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

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Abstract

This paper contrasts real exchange rate (RER) measures based on different deflators (CPI, GDP deflator, and ULC) and discusses potential implications for the link—or lack thereof—between RER and external balance. We begin by documenting patterns in the evolution of different measures of RERs, and confirm that the choice of deflator plays a significant role in RER movements. A subsequent empirical investigation based on 35 developed and emerging market economies over 1995 to 2014 yields comprehensive and robust evidence that only the RER deflated by ULC exhibits patterns consistent with the expenditure-switching mechanism. We rationalize the empirical findings by introducing a simple model featuring nominal rigidity and trade in intermediate goods as the one in Obstfeld (2001) and Devereux and Engel (2007), which is shown to generate qualitatively identical patterns to empirical findings.

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 (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. Real exchange rates are a useful concept that allows for a comparison of the value of goods across economies and time by adjusting for potential differences in prices. The calculation amounts to deflating nominal exchange rates by local prices. Candidates for local prices range from consumer price index (CPI) to GDP deflator, 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 up to two decades, we find that the REER-ULC exhibits a negative and statistically significant correlation with external balance (expressed as the ratio of current account or trade balance to GDP), while real exchange rate measures deflated by CPI or GDP deflator (henceforth, REER-CPI and REER-GDP, respectively) tend to have a positive or statistically insignificant correlation with external balance.

We rationalize these empirical findings by introducing a simple variant of the workhorse model in open macroeconomics à la Obstfeld (2001) and Devereux and Engel (2007), which can generate a qualitatively identical pattern in response to productivity shocks: negative correlation between external balance and REER-ULC but positive or insignificant correlation between external balance 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 adjustment in unit labor cost in response to labor productivity shocks, which triggers the expenditure-switching mechanism in tradable goods via price adjustments. However, since non-tradable 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 from expenditure switching are matched more closely with the movement in REER-ULC than that in REER-CPI or REER-GDP.

In light of the model, our empirical findings can thus be fully consistent with the expenditure switching mechanism. The absence of a significant negative correlation between CPI-based real exchange rate—the most widely used measure of real exchange rate—and external balances is actually not surprising, 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 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 rate and external balance. The pioneering work by Rose and Yellen (1989) finds no robust evidence for the J-curve using over two decades of the U.S. data. Corsetti, Dedola and Leduc (2008) investigate the response in exchange rate and trade balance to productivity shock of five G7 countries and find strong evidence for Balassa-Samuelson effect. Kim and Roubini (2008) focus on the "twin deficit" of the United States and identify that expansionary fiscal policy shock improve the current account and depreciate the real exchange rate. Obstfeld and Rogoff (2005) takes the view of global economy and examine the impact of Asia's greater openness to trade on the U.S. current account. A second strand focuses on the exchange rate pass-through and external balance. Campa and Goldberg (2005) provide evidences of partial pass-through on both time series and cross-section of 23 OECD countries and draw broad implications for its role in large imbalances in trade and international capital flows. Gust, Leduc and Sheets (2009) emphasize that even in the low pass-through environment, exchange rate tends to respond more to shocks, therefore still leads to considerable external adjustment. Our approach complements them by exploring the relationship between external balance and real exchange rate beyond the default use of CPI-based real exchange rate in most of the papers, so it captures the possibly missing information in other cost-side deflators such as unit labor cost and other demand-side deflators such as GDP deflator.

Our paper is closely related to the literature investigating the construction of REER and its implications. Chinn (2006) distinguishes different types of REERs and highlight that commonly used indices may be inadequate to address certain research questions. Bayoumi, Harmsen and Turunen (2011) and Comunale and Hessel (2014) take Euro area as a particular case to examine the effectiveness of different types of REERs in their links to exports, and it also calls for caution when using standard measures of real effective exchange rates. Separately from our paper and the related studies focusing on deflators, there is an emerging literature that focuses exclusively on the weights used in REER calculation, reflecting the growing relevance in 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.

The paper is organized as follows: Section 2 presents and discusses the data, and Section 3 reports empirical investigation. Section 4 lays out a standard open economy model that makes sense of 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 the period from 2000Q1 to 2014Q4. 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 appreciation in home currency.

Given the focus of the paper, we use three different types of price indices—consumer price index (CPI), GDP deflator, and unit labor cost index (ULC)—as a deflator, yielding three distinct REER measures: REER-CPI, REER-GDP, and REER-ULC.

For the choice of deflator to matter, it is necessary that (i) deflators exert non-negligible contribution to variation in REER 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

[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 service (represented by trade in tourism). The overall weight is the weighted average of the three: $\lambda_{ij} = \alpha_M \lambda_{ij}^M + \alpha_C \lambda_{ij}^C + \alpha_T \lambda_{ij}^T$.

covariance term:[2]

$$\begin{aligned} Var(\ln REER) &= Var(\ln NEER + \ln P/P^*) \\ &= \underbrace{Var(\ln NEER) + Cov(\ln NEER, \ln P/P^*)}_{\text{contribution from NEER}} \\ &\quad + \underbrace{Var(\ln P/P^*) + Cov(\ln NEER, \ln P/P^*)}_{\text{contribution from P/P*}} \end{aligned}$$

The variance decomposition results summarized in Table 1 show that relative prices can account for around 10-20 percent of variation in annual growth in REER and substantially larger portions of quarterly growth in REER, lending support to the idea that the choice of deflator may not be innocuous.[3]

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.

Next, we turn to two standard procedures in choosing an appropriate statistical model to study the relationship between external balances and different REER measures: unit root and cointegration tests. First, we investigate whether the variables of interest, real effective exchange rates and current account-to-GDP ratio, exhibit unit root behavior in our sample of countries and time period by conducting a wide series of tests.

All the tests place the null hypothesis stating that all the panels contain a unit root, except for the Hadri test that has as the null that all the panels are stationary. According to p-values reported in Table 2, 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 conservative stance that all the panels contain a unit root in these variables.

We then conduct a set of subsequent cointegration tests, and p-values reported in Table 3 strongly suggest that REER measures are cointegrated with current account-to-GDP ratio. In sum, we interpret statistical test results above as the presence of cointegrating relationship between non-stationary REER and external balance measures.

[2]This decomposition is done using the change in each variable as we have shown below their levels are not stationary.

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

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 co-integrating relationship, an error correction model is expected to deliver more efficient estimation results than other types of dynamic estimators:

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

where Y denotes the external balance measured as current account balance or trade balance in percent of GDP, and GDP, GDP^* stand for the home country real GDP and weighted rest-of-world real GDP (same weights as REER), capturing domestic and foreign demand conditions, respectively.[4]

We focus on the short-run relationship because we are less concerned about structural factors driving both real exchange rates and external balances. This motivation is also influenced by the expenditure switching mechanism and the Keynesian models that appeal to it, which are in their very nature geared towards studying the short-run relationship.

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. 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 discussing the estimation results.

3.2 Baseline Results

Table 4 reports the baseline ECM dynamic fixed effects estimation results from the quarterly frequency data. The top three rows summarize the long-run coefficient estimates,

[4] In the paper, we report estimation results with current account balance only. All the results with trade balance are qualitatively identical throughout the specification/samples, and are available on request.

while the bottom panel shows the short-run coefficient estimates including the error-correction term that captures the speed of adjustment. Column 1-3 corresponds to the estimation results when the deflator used to construct the REER measure in the regression is ULC, CPI, and GDP deflator, respectively.

The coefficient estimate of particular interest in the present context is the short-run REER coefficient (SR_REER). 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 negative coefficient estimate on this variable—implying that REER depreciation (appreciation) is associated with current account balance improvement (deterioration)—, an immediate interpretation is that only the ULC based REER measure is consistent with the expenditure-switching mechanism. 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.[5]

To account for potential heterogeneity in the coefficients across countries, 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 5 summarizes the PMG and MG ECM 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 4. REER-ULC always yield 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 5, 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, the following tables will report the estimation results from the dynamic fixed effects only.

We further investigate whether our findings are driven by particular sample periods. Table 6 reports the ECM dynamic fixed effects estimation results with time fixed effects (columns 1-3) or pre-global financial crisis (GFC) period sample (columns 4-6). 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 year-specific shocks or excluding post-GFC periods.

Are the patterns that we find exclusive to the Eurozone? Several papers have documented that diverging labor productivity (and hence, ULC) across countries is found to explain the bulk of the external imbalances in the common currency area particularly well. Table 7 summarizes the ECM estimation results for non-euro countries (columns 1-3) and euro countries (columns 4-6) separately. It confirms that qualitatively identical

[5] Although there also appears slight difference in the estimated coefficients of the long-run domestic demand (LR_DD) and short-run domestic demand (SR_DD) variables across columns, this is not so stark as the one for the short-run REER variable throughout a battery of regression results reported throughout the paper.

patterns are found in both non-euro and euro countries.

Moreover, we allow for richer short-run dynamics by including additional lags of the short-run REER variable in the estimating equation. Table 8 reports only 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 additional lags included, REER-ULC always yields negative and statistically significant coefficient estimates on the contemporaneous REER variable and insignificant estimates on all the lagged terms. Likewise, all the coefficient estimates with REER-GDP— contemporaneous and lagged—are statistically insignificant.

However, the estimation results with REER-CPI show that negative and statistically significant coefficient estimates are found in two-period lagged terms, suggesting that the seemingly absent expenditure-switching mechanism when measured in REER-CPI can be partly explained by potential delays in the transmission process from REER-CPI to external balance adjustments. Although it may look similar, this seems distinct from the conventional J-curve story that there are lags for trade volumes to adjust while import prices tend to adjust quickly. Rather, this result, in combination with REER-ULC results, suggests that the finding could possibly reflect relative stickiness of CPI compared to ULC.

3.3 Robustness Checks

3.3.1 Annual Sample

We now turn to the annual frequency version of our dataset for additional robustness checks. In addition to the fact that the annual frequency data allows to explore longer time-series at the cost of losing higher-frequency dynamics, it offers a broader set of feasible robustness checks because some of the necessary data series are available only at the 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.

Table 9 reports the baseline ECM dynamic fixed effects estimation results from the annual frequency data. As in Table 4 from the quarterly data, the top three rows 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. Column 1-3 corresponds 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 (SR_REER), 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 instead of the dynamic fixed effects estimator, allowing for heterogeneity in the coefficients of short-run variables only or both short-run and long-run variables across countries. Table 10 summarizes the PMG and MG ECM estimation results across three different REER measures using the annual frequency data. It confirms that the overall estimation results from both the PMG and MG estimators are similar to those from the DFE estimator reported in Table 10. Most importantly, the qualitative pattern from the estimated coefficients across short-run REER variables still holds: REER-ULC always yield negative and statistically significant coefficient estimates of the short-run REER variable, while none of those from REER-CPI and REER-GDP is negative.

According to p-values from Hausman test statistics provided at the bottom of Table 10, the dynamic fixed effects estimator should be preferred to the pooled mean-group or mean-group estimator in terms of efficiencies. Therefore, we henceforth report the estimation results from the dynamic fixed effects alone.

We repeat additional robustness checks that we performed with the quarterly data. Table 11 reports the ECM dynamic fixed effects estimation results with year fixed effects (columns 1-3) or pre-global financial crisis (GFC) period sample (columns 4-6). 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 or excluding post-GFC periods.

To check if the finding is mainly driven by a particular pattern inside the Eurozone, we report the ECM estimation results separately for non-euro countries (columns 1-3) and for euro countries (columns 4-6) in Table 12. It confirms that such patterns are found in both non-euro and euro countries.

We also include additional lags of the short-run REER variable in the estimating equation. Table 13 reports only 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 additional lags included, REER-ULC always yields negative and statistically significant coefficient estimates on the contemporaneous REER variable and insignificant estimates on most of the lagged terms. Likewise, all the coefficient estimates—contemporaneous and lagged—with REER-GDP are statistically insignificant. However, the estimation results with REER-CPI show that negative and statistically significant coefficient estimates are found in two-period lagged terms, suggesting that the seemingly absent expenditure-switching mechanism when measured in REER-CPI can be partly explained by potential delays in the transmission process from REER-CPI to external balance adjustments.

3.3.2 Additional Controls

So far, we have confirmed that our main finding also holds with the annual frequency data. One immediate concern from our baseline specification is whether the results are driven by a potential endogeneity bias. Our quick answer is 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 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 balance would 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. In fact, it is more likely that such an upward bias, if any, to be relatively muted for REER-CPI and more severe for REER-ULC to the extent that the degree of exchange rate pass-through is higher in CPI than in ULC. 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 from different REER measures.

Nevertheless, we go on to check one of the most likely sources of omitted variable bias—namely, commodity terms of trade. Intuitively, a collapse in commodity prices would result in direct price effect, boosting (worsening) external balance in commodity importers (exporters). At the same time, it is expected to strengthen (weaken) currency values in commodity importers (exporters). As a result, omitting this variable may lead to upward bias in the estimated coefficients on short-run REER variables. Table 14 confirms that our main finding is not driven by omitted variable bias caused by not controlling for commodity terms of trade[6]. In fact, compared to the baseline estimation results reported in Table 9, the coefficient estimate on REER-ULC becomes larger negative, while that on REER-CPI or REER-GDP becomes even larger 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.

Another concern related to omitted variable bias is that other types of cost, such as capital cost and/or intermediate input cost might be well present in the error term, which is likely to be correlated with labor cost as they are substitute or complement to labor input. 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,[7] we also acknowledge that Cobb-Douglas function might not be a good approximation for the technology in

[6]Data 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 the 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 WEO. 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).

[7]As a simple demonstration, suppose that the production of domestic intermediate goods uses N types of (domestic) inputs (and labor being the first of them) with a Cobb-Douglas technology.

$$Y = \Pi_{k=1}^{N} \frac{I_k^{\alpha_k}}{\alpha_k^{\alpha_k}}, \quad \text{where} \quad \sum_{k=1}^{N} \alpha_k = 1$$

The cost minimization leads to

$$WL = \alpha_1 MC \cdot Y \Longrightarrow MC = ULC/\alpha_1$$

reality. For instance, as documented by Karabarbounis and Neiman (2014), the labor share is declining globally as oppose to the prediction from Cobb-Douglas function that it is constant. Although it is difficult to obtain all types of production cost data, we try to address the problem by controlling for capital cost. To this end, we employ 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 it as additional control to our baseline regression using REER-ULC. As shown in the last column of Table 14, the negative correlation between REER-ULC and external balance is hardly affected, which helps to ease the concern about omitting other types of production cost.

3.3.3 Tradable Price versus Nontradable Price

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 chain, intermediate goods have become more prominent in international trade (and hence in external balance), of which price 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 up sector-level ULC and GDP deflator in tradable sectors, thereby constructing an alternative set of REER measures covering tradable sectors only.[8] The results summarized in Table 15 suggest that the composition alone could not explain the empirical patterns. The REER measure with a tradable sector GDP deflator still shows no significant short-run relationship with external balance (columns (3)), whereas that with a tradable sector ULC continues to show statistically significant and negative relationship (columns (1)). In column (2) and (4), we employ an alternative way of comparing tradable sector REER whereby additional set of the relative price in tradable and nontradable sector is controlled.[9] The results in column (2) and (4) again show that even constrained on tradable sector, REER-GDP is still not significantly correlated with external balance,

[8]More details in Mano (2016).

[9]Using a simple CPI construction as a geometric average of tradable and nontradable goods, we can obtain that overall REER is:

$$\begin{aligned} p_t &= \alpha p_t^N + (1-\alpha)p_t^T \\ p_t^* &= \alpha p_t^{N*} + (1-\alpha)p_t^{T*} \\ \implies \ln REER &= (s_t + p_t^T - p_t^{T*}) - \alpha(\widehat{p}_t^N - \widehat{p}_t^T) \\ &\text{where } \widehat{p} \text{ denotes the relative price} \end{aligned}$$

while REER-ULC keeps exhibiting its close relationship.

3.3.4 Dominant Currency and Real Exchange Rate

Casas et al. (2016) show that expenditure switching operates through import substitution depending on how a country's currency fares against the USD, or what they call the dominant currency paradigm given that the USD is the main currency of trade invoicing. We hence check whether the patterns that we uncovered hold when considering real exchange rate movements against the United States. Table 16 shows that it is still the case that only ULC-based RER is negatively related to the external balance in the short-run, and thus that the dominant currency paradigm is not a relevant consideration for the problem considered here.

3.3.5 Alternative Measures of External Balance and Demand

In examining the relationship between external balance and real exchange rate, we use the ratio of current account (or trade balance) relative to GDP following the literature. However, Alessandria and Choi (2016) propose a novel decomposition and approximation of the external-balance-to-GDP ratio which links it directly to a demand system derived from classic Armington model. We apply their decomposition and split trade-to-GDP ratio into trade-balance-to-gross-trade ratio and gross-trade-to-GDP ratio. Furthermore, using first-order Taylor expansion, trade-balance-to-gross-trade ratio can be exactly linked to the demand equation.[10] In this context, we check whether the new measure of external balance, which is trade-balance-to-gross-trade ratio, could deliver the relationship between REERs and external balance same as the benchmark.

As shown in Table 17, the new measure of external balance yields a similar empirical pattern to our baseline results: only REER-ULC is negative significant correlated with external balance, while REER-CPI or REER-GDP deflator show disconnection.

We also address potential concerns about whether GDP would be a good proxy for total demand. Recall that in the demand system, total consumption is essentially domestic absorption in each country, which could be approximated by total consumption and investment. Therefore, we replace home and rest-of-world GDP with total consumption and investment to see whether it would change the results. In Table 18, the estimates clearly demonstrate that the alternative measure of aggregate demand does not over-

[10] According to Alessandria and Choi (2016), the external-balance-to-GDP ratio can be expressed as:

$$\begin{aligned}
\frac{X-M}{Y} &= \frac{X-M}{X+M} \times \frac{X+M}{Y} \\
&\approx \frac{1}{2} \times \ln \frac{X}{M} \times \frac{X+M}{Y} \\
\ln \frac{X}{M} &\approx \eta \left[(2\alpha - 1) \ln \frac{P^*}{P} + \ln \frac{Y^*}{Y} \right]
\end{aligned}$$

$$\Longrightarrow \frac{X-M}{X+M} \approx \frac{\eta}{2} \left[(2\alpha - 1) \ln \frac{P^*}{P} + \ln \frac{Y^*}{Y} \right]$$

turn the results, and the robust negative relationship between REER-ULC and external balance still holds.

3.3.6 Alternative Sources of REER

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 European Commission's dataset which contains REERs based on ULC of total economy, ULC of manufactures, Harmonized Index of Consumer Price and GDP deflator. The dataset covers mainly EU countries plus Australia, Japan, Mexico, New Zealand and the U.S. (37 countries in total) from 1994 to 2015.

We apply the baseline error correction model estimation to the new data, and the results that are summarized in Table 19 look remarkably similar to those from our self-constructed data. For instance, the short-run coefficients for REER-ULC is around -0.05, which is very close to our quarterly benchmark -0.048. Also, REER-CPI and REER-GDP do not yield any significant coefficient estimate.

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, and thus cannot be simply attributed to statistical factors. On top of 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

This section introduces a simple variant of the two-country open economy model developed in Obstfeld (2001) and Devereux and Engel (2007), the structure of which is summarized in Figure 2. The upper part represents home country, while the lower part (with *) is the foreign counterpart. The economy in each country operates in the following matter: household presets (agent that presets price is shaded in blue) wage of her differentiated labor and supplies it to labor union where it is assembled to composite labor and provided to intermediate producer; final producer purchases intermediate inputs from both home and foreign and sells it to domestic market at preset price. Therefore, the model features both wage and final goods price rigidity, trade in intermediate goods with flexible intermediate goods prices, and non-tradable final goods.[11] In the rest of the section, we will illustrate each component of the model in detail.

[11] The original purpose of this model set-up in Obstfeld (2001) was to show that the absence of exchange rate pass-through to CPI is not necessarily inconsistent with the presence of the expenditure switching mechanism.

4.1 Household

The household in the model has a dual-role as a supplier of her individual-specific labor and consumer of final goods: she sets wage one-period ahead, provides her labor to labor union, and consumes. We suppress the subscript i here due to symmetry among households.

To characterize the behavior of the household, we begin by solving her presetting wage problem. Since wage is set one-period prior, at $t-1$, household chooses W_t to maximize the expected utility at t. The utility depends on final-good consumption and disutility of working, where ρ represents the risk-aversion and ν is the Frisch elasticity:

$$\max_{W_t} \quad \mathbb{E}_{t-1}\Big[\frac{C_t^{1-\rho}}{1-\rho} - \frac{1}{\nu}L_t^{\nu}\Big]$$

The FOC of the maximization problem yields the labor supply curve. Noting that final goods price is preset (which will be elaborated in detail later) as well, we can further simplify the condition and obtain that the real wage rate is associated with the expected value of labor and consumption:

$$W_t = \frac{\mathbb{E}_{t-1}(L_t^{\nu})}{\mathbb{E}_{t-1}(\frac{L_t}{P_t}C_t^{-\rho})} \Longrightarrow \frac{W_t}{P_t} = \frac{\mathbb{E}_{t-1}(L_t^{\nu})}{\mathbb{E}_{t-1}(L_t C_t^{-\rho})}$$

For the intertemporal consumption allocation, we assume complete asset markets, a standard assumption in the literature[12], whereby households have a full set of nominal state-contingent assets that can be traded ex-ante, and this complete asset market setting leads to the risk sharing between two countries. Therefore, the intertemporal budget constraint for household is composed of wage income, rebated profit from 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:

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

[12]The complete markets framework is used 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 the incomplete market and complete market models predicts similar equilibrium allocations and the transmission mechanism, for instance, Chari, Kehoe and McGrattan (2002) and Corsetti, Dedola and Leduc (2008).

The last piece of household's problem is the intratemporal consumption allocation. We assume that the overall consumption level C_t is a CES aggregator of the consumption on a unit continuum of goods, and it leads to a demand function with elasticity of θ:

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

4.2 Labor Union and Intermediate-Good Producer

Labor union[13] hires differentiated labor from households, and supplies it to the intermediate-good producer whose production requires a composite of all types of labor where ζ is the elasticity across different types of labor:

$$\widetilde{Y}_t = A_t L_t, \quad \text{where} \quad L_t = \Big(\int_0^1 L_{it}^{\frac{\zeta-1}{\zeta}} di\Big)^{\frac{\zeta}{\zeta-1}}$$

Labor union, as the monopoly of the labor supply, it charges manufacturer ($\widetilde{W}_t$) up to a markup and pays to household W_t. In the end, the profit of the labor union will be rebated to its members (i.e., households):

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

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

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

4.3 Final-Good Producer

We embed price rigidity similarly to wage rigidity in our model. Specifically, there is a unit continuum of final-good manufacturers whose optimization problem is to maximize expected profit with subjective discount factor of households who are the owner of the firms:

$$\max_{P_{jt}} \quad \mathbb{E}_{t-1}\Big[\Big((P_{jt} - MC_{jt})C_{jt}\Big)\frac{C_t^{-\rho}}{P_t}\Big] \quad \text{for each } j \in [0, 1]$$
$$s.t. \quad C_{jt} = \Big(\frac{P_{jt}}{P_t}\Big)^{-\theta} C_t$$

The FOC yields that:

$$P_{jt} = \frac{\theta}{\theta - 1} \frac{\mathbb{E}_{t-1}[MC_{jt} \cdot C_t^{1-\rho}]}{\mathbb{E}_{t-1}[C_t^{1-\rho}]}$$

The production of final goods requires both foreign and domestic intermediate goods, and the home bias is represented by $\alpha \in (0.5, 1)$. The CES production function yields

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

the marginal cost being a CES combination of foreign and domestic intermediate-good prices. Producer currency pricing is assumed in our model, hence, the domestic price of foreign intermediate good is $\frac{\widetilde{W}_t^*}{A_t^* S_t}$:

$$Y_{jt} = \left(\alpha^{\frac{1}{\eta}} \widetilde{Y}_t^{\frac{\eta-1}{\eta}} + (1-\alpha)^{\frac{1}{\eta}} \widetilde{Y}_t^{*\frac{\eta-1}{\eta}}\right)^{\frac{\eta}{\eta-1}} \Longrightarrow MC_{jt} = \left[\alpha\left(\frac{\widetilde{W}_t}{A_t}\right)^{1-\eta} + (1-\alpha)\left(\frac{\widetilde{W}_t^*}{A_t^* S_t}\right)^{1-\eta}\right]^{\frac{1}{1-\eta}}$$

4.4 Equilibrium

To close the model, we need to specify monetary policy for floating exchange rate regime case or fix exchange rate for peg regime. The monetary policy is specified as domestic absorption stabilization[14]:

$$CP = M$$

The equilibrium is constituted by $\{P, W, \widetilde{W}, MC, L, C, P^*, W^*, \widetilde{W}^*, MC^*, L^*, C^*; S\}$ that satisfying (1) to (6) for both home and foreign countries and risk-sharing condition (7) given exogenous processes (8) to (9):

$$\text{labor supply:} \quad \frac{W_t}{P_t} = \frac{\mathbb{E}_{t-1}(L_t^\nu)}{\mathbb{E}_{t-1}(L_t C_t^{-\rho})} \tag{1}$$

$$\text{final good supply:} \quad P_t = \frac{\theta}{\theta-1} \frac{\mathbb{E}_{t-1}[MC_t \cdot C_t^{1-\rho}]}{\mathbb{E}_{t-1}[C_t^{1-\rho}]} \tag{2}$$

$$\text{labor union wage:} \quad \widetilde{W}_t = \frac{\zeta}{\zeta-1} W_t \tag{3}$$

$$\text{intermediate goods market clear:} \quad A_t L_t = \alpha\left(\frac{\widetilde{W}_t / A_t}{MC_t}\right)^{-\eta} C_t + (1-\alpha)\left(\frac{\widetilde{W}_t / A_t \cdot S_t}{MC_t^*}\right)^{-\eta} C_t^* \tag{4}$$

$$\text{marginal cost:} \quad MC_t = \left[\alpha\left(\frac{\widetilde{W}_t}{A_t}\right)^{1-\eta} + (1-\alpha)\left(\frac{\widetilde{W}_t^*}{A_t^* S_t}\right)^{1-\eta}\right]^{\frac{1}{1-\eta}} \tag{5}$$

$$\text{monetary policy:} \quad P_t C_t = M_t \tag{6}$$

$$\text{risk sharing:} \quad P_t C_t^\rho = P_t^* C_t^{*\rho} / S_t \tag{7}$$

$$\text{productivity shock:} \quad \ln A_t = \rho^A \ln A_{t-1} + \epsilon_t^A \tag{8}$$

$$\text{monetary policy shock:} \quad \ln M_t = \rho^M \ln M_{t-1} + \epsilon_t^M \tag{9}$$

Before turning to the numerical analysis, a couple of features of the model might be worth mentioning. First, the model features imports and exports of intermediate goods only. Although it might sound extreme to abstract away from trade in final goods, if we view the final goods manufacturers as retailers and intermediate goods manufacturers as final goods producers, then it is isomorphic to a setting where trade is exclusively on final goods. Therefore, the model provides a flexible framework in terms of production and product trade for discussing the relationship between RER and external balance. Second, the risk-sharing condition and monetary policy are crucial in determining nominal

[14] This seemingly ad-hoc monetary policy can be derived from money-in-utility framework with $U = \frac{C^{1-\rho}}{1-\rho} - \frac{\kappa}{\nu} L^\nu + \frac{1}{\chi} \ln(M/P)$, and it is the same as Devereux and Engel (2007).

exchange rate for floating regime country. Combining the two conditions yields that $M_t C_t^{\rho-1} = M_t^* C_t^{*\rho-1}/S_t$, we can observe that expansionary monetary policy generates exchange rate depreciation, so does any shock leading to home consumption boom.

4.5 Parametrization

We apply a standard parameterization to our model and use it as laboratory to analyze the impulse responses of different types of RERs and external balance. 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.[15] The risk aversion level is set to be 2 and Frisch elasticity to be 1, which are 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)). Time discount factor, β, is set to be 0.99, corresponding to annual interest rate four percent.

Since we are interested in different types of RER and their relationship with external balance, it would be useful to map them into the model. As can be noted below, wage rigidity and price rigidity adds wedge between ULC and CPI, and the imported intermediate goods further divorces CPI and GDP deflator from ULC:

$$\text{RER-ULC} = \frac{W_t/A_t}{W_t^*/A_t^*} \cdot S_t \tag{10}$$

$$\text{RER-CPI} = \frac{P_t}{P_t^*} \cdot S_t \tag{11}$$

$$\text{RER-GDP} = \frac{P_t C_t + TradeBalance_t}{A_t L_t} \Bigg/ \frac{P_t^* C_t^* + TradeBalance_t^*}{A_t^* L_t^*} \cdot S_t \tag{12}$$

$$\text{Trade Balance} = (1-\alpha)\left[\frac{MC_t^* C_t^*}{S_t} - MC_t C_t\right] \tag{13}$$

$$\text{tby} = 1 - \frac{P_t C_t}{P_t C_t + TradeBalance_t} \tag{14}$$

Current account is less clear to keep track of given the whole set of complete 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, we can define current account as:

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

Furthermore, current account can be written as the sum of trade balance and net investment income as well[16]:

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

[15] 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.

[16] See Schmitt-Grohé and Uribe (2016) for more details.

For simulation exercises, we experiment with 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, so it would be natural to apply them to our model as well. Moreover , we view these two not only as two shocks by themselves but also representatives of two broader types of shock, which are the shocks that apply universally to all types of REERs (monetary policy shock in this case) and the shocks that distinguish different types of REERs (productivity shock in this case). More explanation will be provided in the discussion of impulse responses. For the magnitude of the shocks, we experiment with 20 basis point of monetary shock and 0.0015 as productivity shock[17] to evaluate the dynamics of the external balance and RERs:

$$\epsilon_t^A \sim \mathcal{N}(0, \sigma_A^2), \quad \sigma_A = 0.0015$$
$$\epsilon_t^M \sim \mathcal{N}(0, \sigma_M^2), \quad \sigma_M = 0.0020$$

4.6 Productivity Shock

Figure 3 shows the impulse responses of productivity shock. Upon the arrival of a positive productivity shock, on the external balance side, home country runs a surplus. On the real exchange rate side, a significant depreciation can be observed in RER-ULC, while RER-CPI does not respond contemporaneously and RER-GDP shows a much milder depreciation[18] than the ULC counterpart.

The surplus in external balance is intuitive: productivity boom results in lower cost, giving price advantage to home country intermediate goods, such that households will tilt their consumption to home country through the expenditure-switching channel.

As far as the evolution of prices is concerned, the underlying mechanism links closely to nominal rigidities. Given wage rigidity, a positive shock in home productivity will be transmitted one-to-one to unit labor cost, W_t/A_t. On the contrary, final goods price is preset, therefore CPI will not respond contemporaneously. The pattern of GDP deflator, as a combination of both home and foreign prices, is a mixture of ULC and CPI, and it declines much less compared to ULC. On the nominal exchange rate side, with preset price and money supply fixed, there will not be any contemporaneous change in consumption. Since price and consumption will not jump, the marginal utility stays the same in two countries and risk-sharing condition insures that nominal exchange rate will not respond on spot.

At a longer horizon, since home country has higher productivity, the risk-sharing condition should enable consumption to switch to home country. However, because the adjustment in price is sluggish, nominal exchange rate has to depreciate in order to support higher home consumption. Therefore, RER-CPI roughly follows the dynamics of

[17]These standard deviations align with the values in literature, for instance, Gali and Monacelli (2005), Carvalho (2006) etc.

[18]The extent to which GDP deflator-based RER depreciates is closely related to the level of home bias. As home bias becomes smaller, GDP deflator-based RER behaves more similarly to ULC counterpart; as home bias goes to 100%, GDP deflator-based RER coincides with CPI counterpart. More details can be found in Appendix A.2.

nominal exchange rate, i.e. depreciates at first and then appreciates back to the original steady state level. In the meantime, wage increases due to the increasing demand in labor, together with nominal exchange rate going strong, RER-ULC appreciates as well and at an even higher speed.

Overall, the model predicts a complete pass-through of productivity shock to ULC and no pass-through to CPI once the productivity shock materializes, and these plays a key role in the negative correlation between external balance and RER-ULC and its disconnect with RER-CPI in the short-run.

4.7 Monetary Policy Shock

Another shock that we experimented is expansionary monetary shock (Figure 4). The most significant feature of the impulse responses is that different RERs react in a remarkably similar way—contemporaneous depreciation and gradual appreciation. The intuition is that in response to positive money supply shock, consumption jumps one-to-one to the shock because of the preset price, and it results in depreciation and external balance deficit. More specifically, due to perfect risk sharing among countries, relative increase in domestic consumption lowers the marginal utility of extra unit consumption in home country, and it triggers a nominal depreciation to facilitate consumption tilting to foreign country where marginal utility is higher. Therefore, all RERs experience depreciation immediately. On the external balance side, consumption increase leads to external balance deficit as home country expenses more. Also, although households have consumption smoothing motive to save the extra money, they understand that price will increase in the next period as the wage and final goods' price being reset. Therefore they would very much like to take advantage of the current relatively low price and consume more. This incentive even outweighs the consumption smoothing motive for the temporary positive monetary shock, as a result, household will borrow in the global financial market and run external balance. This is the reason that current account deteriorates contemporaneously with expansionary monetary policy shock.

After one period, price and wages are reset, and thus RERs appreciate and move their way back to the steady state. In the meantime, external balance increases relative to the last period due to the RER appreciation. One pattern noted here is that external balance deteriorates before going back to balance, and the second dip is due to the fact that foreign consumption diminishes and reduces importing.

Comparing monetary policy shock to productivity shock, we can find that it might not be the driving force behind the different pattern of RER-ULC comparing to the rest regarding its correlation with external balance. The reason of the lack of distinction in the case of monetary policy shock is that it is a "generic" shock to all nominal terms. For instance, it appreciates nominal exchange rate contemporaneously, which affects all RERs in the same way; it boosts consumption, which also affects CPI, ULC and GDP deflator all in the same direction. However, we do not view this as the inability of the model, instead, it sheds light on how we can learn about the fundamental shocks through the lens of the observed (or lack of) correlations.

4.8 Correlations

We simulate the model for 4000 periods with both productivity and monetary policy shocks with the first half burn-in[19] to calculate the second moment between RERs and external balance both contemporaneously and lagged. In order to make it comparable to the empirical results, we calculate $Cov(RER, CA/Y)/Var(RER)$. The results are presented in Figure 5 where the solid black line is the point estimate and the red band is the 99% confidence interval. As can be observed, the simulated moments confirm that RER-ULC shows a significant and negative correlation with external balance, whereas RER-CPI and RER-GDP are not negatively correlated with external balance, with point estimates being positive for RER-CPI and insignificant for RER-GDP. This pattern matches our empirical findings very well, and the magnitude is also comparable.

We calculate lagged moments since our model features nominal rigidity at the one-period horizon. As can be observed from the Figure 5, in lag one, RER-CPI and RER-GDP show significant negative correlation with external balance. The logic is intuitive: when price setters get the chance to reset price in the next period, much of the mispricing will be undone. One can expect, if the price rigidity lasts more than one period, or it is relaxed gradually in the Calvo fashion, it will take longer time for price setters to reset the price to the optimal (flexible) level and thus, the same is true for the negative correlation with external balance to show up.

Our model also captures the property that the negative correlation between RER-ULC and external balance goes beyond the contemporaneous period. In Figure 5, we can see that when RER-CPI and RER-GDP begin to show negative correlation with external balance, while the negative correlation based on RER-ULC preserves as well. The intuition is that, when households have the opportunity to reset price, although the new wage would increase due to rising demand, the change in wage is still smaller than the magnitude of the shock. As a result, we still see the depreciation in RER-ULC in the period of external balance surplus.

In general, our model with a parsimonious form of nominal 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.

5 Conclusion

This paper investigates the role of price deflators for the empirical relationship between RER and external balance. We document a strong negative correlation between RER-ULC and external balance and the absence of significant relationship for RER-CPI or RER-GDP deflator. Using a comprehensive sample of 35 major economies covering two decades, we estimate the correlation using an error correction model and further check robustness of this finding using different regression specifications, subsample of countries

[19] In each period, we generate a realization of ϵ_{At} and ϵ_{Mt} from their normal distribution and calculate the value of A_t, M_t and the rest of the model using the conditions (1) to (7).

and years. Motivated by the empirical findings, we developed 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 RERs and external balance.

The key insight of the model is the dual-role of nominal rigidity on ULC (as the factor cost), which is closely related to the trade in intermediate goods, and CPI (as the final price), which is linked to the domestic transaction in final goods. Upon the arrival of the shocks, wage rigidity prevents wage from offsetting the shocks thereby allowing full pass-through of shocks to ULC; 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 RER-ULC relates to movements in external balance, while the lack of change in CPI and GDP deflator disconnects RER-CPI/-GDP from the change in the external balance. Our baseline simulation demonstrates that the model can match reasonably well our empirical patterns.

These results suggest that the choice of price deflators matters in assessing the relationship between RER and external balance, and warrant strong caution in interpreting observed empirical patterns. Our findings 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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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 IMFs Information Notice System (INS), while CPI and GDP deflator are from the International Financial Statistics (IFS).[20]. 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.

A.2 The Role of Home-Bias

One of the most important parameters in our simulation is the home bias, α, which governs to what extent the exchange rate dynamics will be passed through to price indices. Therefore, in this section, we examine how home bias shape the evolution of RERs and their relationship with external balance.

In Figure 6, we plot the impulse responses corresponding to no home bias ($\alpha = 0.5$) to complete home bias ($\alpha = 1$) with the color of lines going from blue to green. In the no home bias case, CPI-based RERs never response to productivity shock because of the same composition in these indices between two countries. As a result, there is no dynamics in external balance, neither. On the contrary, ULC/GDP deflator-based RERs show a significant depreciation in response to productivity increase, and it is resulted from the nominal rigidity in wage level. To the other side of the extreme, in the case of complete home bias, PPI- and ULC-based RERs perform in a similar fashion, while GDP deflator-based RER resembles CPI-based one well. In our parameterization, α takes the value of 0.75, which is large enough to generate the dynamics in external balance and small enough to distinguish ULC-based RER from the rest.

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

Figure 1: REERs and External Balance

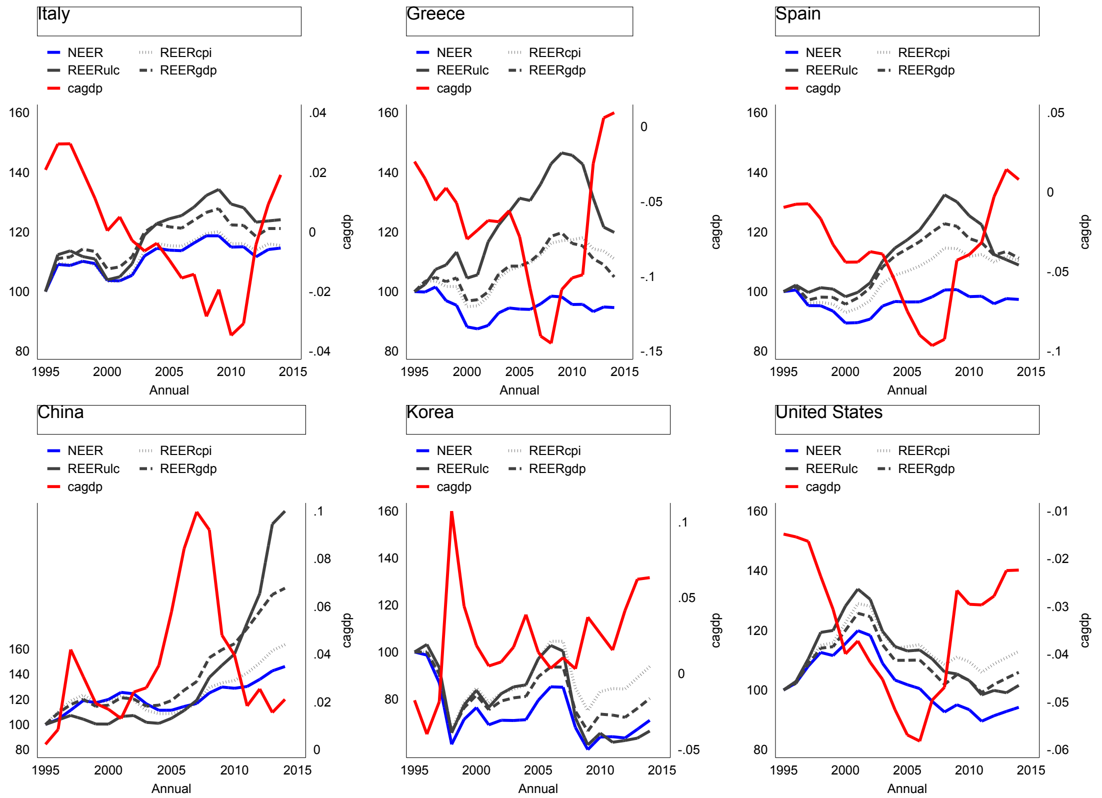
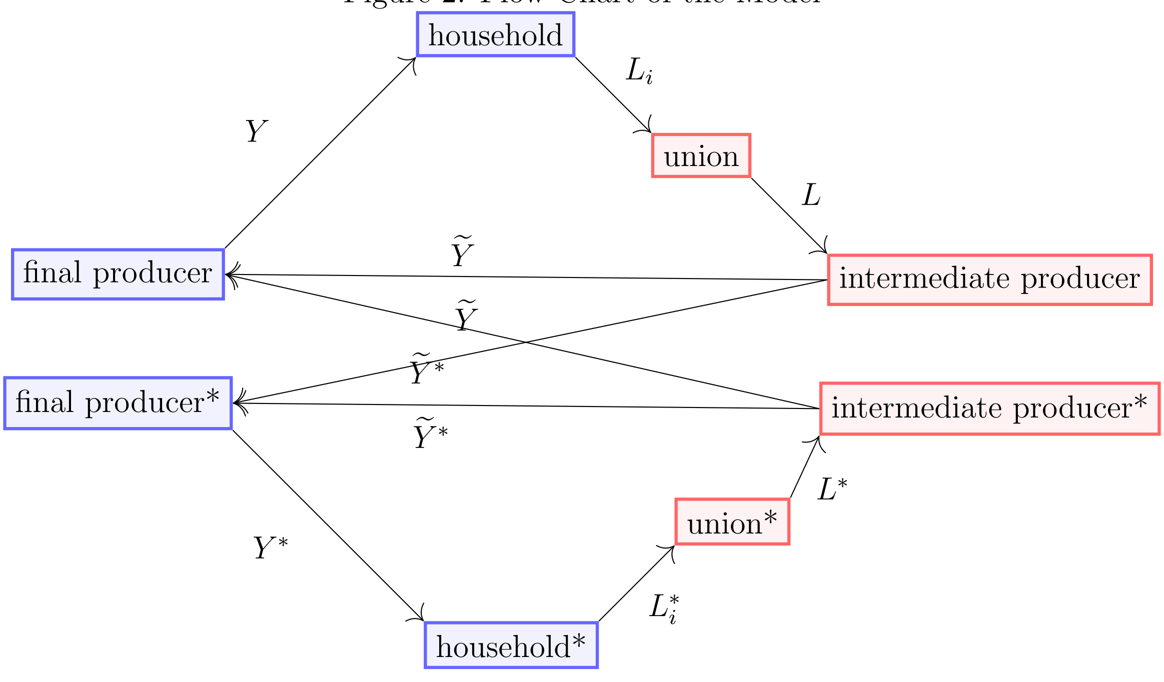


Figure 2: Flow Chart of the Model



Note: the agent shaded in blue is the one preseting price/wage.

Figure 3: Impulse Response to Labor Productivity Shock

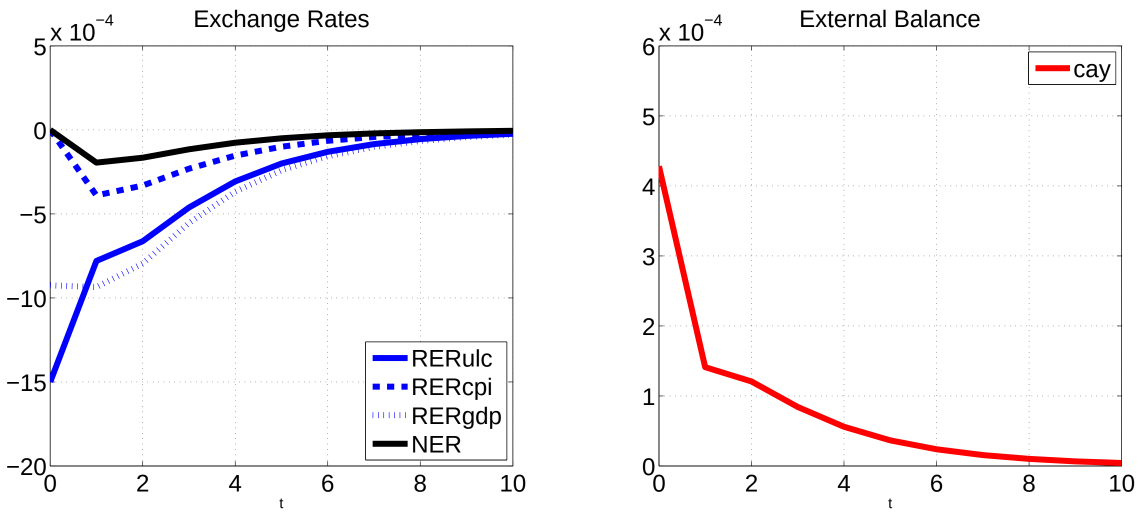


Figure 4: Impulse Response to Monetary Policy Shock

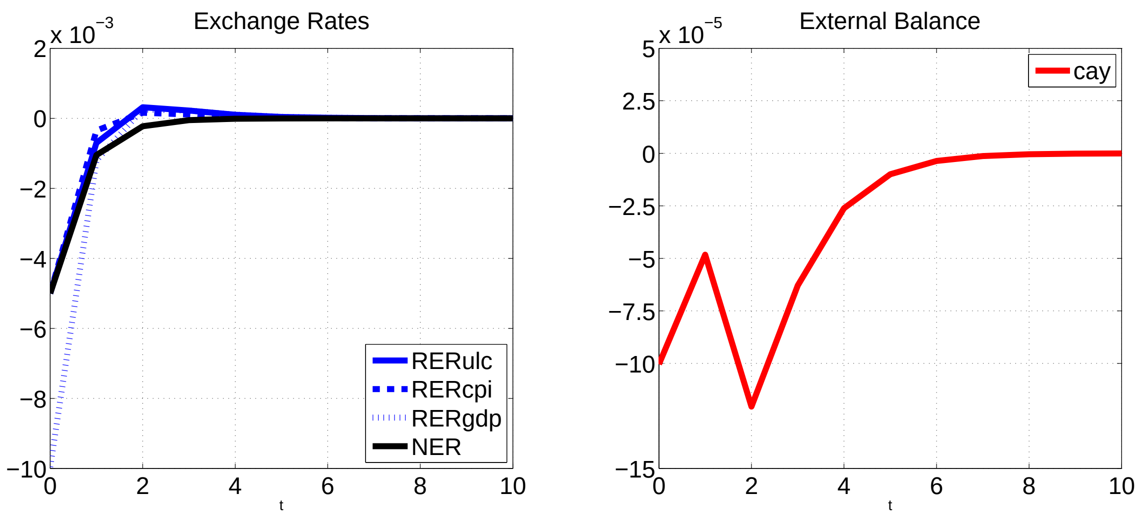


Figure 5: Contemporaneous and Lagged Correlations

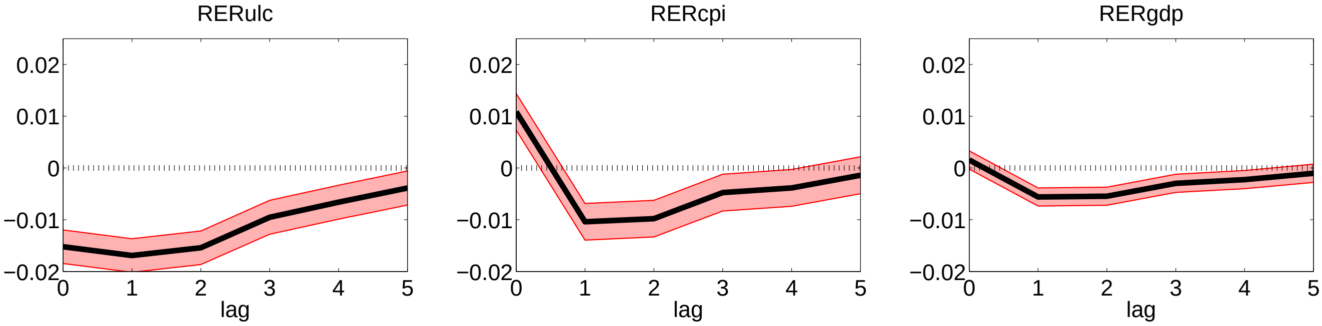


Figure 6: The Role of Home-Bias

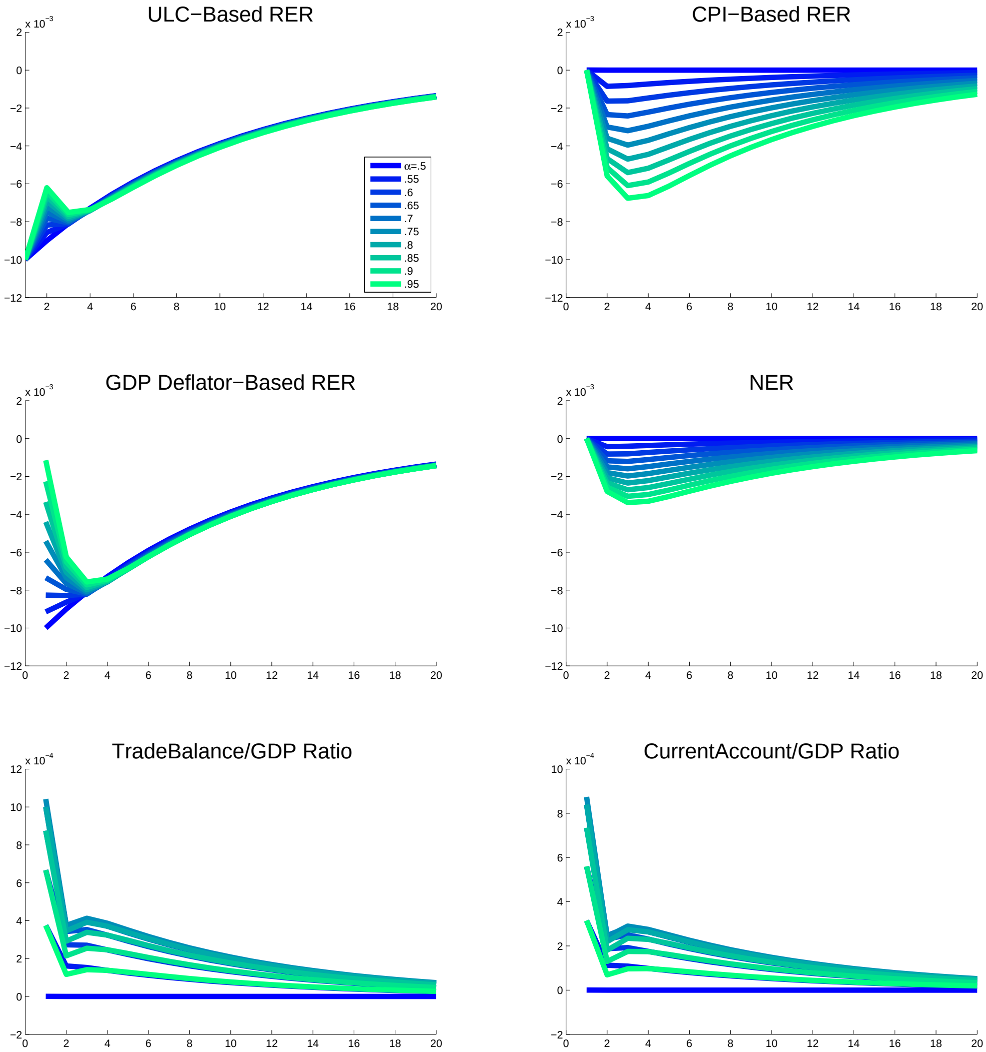


Table 1: Variance Decomposition of REER

Quarterly	NEER	P/P*	Annual	NEER	P/P*
REER-ULC	66%	34%	REER-ULC	79%	21%
REER-CPI	93%	7%	REER-CPI	83%	17%
REER-GDP	60%	40%	REER-GDP	87%	13%

Note: This table reports the contribution of nominal effective exchange rate (column 2, 5) and relative price (column 3, 6) to the variation in real effective exchange rate.

Table 2: Panel Unit Root Test

	cagdp	ln REER ulc	ln REER cpi	ln REER gdp
Quarterly				
$H_0:$ *Unit Root*				
Levin-Lin-Chu	0.45	0.04	0.00	0.00
Harris-Tzavalis	0.00	0.93	0.24	0.21
Breitung	0.02	0.61	0.16	0.31
Fisher-type(inverse Chi-square)	0.15	0.95	0.19	0.76
Fisher-type(inverse Normal)	0.36	0.88	0.11	0.52
Fisher-type(inverse Logit)	0.29	0.88	0.11	0.50
Fisher-type(Modified Inverse Chi-Square)	0.15	0.94	0.20	0.77
$H_0:$ *Stationary*				
Hadri	0.00	0.00	0.00	0.00
Annual				
$H_0:$ *Unit Root*				
Levin-Lin-Chu	0.77	0.24	0.02	0.00
Harris-Tzavalis	0.00	0.58	0.05	0.39
Breitung	0.07	0.27	0.23	0.61
Fisher-type(inverse Chi-square)	0.20	0.92	0.74	0.75
Fisher-type(inverse Normal)	0.61	0.98	0.62	0.84
Fisher-type(inverse Logit)	0.56	0.97	0.62	0.84
Fisher-type(Modified Inverse Chi-square)	0.21	0.91	0.75	0.76
$H_0:$ *Stationary*				
Hadri	0.00	0.00	0.00	0.00

Note: This table reports the p-value for panel unit root test of quarterly sample (top panel) and annual sample (bottom panel). Column 1 to 4 represents current account to GDP ratio, REER-ULC, -CPI, and -GDP deflator, respectively.

Table 3: Cointegration Test

with cagdp	ln REER ulc	ln REER cpi	ln REER gdp
Quarterly			
Pedroni	0.00	0.04	0.00
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	0.40	0.51	0.45
Pt	0.00	0.00	0.00
Pa	0.00	0.00	0.00

Note: This table reports the p-value from cointegration test using Pedroni test for quarterly sample (top panel) and annual sample (bottom panel). REER-ULC, -CPI, -GDP deflator correspond to column 1, 2, 3, respectively.

Table 4: CA to GDP ratio vs. REER

	(1) ulc b/se	(2) cpi b/se	(3) gdp b/se
ec			
LR_DD	-0.061	-0.111**	-0.078*
	(0.04)	(0.05)	(0.04)
LR_FD	0.177**	0.222**	0.200**
	(0.08)	(0.08)	(0.08)
LR_REER	0.018	0.139	0.047
	(0.06)	(0.10)	(0.07)
SR			
SR_ec	-0.149***	-0.152***	-0.148***
	(0.02)	(0.02)	(0.02)
SR_DD	0.003	-0.013	-0.022*
	(0.01)	(0.02)	(0.01)
SR_FD	-0.024	0.000	0.016
	(0.05)	(0.05)	(0.05)
SR_REER	-0.048***	-0.005	0.016
	(0.01)	(0.03)	(0.01)
obs	2065	2065	2065

Note: This table reports the baseline error correction model estimation. Column 1, 2 and 3 show the results of REER-ULC, -CPI and GDP deflator. Standard error (clustered at country level) is reported in parentheses. ***, **, * represent significance of 1%, 5% and 10%, respectively.

Table 5: Different Longrun/Shortrun Restrictions

	(1)	(2)	(3)	(4)	(5)	(6)
	ulc	cpi	gdp	ulc	cpi	gdp
	b/se	b/se	b/se	b/se	b/se	b/se
ec						
LR_DD	0.020	-0.252***	-0.009	-0.197**	-0.205***	-0.218***
	(0.01)	(0.02)	(0.02)	(0.08)	(0.05)	(0.05)
LR_FD	0.073**	0.495***	0.140***	0.399**	0.269***	0.319***
	(0.03)	(0.04)	(0.04)	(0.13)	(0.07)	(0.09)
LR_REER	-0.076***	0.239***	-0.056**	0.164	0.341***	0.314***
	(0.01)	(0.03)	(0.02)	(0.11)	(0.10)	(0.09)
SR						
SR_ec	-0.197***	-0.178***	-0.183***	-0.415***	-0.440***	-0.409***
	(0.03)	(0.02)	(0.03)	(0.04)	(0.04)	(0.04)
SR_DD	0.001	-0.040	-0.034*	-0.015	-0.040	-0.057**
	(0.02)	(0.02)	(0.02)	(0.02)	(0.03)	(0.02)
SR_FD	-0.012	0.084	0.035	0.104	0.131*	0.134*
	(0.07)	(0.07)	(0.07)	(0.07)	(0.08)	(0.08)
SR_REER	-0.066**	0.037	0.017	-0.053**	0.034	0.049
	(0.02)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
obs	2065	2065	2065	2065	2065	2065
hausman_vsDFEpvalue	1.000	1.000	1.000	1.000	1.000	1.000

Note: This table reports the robustness check using various sets of long-run/short-run restrictions. Column 1, 2 and 3 show the results of pooling mean group, and the rest are of mean group. The last row lists the p-value of Hausman test of pooling mean group/mean group specification versus dynamic fixed effect specification. Standard error (clustered at country level) is reported in parentheses. ***, **, * represent significance of 1%, 5% and 10%, respectively.

Table 6: Time Fixed Effect and Pre-crisis Period

	+Time FE			Pre-crisis		
	ulc	cpi	gdp	ulc	cpi	gdp
	b/se	b/se	b/se	b/se	b/se	b/se
ec						
LR_DD	-0.030	-0.083**	-0.046*	-0.036	-0.051	-0.055
	(0.03)	(0.03)	(0.03)	(0.03)	(0.04)	(0.04)
LR_FD	0.021	0.040	0.016	0.004	0.023	0.030
	(0.17)	(0.17)	(0.17)	(0.09)	(0.10)	(0.10)
LR_REER	0.000	0.106**	0.023	-0.064**	-0.054	-0.043
	(0.02)	(0.04)	(0.03)	(0.03)	(0.04)	(0.04)
SR						
SR_ec	-0.158***	-0.157***	-0.155***	-0.254***	-0.243***	-0.242***
	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)
SR_DD	0.007	-0.011	-0.024*	0.032**	0.028	0.009
	(0.01)	(0.02)	(0.01)	(0.02)	(0.02)	(0.02)
SR_FD	-0.034	0.004	0.021	0.080	0.087	0.117
	(0.10)	(0.10)	(0.10)	(0.07)	(0.07)	(0.07)
SR_REER	-0.047**	-0.004	0.020	-0.059**	-0.046	0.007
	(0.02)	(0.02)	(0.02)	(0.02)	(0.03)	(0.02)
obs	2065	2065	2065	1085	1085	1085

Note: This table reports the robustness check adding time fixed effect and pre-crisis subsample period. Column 1, 2 and 3 show the results of time fixed effect, and the rest are of pre-crisis subsample. Standard error (clustered at country level) is reported in parentheses. ***, **, * represent significance of 1%, 5% and 10%, respectively.

Table 7: Euro vs. Noneuro

	(1) nonEuro ulc b/se	(2) cpi b/se	(3) gdp b/se	(4) Euro ulc b/se	(5) cpi b/se	(6) gdp b/se
ec						
LR_DD	-0.035	-0.067	-0.043	-0.173***	-0.287***	-0.244***
	(0.04)	(0.05)	(0.04)	(0.05)	(0.05)	(0.06)
LR_FD	0.094	0.126	0.108	0.409***	0.486***	0.497***
	(0.08)	(0.08)	(0.08)	(0.09)	(0.10)	(0.09)
LR_REER	0.009	0.083	0.019	-0.077	0.320**	0.117
	(0.05)	(0.10)	(0.06)	(0.08)	(0.13)	(0.15)
SR						
SR_ec	-0.166***	-0.166***	-0.164***	-0.176***	-0.173***	-0.166***
	(0.03)	(0.03)	(0.03)	(0.03)	(0.02)	(0.02)
SR_DD	-0.000	-0.019	-0.029**	0.016	0.017	0.005
	(0.01)	(0.02)	(0.01)	(0.03)	(0.03)	(0.03)
SR_FD	-0.011	0.014	0.029	-0.031	-0.047	-0.022
	(0.05)	(0.05)	(0.05)	(0.10)	(0.09)	(0.10)
SR_REER	-0.047***	-0.001	0.020	-0.069*	-0.063	-0.019
	(0.01)	(0.03)	(0.02)	(0.04)	(0.05)	(0.04)
obs	1327	1327	1327	738	738	738

Note: This table reports the robustness check using non-Euro countries subsample (column 1 - 3) and Euro countries subsample (column 4 - 6). Standard error (clustered at country level) is reported in parentheses. ***, **, * represent significance of 1%, 5% and 10%, respectively.

Table 8: With Differentnt Lags [REER-ulc, DFE]

	(1)	(2)	(3)	(4)	(5)
	ADL(1.1)	(2.2)	(3.3)	(4.4)	(5.5)
	b/se	b/se	b/se	b/se	b/se
ec					
LR_ulc	0.018	0.025	0.022	0.040	0.043
	(0.03)	(0.06)	(0.06)	(0.06)	(0.07)
SR					
SR_ulc	-0.048**	-0.051***	-0.052***	-0.049***	-0.053***
	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)
lag_1		-0.008	-0.007	-0.006	-0.005
		(0.02)	(0.02)	(0.02)	(0.02)
lag_2			-0.016	-0.017	-0.016
			(0.01)	(0.01)	(0.01)
lag_3				0.004	0.003
				(0.01)	(0.01)
lag_4					0.010
					(0.01)
obs	2065	2030	1995	1960	1925
LR_cpi	0.139***	0.160	0.148	0.175	0.188*
	(0.04)	(0.10)	(0.10)	(0.11)	(0.11)
SR					
SR_cpi	-0.005	-0.009	-0.012	-0.014	-0.018
	(0.02)	(0.03)	(0.03)	(0.03)	(0.03)
lag_1		0.007	0.012	0.013	0.014
		(0.01)	(0.01)	(0.01)	(0.01)
lag_2			-0.036**	-0.037**	-0.037**
			(0.02)	(0.02)	(0.02)
lag_3				0.022	0.023*
				(0.01)	(0.01)
lag_4					0.007
					(0.01)
obs	2065	2030	1995	1960	1925
LR_gdp	0.047	0.059	0.053	0.072	0.078
	(0.03)	(0.08)	(0.08)	(0.08)	(0.08)
SR					
SR_gdp	0.016	0.009	0.007	0.008	0.002
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
lag_1		-0.020	-0.019	-0.019	-0.018
		(0.02)	(0.02)	(0.02)	(0.02)
lag_2			-0.016	-0.017	-0.015
			(0.01)	(0.01)	(0.01)
lag_3				0.000	0.001
				(0.01)	(0.01)
lag_4					0.000
					(0.01)
obs	2065	2030	1995	1960	1925

Note: This table reports the baseline error correction model with different lags. The top panel is REER-ULC, the middle REER-CPI and the bottom REER-GDP. Column 1 to 5 represent lag 1 to 5, respectively. Standard error (clustered at country level) is reported in parentheses. ***, **, * represent significance of 1%, 5% and 10%, respectively.

Table 9: CA to GDP ratio vs. REER

	(1)	(2)	(3)
	ulc	cpi	gdp
	b/se	b/se	b/se
ec			
LR_DD	-0.028	-0.064**	-0.047**
	(0.02)	(0.02)	(0.02)
LR_FD	0.099**	0.107**	0.108**
	(0.04)	(0.04)	(0.04)
LR_REER	0.006	0.138*	0.059
	(0.06)	(0.08)	(0.07)
SR			
SR_ec	-0.272***	-0.268***	-0.271***
	(0.03)	(0.03)	(0.03)
SR_DD	-0.033***	-0.072**	-0.060**
	(0.01)	(0.03)	(0.02)
SR_FD	-0.036	0.001	-0.008
	(0.04)	(0.06)	(0.05)
SR_REER	-0.048***	0.036	0.011
	(0.01)	(0.05)	(0.03)
obs	665	665	665

Note: This table reports the baseline error correction model estimation. Column 1, 2 and 3 show the results of REER-ULC, -CPI and GDP deflator. Standard error (clustered at country level) is reported in parentheses. ***, **, * represent significance of 1%, 5% and 10%, respectively.

Table 10: Different Longrun/Shortrun Restrictions

	(1) ulc b/se	(2) cpi b/se	(3) gdp b/se	(4) ulc b/se	(5) cpi b/se	(6) gdp b/se
ec						
LR_DD	-0.039**	-0.238***	-0.189***	-0.042	1.775	-0.110
	(0.02)	(0.03)	(0.03)	(0.21)	(2.25)	(0.09)
LR_FD	0.155***	0.457***	0.377***	0.100	-15.089	-0.008
	(0.03)	(0.05)	(0.05)	(0.28)	(16.15)	(0.30)
LR_REER	0.004	0.247***	0.225***	0.002	9.265	0.058
	(0.02)	(0.04)	(0.04)	(0.22)	(9.29)	(0.24)
SR						
SR_ec	-0.307***	-0.255***	-0.240***	-0.581***	-0.571***	-0.574***
	(0.05)	(0.05)	(0.04)	(0.06)	(0.06)	(0.06)
SR_DD	-0.017	-0.169***	-0.144**	-0.004	-0.162**	-0.130**
	(0.04)	(0.05)	(0.05)	(0.05)	(0.06)	(0.06)
SR_FD	0.003	0.178**	0.134*	-0.029	0.152	0.105
	(0.07)	(0.07)	(0.07)	(0.08)	(0.10)	(0.09)
SR_REER	-0.100**	0.112*	0.070	-0.102*	0.196**	0.096
	(0.03)	(0.06)	(0.05)	(0.05)	(0.08)	(0.07)
obs	665	665	665	665	665	665
hausman_vsDFEpvalue	1.000	1.000	1.000	1.000	1.000	1.000

Note: This table reports the robustness check using various sets of long-run/short-run restrictions. Column 1, 2 and 3 show the results of pooling mean group, and the rest are of mean group. The last row lists the p-value of Hausman test of pooling mean group/mean group specification versus dynamic fixed effect specification. Standard error (clustered at country level) is reported in parentheses. ***, **, * represent significance of 1%, 5% and 10%, respectively.

Table 11: Year Fixed Effect and Pre-crisis Period

	(1)	(2)	(3)	(4)	(5)	(6)
	ulc	cpi	gdp	ulc	cpi	gdp
	b/se	b/se	b/se	b/se	b/se	b/se
ec						
LR_DD	-0.023	-0.054**	-0.039**	-0.033*	-0.050**	-0.044**
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
LR_FD	-0.240**	-0.193	-0.243**	0.005	-0.002	-0.001
	(0.12)	(0.12)	(0.12)	(0.04)	(0.05)	(0.04)
LR_REER	-0.016	0.100**	0.025	-0.125***	-0.072*	-0.089**
	(0.02)	(0.04)	(0.03)	(0.04)	(0.04)	(0.04)
SR						
SR_ec	-0.289***	-0.281***	-0.288***	-0.298***	-0.298***	-0.306***
	(0.03)	(0.03)	(0.03)	(0.04)	(0.04)	(0.04)
SR_DD	-0.039**	-0.072***	-0.063***	-0.036**	-0.057***	-0.057***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
SR_FD	-0.140**	-0.111*	-0.114*	0.081**	0.101**	0.105***
	(0.06)	(0.06)	(0.06)	(0.03)	(0.03)	(0.03)
SR_REER	-0.041**	0.035*	0.017	-0.066***	-0.020	-0.009
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
obs	665	665	665	420	420	420

Note: This table reports the robustness check adding time fixed effect and pre-crisis subsample period. Column 1, 2 and 3 show the results of time fixed effect, and the rest are of pre-crisis subsample. Standard error (clustered at country level) is reported in parentheses. ***, **, * represent significance of 1%, 5% and 10%, respectively.

Table 12: Euro vs. Noneuro

	(1) nonEuro ulc b/se	(2) cpi b/se	(3) gdp b/se	(4) Euro ulc b/se	(5) cpi b/se	(6) gdp b/se
ec						
LR_DD	-0.023	-0.043**	-0.034**	-0.517**	-0.784***	-0.636**
	(0.01)	(0.01)	(0.01)	(0.23)	(0.15)	(0.20)
LR_FD	0.078**	0.078**	0.081**	0.726**	0.890***	0.854***
	(0.04)	(0.03)	(0.04)	(0.25)	(0.21)	(0.20)
LR_REER	0.001	0.083	0.032	0.249	1.116***	0.485
	(0.05)	(0.08)	(0.06)	(0.29)	(0.30)	(0.35)
SR						
SR_ec	-0.349***	-0.343***	-0.351***	-0.145**	-0.145***	-0.147***
	(0.05)	(0.05)	(0.05)	(0.05)	(0.04)	(0.04)
SR_DD	-0.037***	-0.067**	-0.059**	0.035	-0.065	-0.018
	(0.01)	(0.03)	(0.02)	(0.05)	(0.07)	(0.06)
SR_FD	-0.042	-0.017	-0.020	-0.142	-0.028	-0.066
	(0.06)	(0.07)	(0.07)	(0.09)	(0.11)	(0.08)
SR_REER	-0.041**	0.030	0.012	-0.098*	0.117	-0.031
	(0.01)	(0.05)	(0.04)	(0.06)	(0.12)	(0.10)
obs	468	468	468	197	197	197

Note: This table reports the robustness check using non-Euro countries subsample (column 1 - 3) and Euro countries subsample (column 4 - 6). Standard error (clustered at country level) is reported in parentheses. ***, **, * represent significance of 1%, 5% and 10%, respectively.

Table 13: With Differentnt Lags [REER-ULC, DFE]

	(1)	(2)	(3)	(4)	(5)
	ADL(1.1)	(2.2)	(3.3)	(4.4)	(5.5)
	b/se	b/se	b/se	b/se	b/se
ec					
LR_ulc	0.006	0.024	0.019	-0.020	0.019
	(0.03)	(0.06)	(0.06)	(0.06)	(0.08)
SR					
SR_ulc	-0.048**	-0.033**	-0.010	-0.022	-0.007
	(0.02)	(0.01)	(0.03)	(0.04)	(0.04)
lag_1		-0.029	-0.019	-0.018	-0.014
		(0.02)	(0.02)	(0.02)	(0.02)
lag_2			-0.021*	-0.018	-0.012
			(0.01)	(0.01)	(0.02)
lag_3				0.004	-0.002
				(0.02)	(0.02)
lag_4					0.004
					(0.01)
obs	665	630	595	560	525
LR_cpi	0.138***	0.153	0.220**	0.188	0.236*
	(0.04)	(0.11)	(0.11)	(0.13)	(0.14)
SR					
SR_cpi	0.036*	0.044	0.255**	0.256**	0.248**
	(0.02)	(0.05)	(0.08)	(0.08)	(0.10)
lag_1		-0.032	-0.019	-0.012	-0.016
		(0.03)	(0.02)	(0.02)	(0.03)
lag_2			-0.027**	-0.028**	-0.031
			(0.01)	(0.01)	(0.02)
lag_3				-0.007	-0.008
				(0.02)	(0.02)
lag_4					-0.014
					(0.02)
obs	665	630	595	560	525
LR_gdp	0.059*	0.068	0.098	0.043	0.094
	(0.03)	(0.09)	(0.07)	(0.08)	(0.09)
SR					
SR_gdp	0.011	0.016	0.183**	0.162**	0.166**
	(0.02)	(0.03)	(0.07)	(0.06)	(0.07)
lag_1		-0.043	-0.023	-0.019	-0.019
		(0.03)	(0.02)	(0.02)	(0.02)
lag_2			-0.016	-0.020	-0.021
			(0.02)	(0.02)	(0.02)
lag_3				-0.008	-0.009
				(0.02)	(0.02)
lag_4					-0.014
					(0.01)
obs	665	630	595	560	525

Note: This table reports the baseline error correction model with different lags. The top panel is REER-ULC, the middle REER-CPI and the bottom REER-GDP. Column 1 to 5 represent lag 1 to 5, respectively. Standard error (clustered at country level) is reported in parentheses. ***, **, * represent significance of 1%, 5% and 10%, respectively.

Table 14: Additional Controls

	(1)	(2)	(3)	(4)
	ulc	cpi	gdp	ulc[control
	b/se	b/se	b/se	b/se
ec				
LR_DD	-0.042	-0.121**	-0.114**	0.031
	(0.03)	(0.04)	(0.05)	(0.04)
LR_FD	0.099*	0.170**	0.163**	-0.070
	(0.05)	(0.06)	(0.06)	(0.06)
LR_REER	-0.037	0.133	0.098	0.021
	(0.05)	(0.10)	(0.10)	(0.06)
L.commodity	-0.145	-0.313*	-0.365*	
	(0.14)	(0.16)	(0.21)	
L.totalCost/laborCost				-0.253**
				(0.09)
SR				
SR_ec	-0.217***	-0.184***	-0.187***	-0.304***
	(0.04)	(0.04)	(0.04)	(0.05)
SR_DD	-0.032	-0.133***	-0.129**	0.064**
	(0.04)	(0.04)	(0.04)	(0.03)
SR_FD	0.036	0.164**	0.157**	-0.113*
	(0.07)	(0.06)	(0.07)	(0.06)
SR_REER	-0.058**	0.077**	0.066*	-0.084**
	(0.02)	(0.03)	(0.04)	(0.03)
D.commodity	0.489***	0.460***	0.414***	
	(0.09)	(0.10)	(0.09)	
D.totalCost/laborCost				-0.272***
				(0.07)
obs	551	551	551	438

Note: This table reports the robustness check controlling terms-of-trade of commodity and other type of production cost. Column 1, 2 and 3 show the commodity terms-of-trade results of REER-ULC, -CPI and GDP deflator, respectively, and the last column is for capital cost control. Standard error (clustered at country level) is reported in parentheses. ***, **, * represent significance of 1%, 5% and 10%, respectively.

Table 15: Tradable-Sector-Price Deflated REER

	(1) REER-ULC(T) b/se	(2) REER-ULC controlling for (T-N) b/se	(3) REER-GDP(T) b/se	(4) REER-GDP controlling for (T-N) b/se
ec				
LR_DD	0.036	0.051	0.044	0.055
	(0.03)	(0.03)	(0.03)	(0.03)
LR_FD	-0.097**	-0.093**	-0.106**	-0.109**
	(0.04)	(0.04)	(0.04)	(0.04)
LR_REER	-0.034	-0.037	-0.050	-0.036
	(0.03)	(0.03)	(0.03)	(0.03)
SR				
SR_ec	-0.298***	-0.321***	-0.301***	-0.322***
	(0.04)	(0.04)	(0.04)	(0.04)
SR_DD	-0.328***	-0.331***	-0.335***	-0.323***
	(0.03)	(0.03)	(0.03)	(0.03)
SR_FD	-0.023	-0.017	-0.024	-0.027
	(0.03)	(0.03)	(0.03)	(0.03)
SR_REER	-0.025**	-0.026**	-0.015	-0.009
	(0.01)	(0.01)	(0.01)	(0.02)
obs	490	490	490	490

Note: This table reports the robustness check using REER containing only tradable sector. Column 1 - 2 and 3 - 4 are for REER-ULC and GDP deflator, respectively. Column 1/3 and 2/4 are for REER tradable sector and adding control of the deviation between tradable and non-tradable sectors, respectively. Standard error (clustered at country level) is reported in parentheses. ***, **, * represent significance of 1%, 5% and 10%, respectively.

Table 16: Real Exchange Rate Against the U.S.

	(1) ulc b/se	(2) cpi b/se	(3) gdp b/se
ec			
LR_DD	-0.021	-0.054**	-0.040**
	(0.02)	(0.02)	(0.02)
LR_FD	0.114**	0.078	0.102**
	(0.04)	(0.05)	(0.05)
LR_REER	-0.017	0.068	0.019
	(0.04)	(0.05)	(0.05)
SR			
SR_ec	-0.280***	-0.271***	-0.276***
	(0.04)	(0.03)	(0.03)
SR_DD	-0.035**	-0.066**	-0.059**
	(0.01)	(0.03)	(0.02)
SR_FD	0.008	-0.022	-0.021
	(0.04)	(0.05)	(0.04)
SR_REER	-0.037**	0.030	0.014
	(0.01)	(0.03)	(0.03)
obs	665	665	665

Note: This table reports the robustness check using REER based on bilateral nominal exchange rate with U.S. dollar exclusively. Column 1, 2, 3 are for REER-ULC, -CPI and GDP deflator, respectively. Standard error (clustered at country level) is reported in parentheses. ***, **, * represent significance of 1%, 5% and 10%, respectively.

Table 17: Trade Balance to Gross Trade Ratio vs. REER

	(1) ulc b/se	(2) cpi b/se	(3) gdp b/se
ec			
LR_DD	-0.022	-0.068	-0.053
	(0.03)	(0.05)	(0.04)
LR_FD	0.116*	0.126*	0.130*
	(0.06)	(0.07)	(0.07)
LR_REER	-0.032	0.122	0.047
	(0.08)	(0.11)	(0.10)
SR			
SR_ec	-0.193***	-0.207***	-0.207***
	(0.03)	(0.03)	(0.04)
SR_DD	-0.025*	-0.067**	-0.062*
	(0.02)	(0.03)	(0.03)
SR_FD	0.003	0.046	0.042
	(0.04)	(0.06)	(0.06)
SR_REER	-0.076***	0.009	0.006
	(0.02)	(0.05)	(0.05)
obs	665	665	665

Note: This table reports the robustness check using trade-balance-to-gross-trade ratio as external balance. Standard error (clustered at country level) is reported in parentheses. ***, **, * represent significance of 1%, 5% and 10%, respectively.

Table 18: Total Consumption and Investment as Proxy for Total Demand

	(1) ulc b/se	(2) cpi b/se	(3) gdp b/se
ec			
LR_DD	0.055	-0.043	-0.015
	(0.06)	(0.05)	(0.05)
LR_FD	-0.051	-0.006	-0.023
	(0.11)	(0.10)	(0.10)
LR_REER	-0.160**	-0.046	-0.083
	(0.07)	(0.10)	(0.09)
SR			
SR_ec	-0.164***	-0.167***	-0.168***
	(0.03)	(0.03)	(0.03)
SR_DD	-0.315***	-0.333***	-0.346***
	(0.05)	(0.04)	(0.05)
SR_FD	0.060	0.071	0.069
	(0.05)	(0.06)	(0.05)
SR_REER	-0.053***	-0.023	0.009
	(0.02)	(0.03)	(0.03)
obs	665	665	665

Note: This table reports the robustness check using the total account of consumption and investment as aggregate demand. Standard error (clustered at country level) is reported in parentheses. ***, **, * represent significance of 1%, 5% and 10%, respectively.

Table 19: With Data from European Commission

	(1) ulc[tot] b/se	(2) ulc[mfg] b/se	(3) cpi b/se	(4) gdp b/se
ec				
LR_DD	-0.049	-0.019	-0.083**	-0.079**
	(0.03)	(0.04)	(0.04)	(0.04)
LR_FD	0.023	0.016	0.036	0.036
	(0.04)	(0.04)	(0.04)	(0.04)
LR_REER	0.026	-0.021	0.076*	0.057*
	(0.03)	(0.03)	(0.04)	(0.03)
SR				
SR_ec	-0.255***	-0.250***	-0.250***	-0.252***
	(0.03)	(0.03)	(0.03)	(0.03)
SR_DD	-0.352***	-0.354***	-0.374***	-0.364***
	(0.06)	(0.07)	(0.07)	(0.07)
SR_FD	0.054	0.068	0.062	0.061
	(0.07)	(0.07)	(0.07)	(0.07)
SR_REER	-0.053***	-0.055***	-0.013	-0.023
	(0.01)	(0.01)	(0.02)	(0.02)
obs	768	768	768	768

Note: This table reports the baseline error correction estimation using alternative REERs from European Commission. Column 1 - 4 represent REERs with ULC based on the whole economy, ULC based on manufacture sectors, Harmonized CPI, and GDP deflator. Standard error (clustered at country level) is reported in parentheses. ***, **, * represent significance of 1%, 5% and 10%, respectively.