IMES DISCUSSION PAPER SERIES

Monetary Policy in East Asia: the Case of Singapore

Bennett T. McCallum

Discussion Paper No. 2007-E-10

IMES

INSTITUTE FOR MONETARY AND ECONOMIC STUDIES

BANK OF JAPAN

C.P.O BOX 203 TOKYO
100-8630 JAPAN

IMES Discussion Paper Series 2007-E-10
August 2007

Monetary Policy in East Asia: the Case of Singapore

Bennett T. McCallum*

Abstract

The Monetary Authority of Singapore (MAS) conducts policy by adjusting the Singapore dollar's effective exchange rate so as to achieve macroeconomic goals for the economy's inflation rate and output gap. Estimates of a policy rule of the Taylor type, except with exchange rate appreciation serving as the instrument/indicator variable, substantiate this interpretation. That this rule reflects policy that is much like inflation targeting is evidenced by the absence of any significant role for the real exchange rate as a distinct target variable in addition to inflation and the output gap. Simulations with a dynamic model of a small open economy illustrate that this type of rule can be relatively more advantageous in economies that (like Singapore) are extremely open to international trade. The analysis illustrates that monetary policy and exchange-rate policy are two sides of the same coin, which suggests that assignment of exchange-rate management to a nation's fiscal authority is an anachronism.

Keywords: exchange rate; inflation targeting; instrument variable; target variable; open economy; monetary policy
JEL classification: E42, E58, F31, F41

* Professor, Carnegie Mellon University and National Bureau of Economic Research (E-mail: bmccallum@cmu.edu)

This paper was prepared for presentation at the 14th International Conference of the Institute for Monetary and Economic Studies, Bank of Japan, held in Tokyo on May 30-31, 2007. I am grateful to Stefan Gerlach, Petra Gerlach-Kristen, Marvin Goodfriend, John Taylor, and Lin Tian for various contributions.

1. Introduction

A wide variety of monetary policy arrangements exists among the countries of East Asia, ranging from the currency board system of Hong Kong and the constantly-discussed regime in China to official inflation targeting in South Korea, Thailand, The Philippines, and elsewhere. One case that should be of particular interest is that of Singapore. Of course, Singapore is a very small country—just a medium-large city—yet it has more population and a larger GDP in dollar terms than those of New Zealand, whose central bank has been notable as a leader in the world-wide surge toward inflation targeting.[1] More importantly, however, Singapore's monetary policy system is unique, fundamentally interesting, and not widely understood. There are a few papers in existence that discuss the system, including items by Devereux (2003), Gerlach and Gerlach-Kristen (2005), Khor, Robinson, and Lee (2004), McCallum (2006), McCauley (2001), Moreno (1988), Parrado (2004), Rajan and Siregar (2002), Tian (2006), and Williamson (1998, 1999), plus several by the Monetary Authority of Singapore. These reflect important differences in interpretation, however, over the system's essential nature. Accordingly, I propose to discuss aspects of the Singapore system in the present paper, drawing heavily upon McCallum (2006).

2. Nature of the Singapore Monetary System

Let us begin with an informal description of the Singapore system, before turning to a presentation in terms of an analytical model. A useful quote from a one-page summary by the Monetary Authority of Singapore (MAS) itself is as follows:

[1] International Financial Statistics figures for 2005 are 4.33 million persons and $115 billion for Singapore as compared with 4.03 million persons and $98.7 for New Zealand.

> "Since 1981, monetary policy in Singapore has been centered on the management of the exchange rate. The primary objective has been to promote price stability as a sound basis for sustainable economic growth. The exchange rate represents an ideal intermediate target of monetary policy in the context of the small and open Singapore economy.... First, the Singapore dollar is managed against a basket of currencies of our major trading partners and competitors.... Second, MAS operates a managed float regime.... The trade-weighted exchange rate is allowed to fluctuate within a policy band, the level and direction of which is announced semi-annually to the market.... Third, the exchange rate policy band is periodically reviewed to ensure that it remains consistent with the underlying fundamentals of the economy." (MAS, undated)

A careful reading of the foregoing, plus additional descriptions by MAS officials, reveals a crucial aspect of this procedure. It is that the band, within which the Singapore dollar (S$) effective exchange rate is kept, is not at all constant through time. Instead, the band may move upward or downward automatically as time passes (to allow for expected ongoing appreciation or depreciation) and, more importantly, both the level and slope of the band—and even its width—may be discretely adjusted each decision period.[2] Crucially, these adjustments are made in a manner that is designed to keep inflation low—i.e., to promote price stability. Some adjustments of the band may, in addition, be made in response to prevailing (or forecasted) behavior of real variables such as aggregate output or employment. Thus the type of exchange rate management employed by the MAS is very different from a traditional fixed exchange rate. In fact, it would

[2] The MAS often refers to the "BBC" aspects of its procedure, these letters referring to "band, basket, and crawl." That terminology, which draws upon Williamson (1999, 2001), will be discussed further in Section 3.

appear that the MAS operates with policy objectives quite similar to those of the Federal Reserve or the European Central Bank or the Bank of England, i.e., to maintain low inflation as a priority, with some attention also paid to output and/or employment considerations. Indeed, the MAS system might even be regarded as basically a variant of inflation targeting, not a fixed exchange-rate system!

To continue in this vein, the MAS procedures seem very much like those of inflation-targeting central banks <u>except</u> that its policy management involves periodic adjustments in the exchange rate, rather than a short term nominal interest rate.[3] The reason for this difference in policy behavior is, moreover, quite straightforward and simple: the Singapore economy is much more open to foreign trade than those of (e.g.) the United States, Japan, the euro area, or the United Kingdom. Instead of an export/GDP ratio of about 0.15 (or about 0.25 for the UK), for Singapore the value is currently about 1.4-1.5! Thus the exchange rate channel of monetary policy transmission is much more important, relative to the familiar interest-rate channel, than in larger economies that are less open to international trade. Accordingly, use of the exchange rate, rather than a short-term interest rate, as the principal instrument/indicator variable for monetary policy, may provide a relatively more effective way of managing aggregate demand.[4] This policy comparison will be analytically illustrated below.

The foregoing suggestion that the MAS policy framework is basically one in which inflation is the main target variable, with the exchange rate being used primarily as

[3] The MAS system does, as will be seen below, include practices that do not reflect policy transparency of the degree usually attributed to inflation-targeting central banks.

[4] One should not infer, however, that adjustments in the exchange rate are necessarily implemented by open market purchases in the foreign exchange market. Except when interest rates are at (or near) zero, such adjustments could alternatively be implemented by purchases in the domestic money market. Throughout, I presume that purchases or sales in the foreign exchange market are not sterilized. If a policy action concerning the exchange rate is undertaken for the purpose of affecting aggregate demand, it makes no sense at all to use sterilized interventions.

an instrument or indicator for specifying policy changes that are designed to keep inflation close to target, is supported by the behavior of the exchange rate over the years 1981-2005. The period discussed begins with 1981 because that is the year in which the current MAS policy regime was put in place, according to MAS (undated, 2001). The statistics indicate that, over the span from 1981 to the middle of 1997, the S$ appreciated in value by about 45 percent relative to the policy basket, despite a large drop in 1985-87. This appreciation was needed to prevent inflation since (i) foreign inflation was proceeding at a rate higher than the Singapore target and also (ii) because rapid productivity growth in Singapore was bringing about an ongoing appreciation in real terms, due perhaps to the Balassa-Samuelson effect. After a fall during the Asian financial crisis of 1997-98, the value of the S$ levelled off and has not changed much since. Even so, the value of the S$ remained about 35 percent higher in 2005 than in 1981 in terms of the (trade-weighted) basket.

More formal evidence in this regard requires a more analytical description of policy behavior. The most common formulaic representation of monetary policy procedures for more typical economies is provided by some variant of the "Taylor rule," introduced by John Taylor (1993), which relates periodic adjustments in a money-market interest rate made in response to existing (or predicted) inflation and output-gap measures. A standard formulation is

$$(1) \qquad R_t = r + \Delta p_t + \mu_1(\Delta p_t - \pi^*) + \mu_2(y_t - \bar{y}_t) + \eta_t \qquad \mu_1, \mu_2 \geq 0$$

where R_t is the interest rate, Δp_t is the current inflation rate, π^* is the target inflation rate (at which the central bank wishes to keep inflation on average), and $y_t - \bar{y}_t$ is the output gap, i.e., the percent (or fraction) by which real output exceeds the "natural rate" of output that represents an efficient, market-clearing level. The term η_t represents random policy influences by the central bank, which in principle should be very small.

In comparison to (1), the Singapore policy rule might be represented as follows:

$$(1') \quad \Delta e_t = \Delta e - \Delta p_t + \mu_1(\Delta p_t - \pi^*) + \mu_2(y_t - \overline{y}_t) + \eta_t, \qquad \mu_1, \mu_2 \geq 0.$$

Here e_t is the log of the nominal exchange rate, expressed as foreign currency units per unit of home-country money (e.g., yen/dollar if the United States is taken as the home country). Correspondingly, Δe is the average rate of appreciation of the currency (perhaps negative) that reflects the sum of the long-run rate of appreciation of the real exchange rate plus the average inflation rate abroad. Clearly, monetary policy designed to reduce inflation when it is above its target value would call for an increase in Δe_t under this rule, rather than an increase in R_t. This desired increase could in principle be brought about by the central bank by conducting open-market sales of foreign exchange, although in normal circumstances it could alternatively be effected by the sale of short-term domestic securities, as would usually be the case with the Taylor rule (1).[5] It should be emphasized that the policy behavior described by (1') is not intended to keep the exchange rate at any particular value other than whatever would be consistent with the inflation and output-gap targets specified on the right-hand side of the relationship.

Is there any reason to believe that in reality MAS behaves in a manner similar to rule (1')? In that regard, MAS Staff Paper No. 31, 2004, written by Eric Parrado, then of the IMF, uses monthly data for 1991-2002 to estimate a rule of the form (1') but with inclusion of an additional Δe_{t-1} term to reflect smoothing of the exchange rate. (Also, his

[5] If foreign exchange and domestic short-term securities were perfect substitutes, then a purchase (of a given size) of either would have the same effect. This paper's analysis presumes that these two assets are close but not perfect substitutes.

preferred equation uses the expected inflation rate nine months into the future, rather than the current rate.) Parrado's instrumental-variable estimates are as follows:[6]

(2) $$\Delta e_t = -0.006 + 1.89E_{t-1}\Delta p_{t+9} + 0.42(y_t - \bar{y}_t) + 0.85\Delta e_{t-1}$$

$$\quad\quad\quad (0.009) \quad (0.55) \quad\quad (0.14) \quad\quad (0.022)$$

$R^2 = 0.86$ J-stat p-value = 0.85

Clearly these estimates provide considerable support for the suggestion made above.

It must be said that the MAS normally does not describe its policy in this manner, instead emphasizing the "BBC" aspects (basket, band, crawl) aspects of exchange-rate policy that have been promoted in the work of Williamson (1999)—see Khor, Robinson, and Lee (2004). But if the band and its crawl are designed primarily so as to achieve targets for Δp_t and $y_t - \bar{y}_t$, then this amounts basically to the same thing as inflation targeting, as is argued above.

3. Empirical Evidence

While the arguments and evidence presented in the previous section are highly suggestive, a more direct test of our proposition—i.e., that the Singapore system is much like a variant of inflation targeting—would clearly be useful. Such a test should be based on aspects of inflation targeting that differ from those of the Williamson (1999, 2001, 2006) approach to policy management, as the latter has been prominent in the MAS literature. I would argue that the most important operational difference between the two is that inflation targeting presumes that there will be no response of policy to exchange-rate movements (or departures from target values) beyond those called for by inflation and output gaps relative to target. That characteristic is implied by the Taylor-style

[6] Here the figures in parentheses are standard errors, the R^2 statistic is unadjusted, and the reported p-value is for Hansen's J statistic for testing the hypothesis that the assumed orthogonality conditions are valid.

formulation (1') above. By contrast, Williamson's writings, which explicitly advertise their distinction from inflation targeting, call for an international system based on "reference rates" that are basically targets for each economy's real exchange rate. A quote from Williamson (2006) may be helpful.

> The concept of a reference rate was introduced many years ago by Ethier and Bloomfield (1975). They thought of a reference rate as an officially agreed exchange rate that would carry with it an obligation not to intervene ... in a way that would tend to push the market exchange rate away from the reference rate. Countries would be allowed to intervene, but only in an internationally sanctioned way—to push the rate toward the reference rate... Ethier and Bloomfield did not address exactly what concept of the exchange rate was ... [relevant], but clearly it is what matters for the macroeconomy: the real effective exchange rate (2006, pp. 7-8).

Our strategy will be to estimate a policy equation, analogous to that in the Parrado study, to demonstrate independently that the Singapore exchange-rate movements are consistent with a policy of the type expressed in equation (1'), and then to add additional variables, designed to reflect departures of the real effective exchange rate from some target value, to see if these have any additional explanatory power beyond that provided by the inflation and output-gap variables in (1').[7] Accordingly, we begin with estimation of an equation similar to that of Parrado, but using quarterly—rather than monthly—observations. Also, following Gerlach and Gerlach-Kristen, I use a four-quarter average inflation rate Δp_t^a instead of Parrado's inflation rate for nine months into the future. The

[7] This approach is used by Tian (2006).

sample period is 1981.1-2005.4, the start date being that of the regime's inception and the end date omitting recent observations that might be subject to revision. The data series are mostly taken from the IMF's International Financial Statistics; details are reported in an appendix at the end of the paper. Least squares estimates are:[8]

$$(3) \qquad \Delta e_t = -0.0025 + 0.3245\,\Delta p_t^a + 0.174(y_t - \bar{y}_t) + 0.0735\Delta e_{t-1}$$

$$\qquad\qquad (0.0017) \quad (0.0765) \quad (0.0494) \qquad (0.0988)$$

$R^2 = 0.379$ SE = 0.01274 DW = 2.05 T = 100

Here the results are reasonably similar to those of Parrado, with inflation entering strongly and the output gap significantly. One major difference is that in (3) the lagged dependent variable provides almost no explanatory power, whereas in Parrado (2004) it is quite important. This difference is presumably attributable to the use here of quarterly data series, Parrado's being monthly. Our R^2 value is considerably lower, but that is not of importance since our parameters' standard errors are of the same order of magnitude.[9]

In considering the specification of (3), one reaction is to doubt the availability of data on inflation and the output gap for quarter t, to the central bank when setting the S$ exchange rate for that quarter. More sensible would be to believe that the MAS policymakers have at their disposal only values of those variables for previous periods. Accordingly, equation (3) should be re-estimated by instrumental variables, using as instruments the constant term and once-lagged values of the other right-hand side variables (if not already lagged). The resulting estimates are as follows:

[8] In (3) and in subsequent equations, SE denotes the estimated standard deviation of the disturbance term, DW is the Durbin-Watson statistic, and T is the number of observations.
[9] Evidently Parrado's exchange rate data, which is not described, features much more variability because of its monthly frequency. Since the variables are changes, this seems entirely plausible.

(4) $\Delta e_t = -0.0025 + 0.3256\,\Delta p_t^a + 0.220(y_t - \bar{y}_t) + 0.0385\Delta e_{t-1}$

(0.0019) (0.0895) (0.0647) (0.108)

$R^2 = 0.372$ SE = 0.01284 DW = 1.997 T = 99

These results are qualitatively similar to those in (3).

At this point we wish to test whether the real exchange rate, or its deviation from a target value, provides independent explanatory power. As a start, we include the log of the real exchange rate from the previous period as an additional regressor; the idea being that if this variable (lreer) is "high," then it will exert a downward influence on the change in the nominal rate—its coefficient will be negative. Since the variable is lagged, it serves as its own instrument. Instrumental variable estimates are as follows:

(5) $\Delta e_t = 0.1350 + 0.3435\,\Delta p_t^a + 0.2475(y_t - \bar{y}_t) + 0.0335\Delta e_{t-1} - 0.0300\ \text{lreer}_{t-1}$

(0.0777) (0.0882) (0.0647) (0.107) (0.0169)

$R^2 = 0.383$ SE = 0.01279 DW = 1.994 T = 99

In this case, the real exchange rate variable provides only marginally significant incremental explanatory power. Simply adding the (log) variable in this way amounts, however, to treating its target value as constant over the entire sample period. As that implication seems implausible, we next try entering (in the same way) the variable's departure from a fitted linear trend:

(6) $\Delta e_t = -0.0027 + 0.3368\,\Delta p_t^a + 0.2473(y_t - \bar{y}_t) + 0.0352\Delta e_{t-1} - 0.0290\ \text{lreerresid}_{t-1}$

(0.0019) (0.0885) (0.0648) (0.107) (0.0170)

$R^2 = 0.382$ SE = 0.01280 DW = 1.994 T = 99

Again the incremental explanatory power is barely significant, and experimentation with higher polynomials in time yields results even more unfriendly to the tested hypothesis.

Again, however, the implied "equilibrium" real rate is represented in a rather unsatisfactory manner. More ambitiously, one might attempt to construct a model of the target rate—but that would be both problematic and beyond the scope of this study. A feasible representation of the target rate can be constructed, however, by means of the popular Hodrick-Prescott filter, with the departure of actual from "trend" used as the variable to enter into the estimated policy rule. Indeed, this procedure seems rather consistent with Williamson's (2006) characterization of his reference value. Accordingly, we now enter the Hodrick-Prescott "cycle" component as the real exchange rate variable:

$$(7) \qquad \Delta e_t = \underset{(0.0018)}{-0.0025} + \underset{(0.0886)}{0.3174}\,\Delta p_t^a + \underset{(0.0613)}{0.2666}(y_t - \bar{y}_t) + \underset{(0.1067)}{0.0472}\Delta e_{t-1} - \underset{(0.0378)}{0.0972}\ \text{lreerhpc}_{t-1}$$

$R^2 = 0.4006$ SE = 0.01261 DW = 1.971 T = 99

In this case, the estimated coefficient on the real rate variable is 2.56 times its standard error, thereby being of greater than marginal significance. So in this case, there is some appreciable evidence of a separate role for the real exchange rate, even though its contribution to the adjustment of the policy variable, Δe_t, is considerably less than that of either the inflation or output-gap variables.[10]

Before drawing that conclusion, however, one should consider the possibility that the nature of the MAS policy practice has evolved over the 25 years since its inception. Indeed, it would seem highly unlikely that significant changes have not occurred, especially as the development of inflation targeting as a practical policy system began only around 1990! As a matter of local concern, the recession of 1985 in Singapore was rather severe and a major exchange rate adjustment took place during the first two

[10] The incremental contributions of the different regressors are monotonically related to the relevant t-ratios—see, e.g., Goldberger (1964).

quarters of 1986. Accordingly, I have applied the Chow parameter-stability test to equation (7) for two breakpoints, 1987.1 and 1989.1. The P-values for these tests are 0.0079 and 0.0399, clearly indicating the presence of a break. Then re-estimating (7) with a start date of 1990.1, we obtain

$$(7') \quad \Delta e_t = -0.0040 + 0.5304\,\Delta p_t^a + 0.1735(y_t - \bar{y}_t) - 0.104\Delta e_{t-1} - 0.0121\ lreerhpc_{t-1}$$

$$\quad (0.0023) \quad (0.1396) \quad (0.0782) \quad (0.146) \quad (0.0957)$$

$R^2 = 0.2937$ SE = 0.01086 DW = 2.027 T = 64

In this case, the role of the real exchange rate variable is not even slightly significant, whereas the inflation variable continues to be highly important. Chow stability tests for this sample period do not indicate breaks at any of the following dates: 1995.1, 1997.1, 1999.1, and 2001.1.

In sum, the results of the foregoing investigation provide substantial support for the hypothesis that Singapore monetary policy has not, since 1990, given the real exchange rate a role as an independent objective, in addition to the objectives of stabilizing inflation and output around their desired levels. The MAS policy, that is, has since 1990 been more of an inflation targeting regime than one of the BBC type promoted by Williamson (1999, 2001, 2006).[11]

4. Analysis with Open-Economy Model

Let us now illustrate how any of the foregoing monetary policy rules—or others—could be utilized in combination with a formal quantitative model, of a small economy open to foreign trade, for the purpose of monetary policy analysis. One particular example of such a model is the one utilized by McCallum and Nelson (1999)

[11] In other words, the results constitute positive analysis indicating that Singapore has conducted policy in a manner consistent with that suggested from a normative point of view by Taylor (2001, 264-266).

and McCallum (2005). This model differs from a more standard optimizing specification (e.g., Clarida, Gali, and Gertler, 2002) by treating imports as raw materials for the production process rather than as finished consumer goods, but in both cases the basic role of the (real) exchange rate is to induce substitution away from usage of foreign-produced goods when they are relatively expensive. It is a small-open-economy model that can be summarized by means of the following equations:

(8) $c_t = E_t c_{t+1} + b_0 - b_1 r_t + v_t$

(9) $y_t = \omega_1 c_t + \omega_2 g_t + \omega_3 x_t$

(10) $im_t = y_t - \sigma q_t + \text{const}$

(11) $q_t = s_t - p_t + p^*_t$

(12) $x_t = y^*_t + \sigma^* q_t + \text{const}$

(13) $\bar{y}_t = (1-\alpha_2)^{-1}[\alpha_1 a_t - \sigma\alpha_2 q_t] + \text{const}$

(14) $\Delta p_t = (1+\beta)^{-1}[\beta E_t \Delta p_{t+1} + \Delta p_{t-1}] + \kappa(y_t - \bar{y}_t) + u_t$

(15) $R_t - R^*_t = E_t \Delta s_{t+1} + \xi_t$

(16) $r_t = R_t - E_t \Delta p_{t+1}$

A very brief description of each will be provided. Equation (8) is a consumption (c_t) Euler equation, reflecting intertemporal optimization, while (9) is a log-linearized approximation to an identity that splits output y_t—not value added!—into three components: consumption, government consumption g_t, and exports x_t.[12] Next, in (10) import demand im_t is given by cost minimization for a production function of the CES type with σ as the elasticity of substitution between imports and labor. An analogous

[12] Domestic investment would also be included in a model that distinguishes between consumption and investment spending. The variables c_t, g_t, x_t, and im_t (as well as y_t, p_t, s_t, and q_t) are in logarithms.

relation (12) governs demand from abroad for home-country exports. Equation (11) defines the log of the real exchange rate q_t in relation to the log of the nominal exchange rate s_t ($s_t = -e_t$) and the logs of home and foreign price levels, p_t and p^*_t. Equation (13) specifies the natural rate (i.e., flexible-price) value of the log of real output, $\bar{y}_t$, with this value depending upon a stochastic term a_t that reflects the results of technology shocks (assumed to follow an exogenous AR(1) process with autocorrelation parameter 0.95) and the real price of imported inputs to production. A variant of the Calvo model of nominal price stickiness appears as (14) while (15) represents uncovered interest rate parity, with a stochastic disturbance.[13] Finally, (16) is the Fisher identity that defines the one-period real rate of interest r_t in relation to the nominal rate R_t and expected inflation.

Together with the Taylor style policy rule (1), this model provides 10 structural equations to generate values of the system's 10 endogenous variables, namely, c, y, g, x, im, p, s, q, R, and r. Thus we can very simply establish the main point of this section, which is that adoption of the Δs_t policy rule (1') would not alter the lists of endogenous and exogenous variables. Consequently, it follows that use of s_t as the policy-rule instrument, rather than the more standard R_t, is perfectly sensible and coherent. Which of the two instrument/indicator variables would be more desirable will be determined by quantitative aspects of the economy under consideration.

To make such a determination for the model given above, quantitative values have to be assigned to each of the model's parameters, including those that describe the stochastic behavior of the exogenous variables and shocks that impinge upon the system. In McCallum (2005) I have calibrated the model (8)-(16) to represent a "typical"

[13] This disturbance incorporates our assumption that foreign and domestic securities are not perfect substitutes.

industrial economy, setting the average ratio of imports (and exports) to production (not value added) at 0.15.[14] For Singapore the comparable figure is approximately 0.6.[15] It will be of interest to compare the performance of policy rules (1) and (1'), with $\mu_1 = \mu_2 = 0.5$ and smoothing of the policy variable ($\mu_3 = 0.8$) added in each case, under these (and other) specifications of the economy's degree of openness, with the other aspects of the calibration kept the same.

The relevant comparison is provided in Table 1. There X/Y denotes the ratio of the economy's exports (and imports) to production, which is varied over a wide range in

Table 1: Effects of Openness on Policy Rule Performance
Cell entries are standard deviations of Δp_t, $\tilde{y}_t$, R_t, Δs_t

	X/Y = 0.01	X/Y = 0.15	X/Y = 0.30	X/Y = 0.60
R_t rule (1)	2.72 2.11 2.96 19.36	2.34 1.95 2.45 18.46	2.22 2.37 2.30 17.75	2.30 4.81 2.42 16.01
Δs_t rule (1')	4.27 2.76 9.37 1.83	3.61 2.41 9.28 1.65	3.25 2.21 9.29 1.56	2.62 2.20 9.26 1.44

the different columns. For a given calibration of the model, described in McCallum (2005), the two rows of cells report the variability of inflation, the output gap, the interest rate, and the exchange rate's rate of appreciation. With all variables measured as percentage deviations from steady-state values, quarterly but in annualized units, the figures for inflation and the output gap represent root-mean-square deviations from target. Accordingly, small values are more desirable than large values.

[14] The model used also includes a feature representing habit formation in consumption behavior.
[15] Singapore exports (X) and imports (M) are each about 1.5 times as large as GDP, implying a value of 0.6 for M/Y. To see this, note that GDP = Y – M, so Y/M = 1 + GDP/M.

Going across the top row, we see that with an interest rate instrument rule, poorer performance is realized with highly open economies. Moving from X/Y of 0.15 to 0.60, to be specific, results in approximately no change in inflation variability but a major increase in output gap variability. Effects on the variability of interest and appreciation rates are minor. In the second cell row, by comparison, the exchange rate rule is increasingly effective in stabilizing inflation and output as the degree of openness is increased. Thus, for the model at hand, it is clearly the case that an increased degree of openness makes use of the exchange rate rule relatively more attractive.

Does the very high level of openness reflected by X/Y = 0.6 also make rule (1') more attractive in absolute terms? From the last column of Table 1 we see that in that case variability of inflation is (slightly) increased but variability of the output gap is (greatly) reduced by use of the exchange rate rule (relative to the case with use of the interest rate rule). The answer will then depend upon the weight assigned by the relevant objective function to output-gap variability relative to inflation variability.[16] If the value were 0.1 for the latter relative to inflation variability (in terms of variances), then the exchange rate rule (1') would be preferable. Weights somewhat lower than 0.1 are not uncommon in the literature, however, so the absolute superiority of (1') is not a foregone conclusion. Also, it is possible that the variability of R_t and Δs_t or s_t would be taken into account by the relevant central bank. Accordingly, no conclusion of the absolute type can be made on the basis of our simple study.[17] For this type of comparison, a more precise numerical calibration of the model and a more careful consideration of the

[16] If X/Y were assumed to be 0.75, however, the exchange rate rule would result in inflation and output standard deviations of 2.08 and 2.15, both smaller than the values 2.56 and 7.11 provided by the interest rate rule.

[17] It is also the case that the two rules utilize "realistic" parameters, not ones optimized in terms of the model and some specific objective function.

appropriate objective function would have to be developed. These are tasks that are beyond the scope of this paper.

5. Conclusions

The past three sections have developed a characterization of Singapore monetary policy—as featuring periodic adjustments of the exchange rate, used as an instrument/information variable, designed to achieve objectives involving inflation and output—and have illustrated analytically this type of policy's relative effectiveness for economies with very high ratios of trade to domestic production. In light of Singapore's macroeconomic success over the past 15 years, as discussed by various writers including Devereux (2003), Gerlach and Gerlach-Kristen (2005), McCauley (2001), Parrado (2004), and Rajan and Siregar (2002), it seems apparent that this type of policy regime could be an attractive contender for adoption by other highly open economies.

There is a more general conclusion that can be drawn, however, that is applicable also to economies that are not of the small and extremely open type and which do not conduct policy via an exchange rate instrument. It concerns the relationship between "monetary policy" and "exchange rate policy." The main point, which should be apparent from the policy exercises of Section 4, is that basically these are not two different aspects of macroeconomic policy but, instead, two ways of thinking about one macroeconomic policy tool. That is, a nation's monetary authority can use as its instrument/indicator variable only one chosen nominal variable—a nominal interest rate, a nominal exchange rate, or some accurately-controllable monetary aggregate (e.g., the monetary base). Its policy is then described by a rule for adjusting, upward or downward, this nominal variable in response to important measures of the current macroeconomic situation. It will make such adjustments in an attempt to keep chosen target variables, possibly including real variables such as employment or the output gap but necessarily including some nominal variable, close to desired target values. But, in a market economy substantially free from distorting controls, there can be only one such rule. In essence, then, monetary and exchange rate rules are merely two aspects of one policy—most usefully thought of as monetary policy. Analytically, this can be illustrated as follows. If one included both equations (1) and (1') with the model in (2)-(10), the system would be overdetermined. Thus there could be, except by chance, no solution for the ten endogenous variables.[18]

In light of these observations, the widespread practice of official assignment of (nominal) exchange-rate responsibility to a nation's fiscal authority—i.e., its Finance Ministry or Treasury—should be recognized as unfortunate and undesirable. Such an assignment, pertaining to a monetary variable, is inconsistent in spirit with the raison-d'etre of central-bank independence and can potentially interfere drastically with the conduct of monetary policy. Legal arrangements of this type are in fact present in numerous economies including the United States, the European Union, and Japan.[19] For some of these, such as the European Union, the potential undesirability under discussion has not been highly disruptive in practice in recent years, for the fiscal authorities have not attempted to bring about an exchange-rate path for their economy that is inconsistent with the price level path implied by the central bank's monetary policy.[20] Some

---

[18] This does not imply that a single monetary policy rule cannot respond (with specified weights) to two or more nominal variables nor that more than one nominal variable cannot appear in the central bank's objective function.

[19] This is well known in the case of Japan and the ECB; for the United States, see the discussion of Broaddus and Goodfriend (1996).

[20] Our argument does not imply that fiscal authorities should not have responsibility for real fiscal magnitudes, such as the real fiscal deficit or even possibly the real trade balance, that may be structurally

economists, however, would argue that exchange-rate legalisms in Japan contributed significantly to its poor macroeconomic performance over the decade 1993-2003.[21] [22] More drastically, the current situation in China illustrates quite clearly that major difficulties for monetary policy can be brought about by exchange rate paths that are inconsistent with appropriate and desired monetary policy. In any event, the assignment of exchange-rate responsibility to a nation's fiscal authority is an anachronism, left over from the pre-1973 era when exchange rates, not central bank policy rules, provided nations' nominal anchors.[23] The practice is bound to cause confusion, if not actual mismanagement.

---

related to real exchange rates. Management of nominal exchange rates will have only temporary effects on these real magnitudes, of course.

[21] Economists including Svensson (2001) and McCallum (2000) argued that effective monetary stimulus to combat the Japanese deflation of 1995-2003 could have been provided by central bank purchases of foreign exchange, and some members of the BOJ staff believed that such a strategy deserved consideration, given the apparent (and theoretical) inability of the BOJ to affect spending by purchase of short-term domestic securities. It was decided, however, that foreign exchange operations could only be made at the direction of the Ministry of Finance. For additional discussion, see McCallum (2003, pp. 22-27).

[22] Some would also argue that Japanese exchange rate management by the Ministry of Finance during the late 1980s, based to some extent on urgings of the United States government, contributed strongly to the asset price bubble that in turn led to the tightening of Japanese monetary policy in 1989 that began the deflation.

[23] The anachronistic nature of this assignment comes through strongly in Broaddus and Goodfriend (1996).

References

Broaddus, J. Alfred, Jr., and Marvin Goodfriend, "Foreign Exchange Operations and the Federal Reserve," Federal Reserve Bank of Richmond Economic Quarterly 82, Winter 1996, 1-19.

Clarida, Richard, Jordi Gali, and Mark Gertler, "A Simple Framework for International Monetary Policy Analysis," Journal of Monetary Economics 49, July 2002, 879-904.

Devereux, Michael B., "A Tale of Two Currencies: The Asian Crisis and the Exchange Rate Regimes of Hong Kong and Singapore," Review of International Economics 11, 2004, 38-54.

Khor, Hoe Ee, Edward Robinson, and Jason Lee, "Managed Floating and Intermediate Exchange Rate Systems: The Singapore Experience," Monetary Authority of Singapore, MAS Staff Paper No. 37, December 2004.

Gerlach, Stefan, and Petra Gerlach-Kristen, "Monetary Policy Regimes and Macroeconomic Outcomes: Hong Kong and Singapore," BIS Working Paper No. 204, April 2006.

Goldberger, Arthur S., Econometric Theory. John Wiley & Sons, 1964.

McCallum, Bennett T., "Theoretical Analysis Regarding a Zero Lower Bound on Nominal Interest Rates," Journal of Money, Credit, and Banking 32, 2000, 870-904.

__________________, "Japanese Monetary Policy, 1991-2001," Federal Reserve Bank of Richmond Economic Quarterly 89, Winter 2001, 1-31.

__________________, "A Monetary Policy Rule for Automatic Prevention of a Liquidity Trap," NBER Working Paper 11056, January 2005. [Also in Takatoshi Ito and Andrew Rose, eds., Monetary Policy with Very Low Inflation in the Pacific Rim. University of Chicago Press for NBER, 2006.]

____________, "Singapore's Exchange Rate-Centered Monetary Policy Regime and Its Relevance for China," Monetary Authority of Singapore, Staff Paper 43, 2006.

McCallum, Bennett T., and Edward Nelson, "Nominal Income Targeting in an Open-Economy Optimizing Model," Journal of Monetary Economics 43, June 1999, 553-578.

McCauley, Robert N., "Setting Monetary Policy in East Asia: Goals, Developments, and Institutions," in D. Gruen and J. Simon, eds., Future Directions for Monetary Policies in East Asia. Reserve Bank of Australia, 2001.

Monetary Authority of Singapore, "Singapore's Monetary Policy Framework," undated.

__________________________, "Singapore's Exchange Rate Policy," February 2001.

_________________________, "Monetary Policy Operations in Singapore," January 2003.

Mundell, Robert, "One World, One Money?" (Debate with Milton Friedman) Options Politiques, May 2001, 10-30.

Parrado, Eric, "Singapore's Unique Monetary Policy: How Does it Work?" Monetary Authority of Singapore, MAS Staff Paper No. 31, June 2004.

Rajan, Ramkishen S. and Reza Siregar, "Choice of Exchange Rate Regime: Currency Board (Hong Kong) or Monitoring Band (Singapore)?" Australian Economic Papers 41, 2002, 538-556.

Robinson, Edward S., "Discussion," in D. Gruen and J. Simon, eds., Future Directions for Monetary Policies in East Asia. Reserve Bank of Australia, 2001.

Svensson, Lars E. O., "The Zero Bound in an Open Economy: A Foolproof Way of Escaping from a Liquidity Trap," Bank of Japan Monetary and Economic Studies 19 (February 2001, special edition S-1), 277-312.

Taylor, John B., "Discretion Versus Policy Rules in Practice ", Carnegie-Rochester Conference Series on Public Policy 39, December 1993, 195-214.

____________, "The Role of the Exchange Rate in Monetary-Policy Rules," American Economic Review Papers and Proceedings 91, May 2001, 263-267.

Tian, Lin, "Singapore's Monetary System: How Does it Work?" Senior Honors Thesis, Carnegie Mellon University, April 2006.

Williamson, John, "Crawling Bands or Monitoring Bands: How to Manage Exchange Rates in a World of Capital Mobility," International Finance 1, October 1998, 59-79.

_____________, "Future Exchange Rate Regimes for Developing East Asia: Exploring The Policy Options," presented at conference organized by the Institute of Policy Studies, Singapore, June 21-22, 1999.

______________, "The Case for a Basket, Band, and Crawl (BBC) Regime for East Asia," in D. Gruen and J. Simon, eds., Future Directions for Monetary Policies in East Asia. Reserve Bank of Australia, 2001.

______________, "A Worldwide System of Reference Rates," Oesterreichische Nationalbank Working Paper 130, August, 2006.

Data Appendix

obs	NEER	REER	CPI	GDPRSG
1980Q1	71.81000	98.59700	66.00700	8966.000
1980Q2	71.06000	96.32330	66.94400	9317.000
1980Q3	71.12300	95.44300	68.12400	9648.000
1980Q4	72.02300	95.54700	68.69800	10028.00
1981Q1	73.22000	96.35300	69.69600	9790.000
1981Q2	75.14000	100.4370	72.11500	10268.00
1981Q3	77.90000	105.0330	74.62500	10628.00
1981Q4	78.98000	106.1930	75.41100	10967.00
1982Q1	80.14300	107.6370	76.16700	10682.00
1982Q2	80.98000	106.5700	75.29000	11015.00
1982Q3	82.27700	106.8330	75.65300	11311.00
1982Q4	82.07300	106.5970	76.16700	11614.00
1983Q1	83.70000	108.3270	76.53000	11471.00
1983Q2	84.51700	108.4530	76.37800	11883.00
1983Q3	84.94300	108.0200	76.65000	12292.00
1983Q4	84.71300	107.7200	77.34600	12777.00
1984Q1	85.28000	109.0930	78.82800	12712.00
1984Q2	86.11000	109.4570	78.55500	13009.00
1984Q3	87.29300	110.4030	78.97900	13306.00
1984Q4	88.72000	110.8070	78.52500	13431.00
1985Q1	89.14300	110.9070	79.00900	13084.80
1985Q2	88.09300	109.0000	79.00900	12890.50
1985Q3	85.72700	105.5400	79.40200	12904.20
1985Q4	84.76300	103.4030	78.97900	12822.50
1986Q1	80.55700	97.13700	78.58600	12625.90
1986Q2	75.52300	90.42300	77.76900	13019.60
1986Q3	74.88300	88.95700	77.73900	13388.20
1986Q4	75.14000	89.04000	77.92000	13775.30
1987Q1	74.07000	87.25000	77.95100	13571.10
1987Q2	72.29300	84.80000	78.10200	14165.10
1987Q3	73.71300	86.26700	78.70700	14821.50
1987Q4	72.73700	84.80000	78.88800	15390.50
1988Q1	72.71000	84.55700	79.19000	15055.60
1988Q2	72.55000	83.85300	79.28100	15909.20
1988Q3	74.27000	85.21700	79.91600	16583.60
1988Q4	74.50000	84.71670	80.03700	16954.50
1989Q1	77.05700	86.90300	80.18800	16513.20
1989Q2	78.65700	88.52000	81.18600	17785.20
1989Q3	78.91700	88.75000	81.91200	18149.60
1989Q4	79.21700	89.11000	82.60700	18451.40
1990Q1	80.92300	93.15000	83.30300	18642.20
1990Q2	82.40300	94.32700	83.81700	19058.10
1990Q3	82.97300	94.45000	84.39100	19657.90

1990Q4	83.55300	95.18700	85.66100	19940.70
1991Q1	83.71700	95.60700	86.35700	19840.70
1991Q2	85.41700	97.43000	87.05200	20285.90
1991Q3	87.50000	99.28000	87.41500	21108.40
1991Q4	88.04700	99.35700	87.89900	21289.50
1992Q1	89.00300	100.0830	88.29200	20921.10
1992Q2	89.15300	99.96700	89.01700	21452.20
1992Q3	88.26000	98.87000	89.44100	22532.90
1992Q4	89.68700	100.2730	89.86400	23140.90
1993Q1	90.22000	100.5570	90.46900	22880.90
1993Q2	89.61700	99.45000	90.92200	24269.60
1993Q3	90.38300	100.1030	91.37600	25286.60
1993Q4	92.41000	102.3800	92.01100	26401.10
1994Q1	93.02300	102.9270	92.79700	26169.60
1994Q2	93.90000	104.2700	93.76500	26726.00
1994Q3	94.25000	104.4530	94.49000	28433.30
1994Q4	95.90000	106.1230	95.03400	28780.50
1995Q1	96.68300	106.2870	95.12500	27892.30
1995Q2	95.63700	105.0100	95.73000	28947.30
1995Q3	97.15000	106.0330	95.79000	30867.40
1995Q4	98.82700	107.4300	95.91100	31255.70
1996Q1	100.3770	108.6570	96.36500	31356.50
1996Q2	101.2330	109.1170	96.84900	31674.80
1996Q3	101.1200	108.5030	97.15100	32306.30
1996Q4	102.3670	109.4600	97.48400	33315.00
1997Q1	103.8830	111.0330	98.02800	32909.40
1997Q2	103.4400	110.4000	98.51200	34567.80
1997Q3	103.0970	110.0170	99.35800	35913.50
1997Q4	102.6270	109.2030	99.72100	36208.00
1998Q1	105.9830	110.6200	99.15940	34262.10
1998Q2	107.4400	110.4130	98.63200	34293.20
1998Q3	103.9230	105.5930	98.50000	34670.50
1998Q4	102.6330	103.4100	98.26900	35173.40
1999Q1	99.24300	99.92670	98.43400	34978.80
1999Q2	99.70000	100.5000	98.59900	36541.20
1999Q3	100.0600	100.5970	98.79700	37585.90
1999Q4	99.66000	99.77330	98.79700	38181.60
2000Q1	99.09700	99.37330	99.52200	38347.50
2000Q2	99.17700	99.13670	99.42300	39554.00
2000Q3	100.0300	99.96000	100.2800	41355.20
2000Q4	101.6970	101.5230	100.7750	41886.10
2001Q1	102.3400	101.9030	101.2030	39906.10
2001Q2	101.2900	100.3870	101.1040	39058.50
2001Q3	102.5870	101.1870	101.1040	39018.50
2001Q4	100.2730	98.41670	100.5770	39335.40
2002Q1	101.3170	98.72000	100.3460	39292.10

2002Q2	100.5870	98.00000	100.6760	40551.10
2002Q3	100.5800	97.47670	100.6760	40485.40
2002Q4	100.7170	97.31000	100.7090	40524.80
2003Q1	100.0730	96.24330	101.0380	39802.90
2003Q2	98.44000	94.48000	100.8740	39010.20
2003Q3	97.94300	93.87700	101.1700	41457.00
2003Q4	96.94700	92.69670	101.3680	42822.00
2004Q1	97.04700	92.99330	102.3050	42947.30
2004Q2	98.04700	93.75330	102.7510	43808.40
2004Q3	97.79000	93.05670	103.0940	44441.90
2004Q4	98.58700	93.24330	103.0250	45605.40
2005Q1	98.33000	92.18000	102.5450	44106.90
2005Q2	98.25300	91.73670	102.7850	46086.40
2005Q3	98.72300	91.85700	103.5740	47788.00
2005Q4	99.48300	92.47300	104.1900	49921.00

NEER, REER, and CPI, and are taken from the IMF's International Financial Statistics electronic data base. These are index values of Singapore's nominal effective exchange rate, real effective exchange rate, and the consumer price index, respectively. The other series, GDPRSG, is real gdp. The values for 1982.3-2004.3 were provided by Gerlach and Gerlach-Kristen (from the BIS data base), with 2004.4-2005.4 values spliced on from International Financial Statistics.