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Government Debt and Inflation Targeting in Brazil

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ABSTRACT

The objective of this paper is to understand the Brazilian inflation targeting policy under the flexible exchange rate system. Brazil was in a circumstance so-called "fiscal dominance". For instance, the Brazilian country risk suddenly jumped due to the market perceptions about the presidential election, which led to large capital outflows and exchange rate depreciation in 2002. How did the Brazilian government get along with such a situation in setting the interest rate?

We estimated the response function of the Brazilian Central Bank with respect to interest rate setting. We selected the sample period from 2001 to 2003 when the actual inflation rates exceeded the range of inflation targeting. The basic findings are as follows. (1) The Bank sets the interest rate referring to the deviation of the expected inflation and the target rate. (2) The exchange rate (its rate of change) is not statistically significant in determining interest rate. (3) Not only through the channel of exchange rate, the Bank set the interest rate directly responding to the increase in country risk and government debts. When the country risk worsens, interest rate tends to be increased, and on the other hand when the government debts increase, it tends to be reduced. Therefore, it would be appropriate to think at least that, facing to a serious default risk and sustainable government debts particularly in 2001 to 2003, the Brazilian Central Bank flexibly set the interest rate that is deviated to some extent from the basic formula of inflation targeting.

Key Words: Brazil, inflation targeting, interest rate, country risk, exchange rate risk premium
JEL classification: E5, F33, O54

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Introduction

While the Brazilian economy was confronted with hyperinflation from the middle of 1980s to the beginning of 1990s, the stabilization policy called *Real Plan* implemented in July 1994 successfully got rid of high inflation by adopting exchange rate anchor system. It is very evident that the policy reforms in the 1990s helped this disinflation process by liberalizing trade and capital market, which significantly increased the market competition and capital inflows. But, stabilization policy based on the dollar peg inevitably caused overvaluations of real exchange rates, which led to external imbalances and higher dependence on foreign capital.

As is well known from the Open-macroeconomics, a country cannot adopt fixed exchange rate, free capital movement and independent monetary policy at the same time and is not avoidable to have compelled adjustments like currency crisis. Brazil was not an exception. Facing with the currency crises prevailed in the second half of 1990s, Brazil eventually had to decide to abandon fixed exchange rate system in January 1999 triggered by large capital outflows and speculative attacks. Under the new exchange rate regime—flexible exchange rate system—, the Brazilian government adopted the inflation targeting as a new anchor for inflation.

From 1999 to 2000, inflation rates were within the target range, which created a high reputation to the Brazilian monetary policy. However, the actual inflation rates exceeded the target range in 2001 through 2003. In particular, the inflation rate reached to 12.53% in 2002 much higher than the upper limit of 6% due to sudden changes of country risk and exchange rates that were provoked by market expectations about the presidential election. This event provides us a typical story that a country in "fiscal dominance" is likely to face to difficulties in managing inflation targeting policy.

The purpose of this paper is to discuss the main problems of the current monetary policy in Brazil under flexible exchange rate system. Section 1 argues briefly some characteristics of inflation targeting policy implemented in July 1999. Section 2 overviews the institutional aspects of the policy and the macroeconomic performance under the regime. Section 3 presents a theoretical model for inflation targeting that takes public debts and exchange rate risk premium into consideration. These two factors are very important for managing inflation targeting policy, particularly in the context of emerging markets, which are facing to the fiscal dominance problem. In Section 4, the Brazilian inflation targeting policy is investigated by estimating response functions regarding interest rate. The estimation verifies that the Central Bank determined interest rates considering the external shocks of risk premium and public debts.

1. Some Problems of Inflation Targeting under Flexible Exchange Rate System

Researches regarding the theories and the experiences of inflation targeting are found, among others, in Blejer, et al. (2000), Bernanke, et al. (1999), Taylor (1999) and Svensson (1999). The regime of setting an inflation target means that the monetary authority conducts stabilization policy using traditional instruments of monetary policy—basically short term interest rates—to realize the target rate set in advance. According to Haldane (2000), Bernanke, et al. (1999), Svensson (1997), the main advantages of inflation targeting are recognized as; (1) the monetary authority can set an inflation target as a nominal anchor for monetary policy or as a reference index for inflation expectation, (2) it can increase not only transparency of monetary policy but also ability for evaluation of monetary policy and its performance, (3) it can show to the public that monetary policy has long-run effects for stabilization.

However, inflation targeting policy in open economy is likely to have some problems in the context of Latin America. Under flexible exchange rate system, inflation targeting policy faces difficulties due to large and volatile changes of exchange rates. The changes of exchange rates affect price levels directly through imported prices and indirectly through aggregated demand and supply. In turn, exchange rates are affected by external shocks and expectations. Historically in Latin American countries exchange rate changes have high pass-through to price levels (Mishkin (2001)).

Particularly when a country is in fiscal dominance with unsustainable public debts and budget deficits, it is inevitable that market's credibility for the public debt decreases and default risk becomes serious, which immediately lead to a deterioration of risk premium and a large depreciation, and eventually to a higher inflation. According to Blanchard (2004), while a standard argument predicts that an increase in interest rate will appreciate exchange rates by attracting foreign capitals, the fiscal dominance makes inflation targeting policy difficult by higher default risk and depreciation caused by increase in interest rate.

In reality inflation targeting policy does not assure fiscal discipline. The public debts in Brazil had been increasing significantly even after the introduction of inflation targeting policy. Whereas public debt per GDP in July 1999 was 46%, it reached to a peak of 60% in September 2002. Moreover, about 80% of Brazilian debt is denominated in dollars or indexed to either exchange rates or interest rates. This means that a large depreciation increases debt payments in terms of local currency, which will reduce credibility for the government bonds. This, in turn, aggravates default risk and increases risk premium, and again leads to depreciation through a vicious cycle.

In several months ahead of the presidential election of October 2002, along with the expectations that the candidate Lula's would win, the Brazilian EMBI+ spread suddenly boosted from 732 basis points in March 2002 to 2001 basis points in August.

Based on his career and political attitude, the market expected that Lula would not take rigorous policies to reduce budget deficits and would be hostile against international financial market. Exchange rate depreciated drastically from *Real* 2.4 per US dollar in January 2002 to *Real* 3.9 in August, and inflation rates (IPCA) increased from 7.6% in January 2002 to 16.8% in April 2003. Blanchard (2004), using empirical evidence in Brazil, found the link from expected debt to the probability of default, which in turn has effects on exchange rate. Favero and Giavazzi (2004) discussed that the default risk in this period reinforced the possibility of vicious circle that made the fiscal constraint on monetary policy more stringent.

Here we discuss the effects of exchange rate on interest rate using an inflation targeting model, in which exchange rate is incorporated into aggregate demand and supply function (Mishkin and Savastano (2001)). Aggregate supply function is given by

$$\pi_t = \pi_{t-1} + \alpha_1 y_{t-1} + \alpha_2 e_{t-1} + \varepsilon_t ,$$

and aggregate demand function is given by

$$y_t = \beta_1 y_{t-1} - \beta_2 (i_{t-1} - \pi_{t-1}) + \beta_3 (e_{t-1} - e_{t-2}) + \eta_t ,$$

where π_t is the inflation rate, y_t is the output gap (the log of the actual to potential output), i_t is the nominal interest rate, e_t is the log of the real interest rate (a deviation from a normal level), ε_t and η_t represent aggregate supply and demand shocks, respectively. Exchange rate is determined by

$$e_t = \varphi i_{t-1} + u_t ,$$

where the external shocks and φ capture the relation of interest rate on exchange rate. Monetary authority determines the optimal interest rate by minimizing the following inter-temporal loss function.

$$E_t \sum_{\tau=1}^{\infty} \delta^{\tau-1} \{(\pi_\tau - \pi^*)^2 / 2 + \lambda y_\tau{}^2 / 2\}$$

where E is the operator to express expectation, $\delta<1$ is the government discount rate and π^* is the target inflation level. The optimal interest rate is expressed by a modified Taylor rule.

$$i_t = \pi_t + b_1(\pi_t - \pi^*) + b_2 y_t + b_3 e_t$$

The view, regarding Latin America under flexible exchange rate regime, that exchange rate changes significantly affect interest rate by the changes of aggregate demand and supply through relatively a large pass-through is expressed by a large b_3 in the modified Taylor rule. Moreover, considering that φ captures the extent of the effects on exchange rate (caused, for instance, by capital inflows that are induced by interest rate differential between home and abroad) and u_t captures the extent of such an external shock as country risk, the larger extent of these factors indicates that the interest rate has to change greater in the inflation targeting regime.

Under such a circumstance, if a country is in fiscal dominance, an increase in interest rate will aggravate the debt payment burden. Therefore an automatic increase in interest rate due to inflation targeting policy will deteriorate further the default risk of the country. This means that, even when a country faces a sudden jump of default risk caused by a certain reason, it will face a difficulty in increasing interest rate. The experience of Brazil in 2002 is a typical case in which a county in fiscal dominance is confronted with such a difficulty. How did the Brazilian government determine interest rate in that period? We will make an empirical investigation by estimating the response function of the Brazilian Central Bank to discuss this question in Section 5.

2. Inflation Targeting Policy in Brazil

(1) Institutional Aspects

In Brazil the inflation targeting policy was institutionalized legally by the presidential decree No. 3088 starting from July 1st. 1999 with the objective of substituting the exchange rate anchor with inflation target as a nominal anchor. From July 1994 (when the *Real Plan* was implemented) to January 1999 (when the currency crisis happened), the Brazilian government maintained monetary stability through crawling peg and high level of international reserves. When currency crises happened in Mexico, Asia and Russia in the second half of 1990s, Brazil could defense its exchange rate system by high interest rate policies and exchange market interventions. However, in addition to the delay of fiscal reforms for tax and pension system, the high interest rate policies brought about the huge increases of debt payments and gradually weakened the market's credibility for the Brazilian government.

Since the flexible exchange rate system was introduced on January 15 of 1999, the *Real* depreciated noticeably from R$1.21 per US$1 in the beginning of January to R$2.06 in the end of February. Turning into March, the Central Bank increased interest rate and announced an alteration of procedures for its determination; the president of the Central Bank is authorized to set the interest rate without notifying to Monetary Policy Committee (Copom) in advance. Until then interest rate was determined exclusively by the Copom. At the same time, the Bank announced the introduction of a new base interest rate named SELIC and the abolishment of the interest rate band system (TBC/TBAN).

The main characteristics of the Brazilian inflation targeting system are as follows:

(1) The target rate and the tolerance range are set by the National Monetary Council (*Conselho Monetário Nacional*) based on a proposal of the Ministry of Finance.

(2) The Central Bank is assigned to implement monetary policies needed to attain the inflation target.

(3) In case the target is not satisfied, the president of the Bank has a responsibility to issue an open letter to the Minister of Finance explaining the reasons of the deviation, the measures to eliminate it, and the time necessary to get back the inflation rate within the tolerance, but the president of the Bank does not have any penalty.

(4) As inflation targeting reference index, IPCA (Broad Consumer Price Index) is adopted that does not exclude any particular items. The IPCA is calculated by the Brazilian Institute for Geography and Statistics based on the price survey of the consumption basket of families with monthly incomes ranging from 1 to 40 times the minimum wage in 11 large cities.

(5) The Bank has a responsibility to issue *Inflation Report* every quarter, in which the consequences of the monetary policy and the inflation forecasts is reported.

(6) The Central Bank makes public the basic economic concept and theory for inflation targeting policy, while the econometric model to determine interest rate is not open to the public.

(7) Target rate should be announced by June 30 of the year onward 2 years in advance.

(8) The target rates for 1999, 2000 and 2001 were set in 8%, 6% and 4% respectively with 2% tolerance interval (upward and downward).

Because of the long history of high inflation and the low credibility for the monetary authority, the Brazilian government requires rigorous rules of the Central Bank in conducting inflation targeting policy, particularly, by not allowing escape clause and by adopting inflation index that covers every item without any exclusion. Some countries such as England, Canada, Australia and New Zeeland that have previously implemented inflation targeting policy are commonly excluding some specific components from the inflation indexes. The reason why Brazil preferred not to create an index with exclusions to measure its inflation rates is to prevent the improper use of exclusion that frequently happened in the past, and to avoid its negative influence on the credibility for the new monetary regime. For the same reason, a new index IPCA was created and substituted with the old index IPC that had been widely used for a long time. The IPCA is allowed to have 2% rage of tolerance interval because it is expected to have more instable movements than that of the core inflation index.

Notwithstanding that many factors were considered to elaborate a new monetary regime, the monetary authority failed to create an adequate credibility for political reasons. For instance, the president of the Central Bank is required to do some obligatory procedures in case of not achieved the target, but was not introduced a severe punishment like replacement. In addition, a special legislation that prevents political intervention into Copom was not prepared. In this respect, the President of the Republic is able to restructure the Copom by altering its membership and changing the formula to set the interest rate.

(2) Macroeconomic Performance in Brazil under Inflation Targeting Policy

The following figures indicate the monthly movements of 6 variables from June 1999 to September 2004; IPCA (Broad Consumer Price Index), SP (EMBI+), B (% of public debts over GDP), R (basic interest rate SELIC), R$RATE (exchange rate), y (capacity utility ratio of manufacturing sectors).

One of the most salient features of this period is seen in the following fact. Along with a gradual increase in public debts from 2000, the Brazilian country risk and the exchange rate suddenly jumped from April 2002 due to the concerns about the presidential election of October near at hand. At the same time, inflation rates also started to rise with a few months lags. Facing with these changes, the Brazilian government raised SELIC rate up to 26.5% in October. But, in a couple of months, due to the significant changes in market concerns about Lula, the Brazilian EMBI+ started to fall. The exchange rates and inflation rates also showed a sudden decrease as well.

While inflation rates were within the upper limit in 1999 and 2000, the government was unsuccessful to control inflation within the limit from 2001 facing with the turbulences just before the election. It reached 7.67% in 2001 and 12.53% in 2002. Since 2003, however, inflation rates had a tendency to reduce.

	IPCA	Target	Lower limit	Upper limit	
1999	8.94	8	6	10	
2000	5.97	6	2	6	
2001	7.67	4	2	6	*
2002	12.53	3.5	1.0	6	*
2003	9.30	4	1.5	6.5	*
2004	6.68	5.5	3.5	7.5	

Source: Central Bank of Brazil
Note: * means the years in which the inflation rate surpassed the target.

Figure 1

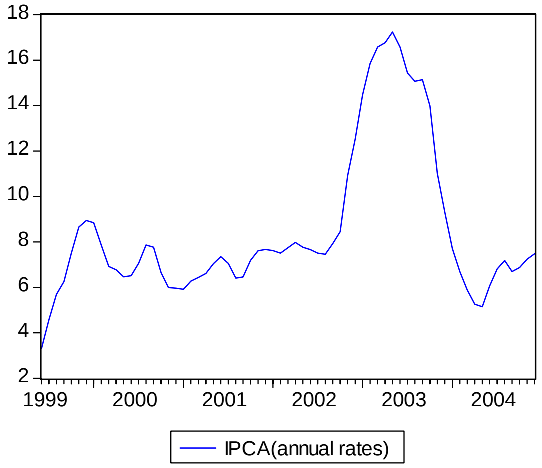


Figure 2

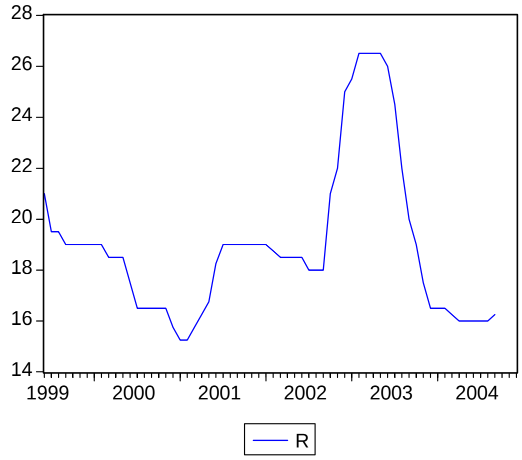


Figure 3

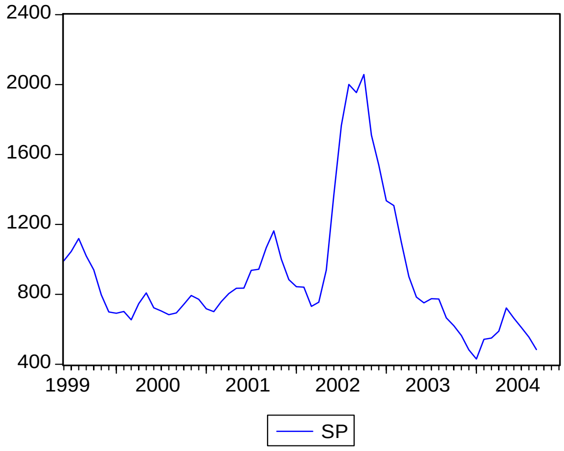


Figure 4

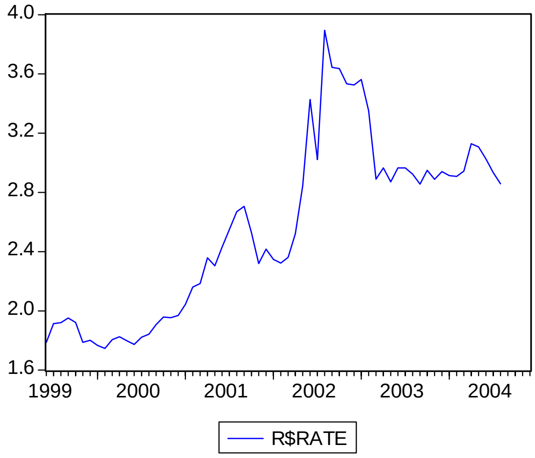
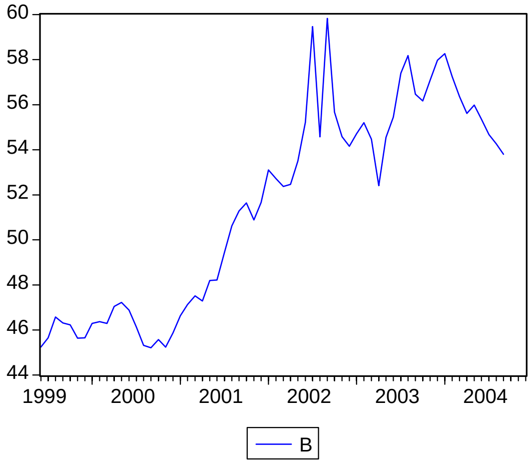


Figure 5



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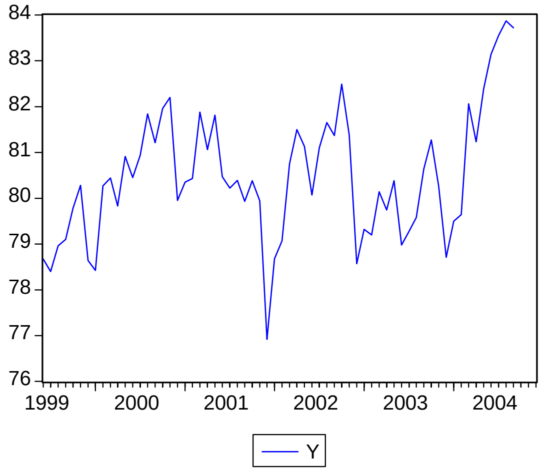

Regarding these macroeconomic performances in this period, Mishkin (2004) gave a rather positive evaluation. While the inflation rates were greater than the targets in 2001 through 2003, "the response of the Brazilian government and central bank to the overshoots of the inflation targets illustrates that inflation targeting can help keep inflation under control in the face of big shocks like the real depreciation 2002"(p.19). He listed the following factors to explain the success of the inflation targeting policy; (1) the procedure had tremendous transparency in determining and explaining the policy, (2) the central bank recognized that adjusting the target was absolutely necessary to retain credibility, (3) the central bank was able to demonstrate that it did not only care about controlling inflation but did care about the output fluctuation, (4) President Lula was succeeded in legislation to reform the public pension system and fiscal policy to attain the budget surplus goal.

With respect to (2) above, we need some attention. In fact, the Central Bank has issued six resolutions regarding the inflation target so far. But, by the resolution of June 27 of 2002, the Bank altered the target for 2003 to 4% from 3.25% that was set in June 28 of 2001. The tolerance interval was also changed from 2% to 2.5%. Moreover, by the resolution of June 25 of 2003, the target for 2003 was increased to 5.5% from 3.75% that was set in June 2002 and the tolerance interval was reduced again to 2%. Generally changes in the target are likely to produce market perceptions that the policy is discretional and therefore deteriorate market credibility. In this sense, although the interpretation by Mishkin is different from the common understandings, it seems worth making a further investigation.

At any rate, Brazil was confronted with a default risk triggered by a political reason. In such a circumstance, the Brazilian government was forced to immediately respond by increasing interest rates. But the increase in interest rate would eventually accelerate the default risk by raising the debt payment burdens. How did the Brazilian government get along with such a dilemma and retain credibility under the inflation targeting system?

3. A Theoretical Model

In this section, we introduce a model based on the works of BCB (2000a), Ball (1999) and Svensson (1997) to include fiscal variables. Particularly the model focuses on the effects of risk premium and government debts on the optimal monetary policy. The model was initially developed in Nishijima and Tonooka (2000).

(1) $y_t = \alpha_y y_{t-1} - \alpha_r r_{t-1} - \alpha_e e_{t-1} + \upsilon_{1t} \qquad 0 < \alpha_y < 1, \quad \alpha_r, \alpha_e > 0,$

(2) $\pi_t = \pi_{t-1} + \beta_y y_{t-1} - \beta_e (e_{t-1} - e_{t-2}) + \upsilon_{2t} \qquad \beta_y, \beta_e > 0,$

(3) $s_t = \gamma_r r_t - \gamma_X X_t + \upsilon_{3t} \qquad \gamma_r, \gamma_X > 0$,

(4) $X_t = X_{t-1} + \delta_d d_t + \upsilon_{4t} \qquad \delta_d > 0$,

(5) $d_t = \varepsilon_r r_t + \varepsilon_D D_{t-1} - \varepsilon_y y_t + \upsilon_{5t} \qquad \varepsilon_r, \varepsilon_D, \varepsilon_y > 0$,

where y is the log of output gap, π is the log of inflation rate, r is the log of real interest rate, s is the log of real exchange rate (increase means appreciation), X is the log of risk premium, d is the log of budget deficit per GDP, D is the log of government debts per GDP (where $D_t = D_{t-1} + d_t$), and υ_i is the stochastic shocks.

Equation (1) denotes the aggregate demand, which is negatively dependent on real interest rate and real exchange rate. Considering time lags to effect on real output, they have one period lag. υ_{1t} stands for demand side stochastic shocks.

Equation (2) is the aggregate supply curve (Phillips curve) according to Ball (1999). Inflation rate is dependent on real output with one period lag and on real exchange rate through changes of import prices. Exchange rate has two period lags because of slow response of price setting (by a hypothesis of Ball). Inflation inertia is expressed by one period lag of endogenous variable. υ_{2t} represents supply shocks.

Equation (3) is a relation between exchange rate and interest rate. Increase in domestic interest rate attracts foreign capital inflows, which leads to exchange rate appreciation. Increase in risk premium makes the exchange rate devaluated. υ_{3t} stands for such shocks as foreign interest rate fluctuations, foreign capital market instability and other external shocks. Here we assume for a simplification that exchange risk premium is the same to the country risk.

Equation (4) captures the effects of fiscal variables on risk premium that are considered important in the context of Brazilian case; in fact, when the currency crisis happened in 1999 and when the presidential election caused market turbulence in 2002, the Brazilian risk premium (country risk) had sudden increases. υ_{4t} denotes shocks that affect risk premium like changes in international reserves and political instability, etc.

Equation (5) determines budget deficits, which depend on two components; the debt payments dependent on both interest rate and amount of the debts, and the government current balance dependent on real output. υ_{5t} represents shocks regarding budget deficits.

The objective of the monetary authority is to determine the present and future optimal interest rates that minimize the expected deviations between the target rate and the future inflation rate. The objective function is expressed as

(6) $\min E_t 0.5 \sum_{i=0}^{\infty} \theta^i (\pi_{t+i} - \pi^*)^2$,

where E_t is the conditional expectation based on the available information at time t, θ

(0<θ<1) is the discount rate, and π^* is the target rate.

Using Equations (3), (4) and (5), we obtain Equation (7).

$$(7)\quad s_t = (\gamma_r - \gamma_X \delta_d \varepsilon_r) r_t - \gamma_X X_{t-1} - \gamma_X \delta_d \varepsilon_D D_{t-1} + \gamma_X \delta_d \varepsilon_y y_t - \upsilon_{7t}.$$

By substituting Equation (7) into Equations (1), (2), and expressing π at one period ahead, we obtain

$$(8)\quad \begin{aligned} y_t &= (\alpha_y - \alpha_e \gamma_X \delta_d \varepsilon_y) y_{t-1} - [\alpha_r + \alpha_e(\gamma_r - \gamma_X \delta_d \varepsilon_r)] r_{t-1} + \alpha_e \gamma_X X_{t-2} \\ &\quad + \alpha_e \gamma_X \delta_d \varepsilon_D D_{t-2} + \upsilon_{1t} + \alpha_e \upsilon_{7t-1} \end{aligned}$$

$$(9)\quad \begin{aligned} \pi_{t+1} &= \pi_t + (\beta_y - \beta_e \gamma_X \delta_d \varepsilon_y) y_t + \beta_e \gamma_X \delta_d \varepsilon_y y_{t-1} - \beta_e(\gamma_r - \gamma_X \delta_d \varepsilon_r) r_t \\ &\quad + \beta_e(\gamma_r - \gamma_X \delta_d \varepsilon_r) r_{t-1} + \beta_e \gamma_X X_{t-1} - \beta_e \gamma_X X_{t-2} + \beta_e \gamma_X \delta_d \varepsilon_D D_{t-1} - \beta_e \gamma_X \delta_d \varepsilon_D D_{t-2} \\ &\quad + \upsilon_{2t+1} + \beta_e \upsilon_{7t} - \beta_e \upsilon_{7t-1} \end{aligned}$$

Equation (9) is rewritten by using Equation (8) to get Equation (10),

$$(10)\quad \begin{aligned} \pi_{t+1} &= \pi_t + [(\beta_y - \beta_e \gamma_X \delta_d \varepsilon_y)(\alpha_y - \alpha_e \gamma_X \delta_d \varepsilon_y) + \beta_e \gamma_X \delta_d \varepsilon_y] y_{t-1} - \beta_e(\gamma_r - \gamma_X \delta_d \varepsilon_r) r_t \\ &\quad - \{(\beta_y - \beta_e \gamma_X \delta_d \varepsilon_y)[(\alpha_r + \alpha_e(\gamma_r - \gamma_X \delta_d \varepsilon_r)] - \beta_e(\gamma_r - \gamma_X \delta_d \varepsilon_r)\} r_{t-1} \\ &\quad + \beta_e \gamma_X (X_{t-1} - X_{t-2}) + (\beta_y - \beta_e \gamma_X \delta_d \varepsilon_y) \alpha_e \gamma_X X_{t-2} + \beta_e \gamma_X \delta_d \varepsilon_D (D_{t-1} - D_{t-2}) \\ &\quad + (\beta_y - \beta_e \gamma_X \delta_d \varepsilon_y) \alpha_e \gamma_X \delta_d \varepsilon_D D_{t-2} + \upsilon_{2t+1} + (\beta_y - \beta_e \gamma_X \delta_d \varepsilon_y) \upsilon_{1t} \\ &\quad + [(\beta_y - \beta_e \gamma_X \delta_d \varepsilon_y) \alpha_e - \beta_e] \upsilon_{7t-1} \end{aligned}$$

Since interest rate at time t affects the inflation rate at time $t+1$, and the interest rate at time $t+1$ affects the inflation rate at time $t+2$,…, we can find the inter-temporal minimization problem for the monetary authority as the solution to the simple period-by-period minimization problem (Svensson (1997), pp.1139-40). The period-by-period loss function is expressed as

$$(11)\qquad \min E_t 0.5\theta(\pi_{t+1} - \pi^*)^2 \quad .$$

Using Equation (10), we get the first order condition with respect to r_t.

$$\begin{aligned} \partial E_t[0.5\theta(\pi_{t+1} - \pi^*)^2] / \partial r_t &= E_t[\theta(\pi_{t+1} - \pi^*) \partial \pi_{t+1} / \partial r_t] \\ &= -\theta \beta_e (\gamma_r - \gamma_X \delta_d \varepsilon_r) E_t(\pi_{t+1} - \pi^*) = 0 \end{aligned}$$

Therefore, under the optimal setting of the interest rate, it follows

$$E_t \pi_{t+1} = \pi^*.$$

In other words, the optimal interest rate is determined by setting the expected rate of inflation conditional upon information available at time t equal to the target rate. By obtaining the expected rate of inflation from Equation (10) and using the relation

$E_t\pi_{t+1}=\pi^*$, we get the response function of the central bank.

$$
(12)\quad \begin{aligned}
r_t =& 1/\beta_e(\gamma_r - \gamma_X\delta_d\varepsilon_r)\{(\pi_t - \pi^*) + [(\beta_y - \beta_e\gamma_X\delta_d\varepsilon_y)(\alpha_y - \alpha_e\gamma_X\delta_d\varepsilon_y) + \beta_e\gamma_X\delta_d\varepsilon_y]y_{t-1} \\
& - \{(\beta_y - \beta_e\gamma_X\delta_d\varepsilon_y)[\alpha_r + \alpha_e(\gamma_r - \gamma_X\delta_d\varepsilon_r)] - \beta_e(\gamma_r - \gamma_X\delta_d\varepsilon_r)\}r_{t-1} \\
& + \beta_e\gamma_X(X_{t-1} - X_{t-2}) + (\beta_y - \beta_e\gamma_X\delta_d\varepsilon_y)\alpha_e\gamma_X X_{t-2} + \beta_e\gamma_X\delta_d\varepsilon_D(D_{t-1} - D_{t-2}) \\
& + (\beta_y - \beta_e\gamma_X\delta_d\varepsilon_y)\alpha_e\gamma_X\delta_d\varepsilon_D D_{t-2}\}
\end{aligned}
$$

This reaction function is of the modified form as the Taylor rule. The interest rate is positively dependent on the excess of inflation at time *t* over the target and on the real output with one period lag (here we assume the coefficient are positive). As Svensson (1997, p.1119) argues, however, the interest rate depends on current inflation, not because current inflation is targeted but because current inflation together with output affect the inflation expectation in the future (current inflation is predetermined).

Equation (12) shows in an explicit way the effects of risk premium and government debts on the optimal instrument, which are not analyzed in Svensson (1997) and Ball (1999). Both risk premium and debts affect the optimal interest rate in the form of the rate of change (X_{t-1}-X_{t-2}, D_{t-1}-D_{t-2}) and the level (X_{t-2}, D_{t-2}). This implies that the inflation targeting policy should be conducted carefully by taking account of the technical difficulties that are caused by risk premium and government debts. At the same time, it implies that rigorous fiscal reform as a precondition is required to make the targeting policy successful.

In next section we estimate the response function of the monetary authority with respect to interest rate based on the model in this section. However, in the real world, it is very probable that actual policy implementation is different from the theory and is affected by a various incidents. Thus, it would be necessary to modify the estimation equation taking account of the following realities.

(1) According to the econometric researches of BCB (2003) and BCB (2004), their results demonstrate that interest rate is determined by referring to the expected deviation of 12 months ahead between inflation forecast and the target, not to the deviation at time *t* as mentioned in the model.

(2) In the model discussed above, an increase in government debts would lead to a deterioration of risk premium through an increase in budget deficit, and then lead to a depreciation of exchange rate. This in turn brings about an increase in interest rate eventually by an increase in real output and actual inflation. However, there is a vicious circle in which an increase in interest rate would raise the debt payments and the budget deficits, and then raise the default risk. In such a circumstance, it would be proper to think that the monetary authority is reluctant or careful to increase interest rate by taking the vicious circle into account.

(3) On the other hand, in case that the investor's credibility with respect to

government debt collapses and a sudden outflow of foreign capital causes an overshoot of default risk, the government will be forced to increase interest rates in order to avoid a default crisis.

In the following section, we estimate the response function of the Brazilian Central Bank with respect to interest rate considering these points.

4. Estimation of Response Function of SELIC Rate

(1) Preceding Research

Two working papers of the Brazilian Central Bank (Minella et al. (2002) and Minella et al. (2003)) estimated the interest rate function under the inflation targeting regime[1]. In Minella (2003) the basic formula for SELIC target function is specified as

$$i_t = \alpha_1 i_{t-1} + (1-\alpha_1)(\alpha_0 + \alpha_2(E_t \pi_{t+j} - \pi^*_{t+j}) + \alpha_3 y_{t-1} + \alpha_4 \Delta e_{t-1}) ,$$

where i_t is the SELIC rate decided by the Copom, $E_t \pi_{t+j}$ is inflation expectation at time j, π^*_{t+j} is the inflation target at time j, y_{t-1} is the output gap, Δe_{t-1} is the nominal exchange rate variation (twelve month change).

The estimation used two types of expected inflation to measure the deviations from the target rate. The first one is the inflation forecasts by the Bank presented in *Inflation Report* and the other is the inflation forecasts (named market forecast) based on a daily survey conducted by the Bank. As the main results of the estimation, they found that, in both cases of the inflation forecasts, the deviations of the expected inflation from the target[2] are statistically significant in various model specifications. Therefore they concluded that the Bank has been reacting strongly to expected inflation on a forward-looking basis. In addition, they found that the output gap has a wrong sign but statistically significant in one of the specifications, and the exchange rate is not significant in the case of market forecast. However it must be noted here that the paper did not show the results of unit root test of the data used in the estimations.

(2) Confirmation of the Central Bank Formula Estimated in a Different Period

Here we estimate the same response function discussed above using a different period from January 2001 to December 2003 when the targeting policy did not control

[1] Garcia and Didier (2003) analyzed the relations among interest rate, exchange risk and country risk in Brazil for 1990s, but not in the context of inflation targeting policy.

[2] Minella (2003) constructed a series of data regarding the deviation of inflation from the target using a weighted average of current year and following year expected deviations.

the inflation within the target range[3]. We specify two models using the deviations of expected inflation from the target and the deviations of actual inflation from the target.

$$i_t = \alpha_0 + \alpha_1 i_{t-1} + \alpha_2 (E_t \pi_{t+j} - \pi^*_{t+j}) + \alpha_3 y_{t-1} + \alpha_4 ex_{t-1} + u_t ,$$

$$i_t = \alpha_0 + \alpha_1 i_{t-1} + \alpha_2 (\pi_t - \pi^*_t) + \alpha_3 y_{t-1} + \alpha_4 ex_{t-1} + u_t ,$$

where i_t is SELIC rate, $E_t \pi_{t+j}$ is expected rate of inflation either 6 months ahead or 12 months ahead, π^*_{t+j} is the target rate either 6 months ahead or 12 months ahead, π_t-π^* is a deviation of the inflation rate from the target at time t, y_t is output gap at t, and ex_{t-1} is the rate of changes of nominal exchange rate[4]. Unit root test of the variable used here is reported in footnote 5[5].

Table 4 reports the results of estimation. In the case that the equations specified above are estimated with respect to the period from January 2001 to December 2003 when the inflation targets were not attained, the coefficients of deviations of the inflation expectation from the target have a correct sign and are statistically significant in both $E\pi_{12}$-π^*_{12} and $E\pi_6$-π^*_6 cases. Moreover, the deviation at time t between the actual

[3] All the data we use in the paper, except EMBI+, is available from the web pages of the Central Bank of Brazil (http://www.bcb.gov.br/?INDICATORS) and Instituto de Pesquisa Econômica Aplicada (http://www.ipeadata.gov.br/).

[4] We adopt here a simple measure of deviation of inflation expectation from the target, that is, just a difference between $E_t\pi_{t+j}$ and π^*_{t+j}, not the measure used in Minella et al. (2003) in which current and future inflation rates are weighted. Moreover, we use the rate of changes of nominal exchange rate instead of using the nominal exchange rate variation (twelve month change) used in Minella et al. (2003), because the data of twelve month change that we made is not stationary according to the unit root test.

[5] Stationality of the variable is examined by Augmented Dickey-Fuller test with a constant term during the period from September 1999 to September 2004.

		t-Statistic	Prob.	
interest rate (SELIC rate)	i	-3.199	0.025	
nominal exchange rate change (12 months change)	Δex	-2.252	0.190	#
rate of change in exchange rates	ex	-4.258	0.001	
inflation rate (IPCA)	π	-4.027	0.002	
target inflation rate	π^*	-3.518	0.011	
expected rate of inflation 12 months ahead	$E\pi_{12}$	-3.653	0.007	
expected rate of inflation 6 months ahead	$E\pi_6$	-3.751	0.006	
expected deviation of $E\pi_{12}$ from the π^*	$E\pi_{12}-\pi^*_{12}$	-3.969	0.003	
expected deviation of $E\pi_6$ from the π^*	$E\pi_6-\pi^*_6$	-3.473	0.012	
deviation of actual inflation rate from the target	$E\pi-\pi^*$	-2.897	0.052	
capacity utilization ratio	y	-2.923	0.048	
deviation of EMBI from trend	$sptr$	-3.481	0.012	
deviation of government debt/GDP from trend	btr	-3.324	0.018	
rate of change of EMBI	gsp	-4.405	0.001	
rate of change of government debt/GDP	gb	-7.835	0.000	
real interest rate	ri	-1.792	0.381	#

Note: # denotes the cases that the hypothesis (the data has unit root) is not rejected.

According to ADF test, except nominal exchange rate change (12 months change) and real interest rate, all other variables are judged as stationary.

inflation and the target inflation is significant as well. On the other hand, output gap and exchange rate change are not statistically significant. Therefore, basically we can confirm the results of Minella et al. (2003), but it must be emphasized that both the deviations of inflation expectations ahead 12 months and 6 months are statistically significant, and rate of change in nominal exchange rates is not statistically significant in determining of interest rate.

(3) Estimation of Response Function Derived from the Theoretical Model

In the theoretical model interest rate is expressed in term of real interest rate. But, because the real interest rate is judged as not stationary by unit root test, we use nominal interest rate as dependent variable to estimate the response function on the Central bank. The results are reported in Table 2. As an alternative estimation instead of using real interest rate, we estimate the equation adding actual inflation rates into explanatory variable. The results are shown in Table 3[6].

While the model for the estimation is specified according to the theoretical model, we use the deviation of expected rate of inflation from the target rate. At the same time, we use the deviation of actual inflation rate from the target rate.

$$i_t = \alpha_0 + \alpha_1 i_{t-1} + \alpha_2 (E\pi_{t+j} - \pi^*_{t+j}) + \alpha_3 y_{t-1} + \alpha_4 sptr_{t-2} + \alpha_5 gsp_{t-1} + \alpha_6 btr_{t-2} + \alpha_7 gb_{t-1} + u_t$$

$$i_t = \alpha_0 + \alpha_1 \pi + \alpha_2 i_{t-1} + \alpha_3 (\pi_t - \pi^*_t) + \alpha_4 y_{t-1} + \alpha_5 sptr_{t-2} + \alpha_6 gsp_{t-1} + \alpha_7 btr_{t-2} + \alpha_8 gb_{t-1} + u_t$$

where *sptr* is the deviation of country risk (EMBI+) from its trend, *gsp* is the rate of change of country risk, *btr* is the deviation of government debt from its trend, *gb* is the rate of change of government debt. The s*ptr* and *gsp* are derived as the residuals of the regressions of country risk and government debt respectively using ARCH method in the form of cubic function.

Table 2 and Table 3 report the results of the estimations by OLS but Table 4 represents the results by instrumental variable method to confirm the robustness. In addition Table 2 reports the results of a different combination of explanatory variables to confirm the stability of the estimation.

The coefficients of $E\pi_{12}$-π^*_{12} and $E\pi_6$-π^*_6 have the correct sign and the statistical significance at 1% level, but that of π-π^* is not statistically significant. Therefore we can confirm the results by Minella et al. (2003) that the Central Bank has been determining the interest rate taking account of the future expected rate of inflation, not the current rate of inflation. However as far as concerned about our results, both $E\pi_{12}$-π^*_{12} and $E\pi_6$-π^*_6 have no essential statistical differences in determining the interest

[6] We did not find any essential differences in the estimation that uses real interest rate.

rate.

The output gap measured by capacity utilization is expected to have negative sign, but the coefficient has a wrong sign with a statistically insignificance. Probably the real output was affected by a series of external shocks or needed more time to have effects on interest rate. But, it is difficult to judge whether the monetary authority has disregarded the output gap in setting the interest rate or not.

Regarding the country risk, its growth rate (*gsp*) is statistically significant at 10% level in two of the three cases with a correct sign. Moreover its deviation from the trend (*sptr*) is strongly significant at 1% level in three cases. These results imply that the Central Bank has decisively increased interest rate in order to avoid a default crisis when the EMBI+ overshot in 2002 in particular. When we consider the results in Table 1 that exchange rate has no significant effects on interest rate, it would be safe to say that the monetary authority tried to change its policy instrument (SELIC) directly against the country risk overshoot, not merely taking account of exchange rate changes that the theoretical model mentions.

Growth rate of government debts (*gb*) is not statistically significant but with a correct sign. Its deviation from the trend (*btr*), however, is strongly significant at 1% level with negative sign in ether case. This means that the Central Bank has reduced interest rate when the debts deviated from its trend, fearing an aggravation of default crisis due to the increase of government debts. At least, a decrease in interest rate is likely to lessen the debt payment burden of the government bonds that are indexed to interest rates.

Although both country risk and government debt are directly affecting the interest rates, there is a large difference regarding the size of coefficients; those of *btr* (negative sign) are greater than *sptr* (positive sign). This difference might be a one of the reasons for having inflation rates greater than the target rates during 2001 to 2003. In other words, the effect of *btr* to reduce the interest rate is larger than that of *sptr* to increase it, which might be one of the causes that brought higher inflation rates than the target rates. On the other hand, the result that *gb* is not significant may imply that the monetary authority was more sensitive to the deviations of the debt from its trend than to its growth rates, because the latter tends to fluctuate frequently and unstably due to, for instance, short-term market operations.

Table 3 reports the results of the estimation in which actual inflation rate π is included as one of independent variables, instead of estimating directly the real interest rate as a dependent variable. We found that there is no significant difference comparing with the estimation using nominal interest rate. But, since the actual inflation rate is not statistically significant, it is not possible to judge whether the Central Bank referred to the real interest rate in setting the monetary instrument as the model indicates.

Conclusion

The objective of this paper is to understand the Brazilian inflation targeting policy under the flexible exchange rate system. Brazil was in a circumstance so-called “fiscal dominance” in which the government debt is reaching to a critical level and the country risk becomes very sensitive to the market expectations. For instance, the Brazilian country risk (EMBI+) suddenly jumped due to the market perceptions about the presidential election, which led to large capital outflows and exchange rate depreciation in 2002. In such a situation, it is very likely that the inflation targeting policy faces with serious difficulties in setting appropriate interest rate.

We presented a theoretical model for an inflation targeting in which country risk and government debt are introduced. Based on this model, we estimated the response function of the Brazilian Central Bank with respect to interest rate setting. We selected the sample period from 2001 to 2003 when the actual inflation rates exceeded the range of inflation targeting. The basic findings are as follows. (1) The Bank sets the interest rate referring to the deviation of the expected inflation and the target rate. (2) The exchange rate (its rate of change) is not statistically significant in determining interest rate. (3) Not only through the channel of exchange rate, the Bank set the interest rate directly responding to the increase in country risk and government debts. When the country risk worsens, interest rate tends to be increased, and on the other hand when the government debts increase, it tends to be reduced. Therefore, it would be appropriate to think at least that, facing to a serious default risk and sustainable government debts particularly in 2001 to 2003, the Brazilian Central Bank flexibly set the interest rate that is deviated to some extent from the basic formula of inflation targeting. Of course such an interpretation may be too simple and straight to understand the actual and complicated setting process of interest rate. Further investigations about the causalities between these factors and interest rate are necessary.

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Table 1 Estimation of Basic Formula by Brazilian Central Bank

Dependent Variable: *i* (SELIC)
Method: Least Squares
Sample: 2001M01 2003M12
Included observations: 36
White Heteroskedasticity-Consistent Standard Errors & Covariance

	(1)	(2)	(3)
	Coefficient t-value	Coefficient t-value	Coefficient t-value
c	-4.774	-6.893	2.178
	-0.487	-0.770	0.208
i (-1)	0.891	0.697	1.133
	25.835 ***	15.500 ***	14.799 ***
i (-3)			-0.561
			-6.730 ***
$E\pi_{12}-\pi^*_{12}$	0.583		
	6.979 ***		
$E\pi_6-\pi^*_6$		0.346	
		7.920 ***	
$E\pi-\pi^*$			0.291
			2.968 ***
y (-1)	0.081	0.145	0.057
	0.682	1.367	0.499
ex (-1)	0.016	0.019	0.028
	0.809	1.028	1.036
R2	0.976	0.978	0.976
Ad.R2	0.972	0.976	0.972
LM Test:	Probability	Probability	Probability
lag1	0.416	0.443	0.703
lag2	0.628	0.748	0.899
lag3	0.289	0.395	0.418
lag4	0.450	0.555	0.476

Notes: Breusch-Godfrey Serial Correlation LM Test
The lower berth is t-value. *** means significance at 1%.

Table 2　Estimation of Response Function of Brazilian Central Bank (1)

Dependent Variable: *i* (SELIC)
Sample: 2001M01 2003M12
Included observations: 36
Method: Least Squares
White Heteroskedasticity-Consistent Standard Errors & Covariance

(1)			(2)			(3)		
	(a)	(b)		(c)	(d)		(e)	(f)
	Coefficient t-value	Coefficient t-value		Coefficient t-value	Coefficient t-value		Coefficient t-value	Coefficient t-value
c	-9.142	-10.661	*c*	-8.554	-10.670	*c*	-5.942	-10.320
	-1.050	-1.274		-1.144	-1.491		-0.558	-1.044
i (-1)	0.859	0.856	*i* (-1)	0.748	0.735	*i* (-1)	1.073	1.128
	21.166 ***	24.166 ***		16.203 ***	17.433 ***		8.530 ***	9.804 ***
						i (-2)	-0.299	-0.324
							-1.618	-1.947 *
$E\pi_{12}-\pi^*_{12}$	0.355	0.398	$E\pi_6-\pi^*_6$	0.206	0.217	$E\pi-\pi^*$	0.090	0.061
	3.267 ***	3.793 ***		5.365 ***	5.464 ***		1.080	0.777
y (-1)	0.142	0.161	*y* (-1)	0.155	0.185	*y* (-1)	0.117	0.167
	1.345	1.597		1.726 *	2.177 **		0.983	1.512
gsp (-1)	0.007		*gsp* (-1)	0.010		*gsp* (-1)	0.012	
	1.149			1.802 *			1.733 *	
sptr (-2)	0.002	0.002	*sptr* (-2)	0.002	0.002	*sptr* (-2)	0.003	0.003
	3.261 ***	2.910 ***		4.734 ***	4.328 ***		5.934 ***	6.243 ***
gb (-1)	-0.021		*gb* (-1)	-0.015		*gb* (-1)	-0.021	
	-0.609			-0.427			-0.540	
btr (-2)	-0.281	-0.251	*btr* (-2)	-0.240	-0.226	*btr* (-2)	-0.332	-0.308
	-3.603 ***	-3.723 ***		-3.029 ***	-3.651 ***		-3.473 ***	-4.072 ***
R^2	0.983	0.983	R^2	0.9859		R^2	0.981	0.980
Adj.R^2	0.979	0.980	Adj.R^2	0.9836		Adj.R^2	0.976	0.976
LM Test	Probability	Probability	LM Test	Probability	Probability	LM Test	Probability	Probability
lag1	0.211	0.204	lag1	0.522	0.548	lag1	0.778	0.885
lag2	0.464	0.453	lag2	0.816	0.837	lag2	0.625	0.500
lag3	0.306	0.552	lag3	0.746	0.948	lag3	0.539	0.709
lag4	0.241	0.617	lag4	0.697	0.962	lag4	0.215	0.708

Notes: *** means significant at 1% leve, ** at 5% and * 10% level.

Table 3 Estimation Added π as an Explanatory Variable

Dependent Variable: *i* (SELIC)
Sample: 2001M01 2003M12
Included observations: 36
Method: Least Squares
White Heteroskedasticity-Consistent Standard Errors & Covariance

(1)				(2)				(3)		
	Coefficient t-value				Coefficient t-value				Coefficient t-value	
c	-10.5404			*c*	-8.4203			*c*	-6.1671	
	-1.1003				-1.0385				-0.5671	
π	-0.0237			π	0.0022			π	-0.3430	
	-0.4105				0.0455				-1.1886	
i (-1)	0.8835			*i* (-1)	0.7458			*i* (-1)	1.0526	
	12.7572	***			11.5698	***			8.6184	***
								i (-2)	-0.2953	
									-1.6189	
$E\pi_{12}-\pi^*_{12}$	0.3519			$E\pi_6-\pi^*_6$	0.2066			$E\pi-\pi^*$	0.3954	
	3.2082	***			5.4648	***			1.3633	
y (-1)	0.1559			*y* (-1)	0.1540			*y* (-1)	0.1446	
	1.3684				1.5998				1.1478	
gsp (-1)	0.0055			*gsp* (-1)	0.0098			*gsp* (-1)	0.0071	
	0.8012				1.6120				0.7929	
sptr (-2)	0.0020			*sptr* (-2)	0.0022			*sptr* (-2)	0.0032	
	2.9366	***			4.4554	***			6.2359	***
gb (-1)	-0.0210			*gb* (-1)	-0.0146			*gb* (-1)	-0.0405	
	-0.5847				-0.4203				-1.0040	
btr (-2)	-0.2816			*btr* (-2)	-0.2394			*btr* (-2)	-0.4236	
	-3.3284	***			-2.9832	***			-3.5955	***
R^2	0.9832			R^2	0.9869			R^2	0.982357	
Adj.R^2	0.9783			Adj.R^2	0.9830			Adj.R^2	0.97625	
LM Test	Probability			LM Test	Probability			LM Test	Probability	
lag1	0.2090				0.4291				0.9119	
lag2	0.4398				0.7240				0.9348	
lag3	0.3565				0.7245				0.6646	
lag4	0.2788				0.7107				0.2958	

Table 4 Estimation by Intrumental Variable Method

Here we estimate Equation (b), (d), (f) in Table 2 in order to confirm the robustness. The instrumental variables are defined by adding more 1 and 2 backward time lags to the explanatory variables. Comparing with the results by OLS method, there is no considerable difference with respect to signs and significance. Therefore we judge that the estimation in Table 2 has no serious correlation between independent variables and the residuals.

Dependent Variable: *i* (SELIC)
Sample: 2001M01 2003M12
White Heteroskedasticity-Consistent Standard Errors & Covariance
Method: Two-Stage Least Squares

(b')					(d')					(f')				
Instrumental variables: *i* (-2), *i* (-3), Dπ12(-1), Dπ12(-2), y(-2), *y* (-3), *sptr* (-3), *sptr* (-4), *btr* (-3), *btr* (-4)					Instrumental Variables: *i* (-2), *i* (-3), Dπ6(-1), Dπ6(-2), *y* (-2), *y* (-3), *sptr* (-3), *sptr* (-4), *btr* (-3), *btr* (-4)					Instrumental Variables: *i* (-2), *i* (-3), Dπ(-1), Dπ(-2), *y* (-2), *y* (-3), *sptr* (-3), *sptr* (-4), *btr* (-3), *btr* (-4)				
	Coeffici	t-Statisti	Prob.			Coeffici	t-Statisti	Prob.			Coefficie	t-Statisti	Prob.	
c	1.812	0.166	0.869		*c*	-2.460	-0.231	0.819		*c*	-33.678	-1.395	0.173	
i (-1)	0.827	17.073	0.000	***	*i* (-1)	0.722	15.497	0.000	***	*i* (-1)	1.033	6.063	0.000	***
$E\pi_{12}-\pi^*_{12}$	0.288	1.711	0.097	*	$E\pi_6-\pi^*_6$	0.190	3.939	0.001	***	$E\pi-\pi^*$	-0.109	-0.971	0.340	
y (-1)	0.012	0.095	0.925		*y* (-1)	0.086	0.666	0.510		*y* (-1)	0.412	1.510	0.142	
sptr (-2)	0.003	2.847	0.008	***	*sptr* (-2)	0.003	5.795	0.000	***	*sptr* (-2	0.004	7.208	0.000	***
btr (-2)	-0.304	-2.246	0.032	**	*btr* (-2)	-0.297	-3.139	0.004	***	*btr* (-2)	-0.293	-1.778	0.086	*
R^2	0.980				R^2	0.984				R^2	0.973			
Adj.R^2	0.976				Adj.R^2	0.981				Adj.R^2	0.968			