Accounting for Real Exchange Rate Changes with Individual Goods

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Abstract

In this paper, we examine the role of individual goods’ prices in explaining real exchange rate fluctuations. We show that deviations from the law of one price in even a single good, such as a haircut, can account for virtually all of the real exchange rate movements. We compare this finding with that of Engel (1999), who shows that virtually all of the fluctuation can be accounted for by aggregate deviations from the law of one price in traded goods.

Key Words: Real Exchange Rates, PPP, MSE decomposition
JEL Classification Codes: F3, F4

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Introduction

For nearly three decades, the U.S. real exchange rate – by any measure – has fluctuated dramatically. The extent of its variability is well documented, but an understanding of the source of its variability remains elusive. In an influential empirical paper, Engel (1999) decomposes the real exchange rate and finds that virtually all of the fluctuations in the real exchange rate can be accounted for by deviations from the law of one price in traded goods. Specifically, he finds that the deviations account “for nearly 100 percent of the mean square error of the U.S. real exchange rate changes . . . .” In this paper, we examine several alternative decompositions and find that each one provides a different accounting for the real exchange rate’s movements.

We begin by using decompositions similar to Engel’s, along with data on individual goods prices. We examine the ability of specific goods to account for real exchange rate variability. The results are striking. We find that just a single good can account for about as much of the real exchange rate variability as Engel’s aggregate bundle of traded goods can. That is, a component reflecting the deviation from the law of one price in a single good can be said to account for nearly 100 percent of the mean square error of the U.S. real exchange rate changes. This turns out to be true of every individual good that we examine. For example, we find that deviations from the law of one price in haircuts can account for nearly all of the real exchange rate variation. Similarly, we find that deviations from the law of one price of eggs can account for nearly all of the real exchange rate variation. We report detailed results only for haircuts and for eggs. However, the results are comparable for all of the other prices that we examine.

The difference in the two sets of results – ours and Engel’s – stems from a difference in how the real exchange rate is decomposed. In each decomposition, a different subset of available prices is linked to the nominal exchange rate. In Engel’s decomposition, aggregate traded goods’ prices are linked to the nominal exchange rate to form the ‘traded-goods’ component. Movements in the real exchange rate are then attributed either to the traded goods component or to the remainder. In contrast, we link the nominal exchange rate with the prices of an individual good, thereby defining an individual good-specific component. Largely because the nominal exchange rate is so much more volatile than prices, whichever component contains the nominal exchange rate will appear to account for most of the real exchange rate variation. In Engel’s version, traded goods’ prices are linked with the nominal exchange rate; so he finds that the traded goods component accounts for most of the fluctuation. Here, individual goods’ prices are linked with the exchange rate; so, we find that the individual good-specific component accounts for most of the fluctuation, regardless of the choice of the individual good.

In our next real exchange rate decomposition, we examine the effect of associating nontraded, rather than traded, goods with the nominal exchange rate. In this case, we find that the

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1 Engel’s paper has been cited many times and appears on the reading lists of Ph.D. courses in international finance at many major U.S. universities, including Berkeley, Harvard, Michigan, Minnesota, Northwestern, Princeton, Rochester, Wisconsin, and Yale. Recent papers exploring the robustness of the paper’s findings include: Betts and Kehoe (2001), Engel (2002), Mendoza (2000) and Parsley (2001).
nontraded goods component can account for nearly all of the mean square error in U.S. real exchange rates.

Finally, we also decompose movements in the real exchange rate into shares attributable to the nominal exchange rate by itself, on one hand, and aggregate prices on the other. While this may not be completely in the econometric spirit of the decomposition – since even at very long horizons the nominal exchange rate will not necessarily be stationary – we think it helps to illustrate the importance of the decomposition choice. By itself the nominal exchange rate usually accounts for more than 85 percent of the variation in the real exchange rate. While substantial, this fraction differs from the “nearly 100 percent” we get when the nominal exchange rate is associated with any of the goods’ prices in our sample.

While in one sense our nontraded goods finding turns Engel's finding on its head, in another sense our work as a whole retells and develops Engel's deeper contention. Engel emphasizes that his finding reflects international similarities in the behavior of the relative prices of traded to nontraded goods. After associating the traded component with the nominal exchange rate, what is left over in Engel's decomposition is a difference across countries in the relative price of traded to nontraded goods. (Engel calls this the relative-relative price.) While in the United States, nontraded goods have become more expensive relative to traded goods, the same is true for the other industrialized countries. So, international differences in those relative prices have changed little. That is why their behavior cannot account for the large fluctuations in the real exchange rate. While in this paper we associate first individual goods' prices then nontraded goods' prices with the nominal exchange rate, what is left over in each case is also a relative-relative price. Like Engel's, these relative-relative prices cannot account for much of the real exchange rate's variability because they too have been so stable. We emphasize that the inability of international differences in relative prices to account for real exchange rate changes does not depend on whether one isolates traded goods, individual goods, or nontraded goods. In this regard, our point echoes that of Mussa (1986); namely, in accounting for real exchange rate fluctuations, it is the nominal exchange rate that matters.

**Decomposing the Real Exchange Rate**

This section describes the decomposition in detail. We first review Engel’s decomposition, using his notation. Then we describe the decompositions used in our empirical work.

As Engel points out, the price index in each country reflects the prices of both traded and nontraded goods. So, the price index, the log of which is denoted $p_t$, can be written as a sum of the logs of the traded goods price index, $p_t^T$, and a nontraded goods price index $p_t^N$. This is also true of the foreign price index. So, we can write:

$$p_t = (1-\alpha) p_t^T + \alpha p_t^N$$

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

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2 We thank Shang-Jin Wei for suggesting this final decomposition.

3 Correspondingly, there is no reason for international differences in the nominal prices in different currencies to be stationary.
where asterisks denote foreign variables. Next, we note that the log of real exchange rate, $q_t$, is simply the (log) nominal exchange rate, $s_t$, adjusted for the price level in each country:

$$q_t = s_t + p_t^* - p_t$$

Engle decomposes the log of real exchange rate into two parts, $x$ and $y$, as follows:

$$q_t = x_t + y_t$$

$$x_t = s_t + p_t^* - p_t^T, \text{ a traded goods portion}$$

$$y_t = \beta(p_t^N - p_t^T) - \alpha(p_t^N - p_t^T), \text{ a portion reflecting relative prices.}$$

It is the first component, $x_t$, that Engel shows can account for virtually all of the variation in the real exchange rate, $q_t$. Notice that this decomposition lumps all changes in the nominal exchange rate into the traded goods portion, $x_t$. This component is the deviation from the law of one price in traded goods.

In this paper, we would like to examine how much of the variation in the real exchange rate can be accounted for by the deviation from the law of one price for just a single good. So, we decompose the exchange rate in an analogous way; however, we separate out an individual good, instead of an aggregate bundle of traded goods.

To isolate the role of a single good, we note that we can write the domestic price index as a weighted sum of the price of the $i$th good, $p_t^i$, and the prices of all other goods, $p_t^{-i}$. This is true for both the domestic and the foreign price indices. Denoting the weights in the price indices as $\epsilon$ and $(1-\epsilon)$, for the domestic prices, and $\zeta$ and $(1-\zeta)$ for the foreign prices, we have:

$$p_t = (1-\epsilon)p_t^i + \epsilon p_t^{-i}$$

$$p_t^* = (1-\zeta)p_t^{i*} + \zeta p_t^{-i*}$$

Now, we can re-decompose the exchange rate into the two analogous portions,

$$q_t = w_t + z_t$$

$$w_t = s_t + p_t^{i*} - p_t^i, \text{ good i’s portion.}$$

$$z_t = \zeta(p_t^{i*} - p_t^{i*}) - \epsilon(p_t^i - p_t^i), \text{ a portion reflecting relative prices.}$$

In the same way that Engel uses (1) to gauge how much of the variation in the real exchange rate can be accounted for by the traded-goods component, we can use (2) to gauge how much of the variation can be attributed to a single good. That is, instead of $x_t$, the deviation from

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4 Our equation 1 is also Engel’s equation 1.
the law of one price for an aggregate bundle of traded goods, we can now examine \( w_t \), the deviation from the law of one price for good \( i \).\(^5\)

Before proceeding to the empirical exercise, we describe the two additional decompositions that further illustrate the nominal exchange rate’s key role. The first decomposition separates the real exchange rate into a portion attributable to nontraded goods, on the one hand, and to ‘everything else’ on the other hand (the “reverse” of equation 1). The final decomposition separates the real exchange rate into the nominal exchange rate, on the one hand, and prices on the other hand.

To focus on nontraded goods, we simply rewrite equation 1 with a slightly different weighting scheme in the aggregate price index. Redefining the weights as \( \delta = (1-\alpha) \) and \( \gamma = (1-\beta) \), we rewrite the price equations as follows:

\[
\begin{align*}
  p_t &= \delta p_t^T + (1-\delta) p_t^N \\
  p_t^* &= \gamma p_t^{T*} + (1-\gamma) p_t^{N*}.
\end{align*}
\]

Now, we can decompose the exchange rate into two, new parts, \( u_t \) and \( v_t \).

\[
(3) \quad q_t = u_t + v_t
\]

\[
\begin{align*}
  u_t &= s_t + p_t^{N*} - p_t^N, \text{ a nontraded goods portion} \\
  v_t &= \gamma (p_t^{T*} - p_t^{N*}) - \delta (p_t^T - p_t^N), \text{ a portion reflecting relative prices.}
\end{align*}
\]

Notice that \( x_t \), from equation 1, is the deviation from the law of one price in traded goods, while \( u_t \), from equation 3, is the analogous difference in nontraded goods prices. While one might expect \( x_t \) to be close to zero, one would only expect \( u_t \) to become close to zero over the very long run – when the factors of production become mobile. Thus, at one level, one might expect \( x_t \) and \( u_t \) to be very different in terms of their ability to account for the fluctuations in the real exchange rate, \( q_t \). However, if the fluctuations in \( q_t \) are primarily driven by \( s_t \), rather than by goods’ prices – whether traded or not, then we would expect \( u_t \) to account for as much of the volatility as \( x_t \). That is, if the nominal exchange rate is much more volatile in general than goods prices, the nontraded goods portion might now account for as much of the volatility as the traded good portion of equation 1.

Finally, we separate changes in the real exchange rate into the part attributable to the nominal exchange rate and the part attributable to prices.

\[
(4) \quad q_t = a_t + b_t
\]

\[
\begin{align*}
  a_t &= s_t \\
  b_t &= p_t^* - p_t
\end{align*}
\]

\(^5\) Empirically, \( z_t \) is constructed as the residual from a regression of the aggregate price index on \( p^t \).
Using this last decomposition, we simply replicate the already well-documented finding that nominal exchange rates move around more than aggregate price indices. Unlike the other decompositions, however, this one does not necessarily yield two stationary series. Nevertheless, we feel that it will satisfy the curiosity of some of our readers.

**The Empirical Accounting**

We examine the real exchange rate between the United States and Japan from January, 1970 to May, 1997, using monthly data on nominal exchange rates and consumer prices. Following Engel, we measure variability using the mean-squared error (MSE) of the change in the real exchange rate. We describe how much of the MSE can be accounted for by each of the real exchange rate’s components, as they are defined in equations 1 through 4. As described above, the difference between our work and Engel’s work stems from how the exchange rate is decomposed into its components. Equation 1 gives Engel’s decomposition. Equation 2 gives the decomposition using an individual good; and equations 3 and 4 give the alternatives. We replicate Engel’s findings using equation 1, and we use the same empirical techniques to examine equations 2 through 4. Following Engel, the decompositions are done at all of the horizons that the data allow.

We first reproduce Engle’s results in Figure 1. As shown, the traded goods components can account for most of the MSE of the real exchange rate at all of the possible horizons.

We next examine how much of the MSE can be accounted for by a single good. That is, we examine how much of the MSE can be accounted for by \(w_t\) in Equation 2. Figure 2a gives the results when the single good is a haircut. At nearly all horizons, haircuts appear to account for virtually all of the variability in real exchange rates. That is, deviations in the law of one price of haircuts account for nearly all of the variability of the real exchange rate.

Figure 2b presents the results when the single good is eggs. The individual price component, \(w_t\), again appears to account for nearly all of the MSE. That is, deviations from the law of one price of eggs can be said to account for most of the fluctuation in the real exchange rate.

We have repeated this exercise for the prices of 26 other individual goods and services, all the items available to us. Table 1 summarizes the findings. For any good and at any horizon that the dataset allows, deviations from the law of one price in a single good can account for the bulk of the real exchange rate fluctuation. This means that associating the prices of any good in our sample with the nominal exchange rate yields a component that accounts for virtually all of the fluctuations in the real exchange rate.

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6 Work by Engel (2002) and by Parsley (2001) show that Engel’s (1999) results apply to many countries and many sources of aggregate price data. So we focus on what is examined most closely by Engel (1999), the Japanese-U.S. exchange rate and consumer prices. The data were obtained from Engel’s web site.

7 Traded and nontraded price indices were constructed as in Engel (1999). We also follow Engel in examining changes in these persistent variables and in setting aside the small, negative correlations between the components. Specifically, the amount of the MSE of \(q_{t+k}-q_t\) accounted for by (say) \(x\) (at horizon \(k\)), is:

\[
\text{MSE}(x_{t+k}-x_t)/\{\text{MSE}(x_{t+k}-x_t)+\text{MSE}(y_{t+k}-y_t)\}.
\]

8 The individual goods and services price data are described in more detail in Parsley and Wei (2001).
Next, we examine the fraction the MSE of the real exchange rate that can be accounted for by a nontraded goods component, as defined in equation 3. Figure 3a presents the results of that decomposition, along with Engel’s decomposition, from equation 1. Specifically, the figure gives the fraction of the MSE attributable to our measure of the nontraded goods portion, $u_t$, and the fraction attributable to Engel’s measure of the traded-goods portion, $x_t$. At nearly all horizons, the nontraded goods’ component can account for nearly all of the fluctuations in the real exchange rate, as can the traded goods’ component.

Either measure can be said to account for the lion’s share of the variability in the real exchange rate. The difference between the two is extremely small and is graphed in Figure 3b. That is, when – as Engel’s paper shows – traded goods are associated with the nominal exchange rate, it is the international price of traded goods that appears to explain real exchange rate variability. In contrast, when nontraded goods are associated with the nominal exchange rate, it is the international price of nontraded goods that appears to explain the variability. Traded and nontraded goods differ only negligibly in their ability to account for fluctuations in the real exchange rate.

Finally, we examine how much of the MSE can be accounted for by the nominal exchange rate alone, as per equation 4. Figure 4 shows the results. At most horizons, the nominal exchange rate accounts for over 85 percent of the real exchange fluctuation. While this fraction is substantial, it is clearly less than can be accounted for if the nominal exchange rate is associated with any good or any set of goods that we examine.

**Conclusion**

Engel (1999) shows that fluctuations in traded goods prices can account for virtually all of the fluctuation in the real exchange rate. Here, we show that the same can be said for virtually any good or set of goods. An individual good or a set of nontraded goods also can account for virtually all of the fluctuation in the real exchange rate. Whichever goods’ prices are associated with the nominal exchange rate seem to account for nearly 100 percent of the real exchange rate’s fluctuations.

We want to emphasize that in all of the decompositions, Engel’s and our own, the second component (the one that excludes the exchange rate) is a difference across countries in relative prices. In terms of equations 1 and 3, it is the difference across countries in the relative prices of traded and nontraded goods. In terms of equation 2, it is the difference across countries in the price of a single good, such as haircuts, relative to all other goods. As stressed by Engel, such international differences change little over time. That is why they explain so little. In this important regard, our results reinforce Engel’s result. No matter how the decomposition is done, we cannot attribute fluctuations in the real exchange rate to international differences in relative prices. Our results illustrate that, in accounting for real exchange rate fluctuations, it is the nominal exchange rate that matters. One cannot stop at saying that the traded goods component can account for most of the fluctuations. The point is that, relative to the role of the nominal exchange rate, the distinction between traded and nontraded goods is utterly unimportant.

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9 Based on the confidence intervals indicated by Engel’s figures, these are indistinguishable.
References


Figure 1
Mean Square Error Decomposition

Horizon (k) in Months
Figure 2: MSE Decomposition
(Contribution of Individual Goods)

2a: Haircuts

2b: Eggs
Figure 3: Mean Square Error Decomposition
Traded Goods and Nontraded Goods

3a: Fraction of MSE of \((q_{t+k} - q_t)\)

3b: Decomposition Difference
Contribution of traded goods component, \(x_t\), less contribution of nontraded goods component, \(u_t\)
Figure 4: MSE Decomposition
Nominal Exchange Rate Contribution
### Table 1: Fraction of Mean Squared Error Attributable to Deviations in the Law of One Price (by good)

<table>
<thead>
<tr>
<th>Good</th>
<th>Horizon in quarters</th>
<th>5</th>
<th>20</th>
<th>35</th>
<th>50</th>
<th>65</th>
<th>80</th>
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<td>Steak</td>
<td></td>
<td>0.9959</td>
<td>0.9986</td>
<td>0.9985</td>
<td>0.9985</td>
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<td>0.9959</td>
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<td>0.9522</td>
<td>0.9965</td>
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<td>Parmesan Cheese</td>
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<td>0.9587</td>
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<td>0.9974</td>
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</table>

Notes: Deviations from the law of one price between Japan and the U.S. were computed using prices observed in Osaka and Houston. The sample period is from 1976.1 to 1997.4. Missing values (“NA”) preclude the MSE decomposition from being computed for all goods for all horizons.