Abstract

This paper examines the use of exchange rates as an instrument in attaining monetary policy objectives, as has been practiced in Singapore since 1981. Our basis for comparison is interest rate targeting. We present a model of the economy and examine the performance of "Taylor rule"-styled interest rate and exchange rate rules in stabilizing macroeconomic variables. We conclude that exchange rate targeting does confer considerable benefits to a small open economy that is highly dependent on trade, but these advantages diminish or disappear entirely for a less trade-dependent economy.

*I would like to thank Professor John Taylor for his invaluable guidance and unwavering support. This is difficult to overstate, but this thesis would simply not have been possible without his patience and encouragement.
# Contents

1. Introduction .............................................. 3

2. A Small Open Economy Model ................................. 4
   2.1 Model Setup ........................................... 4
   2.2 Model Calibration ...................................... 6
   2.3 Model Considerations .................................. 8

3. Simulation Analysis ......................................... 11
   3.1 Deterministic Shocks .................................... 11
   3.2 Stochastic Shocks ...................................... 18

4. Effect of Trade Dependency .................................. 23

5. Concluding Remarks ......................................... 29

6. References .................................................. 31

Appendix A .................................................... 35
1 Introduction

Among the open economies of the world, Singapore stands unique in having her monetary policy target the exchange rate of her national currency. With the aim of “[promoting] price stability as a sound basis for sustainable economic growth,” the Monetary Authority of Singapore (MAS) introduced the managed float regime for the Singapore dollar in 1981, ensuring that the Singapore dollar traded within an unspecified band (subject to periodic updates) in relation to a basket of currencies of trading partners and competitors. MAS maintains that this regime has not only allowed the Singapore economy to keep inflation to a minimum, but the explicit targeting of exchange rates has also ensured that it remain relatively stable, even in periods of uncertainty such as the Asian Financial Crisis of 1997-98 (MAS, 2001).

In this paper, we examine the use of the exchange rate as an intermediate monetary policy target with respect to its ability to promote stability in the macroeconomy, particularly in the face of exogenous volatility. The basis for comparison is the use of the interest rate as the target variable, arguably the predominant method in the world’s economies. Building upon the theoretical model of the economy presented in McCallum (2007), we evaluate the two monetary policy rules and demonstrate that under certain circumstances, exchange rate targeting may in fact be the monetary policy regime of choice.
## 2 A Small Open Economy Model

### 2.1 Model Setup

The model presented in McCallum (2007) comprises 10 equations, each describing a different aspect of the economy. The first 9 are given by:

\[c_t = E_t c_{t+1} + b_0 - b_1 r_t + v_t\]  \hspace{1cm} (1)

\[y_t = \omega_1 c_t + \omega_2 g_t + \omega_3 x_t\]  \hspace{1cm} (2)

\[m_t = y_t - \sigma q_t + \text{const}^1\]  \hspace{1cm} (3)

\[q_t = s_t - p_t + p_t^*\]  \hspace{1cm} (4)

\[x_t = y_t^* + \sigma^* q_t + \text{const}\]  \hspace{1cm} (5)

\[\bar{y}_t = \frac{\alpha_1 a_t - \sigma \alpha_2 q_t}{1 - \alpha_2} + \text{const}\]  \hspace{1cm} (6)

\[\Delta p_t = \frac{\beta E_t \Delta p_{t+1} + \Delta p_{t-1}}{1 + \beta} + \kappa(y_t - \bar{y}_t) + u_t\]  \hspace{1cm} (7)

\[R_t - R_t^* = E_t \Delta s_{t+1} + \xi_t\]  \hspace{1cm} (8)

\[r_t = R_t - E_t \Delta p_{t+1}\]  \hspace{1cm} (9)

A brief description of each of the above equations is provided below. Equation (1) follows from consumption-optimizing behavior, where \(c_t\) is the log of aggregate private consumption in the economy, \(r_t\) is real interest rate and \(v_t\) is a stochastic shock term derived from preferences relating to the intertemporal tradeoff in consumption. This follows the convention in other models of consumption, such that consumption is a negative function of the real interest rate.

Equation (2) approximates the national income identity, where \(y_t\), \(g_t\) and \(x_t\) are logarithms of real output, government consumption and exports. The coefficients \(\omega_1, \omega_2\) and \(\omega_3\) are steady-

\footnote{In this and following equations, “const” denotes some constant that may differ across different equations.}
state shares of output for consumption, government consumption and exports\textsuperscript{2}. Equation (3) reflects cost minimization for inputs, with \( m_t \) as the logarithm of imports, \( \sigma \) the elasticity of substitution between materials and labor, and \( q_t \) the log of real exchange rate. Purchasing power parity is expressed in (4), where \( s_t \) is the log of nominal exchange rate (price of foreign exchange in the home country’s currency) and \( p_t \) and \( p_t^* \) are the logs of domestic and foreign price levels. Equation (5) determines export demand, where \( y_t^* \) is foreign output and \( \sigma^* \) is price elasticity of demand abroad for domestic goods.

Equation (6) defines the “natural” value of log of real output \( \bar{y}_t \) if we had perfectly flexible prices. Equation (7) reflects price stickiness, since the inflation rate is a function of both the lagged and the future inflation rates. Uncovered interest parity is assumed in equation (8), where \( R_t \) and \( R_t^* \) are domestic and foreign nominal interest rates and \( \xi_t \) is a risk premium term. Equation (9) is simply the Fisher equation, giving us the real interest rate.

The tenth and final equation is the monetary policy rule employed by the central bank. A monetary policy that operates through the interest rate mechanism may be represented by the “Taylor rule”, as introduced in Taylor (1993), and given by:

\[
R_t = \tilde{r} + \Delta p_t + \mu_1(\Delta p_t - \tilde{\pi}) + \mu_2(y_t - \bar{y}_t) + \eta_t \tag{A}
\]

Here \( \tilde{r} \) is the equilibrium real interest rate, \( \tilde{\pi} \) is the target inflation rate and \( y_t - \bar{y}_t \) is the output gap, where we also note that \( \mu_1, \mu_2 \geq 0 \).

Meanwhile, McCallum (2007) proposes that exchange rate targeting may also be represented by a “Taylor rule” styled equation (see also Parrado, 2004):

\[
\Delta s_t = \tilde{\Delta}s + \Delta p_t - \mu_1(\Delta p_t - \tilde{\pi}) - \mu_2(y_t - \bar{y}_t) + \eta_t \tag{B}
\]

\textsuperscript{2} We assume that there are no investments in this model, and that imports are used only in the production of domestic goods.
Here $\Delta s$ refers to an equilibrium rate of change in the exchange rate. Thus an increase in inflation beyond the target inflation rate and/or an increase in the output gap would prescribe a decrease of $\Delta s_t$, i.e. the domestic currency should appreciate. This appreciation would make exports more expensive abroad and hence less attractive, while also reducing imported inflation. In practice, this contractionary monetary policy is effected by a central bank sale of foreign exchange, hence increasing demand for the home currency. An expansionary monetary policy would operate through the purchase of foreign exchange with reverse effects.

With a choice of equation (A) or (B) as our monetary policy, we have a total of 10 equations with 10 endogenous variables, namely $c_t, y_t, \bar{y}_t, x_t, m_t, p_t, s_t, q_t, R_t$ and $r_t$. Since we are modeling a small economy, we assume that all foreign variables ($y^*_t, p^*_t, R^*_t$) are exogenous. The remaining exogenous variables are $a_t, \xi_t, \upsilon_t, g_t, u_t$ and $\eta_t$.

EViews is used for the solution of this model. Due to the presence of lead terms in the model, we need to specify the nature of expectations in the economy. Here we follow the lead in Lucas (1995) and assume that people have rational expectations.

### 2.2 Model Calibration

We are interested in this paper in the change in variables relative to a baseline, thus all variables are detrended. We may simplify our computations by assuming that all additive constants, i.e. $b_0, \tilde{r}, \tilde{\pi}, \tilde{\Delta}s$ are set to 0. Following McCallum (2005, 2007), the model parameters are chosen as follows: $b_1 = 0.5, \omega_1 = 0.2, \omega_2 = 0.2, \omega_3 = 0.6, \sigma = 0.6, \sigma^* = 0.6, \alpha_1 = 0.6, \alpha_2 = 0.6, \beta = 0.97, \kappa = 0.03, \mu_1 = 0.5$ and $\mu_2 = 0.5$. The high calibrated value of $\omega_3$ is appropriate for an economy that is highly dependent on trade, as is the case with Singapore. Meanwhile, the values of $\mu_1$ and $\mu_2$ are chosen as per Taylor (1993) for use in the interest rate rule (A),

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3This also includes all instances of “const”.
and the use of these same values in the exchange rate rule (B) allows us to compare outcomes arising purely from a difference in the monetary policy tool and not its magnitude.

We also have the following specifications for our exogenous stochastic variables. Here \( \nu_t^{(i)} \) is a zero mean Gaussian white noise process of unit standard deviation:

\[
y_t^* = 0.95 y_{t-1}^* + 0.03 \nu_t^{(1)} \\
a_t = 0.95 a_{t-1} + 0.007 \nu_t^{(2)} \\
\xi_t = 0.5 \xi_{t-1} + 0.02 \nu_t^{(3)} \\
v_t = 0.5 v_{t-1} + 0.01 \nu_t^{(4)} \\
g_t = 0.97 g_{t-1} + 0.02 \nu_t^{(5)} \\
u_t = 0.002 \nu_t^{(6)} \\
\eta_t = 0.0017 \nu_t^{(7)}
\]

I also propose the following specifications for \( p_t^* \) and \( R_t^* \).

\[
p_t^* = 0.97 p_{t-1}^* + 0.01 \nu_t^{(8)} \\
R_t^* = \tilde{r}^* + \Delta p_t^* + \theta_1 (\Delta p_t^* - \tilde{\pi}^*) + \theta_2 (y_t^* - \bar{y}_t^*) + \eta_t^*
\]

This corresponds to the use of an interest rate rule (A) by the foreign central bank. We equate the foreign parameters with their domestic counterparts, so that \( \tilde{r}^* = 0 \), \( \theta_1 = 0.5 \) and \( \theta_2 = 0.5 \). As for the stochastic process \( \eta_t^* \), we also mirror the domestic case by setting \( \eta_t^* = 0.0017 \nu_t^{(9)} \). We further make the simplifying assumption here that \( \bar{y}_t^* \equiv 0 \). Note that equation (18) is a departure from McCallum (2007), where \( R_t^* \) is not itself an instrument for the foreign economy but a randomly generated variable, although this specification should better reflect reality.
Note that an alternative specification for the exogenous variables is simply to set them to be identically zero, hence disregarding equations (10) to (18). In this case, we obtain an equilibrium state as our model solution in which every endogenous series is also identically zero. This simplification is a useful starting point in helping us elucidate the distinction between rules (A) and (B), which we proceed to do in Section 3.

2.3 Model Considerations

In this section, we treat three potential issues that may arise with the use of this model concerning its specification.

Firstly, equation (2) is supposed to be a log-linear approximation to the national income identity $Y = C + I + G + (X - M)$. Such a formulation may seem somewhat unusual, but using Singapore annual data from 1965 to 2006\(^4\), one can in fact show that it is rather accurate.

$$y_t = 0.5774c_t + 0.0107g_t + 0.4618x_t$$

$(0.0428)$ $(0.0846)$ $(0.0620)$

$R^2 = 0.997$, $\hat{\sigma}_\eta = 0.0806$

The $R^2$ is almost 1, and $\hat{\omega}_1 = 0.5774$ and $\hat{\omega}_3 = 0.4618$ are both significant at the 0.1\% level, hence highly significant. This reassures us of the validity of equation (2).

Secondly, McCallum (2007) uses Singapore quarterly data from 1981 to 2005 to demonstrate the validity of the specification in equation (B). He estimates the equation using an instrumental-variables approach, along with a lag term to reflect smoothing of exchange rate. Here $e_t = -s_t$ is the log of the nominal exchange rate (given by the price of domestic money

\(^4\)In this and subsequent estimated regressions, figures in parentheses are standard errors, while $\hat{\sigma}_\eta$ is the standard error of the disturbance term. Data obtained from IMF International Financial Services Database.
in foreign currency), and $\Delta p^a_t$ is a four-quarter average inflation rate:

$$\Delta e_t = -0.0025 + 0.3256 \Delta p^a_t + 0.220(y_t - \bar{y}_t) + 0.0385 \Delta e_{t-1}$$

$\hat{\mu}_1 = 1.3256^{(5)}$ and $\hat{\mu}_2 = 0.220$ are clearly both significant, hence providing support for the specification in (B). This is also visually corroborated by the trends in Figure 1$^6$. Appreciation of the Singapore dollar occurs in periods of high inflation, while depreciation is generally associated with low inflation or even deflation.

Finally, this model does not allow us to work with many permanent shocks to the economy. In most of these cases, we are unable to attain a “satisfactory” equilibrium, where we impose relatively loose restrictions on what qualifies as an equilibrium. One not unreasonable

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$^5$($B'$) implies that $\hat{\mu}_1 - 1 = 0.3256$.

$^6$In the context of the model, NEER is the antilogarithm of $e_t$ and CPI the antilogarithm of $p_t$. 

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Figure 1: Singapore Exchange Rate and Consumer Price Index
requirement, for example, would be to have \( \lim_{t \to \infty} c_t = c \) for some \( c \in \mathbb{R} \).

Now consider a permanent shock to \( R^*_t \), such that \( R^*_t = \bar{R} \neq 0 \) for all \( t > t_0 \), with all other exogenous processes set at zero. We may assume without loss of generality that \( \bar{R} > 0 \).

Equilibrium would then require the following:

\[
(1) \implies \quad \lim_{t \to \infty} r_t = 0 \quad (19)
\]

\[
(9), (19) \implies \quad \lim_{t \to \infty} R_t = \lim_{t \to \infty} \Delta p_t \quad (20)
\]

\[
(8) \implies \quad \lim_{t \to \infty} R_t = \lim_{t \to \infty} \Delta s_t + \bar{R} \quad (21)
\]

\[
(20), (21) \implies \quad \lim_{t \to \infty} \Delta (s_t - p_t) = -\bar{R} \quad (22)
\]

\[
(4), (22) \implies \quad \lim_{t \to \infty} \Delta q_t = -\bar{R} \quad (23)
\]

\[
(23) \implies \quad \lim_{t \to \infty} q_t = -\infty \quad (24)
\]

\[
(6), (24) \implies \quad \lim_{t \to \infty} \bar{y}_t = \infty \quad (25)
\]

The last line follows from the assumption that \( \sigma \) and \( \alpha_2 \) are greater than 0. The prediction that potential output would increase to infinity based solely on a permanent increase (possibly infinitesimal) in \( R^*_t \) is clearly problematic. This shortcoming decreases the attractiveness of the model as a tool in examining the effect of long-term monetary policy initiatives. In the following section, I examine only shocks that are either purely temporary or fades off with time, and the predictions in these scenarios agree with economic intuition.

While the model presented in McCallum (2005, 2007) may not be perfect, there are relatively few alternative models proposed in the literature that evaluate the use of interest rates versus exchange rates as a monetary policy instrument. Minor problems notwithstanding, the model does make predictions that confirm economic intuition (as shown in Section 3), and provides a useful framework in one’s attempt to compare the two policy regimes.
3 Simulation Analysis

We conduct a series of simulations in our model economy using both the interest rate policy rule (A) and the exchange rate policy rule (B).

3.1 Deterministic Shocks

We first examine the case where shocks, while unexpected, are known with full accuracy in terms of their magnitude and duration once they occur. Unless otherwise specified, the exogenous variables $y_t^*, a_t, \xi_t, v_t, g_t, u_t, \eta_t, p_t^*$ and $R_t^*$ are assumed to be identically zero for all simulation scenarios in this subsection, thus equations (10) to (18) do not apply. This allows us to isolate the effect of specific shocks to the economy and offers a first comparison of rules (A) and (B).

We may consider a variety of scenarios where one (and only one) of four exogenous variables ($g_t, v_t, p_t^*$ and $R_t^*$) experiences a 1% positive shock, which may be either purely temporary or phases out exponentially. I examine in detail two particular shocks. The interested reader is referred to Appendix A for graphs depicting the remaining shock scenarios, although I offer a few general observations on the entire set of graphs below.

Qualitatively, the graphs traced out by the endogenous variables are substantially smoother when we use the exchange rate rule (B) as compared to the interest rate rule (A). This also means that under rule (B), the economy takes longer to resettle into an equilibrium state. This phenomenon is likely due to the presence of the lag term $s_{t-1}$ in (B) which is absent in (A), and serves to protract shocks to the economy. However, depending on the shock in consideration, the magnitudes of changes in key macroeconomic variables differs between the use of (A) or (B).

In the case of a 1 percentage point temporary increase in $R_t^*$ (as depicted in Figures 2 and
3\(^7\), the most striking difference in outcome is in the movement of home nominal interest rates. With rule (A), interest rates increase by 0.41%, as compared to 0.99% with rule (B). Under rule (B) the central bank allows home interest rates to absorb most of the shock experienced in the economy, whereas in rule (A), since the interest rate is the monetary instrument, there is greater intervention on the part of the central bank to ensure that it does not deviate too much from the target rate. Under (B), the shock in \(R^*_t\) has a relatively small impact on the two gap measures \(\Delta p_t - \pi\) and \(y_t - \bar{y}_t\), and thus calls only for a small change in \(\Delta s_t\). The central bank is thus willing to let interest rates rise almost to the full extent of the rise in \(R^*_t\) while keeping the exchange rate relatively constant. The gap measures are larger for an economy operating with (A), which dictates a slightly larger movement in \(R_t\) as compared to \(\Delta s_t\) in (B), although not to the full extent of the change in \(R_t\) in (B). The tradeoff for this decreased volatility in interest rate is an increase in volatility in exchange rates, leading to a depreciation of the home currency by 0.16% under (A) but only by 0.02% under (B).

There are also some differences in the response of the other macroeconomic variables. A side effect of the depreciation under (A) is a rise in exports by 0.36%, whereas this rise is only 0.02% under (B), almost negligible. This increase in exports is largely responsible for the increase of output under (A) by 0.17%, whereas with rule (B) output actually decreases by 0.09%, likely due to delayed consumption arising from higher interest rates; private consumption falls by 0.49% under (B) but only 0.20% under (A). Also, inflation rises to a peak of 0.035% with (A), while we have a deflation of 0.003% with (B); these magnitudes are relatively small and suggest

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\(^7\)In these figures and similar ones that follow, the first ten graphs are plots of endogenous variables and the last graph (where provided) is the plot of the sole exogenous variable being shocked. Percentage point changes are plotted for \(r_t\), \(R_t\) and \(R^*_t\), while percentage changes in their antilogarithms are plotted for all other series. The vertical line indicates where the shock is (first) introduced.
Figure 2: Temporary Shock in $R^*_t$, using Rule (A)
Figure 3: Temporary Shock in $R^*_t$, using Rule (B)
that price changes are not that important in the adjustment process in this scenario as the economy returns to an equilibrium state.

In another case, we consider a 1% increase in government consumption that phases out, so that $g_t$ increases by 0.01 in the first period (Figures 4 and 5). This expansionary fiscal policy leads to an increase in total output $y_t$ which is larger than the increase in potential output $\bar{y}_t$, at least in its initial stages. This leads to an output gap where $y_t - \bar{y}_t > 0$. There is also a slight increase in inflation $\Delta p_t$ of about 0.01% in both cases. Both these gaps are rather small, but positive, hence triggering monetary policy responses.

Under (A), an increase in interest rates is prescribed, and $R_t$ climbs by 0.02%. In theory, this higher interest rate induces investment from abroad, thus we see an immediate appreciation of the home currency by 0.13%, accompanied by a fall in exports of 0.08%. This is followed by a period of depreciation, which follows from uncovered interest parity since domestic interest rates continue to be higher than foreign interest rates. Another effect of this increase in interest rate is a drop in consumption by 0.06%, and the overall effect on total output is an increase of 0.14%. This adjustment process also sees rising prices, with inflation rates hitting a maximum of 0.010%.

Meanwhile, the exchange rate rule (B) calls for the sale of foreign exchange in the currency market to secure a (mild) appreciation of the home currency of 0.05%. The positive output gap also cause prices to rise simultaneously, with the inflation rate hitting 0.009%. There seems to be some overadjustment in this scenario, as the output gap then becomes negative and deflation sets in. The central bank should then react by allowing their currency depreciate as the economy resettles into an equilibrium.

Comparing the two rules in this scenario, we observe a larger increase in output under (B) of 0.17% as compared to 0.14% under (A). Also, inflation is slightly lower in (B) compared to
Figure 4: Shock in $g_t$ that Phases out, using Rule (A)
Figure 5: Shock in $g_t$ that Phases out, using Rule (B)
(A). This would suggest that, at least under the conditions stipulated in this scenario, fiscal policy is more effective under (B) than (A), with the additional benefit of greater price stability.

3.2 Stochastic Shocks

In this subsection, we incorporate stochastic shocks into our model of the economy, and hence assume that equations (10) through (18) hold. We also assume that economy participants have perfect information on the functioning of the economy, so that the generative processes for all exogenous variables except the foreign nominal interest rate, i.e. equations (10) through (17), are common knowledge. Rational expectations are thus formed about the future values of these variables, so that for example, we have $E_t y^*_t + 1 = 0.95 y^*_t$, $E_t a_{t+1} = 0.95 a_t$ and so on. The one exception is equation (18), where we make the simplifying assumption that people in the domestic economy have imperfect information on how foreign central banks set their interest rates, so that $E_t (R^*_t) = 0$ for all $t_i > t_0$.

This simulation is implemented in practice by the use of a control structure in EViews such that our model of the economy is solved iteratively at each time stage, incorporating full information on expectations of future values of exogenous variables. The model is thus solved at time $t$, substituting expectations at time $t$ of future values of exogenous variables for their actual values, and then solved again at time $t + 1$ with revised expectations from that period, and so on.

We are interested here in comparing the use of rules (A) and (B) to determine which rule performs better in ensuring macroeconomic stability. As a basis for comparison between rules (A) and (B), we use the same sequence of randomly generated exogenous shocks to the economy. The model was then solved for 100 consecutive time periods, separately under rule (A) and rule (B). Figures 6 and 7 track the performance of macroeconomic variables in both
Comparing the two figures, we clearly see that interest rates, both nominal and real, are more volatile under rule (B) than rule (A), though the reverse is true for nominal exchange rates. This confirms conventional wisdom that the monetary policy instrument is subject to relatively small disturbances, due to the active intervention of the central bank to restore it to a certain target rate, while allowing fluctuations in the instrument not being targeted to absorb the shocks in the economy. The graphs also seem to suggest that exports and real output are slightly more volatile under rule (A), while private consumption is more volatile under rule (B), though these observations are not entirely clear.

To provide quantitative rigor to our above observations, we repeat the above simulation process 9 times, each with a new sequence of randomly generated shocks, so we have a total of 10 simulations using rule (A), and another 10 using rule (B) with the same shocks. For each simulation, we compute the standard deviations of tracked macroeconomic variables over the 100 time periods where the model is solved. As each simulation under rule (A) corresponds to another one using rule (B) with the same exogenous shocks, we can apply the paired t-test to these estimated standard deviations to determine if one rule performs better than the other in reducing volatility. Results are reported in Table 1.

The results show that under the interest rate rule (A), we have smaller volatilities in consumption, imports, and interest rates. However, the exchange rate rule (B) performs better in inflation, movement in nominal exchange rate, exports, and output. Moreover, all these

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8 Differences are obtained by subtracting the mean estimated standard deviation under rule (B) from that under rule (A), and figures in parentheses are standard errors for these values. A paired t-test with 9 degrees of freedom is conducted, with * denoting a difference that is significant at the 5% level, ** at the 1% level, and *** at the 0.1% level.
Figure 6: Macroeconomic Performance under Stochastic Shocks, using Rule (A)
Figure 7: Macroeconomic Performance under Stochastic Shocks, using Rule (B)
Table 1: Mean of Estimated Volatilites ($\omega_3 = 0.6$)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Rule (A) (in 10^{-2})</th>
<th>Rule (B) (in 10^{-2})</th>
<th>Difference (in 10^{-3})</th>
</tr>
</thead>
<tbody>
<tr>
<td>$c_t$</td>
<td>3.82</td>
<td>3.99</td>
<td>$-1.79^{***}$ (0.20)</td>
</tr>
<tr>
<td>$m_t$</td>
<td>4.71</td>
<td>4.99</td>
<td>$-2.78^{***}$ (0.57)</td>
</tr>
<tr>
<td>$\Delta p_t$</td>
<td>1.02</td>
<td>0.62</td>
<td>$3.97^{**}$ (0.99)</td>
</tr>
<tr>
<td>$q_t$</td>
<td>3.41</td>
<td>3.66</td>
<td>$-2.47$ (2.65)</td>
</tr>
<tr>
<td>$r_t$</td>
<td>2.17</td>
<td>4.51</td>
<td>$-23.39^{***}$ (1.54)</td>
</tr>
<tr>
<td>$R_t$</td>
<td>2.91</td>
<td>4.62</td>
<td>$-17.12^{***}$ (0.93)</td>
</tr>
<tr>
<td>$\Delta s_t$</td>
<td>2.62</td>
<td>0.88</td>
<td>$17.47^{***}$ (0.49)</td>
</tr>
<tr>
<td>$x_t$</td>
<td>6.84</td>
<td>5.81</td>
<td>$10.26^{***}$ (1.09)</td>
</tr>
<tr>
<td>$y_t$</td>
<td>3.83</td>
<td>3.29</td>
<td>$5.47^{**}$ (0.72)</td>
</tr>
<tr>
<td>$\bar{y}_t$</td>
<td>2.55</td>
<td>3.01</td>
<td>$-4.56$ (2.11)</td>
</tr>
</tbody>
</table>

differences are significant at the 1% level. For a highly trade-dependent small open economy such as Singapore, and a central bank intent on “[promoting] price stability as a sound basis for sustainable economic growth” (see Section 1), these results provide compelling evidence that exchange rate targeting is in fact the policy regime of choice; the decreased volatility in real output is a further plus. These statistically significant results corroborate what is suggested in McCallum (2007) on the attractiveness of exchange rate targeting, even with foreign targeting.
of interest rates.

4 Effect of Trade Dependency

We noted above that our assumption of $\omega_3 = 0.6$ is on the high side for most economies, reflecting the substantial dependence on trade of an economy like Singapore’s. McCallum (2007) suggests that $\omega_3 = 0.15$ may be more representative of the average economy. We may then question how these two rules fare in the average economy, hence we repeat the analysis in Section 3 but now with $\omega_1 = 0.65$, $\omega_2 = 0.2$ and $\omega_3 = 0.15$, so that private consumption now comprises a much larger share of output. Results are given below in Figures 8 through 11, which are essentially redraws of Figures 2 through 5 with the new parameters.

Compared to Figure 2, Figure 8 shows relatively little difference in the performance of the interest rate rule (A), with the exception of the graphs of $m_t$ and $y_t$. That output now declines upon a temporary increase in $R_t^*$ may be attributed to the larger steady-state share of private consumption, which drops, vis-à-vis the decreased share of exports, which rises. This also leads to a greater fall in imports.

On the other hand, Figures 3 and 9 reveal stark contrasts. Inflation and output are now substantially more volatile, more than double that in the original economy, with the latter partly due to the greater effect that the fall in consumption now has on output. An intuitive explanation for these two outcomes lies in the understanding that the exchange rate channel is much less potent in this economy, since exports now comprise a substantially smaller portion of the domestic economy. Hence to effect the same outcome, the central bank needs to intervene in the markets more aggressively as compared to a more trade-dependent economy. We see from Figure 9 that in a less trade-dependent economy, in response to a 1% temporary rise
Scenario A4 (with reduced omega3)

Figure 8: Temporary Shock in $R_t^*$, with $\omega_3 = 0.15$, using Rule (A)
Figure 9: Temporary Shock in $R^*_t$, with $\omega_3 = 0.15$, using Rule (B)
in $R_t^*$, the central bank oversees a maximum depreciation of the home currency by 0.10% (as compared to 0.03%), and while this does increase exports by a larger amount, this is still insufficient to avert the greater fall in output, which now decreases by 0.29% as compared to 0.09%. These 2 figures then illustrate the decreased effectiveness of exchange rate targeting when an economy that is less exposed to trade responds to a shock in the foreign economy. Note however that inflation and exchange rate movements in a less trade-dependent economy using the exchange rate rule (B) are still less volatile than using the interest rate rule (A), as is clear from comparing Figures 8 and 9.

Meanwhile, a comparison of Figures 4, 5, 10, and 11 reveal that this change in export-dependency has negligible impact on the macroeconomic effect of shocks in government expenditure. This may be explained by the fact that $\omega_2$ is held constant, so that the impact on the economy of a shock in government spending is largely unchanged.

To draw broader conclusions on how the two rules fare in such an economy, we repeat the simulations carried out in Section 3.2, though now with $\omega_3 = 0.15$ and $\omega_1 = 0.65$. Table 2 duplicates Table 1 and reports estimated volatilities of a 100-period simulation, averaged across 10 simulations each, where our model uses the new parameters above.

As is the case in Table 1, exchange rates and interest rates are respectively most stable in the regime in which they are being targeted. The exchange rate rule (B) still gives us a smaller inflation volatility, although its advantage over the interest rate rule (A) is now diminished (a decrease of 0.00188 vs. 0.00397). Whereas output $y_t$ was more stable under rule (B) for $\omega_3 = 0.6$, now with $\omega_3 = 0.15$ it is actually more stable under rule (A). We may thus conclude from this analysis that the exchange rate rule (B) tends to perform poorer in a less trade-dependent economy, although it may still retain some benefits over the interest rate rule (A) insofar as macroeconomic stability is desired.
Figure 10: Shock in $g_t$ that Phases out, with $\omega_3 = 0.15$, using Rule (A)
Scenario B5 (with reduced omega3)

Figure 11: Shock in $g_t$ that Phases out, with $\omega_3 = 0.15$, using Rule (B)
Table 2: Mean of Estimated Volatilities ($\omega_3 = 0.15$)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Rule (A) (in $10^{-2}$)</th>
<th>Rule (B) (in $10^{-2}$)</th>
<th>Difference (in $10^{-3}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$c_t$</td>
<td>3.53</td>
<td>3.76</td>
<td>$-2.23^{***}$ (0.32)</td>
</tr>
<tr>
<td>$m_t$</td>
<td>4.22</td>
<td>3.37</td>
<td>$8.54^{***}$ (0.85)</td>
</tr>
<tr>
<td>$\Delta p_t$</td>
<td>0.79</td>
<td>0.61</td>
<td>$1.88^*$ (0.58)</td>
</tr>
<tr>
<td>$q_t$</td>
<td>4.78</td>
<td>2.96</td>
<td>$18.22^{***}$ (1.83)</td>
</tr>
<tr>
<td>$r_t$</td>
<td>1.72</td>
<td>4.48</td>
<td>$-27.59^{***}$ (0.85)</td>
</tr>
<tr>
<td>$R_t$</td>
<td>2.26</td>
<td>4.66</td>
<td>$-24.07^{***}$ (0.88)</td>
</tr>
<tr>
<td>$\Delta s_t$</td>
<td>3.13</td>
<td>0.84</td>
<td>$22.89^{***}$ (0.79)</td>
</tr>
<tr>
<td>$x_t$</td>
<td>9.29</td>
<td>7.87</td>
<td>$14.20^{***}$ (0.78)</td>
</tr>
<tr>
<td>$y_t$</td>
<td>2.00</td>
<td>2.24</td>
<td>$-2.36^{***}$ (0.33)</td>
</tr>
<tr>
<td>$\bar{y}_t$</td>
<td>3.76</td>
<td>1.90</td>
<td>$18.65^{***}$ (1.31)</td>
</tr>
</tbody>
</table>

5 Concluding Remarks

The present paper examined the performance of both interest rate and exchange rate monetary policy rules, using a small open economy model presented in McCallum (2007). The above sections showed that by choosing between the two rules, stability in interest rates was achieved at the expense of volatile exchange rates, and vice versa. A central bank placing more emphasis
on one of the two would have a greater incentive to choose that as the intermediate target. If the ultimate objective of monetary policy is inflation targeting, as outlined by Bernanke and Mishkin (1997), then our analysis suggests that a small open economy might perform better in taming volatility in inflation by choosing to target interest rates. This statistically significant effect is even more pronounced for a highly trade-dependent economy such as Singapore’s, which has a relatively weak interest rate channel and a relatively strong exchange rate channel due to the dominance of imports and exports in the domestic economy.

While we acknowledge minor problems with the model, a model that would provide us with the necessary tools to undertake this comparative study would be necessarily complex and also difficult to validate. As highlighted by Christiano et al. (1999), part of the challenge in formulating accurate models and subsequently calibrating them with precision lies in our difficulty in isolating monetary policy experiments in empirical data (see also Bernanke and Mihov, 1998, and Cushman and Zha, 1997). As a possible extension to this model, it may also be instructive to consider two-country (or even multi-country) models, incorporating elements from Clarida et al. (2002) to examine potential gains from monetary policy coordination between economies operating with different policy rules, and to examine how small economies like Singapore may best factor in the monetary policy decisions of large economies like the United States.

In any case, the relative flexibility and fine-tuning allowed under a managed float regime, using exchange rates as a monetary instrument, is well-documented by several scholars, including Deveraux (2004) and Williamson (2001). Chang and Velasco (1997) moreover suggest it as possibly an optimal policy for developing countries as they seek to build credibility for their currencies and yet reserve the ability to insure themselves from foreign shocks. Khor et al. (2004) remind us of a need for a “supporting framework of consistent macroeconomic
and microeconomic policies as well as strong institutions” for successful implementation of the managed float, to which they give credit for helping Singapore tide over the Asian Financial Crisis. A review of the literature registers general (though qualified) support for the use of exchange rates as an intermediate target for a small economy. This is in agreement with our finding that, under the right conditions, exchange rate targeting may be the regime of choice in attaining monetary policy objectives.

6 References


Appendix A

This appendix contains a series of graphs corresponding to scenarios that are associated with various exogenous, deterministic shocks to the economy coupled with rational expectations. Scenarios that incorporate the use of the interest rate rule have the prefix A, while those using the exchange rate rule have the prefix B. Following the calibration in Section 3, all graphs in this appendix have \( \omega_1 = 0.2, \omega_2 = 0.2 \) and \( \omega_3 = 0.6, \) and is hence appropriate for a small open economy that is highly dependent on trade.

A listing of scenarios identifying the shocked exogenous variable and the duration of the shock is given below:

<table>
<thead>
<tr>
<th></th>
<th>( g_t )</th>
<th>( v_t )</th>
<th>( p_t^* )</th>
<th>( R_t^* )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temporary</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4(^9)</td>
</tr>
<tr>
<td>Phases out</td>
<td>5(^9)</td>
<td>6</td>
<td>7</td>
<td>8</td>
</tr>
</tbody>
</table>

\(^9\)Graphs for these scenarios are found in Section 3.1.
Figure 12: Temporary Shock in $g_t$, using Rule (A)
Figure 13: Temporary Shock in $g_t$, using Rule (B)
Figure 14: Temporary Shock in $v_t$, using Rule (A)
Figure 15: Temporary Shock in $v_t$, using Rule (B)
Figure 16: Temporary Shock in $p^*_t$, using Rule (A)
Figure 17: Temporary Shock in $p^*_t$, using Rule (B)
Figure 18: Shock in $v_t$ that Phases out, using Rule (A)
Figure 19: Shock in $v_t$ that Phases out, using Rule (B)
Figure 20: Shock in $p_t^*$ that Phases out, using Rule (A)
Figure 21: Shock in $p_t^*$ that Phases out, using Rule (B)
Figure 22: Shock in $R_t^*$ that Phases out, using Rule (A)
Figure 23: Shock in $R^*_t$ that Phases out, using Rule (B)