

# ARE POLICY RULES BETTER THAN THE DISCRETIONARY SYSTEM IN TAIWAN?

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*This paper investigates whether the Central Bank of China (CBC) in Taiwan would have had a more successful monetary policy during the period 1978:3 to 1999:4 if it had followed an optimal rule rather than the discretionary policies that were actually employed. The paper examines the use of three different instruments—the rediscount rate, M2, and reserve money—with several different targets—the growth rate of nominal output, inflation, the percentage change in the exchange rate, and the growth rate of a monetary aggregate. Only four of 64 rules considered resulted in a statistically significant improvement in the performance of the Taiwanese economy. Given that this paper analyzes the economy of Taiwan with revised data that were not available to the CBC in real time, and given that so few of the rules would have improved the economy's performance, it is concluded that the performance of the CBC has been very good.*

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## I. INTRODUCTION

How well has the Central Bank of China (CBC) in Taiwan implemented monetary policy during the past three decades? With the exception of two inflationary episodes during periods of oil-price shocks (1973-1974 and 1979-1981), as far as inflation is concerned, the historical record suggests that monetary policy in Taiwan has been very successful. Figure 1 shows that

during other periods the rate of inflation in Taiwan typically has been relatively low, usually between 0% and 5% per year during 1982-1998 and falling to -2% at the end of 1999.

But could the CBC have performed much better than it actually did? That is, could it have achieved a less variable rate of inflation without increasing the variability of output? Because Taiwanese monetary policy has been discretionary, rather than based on a formal rule, there is a strand of macroeconomic theory that suggests the answer to this question must be yes. If the structure of the Taiwanese economy is such that an unexpected increase in the rate of inflation causes output to increase, then policy makers have an incentive to increase inflation. This implies that a discretionary monetary policy will have an inflationary bias [Kydland and Prescott (1977) and Barro (1986)]. The existence of this inflationary bias makes it difficult for policy makers to lower expected inflation without first earning a reputation for price stability. A solution to this reputation or credibility problem is for the monetary authority to follow an explicit formal rule that eliminates its discretion to inflate. It therefore follows that a monetary policy implemented according to a rule will achieve lower inflation than a discretionary monetary policy. For example, Judd and Motley (1991, 1992, 1993) and McCallum (1988) have examined the empirical properties of nominal feedback rules and find that the use of simple feedback rules could have produced price stability for the United States over the past several decades without significantly increasing the volatility of real output.

The purpose of this paper is to examine whether the CBC would have had a more successful monetary policy if it had followed an explicit rule rather than the discretionary policies actually implemented. We use an approach similar to those of Judd and Motley (1991, 1992, 1993) and McCallum (1988, 1993) to evaluate the performances of policy rules. But the methodology employed here differs from that of the above writers in two ways. First, following Svensson

(1998), this paper divides proposed rules for monetary policy into two broad groups, *instrument rules* and *targeting rules*. Secondly, when this paper examines instrument rules, as is explained in section IIIA below, it analytically solves for the policy response parameter that minimizes the variance of inflation, something not done by previous writers.

*Instrument rules* require that the central bank adjust its policy instrument in response to deviations between the actual and desired value of one or more variables being targeted by the monetary authority. Examples of this type of rule are those proposed by both Taylor (1993) and McCallum (1988, 1993). An example of an instrument rule (with the federal funds rate as instrument and nominal GDP as target) is one that requires the Fed to raise the federal funds rate whenever the growth rate of nominal GDP is unexpectedly high regardless of other information available to the Fed. On the other hand, if a monetary policy rule minimizes a specified loss function while allowing the monetary authority to use all available information, then Svensson (1998) calls it a *targeting rule*. The loss function formalizes how important the monetary authority believes are deviations of its various target variables from their optimal values. Hence, for example, a targeting rule would not always require the Fed to raise the federal funds rate when the growth rate of nominal GDP is unexpectedly higher because other information might imply that the relatively high rate of growth of nominal GDP is the result of an increase in the growth rate of real GDP rather than an increase in inflation.

This paper assumes that the goal of the CBC is to minimize the variance of inflation. This is consistent with the growing support among academic economists and central bankers for making price stability the central long-run objective of monetary policy. (See, for example, Svensson (1999) and Bernanke, Laubach, Mishkin, and Posen (1999).) Indeed, the CBC has repeatedly

stated that its number one priority is price stability. The reaction function estimated by Shen and Hakes (1995) confirms that the CBC has behaved as if price stability is an important policy goal.

However, this goal itself does not determine the best policy instrument or the best target variable(s) for Taiwan, because macroeconomic theory shows that the best instrument and target variable(s) for any given economy are a function of the variances and covariances of the shocks that economy in question experiences. (See, for example, Poole (1970), Friedman (1975), and Canzoneri, Henderson, and Rogoff (1983).) Furthermore, the best choices can vary from country to country because the controllability of any particular policy instrument and the effectiveness of each target most likely vary across countries. Therefore, the determination of what is the best policy instrument and what is (are) the best target(s) for any economy is an empirical issue. This paper examines two different types of policy instruments and several targets to search for the best policy rule for Taiwan.

As to the choice between the two types of rules, since instrument rules do not use all information available to the monetary authority, Friedman (1975) and Svensson (1998) argue that they are inferior to targeting rules, which do use all available information. Hence, a targeting rule that seeks to minimize the variance of inflation will yield a lower variance of inflation than an instrument rule with the same goal. However, this lower variance of inflation obtained by use of the targeting rule might come at the expense of a higher variance of output. Furthermore, instrument rules are far more transparent than targeting rules. Hence, this paper presents results for both instrument and targeting rules.

Of the rules considered here, only four out of 64 yield both an output variance and an inflation variance that are statistically significantly lower than those actually realized by the

Taiwanese economy. Hence this paper concludes that the discretionary policies implemented by the CBC were very close to being optimal.

The rest of this paper is organized as follows. Section II discusses the instruments and the targets of monetary policy that this paper considers. Section III describes the method used to derive the policy rules and conduct the simulations. Section IV describes the data and presents the simulation results, while Section V offers some conclusions.

## II. INSTRUMENTS AND TARGETS OF MONETARY POLICIES

The targets of monetary policy are those macroeconomic variables that the monetary authority ultimately desires to influence through its policy actions [Friedman, 1975]. For this reason Svensson (1998) prefers to call target variables only those variables that are important enough to be included in the monetary authority's loss function. The targets of monetary policy therefore are a way to formalize the overall objectives of a monetary authority. On the other hand, the instrument of monetary policy is the variable that the monetary authority chooses to control for the purpose of meeting its overall objectives, i.e. minimizing its loss function.

Monetary policy instruments basically fall into two categories: measures of the stock of money (or monetary aggregates) and short-term interest rates. Proponents of using a monetary aggregate as the instrument of monetary policy argue that the stock of money is the variable that determines the aggregate level of prices, making it a natural instrument for the control of inflation [McCallum (1988, 1993)]. But most central banks, including the CBC, use a short-term interest rate as their instrument of monetary policy. Proponents of an interest rate instrument point out that it insulates the economy against instability in the demand for money, that interest rates are a part of the transmission channel of monetary policy, and that no useful purpose is

served by wide fluctuations in interest rates [Kohn (1994)]. This paper presents simulation results using both types of instruments. Both M2 and reserve money are used as the monetary aggregate, while the rediscount rate is used as the interest rate. The results suggest that the CBC's decision to use an interest rate instrument is reasonable.

This paper examines four target variables: a monetary aggregate growth rate, the percentage change in the exchange rate, the growth rate of nominal income, and the rate of inflation. In addition, whenever the policy instrument is one of the monetary aggregates, an interest-rate target is also considered. (Canzoneri, Henderson and Rogoff's (1983) work on the information content of the rate of interest provides a theoretical rationale for an interest rate target. For a more detailed discussion about different target variables, see Mishkin (1999).) The targeting of a monetary aggregate often is advocated by those who believe that business cycles largely result from changes in the growth rate of the money stock [Warburton (1966), M. Friedman (1960)]. Another reason for choosing a monetary aggregate as the target for monetary policy is its ability to serve as a nominal anchor that limits how much inflation can increase and communicates the monetary authority's long-run policy objectives to the general public. However, as Friedman (1975) points out, by its very nature a monetary aggregate is an inferior choice as a target variable because the monetary authority is only concerned with any given monetary aggregate to the extent that it provides them with information about inflation and output growth. (That is, monetary aggregates are intermediate targets and the use of intermediate targets is not optimal. Svensson's (1998) idea of using forecasts of the target variable as a synthetic intermediate target is implicit in Friedman's (1975) discussion.) In addition, recent instability in the velocity of money for the time being has ended any possibility that a monetary aggregate will be used as a

target for monetary policy in some countries such as the United States. This paper examines both M2 and reserve money as possible target variables for Taiwan.

McKinnon (1984) and Williamson and Miller (1987) argue that monetary policy in an open economy should target the exchange rate. For example, the exchange rate has been the sole or main target for most EMU countries. Pegging the domestic currency to a strong currency prevents changes in the exchange rate from affecting the domestic price level. But a monetary authority that targets the exchange rate cannot have an independent monetary policy. The targeting country cannot respond to domestic shocks that are independent of those hitting the anchor country because exchange rate targeting requires that the domestic interest rate be closely linked to that in the anchor country.

McCallum (1988, 1993) suggests a nominal GDP targeting rule because nominal GDP is closely related to the price level. The nominal GDP target has intrinsic appeal when instability in velocity makes a monetary target unreliable. As long as the growth rate of real GDP is predictable, there is a predictable relationship between nominal GDP and the price level. However, recent studies [e.g., King, et al. (1991)] on the time series properties of real GDP raise questions about the predictability of real GDP. If real GDP does not follow a predictable long-run trend and nominal GDP is to grow at a constant rate under a policy rule, the price level would evolve as a random walk and thus could drift over time. (Because a policy that targets the level of nominal GDP is not considered politically plausible--for reasons similar to why no central banks have adopted a policy that targets the price level--the empirical part of this paper examines a policy that targets the growth of nominal GDP.)

Recently there has been a great upsurge of interest in direct inflation targeting. Critics of inflation targeting argue that the effect of monetary policy actions on the price level occurs with

considerably more delay than its effects on financial variables such as a monetary aggregate or the exchange rate. In addition, attempts by the central banks to achieve a predetermined path for prices may cause large movements in real GDP when the price level is sticky in the short run. However, the apparent success of inflation targeting in New Zealand, Canada, the United Kingdom, Sweden, Finland, Australia, and Spain suggests that these concerns are misplaced. (A careful reading of Friedman (1975) and Svensson (1998) also suggests that these concerns are misplaced.) Also, because the effect of monetary policy on long-term trends in output and employment is now considered to be negligible, many economists are now advocating that monetary authorities should use only inflation (or the price level) as the sole target for monetary policy.

So what combination of policy instrument and target variable would result in the best rule for monetary policy in Taiwan? Would the adoption of such a rule have improved Taiwanese monetary policy? To answer these questions this paper experiments over two types of policy instruments, four target variables, and two types of rules to find what would have been the best *rule* for Taiwan. The historical performance of the Taiwanese economy is then compared with the performance predicted by the "best" *rule* to evaluate how good Taiwanese monetary policy has been. This comparison is made by comparing the volatility of the relevant variables resulting from the proposed rules with those from the historical data.

### **III. THE MODEL AND METHODOLOGY**

#### *A. The Instrument Rule*

An instrument rule adjusts the growth of the policy instrument in response to deviations between the actual and desired value of the target variable. That is,

$$(1) \quad \Delta I_t = \lambda \cdot (\Delta x_{t-1} - \Delta x_{t-1}^*),$$

where  $I_t$  represents the policy instrument,  $\Delta x_t$  is the target variable, the superscript \* denotes the target value desired by the central bank, and  $\lambda$  defines the proportion of a target miss to which the central bank chooses to respond. To make the calculation of variances easier (by matrices multiplication), all the variables are expressed as deviations from their own means. Therefore, there is no cost in terms of generality to set the targeted growth rate desired by the central bank to zero.

The economy is characterized by an open-economy VARX model which includes five variables: the growth rate of real income ( $\Delta y_t$ , calculated by taking the log-first difference), the rate of inflation ( $\Delta p_t$ ), the percentage change in exchange rate ( $\Delta e_t$ ), the growth rate of money ( $\Delta m_t$ ), and the change in the interest rate ( $\Delta r_t$ ). The use of VAR models for the study of alternative monetary policies has been suggested by Litterman (1983). He claims that econometric models such as the Phillips curve are poor forecasters of the response of the economy to changes in policies, and that the risk of biasing results from a misspecified structural model outweighs the benefit from a possible reduction in the variances of the estimates in the structural model. (We tried to adopt Ball's (1998) open-economy Keynesian type model to Taiwan. But this model was not supported by the Taiwanese data.)

Consider the following VARX (4) model:

$$(2) \quad \Delta \mathbf{X}_t = \mathbf{A}_0 + \mathbf{A}_1 \Delta \mathbf{X}_{t-1} + \mathbf{A}_2 \Delta \mathbf{X}_{t-2} + \mathbf{A}_3 \Delta \mathbf{X}_{t-3} + \mathbf{A}_4 \Delta \mathbf{X}_{t-4} + \sum_{i=0}^4 \mathbf{a}_i \Delta I_{t-i} + \boldsymbol{\varepsilon}_t,$$

where  $\Delta \mathbf{X}_t$  is the 4×1 vector that contains variables other than the growth of the policy instrument. The policy instrument has immediate effects on other variables if the 4×1 vector  $\mathbf{a}_0$

is not zero. For example, if the instrument is  $r_t$  and the target is  $\Delta p_t$ , then  $\mathbf{X}_t = [y_t, p_t, e_t, m_t]$  and equations (1) and (2) can be written as:

$$(1)' \quad \Delta r_t = \lambda \Delta p_{t-1},$$

$$(2)' \quad \Delta \mathbf{X}_t = \mathbf{A}_0 + \mathbf{A}_1 \Delta \mathbf{X}_{t-1} + \mathbf{A}_2 \Delta \mathbf{X}_{t-2} + \mathbf{A}_3 \Delta \mathbf{X}_{t-3} + \mathbf{A}_4 \Delta \mathbf{X}_{t-4} + \sum_{i=0}^4 \mathbf{a}_i \Delta r_{t-i} + \boldsymbol{\varepsilon}_t.$$

Previous studies such as Judd and Motley (1991, 1992, 1993) and McCallum (1988, 1993) estimate equation (2) and assume that the economy faces the same set of shocks that actually occurred in the sample period. The estimated equation, the historical shocks (measured by the estimated residuals  $\boldsymbol{\varepsilon}_t$ ), and the policy rule (1) are used to generate the counterfactual data. Statistics calculated from the counterfactual data are then compared to the historical experiences. These studies experiment over a variety of values for the response parameter  $\lambda$  and compare the results obtained from these different values of  $\lambda$ .

However, given the linearity of the model and the variance-covariance matrix of historical shocks, one can analytically solve for the value of  $\lambda$  that minimizes the variance of the inflation rates. Specifically, substituting (1) into (2) yields a VAR(5) in  $\Delta \mathbf{X}_t$ . For convenience, the VAR(5) system can be written as a more compact expression:

$$(3) \quad \Delta \mathbf{W}_t = \mathbf{B}_0 + \mathbf{B}_1 \Delta \mathbf{W}_{t-1} + \boldsymbol{\nu}_t,$$

where  $\mathbf{W}_t = [X_t, X_{t-1}, X_{t-2}, X_{t-3}, X_{t-4}]$  and  $\boldsymbol{\nu}_t = [\boldsymbol{\varepsilon}_t, \mathbf{0}]$  are both  $20 \times 1$ . Assume that  $\Delta \mathbf{W}_t$  is stationary. Denote  $\mathbf{V}_{\Delta \mathbf{W}}$  as the variance-covariance matrix of  $\Delta \mathbf{W}_t$  and  $\mathbf{V}_{\boldsymbol{\nu}}$  the variance-covariance matrix of  $\boldsymbol{\nu}_t$ . Equation (3) implies

$$(4) \quad \mathbf{V}_{\Delta \mathbf{W}} = \mathbf{B}_1 \mathbf{V}_{\Delta \mathbf{W}} \mathbf{B}_1' + \mathbf{V}_{\boldsymbol{\nu}}$$

Given the regression results of (2), the variance of  $\Delta p_t$  is a function of  $\lambda$  only. Therefore, the value of  $\lambda$  that minimizes the variance of  $\Delta p_t$ , given historical shocks, can be calculated.

The advantages of an instrument rule include its simplicity, transparency to the public, and the fact that it is always operational. The central bank responds to observed deviations from the target and does not need to base its policy actions on forecasts that require knowledge of the structure of the economy. However, as noted above, instrument rules are not optimal in the sense that they do not use all available information. The policy instrument only responds to the target variables, which is usually inefficient compared to rules that allow the instrument to respond to all the variables in the model. The following section uses an optimal control method to derive the optimal policy rule, instead of specifying the rule in advance.

### *B. The Targeting Rule*

A targeting rule is derived from the optimal solution of the dynamic programming problem that minimizes a loss function subject to the structure of the economy [equation (2)]. The loss function reflects the policymaker's desired path for the target variable. A commonly used one is a quadratic loss function which penalizes deviations of the target variable from its target value. The resulting rule expresses the growth of the policy instrument as a function of the predetermined variables in the model. That is, the policy instrument responds not only to the target variables but also to all other variables in the model.

To simplify analysis, equation (2) is written as a first-order system,

$$(5) \quad \mathbf{Z}_t = \mathbf{b} + \mathbf{B} \mathbf{Z}_{t-1} + \mathbf{C} \Delta I_t + \boldsymbol{\eta}_t,$$

where  $\mathbf{Z}_t = [\Delta \mathbf{X}_t, \Delta \mathbf{X}_{t-1}, \Delta \mathbf{X}_{t-2}, \Delta \mathbf{X}_{t-3}, \Delta I_t, \Delta I_{t-1}, \Delta I_{t-2}, \Delta I_{t-3}]$ . The constant vector  $\mathbf{b}$  is  $20 \times 1$ ,  $\mathbf{B}$  is  $20 \times 20$ ,  $\mathbf{C}$  is  $20 \times 1$ ,  $\boldsymbol{\eta}_t$  is  $20 \times 1$ , and their arguments should be obvious. Therefore, the central bank's control problem is to minimize a stream of expected quadratic loss function:

$$(6) \quad \frac{1}{T} E_0 \sum_{t=1}^T \mathbf{Z}_t' \mathbf{K} \mathbf{Z}_t,$$

subject to

$$(5) \quad \mathbf{Z}_t = \mathbf{b} + \mathbf{B} \mathbf{Z}_{t-1} + \mathbf{C} \Delta I_t + \boldsymbol{\eta}_t,$$

where the expectation  $E_0$  is conditional on the initial condition  $\mathbf{Z}_0$ . Again, without loss of generality, the target value is set to zero since all the variables are expressed as deviations from mean. The elements in the matrix  $\mathbf{K}$  are weights that represent how important to the central bank are deviations of the target variables from their target values. For example, if the central bank wants to target the inflation rates, then the [2,2] element of  $\mathbf{K}$  is 1 and the other elements are all zeros. The loss function is equivalent to  $(1/T) E_0 \sum_{t=1}^T \Delta p_t^2$ . If the central bank wants to target the nominal GDP, then the 2×2 block on the upper left corner of  $\mathbf{K}$  is a unity matrix and the other elements are all zeros. The loss function in this case is  $(1/T) E_0 \sum_{t=1}^T (\Delta y_t + \Delta p_t)^2$ .

Bellman's (1957) method of dynamic programming is used to choose the policy instrument  $\Delta I_1, \dots, \Delta I_T$  that minimizes (6), given the initial condition  $\mathbf{Z}_0$ . See Chow (1975, ch. 8) for derivation details. The optimal policy rule can be expressed as:

$$(7) \quad \Delta I_t = \mathbf{G} \mathbf{Z}_{t-1} + f,$$

with

$$\mathbf{G} = -(\mathbf{C}' \mathbf{H} \mathbf{C})^{-1} (\mathbf{C}' \mathbf{H} \mathbf{B}),$$

$$f = -(\mathbf{C}' \mathbf{H} \mathbf{C})^{-1} \mathbf{C}' (\mathbf{H} \mathbf{b} - \mathbf{h}),$$

$$\mathbf{H} = \mathbf{K} + (\mathbf{B} + \mathbf{C} \mathbf{G})' \mathbf{H} (\mathbf{B} + \mathbf{C} \mathbf{G}), \text{ and}$$

$$\mathbf{h} = [\mathbf{I} - (\mathbf{B} + \mathbf{C} \mathbf{G})']^{-1} [ - (\mathbf{B} + \mathbf{C} \mathbf{G})' \mathbf{H} \mathbf{b} ].$$

The economy is assumed to face the same set of shocks that actually occurred during the historical period. Therefore, the estimated equations, the policy rule, and the historical shocks (measured by the estimated residuals) are used to generate the counterfactual data. The resulting

statistics are compared.

Even though it is usually more efficient to let the instrument respond to all the relevant variables than to let it respond only to the target variables, instrument rules are more widely discussed in the literature, probably because the performance of targeting rules is more sensitive to a model's specification. For example, the assumption of full information is generally maintained for the computation of an optimal rule. This tends to make the targeting rule less robust to model specification errors than are the simple instrument rules. In addition, the optimal rule may require larger adjustments of the instrument because it responds to more variables. This would in turn yield undesired higher volatility of the other variables such as output growth. Therefore, the choice between the instrument rule and the targeting rule cannot be determined by theory alone and is an empirical issue.

#### IV. EMPIRICAL RESULTS

##### *A. Data*

This paper uses Taiwanese national quarterly time series data for the period 1978:3-1999:4. The sample starts in 1978:3 because this is the first quarter when the exchange rates were allowed to float. The exchange rate equation in the VARX system always reveals a structural change in 1978:3 when the fixed exchange rate period is included. All data are taken from the *National Income Accounts Quarterly* and the CBC web site at <http://cbciso.cbc.gov.tw>.

The rediscount rate is used as  $r_t$  because it indicates the policy intentions of the CBC most directly. The variable  $m_t$  is defined as either M2 or reserve money, seasonally adjusted. The exchange rate is the NT/US dollar rate. The variable  $y_t$  is real GDP in millions of 1996 NT

dollars, and  $p_t$  is defined as the GDP deflator, both seasonally adjusted by the authors using the U.S. Bureau of Census X-11 program.

Except interest rates, all variables are in logarithms. All variables are in first-difference form and expressed as deviations from their means. (Augmented Dickey-Fuller (ADF) tests indicate that all of the original time series are integrated of order one. The results of these tests are available from the authors upon request.) The top row of Tables 1 and 2 presents the historical standard deviations of the variables in the model in order to allow comparison with the values obtained from the simulations.

### *B. VARX Estimation*

In a typical VAR specification, the lag length is chosen sufficiently large to make serial correlation of the residuals unlikely. In addition, the same lag length is used in each equation. However, this approach would consume many degrees of freedom in a system with a large dimension. To conserve degrees of freedom in the regression estimation, we adopt Hsiao's (1981) procedure to choose the optimal lag length for each equation in the VARX system with the maximum lag length set to four. The resulting model fits the data quite well, with an  $R^2$  of about 0.4 for the exchange rate equation and above 0.7 for the other three equations.

We also use the Chow test to test for possible structural change in 1992, when the CBC switched from an interest rate pegging policy to a money supply pegging policy. The null hypothesis of no structural change in each equation of the VARX system is easily accepted.

### *C. Simulation Results Under Instrument Rules*

Panel A in Table 1 presents the standard deviations obtained from simulations of an

instrument rule when the monetary aggregate is M2. The first four rows present results from using an interest rate instrument, while the second four rows present results from using M2 as the instrument. In the first row the target variable is the growth rate of nominal GDP, in the second row inflation, in the third row the percentage change in the exchange rate, and in the fourth row the growth rate of M2. In rows 5 through 8 the targets are the growth rate of nominal GDP, inflation, the percentage change in the exchange rate, and the change in the interest rate.

Notice that in the first six rows of Panel A of Table 1 the standard deviations obtained from the simulations for both inflation and the growth rate of real GDP are less than their historical values, 1.403% and 1.935%. But only in the first row are both values low enough to be statistically significantly lower than their historical values. Hence the only instrument rule in Table 1 that produces standard deviations of inflation and output growth that are significantly lower than the historical values is one with nominal GDP as the target and the interest rate as the instrument. Figures 2 and 3 present plots of the simulated and actual values of inflation and the growth rate of real GDP.

Panel A in Table 2 presents the standard deviations obtained from simulations of an instrument rule when the monetary aggregate is reserve money. In the first four rows the instrument is the interest rate, while in the second four rows reserve money is the instrument. The results are similar to those in Panel A of Table 1. Although all of the standard deviations for inflation and the growth rate of real GDP obtained from the simulations reported in Panel A of Table 2 are less than their historical values, only in the first row are both values low enough to be statistically significantly lower than their historical values. Hence the only instrument rule in Table 2 that produces significantly lower standard deviations of inflation and output growth is once again one with nominal GDP as the target and the interest rate as the instrument.

The simulations whose results are reported in Panels A of Tables 1 and 2 were repeated using the growth rate of the CPI in Taiwan in place of inflation as measured by the GDP deflator. Although in many ways the results were similar to those obtained using the GDP deflator, no instrument rule produced both a statistically significantly lower standard deviation for both output and inflation.

There are two conclusions that can be drawn from the instrument-rule simulations. One is that an instrument rule targeting nominal GDP using an interest-rate instrument is superior to the other instrument rules. But the other is that actual policy in Taiwan has been very good, nearly as good as what could have been obtained by using the best instrument rule. For although in the first rows of Tables 1 and 2 the standard deviations for output growth and inflation are statistically significantly lower than their historical values, there is no way that the CBC could have known in 1978 which rule would have produced the best results. They easily could have chosen one of the thirty other instrument rules considered here. Furthermore, the policy responses in the simulations of these instrument rules assume the CBC has more information than they really would have had at each point in time during the sample. In particular this paper assumes the CBC obtains data in a more timely fashion than it really does and employs data that has possibly been revised at a later point in time. (Orphanides (1998) makes a similar point regarding simulations of monetary policy in the United States.) In other words, our simulations are biased against the discretionary policy actually implemented by the CBC. Given that employing the best optimal rule would have produced only modest gains, and given this bias, the only realistic conclusion is that the CBC's discretionary policy has been close to an optimal policy.

#### *D. Simulation Results Under Targeting Rules*

Panel B of Table 1 presents standard deviations of the variables under the various targeting rules considered here when the monetary aggregate is M2. The first four rows of Panel B present results obtained using an interest rate instrument. In the first row of Panel B the standard deviation of nominal GDP is minimized; in the second row the standard deviation of inflation is minimized; etc. The last four rows of Panel B present results obtained using M2 as the instrument.

Although targeting rules are theoretically superior to instrument rules, since we are considering targeting rules that minimize the variance of only one variable (inflation), a targeting rule that obtains a lower variance of inflation may do so only at the expense of a variance of output higher than that obtained from an instrument rule. The results indicate that this indeed is the case.

Notice that in Panel B of Table 1 only one rule produces a standard deviation of inflation that is statistically significantly lower than its historical value. This rule, which is in the sixth row of Panel B, uses M2 as the instrument and it minimizes the variance of inflation. Although the standard deviation of inflation for this rule is 1.143%, lower than the 1.169% obtained from the best instrument rule (row 1 of Panel A), this small decrease in the variability of inflation comes at the expense of a much larger standard deviation of output (1.554% as compared with 1.273% in row 1 of Panel A).

Panel B of Table 2 presents standard deviations of the variables under the various targeting rules considered here when the reserve money is the monetary aggregate. Notice that none of these simulations produces a statistically significantly lower standard deviation for output growth and only one produces a statistically significantly lower standard deviation for inflation.

The simulations whose results are reported in Panels B of Tables 1 and 2 were repeated using the growth rate of the CPI in Taiwan in place of inflation as measured by the GDP deflator. The results were similar to those obtained using the GDP deflator, with only one targeting rule producing a statistically significantly lower standard deviation for both output and inflation. (The rule in question corresponds to the rule in the first row of section B of Table 1. This rule, however, was not as effective as the instrument rule in the first row of Table 1.)

Again, there are three conclusions that can be drawn from the targeting-rule simulations. First, the best targeting rule is one that minimizes the variance of inflation and uses M2 as the instrument. Second, because the outcome of this policy is not clearly better than that obtained from the best instrument rule, we can also conclude that the theoretical superiority of targeting rules is not of great practical importance for Taiwan. Finally, these results also indicate that actual policy in Taiwan has been very good, nearly as good as what could have been obtained by using the best targeting rule.

## V. Conclusion

Taiwan has been very successful in using discretionary monetary policies. This paper evaluates several monetary policy rules using Taiwanese quarterly data from 1978:3 to 1999:4 in an attempt to see whether there exist policy rules that could have improved the performance of the Taiwanese economy since the late 1970's.

Of the 64 different rules considered here, only four reduced the standard deviations of both inflation and the growth rate of real GDP by a statistically significant amount. The best results were obtained with an interest-rate instrument rule that targets nominal GDP. Furthermore, the analysis employed here assumes that the CBC had data that were not available to it in real time.

Finally, Figures 2 and 3 show that simulated values of inflation and output growth are not dramatically better than the historical data. Hence, it must be concluded that discretionary monetary policy in Taiwan has been very good. Hence, it is unlikely that the CBC could improve its performance by employing a formal rule.

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## FOOTNOTES

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### ABBREVIATIONS

CBC:	Central Bank of China in Taiwan
EMU:	European Monetary Union
VAR:	Vector Autoregression
VARX:	Vector Autoregression with additional exogenous variables
NT dollars:	New Taiwan dollars
GDP:	Gross Domestic Product
ADF:	Augmented Dickey-Fuller tests

TABLE 1  
Standard Deviations of the Variables with M2 as the Monetary Aggregate, 1978:3-1999:4

		$\Delta y_t^a$	$\Delta p_t^a$	$\Delta e_t^a$	$\Delta m_t^a$	$\Delta r_t^a$
<b>Historical Data:</b>		1.935	1.403	2.787	2.330	0.122
<b>Simulated Data:</b>						
<b>(A) Instrument Rules:</b>						
Interest Rate Instrument:	Optimal $\lambda^a$ :					
$\Delta(y_t + p_t)$ Target	0.05	1.273**	1.169*	2.759	1.587**	0.092**
$\Delta p_t$ Target	0.05	1.715	1.269	2.760	1.863**	0.063**
$\Delta e_t$ Target	-0.01	1.812	1.290	2.759	2.201	0.028**
$\Delta m_t$ Target	-0.03	1.758	1.273	2.760	3.358	0.101*
M2 Instrument:						
$\Delta(y_t + p_t)$ Target	1.440	1.622*	1.249	2.764	3.197	0.107
$\Delta p_t$ Target	2.310	1.588**	1.308	2.845	3.021	0.112
$\Delta e_t$ Target	0.190	2.435	1.594	2.261**	0.498**	0.125
$\Delta r_t$ Target	-14.16	2.243	1.477	2.931	2.076	0.147
<b>(B) Targeting Rules:</b>						
Interest Rate Instrument:						
$\Delta(y_t + p_t)$ Target		1.986	1.580	2.783	4.980	0.779
$\Delta p_t$ Target		2.675	1.217	2.793	14.193	0.796
$\Delta e_t$ Target		93.487	45.283	2.563	104.049	16.598
$\Delta m_t$ Target		1.388**	1.318	2.784	1.225**	0.311
M2 Instrument:						
$\Delta(y_t + p_t)$ Target		1.561**	1.500	4.567	9.513	0.290
$\Delta p_t$ Target		1.554**	1.143**	4.779	8.010	0.181
$\Delta e_t$ Target		2.463	1.657	2.648	4.000	0.133
$\Delta r_t$ Target		2.993	1.824	3.120	8.930	0.086**

<sup>a</sup> $\Delta y_t$  is real GDP growth rate.  $\Delta p_t$  is GDP deflator inflation rate.  $\Delta e_t$  is the change in exchange rates.  $\Delta m_t$  is M2 growth rate.  $\Delta r_t$  is the change in rediscount rates.  $\lambda$  defines the proportion of a target miss to which the central bank chooses to respond.

\*Significantly lower than its historical value at the 10% level.

\*\*Significantly lower than its historical value at the 5% level.

Source: *National Income Accounts Quarterly*, the CBC web site and simulations by authors.

Table 2: Standard Deviations of the Variables (in Percentage)  
(Reserve money as the monetary aggregate)

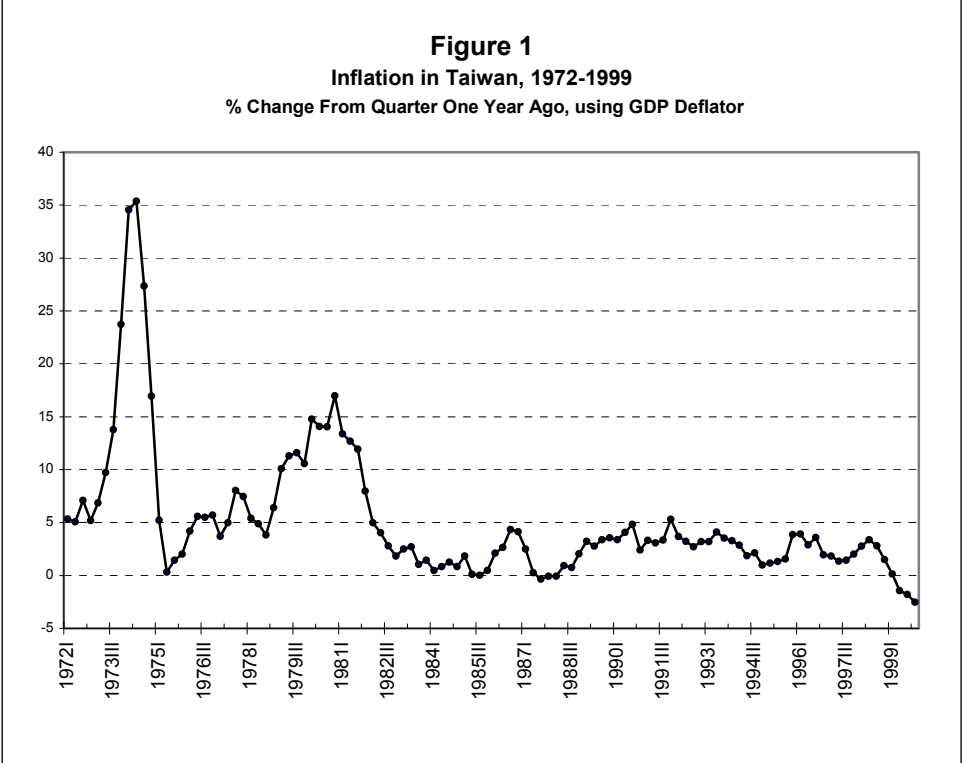
		$\Delta y_t^a$	$\Delta p_t^a$	$\Delta e_t^a$	$\Delta m_t^a$	$\Delta r_t^a$
<b><u>Historical Data:</u></b>		1.935	1.403	2.787	4.498	0.122
<b><u>Simulated Data:</u></b>						
<b>(A) Instrument Rules:</b>						
Interest Rate Instrument:	Optimal $\lambda^a$ :					
$\Delta(y_t + p_t)$ Target	0.03	1.533**	1.195*	2.769	4.586	0.063**
$\Delta p_t$ Target	0.02	1.858	1.243	2.766	4.380	0.025**
$\Delta e_t$ Target	0	1.911	1.245	2.765	4.331	0**
$\Delta m_t$ Target	0	1.911	1.245	2.765	4.331	0**
Reserve Money Instrument:						
$\Delta(y_t + p_t)$ Target	-0.91	1.733	1.250	2.429	2.073**	0.118
$\Delta p_t$ Target	-3.61	1.680	1.234	2.888	4.455	0.123
$\Delta e_t$ Target	-0.26	1.651*	1.256	2.467	0.641**	0.116
$\Delta r_t$ Target	2.17	1.647*	1.257	2.385**	0.252**	0.116
<b>(B) Targeting Rules:</b>						
Interest Rate Instrument:						
$\Delta(y_t + p_t)$ Target		1.913	1.597	3.126	7.295	0.734
$\Delta p_t$ Target		2.204	1.078**	2.990	7.322	0.426
$\Delta e_t$ Target		Diverge				
$\Delta m_t$ Target		2.960	1.651	2.742	3.478**	0.313
Reserve Money Instrument:						
$\Delta(y_t + p_t)$ Target		3.799	3.839	4.047	48.178	0.245
$\Delta p_t$ Target		2.126	1.226	6.017	14.518	0.203
$\Delta e_t$ Target		2.023	1.403	2.167**	4.652	0.118
$\Delta r_t$ Target		2.073	1.450	2.428	5.237	0.114

<sup>a</sup> $\Delta y_t$  is real GDP growth rate.  $\Delta p_t$  is GDP deflator inflation rate.  $\Delta e_t$  is the change in exchange rates.  $\Delta m_t$  is M2 growth rate.  $\Delta r_t$  is the change in rediscount rates.  $\lambda$  defines the proportion of a target miss to which the central bank chooses to respond.

\*Significantly lower than its historical value at the 10% level.

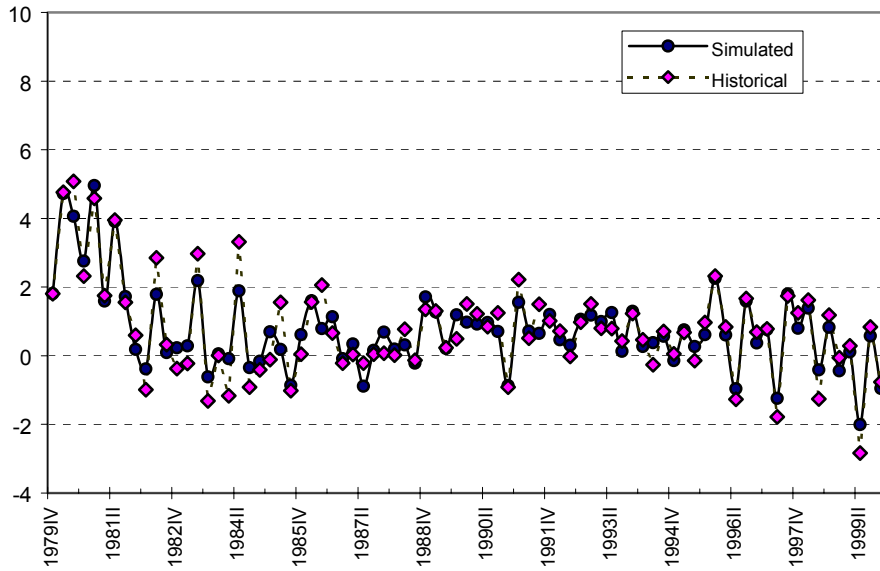
\*\*Significantly lower than its historical value at the 5% level.

Source: *National Income Accounts Quarterly*, the CBC web site and simulations by authors.



**Figure 2**

**Simulated vs. Historical Inflation Rates From Best Rule**  
Instrument rule: interest rate instrument and nominal GDP target from Table 1



**Figure 3**  
**Simulated vs. Historical Real GDP Growth Rates From Best Rule**  
Instrument rule: interest rate instrument and nominal GDP target from Table 1

