

**A Dual-Target Monetary Policy Rule for Open Economies:
An Application to France**

ABSTRACT

This paper proposes a dual targets monetary policy rule for small open economies. In addition to a domestic monetary target, this rule targets the nominal exchange rate at a fixed level. The policy rule is derived from the solution of a dynamic programming problem and evaluated in the context of an open-economy model. Using French quarterly data from 1977:4 to 1998:3, counterfactual simulations show that the dual targets rule performs better than both the historical discretionary policy and the single money-targeting rule in reducing the inflation rates.

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1. Introduction

Monetary aggregates control is commonly used as an intermediate goal of monetary policy because monetary targets have long been considered as an approximate means to communicate longer run policy objectives to the general public. Anchoring exchange rates, on the other hand, is also of utmost importance to the disinflation process in open economies. By keeping exchange rate within given margins around a central parity, an inflation-prone country could "borrow" the low inflation reputation of a foreign country. Examples include France's targeting Deutsche Mark before the inception of the European Central Bank.

France started to participate in the European Exchange Rate Mechanism in 1979. The decision to join an exchange rate target zone was a powerful incentive to disinflation. However, as illustrated in Neely (1994), the target zone of the Franc/Deutsche Mark exchange rates was realigned six times from 1979 to 1987. Such lack of credibility on target values failed to build a reputation for price stability. During this period, French monetary authority resorted to devaluation to boost growth. Businesses relied on the devaluation and had little incentive to increase their competitiveness. However, the growth obtained through devaluation was merely an illusion because of the depreciation of domestic currency. Furthermore, the growth caused higher price level and required more devaluation. This made the agents get used to devaluation, factor further devaluation, and renew inflation into their expectations.

One way to solve this cycle of depreciation, inflation and then more depreciation is to announce an explicit policy rule to target the exchange rate. Recent literature on monetary policies has indicated that the key to lowering expected inflation is to build a reputation for price stability. The mechanism by which this can be achieved is to propose a formal rule that eliminates policymakers' discretion to inflate.

This paper proposes a monetary policy rule in which exchange rate is used as an intermediate target. By proposing an explicit policy rule to an open economy like France, we wish to see whether the French economy could have performed better during the period 1979-

1998. This policy rule is different from those in previous studies in that, first, this rule links a short-term monetary policy instrument to *two* intermediate targets, one external and the other internal, where the external target is the exchange rate. Second, the rule is evaluated in the context of an open-economy model. Finally, the policy rule used is derived from the optimal solution of a dynamic programming problem. The evaluation of the rule is conducted by using statistical simulations of the economy. The performance of the policy rule is gauged by comparing the inflation rates and real GDP growth rates in the simulated and the historical data.

2. Model and Methodology

The objective function is a quadratic loss function that penalizes deviations of the target variables from their target values. Since the effect of monetary policy on prices or output occurs with considerably more delay than that on a financial variable, using a financial variable as an intermediate target could provide an earlier signal that policy has deviated from the goals. Therefore, the variables in the objective function are intermediate targets and the authority bases their decisions on observations of the intermediate targets instead of the goals. The resulting variations of the goals are then used to evaluate the rule.

Specifically, the central bank's objective is to minimize:

$$\frac{1}{T} E_0 \sum_{t=1}^T \{ (1-w) (m_t - m_t^*)^2 + w (e_t - e_t^*)^2 \}, \quad (1)$$

where m_t is monetary aggregate, e_t is exchange rate, and w is the penalty the central bank places on deviations of exchange rates from their target values. The economy is characterized by a small open-economy model that includes:

- (I) The IS function states that real output depends on the expected real interest rate, real exchange rate, an index of fiscal policy, and a fiscal policy shock.

- (II) The LM function equates money demand and money supply. The open economy money demand depends not only on domestic real income and interest rates, but also on real exchange rates.
- (III) Open-economy Phillips curve relates inflation to the lagged change of output, lagged exchange rate, past inflation, and a supply disturbance. The expected price is derived by taking expectations of this equation.
- (IV) Exchange rate determination equation links the interest rate to the nominal exchange rate.
- (V) Government consumption and foreign price level are assumed to be exogenous and can be specified as autoregressive processes.

Denote y_t (real GDP), r_t (nominal Treasury bill rates), g_t (real government consumption), p_t (GDP deflator), p_t^e (expected price at t conditional on information available at $t-1$), $q_t = e_t - p_t + p_t^F$ (real exchange rate), e_t (nominal Franc/Deutsche Mark rate), p_t^F (German price level), and m_t (nominal M3). All the variables, except interest rates, are in logarithms. By using the French quarterly time series data for the period 1977:4-1998:3, the following model provides a good fit of the data (the standard errors are in parentheses):

$$y_t = 2.569 - 1.151[r_{t-1} - (p_t^e - p_{t-1})] + 0.160 q_{t-1} + 0.849 g_{t-1}, \quad (2)$$

(0.272) (0.580) (0.035) (0.037)

$$m_t - p_t = 0.012 + 0.055 y_t - 0.001 r_t + 0.007 q_t + 1.514(m_{t-1} - p_{t-1}) - 0.574(m_{t-2} - p_{t-2}), \quad (3)$$

(0.110) (0.029) (0.130) (0.008) (0.079) (0.076)

$$p_t - p_{t-1} = -0.009 + 0.163(y_{t-1} - y_{t-2}) + 0.011 q_{t-1} + 0.712(p_{t-1} - p_{t-2}), \quad (4)$$

(0.007) (0.102) (0.007) (0.074)

$$e_t = 1.264 - 6.222 r_t, \quad (5)$$

(0.045) (1.854)

$$p_t^F = -0.013 + 1.187 p_{t-1}^F - 0.262 p_{t-1}^F, \quad (6)$$

(0.008) (0.108) (0.105)

$$g_t = 0.090 + 0.759 g_{t-1} + 0.229 p_{t-1}^F, \quad (7)$$

(0.050) (0.107) (0.106)

Equations (2)-(7) are estimated by 3SLS. The estimated structural coefficients all have expected signs. In addition, most of the estimates are significantly different from zero at the 10% level except the interest rate and exchange rate in equation (3).

Combining (1) with (2)-(7), we express the central bank's control problem as:

$$\text{Minimize } \frac{1}{T} E_0 \sum_{t=1}^T Z_t' K Z_t, \quad (8)$$

subject to

$$Z_t = b + B Z_{t-1} + C r_t + \eta_t, \quad (9)$$

where $Z_t = (y_t, m_t - m_t^*, e_t - e^*, p_t, p_t^F, g_t, r_t, m_t^*, y_{t-1}, m_{t-1} - m_{t-1}^*, e_{t-1} - e^*, p_{t-1}, p_{t-1}^F, g_{t-1}, r_{t-1}, m_{t-1}^*)'$, b is a constant vector, η_t is a linear combination of the residuals vector, and B , C , and K are constant matrices. The matrix K is diagonal with $1-w$ on the second diagonal element, w on the third, and zeros elsewhere.

The target path for the money stock, m_t^* , is assumed to be the smoothed money supply process represented by an fitted AR(2) process: $m_t^* = 0.084 + 1.570m_{t-1} - 0.579 m_{t-2}$. The exchange rate is targeted at a fixed level e^* , which is set to the historical value in 1979:1. We choose this value because the objective of the EMS was to stabilize exchange rates between its members, and France participated in all the mechanisms instituted by the EMS since its inception in 1979.

The problem is to choose the domestic nominal interest rates r_1, \dots, r_T to achieve (8), given the initial condition Z_0 . By using Bellman's (1957) method of dynamic programming the problem is solved backward [see Chow (1975, ch. 8)]. That is, the last period T is solved first, given the initial condition Z_{T-1} . Having found the optimal r_T , we solve the two-period problem for

the last two periods by choosing the optimal r_{T-1} , contingent on the initial condition Z_{T-2} , and so on.

Letting $T \rightarrow \infty$, the optimal policy rule can be expressed as (a technical Appendix detailing the derivations is available from the authors upon request)

$$r_t = GZ_{t-1} + f, \quad (10)$$

with $G = -(C' HC)^{-1} (C' HB)$,

$$f = -(C' HC)^{-1} C' (Hb - h),$$

$$H = K + (B + CG)' H(B + CG), \text{ and}$$

$$h = -[I - (B + CG)']^{-1} (B + CG)' Hb.$$

The control variable (r_t) depends only on the predetermined variables.

Substituting the estimated coefficients in (2)-(7) into (10) and simulating over time to get steady state values of the matrices H and G in (10) yield the optimal policy rule. The economy is assumed to face the same set of shocks that actually occurred in the historical period. Therefore the reduced form solutions of the estimated equations, the optimal policy rule, and the historical shocks from the structural model are used to generate the counterfactual data.

We focus on two measures of economic performance that should reflect the concerns of policymakers: the inflation rate and real GDP growth rate. Given the conventional definition of a recession as two quarters of declining GDP, we focus on the two-quarter growth rates of real GDP. Therefore the means and standard deviations of the annual inflation rates and the two-quarter real GDP growth rates over the simulation period are the statistics of particular interest.

To assess the importance of the exchange rate target, we conduct the simulations over various values of w , the penalty weight on the exchange rate target in the loss function (1). By varying the value of w from zero to one, we wish to see how important the external target is relative to the internal target. In particular, we compare the performances of a dual targets rule ($w > 0$) to those of a single monetary target rule ($w = 0$).

3. Simulation results and conclusions

Table 1 reports the means and standard deviations of the annual inflation rates, the standard deviations of the two-quarter real GDP growth rates, and the mean absolute values of the quarterly changes in the interest rates. First of all, when the exchange rate is targeted ($w \neq 0$), the simulation results are very similar across different w 's. On the other hand, the single monetary targeting rule ($w=0$) produces very different results from those of the dual targets rules. This is due to the fact that, compared to the other variables, the exchange rate has much smaller effects on output and inflation [see equations (2) and (4)]. However, since the interest rate elasticity of exchange rates is very high (-6.22), if the variation in exchange rate is not penalized, the adjustments of the interest rates called by economic shocks will significantly affect the exchange rates. For example, a 1% increase in the interest rate will cause a 6.22% drop in the exchange rate. If the exchange rate is not targeted, the effect will be fully transmitted to output and inflation rates. Furthermore, fluctuations in these variables will call for more adjustments of the instrument. This is why the variation in the interest rates is much higher when $w = 0$.

Secondly, compared to the dual targets rule, targeting the money supply alone will cause higher inflation rates. On the other hand, the variance of inflation rates is lower because degrading a domestic nominal anchor will cause price instability. However, the stabilization of the inflation rates requires more rapid adjustments of the interest rate instrument, which results in fluctuations in output growth.

Thirdly, commitment to an explicit policy rule could have stabilized French annual inflation rates. The standard deviation from the single money-targeting rule is about 1% lower than that in the historical data and about 0.3% lower when the exchange rate is targeted.

Finally, compared to the historical data, the single monetary targeting rule causes higher inflation rates. However, if the exchange rate is targeted, the mean annual inflation rate is

significantly lowered. Furthermore, the dual targets rules not only produce lower inflation rates than those in the data but also reduce the fluctuations of the inflation rates.

In sum, simulations of the simple macroeconomic model and the policy rules suggest that, compared to the historical policy, the primary benefit of using a policy rule in France is to reduce the inflation rate volatilities. However, short-run real GDP growth rates would be more volatile than they have been over the past fifteen years. Targeting the nominal exchange rate eliminates inflation expectations resulting from foreign disturbances and strengthens domestic credibility of monetary policy. Therefore the monetary authorities in small open economies should not ignore the influences of the exchange rate volatility on domestic inflation.

The model and the methods of deriving an optimal policy rule stated in this paper can be applied to other targeting mechanisms such as nominal GDP targeting rules and real GDP/Price targeting rules. For example, in equation (8), let $Z_t = (y_t, p_t, A_t)'$, where y_t is real output, p_t is price level, and A_t is a vector of non-target variables. The central bank's objective is equivalent to $(1/T) E_0 \sum_{t=1}^T \{ (1-w) (y_t - y_t^*)^2 + w (p_t - p_t^*)^2 \}$. Then equation (8) becomes a GDP/Price targeting rule. Extensions for future research include evaluating combinations of exchange rate target and other target variables in an open economy setting.

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Table 1. Simulation Results: 1979:1-1997:4

	Mean Annual Inflation Rate(%)	Standard Deviation of Annual Inflation Rate(%)	Standard Deviation of two-quarter Real GDP Growth Rate (%)	Mean Absolute value of Quarterly Change in Interest Rates (Annual Rate %)
Historical Data:	4.981	3.915	0.958	0.629
<u>Simulated Data</u> *				
w=0	5.669	2.972	2.866	2.264
w=0.1	3.448	3.664	1.600	0.085
w=0.2	3.445	3.683	1.602	0.039
w =0.3	3.444	3.689	1.602	0.023
w =0.4	3.444	3.693	1.603	0.015
w =0.5	3.443	3.694	1.603	0.010
w =0.6	3.443	3.696	1.604	0.007
w =0.7	3.443	3.697	1.604	0.004
w =0.8	3.443	3.697	1.604	0.002
w =0.9	3.443	3.698	1.604	0.001
w =1	3.443	3.698	1.604	0.000

* w is the penalty weight received by the exchange rate target in the welfare function: $(1/T) E_0 \sum_{t=1}^T \{ (1-w) (m_t - m_t^*)^2 + w (e_t - e_t^*)^2 \}$.

Technical Appendix: (for referees' review only and not intended for publication)

Equations (2) - (7) can be expressed as

$$X_t = A_0 + A_1 X_t + A_2 X_{t-1} + A_3 X_{t-2} + A_4 r_t + A_5 u_t, \quad (\text{A.1})$$

where $X_t = (y_t, m_t - m_t^*, e_t - e^*, p_t, p_t^F, g_t, r_t, m_t^*)'$. The constant matrices A 's should be obvious.

Rewrite (A.1) as

$$X_t = A_6 + A_7 X_{t-1} + A_8 X_{t-2} + A_9 r_t + A_{10} u_t,$$

where $A_6 = (I - A_1)^{-1} A_0$, $A_7 = (I - A_1)^{-1} A_2$, $A_8 = (I - A_1)^{-1} A_3$, $A_9 = (I - A_1)^{-1} A_4$, and $A_{10} = (I - A_1)^{-1} A_5$. A first-order system can be formed as:

$$\begin{bmatrix} X_t \\ X_{t-1} \end{bmatrix} = \begin{bmatrix} A_6 \\ 0 \end{bmatrix} + \begin{bmatrix} A_7 & A_8 \\ I & 0 \end{bmatrix} \begin{bmatrix} X_{t-1} \\ X_{t-2} \end{bmatrix} + \begin{bmatrix} A_9 \\ 0 \end{bmatrix} r_t + \begin{bmatrix} A_{10} \\ 0 \end{bmatrix} u_t,$$

which can be rewritten as:

$$Z_t = b + B Z_{t-1} + C r_t + \eta_t. \quad (\text{A.2})$$

The central bank's objective is to minimize

$$\frac{1}{T} E_0 \sum_{t=1}^T Z_t' K Z_t,$$

subject to (A.2). The matrix K is diagonal with $1-w$ on the second diagonal element, w on the third, and zeros elsewhere. The problem is to choose r_1, \dots, r_T to achieve the objective, given the initial condition Z_0 . By using Bellman's (1957) method of dynamic programming the problem is solved backward. The following derivations follow those in Chow (1975, ch. 8).

Consider the problem for the last period T . It is to minimize

$$\begin{aligned} V_T &= E_{T-1} (Z_T' K Z_T) \\ &= (b + B Z_{T-1} + C r_T)' K (b + B Z_{T-1} + C r_T) + E_{T-1} (\eta_T' K \eta_T). \end{aligned} \quad (\text{A.3})$$

Let $H_T = K$. Differentiation of (A.3) with respect to r_T yields

$$\frac{\partial V_T}{\partial r_T} = 2 C' H_T (b + B Z_{T-1} + C r_T) = 0. \quad (\text{A.4})$$

The solution of (A.4) gives the optimal policy rule for the last period

$$\hat{r}_T = G_T Z_{T-1} + f_T,$$

where $G_T = -(C' H_T C)^{-1} (C' H_T B)$, $f_T = -(C' H_T C)^{-1} C' H_T b$, and \hat{r}_T is the optimal choice of r_T .

Now consider the problem for one more period $T-1$. By the principle of optimality in dynamic programming we minimize the following value function with respect to r_{T-1} :

$$V_{T-1} = E_{T-2} [(Z_{T-1}' K Z_{T-1}) + \hat{V}_T], \quad (\text{A.5})$$

where \hat{V}_T is the minimum value of V_T . The solution of the first-order condition of (A.5) yields

$$\hat{r}_{T-1} = G_{T-1} Z_{T-2} + f_{T-1},$$

where $G_{T-1} = -(C' H_{T-1} C)^{-1} (C' H_{T-1} B)$,

$$f_{T-1} = -(C' H_{T-1} C)^{-1} C' (H_{T-1} b - h_{T-1}),$$

$$H_{T-1} = K + (B + CG_T)' H_T (B + CG_T), \text{ and}$$

$$h_{T-1} = -(B + CG_T)' H_T b.$$

Having found the optimal r_T and r_{T-1} , we similarly solve the three-period problem by choosing the optimal r_{T-2} , and so on. The optimal policy rule at time t , with initial conditions

$H_T = K$ and $h_T = 0$, can be expressed as:

$$\hat{r}_t = G_t Z_{t-1} + f_t,$$

where $G_t = -(C' H_t C)^{-1} (C' H_t B)$, (A.6)

$$f_t = -(C' H_t C)^{-1} C' (H_t b - h_t), \quad (\text{A.7})$$

$$H_t = K + (B + CG_{t+1})' H_{t+1} (B + CG_{t+1}), \text{ and} \quad (\text{A.8})$$

$$h_t = -(B + CG_{t+1}) (h_{t+1} - H_{t+1} b). \quad (\text{A.9})$$

If all the characteristic roots of the matrix $(B+CG)$ are smaller than one in absolute value, solving (A.5)-(A.9) recursively yields the optimal policy in the steady state:

$$r_t = GZ_{t-1} + f,$$

where $G = -(C' HC)^{-1} (C' HB)$,

$$f = -(C' HC)^{-1} C' (Hb - h),$$

$$H = K + (B+CG)' H (B+CG), \text{ and}$$

$$h = -[I - (B+CG)']^{-1} (B+CG)' Hb.$$