COMMODITY PRICES AND THE MACROECONOMY:

AN EXTENDED DEPENDENT ECONOMY APPROACH

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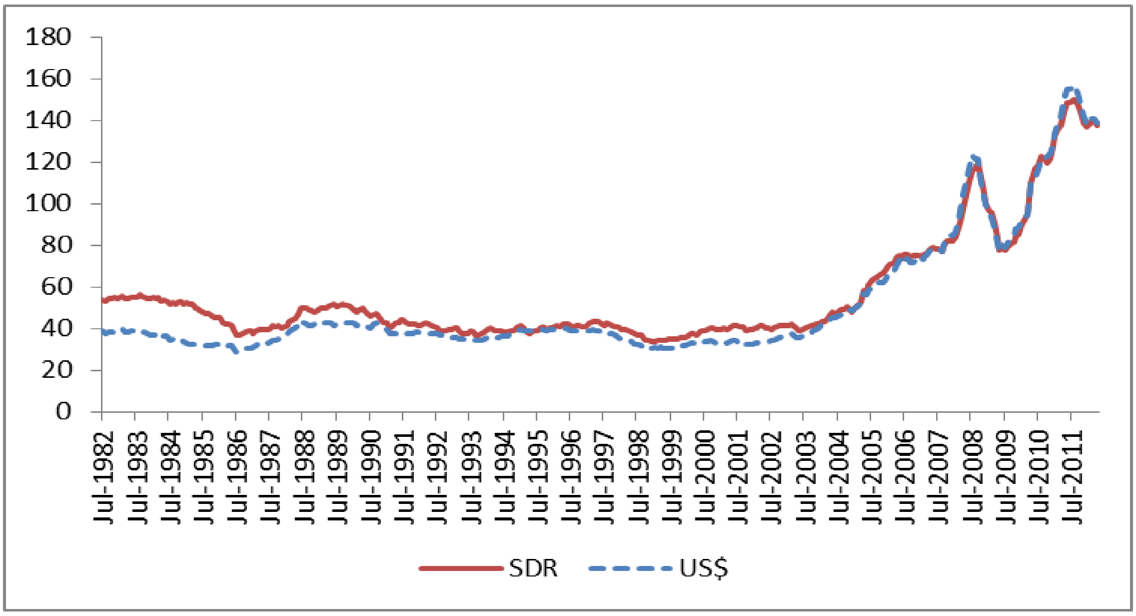
1. Introduction

Commodity price rises have been especially large by historical standards since the Global Financial Crisis of 2008-09, reaching levels comparable in real terms to previous historical highs attained in the 1970s (IMF 2012). This commodity price super-cycle can be dated to just before the turn of the century when a range of major commodity price indexes fell to two decade lows. Sizeable commodity price fluctuations potentially affect national income, trade balances, price levels, and nominal exchange rates or, for those with pegged currencies, international reserves. Hence it is important to consider their implications from a macroeconomic perspective.

Increased commodity demand in rapidly industrialising Asian economies, particularly China and India, has contributed to the price rises, as well as low, sometimes negative, real interest rates which have encouraged commodity stockpiling in anticipation of even higher future prices. Australia, and to a lesser extent New Zealand, are key commodity exporting economies in the Asian region. Although usually classified as industrialised economies, Australia and New Zealand are more reliant on commodity exports than other economies in Asia, as gauged by the proportion of commodity exports in their total exports (IMF 2012). Apart from the United States, their major trading partners are Asian economies.

The scale of recent commodity price rises is evident from Figure 1 which depicts the behaviour of the world prices of key agricultural and mineral commodities since the early 1980s. It is evident that rises since the turn of the century have been unusually high by the standards of the 1980s and 1990s.

Figure 1 – World Commodity Price Index



Notes:
(i) Index values shown on the vertical axis are based on 1989-90 = 100
(ii) Data are sourced from the Reserve Bank of Australia, available at www.rba.gov.au/statistics

Although a literature has developed that focuses on the empirical dimension of the nexus between international commodity prices and economic growth in particular (Deaton and Miller 1995, Kose 2002, Collier and Goderis 2007, Radditz 2007 and Bruckner and Ciccone 2010), there is a dearth of research on the theoretical linkages between export commodity prices and key international macroeconomic variables in small open economies, especially exchange rates, national output levels, trade balances and capital flows. Consequently, there are no straightforward macroeconomic frameworks that provide ready answers to the following basic questions.

Why do the nominal and real exchange rates of many commodity exporters move in sync with world prices received for their particular commodity exports? In other words, why do so-called 'commodity currencies' appreciate with commodity price rises and depreciate with commodity price falls? How does the exchange rate insulate national output and income from world commodity price volatiity? To what extent does this insulation depend on the openness of the economy? How do trade balances behave under these circumstances? And what are the implications for the economy's industry structure and exchange rate management if commodity price movements are sustained rather than temporary?

This paper aims to answer these questions by outlining a straightforward international macroeconomic model for analysing how commodity price fluctuations simultaneously influence the exchange rate, the price level, national output, and the trade balance. To do this, it extends the dependent economy model originally proposed by Salter (1959) and Swan (1960) and adapted by, inter alia, Fischer and Frenkel (1972), Bruno (1976) and Yano and Nugent (1999). Methodologically, in the tradition of the original dependent economy approach, the model focuses directly on macroeconomic variables of most interest to policymakers, without recourse to microeconomic foundations.

The dependent economy approach is based on a dichotomy between tradables, the foreign currency prices of which are set in world markets, and non-tradables, whose prices are set by domestic demand and supply factors. An innovation of this paper is that tradables are further split into exportables, including commodities whose world prices tend to be highly volatile, and importables, including manufactures, whose prices are relatively stable. The ratio of the world price of its exportables to its importables defines an economy's terms of trade which in what follows are driven by world commodity price swings.

The next section develops a simple framework that relates terms of trade shocks to the real and monetary sides of small macroeconomies. Section 3 then employs the framework to answer the questions posed above. Section 4 provides an empirical application by examining the experiences of Australia and New Zealand, two major commodity exporting countries within the Asian region. The final section highlights the main lessons of the analysis.

2. The Analytical Framework

This section develops a straightforward framework for examining the impact of world commodity price shocks on the exchange rate, national income and the trade balance in a small open economy comprised of a real side producing exportable, importable and non-tradable output, and a monetary side where residents' demand a given stock of money determined by the central bank. The key relationships underpinning national income generation are first outlined before turning attention to the monetary foundations of the model.

Real Sector Linkages

Gross domestic product, the total quantity of exportable, importable and non-tradable goods and services made available for sale to resident and non-resident entities, is generated by a macroeconomic production function. Real output is produced in proportion to the capital stock employed in each sector, such that

$$O_x = \gamma K_X, \quad O_M = \varsigma K_M \text{ and } O_N = \xi K_N \qquad (1)$$

where O_X is the volume of exportable production, O_M is the volume of importable production, and O_N is the volume of non-tradable production, K_X, K_M and K_N are the real capital stocks, and γ, ς and ξ are the output to capital ratios in the exportable, importable and non-tradable sectors respectively.

In nominal domestic currency terms, national output, y, is therefore

$$y = p_X O_X + p_M O_M + p_N O_N = p_X \gamma K_X + p_M \varsigma K_M + p_N \xi K_N \qquad (2)$$

where p_X is the price index for exportable output, p_M is the price index for importable output, and p_N is the price index for non-tradable output. Since the nominal exchange rate converts the foreign value of exportables and importables to their domestic currency values, (2) can be re-expressed as

$$y = ep^*_X \gamma K_X + ep^*_M \varsigma K_M + p_N \xi K_n \qquad (3)$$

The exogenous terms of trade, τ, is the ratio p^*_X / p^*_M. If we normalise the foreign currency price index for importables $(p^*_M = 1)$ and divide through by p^*_M, making the foreign price of importables the numeraire, equation (3) becomes

$$y = e\tau\gamma K_X + e\varsigma K_M + p_N \xi K_n \qquad (4)$$

Partially differentiating (4) with respect to the nominal exchange rate yields

$$\partial y / \partial e = \tau\gamma K_X + \varsigma K_M > 0 \qquad (5)$$

This result implies national output is positively related to the nominal exchange rate in the short run and that a movement in the terms of trade due to changing export commodity prices is a shift factor, since $\partial y / \partial \tau > 0$.

For the purposes of the exposition to follow, the exchange rate is redefined as $E = 1/e$, such that a rise (fall) in the value of E denotes appreciation (depreciation). Given the result above, this allows us to draw a downward sloping schedule, labelled the *YY* schedule in exchange rate-output (or $E - y$) space, as shown in Figure 2. The other schedule, the *MM* schedule, reflects equilibrium on the monetary side of the economy. Its underpinnings are outlined as follows.

Monetary Relations

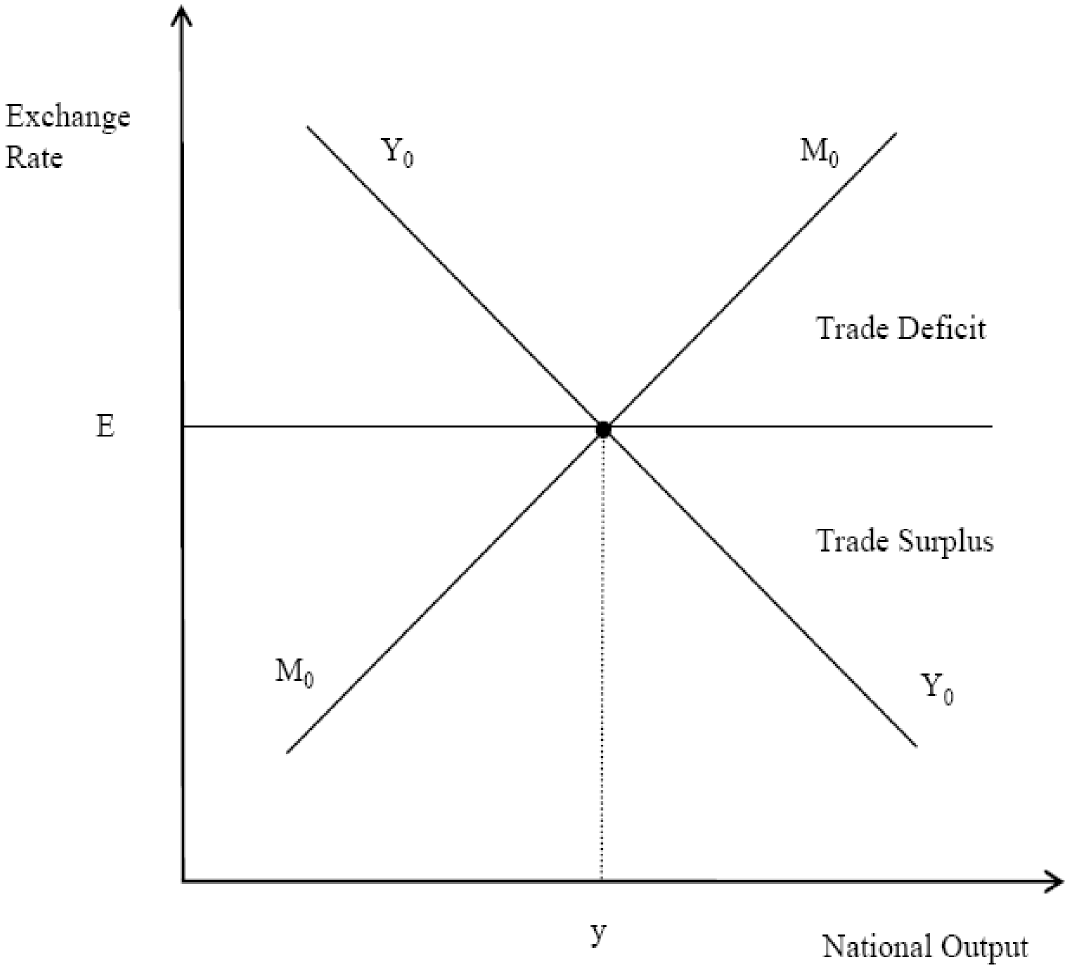
On the monetary side of the economy, residents' demand for cash balances equals the real money supply. In the standard way, money demand depends positively on national income according to parameter, ε, and negatively on the domestic interest rate, r, according to parameter, δ. Hence,

$$\frac{M}{P} = \varepsilon y - \delta r \qquad 0 < \varepsilon, \delta < 1 \tag{6}$$

The national price level is a weighted measure of the domestic currency value of importable and non-tradables prices,

$$P = \alpha e p_M^* + \beta p_N \quad \text{where} \quad \alpha + \beta = 1 \tag{7}$$

Figure 2 - General Equilibrium



It is assumed that the price of the commodity exportables in which the economy specialises for sale abroad does not significantly affect the domestic price level. This assumption can easily be relaxed, but doing so unnecessarily complicates the analysis without altering key results that follow.

Substituting (7) into (6) and solving for e, yields

$$e = \left[\frac{M}{\alpha(\varepsilon y - \delta r)} - \frac{\beta p_N}{\alpha} \right] > 0 \qquad (8)$$

Partially differentiating (8) with respect to the nominal exchange rate, we find that

$$\partial e / \partial y = -\frac{M\alpha\varepsilon}{(\alpha(\varepsilon y - \delta r)^2} < 0 \qquad (9)$$

Again, since $E = 1/e$, this implies an upward sloping schedule labelled *MM* in exchange rate-national income (or $E - y$) space, as shown in Figure 2. The more open the economy the larger is α, the weight for importables in the domestic price index. Expression (9) therefore implies the slope of the MM schedule would be relatively flatter the more open the economy is, and steeper the less open it is.

In reality, the speed at which changes in the foreign currency prices of importables translates to the domestic price level is also governed by the rate of exchange rate pass-through. See, inter alia, Froot and Rogoff (1995), Isard (1995), Frankel and Rose (1996) and Goldberg and Knetter (1997). In the limit case of no short run pass-through, the value of α would be zero and the MM schedule vertical.

In initial equilibrium, it is also assumed that the trade account is balanced. Hence, aggregate demand equals aggregate output at this point with net exports at zero,

$$c + i + (x - m = 0) = y \qquad (10)$$

where c is consumption of, and i is investment in, exportables, importables and non-tradables; x is exports, and m is imports.

A currency appreciation from initial equilibrium will lower net exports, as foreign demand for exportables falls and domestic demand for importables rises. Hence, in Figure 1 the zone above the line drawn from the initial equilibrium exchange rate, E_0, associates equilibria in the real and monetary sectors with a trade deficit (TD), whereas in the zone below the E_0 line a trade surplus (TS) prevails.

Trade deficits (surpluses) are matched by international capital inflow (outflow). These cross border flows arise because it is assumed that in initial equilibrium the domestic interest rate, r, equals the foreign interest rate, r^*, plus a time varying risk premium, ρ, in accordance with the interest parity relation.

$$r = r^* + \rho \tag{11}$$

International capital will flow in response to incipient pressure on the domestic interest which will rise (fall) relative to the world interest rate whenever domestic money demand rises (falls) for a given real money supply, the quantity of which is determined by the central bank. International capital inflow yields a positive capital account balance, KB, which is functionally related to the interest rate differential, and from balance of payments accounting, to the current account balance (or trade balance in the absence of income paid abroad) as

$$KB = KB(r, r^*\rho) = -TB \qquad \partial KB/\partial r > 0, \partial KB/\partial \rho < 0 \tag{12}$$

Intuitively, by increasing the value of output, a positive commodity price shock will, for a given money supply, increase money demand. This will put upward pressure on domestic interest rates and thereby induce capital inflow.

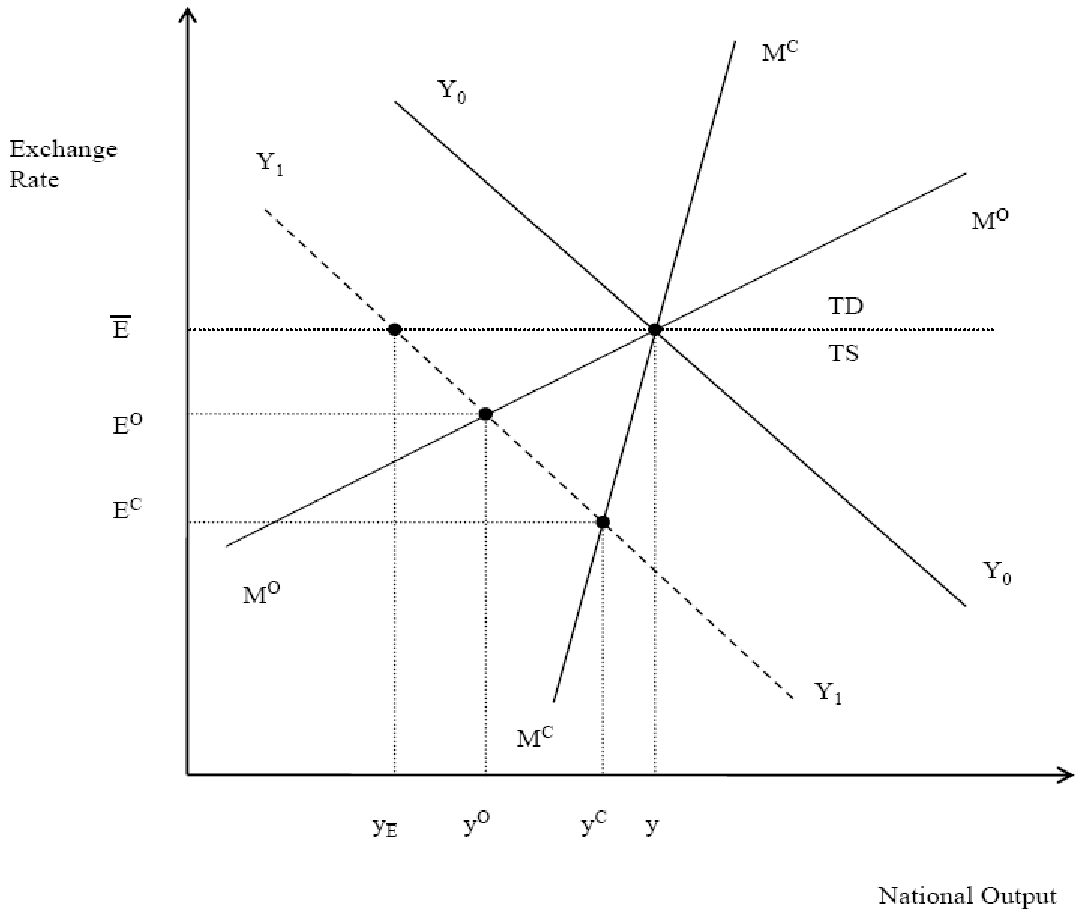
3. Commodity Price Fluctuations and the Macroeconomy

Having established the basic framework, now consider what happens to the economy in response to two different kinds of commodity price fluctuations. First, we examine the effects of a temporary slump in world commodity prices on the exchange rate, national income and the trade balance. Second, we analyse the implications of a more sustained rise in world commodity prices on these key variables.

Temporary Export Commodity Price Falls

As shown in Figure 3, a sharp fall in commodity prices shifts the Y_0Y_0 schedule leftwards to Y_1Y_1, as the value of national output in terms of importables prices decreases. For a given real money supply, the M_0M_0 schedule remains stationary.

Figure 3 - Falling Commodity Prices, Openness, and Exchange Rate Insulation



Under a floating exchange rate, the size of the depreciation and the extent to which real national output is insulated from the commodity price shock depends in the immediate term on the rate of pass-through and in the medium term on the openness of the economy. For instance, if pass-through is minimal and the economy is relatively closed, the MM schedule would be relatively steep, as shown by schedule $M^C M^C$. Accordingly, in the medium term, the commodity price fall would cause a relatively large depreciation, yet allow a minimal fall in output from y to y^C.

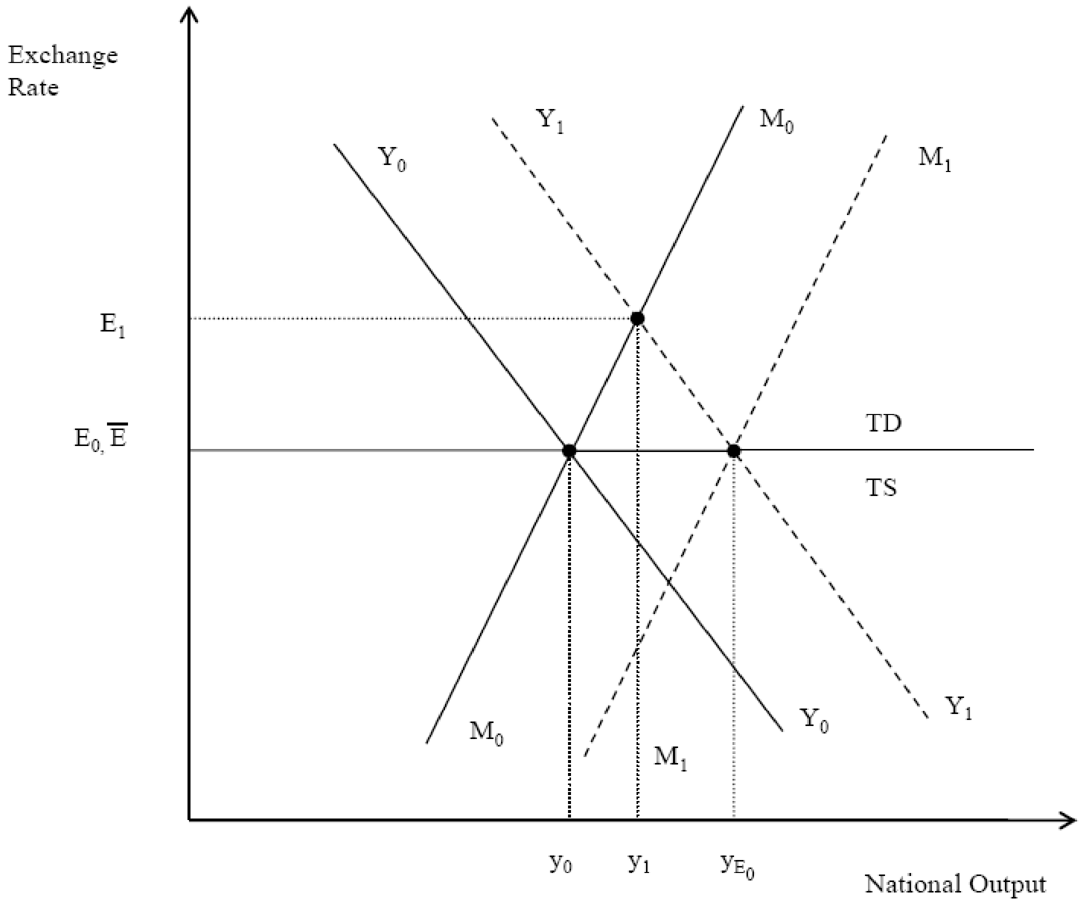
Alternatively, if the economy was relatively open, the MM schedule would be relatively flat, as shown by schedule $M^o M^o$. The commodity price slump would then lead to a smaller depreciation than the relatively closed case, but cause a larger output fall from y to y^o. Hence, the more open (closed) the economy, the less (more) national output is insulated from commodity price fluctuations.

Had the exchange rate been pegged at E_0, the central bank would have had to contract the money supply through foreign exchange market intervention by buying domestic currency with foreign exchange. In the process, assuming the intervention is unsterilized, the MM schedule would shift leftward, causing national output to contract by the full distance between y_0 and y_{E0}. Here, national output is not insulated at all from the commodity price shock under a pegged exchange rate. Instead, national output bears the full recessionary brunt of the commodity price fall.

Sustained Commodity Price Rises and Exchange Rate Management

The foregoing demonstrates that if commodity price rises were temporary and over time simply offset commodity price falls of similar duration, maintaining a fully flexible exchange rate would be the optimal exchange rate system choice because the exchange rate would minimise destabilising fluctuations in national output and hence employment levels. Now consider the case of more sustained export commodity price rises illustrated in Figure 4.

Figure 4 – Sustained Commodity Price Rises and the 'Dutch Disease'



Under these circumstances, arising for instance from increased world commodity demand due to prolonged output expansion in large, rapidly industrialising Asian economies like China and India, the small economy's YY schedule will keep shifting rightward. It is also possible that booming commodity prices could attract foreign direct investment in the exportables sector. By raising the capital stock in that sector, this would imply a larger rightward shift of the YY schedule. Under these circumstances, as shown in Figure 4, the nominal exchange rate would naturally appreciate to E_1 and restrict the output increase to y_1.

Compare this to the case of a pegged exchange rate where monetary policy accommodates the commodity price driven expansion. Then, the exchange rate remains pegged at E_0, the domestic money supply increases to satisfy increased money demand, and national output expands to its maximum potential level of y_{E0}. If commodity price fluctuations were not symmetric or mean-reverting, with secular commodity price rises expected to be the norm, a fully flexible exchange rate may therefore not be optimal, because it would stymie potential output growth.

Moreover, the composition of output would alter irreversibly if commodity price rises were sustained. Specifically, persistent currency appreciation squeezes out traditional tradable industries, such as manufacturing, as a result of lost competitiveness. In this way, the figure illustrates the so-called 'Dutch disease' phenomenon canvassed in an earlier literature in the context of rising world energy prices. The extent of this domestic production squeeze is shown in Figure 3 as the distance between y_1 and y_{E_0}.

4. Empirical Implications: The Australia-New Zealand Experience

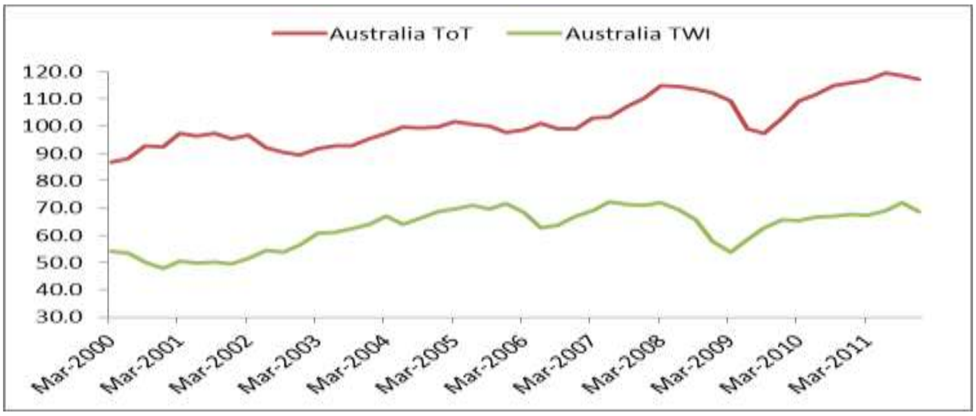
While the main aim of this paper is to provide a theoretical framework for understanding the macroeconomic impact of commodity price fluctuations on commodity exporting economies, the results of the model suggest empirically testable propositions. This section examines some these propositions with reference to the experiences of Australia and New Zealand, economies which are not only significant commodity exporters within the Asian region, but also have other Asian economies, notably China, Japan, and South Korea, amongst their top trading partners. Australia exports mostly minerals, notably coal and iron ore, while New Zealand mostly exports agricultural products.

A key contribution of the above theoretical model is that it provides an alternative rationale for understanding why commodity prices received by commodity exporters and their exchange rates move in sync. Previous studies have established empirically that the Australia and New Zealand dollars are commodity currencies. See, for instance, Chen and Rogoff 2003, and Cashin, Cespedes and Sahav 2004. As Figure 5 clearly shows, movements in the terms of trade of Australia and New Zealand have closely tracked major changes in the values of their exchange rates, suggesting the commodity currency status of their currencies is likely to be confirmed using more recent data.

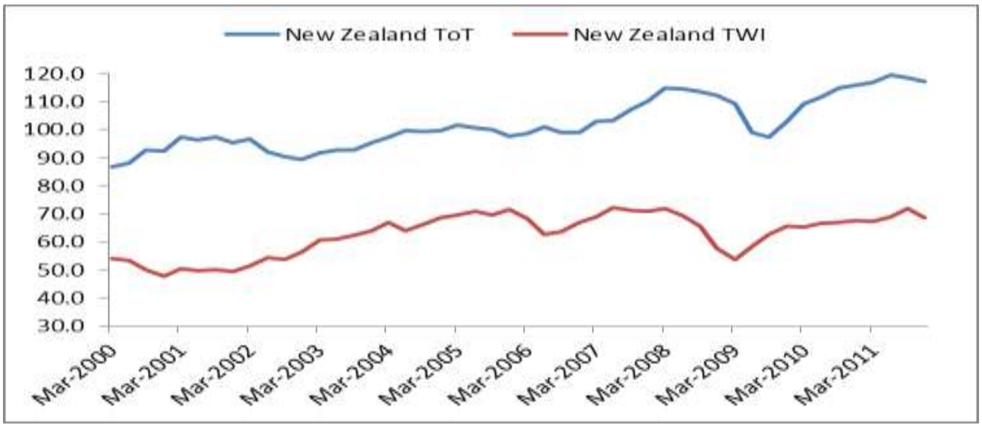
Quarterly terms of trade data were sourced from the International Monetary Fund's, International Financial Statistics, and monthly average effective exchange rate data from the Bank for International Settlements. For both Australia and New Zealand movements in the terms of trade, the ratio of export prices to import prices, essentially reflect export commodity price fluctuations experienced by these economies, since the prices of imports, mainly manufactures, were relatively stable over the period. The quarterly effective exchange rate series were derived by computing three-monthly averages of published average monthly data.

Figure 5 - The Terms of Trade and Effective Exchange Rates, Australia and New Zealand, March 2000 - December 2011

A. Australia



B. New Zealand



Notes:
(i) the terms of trade (ToT) series for both economies represent the ratio of unit export values to unit import values, with data sourced from International Monetary Fund, International Financial Statistics available at http://www.imf.org/external/data.htm

(ii) the effective exchange rate series for both economies is the trade weighted index (TWI) measure, with data sourced from the Bank for International Settlements available at http://www.bis.org/statistics/eer/index.htm

Another important implication of the theoretical model proposed above that has not been tested hitherto relates to the variability of real GDP in major commodity exporting economies. According to the framework, the variability of GDP should be less for a commodity exporter that adopts a floating, rather than pegged, exchange rate system, since floating rates act to insulate such economies from external commodity price shocks. This proposition can also be examined empirically for Australia and New Zealand using more formal methods. In short, the aim is to examine whether the volatility of Australian and New Zealand GDP levels was less for each economy during their respective floating rate periods compared to their pegged rate intervals, as predicted by the theory.

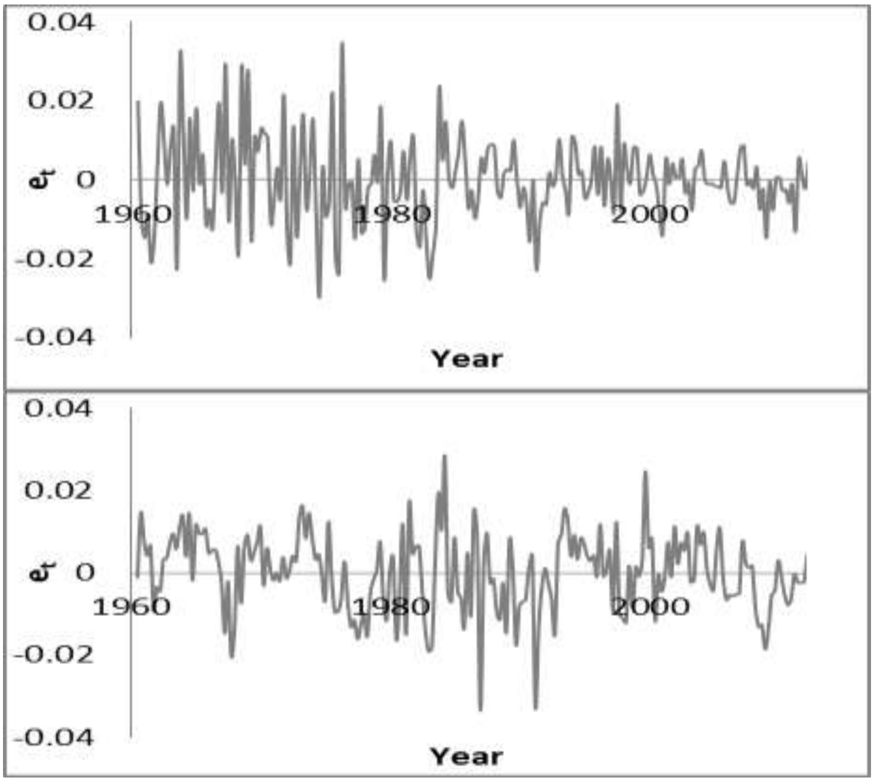
Both economies adopted floating exchange rates in the 1980s, Australia in December 1983, and New Zealand in March 1985. The sample period runs from 1960Q1 to 2012Q1 to allow comparison of the variability of GDP levels over approximately equal pegged versus floating time spans. The Australian data were sourced from the Australian Bureau of Statistics (ABS) and the New Zealand data from Statistics New Zealand and New Zealand Treasury.

The following estimable model is used to examine this question.

$$\log(y_t) - \log(y_{t-1}) = \beta_0 + e_t \qquad (13)$$

where y_t is real GDP in time period t, β_0 is a constant terms designed capture the approximate average growth rate and e_t is a random error term. Residual plots for Eq(1) for Australia and New Zealand are given below in Figure 6. The top panel shows volatility from trend for Australia, while the bottom panel shows volatility from trend for New Zealand.

Figure 6 - Residual Plots Depicting Output Volatility, Australia and New Zealand, March 1960 – March 2012



Notes:
(i) the values of the error term on the vertical axis convey deviations from the average growth rate over the estimated period for both economies
(ii) this figure was generated by Eviews

To measure changes in output volatility the above equation is estimated and the squared residual term $\hat{e}_t^2$ is checked for heteroskedasticity. To do this the general equation used is

$$\hat{e}_t^2 = \alpha_0 + \delta D + v_t \tag{14}$$

where D is a dummy variable designed to allow for a discrete shift in variance at some point in time t. This variable is defined to be equal to zero for unspecified earlier periods and equal to one in the later periods. Equation (14) is then subjected to the Quandt-Andrews test for an unspecified break. This test uses D to partition the data at every point (subject to standard 15% trimming) and searches for the time period at which the structural change (which is categorized by the secondary intercept parameter δ) appears to be maximized.

The significance of this point can also be tested, however as the point is chosen endogenously the standard distributional rules do not apply. Results of the Quandt-Andrews test are reported in Table 1 alongside results from Eq(2).

Table 1. Coefficient Estimates and Breakpoints for Squared Residual Series

Parameter/Test	Australia	New Zealand
$\hat{\alpha}_0$	0.000208***	9.24E-05***
$\hat{\delta}$	-0.00016***	-7.56E-06
Breakpoint (t)	1983 Q4	1993 Q4
F	43.21***	5.38

Notes:
(i) $\hat{\alpha}$ is the estimated intercept value for equation (14)
(ii) $\hat{\delta}$ is the estimated coefficient for variable D in equation (14) which aims to identify the breakpoint at which variance shifts
(iii) the F statistic refers to the statistical significance of the breakpoint. Rejection of the null indicates that a structural break occurs.
(iv) *, **, and *** denote 10%, 5% and 1% significance respectively

Results in Table 1 for Australia yield the remarkable finding that there was a clear structural break in output volatility in 1983 Q4 – precisely when the Australian dollar was floated. The sign and significance for δ indicates that this break coincided with significantly less variation in output after this date. Conversely for New Zealand there was no evidence of a singular break in volatility over the period at any point (hence the insignificant F statistic for the breakpoint test).

Hence the econometric model for Australia strongly supports the hypothesis of greater stability after the float of the dollar proposed in the theory. However, it is not supportive in the New Zealand case, a possible reason being that a characteristic of New Zealand's pegged rate era was that officials manipulated the exchange rate very frequently, to such an extent that this may well have shadowed market forces and been sufficient to absorb the external commodity price shocks.

4. Concluding Comments

In reality, many economies are subject to severe terms of trade fluctuations that arise from their particular export commodity specialisation. To improve understanding of the international macroeconomic implications of terms of trade variation, this paper proposes a new theoretical framework for analysing their impact on exchange rates, national output and trade balances, with empirical reference to the experiences of Australia and New Zealand, major commodity exporters in the Asian region.

Founded on assumptions that underpin the dependent economy model, key innovations of the paper include its extension of the tradables-non-tradables dichotomy to a trichotomy of exportables, importables and non-tradables, as well as the incorporation of a monetary sector explicitly related to the specification of goods and services markets in the real sector. This alternative specification, along with its real economy supply side orientation, distinguishes the approach from other workhorse open economy models. For instance, the still popular Mundell-Fleming model is a demand determined approach which implicitly assumes all goods and services are tradable.

The aggregative perspective adopted in the above framework also differs markedly from the optimising representative agent approach of dynamic stochastic general equilibrium (DSGE) paradigm (see Wickens 2011). The sensitivity of DSGE models to underlying assumptions, such as the nature of utility functions (Sarno and Taylor 2003), their more standard specification of goods and services markets, as well as their inherent complexity can blur lessons they may have for exchange rate policy, in contrast to the framework outlined above.

Meanwhile, exchange rate economics has traditionally been dominated by a preoccupation with purchasing power parity and the role of monetary factors in determining currency values (see, for instance, Dornbusch 1976, Meese and Rogoff 1983, Isard 1995, Taylor 2002, Frankel and Rose 1995, Macdonald 1999, and Sarno and Taylor 2003). The model outlined above however fills a gap in the exchange rate literature by providing a theoretical rationale for the hitherto neglected ‘commodity currency’ phenomenon of particular relevance to Australia and New Zealand, major commodity exporters in the Asian region.

A novel result of this model is that the severity of the Dutch disease during a commodity price boom depends on how open an economy with a floating exchange rate is. Real exchange rate appreciation in response to commodity price surges will squeeze national income more (less), the less (more) open the economy. In other words, the Dutch disease is more lethal for traditional tradable industries like manufacturing if an economy is relatively closed. As a corollary, commodity exporting economies that maintain pegged exchange rates are less susceptible to the Dutch disease, yet instead experience far more variable national income than economies with floating exchange rates, regardless of their exposure to international trade.

In sum, the main lessons for macroeconomic policy are as follows. First, a free floating exchange rate acts as a useful shock absorber for national output in the face of commodity price shocks. Evidence provided in this paper reveals this has clearly been the case for Australia. As a corollary, maintaining a pegged exchange change implies that GDP will bear the full brunt of any commodity price shock and hence be more variable, the more frequent the shocks are.

Yet a flexible exchange rate may not be optimal if over longer periods commodity prices exhibit a sustained trend rise. This is because national output then falls short of its potential level due to persistent currency appreciation which reduces production elsewhere in the economy. In other words, a monetary policy response to a resources boom that simply allows nominal exchange rate appreciation may be ill-advised because this crowds out labour-intensive economic activity in domestic importable industries, such as manufacturing, and simultaneously enlarges the trade deficit.

Finally, under a floating exchange, the trade balance reacts oppositely to what may be expected. For instance, instead of positive commodity price shocks yielding trade surpluses via increased export values on the real side of the economy, they generate trade deficits due to exchange rate appreciation stemming from pressures exerted on the monetary side. This raises an empirical issue worth exploring in future research.

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