Monetary Policy and the Volatility of Real Exchange Rates in New Zealand

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The relationship between interest rates and exchange rates is puzzling and poorly understood. But under some standard assumptions, interest rates can be adjusted to smooth real exchange rate movements at the possible price of increased volatility in other variables. In New Zealand, estimates made under some generous suppositions about what monetary policy is able to accomplish suggest that decreasing real exchange rate volatility by about 25% would require increasing output volatility by about 10-15%, inflation volatility by about 0-15% and interest rate volatility by about 15-40%.

1. Introduction

The primary goal of monetary policy in New Zealand is price stability. But that is not the sole mandate of the Reserve Bank of New Zealand. Recent Policy Targets Agreements have also called on the Bank to "avoid unnecessary instability in output, interest rates and the exchange rate."

Thus the bank is directed to make output, interest rates and the exchange rate variables of interest beyond the usefulness of these variables for understanding and forecasting inflation, perhaps interpretable as a direction to trade off price stability with stability in these other variables. This paper considers the possibility of using interest rate policy to trade exchange rate stability against stability in other variables. It makes

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two points. Section 2 of the paper reminds the reader that the relationship between interest rate policy and exchange rates is quite uncertain. Specifically, I remind the reader of the empirical failure of "uncovered interest parity." In light of such a failure, it will likely be difficult in practice to use interest rate adjustments to stabilize exchange rates with any precision.

The rest of the paper follows a considerable literature that ignores the reminder just noted. It embeds a standard interest parity relationship between interest rates and exchange rates in a linear macro model. It uses counterfactual calculations to supply rough quantitative estimates of that tradeoff, focusing on stability of real exchange rates on the one hand vs. stability of output, inflation and interest rates on the other. The point estimates suggest that a 25% reduction in real exchange rate volatility by about 1990 would require increasing output and inflation volatility by roughly 10% and interest rate volatility by roughly 20%.

The estimates are derived from a simple linear model that is broadly consistent with both textbook and New Keynesian models. The mechanism the Bank is assumed to use to stabilize real exchange rates is to adjust interest rates in response to transitory movements in exchange rates, with interest rate hikes (cuts) coming in response to transitory depreciations (appreciations) of the New Zealand dollar.

Three cautionary notes: First, these estimates are likely to be optimistic ones. This is not only because the model assumes that interest rate adjustments affect exchange rates in a reliable and well understood way. As well, and at a more prosaic level, the computations assume away a host of other practical problems: they assume that the Bank knows the steady state level of the real exchange rate, that the Bank can react to exchange rate movements as quickly as exchange rates react to interest rate movements, that excellent data on output and inflation are available contemporaneously, and so on. So in practice a 25% reduction in real exchange rate volatility is likely to be associated with greater increases in volatility of other variables than stated above.

Second, this paper does not consider the desirability of explicitly targeting real exchange rate movements. As indicated above, statements in recent Policy Targets Agreements serve as my motivation to estimate a tradeoff. I will refer to estimates of changes in volatility as the "price" paid for targeting real exchange rate movements. Of course, the appropriate measure of tradeoff is one of utility and not volatility.

Third, the fact that the focus of this paper is on real exchange rate stabilization should not be interpreted as an assertion that such stabilization is the only or even most important way exchange rates might affect monetary policy. In a small open economy like New Zealand's, exchange rates, both real and nominal, are central to understanding and forecasting the evolution of inflation and output. I take this point as given, and consider the separate question of the cost of real exchange rate stabilization.

Section 2 of the paper notes the uncertainty of the link between interest rates and exchange rates. Section 3 presents the model. Section 4 presents empirical results. Section 5 concludes. An Appendix includes some algebraic details.

2. Uncertain Interest Parity

For countries with roughly similar inflation rates, exchange rate changes are hard to predict. In my view, they are even harder to predict than are stock price changes, which are notoriously difficult to predict. Indeed, a vast literature studying exchange rate prediction has concluded that the best single predictor of the exchange rate next period—tomorrow, next week, next month, maybe even next year—is the exchange rate this period. One generally cannot do better than a "no change" forecast for exchange rates. The seminal reference is Meese and Rogoff (1983); a recent update is Cheung et al. (2000).

Those unfamiliar with the exchange rate models may think this "random walk" result is precisely what is predicted by classic efficient markets theory as expounded by Samuelson (1965). But in fact this is not the case. Explaining why not will take us to the "uncovered interest parity" relationship that is the central link between interest rates and exchange rates in macroeconomic models such as the one developed and estimated in this paper.

Recall that the essence of Samuelson's (1965) model is that asset prices changes are unpredictable but that asset returns are unpredictable. Samuelson explicitly noted that if an asset pays a dividend in a given time period, the asset's return (sum of dividend and price change) will be unpredictable only if there is, on average, an offsetting movement in the asset price. For equity returns, for example, this means that the day a stock goes ex-dividend, its price should fall, on average, by the amount of the dividend. And indeed this implication has that the behavior of U.S. stock price data (an early reference is Elton and Gruber (1970)), at least once once takes into account complications induced by taxes and transactions costs.

The reader may wonder what a discussion about dividends has to do with exchange rates. It is of course true that holding foreign currency does not automatically entitle one to earn money labeled "dividends." But from the point of view of Samuelson's (1965) efficient markets theory, interest payments on nominally riskless government debt play precisely the role of dividends. To see why, let us define the following notation:

(2.1) i: interest rate in New Zealand,
\( \dot{L} \): interest rate in foreign country,
\( \alpha \): log nominal exchange rate, measured as NZ$/foreign currency,
\( \dot{E} \): mathematical expectations conditional on a period t information set.

I follow the convention that a higher value of \( \alpha \) denotes a weaker (depreciated) currency. In the notation of (2.1) uncovered interest parity may be written:

\[
(2.7) \quad i = i' + E_{t} \dot{s} + s_n
\]

The left hand side is the return from investing in domestic (New Zealand) bonds. The right hand side is the expected return from the following investment: convert from New Zealand dollars to foreign currency, buy the foreign bond that pays \( i' \), convert the proceeds back to New Zealand dollars. If investors are risk neutral, as assumed by Samuelson (1965), equality of expected returns should hold, and equation (2.2) follows. (For example, if the New Zealand interest rate \( i \) is (say) 4 percent higher than the foreign interest rate \( i' \), then our hypothetical investor must expect that by investing abroad he will earn 4 percent via depreciation of the New Zealand dollar \( [E_{t+1} = 0.96] \). Alternatively, investors cannot expect to make money by borrowing at rate \( i \) and investing abroad. In (2.2), the expected asset price change is \( E_{t+1} s_n \), while the net "dividend" is \( i' - i \) : Samuelson’s (1965) model says that the total return \( \dot{i} - i + E_{t} \dot{s}_{t+1} - s_n \) is unpredictable.

Observe that uncovered interest parity (2.2) states that exchange rate changes are predictably related to interest rate differentials; according to uncovered interest parity, exchange rates do not follow a random walk. I began this section by noting that exchange rate changes are unpredictable, which means in particular that they are not well predicted by interest rate differentials. This is illustrated by Figures (1a)-(c), which present scatterplots of begin of quarter 90 day interest rate differentials (horizontal axis) with subsequent quarterly percentage changes in nominal exchange rates (vertical axis), for the New Zealand dollar versus the currencies of Australia (Figure 1a), Japan (1b) and the U.S. (1c). The sample period is 1982.2-2003.1. The interest rate differentials are expressed at quarterly rates. Were uncovered interest parity to hold, the dots would be scattered around a forty five degree line. No such pattern is evident. Indeed, the point estimate of correlation between the two series is negative for the U.S. and Japan, and the estimated positive correlation for Australia is insignificantly different from zero. A vast literature finds similar results: see Lewis (1993) for a general survey and Razzak and Margaritis (2003) for recent New Zealand evidence.
So fitting the historical data requires the addition of variables to (2.2). In the empirical work presented below, I take the tack of appending a serially correlated shock, call it $w_t$, the "r" stands for "risk premium":

(2.3) $Y_t - Y_{t-1} = E_{t-1} - Y_{t-1} + w_t$

In this empirical work, I use historical data and regression residuals to construct a series for $w_t$ (and other unobserved shocks, though such shocks are not important at the moment). When I trace out the effects of alternative interest rate policies, I assume that the time series for $w_t$ is invariant to such policies. That is, ceteris paribus, movements in $Y_t$ lead one-to-one to movements in expected exchange rate depreciation, where one of the cetera held fixed is $w_t$. This may not be a good assumption, but it is arguably as good as any. A good assumption about how $w_t$ will change as monetary policy changes requires a good model for the shock $w_t$. We do not have such a model. Possible explanations for $w_t$ include a risk premium generated as the usual covariance with the market portfolio (e.g. Backus et al. (2001)) or misperceptions about determinants of exchange rates (e.g., Gourinchas and Tornell (2001)). Each explanation has substantial empirical or theoretical difficulties.

The lesson to be drawn is that the results about to be developed and presented need to be interpreted with an unusual amount of caution.

3. The Model

A. Specification

The model is broadly consistent with recent New Keynesian work on monetary policy in small open economies, such as Gali and Monacelli (2002). An IS curve, a Phillips curve, a monetary policy rule and an interest parity equation are specified for the foreign currency as a trade weighted average of several foreign currencies. Define the following notation in addition to that defined in (2.1):

(3.1) $y_t = \text{output gap in New Zealand}$; $\psi_t = \text{output gap in foreign country}$; $\beta_t = \text{log price levels (CPI)}$; $\pi_t - \pi_t' = \text{inflation (first difference of log consumer price level)}$; $q_t = \text{real exchange rate}$; $\alpha_t = \text{real exchange rate}$.

I repeat that I follow the convention in which an increase in the exchange rate (real or nominal) corresponds to a depreciation rather than appreciation of the New Zealand dollar.

The IS and Phillips curve equations are:

(3.2) $y_t = \alpha_1 Y_t + \alpha_2 \psi_t - \alpha_3 (1 - E_t \pi_t') + w_t$

(3.3) $\pi_t = \beta_1 E_t \pi_t' + \beta_2 \psi_t + w_t$

In (3.2) and (3.3), $w_t$ and $\alpha_t$ are exogenous shocks, which in the empirical work will be serially correlated. Here and throughout I suppress constant terms.

The IS curve (3.2) can be justified in either of two related ways. The first is as a textbook open economy aggregate demand curve. In this case, $\alpha_1$ and $\alpha_2$ are positive and reflect the responsiveness of net exports to movements in foreign output $Y_t$ and the real exchange rate $\psi_t$. $\alpha_3$ is negative. A second is from New Keynesian models with certain assumptions about preferences, risk sharing and purchasing power parity. For example, in Gali and Monacelli (2002), which assumes that uncovered interest parity and instantaneous purchasing power parity, (3.2) holds with $\alpha_1 > 0$, $\alpha_3 > 0$, and $\alpha_4$ are functions of preference parameters and $\alpha_2 > 0$ is increasing in the share of foreign produced goods in New Zealand consumption, and $\alpha_3$ depends on the level of productivity in New Zealand relative to the foreign country.

Equation (3.3) again is consistent with both textbook and New Keynesian models. In textbooks, $\beta_1 = 1$; in the Calvo sticky price model, $\beta_2$ is less than 1. In either, $\beta_2$ is positive. In both textbook and New Keynesian models, the measure of inflation that appears in the Phillips curve is domestic rather than overall inflation $\pi_t$. The use of overall inflation is a shortcut that allows me to avoid modeling the pass through of exchange rates to prices. Explicit modeling of pass through is an important task for future research.

I assume that monetary policy is New Zealand is adequately captured by a Taylor rule with a serially correlated shock $w_t$. 


(3.4) \[ i_t = \gamma_y y_t + \gamma_h h_t + u_{it} \]

In (3.4), \( \gamma_y > 1, \gamma_h \geq 0 \) and \( \gamma_h \geq 0 \). The use of actual inflation is for consistency with work at the Reserve Bank (see Drew and Plantier (2000) and Plantier and Scrivengour (2002)). From a technical point of view, I could proceed if expected inflation were in the monetary policy rule (3.4) as suggested by Huang et al. (2001), whether use of expected inflation generates substantively different results remains to be seen. A similar statement applies to the output gap.

The term in the real exchange rate \( y_t \) is key to this study. To interpret this term, begin by noting that I sidestep altogether any questions about levels of variables, to focus on variability. Let me temporarily restore the levels, by rewriting (3.4) as follows:

(3.4)’ \[ i_t - E_t \pi_{t+1} = \text{natural real interest rate} + (\gamma_y - 1)(E_t \pi_{t+1} - \text{inflation target}) + \]

\[ y_t \cdot (\text{log GDP} - \text{log potential output}) - \gamma_h \cdot q_t \cdot \text{equilibrium value of } q_t \cdot u_{it} \]

We see in (3.4)’ that this reaction function, which was also used in Clarida et al. (1998) and Engle and West (2002), allows the monetary authority to lean against the transitory movements in the real exchange rate. The larger is \( \gamma_y \), then, the more does monetary policy attempt to lean against such transitory movements. (Whether it is reasonable to allow reaction to contemporaneous real exchange rates is discussed briefly below.) The empirical work proceeds essentially by tracing out how variations in \( y_t \) affect volatility of output, inflation, interest rates and the real exchange rate.

In this empirical work, I abstract altogether from thorny questions about the determinants of the quantities present in (3.4)’ but not (3.4) (i.e., the natural real interest rate, inflation target, potential output and equilibrium value of the real exchange rate). The empirical work relies on the Bank’s staff to construct potential output and the equilibrium real exchange rate, and assumes the other quantities are constants, set equal to the mean value in the sample. It is technically feasible to use other deterministic models (trends, or step functions, for example) rather than constants, but I did not do so.

The next equation is interest parity (2.3), but written in real form, and with an exogenous risk premium shock \( u_{it} \).

(3.5) \[ i_t - q_t = E_t \pi_{t+1} - E_t \pi_{t+1} = E_t \pi_{t+1} - q_t + u_{it} \]

Equation (3.5) is obtained by subtracting \( E_t \pi_{t+1} - E_t \pi_{t+1} = E_t \pi_{t+1} - q_t - (E_t \pi_{t+1} - q_t) \)

from both sides of (2.3).

Note that the current values of \( i_t \) and \( q_t \) appear in the monetary rule (3.4) and in interest parity (3.5). The model will be solved under the assumption that the quarterly interest rate can be set to react to the contemporaneous real exchange rate, even while the exchange rate is reacting to the exchange rate movements. There are at least two reasons why one might find it objectionable to allow the current value of the exchange rate in the monetary policy rule. The first is one familiar from recent literature on Taylor rules, namely, that data on price levels, which are required to compute a real exchange rate, are not available contemporaneously.

The second reason, which is probably more important for the present study, is that it is questionable that the monetary authority can react to the exchange rate (equation (3.4)) as rapidly as the exchange rate reacts to monetary policy (one interpretation of equation (3.5)). Specifically, with a monetary rule in the form (3.4), it is possible for the monetary authority to achieve very low variability in the real exchange rate by setting \( \pi_y \) very high relative to \( y_t \) and \( \gamma_h \). Of course, the same applies to inflation when \( \gamma_y \) is set very high relative to \( y_t \) and \( \gamma_h \), or to output when \( \gamma_y \) is set very high relative to \( y_t \) and \( \gamma_h \). But the implication may be tolerable for variables like inflation and output, in that these variables move relatively sluggishly in the intervals between monetary policy decisions. But it is difficult to argue that exchange rates move sluggishly between interest rate decisions. This suggests a bound on the Bank’s ability to lower variability in exchange rates, a bound that may not be well captured in a model that (as just stated) allows interest rates to react to exchange rates as rapidly as exchange rates react to interest rates. So for this reason as well the results presented here likely understate the cost of achieving a given reduction in exchange rate volatility.

To return to the model: equations (3.2): (3.5) are four equations in seven variables: the four New Zealand variables \( \pi_t, \pi_{t+1}, i_t, q_t \) and the three foreign variables \( \pi_{t+1}' \) and \( \pi_{t+1}' \). To close the model requires three more equations. I do not attempt to model the three foreign variables, but instead assume simply that they follow exogenous processes.

(3.6) \[ \pi_{t+1}' = u_{t+1}' \]

(3.7) \[ \pi_{t+1}' = u_{t+1}' \]

(3.8) \[ i_t' = u_t' \]
8. The monetary policy rule and volatility trade-offs

Is there indeed a cost to stabilizing the real exchange rate? Might it be that setting \( Y_e > 0 \) leads to greater stability in not only the real exchange rate but also in output, inflation and interest rates? These questions are prompted by the observation that optimal control typically requires a response to all state variables. So even if the Reserve Bank were interested only in inflation stability, it could in principle achieve greater inflation stability with an interest rate rule that responds not only to output and inflation but also to the real exchange rate. If the inflation stabilizing choice involves a positive \( Y_e^* \), as assumed above, then the additional term in \( q \) will be beneficial rather than costly in terms of inflation volatility.

The aim of this paper is to use the data to supply an answer to the questions at the beginning of the preceding paragraph. But in simplified versions of the model, it is possible to answer the question analytically. And even in simplified versions, the answer is: it depends. Whether a monetary policy rule expanded to include a term \( Y_e \), lessens or exacerbates volatility in other variables depends on variances of shocks and parameter values. Rather than catalog the dependence exhaustively, let me illustrate with two examples. I worked through both examples in a simplified setting in which all shocks are i.i.d. (not plausible empirically, but tractable analytically). The aim is to distinguish the implications for volatility of the real exchange rate \( q \), output \( y \), inflation \( \pi \) and the interest rate \( i \) of \( Y_e > 0 \) vs. \( Y_e = 0 \).

Consider first the response to a positive shock to the risk premium \( \omega \). For both \( Y_e = 0 \) and for \( Y_e > 0 \), the impact effect of this shock is for \( q, y, \pi \) and \( i \) to rise. This is intuitive: an increase in exchange rate risk causes the currency to depreciate, which in turn is associated with a rise in output and inflation. For both \( Y_e = 0 \) and \( Y_e > 0 \), the monetary rule (3.6) causes interest rates to rise in response. But for \( Y_e > 0 \), interest rates respond more strongly. The stronger interest response means that, in equilibrium, the responses of \( q, y, \) and \( \pi \) are less for \( Y_e > 0 \) than for \( Y_e = 0 \).

Thus the rule with \( Y_e > 0 \) lessens volatility of \( y \) and \( \pi \) (and of course \( q \)) but increases volatility of \( i \).

As a second example, consider instead the effect of positive IS shock \( \omega \), interpreted in Giav and Monacelli (2002) as an increase in productivity in the home country (New Zealand, in the present application) relative to abroad. For both \( Y_e = 0 \) and for \( Y_e > 0 \), \( q \) falls (appreciation), \( y, \pi \), and \( i \) rise. The effects on \( q, y \), and \( \pi \) are intuitively expected; the rise in \( i \) is necessary to maintain interest parity. The equilibrium increase in \( i \) is less for \( Y_e > 0 \) than for \( Y_e = 0 \) (because \( q \) falls). So volatility of \( i \) is lower for \( Y_e > 0 \). Consequently, volatility of \( y \) and \( \pi \) increases.

These two examples illustrate that one cannot tell a priori whether the addition of the term \( Y_e \) to the monetary policy rule will lessen or increase volatility of other variables. For the effect on volatility of output, inflation and interest rates is directly opposed for the two shocks:

<table>
<thead>
<tr>
<th>Volatility more (+) or less (-) for ( Y_e &gt; 0 ) than for ( Y_e = 0 )</th>
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</thead>
<tbody>
<tr>
<td>( i )</td>
</tr>
<tr>
<td>Risk premium shock</td>
</tr>
<tr>
<td>IS shock</td>
</tr>
</tbody>
</table>

The volatility of \( q \) is unambiguously lessened by including \( Y_e \) in the monetary rule. The previous analysis illustrates that whether inclusion of the new lesser or increases volatility of other variables depends on the variances of the shocks and on model parameters. Even in an i.i.d. world, one would have to turn to data to decide the sign of the change in volatility of output, inflation and interest rates. (N.B.: the point of this subsection is illustration, not development of a complete set of comparative statics results that could be used to interpret the empirical results. In presentation of results, I will have occasion to refer to this subsection only to remind the reader that real exchange rate smoothing may result in either increases or decreases of volatility of other variables.)

C. Model solution and identification

Define the \((7+1)\) vectors \( X_t \) and \( U_t \) as

\[
X_t = \left( y_t, \pi_t, \omega_t, \pi_t^R, \pi_t^L, i_t, Y_e^t \right), \quad U_t = \left( \mu_{y, \pi}, \mu_{\omega, \pi}, \mu_{\pi}, \mu_{\omega, \pi}^*, \mu_{\pi}^*, \mu_{\omega, \pi}^* \right).
\]

With suitable definitions of \((7+7)\) matrices \( A_t \) and \( A_s \), the system (3.2)-(3.8) may be written as
(3.10) \( A_E X_{t+1} + A_X U_t = U_t \).

The form of the solution to (3.10) depends on the nature of the shock process \( U_t \). It is easily seen from (3.10), for example, that if \( U_t \) is i.i.d., then one solution is \( X_t \) i.i.d., with \( A_E U_t \) and \( E X_{t+1} = 0 \). Clearly if this model is to pick up serial correlation that is manifest in aggregate data, the shock \( U_t \) will have to be serially correlated. An assumption that is technically manageable, and leads to serial correlation in \( X_t \) that is roughly what we see in the data, is that \( U_t \) follows a vector autoregression of order 1:

(3.11) \( U_t = \Phi U_{t-1} + \nu_t \).

Here, \( \Phi \) is the \((7 \times 7)\) matrix of autoregressive coefficients \( \Phi \) and \( \nu_t \) is the serially uncorrelated \((7 \times 1)\) vector of innovations in \( U_t \).

It may be shown that (3.10) and (3.11) imply that \( X_t \) also follows a vector AR(1), say

(3.12) \( X_t = F X_{t-1} + \nu_t \).

Here, \( F \) depends on both the parameters of the model embedded in \( A_E \) and \( A_X \) (that is, on \( \alpha_{tr}, \alpha_{tr}, \beta_{tr}, \beta_{tr}, \gamma_{tr}, \gamma_{tr} \)) and the serial correlation parameters \( \Phi \); the serially uncorrelated shock \( \nu_t \) is a linear transformation of the shock vector \( \nu_t \), with the parameters of the transformation again dependent on both the model parameters and \( \Phi \). See the Appendix.

Clearly one can estimate \( F \) and the variance-covariance matrix of \( \nu_t \), by least squares. The strategy I take to identify the model is to assume values for the model parameters \( \alpha_{tr}, \alpha_{tr}, \beta_{tr}, \beta_{tr}, \gamma_{tr}, \gamma_{tr} \) and, let the data tell me what values of the serial correlation matrix \( \Phi \) and the variance-covariance matrix of \( \nu_t \) are consistent with the estimates of \( F \) and \( E \nu_t \nu_t^\prime \). The values I impose on the model parameters are ones that are presumed to apply during the period of estimation. For example, I set the monetary policy parameter \( \gamma_{tr} \) to zero on the thought that exchange rate smoothing has not played a determinable role in New Zealand monetary policy during my sample. At any rate, given the assumed values, one can map the estimates of \( F \) and of the variance-covariance matrix of \( \nu_t \) into estimates of \( \Phi \) and of the variance-covariance matrix of \( \nu_t \). I allow \( \Phi \) to be unrestricted—that is, I do not attempt restrictions conventional in calibration work, such as univariate AR(1) processes for all shocks. My aim is to well-capture the dynamic behavior of the data, recognizing since all the dynamics are in the shocks I provide an accounting but not an economic explanation of the persistence in the data.

I also do not attempt to test for or impose unit roots or cointegrating relations (though this setup in principle allows \( \Phi \) to have eigenvalues with unit modulus). Rather, I take it as a priori reasonable that the variables here are stationary, though mean reversion might be quite slow.

To trace out the effects of alternative policies to smooth exchange rates, I vary \( \gamma_{tr} \) in (3.4), holding fixed other model parameters and the serial correlation matrix \( \Phi \). This allows me to solve for how \( F \) and \( \nu_t \) would have varied, had the Reserve Bank of New Zealand followed a policy with alternative parameters. (Formulas are in the Appendix.) To summarize variation in \( F \) and \( \nu_t \), I report implied standard deviations around steady state of New Zealand interest rates, output, inflation and the real exchange rate. My presumption is that if the variations in policy are suitably modest, serial correlation parameters and steady state values can reasonably be held fixed while serial correlation parameters and steady state values can reasonably be held fixed while serial correlation parameters and steady state values can reasonably be held fixed.

And similarly for the model parameters in the IS and Phillips curves. By construction, variations in \( \gamma_{tr} \) will not affect standard deviations of foreign variables, since \( \gamma_{tr}, \gamma_{tr} \) and \( \gamma_{tr} \) by assumption evolve exogenously (equations (3.6)-(3.8)).

4. Empirical Results

A Data

The data are quarterly, 1992.1-2002.3. Specific variables (names from the Bank’s model or data series given in quotes when applicable) are:

- \( y \) (NZ output gap: "gap"): the output gap
- \( \pi \) (NZ inflation): headline CPI inflation
- \( i \) (NZ interest rate: "r900D"): 90 day bank bill rate
- \( g \) (real exchange rate: "r")
- \( c \): five country trade weighted index, constructed with GDP deflators
- \( \pi^f \) (foreign output gap: "gapfou"): fourteen country trade weighted output gap
- \( \pi^f \) (foreign inflation: "cpirow"): five country trade weighted CPI
- \( i^f \) (foreign interest rate): five country trade weighted 90 day interest rates
In $q$, $\pi^*$ and $\pi^*$, the five countries are: Australia, United States, United Kingdom, Germany/Euro area and Japan. In $\pi^*$, the fourteen countries are: United States, Japan, Germany, France, United Kingdom, Italy, Canada, Australia, China, Hong Kong, Malaysia, Singapore, South Korea, and Taiwan.

Figure 2 plots the data from 1986-2002, with a vertical line denoting the start of the 1992 sample that I use. Note that the scale in the graphs is different; interest rates $r$ and inflation $\pi$ generally are higher in New Zealand than in the foreign country ($\pi^*$ and $\pi^*$). Note as well that the exchange rate series is plotted in levels, but appears in logs in the regressions.

The figure suggests that the data are generally slowly mean reverting. Indeed, one reason for beginning the sample in 1992 rather than 1986 was to avoid having to model the downward trend in New Zealand inflation $\pi$ and interest rates $r$. But even in the post-1992 sample, the figures suggest that mean reversion has been more honored in the breach than in the observance for some variables, including in particular the foreign inflation $\pi^*$. The empirical work implicitly interprets the seeming trend in these variables as a reflection of a small sample, since this work assumes the data are stationary around a constant mean. Alternative treatments of trends would be desirable, but are not considered in this paper.

**VAR Results**

The estimates of the first order vector autoregression in $(\Pi, \pi, i, q, q, \pi, \pi, r)^*$ is reported in Table 1.

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>Regressors</th>
<th>Summary Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>$y_{t}$</td>
<td>$\Pi_{t-1}$, $\pi_{t-1}$, $i_{t-1}$, $q_{t-1}$, $\pi^<em>_{t-1}$, $\pi^</em>_{t-1}$</td>
<td>$R^2$ = 0.90</td>
</tr>
<tr>
<td>$\pi_{t}$</td>
<td>$0.06$ (0.01), $-0.19$ (0.12), $-0.63$ (0.11), $0.03$ (0.01), $-0.24$ (0.01), $0.01$ (0.01)</td>
<td>$R^2$ = 0.90</td>
</tr>
<tr>
<td>$i_{t}$</td>
<td>$0.13$ (0.12), $-0.21$ (0.15), $0.12$ (0.14), $0.04$ (0.02), $0.25$ (0.22), $0.37$ (0.11)</td>
<td>$R^2$ = 0.90</td>
</tr>
<tr>
<td>$q_{t}$</td>
<td>$0.19$ (0.09), $0.07$ (0.11), $0.58$ (0.10), $-0.02$ (0.01), $0.28$ (0.19), $0.05$ (0.09)</td>
<td>$R^2$ = 0.90</td>
</tr>
<tr>
<td>$\pi^*_{t}$</td>
<td>$-0.05$ (0.33), $-0.36$ (0.42), $0.93$ (0.39), $2.43$ (0.72), $0.50$ (0.33)</td>
<td>$R^2$ = 0.90</td>
</tr>
<tr>
<td>$\pi^*_{t-1}$</td>
<td>$0.09$ (0.04), $0.04$ (0.05), $-0.13$ (0.05), $-0.01$ (0.01), $0.78$ (0.08)</td>
<td>$R^2$ = 0.90</td>
</tr>
<tr>
<td>$\pi^*_{t-2}$</td>
<td>$0.19$ (0.14), $-0.13$ (0.18), $0.61$ (0.17), $1.02$ (0.02), $0.40$ (0.30)</td>
<td>$R^2$ = 0.90</td>
</tr>
</tbody>
</table>

Notes: 1. The data are quarterly, 1992 II-2002 III.
2. Variable definitions: $y$=output gap, $\Pi$=inflation rate, $\pi$=inflation, $i$=real exchange rate, $\pi^*$=foreign inflation.

Predicatively, lagged dependent variables typically earn coefficients that are numerically large and statistically significant, with the peculiar exceptions of inflation $\pi$ and foreign inflation $\pi^*$. As one would expect, there is more evidence that foreign inflation $\pi^*$.
variables Granger cause New Zealand variables than vice versa: $\pi_t^G$ Granger causes $\pi_t$, (t-value of 3.73/0.11 = 3.4) and $\pi_t^G$ Granger causes $\pi_t$ (t-value of 0.32/0.12 = 2.7). The New Zealand output gap $y_t$ does Granger cause the foreign output gap (t-value of 0.09/0.4 = 2.3), perhaps a manifestation of what Bank economists have described to me as a tendency for the New Zealand output gap to have led the foreign output gap in recent years. The real exchange rate is statistically significant in the inflation and interest rate equations with numerically small coefficients of 0.05 and -0.02.

Most other coefficients are numerically small and statistically insignificant, suggesting a population value of zero or thereabouts; such zeroes would be rationalized in the model described in section 2 by a particular pattern of zeroes in the matrix $D$ (defined in 3.11).

(We do see some nonzero coefficients on variables other than own logs in the equations for the foreign variables $y_t^x, \pi_t^x$, and $\pi_t^x$. To clarify, such nonzero coefficients in the equations for foreign variables are rationalized by multivariate linkages between the various shocks. For example, let us use the estimates in Table 1 and the formulas in the Appendix to construct the equation for the exogenous process for foreign inflation $\pi_t^x$ (defined in 3.7). Then the result happens to be

$$4.12\pi_t^x = 0.06\pi_{t-1}^x + 0.43\pi_{t-1}^x + 0.04y_{t-1}^x + 0.44\pi_{t-1}^x - 0.50\pi_{t-1}^x + 0.62\pi_{t-1}^x + \epsilon_{t-1}^x.$$ 

[Standard errors not available.] Unsurprisingly, the large coefficients on $\pi_{t-1}^x$ and $\pi_{t-1}^x$ are associated with large coefficients on $y_{t-1}^x$ and $\pi_{t-1}^x$ in the $\pi_t$ equation reported in Table 1.)

C. Effects of alternative monetary policy rules

Alternative values for the parameters $\alpha_x, \alpha_y, \alpha_\pi, \beta_x, \beta_y, y_0, y_1$, and $y_2$ are presented in Table 2.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Value</th>
<th>Value</th>
<th>Value</th>
<th>Value</th>
<th>Value</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha_x$</td>
<td>1.5</td>
<td>0.15</td>
<td>0.0</td>
<td>99</td>
<td>0.1</td>
<td>1.5</td>
<td>0.5</td>
</tr>
<tr>
<td>$\alpha_y$</td>
<td>1.5</td>
<td>0.15</td>
<td>0.0</td>
<td>99</td>
<td>0.1</td>
<td>1.5</td>
<td>0.5</td>
</tr>
<tr>
<td>$\alpha_\pi$</td>
<td>1.5</td>
<td>0.15</td>
<td>0.0</td>
<td>99</td>
<td>0.2</td>
<td>1.5</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Note: 1. For variables defined in notes to Table 1, and with "y" denoting a shock, the equations of the model are as follows:

IS curve: $y_t = \alpha_x y_{t-1} + \alpha_y \pi_{t-1} + c(y_{t-1} - 1 - \pi_{t-1}) + \epsilon_{t-1}$;

Phillips curve: $\pi_t = \beta_x E_{\pi_{t+1}} + \beta_y y_{t-1} + \epsilon_{t-1}$;

Monetary policy: $\pi_t = \alpha_{\pi} \pi_{t-1} + \pi_{t-1} + y_{t-1} + \pi_{t-1} + \epsilon_{t-1}$.

My aim is to choose values more or less consistent with the structural models used at the RBNZ. My understanding is that one or more RBNZ models use a within-quarter at the RBNZ. My understanding is that one or more RBNZ models use a within-quarter elasticity of the New Zealand output gap with respect to world output of 1.5, with respect to the real exchange rate of about 0.15–hence the values for $\alpha_x$ and $\alpha_\pi$.

These models find it difficult to find a within-quarter effect of the interest rate, but there is some evidence that the elasticity may be as high as 0.5, so I set $\alpha_\pi = 0$ or $\alpha_x = 0.5$. (Of course, even with $\alpha_x = 0$ monetary policy affects output: given time series for foreign variables $y_t^x, \pi_t^x$, and $\pi_t^x$, equations (3.2)–(3.5) determine the values of $\pi_{t-1}^x, \pi_t^x, \pi_t^x, \pi_t^x$, and $\epsilon_t^x$ simultaneously.) Setting $\beta_x = 0.99$ is consistent with quarterly calibration of the Calvo model, and, more generally, with a more or less long run vertical Phillips curve. The value $\beta_y = 0.11 - 0.2$ is consistent with my understanding of estimates of the short run slope of the Phillips curve in New Zealand. The monetary policy parameters ($\pi_{t-1}^\pi = 1.5, \pi_{t-1}^\pi = 0.5, \pi_{t-1}^\pi = 0$) seem, I am told, to do as good a job as any if New Zealand monetary policy is to be described via a Taylor rule (Drew and Plantier 2000) and Plantier and Scrimgeour 2002).

Table 3: Standard Deviations Under Alternative Monetary Policy

<table>
<thead>
<tr>
<th>Parameter</th>
<th>1992-2002</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\pi_t$</td>
<td>1.55</td>
</tr>
<tr>
<td>$\pi_t$</td>
<td>1.13</td>
</tr>
<tr>
<td>$\pi_t$</td>
<td>1.58</td>
</tr>
</tbody>
</table>
B. Standard deviations under hypothetical alternative policies, parameter set A

<table>
<thead>
<tr>
<th>Parameter</th>
<th>$\gamma$</th>
<th>$\eta$</th>
<th>$\pi$</th>
<th>$\iota$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\epsilon$</td>
<td>0.00</td>
<td>10.92</td>
<td>1.84</td>
<td>1.13</td>
</tr>
<tr>
<td></td>
<td>0.01</td>
<td>10.47</td>
<td>1.58</td>
<td>2.13</td>
</tr>
<tr>
<td></td>
<td>0.05</td>
<td>8.95</td>
<td>1.68</td>
<td>1.14</td>
</tr>
<tr>
<td></td>
<td>0.07</td>
<td>8.34</td>
<td>1.72</td>
<td>1.16</td>
</tr>
<tr>
<td></td>
<td>0.15</td>
<td>7.56</td>
<td>1.78</td>
<td>1.19</td>
</tr>
</tbody>
</table>

C. Cost of Lowering Real Exchange Rate Volatility by About 25%, Alternative Parameter Sets

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Percentage increase in standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Set</td>
<td>$\gamma$</td>
</tr>
<tr>
<td>A</td>
<td>0.07</td>
</tr>
<tr>
<td>B</td>
<td>0.06</td>
</tr>
<tr>
<td>C</td>
<td>0.08</td>
</tr>
</tbody>
</table>

Notes:
1. Variable definitions are given in Table 1.
2. $\gamma_a$ is the coefficient on the real exchange rate in the monetary policy rule (24).
3. The standard deviations in the $\gamma_a$ = 0, $\epsilon$ = 0 panel B match those in panel B in construction, because it is restated that during the extension period the rate was allowed to be $\gamma_a = 0$.
4. The negative sign in the $\gamma$ column in panel B means that the volatility of $\gamma$ has fallen.

Panel A of Table 3 reports actual standard deviations of the data. The other panels of Table 3 report the results of varying $\gamma_a$, the reaction coefficient on the real exchange rate in the monetary policy rule (24). Panel B reports detailed results for parameter set A. As $\gamma_a$ increases, the volatility of $\gamma_a$ of course falls. According to the estimates, if $\gamma_a$ had been set at 0.07—a value consistent with some of the estimates for G-10 countries in Clarida et al. (1998)—the volatility of $\gamma$ would have fallen by 24%, from volatility from 0.55 to 0.21. The price paid for a smoother exchange rate is an 11% increase in output ($\epsilon$), a 2% increase in inflation volatility ($\gamma$), and a 18% increase in interest rate volatility (from 1.5 to 1.9). (These are standard deviations centered around steady state values—around long run equilibrium real exchange rate, potential output, target inflation, and average interest rate. An-—to repeat an important point already made in the introduction—it is the welfare effects of exchange rate targeting, and not volatility per se, that is the appropriate metric to measure the desirability of targeting.)

To facilitate interpretation, I present results for other specifications when $\gamma_a$ has been set at a value that decreases volatility of $\gamma$ by about 25%. Results for all three parameter sets are given in Table 3C: the result for parameter set A repeat what is in panel B. The results are broadly consistent across parameter sets.

The results may be contrasted with those of Brook and Stephens (2002) and Lam (2003). Brook and Stephens (2002) use the Reserve Bank’s FPS model to consider the effect of adding to that model’s reaction function a term that smooths real exchange rates. Brook and Stephens do not present standard deviations. That they interpret some impulse responses as suggesting that such smoothing would induce "significantly" greater volatility in inflation, while yielding less volatility in not only real exchange rates for perhaps interest rates as well.

Lam (2003) builds on Hunter (2001) in using a calibrated version of Svensson’s (2000) open economy model. His estimates vary widely across specifications. In one set of results (top panel of Table 3 on p.10 of Lam (2003)), reducing real exchange rate variability by 15% causes the volatility of other variables to skyrocket: the standard deviation of inflation more than triples, that of output increases by 54%, that of the nominal interest rate doubles. (This panel only presents results for a reductions in real exchange rate variability of 15% or less.) In two other sets of results (middle and bottom panels of Table 3 on p.10 of Lam 2003), reducing real exchange rate variability by 25% causes the standard deviations of inflation and output to increase by perhaps 5-20%, while that of the interest rate falls by about 12-20%. (Recall from the discussion in section 3 that even in this paper’s model, an attempt to smooth exchange rates can lessen interest rate volatility as well, depending on the source of shocks.)

These results seem broadly consistent with those presented here, in the sense of suggesting a substantial volatility cost would be paid for smoothing real exchange rates. There is, however, an uncomfortably wide range of results (would interest rates be more or less variable if exchange rates were smoothed?). This underscores the importance of our understanding of the terms of the tradeoff between real exchange rate stability and volatility of other variables.
5. Conclusions

The simple model used in this paper delivers rough estimates of the cost of using interest rate policy to smooth real exchange rate movements. The cost is measured in estimated that a 25% fall in the standard deviation of the real exchange rate can be accomplished at the price of increases in the standard deviations of output of about 10-40%.

The empirical work abstracts from well-known difficulties with uncovered interest parity, assuming that whatever shocks to interest parity occurred during the sample period, the model is highly simplified and stylized, for example not assumptions that discriminate between domestic and foreign exchange rates. Finally, the model assumes that the RBNZ knows the equilibrium value of the real exchange rate, and can react to exchange rate movements in a relaxed manner. This would lead to higher costs associated with any given level of real exchange rate smoothing.

Appendix

This appendix presents linearized equations of the reduced form and structural equations. Those equations are repeated here for convenience:

(A.1) Structural equations:

\[ A_1 X_{t+1} + A_2 X_t + U_t = \Phi U_{t-1} + W, \quad EW = \Omega_u. \]

(A.2) Reduced form equations:

\[ X_t = FX_{t-1} + V_t, \quad EV = \Omega_v. \]

To solve for reduced form parameter matrix \( F \) and shock \( V \) given the structural parameters \( A_1, A_2, \Phi, \) and \( \Omega_v, \) a solution of the form

\[ D X_t = D U_t, \]

where \( D \) is a matrix to be determined. Upon using (A.3) and (A.3) led one period in (A.1), we obtain

\[ A_1 D \Phi + A_2 = D, \]

which can be used to solve for \( D \). Upon combining (A.2) and (A.3), we see that

\[ F = D \Phi D^{-1} + V, \quad EW = \Omega_u. \]

To work from the reduced form to the structure: given \( A_1, A_2, \) and the values of \( \Phi, \Omega_v, \) the solutions for \( \Phi \) and \( \Omega_v \) are:

\[ (A.6) \quad \tilde{D} = \left[ \tilde{A}_1 \tilde{P} + \tilde{A}_2 \right]^{-1}, \quad \tilde{\Phi} = \tilde{D}^{-1} \tilde{F}, \quad \tilde{\Omega}_v = \tilde{D}^{-1} \Omega_v \tilde{D}^{-1}. \]

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Muddling Through and Policy Analysis

David Colander* **

In a variety of books and articles, both published and in process, I've been out pushing the idea of the "economics of muddling through" as the description of the approach to policy that will become standard in economics over the next 20 or 30 years. The argument is both prescriptive - I argue muddling through is what should be done - and descriptive - I argue that muddling through is what is currently being done, although, like Monsieur Jourdain speaking prose in Moliere's Le Bourgeois Gentilhomme, many economists don't recognize that that's what they are doing.

If we've been muddling for so long, why should we be willing to admit it now? I think there are three reasons.

• First, there is a change occurring in formal theorizing in which the holy trinity of rationality, greed, and equilibrium - being abandoned as required aspects of any model, and being replaced by a slightly broader trinity-purposeful behavior, enlightened self-interest, and sustainability.

• Second, the work in the formal general equilibrium model built upon the foundation of the holy trinity has been thoroughly explored, all the low-hanging fruit has been picked, and young theoretical researchers are naturally gravitating to less explored

*Parts of this paper come from early drafts of a book I am currently working on with William Brock entitled The Economics of Muddling Through (Colander and Brock, forthcoming). At this point only I am responsible for the arguments presented here. In the book we discuss the history of the term muddling through. Here, let me just point out that Charles Lindblom (1959) uses the term somewhat differently than we do.

**David Colander, Middlebury College

1 Keynote Address at the New Zealand Economic Association: June 2003

2 Actually, though, I suspect most economists do know that we're muddling; we are just rather hesitant to admit it. In fact, it may be because we know deep down that we are muddling that we spend so much time structuring our analysis so that it looks as if we are not muddling. I should also say that the focus of this article is on academic and textbook approaches to economic policy. Economists in actual line positions in government, business, and policy institutes generally recognize that policy involves muddling through.

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