-0.074*	-0.051
	(0.04)	(0.04)	(0.04)
ln GDP*	0.128**	0.146**	0.137**
	(0.06)	(0.06)	(0.06)
ln REER	0.007	0.109	0.036
	(0.05)	(0.10)	(0.07)
Short-run			
ln GDP	0.023*	0.007	-0.013
	(0.01)	(0.02)	(0.02)
ln GDP*	-0.088**	-0.059	-0.020
	(0.04)	(0.04)	(0.04)
ln REER	-0.048***	-0.013	0.020
	(0.01)	(0.03)	(0.03)
Error Correction Coef (η)	-0.157***	-0.160***	-0.156***
	(0.02)	(0.02)	(0.02)
obs	2485	2485	2485

Note: This table reports the baseline error correction model estimation of equation (1) using quarterly data, with the current account balance-to-GDP as the dependent variable. The results are reported separately for REER-ULC (column 1), REER-CPI (column 2), and REER-GDP (column 3). The top and bottom panel refer to the long-run and short-run relationship, respectively. ln GDP is a country's own GDP (in log) to capture domestic demand, while ln GDP* is trading partners' weighted GDP (in log) to measure foreign demand. Error Correction Coef (η) denotes the error correction coefficient that reflects the speed of the adjustment. Standard errors are reported in parentheses and clustered at the country level. ***, **, * represent significance of 1%, 5% and 10%, respectively.

Table 3: Short-run and Long-run Restrictions on the Baseline Specification with Quarterly Data

Dependent variable:	(1)	(2)	(3)	(4)	(5)	(6)
CA/GDP	ULC	CPI	GDP	ULC	CPI	GDP
	Pooled Mean-Group (PMG)			Mean-Group (MG)		
Long-run						
ln GDP	-0.030**	-0.091***	-0.041**	-0.127***	-0.151***	-0.166***
	(0.01)	(0.01)	(0.01)	(0.04)	(0.04)	(0.04)
ln GDP*	0.197***	0.255***	0.205***	0.206**	0.152***	0.160**
	(0.02)	(0.02)	(0.02)	(0.06)	(0.04)	(0.05)
ln REER	-0.018	0.106***	-0.001	0.102	0.267***	0.255**
	(0.02)	(0.03)	(0.03)	(0.07)	(0.08)	(0.08)
Short-run						
ln GDP	0.019	0.014	-0.025	0.005	-0.013	-0.045**
	(0.01)	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)
ln GDP*	-0.036	-0.029	0.012	0.037	0.068	0.088
	(0.06)	(0.06)	(0.06)	(0.06)	(0.07)	(0.06)
ln REER	-0.073***	-0.045	0.025	-0.061**	-0.007	0.048
	(0.02)	(0.04)	(0.04)	(0.02)	(0.04)	(0.04)
Error Correction Coef (η)	-0.204***	-0.204***	-0.200***	-0.452***	-0.473***	-0.452***
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
obs	2485	2485	2485	2485	2485	2485
Hausman test	1.000	1.000	1.000	1.000	1.000	1.000

Note: This table reports the baseline error correction model estimation results with a set of short-run and long-run restrictions in equation (1) using quarterly data, separately for REER-ULC (columns 1 and 4), REER-CPI (columns 2 and 5), and REER-GDP (columns 3 and 6). Columns 1-3 show the results from the PMG estimator, while columns 4-6 show the results from the MG estimator. P-values from the Hausman test are reported at the bottom of the table. The top and bottom panel refer to the long-run and short-run relationship, respectively. ln GDP is a country's own GDP (in log) to capture domestic demand, while ln GDP* is trading partners' weighted GDP (in log) to measure foreign demand. Error Correction Coef (η) denotes the error correction coefficient that reflects the speed of the adjustment. Standard errors are reported in parentheses and clustered at the country level. ***, **, * represent significance of 1%, 5% and 10%, respectively.

Table 4: Lagged Baseline Specification with Quarterly Data

Dependent variable: CA/GDP				
Panel A: REER-ULC	(1)	(2)	(3)	(4)
Long-run				
ln REER	0.007	0.002	-0.005	0.010
	(0.05)	(0.05)	(0.06)	(0.07)
Short-run				
ln REER	-0.048***	-0.053***	-0.046**	-0.043**
	(0.01)	(0.02)	(0.02)	(0.02)
lag_4		0.005	0.012	0.010
		(0.02)	(0.02)	(0.02)
lag_8			-0.009	-0.012
			(0.02)	(0.02)
lag_12				-0.014
				(0.01)
Panel B: REER-CPI				
Long-run				
ln REER	0.109	0.112	0.124	0.174
	(0.10)	(0.09)	(0.12)	(0.14)
Short-run				
ln REER	-0.013	-0.012	0.008	0.014
	(0.03)	(0.04)	(0.04)	(0.04)
lag_4		0.005	0.025	0.019
		(0.03)	(0.03)	(0.03)
lag_8			0.010	0.011
			(0.02)	(0.02)
lag_12				-0.010
				(0.02)
Panel C: REER-GDP				
Long-run				
ln REER	0.036	0.037	0.036	0.068
	(0.07)	(0.07)	(0.09)	(0.10)
Short-run				
ln REER	0.020	0.035	0.050	0.056
	(0.03)	(0.03)	(0.03)	(0.04)
lag_4		0.016	0.027	0.031
		(0.02)	(0.02)	(0.03)
lag_8			0.011	0.014
			(0.02)	(0.02)
lag_12				-0.004
				(0.02)
obs	2485	2345	2205	2065

Note: This table reports the extended error correction model estimation results from the quarterly version of the specification in equation (1) with different lags in the short-run relationship term. The results are reported separately for REER-ULC (panel A), REER-CPI (panel B), and REER-GDP (panel C). All other variables used in the baseline specification are included but not reported in the table. Standard errors are reported in parentheses and clustered at the country level. ***, **, * represent significance of 1%, 5% and 10%, respectively.

Table 5: Trade Balance-to-GDP Ratio: Baseline Specification with Quarterly Data

Dependent variable: TB/GDP	(1) ULC	(2) CPI	(3) GDP
Long-run			
ln GDP	-0.004	-0.041	-0.023
	(0.04)	(0.04)	(0.04)
ln GDP*	0.110**	0.133**	0.125**
	(0.05)	(0.05)	(0.05)
ln REER	-0.012	0.077	0.021
	(0.06)	(0.10)	(0.07)
Short-run			
ln GDP	0.022	0.024	-0.004
	(0.01)	(0.02)	(0.02)
ln GDP*	-0.044	-0.050	0.006
	(0.03)	(0.04)	(0.04)
ln REER	-0.051**	-0.051	-0.001
	(0.02)	(0.03)	(0.03)
Error Correction Coef (η)	-0.109***	-0.109***	-0.107***
	(0.02)	(0.02)	(0.02)
obs	2485	2485	2485

Note: This table reports the baseline error correction model estimation results from the quarterly version of the specification in equation (1) whereby trade balance-to-GDP is used as the dependent variable. The results are reported separately for REER-ULC (column 1), REER-CPI (column 2), and REER-GDP (column 3). The top and bottom panel refer to the long-run and short-run relationship, respectively. ln GDP is a country's own total consumption and investment (in log) to capture domestic demand, while ln GDP* is trading partners' weighted consumption and investment (in log) to measure foreign demand. Error Correction Coef (η) denotes the error correction coefficient that reflects the speed of the adjustment. ***, **, * represent significance of 1%, 5% and 10%, respectively.

A Appendix

A.1 Data Sources

Our sample includes 35 developed and emerging market economies: Australia, Austria, Belgium, Bulgaria, Canada, China, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Israel, Italy, Japan, Korea, Latvia, Lithuania, Netherlands, New Zealand, Norway, Poland, Portugal, Russia, Slovak Republic, Slovenia, South Africa, Spain, Sweden, Switzerland, United Kingdom, United States.

We collect the data from multiple sources. As for the quarterly frequency data, bilateral nominal exchange rate is extracted from the IMF Information Notice System (INS), while CPI and GDP deflator are from the International Financial Statistics (IFS).[12]. ULC is obtained from the OECD database for Hungary, Israel, Korea, New Zealand, Poland, and Slovenia, and from Haver for the rest of sample countries. Regarding the annual frequency data, bilateral nominal exchange rate and GDP deflator come from the WEO database, CPI from the INS, and ULC from the OECD database for Israel, Korea, and New Zealand as well as from Haver for the rest of countries. For the quarterly sample, if seasonally adjusted series is not available, we employ X12 seasonal adjustment toolkit to eliminate the seasonal component.

In addition, we gather quarterly and annual current account statistics from Haver and WEO, respectively. Export, import, and GDP series, both quarterly and annual, are from the WEO database. Commodity term of variable is taken from the External Balance Assessment (EBA) database at the IMF.

[12]South Africa's GDP deflator comes from the World Economic Outlook (WEO) database

Online Appendix of "Real Exchange Rate and External Balance: How Important Are Price Deflators?"

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1 Additional Tables

Table A1: Panel Unit Root Test

	CA/GDP	REER-ULC	REER-CPI	REER-GDP
Quarterly				
$H_0:$ *Unit Root*				
Levin-Lin-Chu	0.07	0.04	0.00	0.00
Harris-Tzavalis	0.00	0.94	0.02	0.28
Breitung	0.00	0.74	0.14	0.45
Fisher-type(inverse Chi-square)	0.03	0.88	0.32	0.61
Fisher-type(inverse Normal)	0.04	0.87	0.09	0.41
Fisher-type(inverse Logit)	0.03	0.88	0.11	0.42
Fisher-type(Modified Inverse Chi-Square)	0.03	0.87	0.34	0.63
$H_0:$ *Stationary*				
Hadri	0.00	0.00	0.00	0.00
Annual				
$H_0:$ *Unit Root*				
Levin-Lin-Chu	0.50	0.14	0.00	0.00
Harris-Tzavalis	0.00	0.40	0.01	0.09
Breitung	0.04	0.55	0.39	0.58
Fisher-type(inverse Chi-square)	0.65	0.97	0.65	0.42
Fisher-type(inverse Normal)	0.61	0.95	0.39	0.34
Fisher-type(inverse Logit)	0.59	0.94	0.42	0.34
Fisher-type(Modified Inverse Chi-square)	0.67	0.96	0.66	0.45
$H_0:$ *Stationary*				
Hadri	0.00	0.00	0.00	0.00

Note: This table reports the p-values for panel unit root tests of the quarterly sample (top panel) and annual sample (bottom panel) for current account balance (as a ratio to GDP; column 1) and REER measures (in log) deflated by ULC (column 2), CPI (column 3), and GDP deflator (column 4).

Table A2: Panel Cointegration Test

with CA/GDP	REER-ULC	REER-CPI	REER-GDP
Quarterly			
Pedroni	0.00	0.04	0.02
West			
Gt	0.00	0.00	0.00
Ga	0.00	0.00	0.00
Pt	0.00	0.00	0.00
Pa	0.00	0.00	0.00
Annual			
Pedroni	0.00	0.00	0.00
West			
Gt	0.00	0.02	0.00
Ga	0.27	0.25	0.20
Pt	0.00	0.00	0.00
Pa	0.00	0.00	0.00

Note: This table reports the p-values from panel cointegration tests between current account balance (as a ratio to GDP) and REER measures (in log) deflated by ULC (column 1), CPI (column 2), and GDP deflator (column 3), using Pedroni test as well as Westerlund test for the quarterly sample (top panel) and annual sample (bottom panel).

Table A3: Variance Decomposition of REER

Quarterly	NEER	P/P*	Cov	Annual	NEER	P/P*	Cov
REER-ULC	66%	34%	8.4e-06	REER-ULC	78%	22%	-.006
REER-CPI	98%	2%	-2.8e-05	REER-CPI	83%	17%	-.009
REER-GDP	88%	12%	-1.1e-05	REER-GDP	86%	14%	-.008

Note: This table reports the contribution of nominal effective exchange rate (NEER), relative price (P/P*), and covariance between them (Cov) to the variation in real effective exchange rate across different deflators from the quarterly sample (left panel) and annual sample (right panel).

Table A4: Robustness to Quarter- or Period-specific Shocks: Baseline Specification with Quarterly Data

Dependent variable: CA/GDP	(1) ULC	(2) CPI	(3) GDP	(4) ULC	(5) CPI	(6) GDP
	Adding Quarter Fixed Effects			Adding Post-2007 Dummy and Interaction Terms		
Long-run						
ln GDP	-0.010	-0.049	-0.026	-0.017	-0.052	-0.031
	(0.04)	(0.05)	(0.04)	(0.03)	(0.04)	(0.04)
ln GDP*	0.003	0.016	0.008	0.105*	0.125**	0.115**
	(0.09)	(0.09)	(0.09)	(0.06)	(0.06)	(0.05)
ln REER	-0.007	0.080	0.017	-0.003	0.084	0.021
	(0.05)	(0.09)	(0.06)	(0.05)	(0.09)	(0.07)
Short-run						
ln GDP	0.043**	0.026	-0.025	0.028**	0.014	-0.008
	(0.02)	(0.05)	(0.03)	(0.01)	(0.02)	(0.02)
ln GDP*	-0.048	-0.018	0.037	-0.089**	-0.063	-0.022
	(0.07)	(0.05)	(0.07)	(0.04)	(0.04)	(0.04)
ln REER	-0.053***	-0.024	0.037	-0.051***	-0.020	0.017
	(0.01)	(0.06)	(0.04)	(0.01)	(0.03)	(0.03)
ln REER×Post-2007				-0.003	-0.005	-0.004
				(0.00)	(0.01)	(0.01)
ln GDP×Post-2007				0.002	0.001	0.001
				(0.00)	(0.00)	(0.00)
ln GDP*×Post-2007				0.004	0.007	0.006
				(0.01)	(0.01)	(0.01)
Post-2007				-0.005**	-0.004**	-0.005**
				(0.00)	(0.00)	(0.00)
Error Correction Coef (η)	-0.166***	-0.166***	-0.163***	-0.166***	-0.167***	-0.164***
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
obs	2485	2485	2485	2485	2485	2485
p-value ($H_0: \hat{\beta}_{ln\ REER \times Post-2007} + \hat{\beta}_{ln\ REER} = 0$)				0.000	0.462	0.650

Note: This table reports the robustness checks to the baseline error correction model estimation of equation (1) using quarterly data . It adds quarter fixed effects (columns 1-3) or dummy for post global financial crisis and its interaction terms (columns 4-6). The results are reported separately for REER-ULC (columns 1 and 4), REER-CPI (columns 2 and 5), and REER-GDP (columns 3 and 6). The top and bottom panel refer to the long-run and short-run relationship, respectively. ln GDP is a country's own GDP (in log) to capture domestic demand, while ln GDP* is trading partners' weighted GDP (in log) to measure foreign demand. Error Correction Coef (η) denotes the error correction coefficient that reflects the speed of the adjustment. Standard errors are reported in parentheses and clustered at the country level. ***, **, * represent significance of 1%, 5% and 10%, respectively.

Table A5: Robustness to Baseline Specification with Quarterly Data: Exchange Rate Regime

Dependent variable:	(1)	(2)	(3)	(4)	(5)	(6)
CA/GDP	ULC	CPI	GDP	ULC	CPI	GDP
		Floating			Fixed	
Long-run						
ln GDP	0.012	-0.010	0.006	-0.152**	-0.167**	-0.200**
	(0.02)	(0.04)	(0.03)	(0.06)	(0.05)	(0.06)
ln GDP*	0.014	0.034	0.024	0.317***	0.281***	0.319***
	(0.05)	(0.06)	(0.05)	(0.08)	(0.06)	(0.06)
ln REER	-0.047*	-0.002	-0.038	0.131	0.313*	0.329**
	(0.03)	(0.07)	(0.03)	(0.11)	(0.17)	(0.16)
Short-run						
ln GDP	0.026*	0.009	-0.037*	0.028	0.012	0.014
	(0.02)	(0.02)	(0.02)	(0.02)	(0.04)	(0.03)
ln GDP*	-0.053	-0.029	0.042	-0.153**	-0.120	-0.117*
	(0.04)	(0.04)	(0.05)	(0.07)	(0.09)	(0.06)
ln REER	-0.053***	-0.027	0.042	-0.043*	0.029	-0.001
	(0.01)	(0.03)	(0.03)	(0.03)	(0.12)	(0.07)
Error Correction Coef (η)	-0.194***	-0.178***	-0.186***	-0.180***	-0.184***	-0.193***
	(0.05)	(0.04)	(0.04)	(0.03)	(0.03)	(0.03)
obs	1204	1204	1204	1281	1281	1281

Note: This table reports the baseline error correction model estimation results from the quarterly version of the specification in equation (1), separately for sample countries with floating exchange rate regimes (columns 1-3) and those with fixed exchange rate regimes (columns 4-6). The classification of floating and fixed exchange rate regimes is based on Shambaugh (2004). The results are reported separately for REER-ULC (columns 1 and 4), REER-CPI (columns 2 and 5), and REER-GDP (columns 3 and 6). The top and bottom panel refer to the long-run and short-run relationship, respectively. ln GDP is a country's own GDP (in log) to capture domestic demand, while ln GDP* is trading partners' weighted GDP (in log) to measure foreign demand. Error Correction Coef (η) denotes the error correction coefficient that reflects the speed of the adjustment. Standard errors are reported in parentheses and clustered at the country level. ***, **, * represent significance of 1%, 5% and 10%, respectively.

Table A6: Baseline Specification with Annual Data

Dependent variable: CA/GDP	(1) ULC	(2) CPI	(3) GDP
Long-run			
ln GDP	-0.015	-0.039**	-0.027
	(0.02)	(0.02)	(0.02)
ln GDP*	0.101**	0.101**	0.103**
	(0.04)	(0.03)	(0.03)
ln REER	-0.000	0.122	0.052
	(0.07)	(0.08)	(0.08)
Short-run			
ln GDP	-0.021*	-0.045**	-0.040***
	(0.01)	(0.01)	(0.01)
ln GDP*	-0.045**	-0.034	-0.036
	(0.02)	(0.03)	(0.03)
ln REER	-0.052**	0.016	0.002
	(0.02)	(0.04)	(0.03)
Error Correction Coef (η)	-0.235***	-0.234***	-0.235***
	(0.03)	(0.03)	(0.03)
obs	770	770	770

Note: This table reports the baseline error correction model estimation results from the annual version of the specification in equation (1), separately for REER-ULC (column 1), REER-CPI (column 2), and REER-GDP (column 3). The top and bottom panel refer to the long-run and short-run relationship, respectively. Standard errors are reported in parentheses and clustered at the country level. ***, **, * represent significance of 1%, 5% and 10%, respectively.

Table A7: Short-run and Long-run Restrictions on the Baseline Specification with Annual Data

Dependent variable:	(1)	(2)	(3)	(4)	(5)	(6)
CA/GDP	ULC	CPI	GDP	ULC	CPI	GDP
	Pooled Mean-Group (PMG)			Mean-Group (MG)		
Long-run						
ln GDP	-0.095***	-0.313***	-0.166***	-0.163**	-0.220***	-0.097
	(0.02)	(0.03)	(0.02)	(0.08)	(0.06)	(0.09)
ln GDP*	0.286***	0.280***	0.305***	0.235**	0.232**	0.170**
	(0.03)	(0.02)	(0.03)	(0.11)	(0.08)	(0.08)
ln REER	0.024	0.778***	0.230***	0.039	0.321*	-0.071
	(0.02)	(0.07)	(0.04)	(0.13)	(0.18)	(0.22)
Short-run						
ln GDP	-0.044**	-0.118***	-0.090**	-0.042*	-0.113***	-0.098***
	(0.02)	(0.03)	(0.03)	(0.02)	(0.03)	(0.03)
ln GDP*	0.028	0.071*	0.046	0.014	0.068**	0.065*
	(0.04)	(0.04)	(0.04)	(0.04)	(0.03)	(0.04)
ln REER	-0.071**	0.160**	0.026	-0.070**	0.140**	0.052
	(0.02)	(0.05)	(0.04)	(0.03)	(0.07)	(0.05)
Error Correction Coef (η)	-0.231***	-0.166***	-0.216***	-0.500***	-0.504***	-0.504***
	(0.04)	(0.04)	(0.04)	(0.05)	(0.05)	(0.05)
obs	770	770	770	770	770	770
Hausman test	1.000	1.000	1.000	1.000	1.000	1.000

Note: This table reports the baseline error correction model estimation results with a set of short-run and long-run restrictions from the annual version of the specification in equation (1), separately for REER-ULC (columns 1 and 4), REER-CPI (columns 2 and 5), and REER-GDP (columns 3 and 6). Columns 1-3 show the results from the PMG estimator, while columns 4-6 show the results from the MG estimator. P-values from the Hausman test are reported at the bottom of the table. The top and bottom panel refer to the long-run and short-run relationship, respectively. ln GDP is a country's own GDP (in log) to capture domestic demand, while ln GDP* is trading partners' weighted GDP (in log) to measure foreign demand. Error Correction Coef (η) denotes the error correction coefficient that reflects the speed of the adjustment. Standard errors are reported in parentheses and clustered at the country level. ***, **, * represent significance of 1%, 5% and 10%, respectively.

Table A8: Robustness to Year-specific Shocks: Baseline Specification with Annual Data

Dependent variable: CA/GDP	(1) ULC	(2) CPI	(3) GDP
Long-run			
ln GDP	-0.016	-0.039**	-0.028
	(0.02)	(0.02)	(0.02)
ln GDP*	-0.072	-0.067	-0.096
	(0.11)	(0.11)	(0.12)
ln REER	-0.012	0.105	0.034
	(0.06)	(0.08)	(0.08)
Short-run			
ln GDP	-0.025**	-0.050***	-0.044***
	(0.01)	(0.01)	(0.01)
ln GDP*	-0.063*	-0.077*	-0.070*
	(0.03)	(0.04)	(0.04)
ln REER	-0.044**	0.021	0.011
	(0.02)	(0.04)	(0.03)
Error Correction Coef (η)	-0.247***	-0.246***	-0.249***
	(0.03)	(0.03)	(0.03)
obs	770	770	770

Note: This table reports the robustness checks to the baseline error correction model estimation of equation (1) using annual data . It adds year fixed effects (columns 1-3). The results are reported separately for REER-ULC (columns 1), REER-CPI (columns 2), and REER-GDP (columns 3). The top and bottom panel refer to the long-run and short-run relationship, respectively. ln GDP is a country's own GDP (in log) to capture domestic demand, while ln GDP* is trading partners' weighted GDP (in log) to measure foreign demand. Error Correction Coef (η) denotes the error correction coefficient that reflects the speed of the adjustment. Standard errors are reported in parentheses and clustered at the country level. ***, **, * represent significance of 1%, 5% and 10%, respectively.

Table A9: Floating or Fixed Exchange Rate Regimes: Baseline Specification with Annual Data

Dependent variable: CA/GDP	(1) ULC	(2) CPI	(3) GDP	(4) ULC	(5) CPI	(6) GDP
		Floating			Fixed	
Long-run						
ln GDP	-0.007	-0.017	-0.012	-0.108**	-0.131***	-0.155***
	(0.02)	(0.02)	(0.02)	(0.04)	(0.04)	(0.04)
ln GDP*	0.053	0.056	0.058	0.203***	0.175**	0.202***
	(0.04)	(0.04)	(0.04)	(0.05)	(0.06)	(0.05)
ln REER	-0.053	-0.007	-0.032	0.227**	0.591***	0.482***
	(0.04)	(0.06)	(0.04)	(0.08)	(0.15)	(0.12)
Short-run						
ln GDP	-0.028**	-0.045**	-0.046**	-0.025*	-0.047**	-0.040**
	(0.01)	(0.02)	(0.02)	(0.01)	(0.01)	(0.02)
ln GDP*	-0.003	0.011	0.016	-0.065**	-0.070**	-0.070**
	(0.04)	(0.04)	(0.05)	(0.03)	(0.03)	(0.03)
ln REER	-0.035**	0.003	0.011	-0.078**	0.107**	0.012
	(0.01)	(0.03)	(0.03)	(0.03)	(0.05)	(0.05)
Error Correction Coef (η)	-0.332***	-0.314***	-0.328***	-0.216***	-0.186***	-0.204***
	(0.08)	(0.08)	(0.07)	(0.03)	(0.03)	(0.03)
obs	387	387	387	383	383	383

Note: This table reports the baseline error correction model estimation results from the annual version of the specification in equation (1), separately for sample countries with floating exchange rate regimes (columns 1-3) and those with fixed exchange rate regimes (columns 4-6). The classification of floating and fixed exchange rate regimes is based on Shambaugh (2004). The results are reported separately for REER-ULC (columns 1 and 4), REER-CPI (columns 2 and 5), and REER-GDP (columns 3 and 6). The top and bottom panel refer to the long-run and short-run relationship, respectively. ln GDP is a country's own GDP (in log) to capture domestic demand, while ln GDP* is trading partners' weighted GDP (in log) to measure foreign demand. Error Correction Coef (η) denotes the error correction coefficient that reflects the speed of the adjustment. Standard errors are reported in parentheses and clustered at the country level. ***, **, * represent significance of 1%, 5% and 10%, respectively.

Table A10: Trade Balance-to-GDP Ratio: Baseline Specification with Annual Data

Dependent variable: TB/GDP	(1) ULC	(2) CPI	(3) GDP
Long-run			
ln GDP	0.002	-0.032	-0.017
	(0.03)	(0.02)	(0.02)
ln GDP*	0.098*	0.099*	0.103**
	(0.05)	(0.05)	(0.05)
ln REER	-0.069	0.080	0.004
	(0.08)	(0.10)	(0.09)
Short-run			
ln GDP	-0.007	-0.034**	-0.032**
	(0.01)	(0.01)	(0.01)
ln GDP*	-0.028	-0.013	-0.012
	(0.03)	(0.03)	(0.03)
ln REER	-0.082***	-0.015	-0.008
	(0.02)	(0.04)	(0.04)
Error Correction Coef (η)	-0.169***	-0.180***	-0.179***
	(0.02)	(0.03)	(0.03)
obs	770	770	770

Note: This table reports the baseline error correction model estimation results from the annual version of the specification in equation (1) whereby trade balance-to-GDP is used as the dependent variable. The results are reported separately for REER-ULC (column 1), REER-CPI (column 2), and REER-GDP (column 3). The top and bottom panel refer to the long-run and short-run relationship, respectively. ln GDP is a country's own GDP (in log) to capture domestic demand, while ln GDP* is trading partners' weighted GDP (in log) to measure foreign demand. Error Correction Coef (η) denotes the error correction coefficient that reflects the speed of the adjustment. Standard errors are reported in parentheses and clustered at the country level. ***, **, * represent significance of 1%, 5% and 10%, respectively.

Table A11: Commodity Prices and Production Costs: Modified Specification with Annual Data

Dependent variable: CA/GDP	(1) ULC	(2) CPI	(3) GDP	(4) ULC
	Adding Terms of Trade			Adding $\frac{Total\ Cost}{ULC}$
Long-run				
ln GDP	-0.021	-0.045**	-0.038**	0.031
	(0.02)	(0.01)	(0.02)	(0.04)
ln GDP*	0.102**	0.102***	0.103***	-0.070
	(0.04)	(0.03)	(0.03)	(0.06)
REER	0.036	0.167**	0.112	0.021
	(0.07)	(0.07)	(0.09)	(0.06)
ln ToT	-0.019	-0.054	-0.068	
	(0.05)	(0.05)	(0.05)	
ln CC				-0.253**
				(0.09)
Short-run				
ln GDP	-0.034**	-0.057***	-0.049***	0.064**
	(0.01)	(0.01)	(0.01)	(0.03)
ln GDP*	-0.030	-0.020	-0.023	-0.113*
	(0.02)	(0.03)	(0.03)	(0.06)
ln REER	-0.059**	0.008	-0.023	-0.084**
	(0.02)	(0.04)	(0.03)	(0.03)
ln ToT	0.139***	0.126***	0.136***	
	(0.04)	(0.04)	(0.04)	
ln CC				-0.272***
				(0.07)
Error Correction Coef (η)	-0.224***	-0.229***	-0.225***	-0.304***
	(0.03)	(0.03)	(0.03)	(0.05)
obs	770	770	770	438

Note: This table reports the modified error correction model estimation results from the annual version of the specification in equation (1), controlling for commodity terms-of-trade (ToT) as well as capital costs (CC). The results are reported separately for REER-ULC (column 1), REER-CPI (column 2), and REER-GDP (column 3). The top and bottom panel refer to the long-run and short-run relationship, respectively. ln GDP is a country's own GDP (in log) to capture domestic demand, while ln GDP* is trading partners' weighted GDP (in log) to measure foreign demand. ToT (in log) is commodity terms-of-trade and CC (in log) measures capital costs calculated as the ratio of total (labor and capital) cost to labor cost (based on Karabarbounis and Neiman (2014)). Error Correction Coef (η) denotes the error correction coefficient that reflects the speed of the adjustment. Standard errors are reported in parentheses and clustered at the country level. ***, **, * represent significance of 1%, 5% and 10%, respectively.

Table A12: Additional Controls: Modified Specification with Annual Data

Dependent variable: CA/GDP	(1) ULC	(2) CPI	(3) GDP	(4) ULC	(5) CPI	(6) GDP	(7) ULC	(8) CPI	(9) GDP
	Adding Trade Openness			Adding Financial Openness			Adding both Openness		
Long-run									
ln GDP	-0.020	-0.038**	-0.031**	-0.026	-0.042**	-0.031	-0.028*	-0.041**	-0.033**
	(0.02)	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
ln GDP*	0.048	0.049	0.048	0.082**	0.084**	0.081**	0.043	0.045	0.043
	(0.03)	(0.03)	(0.03)	(0.04)	(0.04)	(0.04)	(0.03)	(0.03)	(0.03)
ln REER	0.004	0.099	0.051	-0.010	0.072	0.013	0.001	0.068	0.024
	(0.05)	(0.07)	(0.06)	(0.06)	(0.08)	(0.07)	(0.05)	(0.07)	(0.06)
Trade Openness	0.097***	0.095**	0.100***				0.084***	0.083**	0.084**
	(0.02)	(0.03)	(0.03)				(0.02)	(0.03)	(0.03)
Financial Openness				0.067*	0.050	0.071**	0.041	0.029	0.045
				(0.04)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Short-run									
ln GDP	-0.023**	-0.046***	-0.042***	-0.029**	-0.045**	-0.042***	-0.029**	-0.045**	-0.043***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)
ln GDP*	-0.053**	-0.045	-0.047*	-0.056**	-0.047*	-0.050*	-0.062**	-0.055**	-0.058**
	(0.02)	(0.03)	(0.03)	(0.02)	(0.03)	(0.03)	(0.02)	(0.03)	(0.03)
ln REER	-0.050**	0.016	0.006	-0.040**	0.011	0.003	-0.038**	0.013	0.007
	(0.02)	(0.03)	(0.03)	(0.02)	(0.04)	(0.03)	(0.02)	(0.04)	(0.03)
Trade Openness	0.006	0.011	0.011				0.009	0.013	0.013
	(0.01)	(0.01)	(0.01)				(0.01)	(0.01)	(0.01)
Financial Openness				-0.009	-0.014	-0.011	-0.013	-0.019	-0.017
				(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Error Correction Coef (η)	-0.265***	-0.265***	-0.267***	-0.235***	-0.234***	-0.235***	-0.257***	-0.258***	-0.259***
	(0.04)	(0.04)	(0.04)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
obs	770	770	770	727	727	727	727	727	727

Note: This table reports the modified error correction model estimation results from the annual version of the specification in equation (1), controlling for trade and financial openness (Trade Openness; Financial Openness). The results are reported separately for REER-ULC (column 1), REER-CPI (column 2), and REER-GDP (column 3). The top and bottom panel refer to the long-run and short-run relationship, respectively. ln GDP is a country's own GDP (in log) to capture domestic demand, while ln GDP* is trading partners' weighted GDP (in log) to measure foreign demand. Trade Openness and Financial Openness measure trade and financial openness, respectively. Error Correction Coef (η) denotes the error correction coefficient that reflects the speed of the adjustment. Standard errors are reported in parentheses and clustered at the country level. ***, **, * represent significance of 1%, 5% and 10%, respectively.

Table A13: Additional Controls: Modified Specification with Annual Data

Dependent variable: CA/GDP	(1) ULC	(2) CPI	(3) GDP
Long-run			
ln GDP	-0.053*	-0.076**	-0.067**
	(0.03)	(0.03)	(0.03)
ln GDP*	0.015	0.036	0.029
	(0.04)	(0.04)	(0.04)
ln REER	-0.092*	0.052	-0.037
	(0.05)	(0.08)	(0.08)
ln GDP per capita	0.145***	0.106***	0.137***
	(0.04)	(0.03)	(0.03)
Short-run			
ln GDP	-0.015	-0.037***	-0.035***
	(0.01)	(0.01)	(0.01)
ln GDP*	-0.023	-0.010	-0.011
	(0.02)	(0.02)	(0.02)
ln REER	-0.063**	0.001	-0.000
	(0.02)	(0.03)	(0.02)
ln GDP per capita	-0.245**	-0.227**	-0.233**
	(0.10)	(0.10)	(0.10)
Error Correction Coef (η)	-0.211***	-0.202***	-0.206***
	(0.03)	(0.03)	(0.03)
obs	770	770	770

Note: This table reports the modified error correction model estimation results from the annual version of the specification in equation (1), controlling for GDP per capita (ln GDP per capita). The results are reported separately for REER-ULC (column 1), REER-CPI (column 2), and REER-GDP (column 3). The top and bottom panel refer to the long-run and short-run relationship, respectively. ln GDP is a country's own GDP (in log) to capture domestic demand, while ln GDP* is trading partners' weighted GDP (in log) to measure foreign demand. ln GDP per capita is a country's GDP per capita (in log). Error Correction Coef (η) denotes the error correction coefficient that reflects the speed of the adjustment. Standard errors are reported in parentheses and clustered at the country level. ***, **, * represent significance of 1%, 5% and 10%, respectively.

Table A14: Tradable vs. Nontradable Sector: Baseline Specification with Annual Data

Dependent variable: CA/GDP	(1) ULC	(2) GDP	(3) ULC	(4) GDP
	Tradable Sector		Controlling for relative prices	
Long-run				
ln GDP	0.036	0.044	0.051	0.055
	(0.03)	(0.03)	(0.03)	(0.03)
ln GDP*	-0.097**	-0.106**	-0.093**	-0.109**
	(0.04)	(0.04)	(0.04)	(0.04)
ln REER	-0.034	-0.050	-0.037	-0.036
	(0.03)	(0.03)	(0.03)	(0.03)
Short-run				
ln GDP	-0.328***	-0.335***	-0.331***	-0.323***
	(0.03)	(0.03)	(0.03)	(0.03)
ln GDP*	-0.023	-0.024	-0.017	-0.027
	(0.03)	(0.03)	(0.03)	(0.03)
ln REER	-0.025**	-0.015	-0.026**	-0.009
	(0.01)	(0.01)	(0.01)	(0.02)
Error Correction Coef (η)	-0.298***	-0.301***	-0.321***	-0.322***
	(0.04)	(0.04)	(0.04)	(0.04)
obs	490	490	490	490

Note: This table reports the baseline error correction model estimation results from the annual version of the specification in equation (1), exploring the potential role of composition between tradable and nontradable sectors. The results are reported separately for REER-ULC (columns 1 and 3) and REER-GDP (columns 2 and 4). REER-ULC and REER-GDP in columns 1 and 2 are measured from tradable sectors only. Columns 3 and 4 used general REER-ULC and REER-GDP measures, while controlling for relative prices between tradable and nontradable sectors (not reported). The top and bottom panel refer to the long-run and short-run relationship, respectively. ln GDP is a country's own GDP (in log) to capture domestic demand, while ln GDP* is trading partners' weighted GDP (in log) to measure foreign demand. Error Correction Coef (η) denotes the error correction coefficient that reflects the speed of the adjustment. ***, **, * represent significance of 1%, 5% and 10%, respectively.

Table A15: Trade Balance-to-Gross Trade Ratio: Baseline Specification with Annual Data

Dependent variable: TB/Gross Trade	(1) ULC	(2) CPI	(3) GDP
Long-run			
ln GDP	0.002	-0.032	-0.017
	(0.03)	(0.02)	(0.02)
ln GDP*	0.098*	0.099*	0.103**
	(0.05)	(0.05)	(0.05)
ln REER	-0.069	0.080	0.004
	(0.08)	(0.10)	(0.09)
Short-run			
ln GDP	-0.007	-0.034**	-0.032**
	(0.01)	(0.01)	(0.01)
ln GDP*	-0.028	-0.013	-0.012
	(0.03)	(0.03)	(0.03)
ln REER	-0.082***	-0.015	-0.008
	(0.02)	(0.04)	(0.04)
Error Correction Coef (η)	-0.169***	-0.180***	-0.179***
	(0.02)	(0.03)	(0.03)
obs	770	770	770

Note: This table reports the baseline error correction model estimation results from the annual version of the specification in equation (1) whereby trade balance-to-gross trade is used as the dependent variable. The results are reported separately for REER-ULC (column 1), REER-CPI (column 2), and REER-GDP (column 3). The top and bottom panel refer to the long-run and short-run relationship, respectively. ln GDP is a country's own GDP (in log) to capture domestic demand, while ln GDP* is trading partners' weighted GDP (in log) to measure foreign demand. Error Correction Coef (η) denotes the error correction coefficient that reflects the speed of the adjustment. ***, **, * represent significance of 1%, 5% and 10%, respectively.

Table A16: Alternative Demand Measures: Baseline Specification with Annual Data

Dependent variable: CA/GDP	(1) ULC	(2) CPI	(3) GDP
Long-run			
ln GDP	-0.030**	-0.052***	-0.050**
	(0.01)	(0.01)	(0.02)
ln GDP*	0.088**	0.109**	0.109**
	(0.04)	(0.04)	(0.04)
ln REER	-0.030	0.033	0.013
	(0.06)	(0.07)	(0.08)
Short-run			
ln GDP	-0.062	-0.066	-0.067
	(0.05)	(0.06)	(0.06)
ln GDP*	-0.022	-0.026	-0.023
	(0.06)	(0.06)	(0.06)
ln REER	-0.065***	-0.018	-0.022
	(0.01)	(0.03)	(0.03)
Error Correction Coef (η)	-0.232***	-0.238***	-0.236***
	(0.03)	(0.03)	(0.03)
obs	770	770	770

Note: This table reports the baseline error correction model estimation results from the annual version of the specification in equation (1) with alternative demand measures. Results are reported separately for REER-ULC (column 1), REER-CPI (column 2), and REER-GDP (column 3). The top and bottom panel refer to the long-run and short-run relationship, respectively. ln GDP is a country's own total consumption and investment (in log) to capture domestic demand, while ln GDP* is trading partners' weighted consumption and investment (in log) to measure foreign demand. Error Correction Coef (η) denotes the error correction coefficient that reflects the speed of the adjustment. ***, **, * represent significance of 1%, 5% and 10%, respectively.

Table A17: Global Value Chain: Modified ECM Specification with Annual Data

Dependent variable: various parts in trade balance, all as share of GDP	(1) ULC	(2) CPI	(3) GDP	(4) ULC	(5) CPI	(6) GDP	(7) ULC	(8) CPI	(9) GDP
	$Export^{domestic} - Import^{foreign}$			$Export^{foreign} - Import^{domestic}$			total$(Export - Import)$		
Long-run									
ln GDP	0.001	0.007	-0.007	0.052	0.025	0.049	0.054**	0.027	0.037*
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.02)	(0.02)	(0.02)
ln GDP*	-0.324***	-0.309***	-0.310***	0.351***	0.338***	0.345***	0.023	0.026	0.034
	(0.07)	(0.07)	(0.07)	(0.07)	(0.06)	(0.07)	(0.04)	(0.04)	(0.04)
ln REER	-0.106**	-0.169**	-0.089*	0.051	0.190**	0.068	-0.084*	0.014	-0.040
	(0.05)	(0.05)	(0.05)	(0.07)	(0.09)	(0.08)	(0.05)	(0.08)	(0.05)
Short-run									
ln GDP	-0.016	-0.024	-0.037**	0.016	0.008	0.018*	0.006	-0.015	-0.015
	(0.02)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
ln GDP*	-0.130***	-0.120***	-0.115**	0.121***	0.121***	0.118***	-0.014	-0.004	-0.001
	(0.03)	(0.03)	(0.04)	(0.04)	(0.04)	(0.03)	(0.02)	(0.03)	(0.03)
ln REER	-0.060**	-0.040	0.010	-0.014	-0.001	-0.028*	-0.083***	-0.041	-0.026
	(0.02)	(0.03)	(0.03)	(0.01)	(0.01)	(0.02)	(0.02)	(0.03)	(0.03)
Error Correction Coef (η)	-0.228***	-0.247***	-0.239***	-0.158***	-0.169***	-0.159***	-0.179***	-0.182***	-0.191***
	(0.03)	(0.03)	(0.03)	(0.02)	(0.03)	(0.02)	(0.04)	(0.04)	(0.05)
obs	700	700	700	700	700	700	700	700	700

Note: This table reports the modified error correction model estimation results from the annual version of the specification in equation (1), separately for traditional trade component (i.e., domestic value-added in export less foreign value-added in import, columns 1-3), GVC-related trade (i.e., foreign value-added in export less domestic value-added in import, columns 4-6), and the usual trade balance, all as share of GDP (columns 7-9). The results are reported separately for REER-ULC (columns 1, 4, 7), REER-CPI (columns 2, 5, 8), and REER-GDP (columns 3, 6, 9). The top and bottom panel refer to the long-run and short-run relationship, respectively. ln GDP is a country's own total consumption and investment (in log) to capture domestic demand, while ln GDP* is trading partners' weighted consumption and investment (in log) to measure foreign demand. Error Correction Coef (η) denotes the error correction coefficient that reflects the speed of the adjustment. ***, **, * represent significance of 1%, 5% and 10%, respectively.

Table A18: Alternative REER measures: Baseline Specification with Annual Data

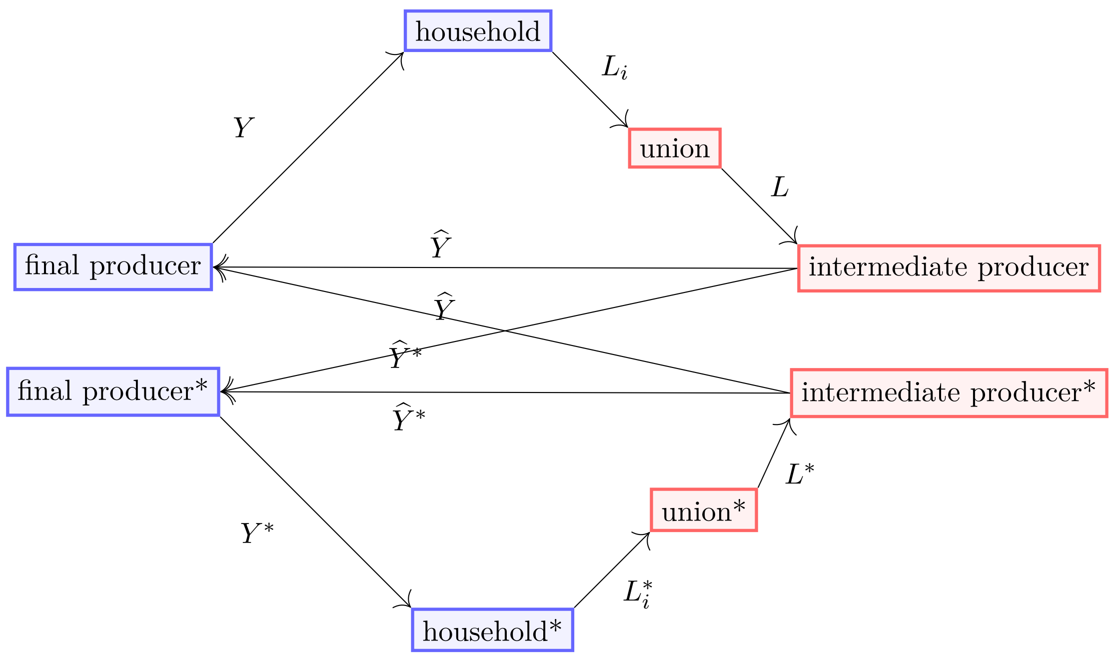
Dependent variable: CA/GDP	(1) ULC	(2) CPI	(3) GDP
Long-run			
ln GDP	-0.008	-0.028	-0.009
	(0.02)	(0.02)	(0.03)
ln GDP*	0.046*	0.054**	0.037
	(0.02)	(0.03)	(0.03)
ln REER	-0.020	0.029	-0.028
	(0.02)	(0.05)	(0.05)
Short-run			
ln GDP	-0.038**	-0.131***	-0.140***
	(0.02)	(0.02)	(0.03)
ln GDP*	-0.039	0.111**	0.121**
	(0.04)	(0.04)	(0.05)
ln REER	-0.023*	0.109***	0.100***
	(0.01)	(0.03)	(0.03)
Error Correction Coef (η)	-0.257***	-0.253***	-0.252***
	(0.02)	(0.02)	(0.02)
obs	902	902	902

Note: This table reports the baseline error correction model estimation results from the annual version of the specification in equation (1) with alternative REER measures from the European Commission. Results are reported separately for REER-ULC (column 1), REER-CPI (column 2), and REER-GDP (column 3). The top and bottom panel refer to the long-run and short-run relationship, respectively. ln GDP is a country's own total consumption and investment (in log) to capture domestic demand, while ln GDP* is trading partners' weighted consumption and investment (in log) to measure foreign demand. Error Correction Coef (η) denotes the error correction coefficient that reflects the speed of the adjustment. ***, **, * represent significance of 1%, 5% and 10%, respectively. The 42 countries within the samples are: Australia, Austria, Belgium, Brazil, Bulgaria, Canada, China, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hong Kong, Hungary, Ireland, Italy, Japan, Korea, Latvia, Lithuania, Luxembourg, Malta, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Russia, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom, and United States.

2 Details of the Model

This section presents the details of the model discussed in Section 4 of the main text. This two-country open economy model includes nominal wage and price rigidities *a la* Calvo as in Ferrero (2015), trade in intermediate goods in the spirit of Obstfeld (2001) and Devereux and Engel (2007), and non-tradable final goods. The structure of the model is summarized in Figure B.1. The upper part represents the *home* country, while the lower part (with *) represent *foreign*. The economy in each country operates as follows: household sets wages for differentiated labor, which is supplied to the labor union where a composite labor is assembled and in turn provided to the intermediate producer. There is a positive probability that households cannot change wages in each period. The final producer uses intermediate inputs from both *home* and *foreign* to produce final goods and sells it to the domestic market. When setting the final goods price, the producer is also subject to a positive probability that she will not be able to change it. In the rest of the section, we illustrate each component of the model in detail.

Figure B.1: Flow Chart of the Model



Note: This chart illustrates the framework of our two-country New Keynesian model, the agent shaded in blue is the one setting price/wage in a Calvo fashion.

2.1 Household

The household in the model has a dual-role as a supplier of her individual-specific labor and a consumer of final goods: she resets wage in each period with a probability λ_w $(0 < \lambda_w < 1)$, provides labor to the labor union, and consumes. We suppress the subscript i here because we assume symmetry among households.

The representative household maximizes its expected lifetime utility, which depends on final goods consumption and labor supply. The utility is separable in consumption and labor, with ρ representing risk-aversion and ν the Frisch elasticity:

$$\max \quad \mathbb{E}_t \sum_{s=0}^{\infty} \beta^s \Big[\frac{C_t^{1-\rho}}{1-\rho} - \frac{1}{\nu} L_t^{\nu}\Big]$$

For the intertemporal consumption allocation, we assume complete asset markets[1], whereby households have a full set of nominal state-contingent assets that can be traded ex-ante. There is thus full risk sharing between the two countries. Therefore, the household's intertemporal budget constraint is composed of wage income, rebated profit from the labor union and producers (Π), international lending/borrowing (B) and consumption expenditure:

$$P(\lambda^t)C(\lambda^t) + Q(\lambda^{t+1}|\lambda^t)B(\lambda^{t+1}) = W(\lambda^t)L(\lambda^t) + B(\lambda^t) + \Pi(\lambda^t)$$

where $Q(.|.)$ represents the price of Arrow-Debreu security that delivers one unit of home currency if state λ^t is realized conditional on λ^{t-1}. Expressing S_t as the nominal exchange rate quoted as foreign currency per home currency (which means the increase in S_t indicates appreciation in home currency), it further follows that:

$$\begin{aligned}
Q(\lambda^t|\lambda^{t-1}) &= \beta\pi(\lambda^t|\lambda^{t-1})\frac{U_c(\lambda^t)}{U_c(\lambda^{t-1})}\frac{P(\lambda^{t-1})}{P(\lambda^t)} \\
Q(\lambda^t|\lambda^{t-1}) &= \beta\pi(\lambda^t|\lambda^{t-1})\frac{U_c^*(\lambda^t)}{U_c^*(\lambda^{t-1})}\frac{P^*(\lambda^{t-1})}{P^*(\lambda^t)}\frac{S(\lambda^{t-1})}{S(\lambda^t)} \\
\implies P_t C_t^{\rho} &= P_t^* C_t^{*\rho}/S_t
\end{aligned}$$

For the intratemporal consumption allocation, we assume that overall consumption, C_t, is a CES aggregator of a unit continuum of goods. This leads to a demand function with elasticity of θ:

$$C_t = \Big(\int_0^1 C_{jt}^{\frac{\theta-1}{\theta}} dj\Big)^{\frac{\theta}{\theta-1}} \implies C_{jt} = \Big(\frac{P_{jt}}{P_t}\Big)^{-\theta} C_t$$

with $P_t = \Big(\int_0^1 P_{jt}^{1-\theta} dj\Big)^{\frac{1}{1-\theta}}$.

2.2 Labor Union and Wage Setting

Labor union[2] hires differentiated labor from households, and supplies composite labor to the intermediate-good producer, whose production requires a composite of all types of labor with an

[1] Complete markets are assumed in a large body of international macro literature, e.g. Devereux and Engel (2007), Gali and Monacelli (2005), Chari, Kehoe and McGrattan (2002)) etc. Also, a strand of papers show examples where models under incomplete and complete markets predict similar equilibrium allocations and transmission mechanisms, for instance, Chari, Kehoe and McGrattan (2002) and Corsetti, Dedola and Leduc (2008).

[2] Labor union is usually introduced in models with wage rigidity, for instance, Ferrero (2015), Schmitt-Grohé and Uribe (2012) among others.

elasticity of ζ across different types:

$$L_t = \Big(\int_0^1 L_{it}^{\frac{\zeta-1}{\zeta}} di \Big)^{\frac{\zeta}{\zeta-1}}$$

The labor union's demand for each type i of labor is:

$$L_{it} = \Big(\frac{W_{jt}}{W_t} \Big)^{-\zeta} L_t$$

with W as the aggregate wage level

$$W_t = \Big(\int_0^1 W_{jt}^{1-\zeta} dj \Big)^{\frac{1}{1-\zeta}}$$

Facing this labor demand, the household sets wages knowing that she can only change the wage with probability λ_w in each period. Therefore, the household that is able to reset wages at t chooses W_{it} solving

$$\max_{\widetilde{W}_{it}} \quad \mathbb{E}_t \sum_{s=0}^{\infty} \beta^s (1-\lambda_w)^s \Big[\phi_{t+s} \widetilde{W}_{it} L_{it+s} - \frac{1}{\nu} L_{it+s}^{\nu} \Big]$$

where $L_{it} = \Big(\frac{\widetilde{W}_{jt}}{W_t} \Big)^{-\zeta} L_t$ and ϕ_t is the shadow price of income at time t.

The labor union, has a monopoly over labor, and charges the intermediate goods producer a wage subject to a markup ($\widehat{W}_t$) while paying households only W_t:

$$\widehat{W}_t = \frac{\zeta}{\zeta - 1} W_t$$

The profit of the labor union is rebated to households

2.3 Intermediate-Goods Producer and Final-Goods Producer

Intermediate goods production requires a composite of all types of labor, and the production function is assumed to exhibit constant return to scale.

$$\widehat{Y}_t = A_t L_t$$

Also, we assume there is a perfectly competitive market for intermediate goods, and thus, the price of intermediate goods is equal to their marginal cost:

$$\widehat{P}_t = \frac{\widehat{W}_t}{A_t}$$

The production of final goods requires both foreign and domestic intermediate goods, and home bias in production is represented by $\alpha \in (0.5, 1)$. Producer currency pricing is assumed and hence the domestic price of foreign intermediate good is $\frac{\widehat{W}_t^*}{A_t^* S_t}$:

$$Y_{jt} = \Big(\alpha^{\frac{1}{\eta}} \widehat{Y}_{jt}^{\frac{\eta-1}{\eta}} + (1-\alpha)^{\frac{1}{\eta}} \widehat{Y}_{jt}^{*\,\frac{\eta-1}{\eta}}\Big)^{\frac{\eta}{\eta-1}} \Longrightarrow MC_{jt} = \Big[\alpha\Big(\frac{\widehat{W}_t}{A_t}\Big)^{1-\eta} + (1-\alpha)\Big(\frac{\widehat{W}_t^*}{A_t^* S_t}\Big)^{1-\eta}\Big]^{\frac{1}{1-\eta}}$$

We embed price rigidity through a Calvo price-setting, similar to what was assumed for wages. Specifically, there is a unit continuum of final-good producers whose objective is to maximize expected profit using the subjective discount factor of households, who own firms. However, they can only reset price with probability λ_p $(0 < \lambda_p < 1)$ each period. Therefore, for a final-goods producer who can reset price at time t, she solves the maximization problem below subject to the household's demand function.

$$\max_{\widetilde{P}_{jt}} \quad \mathbb{E}_t \sum_{s=0}^{\infty} \beta^s (1-\lambda_p)^s \phi_{t+s} \Big[\widetilde{P}_{jt} C_{jt+s} - MC_{jt+s} C_{jt+s}\Big]$$

$$s.t. \quad C_{jt+s} = \Big(\frac{\widetilde{P}_{jt}}{P_{t+s}}\Big)^{-\theta} C_{t+s}, \ \forall s \geq 0$$

2.4 Equilibrium

To close the model, we specify the monetary policy for floating exchange rate regimes, i.e. the central bank follows a Taylor rule of the form:

$$\ln R_t = \rho_R \ln R_{t-1} + (1-\rho_R)\big[\ln(1/\beta) + \rho_\pi \ln \pi + \rho_y(\ln y - \ln y^{natural})\big] + \epsilon_{Rt}$$

The equilibrium is a set of $\{\widetilde{W}_t, W_t, \widetilde{P}_t, MC_t, \pi_t, \widehat{Y}_t, L_t, C_t, RER-CPI_t;\ \widetilde{W}_t^*, W_t^*, \widetilde{P}_t^*, MC_t^*, \pi_t^*, \widehat{Y}_t^*, L_t^*, C_t^*\}$ satisfying household utility maximization, optimal wage setting, labor union and intermediate goods producer profit maximization, final goods producer optimal price setting and profit maximization, market clearing conditions for intermediate goods and final goods, risk sharing between two countries, and monetary policy.[3]

Overall, this model is the standard New Keynesian two-country open economy model of exactly like Gali and Monacelli (2005) except here we allow imports and exports of intermediate goods only. Although it might sound extreme to abstract away from trade in final goods, if we view final goods manufacturers as retailers and intermediate goods manufacturers as final goods producers, then the setting here is isomorphic to one where trade is exclusively on final goods. Therefore, the model provides a flexible framework in terms of production and trade to discuss the relationship between the real exchange rate and external balances.

[3]The wage/price reset blocks, intermediate goods production/demand blocks hold for both home country and foreign country.

2.5 Equilibrium Conditions

The equilibrium is a set of $\{\widetilde{w}_t, w_t, K_{wt}, F_{wt}, \widetilde{p}_t, K_{pt}, F_{pt}, mc_t, \pi_t, DS_{wt}, DS_{pt}, \widehat{Y}_t, L_t, C_t, RER-CPI_t;$ $w_t^*, w_t^*, K_{wt}^*, F_{wt}^*, \widetilde{p}_t^*, K_{pt}^*, F_{pt}^*, mc_t^*, \pi_t^*, DS_{wt}^*, DS_{pt}^*, \widehat{Y}_t^*, L_t^*, C_t^*\}$ satisfying the following conditions.[4]

Wage reset

$$(\frac{\widetilde{w}_t}{w_t})^{1+\zeta\nu} = \frac{K_{wt}}{F_{wt}}, \qquad \widetilde{w}_t \equiv \widetilde{W}_t/P_t,\ w_t \equiv W_t/P_t \tag{1}$$

$$K_{wt} = \frac{\zeta}{\zeta-1}L_t^{1+\nu} + \beta\lambda_w\mathbb{E}_t\Big[(\frac{w_{t+1}}{w_t}\pi_{t+1})^{\zeta(1+\nu)}K_{wt+1}\Big] \tag{2}$$

$$F_{wt} = C_t^{-\sigma}w_tL_t + \beta\lambda_w\mathbb{E}_t\Big[(\frac{w_{t+1}}{w_t}\pi_{t+1})^{\zeta-1}F_{wt+1}\Big] \tag{3}$$

$$(w_t\pi_t)^{1-\zeta} = \lambda_w w_{t-1}^{1-\zeta} + (1-\lambda_w)(\widetilde{w}_t\pi_t)^{1-\zeta} \tag{4}$$

Intermediate goods production and labor demand

$$DS_{wt} = (1-\lambda_w)\frac{\widetilde{w}_t}{w_t}^{-\zeta} + \lambda_w\frac{w_{t-1}}{w_t\pi_t}^{-\zeta}DS_{wt-1} \tag{5}$$

$$\widehat{Y}_t = \frac{A_tL_t}{DS_{wt}} \tag{6}$$

Final goods price reset

$$\widetilde{p}_t \equiv \frac{\widetilde{P}_t}{P_t} = \frac{K_{pt}}{F_{pt}} \tag{7}$$

$$K_{pt} = \frac{\theta}{\theta-1}C_t^{1-\sigma}mc_t + \beta\lambda_p\mathbb{E}_t\Big[\pi_{t+1}^{\theta}K_{pt+1}\Big] \tag{8}$$

$$F_{pt} = C_t^{1-\sigma} + \beta\lambda_p\mathbb{E}_t\Big[\pi_{t+1}^{\theta-1}F_{pt+1}\Big] \tag{9}$$

$$mc_t \equiv \frac{MC_t}{P_t} = \Big[\alpha(\frac{w_t}{A_t})^{1-\gamma} + (1-\alpha)(\frac{w_t^*}{RER-CPI_t})^{1-\gamma}\Big]^{\frac{1}{1-\gamma}} \tag{10}$$

Intermediate goods demand

$$\widehat{Y}_t = \alpha(\frac{w_t/A_t}{mc_t})^{-\gamma}C_tDS_{pt} + (1-\alpha)(\frac{RER-CPI_tw_t/A_t}{mc_t^*})^{-\gamma}C_t^*DS_{pt}^* \tag{11}$$

$$DS_{pt} = (1-\lambda_p)(\widetilde{p}_t)^{-\theta} + \lambda_p\pi_t^{\theta}DS_{pt-1} \tag{12}$$

Euler equation

$$C_t^{-\sigma} = \beta R_t\mathbb{E}_t\Big[\frac{C_{t+1}^{-\sigma}}{\pi_{t+1}}\Big] \tag{13}$$

Complete asset market

$$(C_t^*)^{\sigma} = C_t^{\sigma}RER-CPI_t \tag{14}$$

$$\tag{15}$$

[4] $\widetilde{W}_t, \widetilde{P}_t$ are the optimal reset wage and final goods price if reset is allowed, respectively. The wage/price reset blocks, intermediate goods production/demand blocks hold for both home country and foreign country.

Interest rate parity

$$R_t = R_t^* \mathbb{E}_t \Big[\frac{RER-CPI_t}{RER-CPI_{t+1}} \frac{\pi_{t+1}}{\pi_{t+1}^*} \Big] \tag{16}$$

Monetary policy

$$\ln R_t = \rho_R \ln R_{t-1} + (1-\rho_R) \big[\ln(1/\beta) + \rho_\pi \ln \pi + \rho_y (\ln y - \ln y^{natural}) \big] + \epsilon_{Rt} \tag{17}$$

$$\ln R_t^* = \rho_R \ln R_{t-1}^* + (1-\rho_R) \big[\ln(1/\beta) + \rho_\pi \ln \pi^* + \rho_y (\ln y^* - \ln y^{*natural}) \big] + \epsilon_{Rt}^* \tag{18}$$

Productivity

$$A_t = \rho_A A_{t-1} + \epsilon_{At} \tag{19}$$

2.6 Parametrization

We apply a standard parameterization to our model, and analyze impulse responses of different types of RERs and external balance to shocks. Specifically, we set both the product elasticity and labor elasticity to be 6 (implying a markup of twenty percent), which is consistent with the average estimates from Christiano, Eichenbaum and Evans (2005). For the elasticity of substitution between imports and domestic goods, we set it to be 1.6 which is within the range of previous literature.[5] Risk aversion is set to 2 and the Frisch elasticity to 1, both within the range of common practice in macroeconomics (e.g., Hall (2010) and Ferrero (2015)). Home bias is 0.75, which is common in the international macroeconomics literature (e.g., Obstfeld and Rogoff (2007), Devereux and Engel (2007)). The time discount factor, β, is set to be 0.99, corresponding to annual interest rate four percent. Nominal rigidities are set as $\lambda_p = \lambda_w = 0.75$, corresponding to an average duration of price and wage contracts of four quarters. The Taylor rule parameters are $\rho_R = 0.8, \rho_\pi = 1.5, \rho_y = 0.5$. For the exogenous productivity process, we use fit an AR(1) process to total labor productivity (for the period of 1995 to 2017) for all the available countries in our sample and take the average of the estimates. This results in a one-lag autoregressor of 0.93 and standard deviation of 0.0015. For the monetary policy shock, we take the average from the literature for the countries in our sample[6], the one-lag autoregressor coefficient is 0.53, and the standard deviation is 0.002.

We are interested in different types of RER and their relationship with external balance, and thus need to map them to the model. As noted below, wage rigidity and price rigidity add wedges between ULC and CPI, and the presence of imported intermediate goods further divorces CPI and

[5] For instance, Coeurdacier, Kollmann and Martin (2009) set it to be between 0.6 and 2, while Heathcote and Perri (2013) Obstfeld and Rogoff (2005) consider a value of 0.9 and 2, respectively.

[6] Poutineau and Vermandel (2015) for Euro Area, Christiano, Eichenbaum and Evans (2005) for U.S., Miyamoto, Nguyen and Sergeyev (2018) for Japan.

GDP deflator from ULC[7]:

$$\text{RER-ULC} = \frac{W_t/A_t}{W_t^*/A_t^*} \cdot S_t \tag{20}$$

$$\text{RER-CPI} = \frac{P_t}{P_t^*} \cdot S_t \tag{21}$$

$$\text{RER-GDP} = \frac{P_tC_t + TradeBalance_t}{A_tL_t} \Big/ \frac{P_t^*C_t^* + TradeBalance_t^*}{A_t^*L_t^*} \cdot S_t \tag{22}$$

$$\text{Trade Balance} = (1-\alpha)\Big[\frac{MC_t^*C_t^*}{S_t} - MC_tC_t\Big] \tag{23}$$

$$\text{tby} = 1 - \frac{P_tC_t}{P_tC_t + TradeBalance_t} \tag{24}$$

It is less obvious on how to keep track of the current account given the whole set of state-contingent financial assets. Returning to the fundamental definition of current account being equal to the change in the country's net foreign asset condition absent valuation effects, we can define the current account as:

$$\text{Current Account}_t = NFA_t - NFA_{t-1}, \text{ where } NFA_t = \mathbb{E}_t\Big[\beta\frac{U_{c,t+1}}{U_{c,t}}\frac{P_t}{P_{t+1}}B_{t+1}\Big]$$

Furthermore, the current account can be written as the sum of trade balance and net investment income as well[8]:

$$\text{Current Account}_t = \text{Trade Balance}_t + B_t$$

We simulate both a productivity shock and monetary policy shock. The reason that we are particularly interested in these two shocks is two-fold. First, these two are among the most important shocks in macroeconomics and have very relevant policy implications. Moreover, these also represent two broader types of shock, which are (i) shocks that apply universally to all types of REERs (monetary policy shock in this case) and (ii) shocks that distinguish different types of REERs (productivity shock in this case). This rationale is expanded upon when we discuss the impulse responses.

2.7 Dynamics in Response to Productivity Shock and Monetary Policy Shock

Figure B.2 shows the impulse responses of real exchange rates and external balance to a one standard deviation positive productivity shock. After a positive productivity shock, home country runs an external surplus. At the same time, its RER-ULC significantly depreciates, while RER-CPI and RER-GDP appreciate instead.

The external surplus is intuitive: a productivity boom results in lower production costs, giving

[7] The definitions of CPI and ULC are the same as the literature. GDP deflator is calculated as nominal GDP divided by real GDP, where nominal GDP is the summation of consumption and net export (following the expenditure approach) and real GDP is composed of intermediate goods (following the production approach).

[8] See Schmitt-Grohé and Uribe (2017) for more details.

a price advantage to intermediate goods producers in home. Therefore consumption will tilt to home country through the expenditure-switching channel. As far as the evolution of prices is concerned, the underlying mechanism is fully a byproduct of the presence of nominal rigidities. Given wage rigidity, a positive shock in home productivity will results in a decrease in unit labor cost, W_t/A_t. On the contrary, the price of final goods is rigid, and thus CPI does not drop much contemporaneously and adjusts downwards gradually to align with the higher productivity over several periods. Correspondingly, households postpone consumption to take advantage of the lower price in the future, and RER-CPI appreciates originally and then depreciates to elicit consumption switching to home as the price of final goods fully adjusts. RER-GDP, as a combination of both home and foreign prices, can be viewed as a mixture of ULC and CPI, and it appreciates less compared to RER-CPI.

Essentially, the wage rigidity leads to a high pass-through of the productivity shock into RER-ULC, while the final goods price rigidity results in a low pass-through to CPI. These differences in pass-through drive the distinct patterns of RERs and play a key role in the negative correlation between external balance and RER-ULC and its disconnect with RER-CPI.

We now turn to analyzing a contractionary monetary shock (Figure B.3), i.e. a one-standard-deviation positive shock to the nominal interest rate. The different RERs react to this shock in a remarkably similar way—contemporaneous appreciation and gradual depreciation. In response to the interest rate increase and sluggish price change, households reduce consumption and increase saving. The drop in domestic consumption increases the marginal utility of extra consumption in the home country, triggering a nominal appreciation that tilts consumption towards the foreign country where marginal utility is lower due to perfect risk sharing. Therefore, all RERs appreciate immediately. On the external balance side, the appreciation of RER-ULC, which is the relative price of home country intermediate goods and imported intermediate goods, deteriorates the competitiveness of the home country's intermediate goods and thus leads to consumption switching towards imported intermediate goods. The external balance therefore moves to a deficit.

We conclude that our empirical findings in section 3 are consistent with a prevalence of productivity shocks in the sample we cover, given the relationship between the different RERs and the external balance.

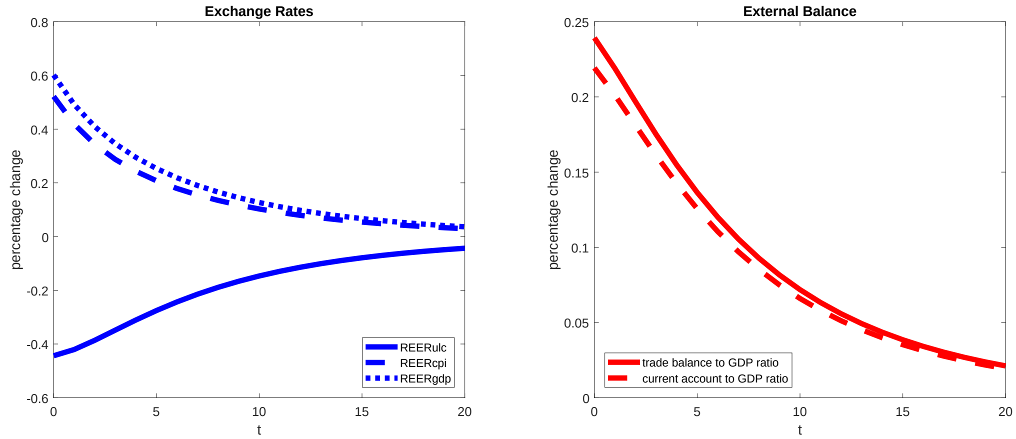
2.8 Model Predicted Trade Elasticity to Real Exchange Rates

We simulate the model for 4000 periods allowing for both productivity and monetary policy shocks, and then computing the correlation, both contemporaneously and lagged, between RERs and external balance in the second half of the sample. In order to make these calculations comparable with the empirical results, we regress trade-to-GDP ratio on the logarithm of each RER controlling for the home and foreign GDP. The results are presented in Figure B.4. The simulated contemporaneous elasticity with respect to the RER-ULC is significant and negative, whereas the RER-CPI and RER-GDP's counterparts are insignificant. This pattern matches our empirical findings very well, and somewhat surprisingly the magnitude is comparable as well.

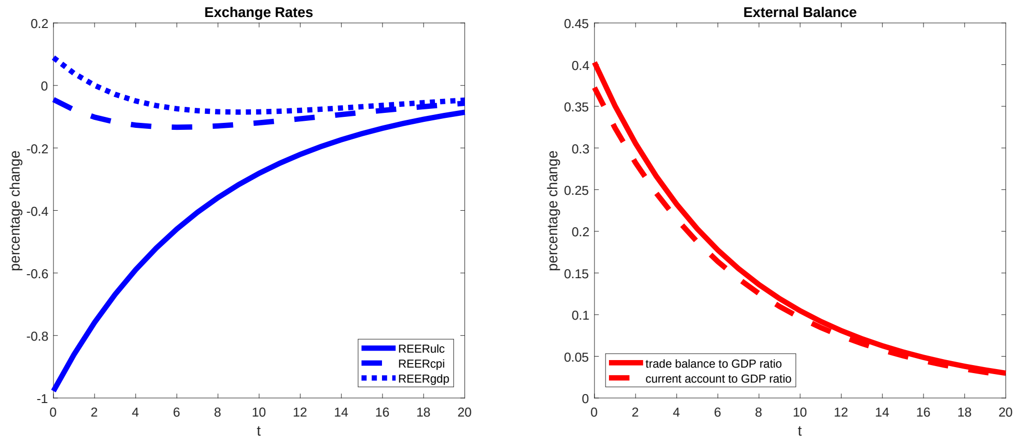
We also calculate the lagged elasticities, which are potentially interesting given the model's

Figure B.2: Impulse Response to Labor Productivity Shock

Floating exchange rate regime

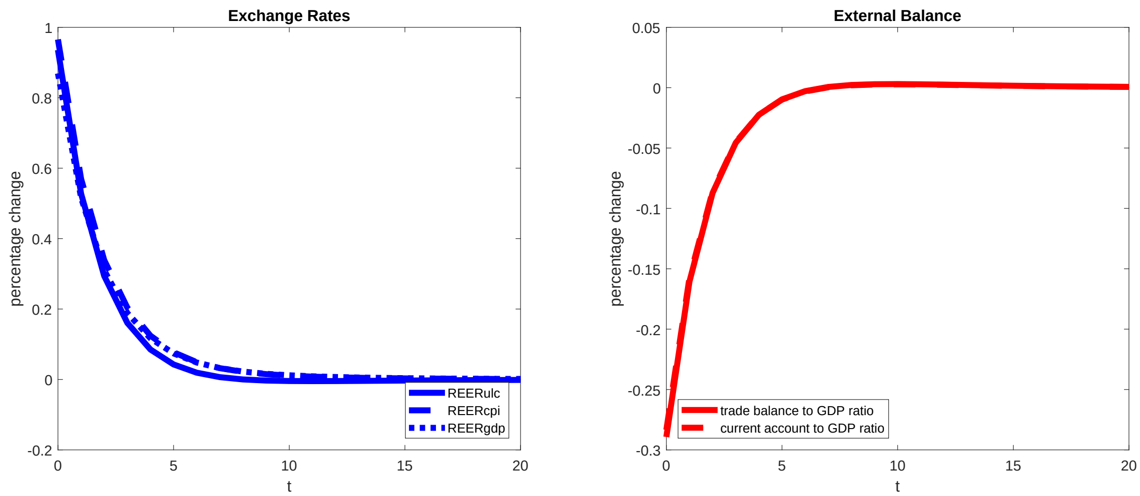


Fixed exchange rate regime



Note: This figure plots the impulse responses of different types of REERs (on the left), trade in percent of GDP and current account in percent of GDP (on the right) in response to one standard deviation positive productivity shock in the home country. For the exchange rates, negative value represents depreciation. The top panel represents floating exchange rate regime, and the bottom is fixed exchange rate regime.

Figure B.3: Impulse Response to Monetary Policy Shock

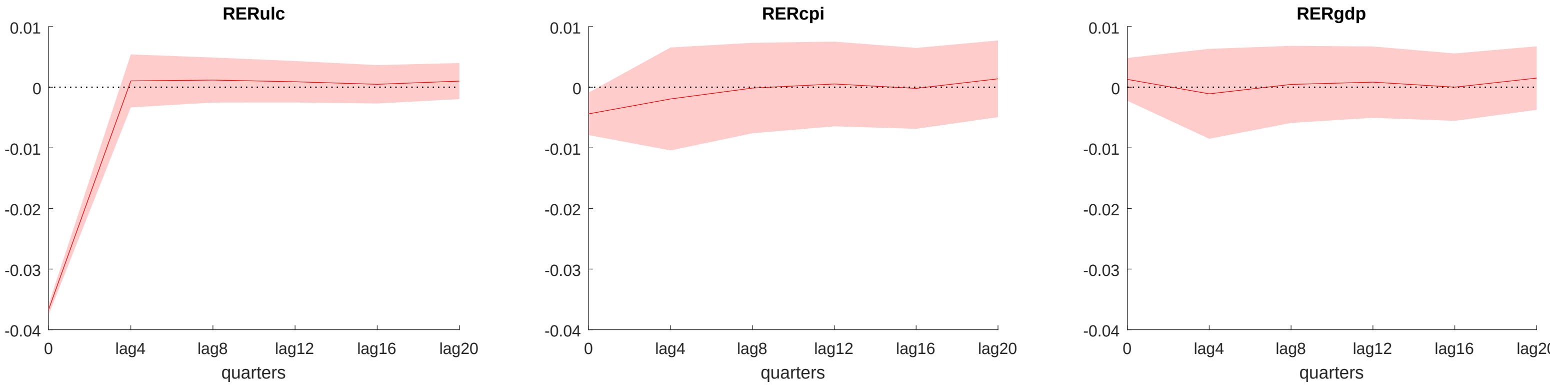


Note: This figure plots the impulse responses of different types of REERs (on the left), trade in percent of GDP and current account in percent of GDP (on the right) in response to one standard deviation positive monetary policy shock in the home country. For the exchange rates, negative value represents depreciation.

staggered price adjustment. Figure B.4 shows that the trade elasticities with respect to all RERs become insignificant after one year. As most households get the chance to reset wages after one year, both wage and ULC increase leading to a decline in home's intermediate goods' competitiveness, and deteriorating the trade balance. Thus, after the first year the trade balance is not significantly correlated with lagged RERs.

In general, our model with a Calvo form of wage and price rigidity and intermediate goods trade does well at replicating the several empirical features of the correlation between RERs and external balance—in particular, the negative contemporaneous correlation between RER-ULC and external balance and the absence of significant correlation regarding RER-CPI and RER-GDP.

Figure B.4: Contemporaneous and Lagged Elasticity of Current Account to RER



Note: This figure plots the elasticity of current-account-to-GDP ratio to different RERs using model-simulated data. From the left to the right, it shows trade elasticity to ULC-, CPI-, and GDP deflator based RERs, respectively. The elasticity is the coefficient of $\ln RER$ by regressing current-account-to-GDP ratio on $\ln RER$ and $\ln GDP$. Solid red lines denote point estimates and the light red band is the 95% confidence interval.

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