Open Economies Review (2020) 31:1117–1145
https://doi.org/10.1007/s11079-020-09586-3

RESEARCH ARTICLE

On Cross-Country Differences in the Contribution of Nontraded Goods to Real Exchange Rate Fluctuations

Erick M. Kitenge[1] · A. K. M. Mahbub Morshed[2]

Published online: 16 June 2020

Abstract

We propose a new Quantity Dual Approach (QDA) to estimate the contribution of nontraded goods to Real Exchange Rate (RER) fluctuations. This method is immune to the bias resulting from the non-inclusion of some goods in CPI calculations and can be applied even in a stringent data environment where Engel's (1999, JPE) approaches would not be possible to implement. The QDA requires only national income accounts data and traded good price indices, which are more reasonably available for many countries. The estimated contributions of nontraded goods to RER fluctuations using both our proposed new approach and Engel's approaches yield negative correlations with income level, government expenditure, exchange rate volatility, and political stability but positive correlations with inflation and private consumption expenditures.

JEL Classification F3 · F4 · O1

Keywords Real exchange rate · Nontraded goods · Quantity dual approach

We would like to thank an anonymous referee, an associate editor, the editor-in-chief, and Charles Engel for their valuable suggestions on earlier drafts. The standard disclaimers apply

✉ A. K. M. Mahbub Morshed
mmorshed@siu.edu

Erick M. Kitenge
ekitenge@centralstate.edu

[1] College of Business, Central State University, Wilberforce, OH 45384, USA

[2] Department of Economics, Southern Illinois University, Mailcode 4515, Carbondale, IL 62901, USA

1 Introduction

We propose a Quantity Dual Approach (QDA) to estimate contributions of nontraded goods to Real Exchange Rates (RER) fluctuations. This approach is essentially the application of Hsieh's (1999) dual approach of growth accounting in the context of RER decomposition. The proposed approach requires only national income accounts data and traded goods prices for a country, and thus allows one to include more countries in a study. Moreover, by using quantity variables that are inclusive of all goods and services in the economy, the QDA approach is immune from bias engendered from the uses of a limited number of commodities in CPI calculations (Crucini and Landry 2019). We also examine the roles that macroeconomic variables could play on the cross-country variations in the contributions of nontraded goods to RER fluctuations.

The RER is the cost of a reference basket of goods and services relative to the costs of the same basket in another country expressed in a common currency. The prices of these goods and services included in these baskets can impact the overall RER differently, depending upon the origins of the shocks (Martin et al. 2018). The RER is used as a crucial measure of international competitiveness. Therefore, a better understanding of the roles played by different components of the overall RER would increase the ability of policymakers to steer the state of international competitiveness to the appropriate directions.

The observed huge fluctuations of the RER for both developing and developed countries warrant a closer look at the determinants of these fluctuations. The tradability of goods and services in the reference baskets used to compute the CPIs has received more attention (Parsley and Wei 1996; Betts and Kehoe 2001; and Crucini et al. 2005; Rabanal and Tuesta 2013). Accordingly, using data from developing countries, Rodrik (2008) has shown that undervaluation of the RER can promote economic growth (see also, Williamson 2009; Gluzmann et al. 2012). Moreover, the presence of a large informal sector in many developing countries clouds the true nature of the international competitiveness measured by the RER. The sheer presence of goods that might not easily be included in baskets of goods used to compute price indexes underscores the importance of understanding the sources of RER fluctuations for both academics and policymakers.

In a seminal paper, Engel (1999) shows that relative prices of nontraded goods account for almost nothing in RER movements for the USA vis-à-vis Canada, France, Germany, Italy, and Japan. Engel decomposes the RER into two components, the relative price of traded goods between the two countries and a weighted difference of the relative price of nontraded to traded goods prices in each country. Parsley (2007), following Engel's methodology, finds similar results for Hong Kong, South Korea, Malaysia, Singapore, Taiwan, and Thailand. However, these researchers were constrained by the paucity of reliable price indices for nontraded goods from developing countries. The QDA, proposed in this paper, circumvents this paucity of reliable data on prices, includes more goods and services in the basket, and allows one to perform the accounting of RER fluctuations for more countries, including data constrained developing countries.

We estimate the contribution of nontraded goods to the RER fluctuations using our proposed approach and compare our findings to those estimated by using two other approaches suggested by Engel (1999). All three approaches yield qualitatively very similar results. We also find significant cross-country variations in contributions of nontraded goods to RER fluctuations, with large contributions of nontraded goods for developing countries but a very modest contribution for rich countries. Our results, based on a sample composed of developed and developing countries, indicate that the findings in this strand of literature might be driven by the sample selection, with a sample composed of only high-income countries likely to observe much lower contributions of nontraded goods to RER fluctuations. Therefore, to get more insights into the cross-sectional variations, we follow a nonparametric approach adopted by Cheung and Lai (2000) to identify which macroeconomic variables could be related to the extent of the contribution of nontraded goods to RER fluctuations. We find that income level, financial development, government spending, and political stability are negatively related to the contribution of nontraded goods while private consumption and inflation are positively related to the size of the contribution of nontraded goods to RER fluctuations.

Our results suggest that financial development, political stability, and higher income levels indicate the presence of more domestically integrated goods markets (both traded and nontraded goods) and factor markets along with internationally integrated traded goods markets. As a result, the traded goods prices cannot deviate much as the prices of traded goods are primarily determined by international prices. Since for rich countries, domestic factor markets are more integrated, the traded goods prices indirectly affect nontraded goods prices. However, for developing countries, the presence of a less integrated domestic factor market creates a wedge between traded goods and nontraded goods prices. Thus, the contribution of nontraded goods to RER fluctuations declines for countries with these features. We also find a negative correlation coefficient between the ratio of government expenditure to GDP and the contribution of nontraded goods to RER fluctuations. This negative correlation is not unexpected as Ortiz-Ospina and Roser (2020) show that the more developed a country, the higher the government expenditure GDP ratio. On the other hand, the increase in private consumption and inflation are generally signs of less developed economies with less integrated output and factor markets and thus the nontraded goods sector does not have a shock-absorbing cushion similar to the traded good sector, resulting in a relatively higher prices for nontraded goods and larger contributions of nontraded goods to RER fluctuation. The positive relationship between private consumption and the contribution of nontraded goods to RER fluctuations indicates the manifestation of the Baumol-Bowen effect.

The remainder of this paper is organized as follows. Section 2 presents the methodology and data. Section 3 presents empirical estimates of the contributions of non-traded goods to RER fluctuations. Section 4 details the explorations in finding the determinants of the contributions of non-traded goods to RER fluctuations. Section 5 details the robustness checks carried out to confirm the main findings. Finally, Section 6 provides the concluding remarks.

2 Methodology and Data

2.1 Methodology

This section describes the decomposition of RER fluctuations into traded and nontraded components following the new QDA as well as the two approaches suggested by Engel (1999).

2.1.1 RER Decomposition

We consider an economy that produces both traded and nontraded goods and with GDP being the sum of total spending on traded (T) and nontraded goods (N). We assume that the aggregate price index is a geometric weighted average of traded and nontraded goods' prices.[1] The overall price index of a country is defined as follows:

$$P_t = \left(P_t^T\right)^{(1-\theta)} \bullet \left(P_t^N\right)^{\theta} \tag{1}$$

where P stands for the overall consumer price index, P^T is the price index of traded goods, P^N is the price index of nontraded goods, θ is the share of nontraded goods in the overall price index, and t is the time subscript. Taking the log of both sides of Eq. (1), we get

$$p_t = (1-\theta)p_t^T + \theta\, p_t^N \tag{2}$$

From which, lower case letters denote the logarithm of variables represented by uppercase letters in Eq. (1). The corresponding equation for the benchmark country (in this paper, the benchmark country is the U.S.A.), can be written as

$$p_t^* = (1-\beta)p_t^{T*} + \beta\, p_t^{N*} \tag{3}$$

where β is the share of nontraded goods in the overall price index of the benchmark economy.[2] The real exchange rate[3] Q_t is defined as

$$Q_t = S_t \frac{P_t^*}{P_t} \tag{4}$$

where S_t is the nominal exchange rate, P_t is the domestic consumer price index, P_t^* is the foreign consumer price index, and t is the time subscript.

Taking logs of Eq. (4) we get

$$q_t = s_t + p_t^* - p_t \tag{5}$$

[1] A general homothetic preference would suffice to approximate this price index.

[2] In our estimation, we assume θ and β are constant. Changes in the shares of traded and nontraded goods over time would add a bias. Since our data span is short (1997–2015), we expect minor changes in these shares. We have examined the changes of these shares and found them to be very small. Thus, the potential bias resulting from our assumption of fixed share is very small. Almost all of the studies on accounting of real exchange rate changes assume fixed shares of traded and nontraded goods.

[3] The nominal exchange rate is the domestic currency price of a foreign currency.

Using Eq. (2) and (3) in Eq. (5), we obtain

$$q_t = \underbrace{s_t + p_t^{T*} - p_t^T}_{x_t} + \underbrace{\beta(p_t^{N*} - p_t^{T*}) - \theta(p_t^N - p_t^T)}_{y_t}$$

where x_t is the traded component and y_t is the nontraded component.

2.1.2 Quantity Dual Approach (QDA)

Taking the total derivative of Equation (6), and denoting $\frac{dZ}{Z} = \widehat{Z}$, we obtain the RER growth equation

$$\widehat{Q}_t = \widehat{S}_t + \widehat{P_t^{T*}} - \widehat{P_t^T} + \beta\left(\widehat{P_t^{N*}} - \widehat{P_t^{T*}}\right) - \theta\left(\widehat{P_t^N} - \widehat{P_t^T}\right) \tag{7}$$

with $\widehat{Q}_t$, $\widehat{S}_t$, $\widehat{P_t^T}$, and $\widehat{P_t^N}$ being respectively the growth in RER, the growth in the nominal exchange rate, the growth of traded goods prices, and the growth of nontraded goods prices. To estimate the inflation of nontraded goods, we implement the QDA.[4] This approach mitigates challenges that one can face to obtain a reliable dataset on the prices of nontraded goods. To circumvent this issue, we follow here essentially the approach proposed by Hsieh (1999) in the context of growth accounting.[5]

For an economy consisting of two sectors, traded and nontraded sectors, the total value of output can be presented as follows:

$$Y = P^T T + P^N N \tag{8}$$

where Y denotes the value of output, and P^T and P^N denote prices for tradable and nontradable goods, respectively. The total derivative of Equation (8) and rearrangement of the terms yields

$$\widehat{Y} = \varnothing_{\mathrm{T}}\, \widehat{P^T} + \varnothing_T\, \widehat{T} + \varnothing_N\, \widehat{P^N} + \varnothing_N\, \widehat{N} \tag{9}$$

with $\varnothing_T$ and $\varnothing_N$ being the shares of traded and nontraded goods in the total production, $\widehat{T}$ is the real traded goods growth rate, $\widehat{N}$ is the growth rate of the real nontraded goods, $\widehat{P^T}$ is the rate of inflation for the traded goods, and $\widehat{P^N}$ is the rate of inflation for the nontraded goods sector.

From Equation (9), we can have a new expression of the nontradable price inflation:

$$\widehat{P^N} = \frac{1}{\varnothing_N}\left(\widehat{Y} - \varnothing_T\, \widehat{P^T} - \varnothing_T\, \widehat{T} - \varnothing_N\, \widehat{N}\right) \tag{10}$$

[4] In the quantity dual approach, output Y is the nominal GDP while quantities T and N are real value added.

[5] Hsieh (1999) estimated the dual of the national income using input prices instead of input quantities. Here, we use quantities and values to obtain prices/inflation.

The data required to calculate the inflation of nontraded goods are the total output, the amount of traded goods and nontraded goods, and price indices for traded goods. The information on output and the amounts of traded goods and nontraded goods can be collected from national income accounting data for each country, while price indices for traded goods are reasonably available for many countries. We collect inflation for the benchmark country in the same way, and then use these estimated nontraded inflations to decompose the growth rate of the RER. We decompose the changes in RER ($\widehat{Q}_t$) into two components $\widehat{S}_t + \widehat{P_t^{T*}} - \widehat{P_t^T}$ and $\beta\left(\widehat{P_t^{N*}} - \widehat{P_t^{T*}}\right) - \theta\left(\widehat{P_t^N} - \widehat{P_t^T}\right)$. The first component is related to traded goods and can be denoted by $\Delta x_t = x_t - x_{t-k}$, while the second component can be seen as the nontraded component and can be denoted by $\Delta y_t = y_t - y_{t-k}$, with k being the time horizon considered in the computation.

To estimate the contribution of nontraded goods to RER fluctuations, we follow Engel (1999), Betts and Kehoe (2008), and Burstein and Gopinath (2014) in computing the variance, the squared-drift, and the Mean Squared Error (MSE) of each RER components. According to Engel (1999), "the drift and the variance measure two different notions of movement in the variable over time. The MSE of the change in the RER- which is the sum of the squared drift and the variance- is a comprehensive measure of movement." (p.511). For the component y_t, the three statistics can be computed as follows.[6]

$$Variance = Var(y_t - y_{t-k}) \tag{11}$$

$$Squared\ Drift = [Mean\ (y_t - y_{t-k})]^2 \tag{12}$$

The MSE is defined as

$$MSE\_y_t = Var(y_t - y_{t-k}) + [Mean\ (y_t - y_{t-k})]^2 \tag{13}$$

The contribution of the nontraded goods to RER fluctuations can then be estimated by the following expression.[7]

$$\frac{MSE_{y_t}}{MSE_{x_t} + MSE_{y_t}} = \frac{Var(y_t - y_{t-k}) + [Mean\ (y_t - y_{t-k})]^2}{Var(x_t - x_{t-k}) + [Mean\ (x_t - x_{t-k})]^2 + Var(y_t - y_{t-k}) + [Mean\ (y_t - y_{t-k})]^2} \tag{14}$$

Following Azcona (2015), we are assuming that the covariance term is proportionally allocated to each component (Δx_t and Δy_t) and thus it is excluded from Equation (14). Contributions of nontraded goods (in this case, Δy_t) are computed for 1 up to 10 years horizon (k = 10).

[6] For the x component, we can use the same formulas to obtain the variance, the squared-drift, and the MSE.
[7] Chen et al. (2015) argue that Engel's (1999) method of calculating MSE is biased and it is more relevant for longer horizons. Since we compute MSE for shorter horizons in this paper, we postulate that this does not plague our results.

2.1.3 Engel Approach I[8]

While the QDA approach computes the nontraded-goods inflation by using quantity values and only prices of traded goods, Engel (1999) approximated the price of nontraded goods by using the overall price index, prices of traded goods, and shares of each type of goods in the overall price index. Accordingly, from the overall price index in Equation (1), can be extracted the expression for P_t^N in terms of P_t, P_t^T, and the share of nontraded-goods in the overall price index as follows:

$$P_t^N = \left[\frac{P_t}{\left(P_t^T\right)^{(1-\beta)}}\right]^{1/\beta} \tag{15}$$

The nontraded component from Equation (7) can then be rewritten by replacing p_t^N by the log of Equation (15).

The contributions of nontraded goods to RER fluctuations are computed as follows.

$$\frac{MSE_{y_t}}{MSE_{x_t} + MSE_{y_t}} = \frac{Var\left(y_{t+k} - y_t\right) + \left[Mean\left(y_{t+k} - y_t\right)\right]^2}{Var\left(x_{t+k} - x_t\right) + \left[Mean\left(x_{t+k} - x\right)\right]^2 + Var\left(y_{t+k} - y_t\right) + \left[Mean\left(y_{t+k} - y_t\right)\right]^2} \tag{16}$$

2.1.4 Engel Approach II

Engel (1999) also suggested a more general aggregation of traded and nontraded goods prices to obtain the overall price index and used a direct way to decompose the RER. However, Engel himself has reservations about this approach (see Engel 1999, page 522).

If we multiply and divide the right-hand side of the Equation (4) by the benchmark and a country's prices of traded goods $\left(P_t^{T^*}, P_t^T\right)$, take the log and rearrange the terms, we obtain the following expression:

$$q_t = \underbrace{s_t + p_t^{T^*} - p_t^T}_{x_t} + \underbrace{\left(p_t^* - p_t^{T^*}\right) - \left(p_t - p_t^T\right)}_{y_t}$$

Equation (17) can be rewritten as $q_t = x_t + y_t$, with $x_t = s_t + p_t^{T^*} - p_t^T$ being the traded component (or the external RER) and $y_t = \left(p_t^* - p_t^{T^*}\right) - \left(p_t - p_t^T\right)$ being the nontraded component. Then, as in the previous approach, we estimate the variance, squared-drift, and mean square error and compute the contributions of nontraded goods to RER fluctuations.

[8] This section draws heavily from Engel (1999).

2.2 Data

We have used annual data for the period from 1997 to 2015. Annual data for the PPI, the WPI, the CPI, and nominal exchange rates were collected from International Financial Statistics (IFS) of the International Monetary Fund (IMF). Engel (1999, section IV) suggested that the overall PPI can be treated as an index for traded-goods prices which allows us to conduct a similar accounting exercise on the RER for developing countries, as CPIs and PPIs and WPIs data are reasonably available for them.[9] Moreover, the shares of nontraded-goods in the CPIs are proxied by the share of non-traded goods in the Gross Domestic Product (GDP), and these data are also obtained from the WDI. More specifically, we took the share of value-added related to agriculture, manufacturing, and industries in the GDP as the share of the traded sector. A list of countries is given in Appendix Table 12.

3 Results[10]

3.1 Contributions of Nontraded Goods to RER Fluctuations: Quantity Dual Approach

The contribution of nontraded goods to RER fluctuations using Equation (14) is reported for 48 countries when we have used WPI and for 39 countries when we have used PPI as the traded goods price indices.[11] Because the QDA approach requires sectoral, national income data and only one price variable, the traded-goods price index, it can allow the inclusion of relatively more countries in the analysis. We also calculate this contribution of nontraded goods for different time horizons from 1 year to 10 years.[12] Contributions of nontraded goods to RER fluctuations using the QDA approach are reported in Table 1. We find that, on average, the contribution of nontraded goods is about 26.2% for high-income countries while the same is 58.5% for low-income countries when WPI is the price index for traded goods. When the PPI is used as the proxy for traded goods prices, the average contribution of nontraded goods is about 22.8% for high-income countries but 44.4% for low-income countries. The pattern remains the same for longer horizons. It is also important to note that the extent of contributions of nontraded goods to RER fluctuations tend to be higher for longer horizons. This reflects, as stated by Engel (1999), the fact that when nominal prices are sticky, and nominal exchange rates have higher fluctuations, RER movements can be dominated at shorter horizons by the traded-goods component, while the

[9] One should note that there are potential shortcomings in using the PPI as a proxy for traded goods price due to various traditions of excluding/including import and export prices.

[10] In this section, for improved comparison for results using different methods, we report the results for only the same sets of countries (48 countries when using WPI and 39 countries when using PPI). However, we have estimated the contributions of nontraded goods to RER fluctuations for more but not the same set of countries while using different approaches. These results are available upon request.

[11] Based on the classification from WDI, High-income OECD and non-OECD countries, upper middle income, and Low-income and Lower-middle-income countries are respectively categorized in our paper as Higher, Middle, and Lower income countries.

[12] The MSE share of x and y calculated using Equations (14 and 16) are valid if the covariance between x and y are very small. We have calculated covariance of x and y under different assumptions about traded goods prices and have found that they are small.

Table 1 Contribution of nontraded goods to RER fluctuations: Quality Dual Approach

Whole sale Price Index	# countries	k = 1	k = 2	k = 3	k = 4	k = 5	k = 6	k = 7	k = 8	k = 9	k = 10
High income	19	0.288	0.261	0.26	0.26	0.251	0.248	0.256	0.262	0.265	0.264
Middle income	18	0.447	0.424	0.415	0.413	0.415	0.414	0.425	0.429	0.437	0.443
Low Income	11	0.549	0.534	0.554	0.567	0.585	0.604	0.616	0.613	0.611	0.614
Producer Price Index											
High income	17	0.284	0.254	0.249	0.236	0.212	0.212	0.21	0.211	0.21	0.204
Middle income	16	0.398	0.368	0.366	0.37	0.379	0.38	0.388	0.399	0.418	0.428
Low Income	6	0.352	0.379	0.409	0.433	0.459	0.47	0.472	0.484	0.493	0.491

Using data from 1997 to 2015, we estimate the contributions of nontraded-goods at different time horizons(k). The PPI and the WPI are retrieved from IFS and WDI, repectively

contribution of the nontraded component can increase at longer horizons since prices adjust over time.[13]

We show contributions of nontraded goods to RER fluctuations calculated using QDA for one period lag in Fig. 1 under different proxies for the traded goods price index. It reveals that there exist wide variations in contributions of nontraded goods to RER fluctuations even for countries with similar income levels. Also, as the income increases, the contribution of nontraded goods to RER fluctuation decreases.

3.2 Contribution of Nontraded Goods to RER Fluctuations: Engel Approach I

Average contributions of nontraded goods to RER fluctuations by income groups using Equation (16) are reported in Table 2.

As we can see from Table 2, contributions of nontraded goods to RER fluctuations are different for different country groups. For example, for the one-period horizon with WPI as the traded goods price index, the contribution of nontraded goods is about 30.2% for high-income countries while the same is 36.4% for low-income countries. This pattern also holds when we use PPI as the traded goods price index.

To examine how dispersed the contributions of nontraded goods for different countries are, we plot, in Fig. 2, the contributions of nontraded goods to RER fluctuations on the vertical axis and relative income level on the horizontal axis for the time horizon of 1 year under different proxy variables for traded goods prices. These figures suggest a negative association between income levels and nontraded goods contributions, irrespective of the proxy variable chosen for traded goods prices. Thus, the general trend is that the higher the income level, the lower the contribution of nontraded goods to RER fluctuations.

[13] Chen et al. (2015) raised some methodological issues regarding using MSE in decomposing the RER fluctuations.

Fig. 1 Nontraded Goods Contributions to RER Fluctuations: Quantity Dual Approach (k = 1, 1997–2015). Notes: In the horizontal axis we have relative GDPCAP = ln (GDP per Capita of a country/GDP per capita in the USA)

3.3 Contributions of Nontraded Goods to RER Fluctuations: Engel Approach II

Contributions of nontraded goods to RER fluctuations using the Engel Approach II with WPI and PPI as proxy variables for traded goods price index are given in Table 3.

We find that the contribution of nontraded goods is lower for high-income countries than for middle and low-income countries. We also show the contributions of nontraded goods to RER fluctuations in Fig. 3 where the contribution is calculated for the time horizon $k = 1$. This figure portrays significant cross-country variations in

Table 2 Contribution of nontraded goods to RER fluctuations: Engel Approach I

Whole sale Price Index	# countries	k = 1	k = 2	k = 3	k = 4	k = 5	k = 6	k = 7	k = 8	k = 9	k = 10
High income	19	0.307	0.274	0.262	0.277	0.298	0.302	0.306	0.314	0.326	0.345
Middle income	18	0.351	0.306	0.284	0.291	0.301	0.318	0.332	0.337	0.256	0.382
Low Income	11	0.364	0.329	0.319	0.311	0.305	0.306	0.317	0.324	0.328	0.341
Producer Price Index											
High income	17	0.329	0.292	0.276	0.283	0.294	0.301	0.299	0.309	0.324	0.345
Middle income	16	0.388	0.342	0.307	0.316	0.346	0.367	0.368	0.390	0.420	0.450
Low Income	6	0.371	0.394	0.369	0.376	0.382	0.347	0.322	0.331	0.337	0.342

Using data from 1997 to 2015, we estimate the contributions of nontraded-goods at different time horizons(k). The CPI and the PPI are retrieved from IFS and WDI

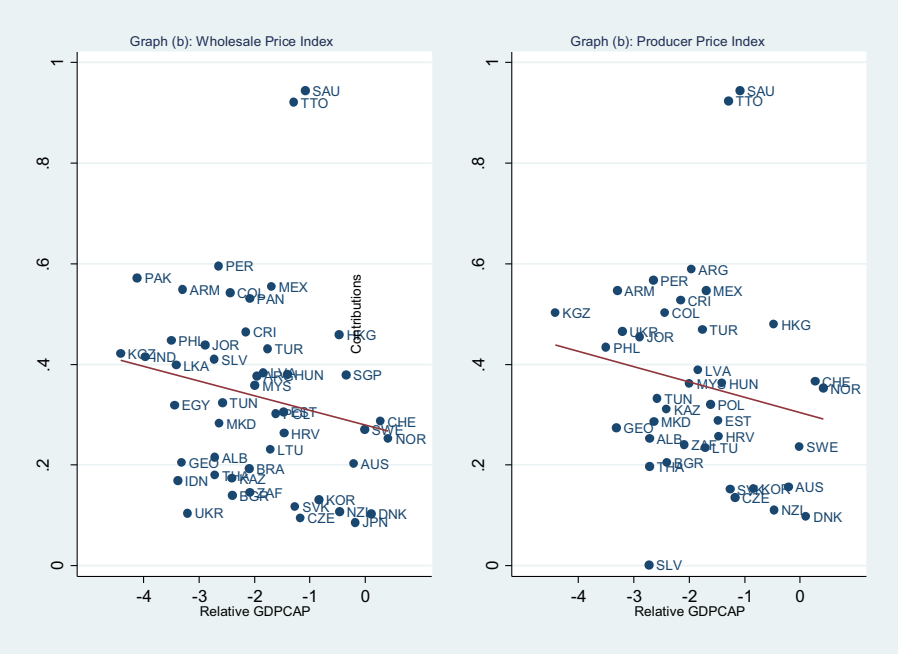

Fig. 2 Nontraded Goods Contributions to RER Fluctuations: Engel Approach I (k = 1, 1997–2015). Notes: In the horizontal axis we have relative GDPCAP = ln (GDP per Capita of a country/GDP per capita in the USA)

the level of nontraded goods contributions, regardless of the variables used as proxies for traded goods prices. It is important to note that the gap between the contributions of nontraded goods to RER fluctuations for the rich and the poor countries becomes smaller with larger k. This suggests that the recent rapid growth of poor countries and slower growth in rich countries plays a role in determining the sizes of these contributions.

These figures show wide variations in the contribution of nontraded goods to RER fluctuations even for countries with similar income levels.

Table 3 Contribution of nontraded goods to RER fluctuations: Engel Approach II

Wholesale Price Index	# countries	k = 1	k = 2	k = 3	k = 4	k = 5	k = 6	k = 7	k = 8	k = 9	k = 10
High income	19	0.306	0.272	0.261	0.276	0.300	0.304	0.307	0.313	0.324	0.343
Middle income	18	0.354	0.307	0.284	0.291	0.300	0.317	0.331	0.336	0.355	0.382
Low Income	11	0.364	0.329	0.319	0.311	0.305	0.306	0.317	0.324	0.328	0.341
Producer Price Index											
High income	17	0.327	0.289	0.275	0.282	0.296	0.304	0.300	0.308	0.323	0.343
Middle income	16	0.390	0.342	0.307	0.315	0.345	0.366	0.367	0.389	0.418	0.448
Low Income	6	0.371	0.394	0.369	0.376	0.382	0.347	0.322	0.331	0.337	0.342

Using data from 1997 to 2015, we estimate the contributions of nontraded-goods at different time horizons(k). The CPI and the PPI are retrieved from IFS, while WPI is retrieved from WDI

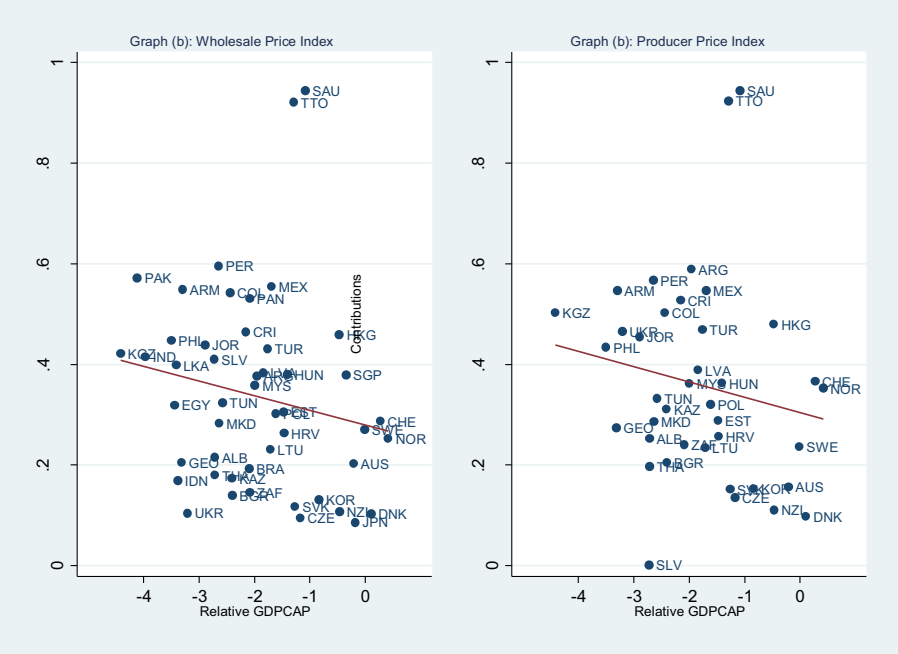

Fig. 3 Nontraded Goods Contributions to RER Fluctuations: Engel Approach II (k = 1, 1997–2015). Notes: In the horizontal axis we have relative GDPCAP = ln (GDP per Capita of a country/GDP per capita in the USA)

3.4 Assessment of the Performance of the Three Approaches

In order to compare the results obtained using the three approaches, we examine the statistical significance of the differences in the contribution of nontraded goods to RER fluctuations. The results obtained are presented in Table 4 where WPI and PPI are proxies for traded goods prices.

As shown in Table 4, when WPI and PPI are treated as the traded goods price indices, The QDA, the Engel Approach I, and Engel Approach II yield similar results for all cases when we use produce price index as a proxy for traded goods prices, as the differences calculated from using different approaches are all statistically insignificant. However, when we use the wholesale price index as a proxy for traded goods, we find a few of these differences weakly statistically significant for the short-horizon, while for the longer horizon all these differences are statistically insignificant. On the whole, we argue that our QDA yields result comparable to result from Engel's approaches.

3.5 An Alternative Three-Component Decomposition of the RER

In the conventional decomposition approach such as Engel's (1999), the traded component, portrayed in Equation (6), includes the nominal exchange rate. One may argue that the results from the RER decomposition done in this way would be shrouded by the presence of the nominal exchange rate in the traded goods component.[14] In order to

[14] We thank an associate editor for suggesting this exercise.

Table 4 Tests of difference [(a)-(b)] between estimates from the three approaches

Wholesale Price Index	(a)	(b)	k = 1	k = 2	k = 3	k = 4	k = 5	k = 6	k = 7	k = 8	k = 9	k = 10
	Engel I	Engel II	−0.001	0	0	0.001	0	−0.001	0	0.001	0.001	0.001
	Engel I	QDA	−0.071*	−0.086*	−0.086**	−0.103**	−0.089*	−0.083	−0.084	−0.08	−0.071	−0.053
	Engel II	QDA	−0.07*	−0.087*	−0.087**	−0.103**	−0.088*	−0.082	−0.084	−0.081	−0.072	−0.054
Producer Price Index												
	Engel I	Engel II	0	0.001	0.001	0.001	−0.001 -	−0.001	0	0.001	0.001	0.001
	Engel I	QDA	0.019	0.008	0.008	−0.018	0.01	0.015	0.007	0.015	0.026	0.047
	Engel II	QDA	0.018	0.007	0.007	−0.019	0.011	0.015	0.007	0.015	0.025	0.046

Mean differences of contributions of nontraded goods are reported in this table at k horizons. *,**, and *** respectively denote statistical significance at 10%, 5%, and 1%

explore this, we now deviate from the conventional approach and decompose the RER into three components: the nominal exchange rate, the international traded goods price differentials, and the nontraded component as derived before. The new decomposition of the log of RER (q_t) can be written as follows:

$$q_t = s_t + \underbrace{p_t^{T*} - p_t^{T}}_{x_t} + \underbrace{\beta(p_t^{N*} - p_t^{T*}) - \theta(p_t^{N} - p_t^{T})}_{y_t}$$

The variance of $q_t = s_t + x_t + y_t$ can be expanded as:

$$\mathrm{Var}\,(s_t + x_t + y_t) = \mathrm{Var}(s_t) + \mathrm{Var}(x_t) + \mathrm{Var}(y_t) + 2\mathrm{Cov}(s_t, x_t) + 2\mathrm{Cov}(s_t, y_t) + 2\mathrm{Cov}(x_t, y_t).$$

With $\mathrm{Var}\,(x_t) = \mathrm{Var}\left(p_t^{T*}\right) + \mathrm{Var}\left(p_t^{T}\right) - 2\mathrm{Cov}\left(p_t^{T*}, p_t^{T}\right)$

From this expression, $\mathrm{Cov}\left(p_t^{T*}, p_t^{T}\right)$ may capture international market arbitrage and Cov (s_t, x_t) may capture international pricing strategies (Adams and Chadha 1991). If we assume that $2\mathrm{Cov}(x_t, y_t)$ is proportionally allocated[15] to each component like Azcona (2015) and others in the literature, the contribution of nontraded goods can be represented by the following equation:

$$= \frac{\frac{\mathrm{MSE}_{y_t}}{\mathrm{MSE}_{x_t} + \mathrm{MSE}_{y_t} + \mathrm{MSE}_{st}}}{\mathrm{Var}(x_t - x_{t-k}) + [\mathrm{Mean}\,(x_t - x_{t-k})]^2 + \mathrm{Var}(y_t - y_{t-k}) + [\mathrm{Mean}\,(y_t - y_{t-k})]^2 + \mathrm{Var}(s - s_{t-k}) + [\mathrm{Mean}\,(s_t - s_{t-k})]^2}$$

We have decomposed the RER using this unconventional method and the computed contributions of nontraded goods to the RER changes are reported in Table 5a-5c.

While our original results follow the standard procedure used in the literature (reported in Tables 1, 2 and 3), this alternate procedure, in general, yields lower contributions of non-traded goods to the RER fluctuations. However, we still observe cross-country variations in the contributions of nontraded goods. Similar to the results obtained using the conventional methods, we find lower contributions of nontraded goods to the RER fluctuations for high-income countries when adopting the QDA approach (reported in Table 5.a with WPI). However, the obtained cross-country variations of the contributions of nontraded goods using Engel's approaches are different from the results using the conventional two-part decompositions. Still, the contributions of nontraded goods to the RER fluctuations are substantial.

[15] We understand that this a heroic assumption yet we have computed variances of the two components as well as the covariance between them and they are very small.

Table 5 A. Contribution of nontraded goods to RER fluctuations: Quantity Dual Approach (with 3 components). B. Contribution of nontraded goods to RER fluctuations: Engel Approach I (with 3 components). C. Contribution of nontraded goods to RER fluctuations: Engel Approach II (with 3 components)

Wholesale Price Index	# countries	k = 1	k = 2	k = 3	k = 4	k = 5	k = 6	k = 7	k = 8	k = 9	k = 10
A											
High income	19	0.237	0.214	0.211	0.203	0.183	0.177	0.184	0.191	0.193	0.192
Middle income	18	0.238	0.204	0.182	0.166	0.156	0.15	0.148	0.143	0.134	0.121
Low Income	11	0.257	0.249	0.231	0.202	0.2	0.201	0.202	0.198	0.198	0.198
Producer Price Index											
High income	17	0.233	0.208	0.201	0.185	0.157	0.154	0.155	0.161	0.162	0.161
Middle income	16	0.206	0.173	0.152	0.144	0.136	0.13	0.127	0.122	0.116	0.107
Low Income	6	0.206	0.202	0.179	0.127	0.121	0.122	0.127	0.134	0.144	0.152
B											
High income	19	0.264	0.237	0.225	0.225	0.225	0.225	0.231	0.238	0.247	0.259
Middle income	18	0.195	0.173	0.161	0.166	0.169	0.180	0.192	0.205	0.223	0.240
Low Income	11	0.159	0.134	0.122	0.115	0.114	0.117	0.121	0.127	0.131	0.130
Producer Price Index											
High income	17	0.283	0.255	0.241	0.240	0.237	0.239	0.241	0.253	0.267	0.282
Middle income	16	0.223	0.205	0.177	0.179	0.191	0.207	0.213	0.232	0.251	0.270
Low Income	6	0.229	0.217	0.194	0.192	0.196	0.186	0.180	0.194	0.200	0.205
C											
High income	19	0.262	0.235	0.223	0.225	0.227	0.227	0.232	0.237	0.246	0.257
Middle income	18	0.197	0.174	0.162	0.165	0.169	0.179	0.191	0.203	0.222	0.239
Low Income	11	0.159	0.134	0.122	0.115	0.114	0.117	0.121	0.127	0.131	0.130
Producer Price Index											
High income	17	0.281	0.253	0.240	0.239	0.239	0.242	0.243	0.252	0.266	0.280
Middle income	16	0.224	0.205	0.177	0.178	0.190	0.206	0.211	0.230	0.248	0.268
Low Income	6	0.229	0.217	0.194	0.192	0.196	0.186	0.180	0.194	0.200	0.205

Using data from 1997 to 2015, we estimate the contributions of nontraded-goods at different time horizons(k). The CPI and the PPI are retrieved from IFS, while WPI is retrieved from WDI

4 Empirical Determinants of the Contributions of Nontraded Goods to RER Fluctuations

We have reported earlier a substantial cross-country variation in contributions of nontraded goods to RER fluctuations, irrespective of the methods used to compute the contributions.[16] Generally, the higher the per capita income level, the lower the contribution of nontraded goods to RER fluctuations. An in-depth analysis is warranted to identify the relationship between the size of these contributions and the structural characteristics of the countries.

[16] In this Section, we examine the role of macroeconomic factors in the contribution of nontraded goods to the RER fluctuations where the contributions are calculated using conventional approaches reported in Sections 3.1–3.4.

Following Engel (1999) and Cheung and Lai (2000), a number of potential structural characteristics of an economy are identified as explanatory variables for the cross-country variations. These variables received attention in theoretical models in the tradition of Balassa-Samuelson models of real exchange rate behavior (Balassa 1964; Samuelson 1964) and the new open-economy macroeconomic models of Obstfeld and Rogoff (1995). They include both demand-side and supply-side macroeconomic variables[17] such as income levels, financial development, government spending as a percentage of GDP, openness, exchange rate, private consumption, inflation, and institutional variables like political stability and absence of violence.

Most of the country-specific characteristics are extracted from WDI. Real GDP per capita in 2010 US dollars (GDPCAP) is our level of income variable while financial development is represented by the domestic credit to the private sector by banks as a percentage of GDP and liquid liabilities (M3) as a percentage of GDP. The government spending is the proportion, in percentage, of general government final consumption expenditure to GDP, while private consumption is measured by the household final consumption expenditure as a percentage of GDP. Openness is computed as the ratio of exports plus imports over GDP. The inflation rate is the percentage change in GDP deflator.

We retrieved the nominal exchange rate from International Financial Statistics (IFS). Data on political stability and absence of violence (POS) are collected from Worldwide Governance Indicators (WGI), and it ranges from −2.5(weak) to 2.5(strong). The WGI summarizes the views on the quality of governance provided by a large number of enterprises, citizen and expert survey respondents in industrial and developing countries. Descriptive statistics of these variables are reported in Table 6.

According to Table 6, the high-income countries have better financial structures, a higher share of nontraded goods in GDP, higher government spending, lower nominal exchange rates, more open, lower consumption-GDP ratio, less inflation, and political stability.

Since our main (computed) outcome variable is the contribution of nontraded goods in RER fluctuations, and since the assumption of normality of the distribution of this variable seems untenable, following Cheung and Lai (2000), we use a nonparametric statistical test, the Spearman Rank Test,[18] for correlation. For a pair of variables, say (z_1, z_2), the statistic can be written as[19]

$$r_s = 1 - \frac{6\sum_{j=1}^{N}\left[R(z_{1j}) - R(z_{2j})\right]^2}{\left[N(N^2-1)\right]} \tag{18}$$

where r_s is the Spearman rank correlation coefficient, N is the number of countries, and (z_{aj}), with a = 1 or 2, is the ascending rank of the j^{th} observation of series z_a. In general, $-1 \le r_s \le 1$; $r_s = 0$ for independent variables; and $r_s N^{1/2}$ asymptotically follows the

[17] Dibooglu and Koray (2001) using an SVAR method find that supply shocks explain a relatively higher proportion of RER fluctuations under the modern floating period.

[18] We have attempted to check the robustness of our results by using a parametric procedure described in Appendix IV. We acknowledge an anonymous referee for suggesting this approach.

[19] Drawn heavily from Cheung and Lai (2000, page 391)

Table 6 Medians of country-specific characteristics by income groups

	High-income	Middle-Income	Low-Income
Share of nontraded goods	0.60	0.52	0.43
Gdpcap	35,550.48	5863.18	1130.74
Domestic credit	72.73	34.67	16.70
Money	72.79	45.24	31.83
Government Spending	18.94	14.89	13.89
Openness	92.54	86.69	69.64
Exchange Rate	4.66	7.40	74.35
Private Consumption	54.82	64.33	76.14
Gdp deflator inflation	2.54	6.15	7.40
Political Stability	0.94	0.11	−0.58

Notes: this table reports cross-country medians of averages of countryspecific characteristics

standard normal distribution.[20] The relationship between the contributions of nontraded goods to RER fluctuations and macroeconomic variables will also provide some hints to reconcile the various estimates available in the literature. The correlation coefficient between contributions of nontraded goods and the proximate macroeconomic variables are reported in Table 7a (QDA), 7b (Engel Approach I), and 7c (Engel Approach II).

Changes in any of the determinants of the RER may affect the fluctuations of the RER. However, fluctuations of each of the two components of RER undergo offsetting effects due to at least one of the following factors: the international market integration, the exchange rate pass-through, the lower impact of international prices on domestic nontraded prices, and the mobility of production factors (e.g., labor) across sectors or substitutions between final traded and nontraded goods by consumers (Adams and Chadha 1991).

Since almost all the economic factors will impact directly and/or indirectly at least one element of the two components of RER, the final relationship between any economic factor and the contribution of nontraded goods to RER fluctuations may theoretically be ambiguous but can be sorted out empirically, as suggested by Greenwood (1984). However, the responsiveness of domestic prices to nominal exchange rates has declined because of trade integration as shown by Gust et al. (2010). Thus, higher contributions of the traded component can be more attributed to lower offsetting effects due to market arbitrage. Therefore, countries that are already highly integrated into international markets require lesser market arbitrage and higher contributions of the traded component to RER fluctuations. This statement concurs with Goldberg and Verboven (2005) who suggested that the expected increase in the speed of convergence due to arbitrage may not occur if the absolute price differentials have already declined as a result of integration.

[20] We acknowledge that using bivariate correlations fails to account for other variables that could play a role in the relationships we are seeking to explore.

Table 7 Correlations between contributions of nontraded goods and macroeconomic determinants (A. QDA approach), (B. Engel approach I), (C. Engel approach II)

	Wholesale Price Index			Producer Price Index		
A						
Determinants	Coef.[#]	Prob.	Sig.	Coef. [#]	Prob.	Sig.
Gdpcap	−0.48[48]	0.0006	***	−0.209[39]	0.2023	
Domestic Credit	−0.614[48]	0	***	−0.473[39]	0.0024	***
Money	−0.539[44]	0.0002	***	−0.384[35]	0.023	**
Government Spending	−0.38[48]	0.0078	***	−0.265[39]	0.1025	
Openness	−0.26[48]	0.0746	*	−0.163[39]	0.3204	
Exchange regime	0.149[48]	0.3123		0.071[39]	0.6664	
Private Consumption	0.414[48]	0.0034	***	0.17[39]	0.3019	
Gdp Deflator Inflation	0.562[48]	0	***	0.455[39]	0.0036	***
Political Stability	−0.58[48]	0	***	−0.445[39]	0.0046	***
B						
Determinants	Coef.[#]	Prob.	Sig.	Coef. [#]	Prob.	Sig.
Gdpcap	−0.308[48]	0.0335	**	−0.253[39]	0.1195	
Domestic Credit	−0.4[48]	0.0048	***	−0.501[39]	0.0012	***
Money	−0.281[44]	0.0645	*	−0.44[35]	0.0082	***
Government Spending	−0.368[48]	0.01	**	−0.237[39]	0.1459	
Openness	−0.043[48]	0.7723		−0.144[39]	0.382	
Exchange regime	−0.012[48]	0.9346		−0.004[39]	0.9815	
Private Consumption	0.32[48]	0.0264	**	0.22[39]	0.1779	
Gdp Deflator Inflation	0.207[48]	0.1587		0.501[39]	0.0012	***
Political Stability	−0.418[48]	0.0031	***	−0.455[39]	0.0037	***
C						
Determinants	Coef.[#]	Prob.	Sig.	Coef. [#]	Prob.	Sig.
Gdpcap	−0.32[48]	0.0267	**	−0.274[39]	0.0921	*
Domestic Credit	−0.412[48]	0.0037	***	−0.516[39]	0.0008	***
Money	−0.293[44]	0.0539	*	−0.453[35]	0.0063	***
Government Spending	−0.356[48]	0.013	**	−0.228[39]	0.1632	
Openness	−0.045[48]	0.7633		−0.153[39]	0.351	
Exchange regime	−0.03[48]	0.8392		−0.017[39]	0.9182	
Private Consumption	0.335[48]	0.02	**	0.23[39]	0.1594	
Gdp Deflator Inflation	0.228[48]	0.119		0.533[39]	0.0005	***
Political Stability	−0.424[48]	0.0026	***	−0.475[39]	0.0023	***

Notes: *,**, and *** denote statistical significance at 10%, 5%, and 1%, respectively. This Table is based on the estimated contributions (with k = 1) that are summarized in Table 1, Table 2, Table 3

4.1 Income Level

It is evident from Table 7a that the contribution of nontraded goods to RER fluctuations is negatively related to the real GDP per capita for all the price indices used in the QDA (−0.480 and − 0.209). When using the Engel Approach I, the rank correlation estimate is −0.308 when WPI is used, whereas it is −0.253 when PPI is used (Table 7b). The Spearman rank correlation between real GDP per capita and nontraded-goods contributions, using Engel Approach II, is about −0.320 when using WPI as the proxy for traded goods prices and is equal to −0.274 when we use PPI. In sum, we may conclude that countries with lower GDP per capita yield higher contributions of nontraded goods to RER fluctuations. It is also interesting to note that the higher the GDP per capita, the higher the share of nontraded goods in GDP (see Table 6).

In fact, it is more likely to find parity reversion of the RER in developing countries than in industrial countries (Cheung and Lai 2000); thus developing countries are likely to experience more fluctuating RERs. These developing countries are also likely to experience significant differences in price formation between nontradable and tradable goods (Froot and Rogoff 1995). The presence of a large informal sector in developing countries distorts the market structure specifically for nontraded goods. For both developed and developing countries, although prices of traded goods are different, the differences are less pronounced than those for nontraded goods. Moreover, developed countries are likely to be more integrated into international markets because they produce more and have more income to demand goods from foreign markets. Factor markets in developed countries are also more integrated. Thus, more integrated countries are likely to face less price arbitrage (that could offset movements in tradable and nontradable prices), and then a higher contribution of the traded component to RER fluctuations. These may explain why we find on average, a negative correlation between contributions of nontraded goods to RER fluctuations and GDP per capita.

4.2 Financial Development

Domestic credit to private sectors generally boosts economic activities. Increased economic activities will impact the prices of both the traded and the nontraded goods. Increase availability of credit affects not only the demand for final traded goods and nontraded goods but also affects the nominal exchange rate. Our results show that domestic credit as a percentage of GDP and contributions of nontraded goods are negatively correlated since all six coefficients are negative (Table 7a, b, and c). We also used money supply (M3) as a percentage of GDP as a proxy for financial development and the results are similar.

Financial development tends to be positively associated with income level (with correlation coefficient 0.74, shown in Appendix Table 11) and the bulk of the nontraded goods are produced in the informal sectors in developing countries. Accordingly, the price formation in nontraded goods (Froot and Rogoff 1995) is affected and thus yields a negative correlation between financial development and the contribution

of the nontraded goods to the RER fluctuations.[21] Moreover, financial access enhances participation in international markets, and thus the lower response of nontraded prices to international prices will dampen the contribution of nontraded goods to RER fluctuations.

4.3 Government Spending

The correlation coefficients between government spending as a percent of GDP and the contribution of nontraded goods are found to be negative and significant for three out of six cases (Table 7a, b, and c). Note that, on average, the correlation coefficient between government spending as a percent of GDP and income per capita is about 0.230.

Government spending can affect the relative demand for, and consequently, the relative price of, traded and nontraded goods. Moreover, the government spends mostly on nontraded goods (Froot and Rogoff 1991). Thus, we expect more movements of the nontraded prices with higher government spending. However, Rogoff (1992) noted that the allocation effects of government spending might not be long-lived if productive factors are perfectly mobile across sectors over the long run. This fact was confirmed by Cheung and Lai (2000), who have shown a positive correlation between government spending and the PPP deviations. Therefore, the allocation effects of government spending may be offset either by movements of factors between the sectors or by substitutions between goods from the two sectors (more integrated product and factor market in developed countries). Thus, a negative correlation between the contribution of nontraded goods to RER fluctuations and the size of government spending is not unwarranted.

4.4 Openness

Openness captures movements of tradable goods across national borders. These movements are directly related to the prices of tradable goods. Moreover, any change in the exporting or importing sectors is capable of impacting nontradable sectors because of possible factor mobility and demand-switching across sectors. As a result, we obtain negative correlation coefficients between openness and contributions of nontraded goods to RER fluctuations, but only one coefficient is significant (Table 7a, b, and c).

4.5 Exchange Rates

The nominal exchange rate is part of the traded-goods component of the RER decomposition and can impact this component directly. However, the effect of exchange rates on traded-goods prices will infuse some movements to the nontraded-goods component as well.

Although all the estimated Spearman correlations are not significant, four out of six are negative (Table 7a, b, and c). The more flexible the country's exchange rate regime

[21] Thomas (1992) assumed that production in the informal sector is more labor intensive and many economic models such as the Balassa (1964) and Samuelson (1964) assume that the nontraded sector is more labor intensive. This fact can imply that in developing countries more nontraded goods are produced in the informal (labor-intensive) sector.

is, the less is the contribution of nontraded goods to RER fluctuations; as a matter of fact, the rich countries generally follow a more flexible exchange rate regime and thus the negative relationship seems reasonable.

4.6 Private Consumption

We obtain a positive association between the ratio of private consumption to GDP and the contribution of nontraded goods. The correlation coefficients range from 0.32 (Table 7b) to 0.414 (Table 7a) with three out of six being statistically significant. We note in Table 6 that the share of consumption in GDP declines as the income level of a country increases. The correlation coefficient between private consumption and GDP per capita is negative and large (−0.634, see Appendix Table 11). Generally, a low-income country will have a larger private consumption GDP ratio and will have a less integrated product and factor markets. This results in larger changes in the prices of nontraded goods and imparts a larger impact on RER fluctuations.

4.7 Inflation

For all different assumptions about traded goods prices and all different estimation techniques, we find positive correlation coefficients for inflation and the contributions of nontraded goods in RER fluctuations (four out of six correlation coefficients are significant). It is also important to note that the rate of inflation is smaller for richer countries as the correlation coefficient between inflation and GDP per capita is small (−0.148, Table 8,). A rise in domestic inflation suggests a larger increase in prices of nontraded goods. As developing countries generally face higher inflation, the positive correlation between the contribution of nontraded goods and inflation is not unwarranted.

4.8 Political Stability and Absence of Violence

We also examine the relationship between the political stability and absence of violence (POS) from the World Governance Indicators (WGI) and the contribution of nontraded goods to RER fluctuations. We find negative and significant correlation coefficients between political stability and nontraded-goods contributions to RER fluctuations under all various proxy for traded price indices and all approaches adopted.

Note that the political stability variable assumes a larger value for high-income countries (correlation coefficient for political stability and GDP per capita is 0.653, Table 8). Thus, it can be argued that the nontraded goods market function better with political stability, triggering more offsetting movement within the nontraded component of the RER. Thus one would expect lower contributions of nontraded goods in the RER fluctuations in a country with a stable political system.

5 Robustness Check

Although concurrently using three alternative approaches to estimate the contribution of nontraded goods to RER fluctuations constitutes a robustness check, we also perform

a set of robustness checks for each approach to establish the consistency of our findings. Since all the results reported in the previous sections are computed with the U.S. as the benchmark country, and there are some suggestions that home country choice can bias the results in the RER fluctuations (Papell and Theodoridis 2001), we have also used El Salvador as our alternative benchmark country.

For brevity, only some of the robustness check results are provided in the appendix, while others are available upon request. None of the robustness check results contradict our main findings.

6 Conclusions

The role of nontraded goods in explaining RER dynamics is questioned empirically by the seminal paper of Engel (1999), which created a new category of empirical research on the accounting of RER fluctuations. Since data requirements to conduct such studies are the major bottlenecks even for developed countries, most of the attempts were made for developed countries. We propose a QDA method for RER accounting for which the price data requirement is minimal. For our purposes, this method requires knowledge of only traded-goods prices and quantity variables. Because the suggested method required more quantity variables that are more inclusive of goods and services produced and consumed in a given country, it reduces biases that could be the result of the exclusion of commodities that are not a part of the consumer basket of goods and services.

We estimate contributions of nontraded goods to RER fluctuations using our QDA approach and two other conventional approaches proposed by Engel (1999). We show that the three approaches yield qualitatively similar results. These results suggest researchers can adopt a particular method of their choice with minimal consequences and this choice could be guided by the availability of data. The QDA, with its less stringent data requirements, can be a superior choice in a challenging data environment.

We also find that there exist substantial cross-country variations of nontraded-goods contributions to RER fluctuations. Our results, based on a sample composed of developed and developing countries, indicate that the findings in the extant literature might be driven by the sample selection. We have attempted to examine what potential macroeconomic variables may be associated with those large cross-country variations by employing the nonparametric Spearman rank correlations test between the macroeconomic variables and contributions of nontraded goods to RER fluctuations. These results have provided some hints about crucial macroeconomic determinants of the RER fluctuations. We find that variables like income, financial development, government expenditure, and political stability are negatively related to the contributions of nontraded goods while inflation and private consumption expenditure are positively related.

The increased awareness in the contributions of each component in RER fluctuations would enable researchers to identify which variables to incorporate in economic and econometric models constructed to clearly understand the movements of the RER of a particular country. Since policymakers need to keep an eye on the behavior of the RER to steer the international competitiveness of the country to the desired level, a better understanding of the contributing factors to RER fluctuations would increase the

efficiency of policymaking, which may, in turn, help achieve sustained economic growth.

Appendix I: Spearman Correlation Coefficients when using a different benchmark country

QDA approach

Table 8 Correlations between nontraded-goods contributions and macroeconomic determinants (QDA approach with El Salvador as the base country)

	Wholesale Price Index			Producer Price Index		
Determinants	Coef.	Prob.	Sig.	Coef.	Prob.	Sig.
Gdpcap	−0.411 [46]	0.005	***	0.203 [38]	0.221	
Domestic Credit	−0.585 [46]	0	***	0.016 [38]	0.924	
Money	−0.446 [46]	0.002	***	0.03 [38]	0.86	
Government Spending	−0.432 [46]	0.003	***	0.096 [38]	0.567	
Openness	−0.157 [46]	0.296		−0.014 [38]	0.932	
Exchange regime	0.027 [46]	0.86		−0.582 [38]	0	***
Private Consumption	0.434 [45]	0.003	***	−0.068 [37]	0.69	
Gdp Deflator Inflation	0.445 [46]	0.002	***	0.141 [38]	0.398	
Political Stability	−0.492 [46]	0.001	***	0.045 [38]	0.787	

Notes: *,**, and *** denotes significance at 10, 5, and 1%. Number of countries used in computation of the coefficients are in brackets. Horizon k = 1, and sample 1997–2015

Engel Approach I

Table 9 Correlations between nontraded-goods contributions and macroeconomic determinants (Engel Approach I with El Salvador as the base country)

	Wholesale Price Index			Producer Price Index		
Determinants	Coef.	Prob.	Sig.	Coef.	Prob.	Sig.
Gdpcap	−0.325 [46]	0.027	**	−0.29 [40]	0.07	*
Domestic Credit	−0.376 [46]	0.01	**	−0.387 [40]	0.014	**
Money	−0.252 [46]	0.091	*	−0.314 [40]	0.048	**
Government Spending	−0.347 [46]	0.018	**	−0.242 [40]	0.133	
Openness	0.083 [46]	0.582		−0.073 [40]	0.654	
Exchange regime	−0.173 [46]	0.251		−0.098 [40]	0.547	
Private Consumption	0.255 [45]	0.091	*	0.163 [39]	0.322	
Gdp Deflator Inflation	0.182 [46]	0.226		0.363 [40]	0.021	**
Political Stability	−0.426 [46]	0.003	***	−0.506 [40]	0.001	***

Notes: *,**, and *** denote significance at 10, 5, and 1%. Number of countries used in computation of the coefficients are in brackets. Horizon k = 1, and sample 1997–2015

Engel Approach II

Table 10 Correlations between contribution of nontraded goods and macroeconomic determinants (Engel Approach II, with El Salvador as the base country)

	Wholesale Price Index			Producer Price Index		
Determinants	Coef.	Prob.	Sig.	Coef.	Prob.	Sig.
Gdpcap	−0.258 [51]	0.068	*	0.176 [44]	0.255	
Domestic Credit	−0.353 [51]	0.011	**	−0.008 [44]	0.962	
Money	−0.175 [51]	0.221		0.004 [44]	0.98	
Government Spending	−0.262 [51]	0.063	*	0.129 [44]	0.405	
Openness	0.056 [51]	0.697		−0.04 [44]	0.798	
Exchange regime	−0.195 [51]	0.17		−0.477 [44]	0.001	***
Private Consumption	0.105 [50]	0.468		−0.143 [43]	0.359	
Gdp Deflator Inflation	0.17 [51]	0.232		0.193 [44]	0.209	
Political Stability	−0.358 [51]	0.01	**	0.062 [44]	0.69	

Notes: *,**, and *** denotes significance at 10, 5, and 1%. Number of countries used in computation of the coefficients are in brackets. Horizon k = 1, and sample 1997–2015

Appendix II

Table 11 Correlation coefficients between per capita GDP and structural variables

Variable	Correlation Coefficient
Domestic Credit	0.739
Money Supply	0.560
Government Spending	0.230
Openness	0.221
Exchange Rate Regime	−0.070
Private Consumption	−0.634
Inflation	−0.148
Political Stability	0.653

Appendix III

Table 12 List of countries List of countries

Aruba	Czech Republic	Lao PDR	Poland
Angola	Djibouti	Lebanon	Paraguay
Albania	Dominica	Liberia	Qatar
United Arab Emirates	Denmark	Libya	Russian Federation
Argentina	Dominican Republic	St. Lucia	Rwanda
Armenia	Algeria	Sri Lanka	Saudi Arabia
Antigua and Barbuda	Egypt, Arab Rep.	Lesotho	Sudan
Australia	Estonia	Lithuania	Senegal
Azerbaijan	Ethiopia	Latvia	Singapore
Burundi	Fiji	Morocco	Solomon Islands
Benin	Gabon	Moldova	Sierra Leone
Burkina Faso	Georgia	Madagascar	El Salvador
Bangladesh	Ghana	Maldives	Serbia
The Bahamas	Guinea	Mexico	Suriname
Bosnia and Herzegovina	Guinea-Bissau	Macedonia, FYR	Slovak Republic
Belarus	Grenada	Mali	Slovenia
Belize	Guatemala	Malta	Sweden
Bolivia	Guyana	Myanmar	Swaziland
Brazil	Hong Kong SAR, China	Mongolia	Seychelles
Barbados	Honduras	Mozambique	Syrian Arab Republic

Table 12 (continued)

Aruba	Czech Republic	Lao PDR	Poland
Brunei Darussalam	Croatia	Mauritania	Chad
Bhutan	Hungary	Mauritius	Togo
Botswana	Indonesia	Malawi	Thailand
Central African Republic	India	Malaysia	Tajikistan
Canada	Iran, Islamic Rep.	Namibia	Tonga
Switzerland	Iceland	Niger	Trinidad and Tobago
Chile	Jamaica	Nigeria	Tunisia
China	Jordan	Nicaragua	Turkey
Cote d'Ivoire	Japan	Norway	Tanzania
Cameroon	Kazakhstan	Nepal	Uganda
Congo, Rep.	Kenya	New Zealand	Ukraine
Colombia	Kyrgyz Republic	Oman	St. Vincent and the Grenadines
Comoros	Cambodia	Pakistan	South Africa
Cabo Verde	St. Kitts and Nevis	Panama	Congo, Dem. Rep.
Costa Rica	Korea, Rep.	Philippines	
Cyprus	Kuwait	Papua New Guinea	

Appendix IV: Parametric method to examine the relationship between the contribution of nontraded goods and macroeconomic determinants[22]

We have used Spearman correlation coefficients, in the main text, to find the relationships between nontraded goods contributions to RER fluctuations and macroeconomic variables. In this appendix, we describe how the same goal could be achieved by using a regression approach which is inspired by the work of Otto et al. (2000).

Because all the computed contribution values are included in the interval [0, 1], we assume that there is a function *f (.)* that transforms the linear regression model so that it satisfies the range restriction of contributions of nontraded goods to RER fluctuations. That is, we rewrite the model as

$$g_i = f\left(\overline{X}_i\beta + \varepsilon_i\right)$$

with g_i being the contribution of nontraded goods to RER fluctuations in country i, X_i is a set of averages of macroeconomic determinants, and ε_i is the error term. The function *f(.)* must map from the real line to the interval 0 to 1; we use the following function

$$g = f(x) = \frac{e^x}{e^x - 1}$$

with g being our contribution of nontraded goods to RER fluctuations while x is a set of regressors for which the following holds:

$$\lim_{x\to+\infty}\frac{e^x}{e^x-1}=1\ \lim_{x\to-\infty}\frac{e^x}{e^x-1}=0.$$

Therefore, we use $f^{-1}(g)=-\ln\left(-\frac{g-1}{g}\right)=-ln\left(\frac{1-g}{g}\right)$ as the LHS variable in our regression.

To recover the predicted contribution of nontraded goods to RER fluctuations, we apply the function *f(x)* to the predicted values of the estimated model.

Although the regressions might suffer from endogeneity issues and a lower number of observations, the results reported in the tables below provide indications about relationships. When all the factors are taken into account, three of the determinants are relatively better predictors of the contributions of nontraded goods to RER fluctuations: domestic credit, the nominal exchange rate, and political stability. At least 50% of the estimated coefficients are significant and confirm the story told through spearman correlations. All the predicted values of the contributions derived as detailed above are included in the [0, 1] range. Although at a first glance it looks like per capita GDP yields positive and mainly insignificant coefficients contradicting our results, domestic credit, money supply, government expenditure, and political stability are among other variables that essentially represent the development status of an economy, and together they paint the same picture that we obtained in our correlation exercise.

Table 13 Regressions of Contributions of nontraded goods on macroeconomic determinants (A.QDA appraoch),. (B. Engel appraoch I), (C. Engel appraoch II)

	Without Fixed Effects				With Income group Fixed Effects			
	WPI		PPI		WPI		PPI	
A								
Determinants	Coef.	se.	Coef.	se.	Coef.	se.	Coef.	se.
Log of Gdpcap	0.27	(0.222)	1.040**	(0.473)	0.611**	(0.280)	0.799	(0.584)
Log of Domestic Credit	−0.615**	(0.280)	−0.962*	(0.484)	−0.794***	(0.289)	−0.846	(0.526)
Log of Money	−0.128	(0.232)	−0.036	(0.441)	0.022	(0.239)	−0.205	(0.475)
Log of Government spending	−0.726*	(0.398)	0.027	(0.794)	−0.407	(0.420)	−0.148	(0.852)
Log of Openness	0.127	(0.227)	1.181*	(0.601)	0.225	(0.227)	1.188*	(0.622)
Log of Exchange rate	−0.078**	(0.036)	0.05	(0.064)	−0.086**	(0.035)	0.051	(0.066)
Log of Private consumption	−0.383	(0.771)	−0.755	(1.584)	−0.369	(0.756)	−0.616	(1.613)
GDP deflator inflation	0.005	(0.012)	0.014	(0.020)	0.003	(0.012)	0.013	(0.022)
Political stability	−0.600**	(0.258)	−1.324***	(0.478)	−0.655**	(0.257)	−1.256**	(0.492)
Constant	2.979	(5.659)	−8.657	(12.247)	−1.77	(6.014)	−6.114	(13.221)
r2	0.571		0.419		0.616		0.448	

Table 13 (continued)

	Without Fixed Effects				With Income group Fixed Effects			
	WPI		PPI		WPI		PPI	
N	45		37		45		37	
B								
Log of Gdpcap	0.545**	(0.232)	0.777	(0.512)	0.458	(0.306)	0.698	(0.642)
Log of Domestic Credit	−1.142***	(0.292)	−1.394**	(0.530)	−1.088***	(0.316)	−1.363**	(0.578)
Log of Money	0.163	(0.242)	0.189	(0.479)	0.125	(0.261)	0.101	(0.519)
Log of Government spending	−0.572	(0.416)	0.033	(0.866)	−0.624	(0.459)	−0.01	(0.940)
Log of Openness	0.351	(0.237)	0.997	(0.646)	0.331	(0.248)	1.03	(0.678)
Log of Exchange rate	−0.193***	(0.037)	−0.077	(0.066)	−0.191***	(0.038)	−0.08	(0.069)
Log of Private consumption	−1.385*	(0.806)	−2.673	(1.727)	−1.314	(0.826)	−2.56	(1.782)
GDP deflator inflation	−0.030**	(0.012)	−0.02	(0.018)	−0.026*	(0.014)	−0.024	(0.020)
Political stability	−0.943***	(0.269)	−1.178**	(0.502)	−0.977***	(0.281)	−1.129**	(0.521)
Constant	4.016	(5.913)	3.448	(13.392)	4.868	(6.577)	3.965 (	(14.556)
r2	0.666		0.447		0.673		0.457	
N	45		39		45		39	
C								
Log of Gdpcap	0.202	(0.251)	0.362	(0.432)	0.184	(0.345)	0.197	(0.564)
Log of Domestic Credit	−1.125***	(0.345)	−1.160**	(0.509)	−1.127***	(0.373)	−1.067*	(0.545)
Log of Money	0.066	(0.295)	0.082	(0.462)	0.068	(0.319)	−0.044	(0.494)
Log of Government spending	−1.021**	(0.498)	−0.348	(0.797)	−1.019*	(0.548)	−0.479	(0.864)
Log of Openness	0.055	(0.289)	0.539	(0.619)	0.048	(0.302)	0.562	(0.654)
Log of Exchange rate	−0.216***	(0.045)	−0.082	(0.065)	−0.216***	(0.046)	−0.078	(0.067)
Log of Private consumption	−2.489***	(0.864)	−3.102**	(1.415)	−2.492***	(0.885)	−2.922*	(1.468)
GDP deflator inflation	−0.024	(0.016)	−0.016	(0.018)	−0.022	(0.017)	−0.018	(0.020)
Political stability	−0.39	(0.268)	−0.581	(0.402)	−0.401	(0.276)	−0.571	(0.410)
Constant	14.512**	(6.162)	11.517	(10.533)	14.767**	(7.059)	12.911	(11.864)
r2	0.573		0.392		0.575		0.406	
N	50		43		50		43	

References

Adams C, Chadha B (1991) On interpreting the random walk and unit root in nominal and real exchange rates. IMF Economic Review 38(4):901–920

Azcona N (2015) Non-traded goods and real exchange rate volatility in a two-country DSGE model. Int J Econ Financ 7(2):37–49

Balassa B (1964) The purchasing power parity doctrine: a reappraisal. J Polit Econ 72(6):584–596

Betts, CM, and Kehoe, TJ (2001). Tradability of goods and real exchange rate fluctuations. Federal Reserve Bank of Minneapolis, Research Department Staff Report

Betts, CM and Timothy J. Kehoe. (2008). Real Exchange Rate Movements and the Relative Price of Non-traded Goods *Federal Reserve Bank of Minneapolis Staff Report* 415

Burstein, A. and Gopinath, G. (2014). International prices and exchange rates. *Handbook of International Economics*

Chen L, Choi S, Devereux J (2015) Accounting for real exchange rate changes at long time horizons. J Macroecon 46:264–277

Cheung YW, Lai KS (2000) On cross-country differences in the persistence of real exchange rates. J Int Econ 50:375–397

Crucini MJ, Landry A (2019) Accounting for real exchange rates using micro-data. J Int Money Financ 91:86–100

Crucini MJ, Telmer CI, Zachariadis M (2005) Understanding European real exchange rates. Am Econ Rev 95(23):724–738

Dibooglu S, Koray F (2001) The behavior of the real exchange rate under fixed and floating exchange rate regimes. Open Econ Rev 12(2):123–143

Engel C (1999) Accounting for U.S. real exchange rate changes. J Polit Econ 107(3):507–538

Froot KA, Rogoff K (1991) The EMS, the EMU, and the transition to a common currency. In: Blanchard OJ, Fischer S (eds) 1991 *NBER Macroeconomic Annual*. The MIT Press, Cambridge, pp 269–317

Froot KA, Rogoff K (1995) Perspectives on PPP and long-run real exchange rates. In: Grossman G, Rogoff K (eds) *Handbook of International Economics,* Vol.III, North-Holland, Amsterdam

Gluzmann PA, Levy-Yeyati E, Sturzenegger F (2012) Exchange rate undervaluation and economic growth: Diaz Alejandro (1965) revisited. Econ Lett 117:666–672

Goldberg PK, Verboven F (2005) Market integration and convergence to the law of one Price: evidence from the European car market. J Int Econ 65(1):49–73

Greenwood J (1984) Non-traded goods, the trade balance, and the balance of payments. Can J Econ 17(4): 806–823

Gust C, Leduc S, Vigfusson R (2010) Trade integration, competition, and the decline in exchange-rate pass-through. J Monet Econ 57(3):309–324

Hsieh CT (1999) Productivity growth and factor prices in East Asia. Am Econ Rev 89(2):133–138

Martin B, Devereux MB, Engel C (2018) Real exchange rates and Sectoral productivity in the Eurozone. Am Econ Rev 108(6):1543–1581

Obstfeld M, Rogoff K (1995) The mirage of fixed exchange rates. J Econ Perspect 9(4):73–96

Esteban Ortiz-Ospina and Max Roser (2020). "Government Spending". Published online at OurWorldInData.org. Retrieved from: 'https://ourworldindata.org/government-spending' [Online Resource]

Otto, G., Voss, G., & Willard, L. (2000). Understanding OECD Output Correlations, 59

Papell DH, Theodoridis H (2001) The choice of Numeraire currency in panel tests of purchasing power parity. Journal of Money, Credit and Banking (Ohio State University Press) 33(3):790–803

Parsley D (2007) Accounting for real exchange rate changes in East Asia. J Int Money Financ 26(8):1355–1377

Parsley DC, Wei SJ (1996) Convergence to the law of one Price without trade barriersor currency fluctuations. Q J Econ 111:1211–1236

Rabanal P, Tuesta V (2013) Nontradable goods and the real exchange rate. Open Econ Rev 24(3):495–535

Rodrik D (2008) The real exchange rate and economic growth. Brook Pap Econ Act 2008:2

Rogoff K (1992) Traded goods consumption smoothing and the random walk behavior of the real exchange rate. Bank of Japan Monetary and Economic Studies 10:1–29

Samuelson PA (1964) Theoretical notes on trade problems. Rev Econ Stat 46(2):145–154

Thomas JJ (1992) Informal economic activity. University of Michigan Press, Ann Arbor MI

Williamson J (2009) Exchange rate economics. Open Econ Rev 20(1):123–146