Commodity Currencies

By

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Abstract

Standard exchange rate models cannot explain the high volatility and persistence observed in OECD floating real exchange rates. This paper investigates the determinants of real exchange rate movements by focusing on three OECD economies (Australia, Canada, and New Zealand) where primary commodities constitute a significant share of their exports. Because commodity products are transacted in highly centralized global markets, an exogenous source of terms of trade fluctuations can be identified for these major commodity exporters. For Australia and New Zealand especially, we find that the US dollar price of their commodity exports has a strong and stable influence on their floating real rates, with the magnitude of the effects consistent with predictions of standard theoretical models. However, after controlling for commodity price shocks, there is still a purchasing power parity puzzle in the residual. The results here can offer insight to developing commodity-exporting countries as they liberalize their capital markets and move towards floating exchange rates.

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1. Introduction

The elusive connection between economic fundamentals and exchange rates has been one of the most controversial issues in international finance, manifesting itself in numerous empirical puzzles such as the Meese-Rogoff (1983) forecasting puzzle and the purchasing power parity puzzle. In their comprehensive surveys of the empirical exchange rate literature, Frankel and Rose (1995) and Froot and Rogoff (1995) summarized the various difficulties in empirically relating exchange rate behavior to shocks in macroeconomic fundamentals. More recent research efforts confront these challenges by adopting new focuses such as incorporating non-linearity in modeling exchange rate dynamics.[1] Alternatively, it has also been recognized that if one could find a real shock that were sufficiently volatile, one could potentially go a long way towards resolving these empirical challenges (see Rogoff 1996). For most OECD economies, however, it is difficult to know what that shock might be, much less measure it.[2] In this paper, we focus on three OECD economies where a potential dominant real shock may be identified. While our results by no means overturn the many existing exchange rate puzzles, we find that these bilateral exchange rates do exhibit significant co-movement with world commodity prices, a finding with potentially important policy implications for a broad range of developing countries.[3]

For Australia, Canada, and New Zealand, because primary commodities constitute a significant component of their exports, world commodity price movements – generally exogenous to these small countries for all but a few goods – potentially explain a major component of their terms-of-trade fluctuations.[4] In this paper, we explore the relation between movements in these countries' exchange

[1] Taylor and Peel (2000) and Taylor (2001), among others, explore non-linear exchange rate responses to deviations from economic fundamentals.
[2] Oil prices certainly have sufficient volatility and there is some evidence that they influence the terms of trade (Backus and Crucini, 2000). However, adding these variables to standard monetary equations does not seem to do the trick.
[3] We focus on real exchange rates in this paper. See Chen (2002) for nominal exchange rate behavior in these countries.
[4] Simply incorporating standard measures of terms of trade as an explanatory variable would not be meaningful for most OECD countries (see section 4.2 for further discussion). Our main explanatory variable here is not the terms of trade but a country-specific index of world commodity prices.

rates and the corresponding world price of their commodity exports.[5] We find that for Australia and New Zealand, the connection between exchange rates and commodity prices holds up remarkably well, showing typical commodity price elasticity estimates between 0.5 and 1. This finding is quite robust to alternative assumptions about the underlying time series properties and to the choice of anchor currency. The evidence for Canada, on the other hand, appears more mixed and qualitatively different from that observed in the Antipodes. The Canadian results suggest a long-run cointegrating relation between commodity prices and the real exchange rate, with relatively weak co-movement in the shorter run.[6]

By controlling for this major source of real shocks, one might hope that the standard exchange rate equations – adjusted for commodity prices – might perform better for the commodity currencies than they have been found to perform for the major currencies. However, our results do not offer very strong encouragement for this point of view.

From a policy stand-point, understanding the effects of commodity price shocks on exchange rates should be of considerable interest to developing commodity-exporting countries, particularly as they liberalize capital market controls and adopt more flexible exchange rate regimes. If one can indeed show that commodity prices are a consistent and empirically reliable factor in empirical exchange rate equations, it would have important implications across a variety of policy issues, not least concerning questions such as how best to implement inflation targeting in developing countries.[7] The experiences of these three OECD countries may thus offer valuable lessons on the conduct of monetary and exchange rate policies for developing commodity economies.

[5] Researchers at the Bank of Canada have claimed for many years that not only do their empirical exchange rate equations fit out-of-sample, one can even use variants to successfully predict the exchange rate, both unconditionally and in response to policy alternatives. A key element of the Canadian equation involves augmenting the standard model by a terms-of-trade variable reflecting the volatile movements in world prices of Canadian commodity exports, particularly non-energy commodities. Researchers at the Reserve Bank of Australia have found that over the 1990's, one could have earned a substantial excess profit in trading on the Australian dollar by properly incorporating terms-of-trade movements into exchange rate forecasts. See Amano and van Norden (1993), Gruen and Kortian (1996), and Djoudad, Murray, Chan and Dow (2001).

[6] This likely reflects the de facto moving band exchange rate regime that Canada has operated under for much of the sample period (see Section 3.1 for further discussion).

[7] There has been related work for developing countries that looks at cross-country panel data. For example, Bidarkota and Crucini (2000) find a strong connection between commodity price shocks and the terms of trade,

2. Background and Graphical Evidence

2.1. Background

To better understand the temporal relationship between exchange rates and commodity price shocks, we focus on industrialized economies where internal and external markets operate with relatively little intervention, and where floating exchange rate regimes have been implemented for a sufficiently long period of time.[8] From a macroeconomic perspective, Australia, Canada, and New Zealand are near-perfect examples of such well-developed small open economies. All three are highly integrated into global capital markets and are active participants in international trade. And in terms of monetary and exchange rate policies, they have all been operating under a flexible exchange rate regime for well over a decade. Canada began floating its currency before the collapse of Bretton Woods in 1970, and Australia and New Zealand abandoned their exchange rate pegs in 1983 and 1985 respectively, as part of the economic reform efforts to revitalize their domestic economies. Moreover, around 1990, all three adopted some variant of inflation-targeting monetary policy. (We refer interested readers to Bernanke, Laubach, Mishkin, and Posen, 1998 and Zettelmeyer, 2000 for thorough discussions on the implementation and conduct of inflation-targeting policies in these three countries.)

To varying degrees, all three countries can plausibly be described as "commodity economies", due to the large share of their production and exports accounted for by primary commodity products. For at least the past decade, commodities have maintained a 60% share of Australia's total exports, with wool, wheat, and various metals being examples of its leading exports. In New Zealand, while the share has declined from a hefty two-thirds in the late 1980s, primary commodities continue to account for more than half of its total exports in recent years. By comparison, Canada has a larger and more developed industrial base, though it continues to rely on commodity products such as base metals, forestry products, and crude oil for more than a quarter of its exports. Despite the relatively small size of their overall

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while Mendoza (1995) finds that terms-of-trade shocks account for a significant portion of variation in output in developing countries. See also Kose (2002).

economies, these countries retain a significant share of the global market for a few of their export products. In New Zealand, for instance, over 40 million sheep cohabit with 3.8 million people. Not surprisingly, only 20 percent of its meat production is consumed domestically, and New Zealand supplies close to half of the total world exports of lamb and mutton. Canada similarly dominates the world market in forestry products, and Australia holds significant shares of the global exports in wool and iron ore. However, while each country may have some market power for a few key goods, these countries are, on the whole, price takers in world markets for the vast majority of their commodity exports.

2.2. Graphical Evidence and Data Description

Figures 1a-1c show the value of Australian dollar relative to three reference currencies – the US dollar, the British Pound, and a non-US-dollar currency basket – plotted alongside the world price of Australia's major non-energy commodity exports. The corresponding graphs for Canada and New Zealand are shown in Figures 2 and 3. For all three countries, the sample period starts shortly after their currencies began to float. Real exchange rates are end-of-quarter nominal rates, expressed as the foreign exchange values of the domestic currency, adjusted by the relative CPIs. The non-dollar basket is adopted from the Broad Index of the Federal Reserve. It is a composite of over 30 non-US-dollar currencies, covering all major trading partners of the United States, each weighted by their respective trade shares.[9] By measuring the relevant home currencies against different anchors, especially the Broad Index covering many developing countries, we hope to insulate our analysis from being driven by shocks to the US economy and movements in the US dollar.

The country-specific commodity price indices cover non-energy commodities only, and are geometric averages of the world market prices of the major products produced in each country, weighted

[8] Among other OECD countries, Finland and Norway also export significant amounts of primary commodities (e.g. forestry products for Finland and North Sea oil for Norway). They are excluded from our study because they operated under regulated exchange regimes for much of the past two decades.

[9] It does not matter that the home-country currency appears in our non-dollar index (the New Zealand and Australia weights are zero/very small), since it essentially factors out when we construct the exchange rate of the non-dollar index against the home currency. There is no particular significance to using US trade weights in our analysis; we adopt the Broad Index of the Federal Reserve as a convenient check for the robustness of our results.

by their corresponding domestic production share.[10] Individual real commodity prices are quarterly averaged world market prices in US dollars, deflated by the US CPI. The commodities included in each index and their corresponding weights are provided in the data appendix.

Looking at these sets of graphs, three features especially stand out. First, the correlations between commodity prices and various exchange rates are strikingly apparent. The two series not only appear to mirror each other in movement, the magnitude of their swings are also similar.[11] Secondly, these real exchange rates appear highly persistent and possibly non-stationary, a point we will address in more detail in Section 3. Lastly, the well-documented long-term decline of global commodity prices seems clearly reflected in these country-specific series as well. In the following section, we explore further just how strong and robust the apparent correlations are, and the role common trends (stochastic or not) may play in explaining the co-movements of real exchange rates and commodity prices.

3. Empirical Analysis

While establishing simple correlations seems an appropriate starting point in light of earlier empirical failures, formal empirical analysis cannot avoid addressing the issue of how best to model a small sample of data with near unit root behavior. Our short sample periods simply preclude any meaningful test of stationarity, a well-known problem that has stimulated numerous innovative studies using long-horizon time series or panel data, coupled with new econometric techniques.[12] While many studies provide support for the view that real exchange rates do mean revert (possibly following nonlinear

[10] We focus on non-energy commodities because these countries are not obvious large net exporters of energy commodities as they are with non-energy ones. In addition, non-economic causes, such as international security concerns, often contribute to both global energy price and currency fluctuations and are likely to complicate interpretations. This may potentially explain in part why higher energy prices, at times, appear to lead to a depreciation of the home currency relative to the US dollar, a safe-haven currency (see Appendix Table A.1).

[11] Appendix Table 1 in Chen and Rogoff (2002) reports the regression coefficients between the series plotted in these figures. The commodity price elasticity estimates for various bilateral real exchange rates appear remarkably similar in magnitude (around 0.5).

[12] Tests of unit roots or cointegration have little statistical power in short time series. In fact, as discussed in Engel (2000): Blough (1992), Cochrane (1991), and Faust (1996) point out that a stationary process can always be arbitrarily well approximated by a non-stationary process in finite samples (and vice versa).

dynamics), others have called into questions the statistical validity of some of these conclusions.[13] Engel (2000), for example, states that rejection of the unit-root null in long horizon real exchange rate data may be the result of size distortions. One might also argue that even though most real rates appear to be stationary, the commodity currencies might be an exception if commodity prices themselves have unit roots. However, this does not appear to be the case empirically (see Borensztein and Reinhart (1994); Bleaney (1996); and Cashin, Liang and McDermott (2000)). Moreover, even if commodity prices do have a unit root, it does not necessarily imply that real exchange rates do too. Over the very long run, countries can substitute out of commodity production into manufacturing if the relative price of commodities drifts too low. For example, Korea today exports primarily manufactured goods, but in 1960, almost 90% of its exports were in primary commodity products. Similarly, Finland was much more susceptible to devaluation pressure induced by downward swings in the world price of forestry products prior to the emergence of its Nokia-powered manufacturing economy.

Although there are both theoretical arguments and empirical evidence supporting the view that real exchange rates and commodity prices may be stationary, we recognize that the debate is far from settled. As such, we consider below several alternative underlying data-generating processes, both I(0) and I(1), as robustness checks for our results. We find that for Australia and New Zealand, the connection between their real exchange rates and the world price of their commodity exports is quite strong and stable (whether or not we exclude unit roots). In contrast, the link between the two variables for Canada appears to be primarily a long term cointegrating relationship, and is thus much more sensitive to detrending. We examine the stability of these parameter estimates in Section 3.2.

3.1. Trends, Serial Correlations, and Non-Stationarity

The first column of Tables 1a-1c presents simple OLS estimates for the commodity price elasticity of real exchange rate by country, capturing the simple correlation between the series. Since

[13] Froot and Rogoff (1995)'s survey ofhm the literature concludes that the half-life of real exchange rate shocks in linear models is roughly 3-4 years across a wide variety of historical data. Culver and Papell (1999) find evidence of mean reversion for most industrialized countries' real exchange rates. In addition, using a century of annual data,

results based on different anchor currencies are similar, only results for the US dollar rates are reported. Here we observe similarity in the estimates across the three countries.

As evident from the figures, world commodity prices evolve over time with a clear downward trend. The trend may be stochastic or deterministic, and it is possible that real exchange rates also share this trend. We next consider these different possibilities as robustness checks for the exchange rate-commodity price connection. The second column in the tables reports elasticity estimates using linearly-filtered data, treating the series as trend stationary. (These results are robust to alternative detrending methods such as Hodrick-Prescott filtering and first-differencing.) For Australia and New Zealand, we note that the estimates show up slightly higher but are in general consistent with those obtained without a time trend. For Canada, however, the positive correlation between commodity price and exchange rate does not appear to survive detrending, an issue we will discuss below. The Durbin-Watson statistics in these regressions indicate that substantial positive serial correlations remain in the residuals, even after detrending. Leaving its economic implication to Section 6, here we address alternative methods for correcting the biased standard error estimates. For the majority of the analysis in this paper, the kernel-based nonparametric GMM estimator of Newey-West (1987) is used to account for the serial correlation. Because such non-parametric estimators have poor small sample properties, the third column in Tables 1a-1c presents estimation results using an alternative parametric specification: the error terms are assumed to follow a first order autoregressive process. The AR(1) specifications produce slightly lower coefficients, yet still give estimates consistent with earlier findings.

If real exchange rates and commodity prices follow non-stationary processes, the estimates and hypothesis tests performed so far, based on classical statistical methods, would be invalid. Therefore, as a further robustness check, we consider the case where the series have unit roots. Under the assumption that exchange rates and commodity prices are I(1) processes and share a common stochastic trend (that they are cointegrated), the dynamic OLS (DOLS) procedure proposed by Stock and Watson (1993)

Bleaney (1996) demonstrates that the trade-weighted Australian real exchange rate and the world price of primary commodities (relative to that of manufacturing), are both trend-stationary.

produces efficient estimates for the cointegrating vectors. Alternatively, if the two series are non-stationary but *not* cointegrated, the estimation should then be done in first-differences to avoid spurious regression. The last two columns in Tables 1a-1c report results from the DOLS and the first differenced specifications.[14] Note that for Australia and New Zealand, both specifications produce estimates that are close to those obtained under the assumption of a deterministic trend.[15] For Canada, on the other hand, the commodity price term shows up as significant only under DOLS, suggesting a common long-run trend between the Canadian dollar and its commodity export prices, but perhaps not much more. This lack of shorter-run co-movement points to qualitative differences between the Canadian results and the robust connections observed in the Down Under countries. This may in part reflect Canada's de facto exchange rate policy over much of its floating rate period, which Reinhart and Rogoff (2002) described as maintaining a moving band around the US dollar. It may also be due to Canada's ambiguous status as a "true commodity economy." After all, commodities are the minority of its export base, especially compared to the cases of New Zealand and Australia.[16] In addition, the possibility of structural breaks occurring somewhere during the thirty-year period that we study is certainly another confounding factor.[17] We turn to this issue next.

3.2. Parameter Stability

Rather than testing for structural breaks using all the possible data generating processes discussed above, we focus on the trend-stationary case in this section, as it is where the Canadian result may become significant. Because we are interested in possible shifts in the commodity price elasticities but

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[14] For DOLS, we experimented with including longer leads and lags of the differenced commodity price terms, and the estimation results are qualitatively similar. We are aware of the inference problem put forth by Elliott (1998) that applying cointegration methods on local-to-unit root processes may introduce biases and inefficiencies. Here, we are simply using it as a robustness check. For the same reason, we did not explore other possible specifications with higher order distributed lag structures in the first differenced specification.

[15] Asymptotically, the Stock-Watson DOLS procedure yields the same parameter estimates as conventional OLS, but this may not be the case in finite samples.

[16] While we focus here on non-energy commodities only, in gross terms at least, Canada is a significant exporter of energy products.

[17] Indeed, looking at the Canadian-US exchange rate post-1985 only (a sample period comparable to those used for Australia and New Zealand), we obtain significant positive coefficient estimates of around 0.3 under both the linear and the HP filters. However, unlike the robustness we observed in the Australian and New Zealand estimates, the significance of the estimates disappears when the Canadian rate is measured relative to other anchor currencies.

not so much in instability in the underlying time trends, we use HP-filtered variables for this analysis. Table 2 presents results from the classic Chow test on pre-selected potential breakpoints and the Hansen (1992) test for structural breaks of unknown timing. (The Hansen procedure is approximately the Lagrange multiplier test for the null of constant parameters, against the alternative of structural breaks of unknown timing and/or random walk parameters.[18])

As discussed in Hansen (1992), because pre-selected candidate breakpoints are often endogenous, the Chow test is likely to falsely indicate a break when, in fact, none exists. In our analysis, the candidate break-dates are chosen to be the year each of these countries adopted formal inflation targets (1990 for New Zealand, 1991 for Canada, and 1993 for Australia). It is easy to make a case that these regime shifts were endogenous. Nevertheless, the coefficients on the time dummies in the Chow test provide little indication of parameter shifts pre- and post-inflation targeting, despite a likely bias toward doing so. Similarly, the Hansen procedure provides no strong indication of parameter instability over the full sample periods. The conclusion we draw from these tests is that, while there may have been some parameter shifts over time, the general sign and magnitude of the coefficients are notably stable for this kind of data.

Given the stability of the elasticity estimates, it is natural to explore the out-of-sample forecast performance of the commodity-price-augmented exchange rate equations. Here, rather than presenting the results, we refer the readers to an earlier version of this paper which contains a brief discussion as well as simple forecast outcomes (Chen and Rogoff 2002). In addition, Chen (2002), focusing on nominal exchange rate determination, investigates the forecast performance of various commodity-price-augmented nominal exchange rate models. These studies show that while commodity prices may help predict future exchange rate movements under certain model specifications, the results are far from robust.

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[18] The particular version of the Hansen test we employ does require stationary regressors, or else a different distributional theory applies. So the results are valid only under the assumption that our series are trend-stationary. We also note that the Hansen test relies on asymptotic properties that our small sample size may not adequately satisfy.

4. Possible Misspecifications [19]

4.1. Endogeneity of Commodity Prices

We have thus far treated commodity prices as exogenous in our stationary specifications. In this section, we consider possible channels of endogeneity that could potentially bias the estimates, and show that they are not likely to be dominating our results.

One source of endogeneity can operate through the market power these countries may hold in the world commodity markets. For instance, since New Zealand controls a near majority of the global sheep market, the world price of sheep may be significantly influenced by the value of the New Zealand dollar. To address this potential form of endogeneity, we use a broader "world commodity price index" as an instrument for the country production-weighted price index that we have been using in previous specifications.[20] The world commodity price index is the "non-fuel primary commodity price index" from the IMF, and contains the US dollar prices of about 40 globally traded commodities, each weighted by their 1987-98 average world export earnings.

Table 3 compares GMM-IV regression estimates with their uninstrumented OLS counterparts. As evident from the high first-stage R-squares, the overall world commodity price index works well as an instrument for the country-specific prices, and the IV estimations corroborate the least-squares findings. Namely, for Australia and New Zealand, world commodity price movements are associated with large and significant real exchange rate responses, while the evidence for Canada is weak in trend-stationary setups. Over the sample period where the world price index is available (from 1980Q1 onward), the commodity price elasticity for the Canadian dollar is estimated to be significant in the OLS specification, even with the inclusion of a time trend. However, this result is not robust to either the instrumental

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[19] This section takes the view that real exchange rates and commodity prices are trend stationary. Endogeneity bias is, of course, not an issue in a cointegration framework.

[20] We want to reiterate the point that despite having significant market power in a few commodities, these three countries are relatively small in the *overall* global commodity market. In 1999, for example, Australian exports amounted to less than 5 percent of total world commodity exports, Canada represented about 9 percent, and New Zealand 1 percent. (For non-energy commodities only, the shares were 6.7%, 10%, and 1.6% respectively.) In

variable approach or the use of other anchor currencies. Overall, the consistency between the OLS and the IV estimations supports the view that while these countries may occupy a significant share of the market in a few specific commodity products, due to the size of their overall economies and to the availability of close substitutes for these products, they do not hold much actual market power to influence world prices.

Another potential source of bias may arise from omitted variables related to industrial cycles and shocks in the United States or in the global economy, which may affect both the commodity and the exchange rate markets independently. For example, a broad boom outside of Australia would drive up commodity prices and simultaneously exert pressure on the Australian exchange rate. We note, however, that most models would predict that this independent effect (from high world growth relative to Australian growth) should tend to *depreciate* rather than appreciate the Australian currency. So, the fact that our coefficient estimates are consistently positive and of similar magnitudes across currency pairings, at least for Australia and New Zealand, tends to allay concerns over this source of bias.

4.2. Commodity Prices and the Terms of Trade

Certainly there have been other studies that incorporate terms-of-trade shocks into empirical exchange rate estimations, generally by using movements in the overall export-to-import price ratio (or variants thereof). However, the presence of sluggish nominal price adjustments and incomplete pass-through typically make proper identification close to impossible when the standard measures of terms of trade, rather than the exogenous commodity prices as we have here, are used directly. For example, with sticky producer prices and perfect pass-through, terms of trade and real exchange rates will move one-to-one mechanically with no causal interpretation. The same is true when all goods are priced in local currencies, though the correlation will be of the opposite sign. When a mixture of the two pricing behaviors co-exists, any sign is possible, and the dynamics are likely to be complex (see Obstfeld-Rogoff 2000). In addition, these rigidities prevent standard terms-of-trade measures from adequately

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addition, substitution across similar commodity products further mitigates the market power these countries have, even within the specific markets that they appear to dominate.

incorporating contemporaneous shocks that would induce immediate exchange rate responses. For commodity exporters, because commodity trading is conducted mostly in a few global exchange markets using US dollars, world commodity price fluctuations are not subject to these identification problems and can better capture exogenous shocks to these countries' terms of trade. Results presented in Table 4 support this view. From the OLS regressions, we see that, again with Canada being the exception, the terms of trade – measured as the export to import price ratio – appear strongly correlated with the real exchange rates. Of course, a significant portion of this correlation may be due to price stickiness, so that the terms of trade variable would not be exogenous. To address this endogeneity problem, we use country-specific price indices of both energy and non-energy commodities as instruments for terms of trade. We see that for New Zealand, even though over half of its exports are commodities, the standard terms-of-trade measure responds little to movements in world commodity prices, as evident from the low Wald statistic in the first-stage regression.[21] For Australia, despite valid first-stage regression results connecting terms-of-trade movements to commodity prices, the Hansen (1982) J-test suggests that the instruments are not orthogonal to the second-stage residuals.[22] We take both of these findings as support that world commodity prices appear much better at capturing exogenous terms-of-trade shocks for these countries than do standard measures of terms of trade.

5. A Structural Interpretation of the Coefficients

Given the remarkable consistency in the estimated sign and size of the commodity price elasticity we observe in these real exchange rates, it is worth briefly considering the predictions of simple theoretical models. Below we will look at a flexible price model (reflecting longer-run equilibrium) and one with sticky prices.

First, consider the following extension of the flexible-price Belassa-Samuelson model. Let Home be a small economy whose agents consume three goods – non-traded goods, exports, and imports – but

[21] The coefficients for the energy and non-energy commodity price indices individually are not significantly different from zero either.

produce only the first two. Assume that labor is perfectly mobile across industries, and that physical capital can be freely imported from abroad at real interest rate r, measured in importables. The production function for exportables is $y_X = A_X f(k_X)$, where y and k are output and capital per unit labor, respectively, and $y_N = A_N f(k_N)$, is the analogous function for nontraded goods production. Let p_X be the world price of exportables, which is given exogenously to the small country, and p_N be the Home price of non-traded goods, both measured in terms of importables. Then, assuming that labor mobility leads to common wages across the two Home industries, one can derive the approximate relation:

$$\hat{p}_N = \left(\frac{\mu_{LN}}{\mu_{LX}}\right)\left(\hat{A}_X + \hat{p}_X\right) - \hat{A}_N$$

where a "hat" above a variable represents a logarithmic derivative, and μ_{LN} and μ_{LX} are labor's income share in the non-traded and export goods sectors, respectively. Thus, the effect of a rise in the relative price of exportables is the same as a rise in traded goods productivity in the standard Belassa-Samuelson model. The impact on the real exchange rate depends, of course, on the utility function. Assume a simple logarithmic (unit-elastic) utility function: $U = C_N^{\alpha} C_I^{\beta} C_X^{(1-\alpha-\beta)}$. Normalizing the price of importables to one, the consumption-based consumer price index is then given by $p_N^{\alpha} p_X^{(1-\alpha-\beta)}$. Therefore, as $\hat{p}_N$ moves proportionately in response to $\hat{p}_X$, the effect of an export price shock on the utility-based real CPI is then given by $\hat{p}_X^{(1\text{-}\beta)}$. Assuming that importables account for *25*% of consumption, the elasticity of the CPI with respect to a unit change in the price of exportables would be *0.75*, which is broadly consistent with our estimated coefficients. (If $\mu_{LN} > \mu_{LX}$ – it is standard to assume that non-traded goods production is more labor intensive – one would get a larger effect).

What if the price of non-traded goods is sticky? Assuming that export prices are flexible with complete pass-through, a simple model of optimal monetary policy would require the exchange rate to

[22] Commodity prices may of course be a valid instrument for terms of trade in other specifications, such as ones that incorporate more complex dynamics to reflect the slow adjustment of nominal prices.

accommodate the requisite rise in the relative price of non-traded goods.[23] This implies that the exchange rate should adjust one-for-one with changes in the world price of exportables. If there are nominal rigidities in the export market as well, then a larger change in the exchange rate would be needed. Of course, if the central bank is mechanically trying to stabilize CPI inflation and its rule does not allow any offset for export price shocks, then the authorities would not allow the nominal exchange rate to move by the amount required to mimic the flexible-price equilibrium, but instead only by a smaller amount.

In all of these cases, the empirical coefficients of 0.5 to 1 that we observe appear consistent with model predictions.

6. Empirical Exchange Rate Puzzles

Given the robust connection we find between world commodity price movements and real exchange rate behavior in these commodity economies, we next investigate what incorporating this new shock may imply for standard exchange rate models as well as for the difficulty these models have in explaining empirical exchange rate behavior.[24] In the context of real exchange rates, the failure of standard models is evident from their inability to reconcile the extremely slow pace at which deviations from PPP seem to die out with the enormous short-term volatility observed, the so-called PPP puzzle.[25] The success of our univariate regressions suggests that in commodity economies, because an additional shock that is both very volatile and persistent can be identified, the PPP puzzle may not manifest once we control for commodity price fluctuations. In this section, we explore whether commodity prices, together with cross-country differentials in relative traded-non-traded sector productivity, can sufficiently explain the persistence in real exchange rates so as to allow standard monetary variables to account for the

[23] Here we assume that optimal monetary policy is to replicate the flexible price equilibrium. This condition holds only under certain arguably restrictive assumptions about the economy. As we are interested mainly in obtaining a rough benchmark magnitude for the exchange rate response to export price shocks, we ignore issues such as incomplete risk sharing, mark-up adjustment, and other elements commonly considered in the New Open Economy Macroeconomics literature.
[24] See Frankel and Rose (1995) for example.
[25] As exposited in Rogoff (1996), conventional shocks to the real economy such as taste or technology shocks, while capable of generating slow adjustment, are simply not volatile enough to account for the short-term variation in exchange rates. Models based on monetary or financial shocks may explain this short-term volatility, but the long

remaining shorter-term variations. Although these two real shocks are found to be strong and consistent explanatory variables in exchange rate equations, examining the degree of persistence that remains in real exchange rate residuals, we see that commodity prices are no deus ex machina.[26] That is, its introduction does not otherwise resurrect the monetary approach to exchange rate, at least from an empirical perspective.[27]

6.1. Traded -Non-Traded Productivity Differential

As discussed in Section 5, the Balassa-Samuelson model predicts that country differences in the relative traded to non-traded sector productivity may affect real exchange rates through their impact on relative wages. Figure 4 plots the Australian and New Zealand real exchange rates along with the home country traded versus non-traded sector productivity ratio relative to that of the United States.[28] (Canada is excluded because the productivity data were not available.) Results reported in Table 5 corroborate the correlations observed in the graphs and show that the magnitudes of the estimated coefficients are in general consistent with the Balassa-Samuelson framework.

6.2. The Nagging Persistence

We employ two different methods to examine the degree of persistence in real exchange rates. First, we assume real exchange rate shocks follow an AR(1) process and focus on the magnitude of the autoregressive coefficients.[29] In addition, we consider the case where commodity prices and real exchange rates may be cointegrated, and model the adjustment process in an error correction framework. The results in Table 6 show that the two approaches give us consistent pictures of how persistent shocks

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half-lives of shocks observed in the data are incompatible with the concept of long-run monetary neutrality under these models.

[26] Here we ignore the possibility of non-linear adjustment to PPP but focus on linear models.

[27] Indeed, incorporating commodity prices into standard monetary-type regressions only underscores the "fickleness" of standard models documented in the literature, and provides little support for a commodity-price-augmented Dornbusch model. This section looks why monetary fundamentals in the standard models may be inappropriate in explaining the remaining variation in our augmented exchange rate equations.

[28] We were unable to obtain matching productivity measures across countries, but they are consistent across sectors within a country. This is not ideal, but as we look at differences in within-country productivity ratios, we think the inconsistency is not a serious problem. See Data Appendix for further details.

[29] See Froot and Rogoff (1995) and Rogoff (1996) for discussions of previous literature using this specification and other variants. There are certainly alternative methods for measuring exchange rate persistence. However, our small sample sizes preclude meaningful analysis with richer dynamics.

to PPP are, or how slowly real exchange rates adjust towards their long-run (cointegrating) equilibria.[30] We note that the OLS estimates of the AR roots are well known to have substantial bias, especially when the autocorrelation is close to unity and the sample size is small (see, for example, Mark 2001 and Murray and Papell 2002). Work by Andrews (1993) and Fair (1996), among others, examines this bias extensively and proposes variants of median-unbiased estimators as corrections. More importantly for our purposes, the direction of the bias has been demonstrated to be downward towards zero.[31] As evident from Table 6, after controlling for commodity price shocks and productivity shocks, exchange rate residuals still exhibit an extremely high degree of persistence, even according to the downward biased estimates.[32] Similarly, the error correction framework shows very slow quarterly re-adjustments towards the long-run equilibrium relationships. As the implied half-lives from these coefficients are far longer than one can justify if the main source of the remaining shocks is monetary, it is no surprise that we see little empirical support for commodity-price-augmented standard monetary equations. Hence, we find the PPP puzzle to be like Ukrainian dolls, in that after controlling for *two* promising real shocks – removing two layers of the original PPP puzzle – we are still faced with an identical, though smaller, PPP puzzle.

7. Conclusion

In a literature largely populated by negative findings and empirical puzzles, this paper identifies a source of exogenous shocks and explores its contribution to time series exchange rate behavior, and more broadly, to standard exchange rate models. The world prices of commodity exports, measured in real US dollars, do appear to have a strong and stable influence on the real exchange rates of New Zealand and

[30] Due to space constraints, the AR root estimates for real exchange rates alone are omitted from this table. They are similar to the values shown here (see Chen and Rogoff 2002).

[31] As discussed in Murray and Papell (2002), the LS bias is always downward in the AR(1) model. For higher-order AR specifications, the high degree of persistence observed in real exchange rates should also be sufficient to ensure downward biases. Of course, the precision of these point estimates is another thorny issue. We recognize that the confidence intervals, which can be constructed via various bootstrap methods, are likely to be extremely wide; however, this is a limitation of analysis based on small sample sizes like the ones we have.

[32] We also examined the adjustment dynamics of real exchange rates through impulse response analysis, allowing for possible higher order autocorrelation structures, hence potential non-monotonic responses to shocks (See Cheung and Lai (2000) or Murray and Papell (2002)). The dynamic response patterns show that incorporating higher order

Australia. For Canada, the relationship is somewhat less robust, especially to de-trending. Thus, despite the fact that these countries had open capital markets and free floating exchange rates over the sample period, one can identify an important real explanatory variable. Moreover, the quantitative size of the coefficient is broadly consistent with the predictions of standard theoretical models of optimal monetary policy.

Although Australia, Canada and New Zealand are fairly atypical among OECD countries, commodity price shocks (both export and import) have long been recognized as being of great importance to many developing countries that rely heavily on primary commodity production. The experiences of Australia, Canada, and New Zealand are of particular relevance as many of these developing countries liberalize their capital markets and move towards floating exchange rate systems. While this paper covers mainly the empirical links, understanding exchange rate responses to world commodity price shocks can provide important information for a broad range of policy issues, including especially the conduct of monetary policy and inflation control.

AR terms do not significantly alter the persistence of shocks obtained under the AR(1) specifications. We note again that these persistence estimates are extremely imprecise, given our small sample size.

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Data Appendix:

Real Exchange Rates:

- Real exchange rates are end-of-period nominal rates adjusted by the consumer price indices (CPIs) of the relevant countries. Nominal exchange rate and CPI data are taken from the International Financial Statistics (IFS) of the IMF. To construct the real rates relative to the non-US dollar basket, we use the Broad Index (real) published by the Federal Reserve and the bilateral real rates against the US dollar. The Broad Index measures the foreign exchange value of the US dollar relative to the currencies of a large group of US trading partners.

Terms of Trade:

- Country-specific export and import price indices are provided by the Bank of Canada, the Reserve Bank of Australia, and the Reserve Bank of New Zealand.

Relative Productivity of Traded-to-Non-Traded Sectors:

- For Australia, real output per hours of work in the traded and the non-traded components of the market-sector economy are used. The market sector makes up about two-thirds of the overall Australian economy. Industries are classified as traded or non-traded based on their export and/or import intensity. Traded sectors include agriculture, forestry etc; mining; manufacturing (except wood and paper, printing and publishing, and non-metallic minerals); air transport; and water transport. Non-traded sectors include wood and paper products, printing and publishing, non-metallic minerals, utilities, construction, wholesale trade, retail trade, accommodation etc, road transport, rail and pipelines, transport services and storage, communications, finance and insurance, and cultural and recreational services. The data are provided by the Reserve Bank of Australia.

- For New Zealand, productivity is defined as seasonally adjusted GDP relative to the number of people employed, based on the Household Labor Force Survey. Traded sectors include agriculture, hunting, fishing & forestry; manufacturing; and mining and quarrying. Non-traded sectors include building and construction; business and financial services; community, social, and personal services; electricity, gas, and water; transport, storage, and communication; wholesale and retail trade; and others. The data are provided by the Reserve Bank of New Zealand.

- For the United States, the productivity measure is constructed using quarterly NIPA real GDP and BLS worker-hours. Goods-producing sectors are taken as traded, and service-producing sectors non-traded.

Commodity Prices:

- The country-specific commodity export price index is constructed by geometrically weighting the world market prices in US dollar of each country's major commodity exports. The weights, adopted from Djoudad, Murray, Chan, and Daw (2001), are the average home production value of each commodity over the 1982-90 period (see Appendix Table A.2). We note that some commodities are excluded from the original Djoudad et al indices, as we were unable to update the price series
- The world price index of all non-energy commodities is the "non-fuel primary commodity price index" of the IMF. It comprises the US dollar prices of about 40 globally traded commodities, each weighted by their 1987-98 average world export earnings.
- The world market prices of individual commodities are taken from sources listed in Appendix Tables A.2 and A.3. They are the quarterly average spot or cash prices in US dollars. These commodities are traded in different markets, including NYMEX, IPE, CBT, CME, KCB, ASX and SFE, and the prices are considered "world prices".

Table 1: US Dollar Real Exchange Rates and Commodity Prices:

Different Assumptions on the Data Generating Processes

a: Australia

	No Trend	I(0)/Deterministic Trends		I(1)/Stochastic Trends	
	OLS + Newey-West S.E.	Linear Trend + Newey-West S.E.	Linear Trend + AR(1) Residuals	Cointegration: Dynamic OLS [1]	Non-Cointegration: 1st Differencing
Real Non-Energy Commodity Prices	0.40 * (0.08)	0.81* (0.12)	0.54 * (0.14)	0.39 * (t = 6.19)	0.47 * (0.14)
Durbin-Watson	0.24	0.36			
Adj. R^2	0.39	0.57	0.86	0.36	0.07
Sample Period	1984Q1 – 2001Q2				
N Obs.	70				

b: Canada

	No Trend	I(0)/Deterministic Trends		I(1)/Stochastic Trends	
	OLS + Newey-West S.E.	Linear Trend + Newey-West S.E.	Linear Trend + AR(1) Residuals	Cointegration: Dynamic OLS	Non-Cointegration: 1st Differencing
Real Non-Energy Commodity Prices	0.40 * (0.07)	0.21 (0.15)	0.04 (0.07)	0.40 * (t = 11.94)	0.05 (0.06)
Durbin-Watson	0.11	0.10			
Adj. R^2	0.56	0.06	0.96	0.56	-0.00
Sample Period	1973Q1 - 2001Q2				
N Obs.	114				

c: New Zealand

	No Trend	I(0)/Deterministic Trends		I(1)/Stochastic Trends	
	OLS + Newey-West S.E.	Linear Trend + Newey-West S.E.	Linear Trend + AR(1) Residuals	Cointegration: Dynamic OLS	Non-Cointegration: 1st Differencing
Real Non-Energy Commodity Prices	0.53 * (0.17)	1.10 * (0.23)	0.51 * (0.21)	0.58 * (t = 6.17)	0.59 * (0.26)
Durbin-Watson	0.15	0.19			
Adj. R^2	0.30	0.37	0.90	0.40	0.10
Sample Period	1986Q1 - 2001Q2				
N Obs.	62				

Note: The dependent variables are the real CPI exchange rate relative to the US dollar. All variables are in logs. A * indicates significance at the 5% level. Newey-West heteroskedasticity and autocorrelation consistent (HAC) standard errors are reported in parentheses (except in the AR(1) and the cointegration specifications).

1. One lead and lag of the first-differenced commodity price term are included in the DOLS regressions.

Table 2: Chow and Hansen Parameter Stability Tests using Hodrick-Prescott Filtered Data

	Australia		Canada		New Zealand	
	OLS + Hansen Test	OLS + Break Dummy	OLS + Hansen Test	OLS + Break Dummy	OLS + Hansen Test	OLS + Break Dummy
Real Non-Energy Commodity Prices: β	0.58 * (0.12)	0.60 * (0.15)	0.09 (0.07)	0.13 (0.09)	0.72 * (0.20)	1.23 * (0.45)
Dummy * Real Non-Energy Commodity Prices: γ		-0.05 (0.26)		-0.09 (0.13)		-0.66 (0.50)
Breakpoint [1]		1993Q1		1991Q1		1990Q1
Hansen Statistics [2]	0.49 *		0.38		0.47*	
Adj. R^2	0.37	0.36	0.03	0.02	0.25	0.26
N Obs.	70		114		62	
Sample Period	1984Q1 - 2001Q2		1973Q1 - 2001Q2		1986Q1 - 2001Q2	

Note: A * indicates significance at the 5% level. Newey-West heteroskedasticity and autocorrelation consistent (HAC) standard errors are reported in the parentheses.

1. The specification for the Chow test is: HP-Filtered ln(Real Exchange Rate)$_t$ = $\alpha + d_t + (\beta + \gamma^* d_t)^*$ HP-Filtered ln(Real Commodity Price)$_t$ + ε_t, where $d_t = 1$ if $t \geq$ Breakpoint and $d_t = 0$ otherwise. Breakpoints are selected as the starting year for the use of formal inflation targets in each country.

2. The 5% asymptotic critical value for the Hansen individual parameter test is 0.47 (see Hansen 1992, Table 1).

Table 3: Representative Instrumental Variable Estimations

$\ln(\text{Real Exchange Rate})_t = \alpha + \beta^* t + \gamma^* \ln(\text{Real Commodity Price})_t + \varepsilon_t$

	Australia		Canada		New Zealand	
	OLS	GMM IV [1]: World Commodity Price[2]	OLS	GMM IV: World Commodity Price	OLS	GMM IV: World Commodity Price
Real Non-Energy Commodity Prices	0.81 * (0.12)	0.90 * (0.17)	0.24 * (0.09)	0.10 (0.21)	1.10 * (0.23)	2.29 * (0.64)
OLS: Adj. R^2 IV: 1st Stage R^2	0.57	0.94	0.37	0.89	0.37	0.92
N Obs.	70		85		62	
Sample Period	1984Q1 – 2001Q2		1980Q1 – 2001Q1 [3]		1986Q1 – 2001Q2	

Note: A * indicates significance at the 5% level. Newey-West heteroskedasticity and autocorrelation consistent (HAC) standard errors are reported in the parentheses.

1. Instrumental variable estimations are performed under 2SLS with GMM standard errors, using Bartlett kernel and variable Newey-West bandwidth.
2. The world commodity price index is used as an instrument for the country-specific commodity price in the IV specifications. The world price index is the "non-fuel primary commodity price index" of the IMF. It contains the US dollar prices of about 40 globally traded commodities, weighted by their 1987-98 average world export earnings.
3. The Canadian sample here is limited to 1980Q1 to 2001Q1, the period over which world commodity price data is available.

Table 4: Real Exchange Rates, Terms of Trade, and Commodity Prices

$\ln(\text{Real Exchange Rate})_t = \alpha + \beta{*}t + \gamma{*}\ln(\text{Terms of Trade})_t + \varepsilon_t$

	Australia		Canada		New Zealand	
	OLS	GMM IV: Commodity Prices [1]	OLS	GMM IV: Commodity Prices	OLS	GMM IV: Commodity Prices
Terms of Trade	0.73* (0.33)	1.40 * (0.60)	-0.04 (0.20)	0.54 (0.46)	1.01 * (0.50)	3.41 (2.44)
OLS: Adj. R^2	0.16		0.58		0.23	
IV: 1st Stage Wald		p-value = 0.00		p-value = 0.00		p-value = 0.16
IV: Over ID J-stats [2]		p-value = 0.01		p-value = 0.07		p-value = 0.08
N Obs.	70		118		62	
Sample Period	1984Q1 – 2001Q2		1972Q1 – 2001Q1		1986Q1 – 2001Q2	

Note: A * indicates significance at the 5% level. Newey-West heteroskedasticity and autocorrelation consistent (HAC) standard errors are reported in the parentheses.

1. Instrumental variable estimations are performed under 2SLS with GMM standard errors, using Bartlett kernel and variable Newey-West bandwidth. Country-specific energy and non-energy commodity price indices are both used as instruments.
2. The J-statistics of Hansen (1982) test the null hypothesis that the GMM over-identification restrictions are satisfied.

Table 5: Traded and Non-Traded Productivity Differentials and Real Exchange Rates [1]

$\ln(\text{Real Exchange Rate})_t = \alpha + \beta * t + \gamma_1 * \ln(\text{Real Commodity Price})_t + \gamma_2 * [\ln(\text{Traded/ Non-Traded Productivity})$ of Home relative to the US$]_t + \varepsilon_t$

	Australia		New Zealand	
	OLS + Newey-West	GMM IV: World Comm Price [2]	OLS + Newey-West	GMM IV: World Comm Price
Real Non-Energy Commodity Prices	0.75 * (0.10)	0.86 * (0.15)	1.09 * (0.29)	2.16 * (0.56)
Traded- Non-Traded Prod. Diff	0.87 * (0.29)	0.83 * (0.34)	0.90 * (0.38)	0.87 * (0.43)
Adj. R^2	0.66		0.44	
1^{st} Stage R^2		0.95		0.92
	67		62	
Sample Period	1984Q4 - 2001Q2		1986Q1 - 2001Q2	

Note: A * indicates significance at the 5% level. Newey-West heteroskedasticity and autocorrelation consistent (HAC) standard errors are reported in the parentheses.

1. Canada is not included in this analysis because we were unable to obtain the appropriate productivity data.
2. Instrumental variable estimations are performed under 2SLS with GMM standard errors, using Bartlett kernel and variable Newey-West bandwidth. The IMF world commodity price index is used as an instrument for the country-specific commodity price index.

Table 6: Persistence in the Real Exchange Rates in AR(1) and Error Correction Frameworks [1]

	Australia				Canada		New Zealand			
	AR(1)	AR(1) w/ Prod	EC	EC w/ Prod	AR(1)	EC	AR(1)	AR(1) w/ Prod	EC	EC w/ Prod
Real Non-Energy Commodity Prices	0.54 * (0.14)	0.56 * (0.20)	0.64 * (0.25)	0.54 * (0.27)	0.04 (0.08)	0.56* (0.25)	0.51 * (0.21)	0.53 * (0.20)	1.33 * (0.58)	1.72 (0.91)
Traded-Non-Traded Productivity Differentials		-0.03 (0.15)		0.61 (0.69)				0.14 (0.17)		-0.66 (0.83)
AR(1) root [2]	0.88 * (0.05)	0.89 * (0.05)			0.96 * (0.03)		0.95 * (0.05)	0.95 * (0.05)		
Error Correction			-0.13 * (0.04)	-0.13 * (0.05)		-0.04 (0.03)			-0.11 * (0.05)	-0.11 * (0.05)
Adj. R^2	0.86	0.86	0.05	0.07	0.95	0.01	0.90	0.90	0.11	0.10
	70				113		62			
Sample Period	1984Q1 – 2001Q2				1973Q1 - 2001Q2		1986Q1 - 2001Q2			

Note: A * indicates significance at the 5% level.

1. The dependent variable is the real exchange rate relative to the US dollar. All variables are in logs. A time trend is included in the AR(1) specifications. The error correction coefficients show the quarterly adjustments of exchange rates to previous period deviations from their long-run values implied by commodity prices, or commodity prices together with the productivity differentials.
2. The AR root estimates in this table are downward biased (towards zero); see text for discussion.

Appendix Tables:

Table A.1

Commodity Price Elasticities of Real Exchange Rates relative to Different Anchor Currencies

$\ln(\text{Real Exchange Rate})_t = \alpha + \beta*\ln(\text{Real Commodity Price})_t + \varepsilon_t$

	Australia			Canada			New Zealand		
National Currency	vs. US Dollar	vs. British Pound	vs. Non-Dollar Basket [1]	vs. US Dollar	vs. British Pound	vs. Non-Dollar Basket	vs. US Dollar	vs. British Pound	vs. Non-Dollar Basket
Real Non-Energy Commodity Prices	0.75 * (0.12)	0.31 * (0.15)	0.17 (0.09)	0.64* (0.10)	0.45 (0.28)	0.25 (0.21)	0.58 * (0.20)	0.67 * (0.10)	0.45 * (0.10)
Real Energy Commodity Prices [3]	-0.50 * (0.13)	0.29 (0.22)	0.26 (0.13)	-0.24* (0.11)	0.04 (0.29)	0.10 (0.22)	-0.14 (0.12)	-0.17 (0.09)	-0.10 (0.07)
Adj. R^2	0.55	0.59	0.58	0.61	0.34	0.34	0.32	0.49	0.38
N Obs.	70			114			62		
Sample Period	1984Q1 – 2001Q2			1973Q1 - 2001Q2			1986Q1 - 2001Q2		

Note: A * indicates significance at the 5% level. Newey-West heteroskedasticity and autocorrelation consistent (HAC) standard errors are reported in the parentheses.

1. "Non-dollar Basket" is a US trade-weighted average of over 30 currencies of major US trading partners (the US dollar is excluded). It is based on the Broad Index (real) from the Federal Reserve.

Table A.2.1 Composition of Non-Energy Commodity Price Index
World Market Price in US Dollar

Australia			Canada			New Zealand		
1983Q1 – 2001Q2			1972Q1 - 2001Q2			1986Q1 - 2001Q2		
Product	Wt.	Source	Product	Wt.	Source	Product	Wt.	Source
Aluminum	9.1%	IMF	Aluminum	4.8%	BOC	Aluminum	8.3%	ANZ
Beef	9.2%	IMF	Beef	9.8%	GFD	Apples	3.1%	ANZ
Copper	3.2%	BOC	Canola	2.1%	BOC	Beef	9.4%	ANZ
Cotton	3.4%	IMF	Copper	4.7%	BOC	Butter	6.5%	ANZ
Gold	19.9%	IMF	Corn	1.3%	BOC	Casein	6.7%	ANZ
Iron Ore	10.9%	IMF	Gold	4.5%	GFD	Cheese	8.3%	ANZ
Lead	1.3%	IMF	Hogs	5.1%	GFD	Fish	6.7%	ANZ
Nickel	2.6%	BOC	Lumber	14.4%	IMF	Kiwi	3.7%	ANZ
Rice	0.8%	IMF	Newsprint	13.4%	IMF	Lamb	12.5%	ANZ
Sugar	5.9%	GFD	Nickel	3.9%	BOC	Logs	3.5%	ANZ
Wheat	13.5%	BOC	Potash	2.1%	IMF	Pulp	3.1%	ANZ
Wool	18.3%	ANZ + IMF	Pulp	19.7%	IMF	Sawn Timber	4.6%	ANZ
Zinc	1.8%	BOC	Silver	0.9%	GFD	Skim MP	3.7%	ANZ
			Wheat	8.9%	BOC	Skins	1.6%	ANZ
			Zinc	4.4%	BOC	Wholemeal MP	10.6%	ANZ
						Wool	7.7%	ANZ

Table A.2.2 Composition of Energy Commodity Price Index
World Market Price in US Dollar

Australia			Canada			New Zealand		
1983Q1 – 2001Q2			1972Q1 - 2001Q2			1986Q1 - 2001Q2		
Product	Wt.	Source	Product	Wt.	Source	Product	Wt.	Source
Crude Oil	15.7%	BOC	Crude Oil	62.3%	BOC	Crude Oil	100%	BOC
Natural Gas	11.1%	IMF	Natural Gas	29.9%	IMF	Natural Gas		
Coal	73.2%	GFD	Coal	7.8%	GFD	Coal		

Note: ANZ (Australia-New Zealand Bank); BOC (Bank of Canada); GFD (Global Financial Database)

Fig. 1a: US - Australian Real Exchange Rate and Real Commodity Price

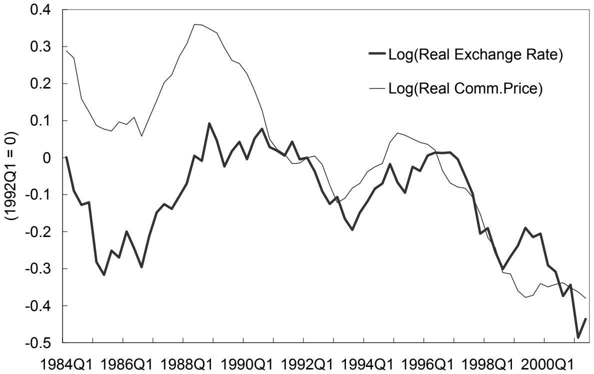

Fig. 1b: Non-Dollar Basket - Australian Real Exchange Rate and Real Commodity Price

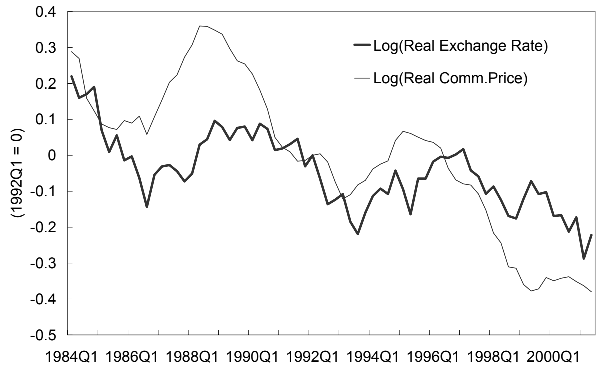

Fig. 1c: UK - Australian Real Exchange Rate and Real Commodity Price

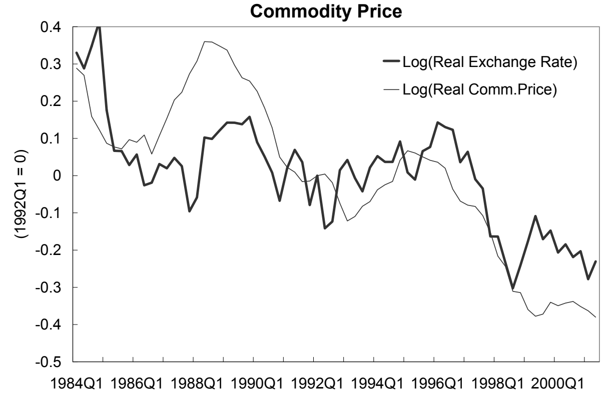

Fig. 2a: US - Canadian Real Exchange Rate and Real Commodity Price

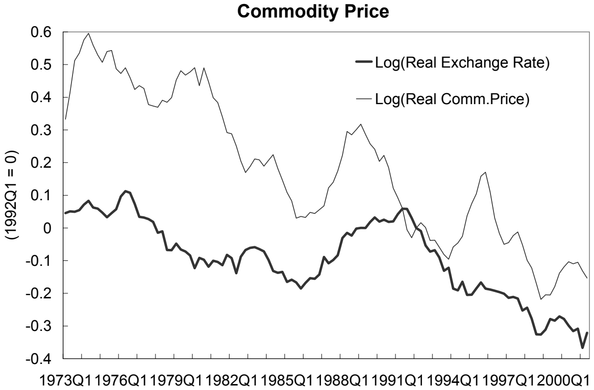

Fig. 2b: Non-Dollar Basket - Canadian Real Exchange Rate and Real Commodity Price

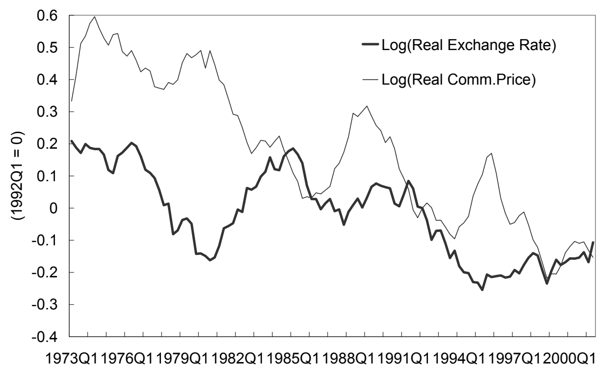

Fig. 2c: UK - Canadian Real Exchange Rate and Real Commodity Price

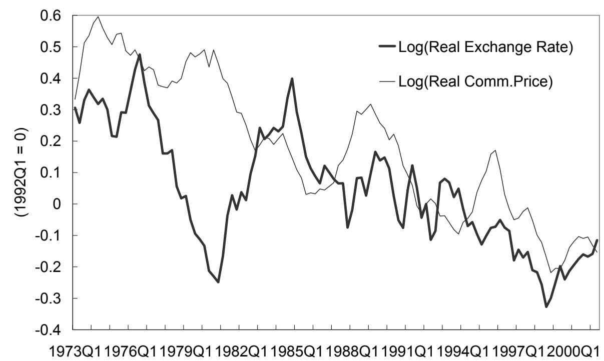

Fig. 3a: US - New Zealand Real Exchange Rate and Real Commodity Price

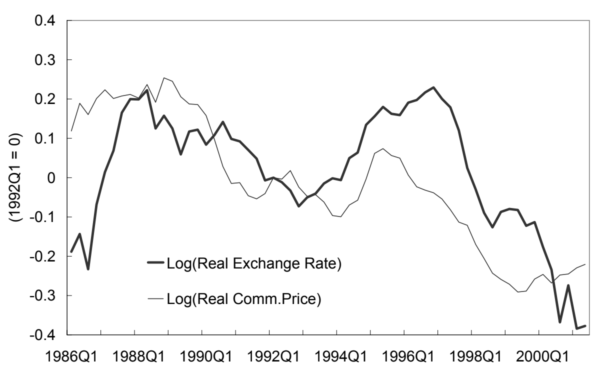

Fig. 3b: Non-Dollar Basket - New Zealand Real Exchange Rate and Real Commodity Price

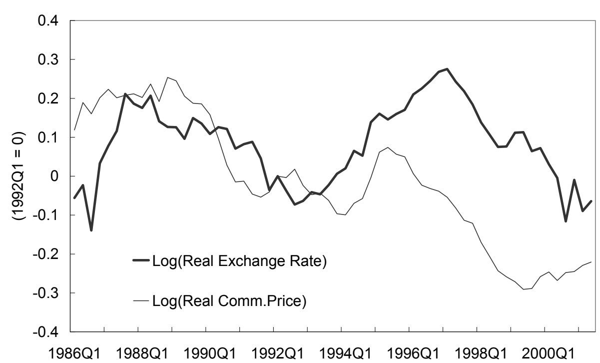

Fig. 3c: UK - New Zealand Real Exchange Rate and Real Commodity Price

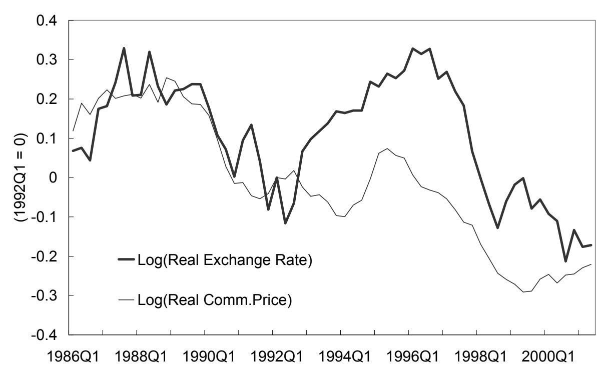

Fig. 4a: Australian-US Real Exchange Rate and Traded vs. Non-Traded Sector Relative Productivity Differential

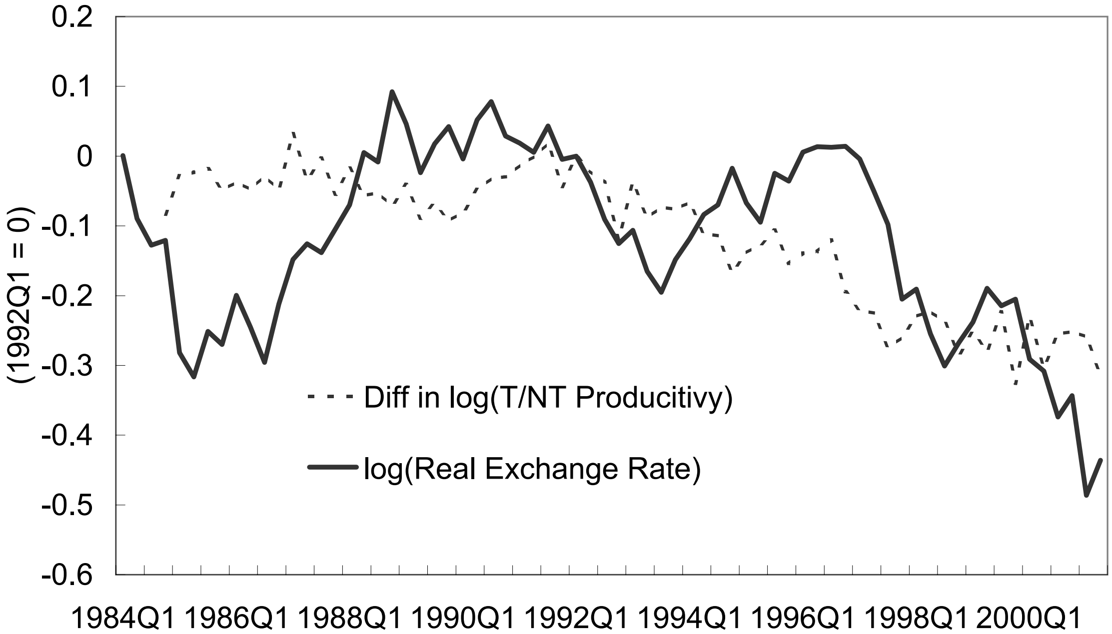

Fig. 4b: New Zealand-US Real Exchange Rate and Traded vs. Non-Traded Sector Relative Productivity Differential