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Inflation Targeting in an Open Financially Integrated Emerging Economy: the case of Brazil[1]

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August 31, 2001

Abstract

This paper conducts a study of the pass-through from the exchange rate devaluation to inflation considering the recent change in the foreign exchange regime in Brazil. Econometric estimations were performed using the specifications of the pass-through suggested by Goldfajn and Werlang (2000). Some simulations of the augmented Taylor rule (with an added exchange rate term) have also been made to analyze the response from supply and external shocks in a simple Inflation Targeting model with trade balance equations. In contrast to Ball (2000), when the exchange rate is included in the Taylor rule, output volatility increases after a negative shock to the capital inflow.

JEL Classification Numbers: E52, E58, 9F31, F32

Keywords: Pass-through, floating exchange rate, Taylor rules

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1 - Introduction

In recent years, one can observe that an increased number of countries have adopted inflation targeting as their monetary policy regime. Even among emerging markets, this policy regime has been adopted recently in a number of countries such as Chile, Brazil, Poland, and Israel. In the opposite direction, some authors such as Calvo and Reinhart (2000) empirically conclude that emerging countries have a bias against flexible exchange rates that are an important feature of the inflation-targeting framework.

They argue that the reasons for the alleged bias against exchange-rate flexibility are in general linked to the high pass-through from the exchange rate to inflation (fear of inflation) and the financial imbalances caused by the high degree of foreign-currency indebtedness of firms in those countries (fear of floating). Ball (2000) doubts the adoption of a purely inflation-targeting framework is efficient, unless the monetary policy rule is modified in order to give some role to the exchange rate.

This paper conducts a study of the pass-through from the exchange rate devaluation to inflation considering the recent change in the foreign exchange regime in Brazil. Econometric estimations were performed using the pass-through specifications suggested by Goldfajn and Werlang (2000).

This paper also conducts simulations in a simple inflation-targeting model for Brazil that include equations for the trade balance and an augmented Taylor rule (with an added exchange rate term) as suggested by Ball (2000). Those simulations enable us to obtain the response for supply and external shocks. In contrast to Ball (2000), when the exchange rate is included, output volatility increases after a negative capital inflow shock.

The paper is organized as follows. Section 2 presents some stylized facts regarding the alleged limited flexibility of the exchange rate in emerging markets countries. Section 3 presents the econometric estimations of the pass-through for Brazil. The following section discusses a simple model with a modified Taylor Rule and an Uncovered Interest Parity rule, which depends on the trade balance surplus. Section 5 shows the simulation exercises and the last section concludes the paper.

2 – Stylized facts about the limited flexibility of the exchange rate in emerging countries

The main reasons that are usually presented as the cause of limited flexibility of exchange rate ins emerging market countries are:

- the high degree of pass-through from the exchange rate to inflation;
- the financial impact of devaluations on dollar denominated liabilities in the balance sheet of firms;
- the recessionary impact of major devaluations.

In this section we discuss each of the above arguments and use them to frame the Brazilian experience with a floating exchange rate regime.

The empirical evidence on the limited flexibility of the exchange rate in emerging countries (even in those that defined themselves as free floating) has been discussed in many papers. Calvo and Reinhart (2000) is the main reference on this matter.

Regarding the pass-through, Haussmann, Panizza and Stein (1999) present a table with the estimations of the inflation pass-through for more than 40 countries. The authors estimate a below 5% 12-months pass-through for G-7 countries, and on the other extreme, countries like Mexico, Paraguai and Poland have a pass-through higher than 50%.

According to Goldfajn and Werlang (2000), the reasons for the low pass-through in the Brazilian January/1999 episode are: (a) the recessionary environment in the period, that unable the firms to increase the prices after the devaluation (b) a perceived overvalued exchange rate before floating, that allows a correction in the ratio of tradeable and non-tradable without a generalized increase in prices and (c) a low initial inflation in 1998. For these reasons, the pass-through indeed was very low in this single episode, but there is no guarantee that this will be the average pass-through for the Brazilian economy. In other phases of the business cycle and with the exchange rate closer to the equilibrium level, the pass-through might be higher. The next section presents some estimations for the pass-through in Brazil.

The second negative consequence of extreme volatility of the exchange rate in emerging markets is the occurrence of financial crises caused by the dollar denominated liabilities of firms. Haussmann, Panizza and Stein (2000) argued that:

> *"Central Banks of countries unable to borrow in their own currency will internalize the potential impact of a depreciation due to currency mismatches when carrying out exchange rate and monetary policy."*

Those mismatches are even more dramatic in a financially integrated world, where any rumor of financial problems can generate capital flight that might produce self-fulfilling crises.

The third undesirable impact of the devaluations is the resulting recession. Calvo and Reinhart (2000) show that there is no evidence of expansionary effects of devaluation even in developed economies, anyway the drop in GDP growth is higher in emerging countries than in developed ones. Rodrik (2000) found that:

> *"There is every reason to think that these real depreciations were an important boost to economic activity, particularly in tradables, and not simply something that went alongside higher growth. They unleashed entrepreneuarial energies and focused them on world markets, boosted exports, and set the stage for economic transformations"*

Goldfajn and Olivares (2001) also contributed to the debate about the choice of exchange regime. They gathered stylized facts as following:

> *"developing countries prefer to allow a higher volatility of reserves and interest rates in exchange for a lower volatility on their exchange rate. (..) Second, the sensitivity of domestic interest rates to the international interest rate is higher under fixed exchange regimes than under floating regimes. Finally, devaluation seems to be more contractionary in developing countries, but limited to currency crisis periods and in the very short run."*

They also concluded using a panel that countries more integrated to the international financial markets and with a weaker current account position are less able to use the exchange rate to respond to external shocks.

Analyzing these stylized facts in regard to the Brazilian recent floating experience, we want to show that exchange rate flexibility is not a major concern for Brazilian policymakers. However, a more careful analysis of the impact of the devaluation on the inflation rate is required including also the exchange rate as a policy instrument. The next section presents some empirical evidence of the pass-through in Brazil, and after that, a model including the exchange rate in the Taylor rule and uncovered interest parity depending upon which fundamentals are presented.

3 – Pass-through in Brazil: empirical evidence

All the econometric estimates for the Brazilian experience are based on two equations presented in Goldfajn and Werlang (2000). Two samples were used and forward-looking terms and instrumental variables were also added to the specifications. In order to choose the best results, some in-and-out-of-sample tests were performed.

The first equation is a standard Phillips curve equation, adding a term for the real exchange rate gap and also for the degree of openness of the economy in the standard Phillips curve:

$$\pi_{t,t+j} = \beta_0 + \beta_1(e_t - e_{t-1}) + \beta_2 RER_{t-1} + \beta_3 h_{t-1} + \beta_4 \pi_{t-1} + \beta_5 OPE_{t-1} + u_t \qquad (1)$$

where h is the output gap measured as GDP minus a linear trend, RER is the real exchange rate gap and OPE is the degree of openness of the economy. The real exchange rate gap is the percentage difference between the actual real exchange rate[3] and a Hodrick-Prescott filter of the real exchange rate. The degree of openness is the ratio of the sum of import and export to GDP.

Table 1 presents the results for the 1980-2000 period (column (3)), as well as for the shorter 1995-2000 period (columns (1) and (2)), considering quarterly data. For the expanded sample the dependent variable is the first difference in the inflation rate. The

[3] The real exchange rate is the price of one dollar in local currency deflated by domestic CPI and US PPI.

presence of unit roots in levels drove us to the first difference world. Also, many dummy variables were necessary for the breaks caused by failed stabilization plans in the late eighties and early nineties. For each sample period, a forward-looking term was also included to cover for inflation expectations (columns (2), (3)). There are many alternatives for modeling expectations. The chosen alternative is the actual inflation rate with a one-period lead as the forward-looking term. This means that economic agents have perfect foresight. When the forward-looking term is used, there is certainly correlation with the error term, so it is important to use instrumental variables to correct it. However the estimated coefficients were not significant so they are not reported here.

Table 1
Linear Phillips

Coefficients	Short Sample /1 without forward-looking (1)	Short Sample with forward-looking (2)	Long Sample /2 with forward-looking (3)
Dependent variable	inf	inf	d(inf)
constant	0.02	0.02	0.005
/3	(2.93)	(2.48)	(0.45)
pass-though	0.10	0.09	0.11
	(3.25)	(3.00)	(3.77)
RER gap	0.03	0.02	0.05
	(1.40)	(1.30)	(0.78)
output gap	0.42	0.40	0.35
	(3.36)	(3.04)	(1.93)
backward inf.	0.34	0.27	-0.03
	(2.35)	(1.68)	(-0.69)
forward inf.		0.14	0.36
		(0.78)	(5.24)
R^2	0.717	0.727	0.944

/1Sample from 1995:1 to 2000:4
/2Expanded sample from 1980:2 to 2000:4
/3 t statistics in parentheses

The pass-through coefficients are robust for all specifications and only in the instrumental variables alternative not significant. The contemporaneous value is around 10% and is comparable to the Goldfajn and Werlang (2000) estimate for the 3-month pass-through. However, it is smaller than the 19.9% value for the America region and similar to the European number. The same occurs with the output gap variable, only the IV estimations are not significant. The fixed effects accumulated in 6 months for emerging markets found by Goldfajn and Werlang (2000) are significantly (0.015) smaller than reported here (around 0.4). The deviation of the real exchange rate from its equilibrium is not significant in any model. The same thing happened with the degree of openness that is not reported in Table 1. The forward-looking inflation term is only significant for the case of the long sample (column 3).

The second equation presented in Goldfajn and Werlang (2000) is a non-linear equation. As explained above, the pass-through is positively related to the output gap, the initial inflation rate and the degree of openness and with the real exchange rate misalignment from its equilibrium.

$$\pi_{t,t+j} = \beta_0 + \beta_1(e_t - e_{t-1}) + \beta_2 RER_{t-1} + \beta_3 h_{t-1} + \beta_4 \pi_{t-1} + \beta_5 OPE_{t-1} + u_t \qquad (2)$$

where $\beta_1 = \beta_6 + \beta_7 RER_{t-1} + \beta_8 h_{t-1} + \beta_9 \pi_{t-1} + \beta_{10} OPE_{t-1}$

Table 2 contains the results for the non-linear equation. The two first columns (4) and (5) are for the shorter period, while for the last column (6) the sample starts in 1980. Columns (5) and (6) contain a forward-looking term. In the non-linear Phillips curve, instrumental variables were not considered. The coefficient for the initial inflation was not significant in any specification and the coefficient for the real exchange rate gap was only significant for the longer sample. Specifications (4) and (5) did present individual coefficients for the pass-through significant at conventional levels. The constant terms inside the pass-through (β_6) in Table 2 (columns (4) and (5)) are very high compared to the ones reported in Table 1. The output gap* $(e_t - e_{t-1})$ is significant only in (4) and does not have the expected sign. In specification (5) and (6) these coefficients move in the expected direction and are similar in value. In the recession phase of the business cycle the pass-through is smaller and then the sign should have been positive. The sign and the magnitude[4] of the real exchange rate gap in the shorter sample specifications are not in line with Goldfajn and Werlang (2000). The intuition behind this is that because exchange was overvalued (meaning a negative RER) in the fixed period (1995-1998), and the pass-through was also very high in this period, explaining the negative sign. Although being statistically different from zero at the 10% level in specification (4), the sign of the cross term $OPE * (e_t - e_{t-1})$ is not correct.

[4] The value of the cross term RER*Ê after 12 months in Goldfajn and Werlang (2000) is 0.67 and highly significant.

Table 2
Non-Linear Phillips

Coefficients	Short Sample /1 without forward-looking (4)	Short Sample with forward-looking (5)	Long Sample /2 with forward-looking (6)
Dependent variable	inf	inf	d(inf)
constant	-0.03		0.013
/3	(-1.29)		(1.03)
RER gap	0.00	0.03	0.24
	(0.25)	(1.99)	(3.13)
output gap	0.28	0.24	0.48
	(2.39)	(3.12)	(1.8)
backward inf.	0.49	0.24	0.05
	(4.28)	(1.50)	(1.51)
forward inf.		0.96	0.07
		(3.48)	(1.52)
constant pass-through	0.24	0.12	0.55
	(2.04)	(1.85)	(3.17)
RER*($e-e_{t-1}$)	-0.56	-0.12	-0.01
	(-1.26)	(-0.55)	(-4.63)
output gap*($e-e_{t-1}$)	-0.01	0.01	0.02
	(-1.99)	(2.36)	(2.92)
open*($e-e_{t-1}$)	0.21	-	0.02
	(1.93)	-	(-1.5)
R^2	0.860	0.820	0.954

/1 Sample from 1995:1 to 2001:1
/2Sample from 1980:2 to 2000:4
/3 t statistics in parentheses

Table 3 presents in-sample and out-of-sample performance tests for the six different specifications. The first two columns are the out-of-sample sum of squared errors (SQE) from 1998:1 to 2000:4. The first is the average of the one to four-steps ahead forecast compared to the actual inflation outcome and the second is only the one-step ahead forecast. For the average of 4 periods ahead the most robust results are by far the long-sample-non-linear model but it also has the worst in-sample SQE result. The short non-linear models have confusing SQE results. The non-linear model without forward-looking expectations has a very good one step ahead SQE result but the worst in the 4 periods ahead SQE. The in-sample test presents the same result but with much smaller errors, due to the huge difference in the forecast of the first quarter of 1999, when the floatation occurred. As an example, if we do not account for the devaluation outcome, using the data until 1998, the forecast for all short-sample linear models are around 20% in comparison with an actual inflation of 2.89% for the period. The unique exception for the out-of-sample forecast is again the long run linear model with a forward-looking term, and two of the non-linear models but the results for third one diverge completely. However all models present good results for the in sample forecast in this quarter.

Table 3
Performance of Different Specifications

Models		Sum of Squared Error out of sample 1 to 4 periods ahead	Sum of Squared Error out of sample 1 period ahead	Sum of Squared Error in sample	Forecast out-sample /1 1999:1	Forecast in sample 1999:1
Linear						
Short Sample						
without forward	(1)	367.67	320.31	10.62	21.13	2.75
with forward	(2)	343.67	251.45	9.68	20.56	2.70
Long						
with forward	(3)	42.45	51.31	73.37	1.16	2.37
Non Linear						
Short						
without forward	(4)	14066.69	9.48	12.42	2.84	2.54
with forward	(5)	4776.48	7.73	10.85	2.83	2.80
Long						
with forward	(6)	18.37	21.57	91.34	2.76	2.86

/1 occured inflation in 1999:1 was 2.83%

Table 4 shows the evolution of the pass-through when the sample is expanded. Before 1999:1, the contemporaneous pass-through coefficient is higher than 50% for the short-sample specifications. This is the explanation for the enormous out-of sample forecast. After the floating the pass-through reduces steadily for the first two columns. The same break did not occur in the long sample model. When the pass-through is corrected for the first difference in inflation it is steady around 8% in during all the period.

Table 4
Pass-Through Adjustments

Period	Short Sample without forward-looking (1)	Short Sample with forward-looking (2)	Long Sample with forward-looking (3)
1998-I	0.6505	0.6595	0.1109
II	0.6304	0.6202	0.1107
III	0.4924	0.4821	0.1111
IV	0.5615	0.5008	0.1101
1999-I	0.1143	0.1094	0.1096
II	0.1134	0.1091	0.1124
III	0.1164	0.1102	0.1114
IV	0.1156	0.1107	0.1068
2000-I	0.1050	0.1000	0.1060
II	0.1048	0.1018	0.1073
III	0.1048	0.1018	0.1038
IV	0.0969	0.0922	0.1056

Table 5
Pass-Through Comparison

Months	Short Sample with forward-looking	Long Sample with forward-looking	Goldfajn&Werlang Panel for Americas
	(2)	(4)	
3 months	0.123	0.117	0.20
6 months	0.131	0.228	0.53
after 1 year	0.134	0.441	0.69
18 months	0.134	0.642	1.24

Table 5 presents the accumulated pass-through for the specifications (2) and (3). Since the estimations in this paper are based on quarterly data, the pass-through after 3 months is almost the contemporaneous pass-through. It is corrected by the backward and forward-looking inflation coefficients. When the long run neutrality of the nominal terms on the Phillips curve is imposed, as is explained in the next section, estimates (2) have a greater accumulated pass-through similar to (3) and compatible with the estimations of Goldfajn and Werlang (2000) for American countries.

In the simulation part of the paper, the chosen specifications were number (2) (the short sample linear model with forward looking expectations), which is the most standard, but with the long run rigidity in nominal variables as explained below and also number 5, which has the coefficient for the cross term output gap and exchange rate difference with the expected sign.

4 – A simple model with trade balance

In order to test for the role of the exchange rate as part of the monetary policy rule, we have to present a complete small inflation-targeting model, which includes an equilibrium condition for the external sector in order to define the exchange rate behavior.

The IS equation is very simple. The aggregate demand only depends on itself with a lag, on the lagged real interest rate and on the real exchange rate.

$$h_{t+1} = a_{10} + a_{11}h_t + a_{12}(i_t - \pi_t) + a_{13}\theta_t + u_t \qquad (3)$$

Where h is the log of the output gap, θ is the real exchange rate, i is the nominal interest rate, π is consumer price inflation, and u is the demand disturbance.

The Phillips equation is compatible with any open economy Keynesian model with the restriction of long-term nominal neutrality, which means a vertical Phillips equation in the long run. The econometric estimations in the previous section have not included this restriction in order to be comparable with Goldfajn and Werlang (2000). This restriction implies that the coefficients associated with the nominal variables should sum up to 1.

$$\pi_t = a_{21}\pi_{t-1} + (1 - a_{21} - a_{22})\pi_{t+1} + a_{22}(e_t - e_{t-1}) + a_{24}h_{t-1} + \varepsilon_t \qquad (4)$$

Where ε is the aggregate supply disturbance and $(e_t - e_{t-1})$ is the first difference of nominal exchange rate.

Neither the coefficients for IS equation nor the Phillips curve are presented. Those are estimated but they are not revealed because similar ones are used in the Central Bank forecast presented in the Inflation Report.

The next equation is a Taylor Rule. However, following Ball (2000) and Mishkin (2000), we add an exchange rate term to the standard rule. In his paper *Policy Rules and External Shocks* Ball reckons that policy rules used in closed economies do not fit well for countries that are more sensitive to external shocks. In open economies, such rules should be modified to include the exchange rate. Hence, he suggested a modification in the Taylor rule so that the exchange rate is also included as an instrument in the left-hand side, which is called the Monetary Condition Index (MCI). He presents a very simplified model similar in many ways with the model that is presented in this section.

Ball (2000) in page 12 obtained the following result that we will test for the Brazilian case:

> *"When there is a shock to net foreign investment, an MCI target keeps output more stable than an interest-rate target."*

The rationale is that when the interest rate is kept constant there is a major devaluation of the exchange rate, which raises aggregate output. On the other hand, when the MCI is held constant, there is a smaller devaluation associated with a rise in the interest rate, with opposite effects on aggregate output that might be held constant.

Ball concludes that "*stability is also enhanced by including the exchange rate in policy reaction function".*

In his recent paper *Mishkin (2000):*

> "*also reinforces the importance of the exchange rate in inflation targeting for emerging countries.*

The author suggests:

> *"that emerging market countries cannot afford to ignore the exchange rate when conducting monetary policy under inflation targeting, but the role they ascribe to is should be clearly subordinated to the inflation objective. It also suggests that inflation targeting in partially dollarized economies may not be viable unless there are stringent prudential regulations on, and strict supervision of, financial institutions that ensure that the system is capable of withstanding exchange rate shocks".*

If Central Banks are willing to respond strongly to defend the exchange rate, this might hurt the credibility of the monetary policy as the public perceives that protecting the exchange rate is more important than assuring price stability.

The conclusion of the author is that

> *"One possible way to avoid this problem is for inflation-targeting central banks in emerging market countries to adopt a transparent policy of smoothing short-run exchange-rate fluctuations that helps mitigate potentially destabilizing effects of abrupt exchange rate changes while making it clear to the public that they will allow exchange rates to reach their market-determined level over longer horizons."*

Hence, there are two instruments in order to reduce inflation rate and the output gap. We are considering that an appreciation will reduce inflation and the output gap, so the second term of the left-hand side of the equation is negative. We are also considering in the rule the first difference of the nominal exchange rate instead of its level. Therefore, the augmented Taylor rule is:

$$\omega i_t - (1-\omega)e_t = a_{30} + a_{31}(\pi_{t-1} - \pi^*_{t-1}) + a_{32}h_{t-1} + a_{33}i_{t-1} \tag{5}$$

When ω is set equal to one, it is again a standard Taylor rule.

The determination of exchange rate is based on the UIP with fundamentals, in line with Muinhos, Freitas and Araujo (2000), as stated in equation (6). In order to estimate the exchange rate path, however, it is necessary to anchor the exchange rate at some point in the future. An alternative to achieve this result is to assume that at period $t+K$ the nominal exchange rate will be consistent with a constant current account/GDP ratio. For each period between t and $t+K$, the nominal exchange rate will move according to the interest rate differential corrected by the risk premium, as predicted by the UIP hypothesis. Therefore, the following 2 equations determine the exchange rate path:

$$E_t e_{t+n} = -\sum_{j=n}^{K-1} E_t(i_{t+j} - i^*_{t+j} - x_{t+j}) + E_t e_{t+K}\text{ , for } n < \text{k} \tag{6}$$

$$E_t e_{t+K} = \theta_{t+K} - p^f_{t+K} + p_{t+K} \tag{7}$$

where θ is the expected real exchange rate compatible with a constant current account/GDP ratio in the medium run, and x_t is an exogenous risk premium that follows an AR(1) process.

The equilibrium equation is:

$$(BS + BC)/y = b$$

where BS is the balance of services surplus in real terms, BC is the trade balance surplus in real terms y is the real GDP and b is a arbitrary current account/GDP equilibrium ratio, that represents a net capital flow consistent with an equilibrium scenario for the capital account. This ratio b is a source of external shock, representing different international finance liquidity conditions as presented in the simulations. *BS* is an exogenous variable and *BC* is determined by:

$$BC = \sum_{j=1}^{2} \alpha_j Q_j(y,\theta) P_j \qquad (9)^5$$

Where *Pj* is the price index vector for exported and imported goods. Qj is the quantitative index for exported and imported goods, which depends on the output gap and the real exchange rate, αs are the weights to transform the indexes in US$ terms.

All the estimates are done using quarterly data with the sample period initiating in 1980. We will report here only the coefficients for the trade balance.

The quantitative index for exports is estimated in level, because we could reject the unit root for the series. The estimated equation for exports including the t-statistics in parentheses is:

$$\exp_t = \underset{(-4,31)}{-2,56} + \underset{(8,85)}{0,61}\exp_{t-1} + \underset{(5,63)}{0,29}\, y_t^* + \underset{(3,56)}{0,26}\,\theta_t + seasonaldummies - \underset{(-6,13)}{0,48}\, dCruzado \quad (10)$$

Where y_t^* is the world GDP measure as the log of the world's import quantitative index. The sample for the above equation comprises the 1991 to 2000 period. We used instrumental variables to avoid correlation between the contemporaneous regressors and the residual. All other information is in the Annex.

When a unit root test is conducted in the import qualitative quantum index, the null of unit root cannot be rejected. However it is clear that a structural break happened in the early 1990's. If a dummy variable is inserted in the unit root test, one can reject the unit root hypothesis. Hence the estimated equation for imports is:

$$imp_t = \underset{(0,56)}{0.34} + \underset{(13,72)}{0.78}\, imp_{t-1} + \underset{(2,13)}{0.23}\, y_t - \underset{(-2,81)}{0.16}\,\theta_t + seasonaldummies + \underset{(3.48)}{0.30}\, dCruzado + \underset{2.85}{.0.22}\, d1993 \quad (11)$$

where d1993 is a dummy that is zero until 1993:3, 0.5 from then to 1994:3 and one afterwards.

5 – Simulation results

For the simulation, the two specifications of the Phillips curve were used: number (2) and number (5). Both are with a forward-looking term for inflation and with the shorter sample.

[5] where $e^v = [e^{v_1} \quad e^{v_2} \quad \ldots \quad e^{v_N}]$ with $v = [v_1 \quad v_2 \quad \ldots \quad v_N]$

For the Phillips equation (2), two types of shocks were tested. The first is to the current account. Three scenarios were considered. The basic one supposes that at the end of 2002 the current account deficit/GDP ratio (net capital flow) will reach 4%. The most favorable scenario assumes an improvement in external financial conditions, enabling the financing of a 5% of GDP deficit on the same date. The worst scenario anticipates a tightening in the international environment, with only a current account deficit of 3% of GDP being sustainable.

The second type is a supply shock, represented by a 1% increase in the inflation rate not caused by demand or exchange rate conditions. This shock could be triggered, for instance, by an increase in the government-managed prices such as energy or gas.

Figure 1 shows the three scenarios for net capital flow. When there is a tightening in the financial markets, the exchange rate has to be devalued to assure a correction in the trade balance to offset the capital shock. This movement increases inflation and so the interest rate reacts to correct the deviation of inflation from the target.

Figure 2 presents the two Taylor rule alternatives when the economy is subject to an external constraint (net capital flow bellow 3% of GDP). In the first alternative no weight is given to the exchange rate. In the second alternative, the parameter ω is 0.85, meaning that the exchange rate is also used as a monetary policy instrument (the so called Monetary Index Condition (MCI)). The benchmark is a scenario with no external shocks nor any value for the exchange rate in the Taylor Rule. After the shock, the exchange rate and the inflation rate increase less than when the exchange rate is taken into account as a monetary instrument. But the sharp increase in the interest rate results in larger output volatility. The trade balance does not present major differences in comparison to the benchmark; if the exchange rate is less depreciated, a smaller output gap offsets in part the exchange rate behavior. The intuition from Ball (2000) does not work in the case of Brazil, because the coefficient for exchange rate in the IS curve is very small. So the exchange rate's devaluation impact on GDP does not offset the impact of the higher interest rate.

Figure 3 shows the short sample Phillips curve hit by a supply shock in the third quarter of 2001 and no shocks in the external front. One can see the nominal interest rate reacting to the increase in inflation. For the longer sample the reaction is the same. When the augmented Taylor Rule is considered, the output gap suffers more due to the hike in the interest rate compared to the case of the absence of exchange rate in the Taylor rule. This result is robust for other exchange rate forecast rules. This result is robust even when one uses a first difference UIP to forecast the exchange rate[6]. Also in this case output gap suffers more with the MCI.

[6] See Bogdanski ei alli (2000) to an explanation of the D(UIP).

Figure 4 compares the two specifications of the Phillips equation. For the same external equilibrium (a net capital flow of 4% GDP), the non linear Phillips curve brings about higher inflation, exchange rate and interest rate and a smaller output gap result. This results if due to the positive coefficient of the cross term output gap and exchange rate first difference, brings higher inflation pass-through in the expansionary phase of the business cycle.

Figure 5 shows how the standard Taylor Rule and the MCI index works for the non-linear Phillips curve under an external shock. The behavior shows the same pattern as in the linear version (Figure2), with a sharper increase in the interest rate and a smoother exchange rate with the MCI rule but with a greater sacrifice ratio.

One can conclude that when the model is hit by a external shock, a pure Taylor rule will allow a major depreciation and according to Ball, it would increase output, but our model presented more stable output. When a MCI is considered the nominal exchange rate did not depreciate as much but the model suggested a decrease in output in opposite to Ball's suggestion of a more stable output.

6 – Final remarks

Even considering that exchange rate devaluations in emerging economies may cause high pass-through, financial instability and sluggish output recoveries, these stylized facts have not been observed in Brazil recently, at least as the high pass-through. These results presented for Brazil show a smaller pass-through than found by Goldfajn and Werlang (2000) for other American countries.

The non-linear Phillips curve with no forward-looking term does not fit well for the Brazilian data, but the other two with the forward term present consistent results for the two different sample periods. The linear models bring about a major break in the 1999 floating episode what would suggest caution by using those for forecasting purpose.

In addition to the fact that some degree of exchange rate devaluation may be well absorbed in the Brazilian economy due to the low pass-through, the introduction of the exchange rate as a monetary policy instrument does not produce lower volatility results in response to external or supply shocks, regardless of using the linear or non-linear specification of the Phillips curve.

In the fixed exchange rate regime the entire burden of the shock adjustment is borne by the interest rate. Increasing the volatility of the exchange rate in order to decrease the volatility of the interest rate may be better for the economy.

Why not allow the exchange rate volatility?

- fear of inflation – the results in this paper showed us that Brazilian pass-through has been very low;
- fear of floating – the recent experience proved to us that the balance sheet effects were not so large that they could be safety absorbed in 1999;
- fear of output volatility – the effect of real exchange rate on IS curve was also very small.

The simulations results show that it is better to use a Taylor rule allowing the exchange rate to float using the interest rate only to control inflation.

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Figure 1
Three Scenarios for Net Capital Flow (Linear)

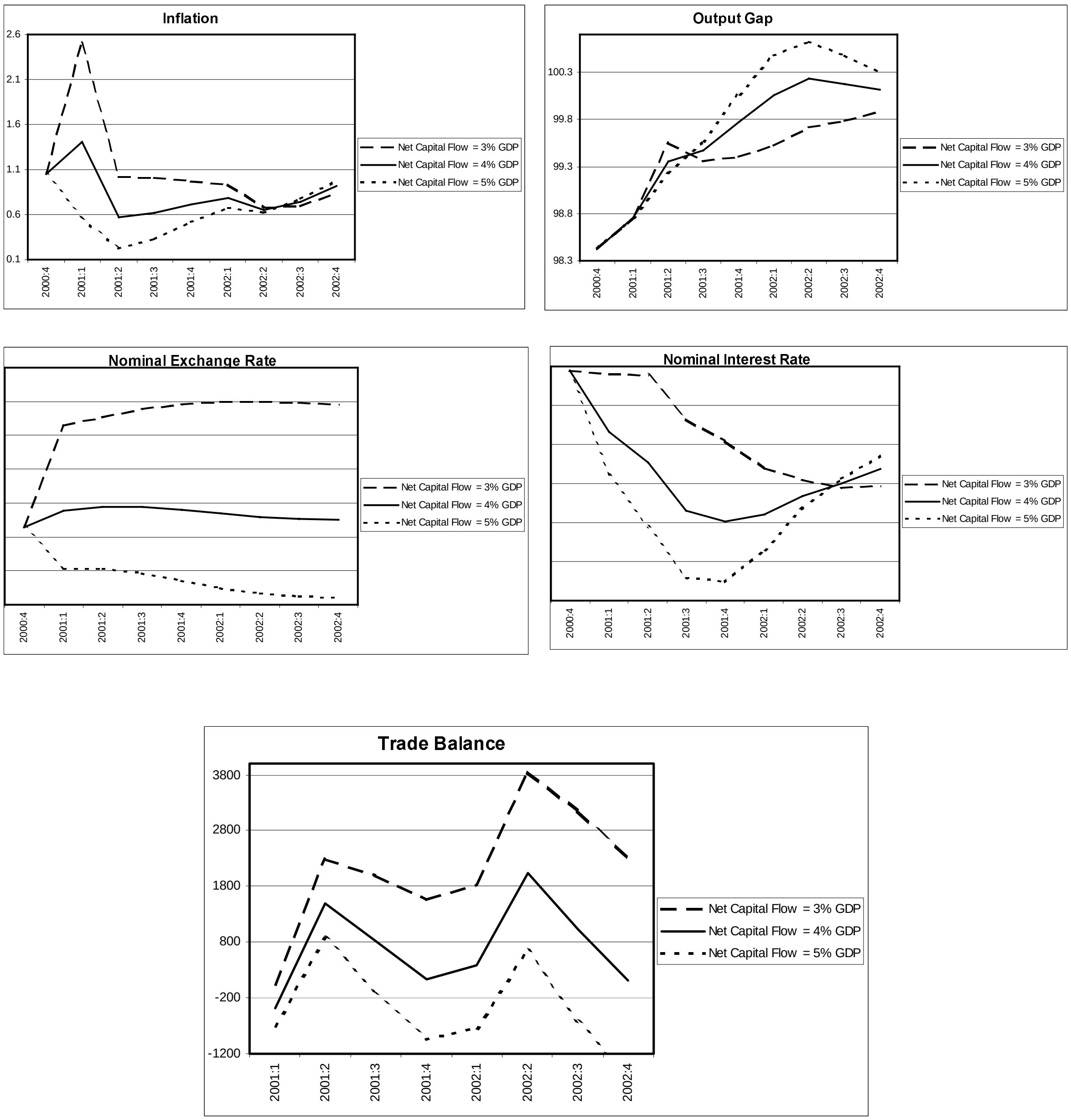


Figure 2
Taylor Rule, MCI and External Shock (Linear)

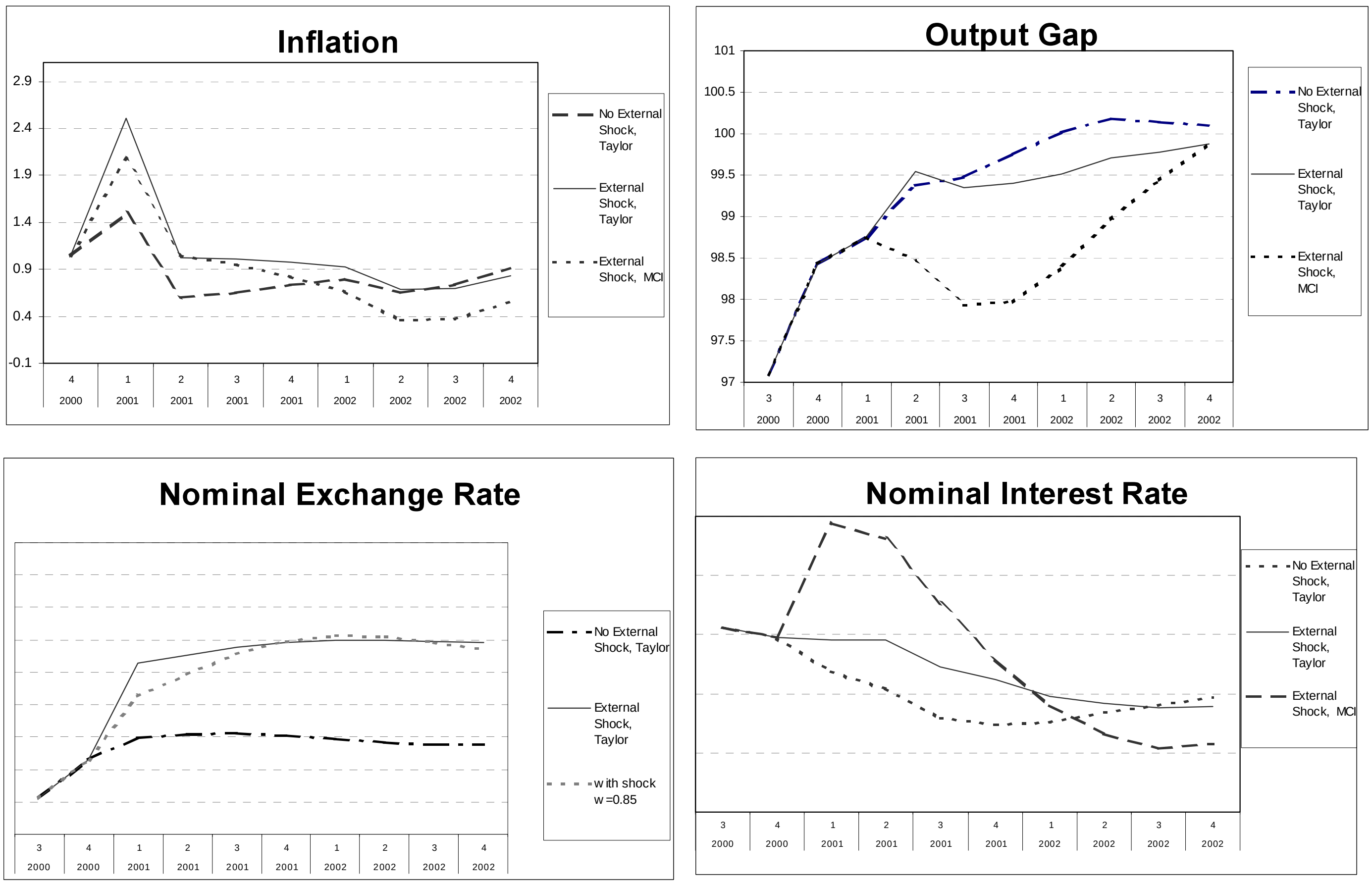


Figure 3
Taylor Rule, MCI and Supply Shock (Linear)

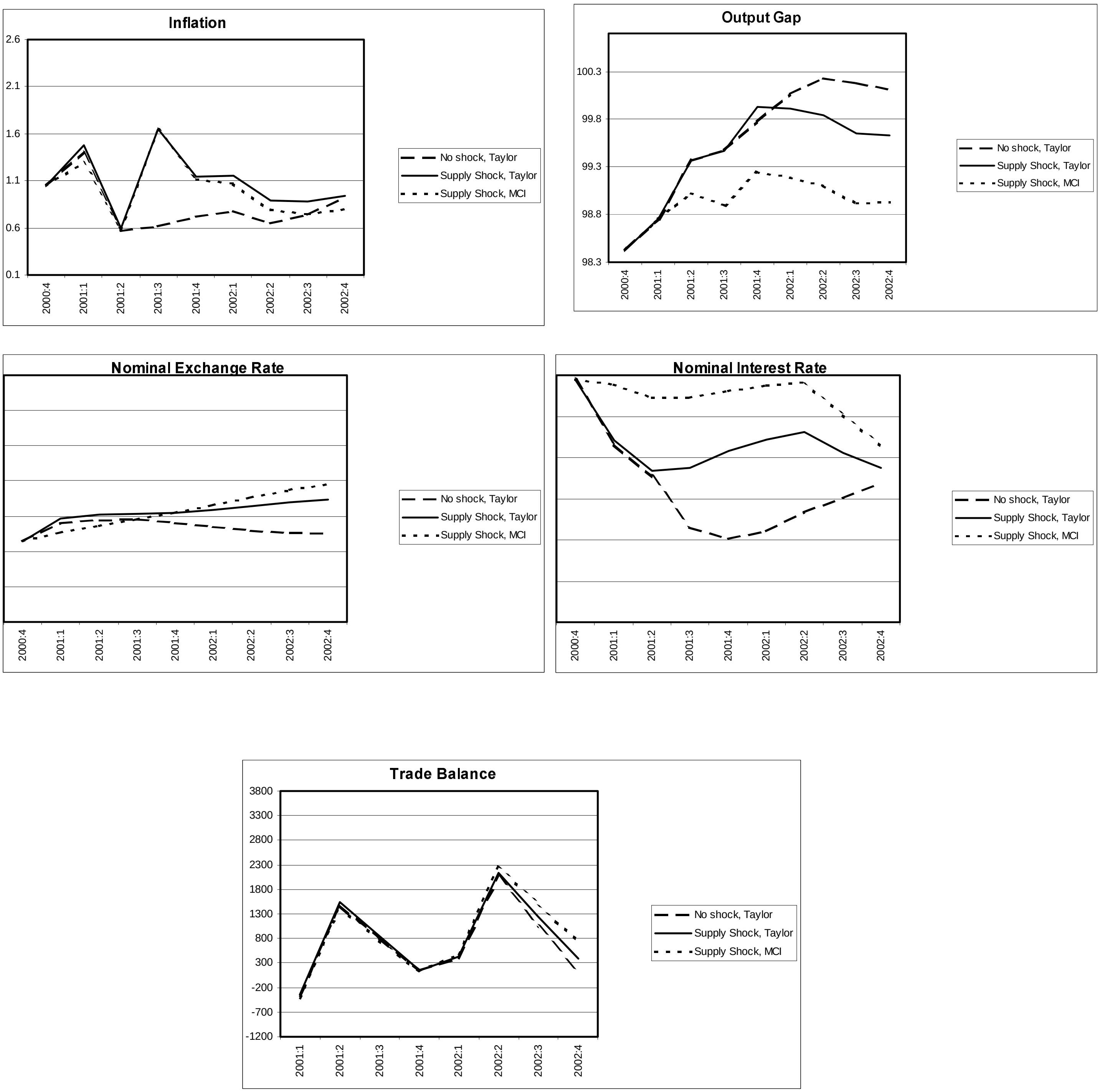


Figure 4
Linear and Non Linear Phillips Equation

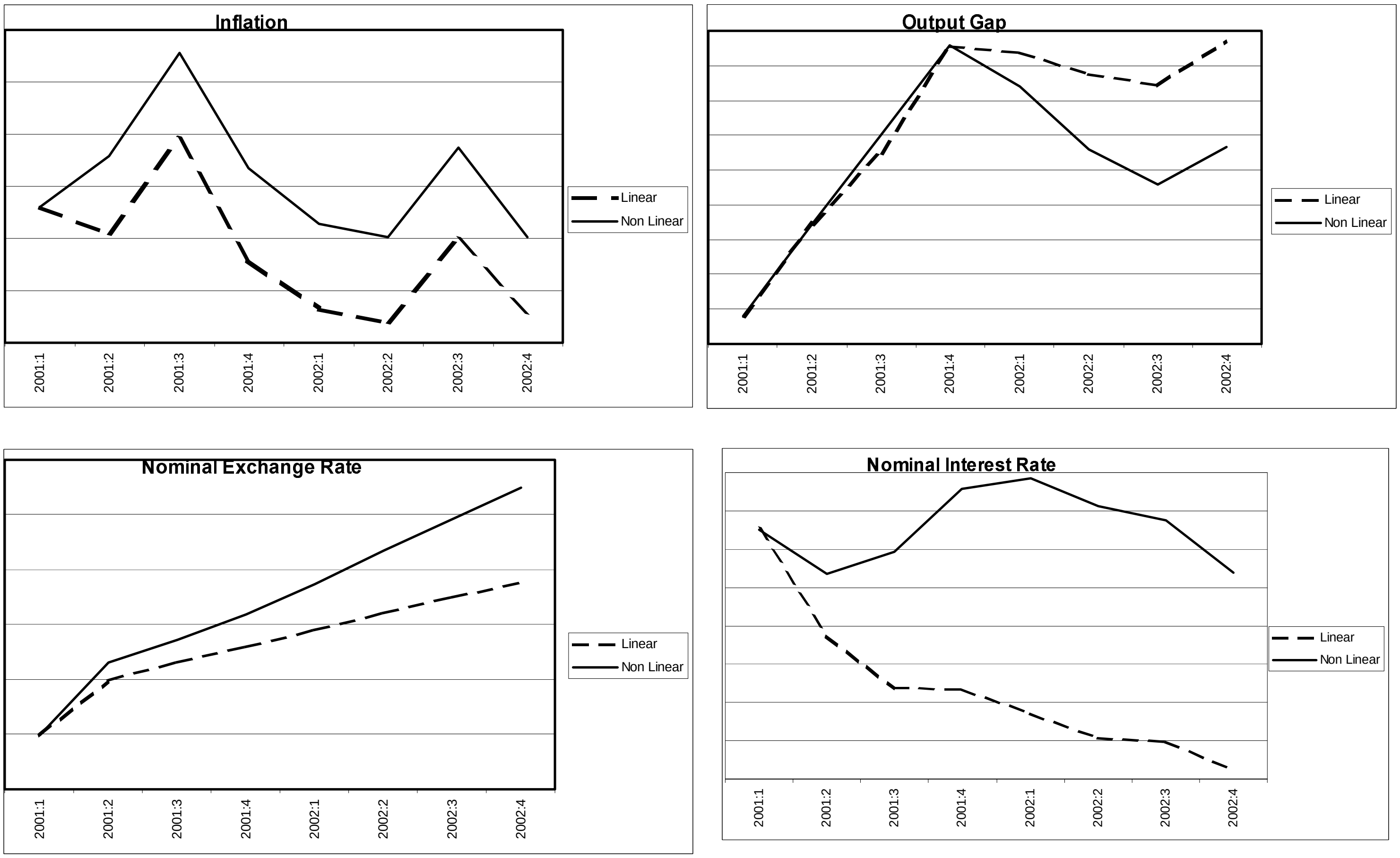
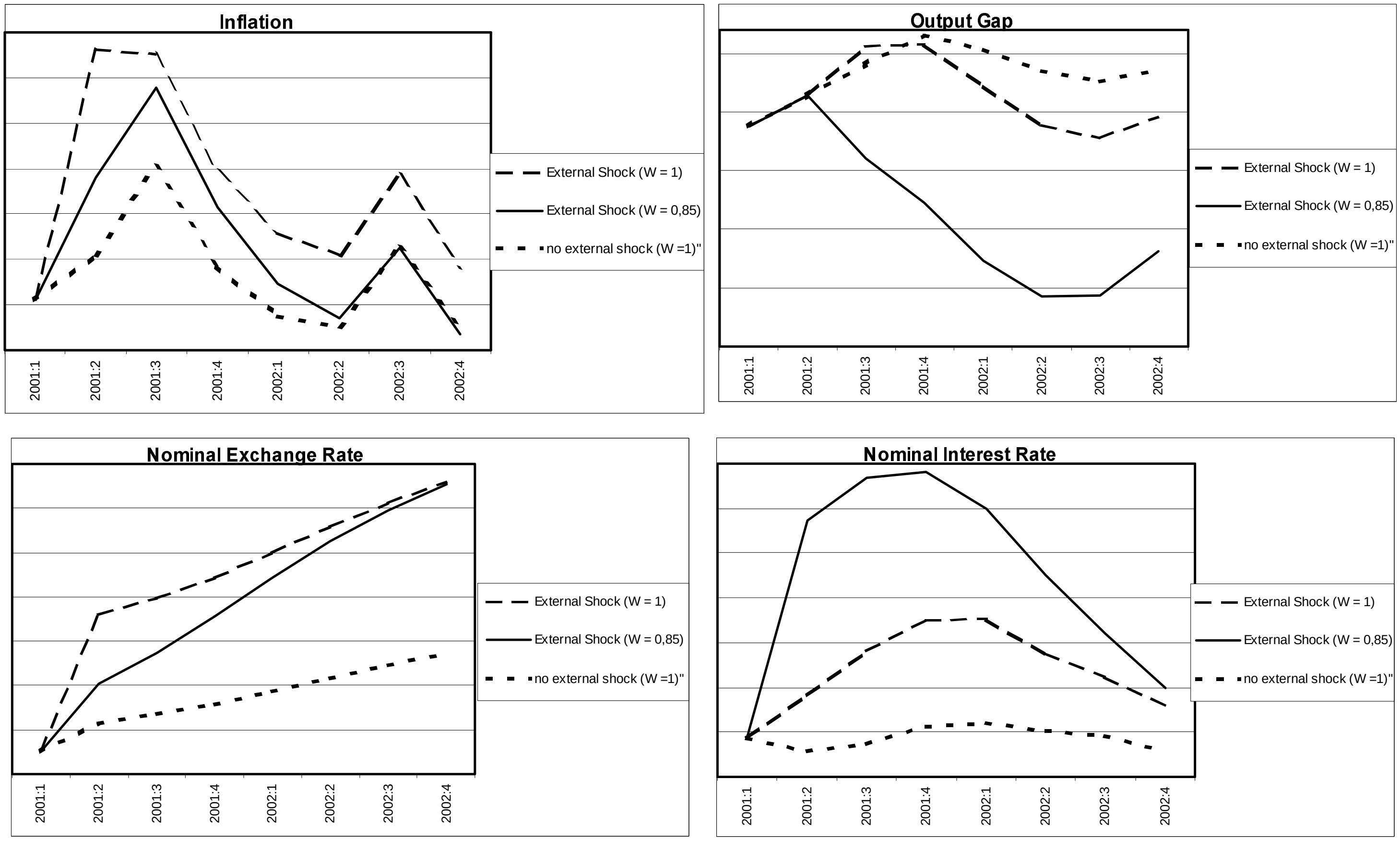


Figure 5
Taylor Rule, MCI and External Shock (Non linear)



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