ABSTRACT

Title of Dissertation: DOES THE EXCHANGE RATE MATTER FOR MONETARY POLICY UNDER INFLATION TARGETING? EVIDENCE FROM MEXICO, NEW ZEALAND AND CANADA

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Recently, many developed and developing countries have adopted inflation targeting as the monetary policy framework. There is large debate regarding the importance of external variables, such as the exchange rate, for monetary policy decisions under this framework, particularly in small open economies. In the first chapter I explore the extent to which the adoption of an explicit inflation target in Mexico can be associated to a *de facto* change in the behavior of the central bank in terms of how it responds to changes in the exchange rate and other external variables, along with conventional variables considered relevant for monetary policy. The results

indicate the presence of a change in the behavior of the central bank in Mexico associated to the adoption of an explicit inflation target in January of 1999. Variables such as policy credibility and the output gap tend to become more important for monetary policy, while the exchange rate becomes relatively less relevant when the inflation target is in operation. As compared to the cases of New Zealand and Canada - two small open economies that have successfully followed this policy prescription - the results suggest that monetary policy implementation in Mexico has become much more like in those countries.

In the second chapter I present a modified version of Drazen and Masson (1994), where instead of assuming exogenous unemployment persistence, an endogenous externality from choosing positive inflation is imposed on unemployment. In face of an adverse shock to unemployment, a policymaker that generates surprise inflation to offset such shock will generate a negative spillover that will translate into future higher unemployment. The result is that this constitutes an additional channel for commitment to zero inflation other than the signaling/reputation channel. This modification may contribute to explain, on the one hand, why a policymaker that is highly committed to lower inflation may still inflate under extreme circumstances, and, on the other, why the central bank in countries like Mexico, where credibility may still be an issue, continue to follow a stringent monetary policy at a cost of "sluggish" economic growth.

DOES THE EXCHANGE RATE MATTER FOR MONETARY POLICY UNDER INFLATION TARGETING? EVIDENCE FROM MEXICO, NEW ZEALAND AND CANADA

by

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Dissertation submitted to the Faculty of the Graduate School of the
University of Maryland, College Park in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy
2003

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To Danielle Ann

"here comes the sun, little darling…"

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"…while monetary policy makes progress as a science, it is still something of a black art…"

Donald Brash[1]

Chapter 1. Determinants of the Monetary Policy Rule in Mexico from 1996 to 2001.

1.1. Introduction.

During the past decade, many countries followed New Zealand in establishing an explicit inflation target as their monetary policy objective. The reasons that led these countries to adopt inflation targets and the circumstances that prevailed at the moment of its adoption were quite different among them, but the goal was basically the same: to keep inflation rates low. Canada for example, adopted an inflation target after completing relatively successful disinflation program, while the United Kingdom adopted this policy after facing the collapse of its exchange rate regime. More recently, some developing countries such as Mexico and Chile in Latin America, Israel and Turkey in the Middle East and Thailand in Asia, have also adopted inflation targeting. In Mexico and Thailand, inflation targets were adopted after the collapse of predetermined exchange rates as nominal anchors under relatively unstable conditions. Conversely, in Israel and Chile inflation targets were adopted under relative stability, and in conjunction with a predetermined exchange rate regime rather than instead of it.

While most of the theoretical and empirical literature on inflation targeting focuses largely on closed economies where only conventional variables such as the output gap and the deviations of observed inflation from a specific target are considered explicitly for monetary policy while exchange rates and other external

[1] Address to the Institute for International Economic Studies, Stockholm, June 1998.

factors have a secondary role or are even fully ignored,[2] a more recent line of research explicitly considers the role of these variables for monetary policy decisions.[3] This research provides a formal background to the idea that changes in the exchange rate and other external variables are relevant for monetary policy decisions in the context of an optimizing monetary authority with an inflation target as one of its policy objectives, since it incorporates the idea that economies are open with free capital mobility, where the exchange rate is key to the transmission mechanism of monetary policy, giving a role to external variables.

An interesting point in this literature is that it has identified three key conditions for inflation targeting to be successful not only in reducing inflation, but also in reducing variations of inflation and output from some specific levels. These conditions are: the announcement of an inflation target; the need for a monetary policy rule; and the achievement of exchange rate flexibility. The relevance of the first condition is reflected on the fact that many countries follow explicit inflation targets, and that central banks convey their goals to the public in a relatively clear and informative fashion through periodic monetary policy reports where they explain the events that lead them to take specific paths of action. With respect to the second condition, it has been somewhat established that the rule should fulfill conditions of operationality, simplicity, feasibility and others, and should provide guidance for monetary policy

[2] See Taylor (1999), Bernanke *et al* (1999), .

[3] See for example Svensson (1998), Ball (2000) and Clarida, Galí and Gertler (2001).

rather than implemented strictly.[4] Arguably, the third condition is valid for closed economies or developed countries. But given the discussion above, it is not clear to what extent exchange rate changes and other external variables should be taken into account for monetary policy for the case of small open economies, particularly under inflation targeting.

Even though it has been documented that exchange rate regimes have been moving towards either hard pegs or free floating and away from intermediate arrangements, the idea of "degrees" of flexibility appears to have empirical support, since some studies argue that in many cases this shift is only apparent, and have identified what is called fear of floating. This concept refers to the observation of an "excess stability" of the exchange rate whenever the official announcement is of free floating.[5] The key result from these studies for the present discussion is that fear of floating is observed *even* in countries with inflation targets. This is fully consistent with the theoretical argument described that external variables are relevant for monetary policy implementation but it is not so with the idea that exchange rate flexibility is necessary for inflation targeting to be successful, particularly in small open economies that follow inflation targets. It can be argued fear of floating in these countries is a matter of economic policy consistency, and that there are different

[4] See for example Svensson (2001). See also Kydland and Prescott (1995), Taylor (1999) and references therein.

[5] See for example Calvo and Reinhart (2000), Hausmann, Panizza and Stein (2000) and Lahiri and Végh (2001).

"degrees" of exchange rate flexibility that small open inflation targeting countries can cope with and therefore the flexibility condition should be interpreted with caution.

This paper explores the extent to which the central bank in a small open economy that follows an explicit inflation target responds to changes in the exchange rate and other external variables, along with conventional variables considered relevant for monetary policy. In particular, the reaction function of the central bank of Mexico is estimated as a modified instrument rule where the policy variable responds to conventional variables such as the output gap, and a measure of policy credibility (usually for closed economies and developed countries), as well as changes in the exchange rate, and other external variables.[6] This policy rule is then subject to tests for structural changes and re-estimated for different sub-samples to explore whether the adoption of an explicit inflation target can be associated with a *de facto* change in the behavior of the central bank in terms of its responses to these variables. The statistical significance and the magnitude of the coefficients of the explanatory variables in each sub-sample are directly interpreted as changes in the relative importance the central bank assigns to them. Finally, the results are contrasted to similar estimations for New Zealand and Canada, two small open economies that have successfully implemented inflation targets.

[6] It is important to keep in mind that estimating a reduced form such as the one presented here does not necessarily capture the "true" policy reaction function. The most appropriate means to identify a policy reaction function is through the construction of an entire macro model (which includes a Phillips curve, an aggregate demand curve, a loss function for the authority, *et cetera*). The estimates of the reaction function would nonetheless be conditional on the assumptions for the model itself.

The results indicate the presence of a *de facto* change in the behavior of the central bank in Mexico associated with the adoption of the inflation target; conventional variables such as policy credibility and the output gap tend to become more important for monetary policy under inflation targeting while the exchange rate has explanatory power only before the adoption of this policy framework. In contrast, for New Zealand and Canada one cannot establish a clear link between the official change in policy regime and a change in policy behavior; conventional variables are significant and relatively stable while the exchange rate is never significant regardless of the inflation target. These results are interpreted as an indication that monetary policy in Mexico has become more similar to that in New Zealand and Canada. Additionally, as compared with these two countries, the results suggest that fear of exchange rate floating was purely transitional for the case of Mexico, since the exchange rate plays no significant role on explaining the behavior of the monetary policy instrument for Canada or New Zealand, and it does so for Mexico only before the inflation target was adopted.

The paper is organized as follows. The next section explores the theoretical and empirical literature on the use of different specifications of monetary policy rules to proxy the behavior of the monetary authority, with particular interest on (small) open economies. In Section 3, using different techniques, a modified Taylor rule is estimated for Mexico from 1996 to 2001. These estimations are then subject to endogenous structural change tests to assess the extent to which the behavior of the central bank has changed over that period. Based on these tests, different sub-samples are compared to quantify the extent of these changes by looking at the magnitude and econometric significance of the parameters included. Section 4 contrasts the evidence from Mexico with that of New Zealand and Canada using a similar approach, and provides a summary of the differences and similarities between these three countries in terms of monetary policy behavior. Section 5 concludes.

1.2. Estimating a Policy Reaction Function in Theory and in Practice.

It is quite difficult first to delimit the literature on monetary policy rules, and second to separate the purely theoretical from the purely empirical literature on this topic. The purely theoretical work goes back to the Barro-Gordon (1983a,b) approach, where they consider a policymaker that minimizes a loss function in terms of deviations of observed inflation from some target, and deviations of output from its potential level, subject to a Phillips curve-type of tradeoff. As a result, the policymaker's optimal choice for inflation depends on the public's expectations, deriving a policy reaction function. There is a vast literature based on this approach that studies how the monetary authorities choose inflation optimally, where the focus is mostly on reputational issues and strategic behavior under specific assumptions about information. One could consider for example the time inconsistency approach of Kydland and Prescott (1977) and that of Calvo (1978); the signaling models of Backus and Driffill (1985a,b), Canzoneri (1985), and Vickers (1986); or the information imperfections model of Drazen and Masson (1994), among many others, as purely theoretical models of monetary policy reaction functions.[7] In these cases, the policy

[7] See Drazen (2000) for a complete survey of this literature, which borrows analytical tools from game theory.

reaction function is not fully derived, but instead it consists of a set of conditions under which different types of equilibria may arise.[8]

There is another set of research on policy reaction functions, based on the original setup developed by Barro and Gordon as well. One of the main differences from the previous literature is that there are no information asymmetries that induce the type of strategic behavior needed to explore reputational issues. Instead, the use of additional macroeconomic theory is incorporated to derive expressions of some policy instrument (mostly an interest rate) as a function of variables that provide information on the stance of the economy over time. These expressions, known as monetary policy rules or instrument rules, are variants of what is known as a Taylor rule (see below), and typically include the standard variables in the Barro-Gordon setup, but also include other economic variables. Clearly, the goal of this part of the literature is different from the one described above, which is nothing but to test for the applicability, robustness, and other properties of different policy reaction functions.[9]

In general, this "second" literature can be classified in two broad groups. The first group consists on models of microeconomic foundations that derive policy rules based on dynamic optimization setups. Most of them introduce a representative agent that maximizes some expected utility over time subject to different constraints. While some of these models consider that expectations are rational, in many of them the

[8] Equilibria in the sense used in Game Theory.

[9] It is worth mentioning that there appears to be no intersection between the purely theoretical approach of the reputational models mentioned, and those models that emphasize the viability of modified instrument rules, though the ultimate objective is to assess their welfare implications.

intertemporal optimization decisions are solved separately. Also, in general, the models in this group are mostly designed to be used for closed economy environments.

The second group of models is based on general macroeconomic theory, where the setup is relatively more *ad hoc* rather than developed from micro-foundations, and expectations are in many cases non-rational. Despite this drawback, the rules derived from this group consistently outperform those derived from the first one in terms of empirical accuracy, and are considered more robust. Some of the models in this group focus on issues related to open economies so that other variables like the exchange rate are included, and they also consider econometric issues such as endogeneity and measurement error.

As Taylor (1999) points out, the models in both groups are general equilibrium, dynamic, stochastic models that rely on some short-run nominal rigidity in order to generate a Phillips curve-type of tradeoff. The micro models rely mostly on monopolistic competition across firms, such that market power induces price rigidities that in turn generate deviations of output from its potential (see for example King and Wolman [1999] and Clarida, Galí and Gertler [1999a]). On the other hand, the macro models assume an expectations-augmented Phillips curve, more in line with the original setup, such that inflation surprises affect real activity in the short run (see for example Ball [2000]).

There are two important features of the literature on monetary policy rules. On the one hand, the goal is to address the extent to which these rules fit into existing macro models and generate accurate predictions. McCallum and Nelson (1999) explain that some studies of monetary policy try to promote research strategies that emphasize robustness and operationality of policy rules. Robustness refers to a policy rule's performance in different macroeconomic models, that is, the tractability of the rule and its ability to generate low variations of both output and inflation around some specific targets. Operationality refers to whether a monetary policy rule is feasible, *i.e.*, it should be stated in terms of policy instruments that could in fact be controlled frequently by the central bank. On the other hand, the goal is to improve the likeliness to implement these rules in real-life policymaking, that is, to improve the extent to which a central bank can actually rely on these rules for monetary policy implementation. John Taylor (1999) argues that simplicity of monetary policy rules is crucial for these purposes, not only from the operational point of view, but also in the sense that a central bank should be able to explain to the public what it is doing.

The different types of models ultimately derive expressions that can be estimated econometrically. These expressions, as already mentioned, specify an instrument variable, which in most cases is a short run interest rate, as a function of other macroeconomic variables. The first and perhaps most general specification of a monetary policy rule is that proposed by Taylor (1993). Based on the quantity equation, he derives rather informally an expression where the nominal interest rate (i_t) responds to lagged inflation (p_{t-1}), the deviation of lagged inflation from a specific target $(p_{t-1} - \bar{p})$, and the output gap $(y_t - \bar{y}_t)$, taking the form

$$i_t = i^* + p_{t-1} + a(p_{t-1} - \bar{p}) + b(y_t - \bar{y}_t) \quad (1)$$

where i^* denotes the long run interest rate consistent with full employment and no inflation deviations from the target. Taylor (1998) shows that (1) provides a good description of the actions of the Federal Reserve during the Volcker-Greenspan administration.

Abstracting from the lack of a formal theoretical derivation, the above expression has several drawbacks. The first problem of Taylor's specification is that it is completely backward looking, and therefore non-rational expectations are implicitly embedded in the underlying optimization problem that generates that rule. As mentioned, Taylor is not the only one who has considered backward looking expectations for individuals in this type of analysis. Rudebusch and Svensson (1999) for example, assume adaptive expectations when studying country cases of explicit inflation targets.

On the opposite extreme, Batini and Haldane (1999) and Clarida *et al* (1999a), instead of using lags of inflation, introduce a "forward looking approach" by considering expected inflation at period t for j periods ahead minus the target announced at t for j periods ahead ($E_t\pi_{t+j} - \bar{\pi}_{t,t+j}$), a measure of credibility, as an explanatory variable for the monetary policy instrument.[10] This is called inflation-forecast targeting; the central bank targets precisely a forecast for inflation for several periods ahead, which from a theoretical point of view allows for a more accurate assumption of rational (forward-looking) expectations for all agents.

[10] Nonetheless, they explain that any forward-looking rule can be given a backward looking representation (see Taylor [1999]).

A second problem of Taylor's specification in (1) is that it does not consider the observation that in many cases the interest rate is relatively stable over time, suggesting that central banks pursue some degree of interest rate smoothing since a highly volatile interest rate may affect financial stability. The argument is that interest rate smoothing reduces output volatility, particularly in face of recurrent money demand shocks, and it can prevent portfolio mismatches of considerable importance. Rotemberg and Woodford (1999) for example, include a lag of the interest rate on the right hand side of (1) when studying monetary policy in the US, formalized by Rudebusch and Svensson (1999) by adding a "smoothing-motive" term to the policymaker's objective function of the form $a\,(i_t - i_{t-1})^2$.

Another drawback of (1) and perhaps the most relevant for the present purposes is that it is mostly appropriate for either closed economies or large open economies. Svensson (1998) argues that "other variables" that account for economic openness should be considered explicitly in monetary policy. He asserts that "[a]ll real world inflation targeting economies are quite open with free capital mobility, where shocks originating [abroad] are important, and where the exchange rate plays a prominent role in the transmission mechanism of monetary policy".[11] For example, he identifies an aggregate demand channel and a direct channel through which the exchange rate affects domestic price behavior, and therefore inflation and output. Moreover, Svensson argues that not only the exchange rate should be considered in monetary policy decisions, but the role of external shocks should be taken into account by policymakers as well. Ball (2000) explores these arguments by extending the use of Taylor's

[11] Svensson (1998), p. 3.

proposition to an open economy framework. He incorporates the real exchange rate and the rate of change of the nominal exchange rate as explanatory variables for the interest rate -on the right hand side of (1) above- arguing that "different rules are required [for open economies] since monetary policy affects the economy through the exchange rate channel as well as the interest rate channel".[12]

Finally, there is some debate in terms of what the instrument variable (the left-hand side variable) should be. Most studies use an overnight primary interest rate on banks' funds or inter-bank transactions as the policy instrument. Batini and Haldane (1999) argue that the relevant variable for decision-making is the *ex-ante* real interest rate, and therefore it should be the one considered as the policy instrument. In this regard, Taylor (1993) explains that the appropriate management of the nominal interest rate by the monetary authority should be exactly to affect the real interest rate in order to stabilize the economy, so that the use of either is practically equivalent so long as inflation expectations are somewhat stable. Levin, Wieland and Williams (1999) use changes in the interest rate on the left hand side of the rule instead of levels. They test for the robustness of different Taylor rules for four different underlying models for the US and find strong support in favor of rules that use changes in the interest rate as the instrument variable in terms of tractability and robustness. Finally, it has also been argued that the policy instrument should be some monetary aggregate (a quantity restriction of some sort) rather than the short-run interest rate. But as Clarida *et al* (1999a) point out, there is an observational equivalence from using a monetary

[12] He proposes the use of a weighted average of interest rates and exchange rates, known as a monetary conditions index (MCI), as the appropriate policy instrument for small open economies.

aggregate or an interest rate so long as one is able to identify shocks to money demand. Otherwise, a money target would induce large interest rate fluctuations that may translate into higher variability of output and consequently a higher loss to the authority.[13]

The most recent issue discussed in the literature is the practical validity of instrument rules as the one described in (1) and those discussed above relative to what is known as target rules, that specify operational objectives for monetary policy or a set of conditions for the target variables.[14] Svensson (2001a) highlights four basic objections to the use of Taylor-type of rules for monetary policy conduction. First, he argues that they are not always optimal, particularly if there is some learning process for the central bank; second that they give no room for the use of judgment and for what is called extra-model information, which he argues is particularly important under model uncertainty;[15] third, that given the suboptimality of instrument rules, there must be "recommitment" from the monetary authority, and dynamic inconsistency problems may arise; and finally, that they are not that operational, that is, no central bank has ever fully committed to a rule of this type. As an alternative, Svensson proposes the use of target rules since they include clear objectives or specific rules in the form of a set of conditions for the forecast of target variables, and they outperform policy rules in

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[13] Some countries that adopted a money target have abandoned it due to this problem. The relationship between the instrument and the velocity of money weakened due to the high volatility of the latter, which severely narrows the scope for monetary policy with an intermediate target.

[14] See Svensson (2001b).

[15] See also Levin, Wieland and Williams (1999).

terms of operationality and robustness. The problem with this argument is exactly that no central bank commits to Taylor-type of specifications blindfolded and there is indeed some room for judgment; what is called "constrained discretion",[16] and Taylor-type rules or instrument rules for that matter, provide for a useful guidance in the conduct of monetary policy (see Taylor [2000]).

1.3. The Case of Mexico.

1.3.1. Monetary Policy Overview: From Domestic Credit Targeting to Inflation Targeting.

From late 1990 until the end of 1994, Mexico observed a sound fiscal stance, an exchange rate band was properly at work, inflation was low relative to previous years and overall macroeconomic performance was reasonable if not spectacular. In the last days of 1994, the central bank let the currency float against the US dollar, which led to a significant depreciation of the peso and a new surge in inflation. In an attempt to offsetting the inflationary effects of the devaluation and regaining stability, the authorities decided to follow an explicit monetary aggregate target where domestic credit was to remain within certain limits during a one-year period. A zero average legal reserve requirement for commercial banks was also imposed in order to limit interest rate volatility through determining penalization rates for excess liquidity demanded.[17]

[16] Bernanke and Mishkin (1997).

[17] Between 1995 and 1998, the central bank sometimes reduced this requirement to a negative number, putting the banking system "short" of cash; although full liquidity was still provided when needed, the

The Federal Government and the central bank agreed upon pursuing goals for yearly CPI inflation, without considering them as official targets.[18] As Figure 1.1 shows, even though by December of 1997 observed inflation almost hit the proposed target, it continued to stay above that target until 1999. This was perhaps in part due to the remaining costs brought about by the collapse of the exchange rate band and in part due to the situation that prevailed in other emerging economies. Indeed, the Asian and Russian crises of 1997 and 1998 affected Mexico's exchange rate volatility to the extent that, given a relatively high passthrough to prices at the time,[19] it jeopardized the goal of bringing inflation back to the proposed target. The significant depreciation of the Mexican peso during the second half of 1998 forced the central bank to intervene directly in the foreign exchange market in September. Nonetheless, yearly inflation reached a peak of about 20 percent that year. In light of these events, the monetary authority decided to revise its inflation goal for 1999. Figure 1.2 illustrates the close relationship between exchange rate changes and observed inflation.

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excess portion was penalized at a higher-than-market cost. This scheme, known as *el corto* prevails as the monetary policy instrument in Mexico, see Box 1.1. For a detailed description of the operation of monetary policy since 1995 see Carstens and Werner (1999) and references therein.

[18] These non-official targets were published in official monetary reports. It was disclosed that the role of the central bank was to conduct its monetary policy to collaborate on the achievement of these goals. See Informe Anual, Banco de México (various volumes).

[19] See Garcés (1999).

Figure 1.1. Observed and Announced Inflation

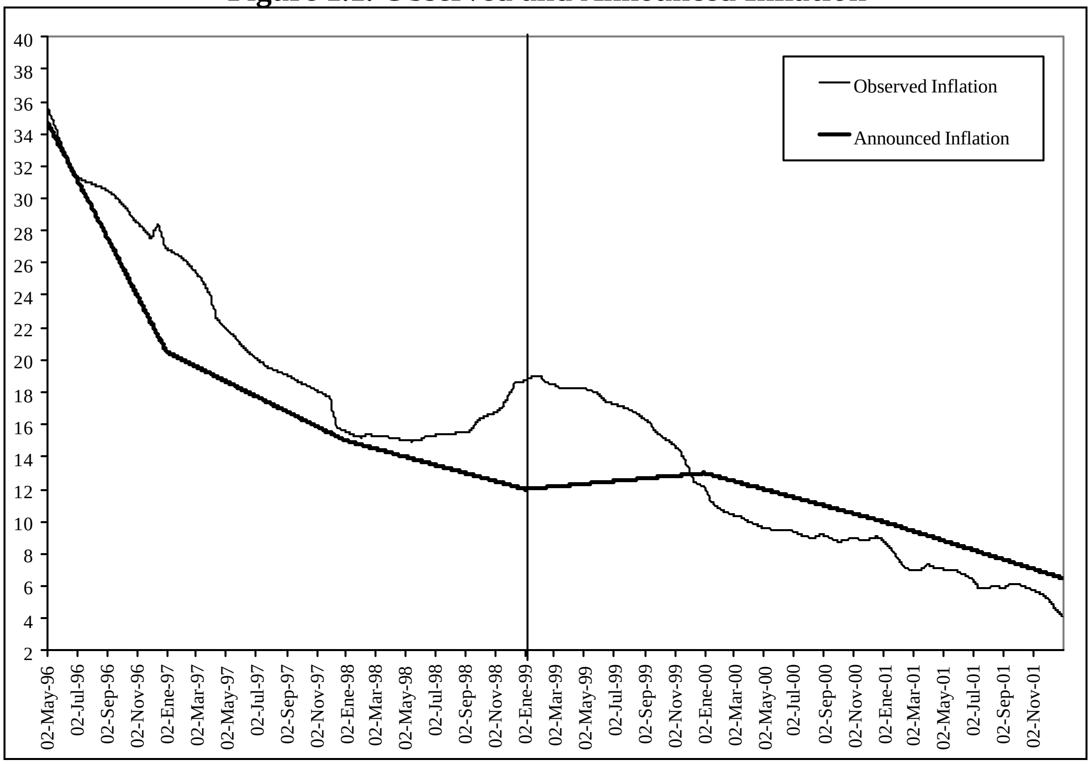
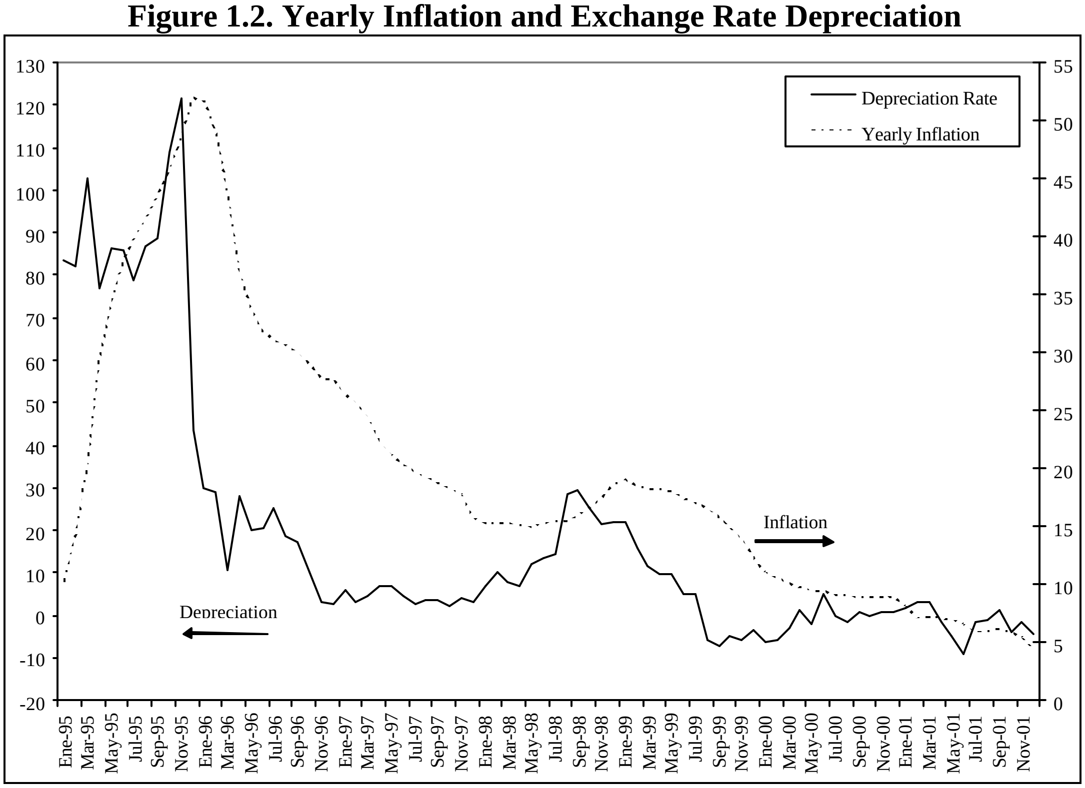


Figure 1.2. Yearly Inflation and Exchange Rate Depreciation



Box 1.1. Monetary Policy in Mexico from 1996 to 2001

-Floating since 1995 (after collapse of exchange rate band). -Intermediate regime (domestic credit target)from 1995 to 1998. -Unofficial goals for yearly CPI inflation from 1995 to 1998. -Unstable relationship between domestic credit and velocity of money. -Failure to achieve proposed targets prior to 1999. -Adoption of scheme: January 1999 (CPI point target, then range). -Announcement at the beginning of the year for end-of-year annualized inflation rate. -External shocks: Asia (1997), Russia (1998), Brazil (1999). -Instrument: commercial banks' cash balances (borrowed reserves) in central bank (*el corto*). -Reduced inflation from almost 20% in 1998 to about 4% in 2001.

In January 1999 an explicit inflation target was announced for the first time, setting a point goal of 13 percent for the end of that year. The shift in policy determination was mostly due to the observed weakening of the relationship between the demand for money and the domestic credit target in use, and to the difficulties derived from the external environment during the previous years.[20] Despite the

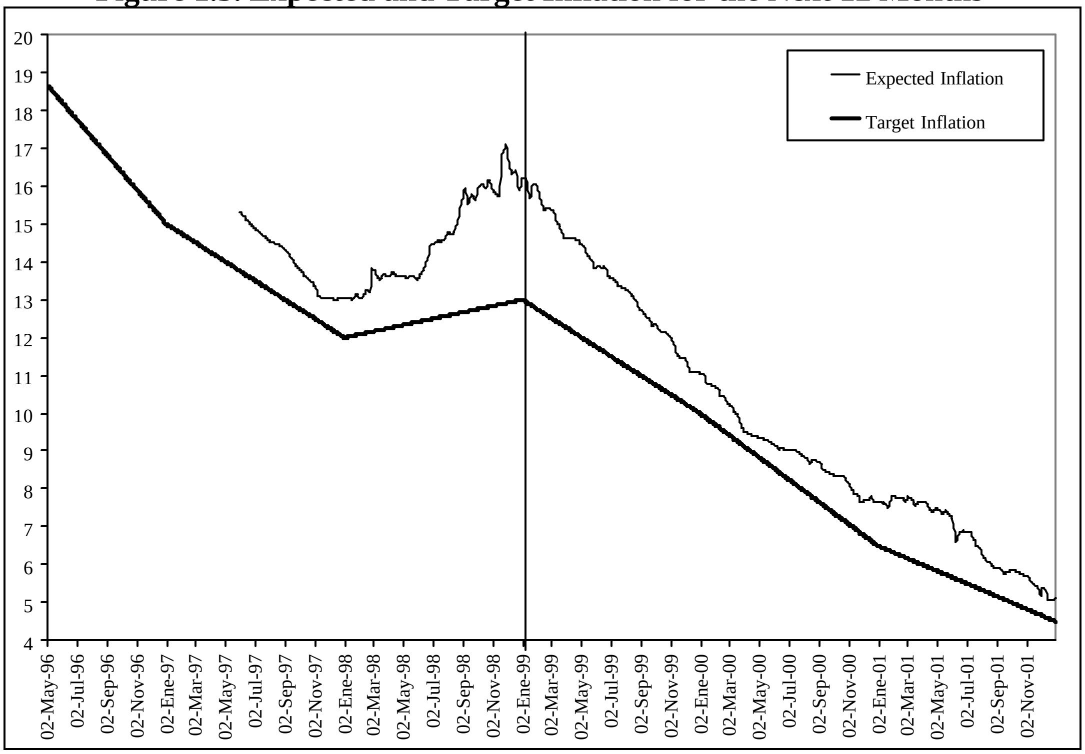
[20] See Informe Anual, Banco de México (various volumes).

Brazilian crisis in early 1999 and the upward revision of the inflation target for the end of that year, the higher transparency in monetary policy and the relative stability abroad were beneficial in the sense that inflation expectations fell considerably, as shown in Figure 1.3.[21] Note that the observed rebounds on inflation expectations coincide with the occurrence of external factors: the Asian and Russian crises before 1999 and oil price fluctuations after that. These shocks directly affected the exchange rate (see Figure 1.2), and consequently people's inflation expectations, which likely translated into credibility losses.

The central bank has met its targets since 1999 and, at the same time, it has increased the credibility of such announcements, an accomplishment that constitutes a very important gain resulting from the adoption of the target. The observed persistence in the gap between announced and expected inflation (interpreted here as lack of credibility) until practically the end of 2001 remains an open question yet to be answered. The scheme is considered successful since inflation has fallen from almost 20 percent in 1998 to about 4 percent in 2001.

[21] Inflation expectations data are available from surveys conducted by the central bank (see Section 3.3.2 below for further details).

Figure 1.3. Expected and Target Inflation for the Next 12 Months



1.3.2. Estimating a Monetary Policy Rule for Mexico From 1996 to 2001.

In the present section I explore the policy reaction function of the central bank in Mexico between 1996 and 2001, and attempt to identify whether the adoption of an explicit inflation target in that country has affected the way the central bank responds to changes in the exchange rate and other external variables, taking into account other conventional variables for monetary policy decisions. Based on the discussion about monetary policy rules outlined in Section 2, and given the nature of the Mexican economy, it is clear that direct estimation of a rule like (1) above would be inappropriate. Instead, since it can be argued that Mexico is following an inflation forecast target *de facto*, a forward looking policy reaction function is considered along the lines of Batini and Haldane (1999) and Clarida *et al* (1999a). Also, by including other external variables, this approach allows me to identify the extent to which exchange rate flexibility is crucial for inflation targeting to be successful, and allows to search for further evidence with respect to the fear of floating phenomenon in Mexico. This will allow me to ultimately determine whether there has been a shift towards "pure inflation targeting" and away from any other type of commitment.

1.3.2.1. Equation Specification.

According to the discussion outlined in Section 2, the specification of any monetary policy rule should capture the forward looking nature of the problem faced by the monetary authority. This implies taking into consideration information regarding individuals' expectations whenever possible. Also, given the nature of the financial sector in that country, the need for a rule that allows for interest rate smoothing should be considered. Perhaps most importantly for the purpose of the present analysis is the idea that external factors should be taken into account for monetary policy in a small open economy like Mexico. This leads to the explicit inclusion of variables that capture such factors. By introducing the exchange rate depreciation rate, the interest rate on long term Mexican government bonds abroad as a proxy of country risk, and the percentage change of the terms of trade as explanatory variables, the specification will capture precisely the fact that Mexico is a small open economy subject to external shocks, and that there is an additional channel through which monetary policy works in this type of country. In principle, the estimated rule takes the form

$$i_t = b_0 + b_1 i_{t-s} + b_2[E_t p_{t+12} - \overline{p}_t^{t+12}] + b_3[y_t - \overline{y}_t] + b_4\left(\frac{\Delta E}{E}\right)_{t-j} + b_5 i_t^{gov} + b_6\left(\frac{\Delta ToT}{ToT}\right)_{t-j} + u_t \qquad (2)$$ [22]

where:

i_t	is the annualized one-day interest rate (the monetary policy instrument, see below)
$E_t p_{t+12} - \overline{p}_t^{t+12}$	is the difference between the public's expectations of inflation for the next 12 months as of time *t* minus the announced inflation target for the next 12 months as of time *t* (labeled as the "inflation gap" or the "credibility measure" hereafter)
$y_t - \overline{y}_t$	is the output gap
$\left(\frac{\Delta E}{E}\right)_{t-j}$	is the monthly rate of change of the exchange rate in the previous *j* periods (defined in domestic currency per unit of foreign currency)[23]
i_t^{gov}	is the interest rate on long term Mexican Government bonds abroad

[22] The time subscripts *s* and *j* represent the use of (different) lags instead of contemporaneous observations of the corresponding variables both under slightly modified specifications of (2) and under the use of different data frequencies (see below).

[23] *j* can take any non-negative value (this also applies for the terms of trade variable below).

$\left(\frac{\Delta ToT}{ToT}\right)_{t-j}$	is the monthly rate of change of the terms of trade in the previous j periods
u_t	is an iid shock with zero mean and finite variance

The inclusion of the exchange rate depreciation rate exactly aims to exploring the extent to which this variable is taken into account for monetary policy decisions under inflation targeting given other variables considered relevant for this purpose. It also provides for a simple tool to explore the nature of the documented fear of floating phenomenon. The country risk variable (i_t^{gov}) allows to control for the impact of the perception of foreign investors over the exchange rate, that is, to control for the occurrence of other external shocks that may affect capital flows, which play a key role in exchange rate determination in small open economies like Mexico. The coefficient of this variable will reflect the role that the central bank assigns to this perception in monetary policy. Also, the coefficient associated to exchange rate changes will be cleaned from any effects of this variable over the policy instrument. The inclusion of the terms of trade variable allows to control for variations in foreign or controlled prices. Alternatively it may account for supply side shocks that affect monetary policy.[24]

As mentioned, the use of the gap between expected and announced inflation captures the forward looking nature of the problem faced by the monetary authority.

[24] An alternative exercise would be to use a measure of underlying inflation, *i.e.*, inflation excluding highly volatile items.

This variable and the (current) output gap measure account for conventional variables in the analysis classified as inflation-forecast targeting (see Section 2 above).

1.3.2.2. The Data and Construction of Variables.

The raw data are available mostly from Banco de Mexico at different frequencies. Among the high frequency data is the annualized one-day interest rate for commercial banks' large-scale operations with other banks or the *Tasa de Fondeo Bancario*, which is the policy variable considered here (i_t above), available on a daily basis.[25] Even though the true policy instrument in Mexico is the zero-average legal reserve requirement for commercial banks known as *el corto* (see Box 1.1 previously), this requirement directly affects the interest rate used here, exactly as if the interest rate was the true policy instrument.[26] The nominal exchange rate is also published daily by the central bank and is constructed as an average of the quotes of large-scale foreign exchange transactions payable overnight. It is used to settle obligations in foreign currency within the Mexican territory.[27] Also published daily is the interest rate of long term Mexican government bonds traded or held abroad (*UMS26*), obtained from Bloomberg.[28] Inflation expectations are available from the central bank biweekly. This series is obtained through a survey conducted by the central bank on the private sector and is not constructed by the central bank itself. Since there are no monthly

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[25] This rate corresponds to large-scale overnight inter-bank operations. It resembles the Federal Funds rate in the US. See Banco de Mexico, www.banxico.org.mx for a full description about the construction of this interest rate.

[26] See Martinez, Sanchez and Werner (2001).

[27] See *Circular* 2019/95 by Banco de México.

[28] *UMS26* is a long-run Mexican government debt bond held outside the country that expires in 2026.

series for real *GDP* available, output is measured by the seasonally adjusted industrial production index constructed by *INEGI* (Mexico's Bureau of Statistics).[29] This series is highly correlated with real *GDP* and is considered a good proxy for *GDP* in that country. The terms of trade index is also published monthly. The lowest frequency observations are those of the inflation targets. They are yearly observations officially published by the central bank in its monetary policy reports.[30]

While some of the exercises presented here were carried out using strictly monthly data, the higher frequencies for the instrument variable, the exchange rate, the *UMS26*, and inflation expectations allowed us to carry out several high frequency (daily) exercises similar to those using monthly data. The low frequency data available: inflation expectations; inflation targets; and the *GDP* variable (and therefore the output gap), were interpolated correspondingly to construct daily series, with the exception of the terms of trade, for which the Mexican oil prices (available daily at Bloomberg) were used as a proxy in daily data exercises.[31]

The credibility measure [$E_t p_{t+12} - \bar{p}_t^{t+12}$] (or inflation gap) was calculated using the data available on inflation expectations and linear interpolations of yearly inflation announcements respectively (see Figure 1.3 previously).[32] Three different measures of

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[29] www.inegi.gob.mx

[30] See Banco de México, Exposición de Política Monetaria, various volumes.

[31] The advantages and disadvantages from these transformations are discussed below.

[32] The numbers between end-of-year observations for the inflation target are calculated as follows: the announcements for the years 2000 and 2001 were 10 percent or less and 6.5 percent or less respectively; thus the in-between observations assume that the central bank pursues the target monotonically towards the next one at a constant rate, about -0.30 per month in this particular case.

the output gap ($y_t - \bar{y}_t$) were considered: deviations from a linear trend; deviations from a linear and a quadratic trend; and deviations from the Hodrick and Presscott (1997) filter (following Martinez, *et al* [2001] and others).[33] The rate of change in the exchange rate, the rate of change in the terms of trade and the rate of change in the oil prices are calculated with respect to the previous month or with respect to the observation 30 days before.

1.3.3. Some Preliminary Results Using Monthly Data.

The first question at this point is to determine what should be expected for the coefficients in (2) from a theoretical point of view. Following the discussion in Section 2, the coefficient of the lagged instrument (b_1) is expected to be between 0 and 1 if there is interest rate smoothing. b_2 and b_3 are associated with conventional variables used in practically all studies about monetary policy rules, and are directly derived from the standard Barro-Gordon setup. The first variable corresponds to what has been labeled as the "inflation gap" or the "credibility measure" (expected minus announced inflation); the less credible the announcement, the larger this measure. It is self-explanatory that there should be a positive relationship between this variable and the interest rate, otherwise the central bank may accommodate people's expectations and thus validate higher inflation expectations, and thus b_2 should be positive. In fact, as Taylor (1993) suggests, this variable should be greater than 1 in order for monetary policy to be stabilizing (see below), since any increases in expected inflation are more

[33] Despite the possible shortfalls of these calculations, McCallum and Nelson (1999) highlight this criticism as endemic to the empirical literature on monetary policy rules.

than offset by the monetary authority. The coefficient b_3 is associated with what is known as the output gap; if output is higher than its potential level –there is a positive gap-, "overheating" may induce higher-than-desired inflation, and it should be offset through tightening monetary policy and *vice-versa*. This implies a positive relationship between the dependent variable and the output gap, and therefore b_3 should be positive.[34]

In an environment of full exchange rate flexibility, one should expect the exchange rate not to affect the policy instrument (at least not directly). In fact, for the case of the US economy for example, Taylor (1998) excludes this variable completely from the analysis. However, the Central Bank of New Zealand, for example, considers this variable (and the terms of trade) explicitly in policymaking.[35] Given the fear of floating results in the literature and Svensson's formalizations discussed above, there is still debate on the extent to which the exchange rate should be explicitly considered in (2). It is assumed here that the exchange rate constitutes an indicator for monetary policy, and therefore the significance of b_4 can be interpreted directly as evidence of fear of floating. More specifically, if the behavior of the exchange rate has any role for the central bank's actions, then one can expect b_4 to be positive and significant. This is because recurrent exchange rate depreciations may induce the central bank to increase nominal (and real) interest rates to avoid price increases and hence keep inflation under control (particularly if a high passthrough prevails, as it has been the case for

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[34] If b_3 is negative, then monetary policy is procyclical. Clarida, Galí and Gertler (1999a, b) argue that if it is greater than 1, it implies that monetary policy is also stabilizing.

[35] See for example Bernanke *et al* (1999), p. 95 and references therein.

Mexico).[36] If, on the other hand, b_4 is not significant, then the exchange rate is not relevant for monetary policy decisions and the interpretation is of no fear of floating.

b_5 and b_6 correspond to variables that are associated with external factors. i_t^{gov} is a proxy of country risk, while $\left(\frac{\Delta ToT}{ToT}\right)_{t-j}$ reflects terms of trade and other external disturbances. If there is a perception from foreign investors that something may "go bad", i_t^{gov} will tend to increase in order to compensate for the higher risks and avoid capital flight (all else equal). Consequently, the instrument rate should increase through an interest parity condition. If the exchange rate adjusts, then the size of this adjustment may depend on both the magnitude of the interest rate change and the exchange rate passthrough, but b_5 should nonetheless be positive. With respect to b_6, a negative terms of trade shock or a "cost push shock" would induce a rise in the exchange rate and/or an increase in domestic inflation,[37] which should in turn induce a

[36] Calvo and Reinhart (2002) argue that the fear of floating phenomenon may arise from the combination of lack of credibility and inflation targeting. They associate lack of credibility with risk premium volatility, which translates into high exchange rate volatility and higher-than-desired inflation given full passthrough (not necessary for the mechanism to work). Fear of floating implies that the monetary authority offsets the effects over the exchange rate derived from risk premium volatility. For other arguments that explain the fear of floating phenomenon with respect to passthrough and currency mismatches see Hausmann *et al* (2000) and Lahiri and Végh (2001).

[37] See Edwards (1989)

more stringent position of the central bank and an increase in interest rates. This implies that b_6 should be negative.[38]

1.3.3.1. OLS and GMM Estimations: From 1996 to 2001.

Expression (2) is estimated for the sample that goes from May of 1996 to December 2001.[39] The results presented in Table 1.1 include slightly different specifications of (2). Column (a) for example includes contemporaneous observations of both the rate of change of the exchange rate and the rate of change of the terms of trade; column (b) substitutes the terms of trade changes with the change in the price of oil,[40] and qualitatively the results remain basically unchanged: there is evidence of interest rate smoothing and both the credibility gap and the output gap are significant.[41] Moreover, all external variables are significant, suggesting first that there is fear of floating in Mexico during this period of analysis and that both country risk and terms of trade shocks are also relevant for monetary policy.

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[38] In Mexico terms of trade shocks are closely linked to changes in the oil prices, which in turn are closely linked to public deficits. This would imply that the use of oil prices may also reflect the stance of fiscal policy (or demand side shocks).

[39] We use Newey-West (1987) (NW) estimations provided the OLS residuals are not only serially correlated but also likely to be heteroskedastic given the nature of the series considered here according to the results from the corresponding tests (not reported).

[40] Among other reasons to be discussed, the use of oil price inflation is to make monthly regressions "comparable" with those using high frequency data (see below).

[41] (sa) stands for "seasonally adjusted".

Table 1.1. OLS with NW Std. Errors for the Full Sample Using Monthly Data for Mexico

Dependent Variable: nominal overnight interest rate				
	(a)	(b)	(c)	(d)
constant	-13.57**	-13.05*	-27.37**	-28.99***
	(5.30)	(6.65)	(11.08)	(10.43)
lagged nominal overnight interest rate	0.49***	0.51***	0.36*	0.37*
	(0.10)	(0.10)	(0.21)	(0.19)
expected - announced inflation	3.34***	3.14***	3.11**	3.02**
	(0.86)	(0.95)	(1.30)	(1.21)
output gap (sa)	0.50***	0.47***	0.58**	0.60***
	(0.11)	(0.12)	(0.22)	(0.21)
exchange rate depreciation	0.52***	0.54***	-	-
	(0.13)	(0.15)	-	-
lagged exchange rate depreciation	-	-	-0.11	-0.17
	-	-	(0.15)	(0.15)
govt. bond yield abroad	1.85***	1.78**	3.59**	3.75***
	(0.61)	(0.79)	(1.39)	(1.30)
change in terms of trade	-0.44***	-	-	-
	(0.15)	-	-	-
lagged change in terms of trade	-	-	-0.12	-
	-	-	(0.20)	-
change in oil prices	-	-0.01	-	-
	-	(0.02)	-	-
lagged change in oil prices	-	-	-	-0.05***
	-	-	-	(0.02)
R Sq	0.93	0.92	0.88	0.88
Adj R Sq	0.92	0.91	0.86	0.87
Std. Error	1.99	2.07	2.55	2.48
Sum Squared Resid	193.90	210.90	317.63	300.30
F Stat	102.15	93.26	59.18	63.06
Prob	0.0000	0.0000	0.0000	0.0000
No. of Observations	56	56	56	56

*, ** and *** denote 10%, 5% and 1% significance respectively

Std. Errors in parentheses

The problem with the results in (a) and (b) is that the exchange rate and the country risk variable are highly correlated. Moreover, there may be a problem of endogeneity between these two variables and the left hand side variable. Interest rate changes may induce changes in the exchange rate and both may induce changes in country risk measures. Conversely, an exogenous change in country risk may affect both the interest rate and the exchange rate to the extent that it generates shifts in the direction and magnitude of international capital flows. The use of lags on both the exchange rate depreciation and the changes in terms of trade allows for partially dealing with this issue, since right hand side variables are predetermined. Columns (c) and (d) present the analogous regressions in (a) and (b) with the use of lags instead of contemporaneous observations of those variables, except for the risk premium variable. Note that the exchange rate variable is no longer significant, but the rest of the results remain, except for the fact that the country risk premium coefficient doubles.[42] The implied long run coefficients for the difference between expected and announced inflation oscillate between 4.8 and 6.5. For the output gap these coefficients are practically equal to 1, while for the rate of change in the exchange rate they oscillate between 1 and 1.1. Since the output gap is constructed using index numbers, this long run coefficient indicates that the monetary authority was exactly accommodating shocks to this variable, which is also the case for changes in the exchange rate. These results suggest a strongly stabilizing monetary policy in Mexico for this period.

Given the possibility of endogeneity of right hand side variables discussed and the fact that the presence of the lagged dependent variable may generate spurious results, following Clarida *et al* (1999b), analogous estimations using GMM are presented in Table 1.2.[43] It is interesting first to see that the lagged dependent variable is significant using GMM only for the second two regressions. Secondly, the

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[42] Probably because of the endogeneity issue mentioned.

[43] As in Clarida, Galí and Gertler (1999b), it is assumed that all the variables (including inflation and the interest rate) are stationary (p. 8). See Appendix 1.

coefficient for the output gap remains basically unaffected. Third, the rest of the variables tend to lose explanatory power except for the exchange rate depreciation and the lagged change in oil prices. Key to these estimations is that both the output gap and the (contemporaneous) exchange rate depreciation remain positive and significant regardless of the estimation methods and the use of terms of trade or oil price changes. Also, it is somewhat surprising that the government bond yield abroad and the terms of trade measures lose significance.

The problem with the estimations in Table 1.2 is that, given the reduced number of observations and the need for the identification of adequate instrument variables, which are usually lags of the explanatory variables themselves, there is a significant loss in the degrees of freedom and the estimations may be misleading. It is for this reason that equivalent exercises using high frequency data are considered in Section 3.3.3 below.

Table 1.2. GMM Estimations for the Full Sample Using Monthly Data for Mexico[1/]

Dependent Variable: nominal overnight interest rate				
	(a)	(b)	(c)	(d)
constant	-41.85*	-37.38	-5.37	-15.80
	(23.04)	(24.63)	(18.45)	(17.41)
lagged nominal overnight interest rate	0.28	0.34	0.61***	0.59***
	(0.25)	(0.26)	(0.15)	(0.14)
expected - announced inflation	2.79	2.62	2.73	2.08
	(2.02)	(1.81)	(2.39)	(2.06)
output gap (sa)	0.53**	0.53**	0.53*	0.49*
	(0.26)	(0.23)	(0.31)	(0.26)
exchange rate depreciation	1.32**	1.29**	-	-
	(0.61)	(0.58)	-	-
lagged exchange rate depreciation	-	-	0.00	-0.12
	-	-	(0.14)	(0.16)
govt. bond yield abroad	5.22*	4.67	0.88	2.11
	(2.84)	(3.04)	(2.17)	(2.05)
change in terms of trade	-0.29	-	-	-
	(0.34)	-	-	-
lagged change in terms of trade	-	-	0.06	-
	-	-	(0.19)	-
change in oil prices	-	0.01	-	-
	-	(0.03)	-	-
lagged change in oil prices	-	-	-	-0.04**
	-	-	-	(0.02)
R Sq	0.71	0.74	0.85	0.87
Adj R Sq	0.67	0.71	0.83	0.85
Std. Error	3.98	3.75	2.88	2.67
Sum Squared Resid	759.55	674.81	398.15	342.52
J Stat	0.0000	0.0000	0.0000	0.0000
No. of Observations	55	55	55	55

*, ** and *** denote 10%, 5% and 1% significance respectively

Std. Errors in parentheses

1/ Instrument list includes lags of dependent variable, lags of observed inflation and lags of explanatory variables

Since the main idea is to explore whether there has been a change in the behavior of the central bank once the inflation target was adopted, the next step is to test for the presence of a structural break for equation (2), where the obvious candidate for such break corresponds to the date of the adoption of the explicit inflation target in January of 1999. If there is a break around that time, estimations for different sub-samples before and after should provide information about differences in the behavior of the central bank given the announcement of the policy shift, and these differences should be reflected in the relative magnitude and significance of the regressors in expression (2) for each sub-sample. However, one problem is that standard structural change tests require an a priori assumption about the time of occurrence of the structural break itself, and lead to ambiguous conclusions, as shown in Table 1.3.

Table 1.3. Structural Change Tests for Mexico at January 1999

	Test Stat	Result
Wald Test (unequal variance)		(null: no structural change)
	40.51*	reject null
Chow Breakpoint Test		
F-stat	8.28*	reject null
LL Ratio	57.29*	reject null
Chow Forecast Test		
F-stat	0.46403	cannot reject null
LL Ratio	719.907	cannot reject null
CUSUM test	--	cannot reject null
CUSUM Sq	--	reject null

* Denotes 5% significance level

1.3.3.2. Analysis of Multiple Endogenous Structural Changes.

Given the official announcement of a policy shift in January 1999, one would expect to observe a *de facto* change in the behavior of the central bank associated to such announcement. The problem is that the conventional structural change tests above do not provide conclusive evidence about the occurrence of a change in policy behavior exactly at that point. In addition to the fact that these policy changes take time, it is possible that the central bank engaged in a transition period some time before the official announcement was made, particularly in face of the Asian and the Russian crises of 1997 and 1998. Alternatively, it may be that the policy shift occurred after the announcement was made, and that the announcement itself was only to set up the adequate conditions for the actual shift to generate best results. It may then be argued that the *de facto* policy shift did not necessarily occur at the time of the announcement and the timing of the "true" change has to be estimated. Moreover, it may be that the highly unstable environment around the second half of 1998 led the authorities to adjust differently and hence there has been more than one policy shift, particularly since towards the second half of 1999 the situation was much more stable than before. To explore these possibilities and estimate the time of a "true" policy shift, if any, expression (2) is tested for the presence of multiple structural changes using the procedure developed by Bai and Perron (1998, 2001). One of the main benefits from the application of this procedure is that it endogenously estimates the *number* and the *dates* the structural breaks occurred rather than setting them exogenously, as it is the case for the conventional structural change tests presented above.

The procedure works as follows. Suppose there are T observations of a random variable w_t and the goal is to estimate not only the first and second moments of w, but also whether these moments have changed over time, that is, if there have been any structural breaks in w. The problem is that the total number of breaks that occurred (if any) and the dates these breaks occurred are ignored. Therefore, there is a need not only to estimate if there have been any breaks, but the number of breaks that have occurred *and* the dates they occurred. Suppose *a priori* that m breaks have occurred. This means that if indeed there are m breaks, then there will be m+1 different sub-samples of T (regimes) for which one pair of first and second moments of w can be estimated, along with the *m* dates for the breaks. Given a prior on *m*, the first step is to define all the possible sets of *m*+1 different sub-samples (segments) of *T* that are at least of length *h* (set exogenously) for which the moments of *w* can be estimated. These sets of *m*+1 segments have to be contiguous but with no common observations, and can be of different lengths. Then, the moments of *w* for all the defined sets of *m*+1 segments are estimated using OLS, and the residuals of each set of *m*+1 segments are utilized to determine which is the best set of *m*+1 segments to minimize the LS function over the full sample. Hence, the selected set of *m*+1 segments will be the one that minimizes the *global* sum of least squares, and will be the one that determines the estimated dates of the breaks. Since the "true" *m* is unknown, the procedure is repeated for *m*=0 to *M* (*M* exogenously defines an upper bound for the number of breaks *m*), and the corresponding sets of square residuals selected under each *m* are compared to determine both the "true" number of breaks *m* and the dates the breaks occurred. Useful for my purposes is that Bai and Perron extend their analysis to a multiple regression model that allows for serial correlation and heteroskedasticity in the disturbances, for the inclusion of lags of the dependent variable, and for the introduction of restrictions on the number of parameters subject to change.[44]

Bai and Perron also developed several *F*-tests for the results provided by the application of their method: a test for multiple breaks, known as $SupF_T(k)$, where the null hypothesis is that there are no breaks (*m*=0) against the alternative of *k*>0 structural breaks for an exogenously given *k*; a "double maximum" test which allows for testing against an unknown number of breaks (for *k* not predetermined, but limited

[44] For a highly detailed explanation of how this procedure works, see Bai and Perron (2001).

above by some number *M*), with test statistics known as *UDMax* and *WDMax*, both based on the global minimization of the sum of square residuals described; and a test denominated $SupF(i+1,i)$ for i=1 to *M*, to test for the presence of additional breaks within each partition of *T*. Finally, to select the dimension of the econometric model estimated, that is, to determine the number of breaks in the estimations, Bai and Perron borrow different information criteria that include the Bayesian Information Criterion (BIC) the Akaikie-Schwarz Information Criterion (AIC), a modified Schwarz Criterion (LWZ), and develop their own Sequential Procedure.[45]

The general specification of equation (2) can be written exactly as in Bai and Perron (2001) as

$$Y = Xb + Zd + U \qquad (3)$$

where *Y* is a column-vector of the dependent variable of the form $(T*1)$; *X* is a $(T*p)$ matrix of regressors whose coefficients *are not* allowed to change (see below); *Z* is a $(T*[q*(m+1)])$ diagonal matrix of regressors whose coefficients *are* allowed to change; *U* is a column-vector $(T*1)$ of disturbances; *T* is the total number of observations; *m* is the number of breaks; *p* is the number of coefficients in *b* not allowed to change; and *q* is the number of coefficients in *d* allowed to change.[46]

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[45] See Bai and Perron (2001) and references therein.

[46] *T* is partitioned into $m+1$ sub-sets, and these partitions define the sizes of the sub-matrices on the diagonal of *Z*, *i.e.*, *Z* is a diagonal matrix where each element of its diagonal is a matrix Z_i for i=1 to m+1 of size (T_s*q) where $S_s T_s = T$, and all the off-diagonal elements are zero.

In the present case, in principle it is assumed that all the coefficients b_i in expression (2) are allowed to change, so that the parameter vector b in expression (3) is empty and the parameter vector d=(b_0, b_1, …, b_6)’, which means that p=0 and q=7. It is also assumed that the maximum number of breaks M=5 and, as mentioned above, the estimations are robust to both autocorrelation and heteroskedasticity in the disturbances; the disturbances are allowed to be distributed differently across regimes as well.[47]

The guidelines for the interpretation of the results are as follows. First, the null hypothesis is of no structural breaks. Second, to select for the number of breaks, the BIC criterion works well when breaks are present, but not under the null, especially if there is serial correlation. Third, the LWZ criterion outperforms the BIC criterion under the null, but performs relatively poorly when breaks are present. Also, model selection procedures based on information criteria cannot take into account potential heterogeneity across segments, unlike the Sequential Procedure. Overall the Sequential Procedure works better, but it is not fully consistent in the presence of multiple breaks under some specifications (for instance, it is possible to reject 0 vs. 1 structural break, but not to reject the hypothesis of 0 vs. 2 structural breaks). In that case, however, one can use the *UDMax* or *WDMax* tests for the presence of at least one break. If these statistics indicate the presence of at least one break, then the final number of breaks can be decided based upon the $SupF(i+1,i)$ tests from global minimums (the number of breaks will be that for which the corresponding *SupF*( ) statistics are significant).

[47] Bai and Perron suggest M=5 to be a plausible number for most empirical applications. Also, given the situation described in Mexico this appears to be a reasonable assumption.

Finally, in general non-symmetric confidence intervals (ci) for *T* are better in the sense that they contain the true value of the changes (if any) whenever the data are non-stationary. The coverage dates (from the ci's) are adequate unless the breaks are too large or too small.

Table 1.4A presents the results from estimating expression (2) using Bai and Perron's procedure allowing all the coefficients to change across regimes.[48] Following the guidelines outlined above, the number and timing of the breaks can be determined as follows. First, the $SupF_T(k)$ tests indicate that all 5 structural breaks are statistically significant, and both the *UDMax* and *WDMax* tests are also significant. Therefore, it is safe to conclude in favor of at least one structural break, supported also by the $SupF(i+1,i)$ tests, which are significant for $i=1$ and $i=2$. Second, the Sequential Procedure identifies only one structural break on September of 1998 at the 5 percent significance level, which is fully consistent with the global optimization results obtained (not shown). Third, there is evidence of two structural breaks as indicated by the BIC criterion while the LWZ criterion indicates no structural changes, which supports the idea that the latter performs relatively poorly when breaks are present.

[48] I tested for structural breaks with other specifications like those in Table 1.1 and Table 1.2 (not presented but available upon request) with fairly similar results.

Table 1.4A. Endogenous Structural Change Tests for Mexico Using Monthly Data

(all coefficients allowed to change, *i.e.*, *p*=0, *q*=7)

Set of regressors: RHS of Equation (2)						
Max number of breaks allowed (*M*): 5						
$SupF_T(k)$ test for (fixed) number of structural breaks						
k=1	*k=2*	*k=3*	*k=4*	*k=5*	*UDMax*[1/]	*WDMax*[1/]
50.68*	47.28*	62.32*	118.95*	724.14*	724.14*	1181.86*
$SupF(i+1,i)$ test for i vs. $i+1$ structural breaks						
i=1	*i=2*	*i=3*	*i=4*	*i=5*		
22.10*	24.36*	2.85	-	-		

	Number of breaks selected
Sequential Procedure	1*
LWZ Criterion	0
BIC Criterion	2

Estimated dates[2/]				
$\hat{T}_1$	$\hat{T}_2$	$\hat{T}_3$	$\hat{T}_4$	$\hat{T}_5$
5/98	9/98**	8/99	12/00	-
(3/98-6/98)	(7/98-4/99)	(8/99-12/99)	(10/00-1/01)	-

[1/] UDMax and WDMax tests for unknown number of structural breaks.

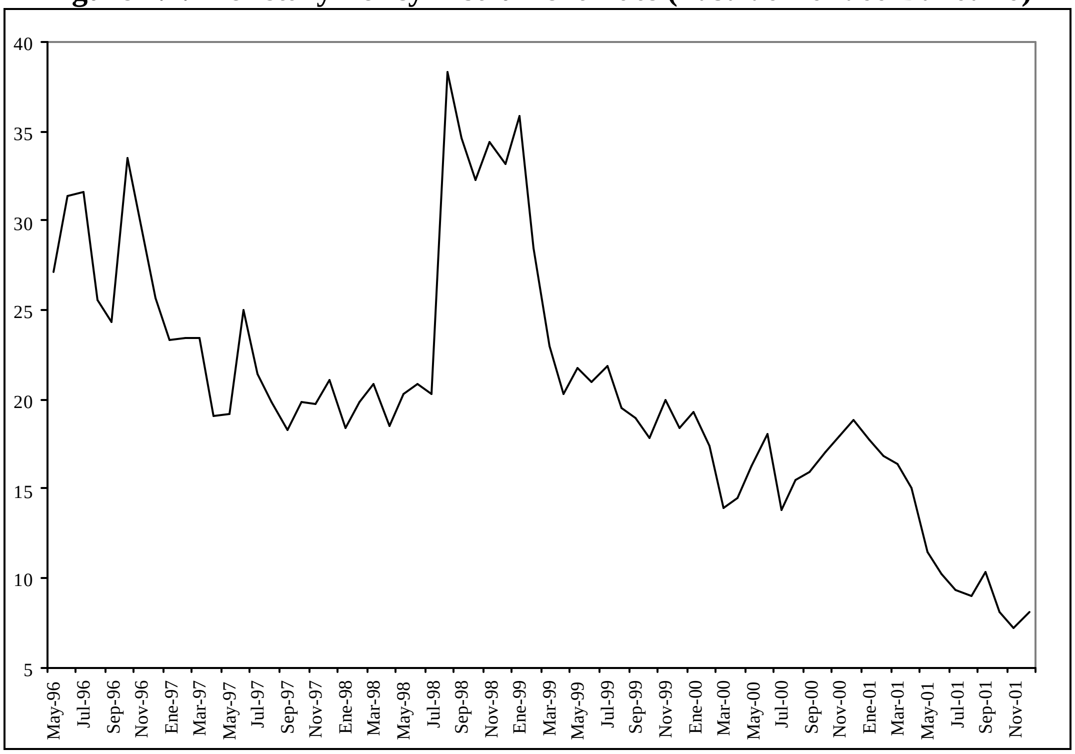
[2/] Intervals reported are significant at 5% level.

* Indicates 5% significance level.

** Selected estimated break(s).

Overall, evidence favors the presence of one structural break as indicated by the sequential procedure, since neither the BIC nor the LWZ criteria are robust to heterogeneity across regimes and the latter also performs relatively poorly when breaks are present. The break selected will therefore correspond to September of 1998. The confidence interval for that break goes from July of 1998 to April of 1999 as indicated in Table 1.4A, so that it includes the date of the adoption of the explicit inflation target in January of 1999. By looking at Figure 1.2 at the beginning of Section 3, the rebound of the exchange rate depreciation observed since October of 1996 lies exactly within this interval, which itself corresponds to the highly turbulent situation that prevailed in international markets due to the Russian crisis in 1998. Also, Figure 1.4 shows the behavior of the instrument rate for the full sample, and it is exactly during the interval obtained when the interest rate reaches its highest overall levels.

Figure 1.4. Monetary Policy Instrument Rate (*Tasa de Fondeo Bancario*)



The results from undertaking Bai and Perron's test not allowing the coefficient for the lagged dependent variable to change across regimes are presented in Table 1.4B. The evidence there points toward four to five breaks according to the sequential procedure.[49] It is interesting to notice that the interval for the break identified previously is somehow decomposed into two separate breaks in this case,

[49] At the 10 percent significance five breaks are identified whereas at the 1 percent significance there are only four breaks.

corresponding precisely to August of 1998 and May of 1999 separately. This may be an indication that the central bank of Mexico was initially forced to impose a stringent monetary policy to counterbalance the pressure from abroad, not only on the exchange rate but on the price level as well.[50] In the end, the high volatility that characterized the second half of 1998 most likely pushed the monetary authority to shift its policy rule towards the adoption of the explicit inflation target at the beginning of 1999.

Table 1.4B. Endogenous Structural Change Tests for Mexico Using Monthly Data
(lagged dep. var. not allowed to change, *i.e.*, *p*=1, *q*=6)

Set of regressors: RHS of Equation (2) except lagged dep. var.						
Max number of breaks allowed (*M*): 5						
$SupF_T(k)$ test for (fixed) number of structural breaks						
k=1	*k=2*	*k=3*	*k=4*	*k=5*	*UDMax*[1/]	*WDMax*[1/]
62.87*	131.65*	111.53*	575.49*	716.74*	716.74*	1205.38*
$SupF(i+1,i)$ test for i vs. $i+1$ structural breaks						
i=1	*i=2*	*i=3*	*i=4*	*i=5*		
212.00*	90.02*	2.54	-	-		
	Number of breaks selected					
Sequential Procedure	4-5*					
LWZ Procedure	0					
BIC Procedure	3					
Estimated dates[2/]						
$\hat{T}_1$	$\hat{T}_2$	$\hat{T}_3$	$\hat{T}_4$	$\hat{T}_5$		
8/98**	5/99**	1/00**	1/01**	-		
(6/98-9/98)	(3/99-6/99)	(11/99-3/00)	(11/00-2/01)	-		

[1/] UDMax and WDMax tests for unknown number of structural breaks.
[2/] Intervals reported are significant at 5% level.
* Indicates 5% significance level (see footnote 40).
** Selected estimated break(s).

[50] With the exception of September 1998, there were no direct interventions on the foreign exchange market by the central bank to offset capital outflows and the corresponding depreciation of the peso.

Based on these results, there are at least two plausible sub-samples that should be taken for consideration: one from May 1996 to June 1998, and another from May 1999 to December 2001. A sensible analysis is to compare the results for the full sample (May 1995 to December 2001) shown in Tables 1.1 and 1.2 with the results obtained for the samples starting on September 1998, and on May 1999, dates associated to structural breaks.[51] This comparison is presented on Table 1.5. The first three columns show the OLS estimations with NW standard errors corresponding to those in column (a) of both Table 1.1 and Table 1.2. The last three columns show the same estimations using GMM estimations.

Table 1.5. Full Sample and Suggested Sub-samples for Mexico Using Monthly Data (OLS and GMM Estimations)

	Dependent Variable. nominal overnight interest rate					
	OLS with NW standard errors			GMM estimation 1/		
	full sample	10/98-12/01	5/99-12/01	full sample	10/98-12/01	5/99-12/01
constant	-13.57**	-14.07***	-14.29**	-41.85*	-20.80**	-24.41***
	(5.30)	(5.09)	(4.95)	(23.04)	(8.59)	(7.41)
lagged nominal overnight interest rate	0.49***	0.57***	0.67***	0.28	0.49***	0.49***
	(0.10)	(0.09)	(0.08)	(0.25)	(0.14)	(0.10)
expected - announced inflation	3.34***	2.69***	1.22	2.79	2.84**	1.82**
	(0.86)	(0.98)	(0.85)	(2.02)	(1.17)	(0.87)
output gap (sa)	0.50***	0.43***	0.33***	0.53**	0.56***	0.50***
	(0.11)	(0.10)	(0.11)	(0.26)	(0.16)	(0.10)
exchange rate depreciation	0.52***	0.34**	0.23	1.32**	0.09	0.05
	(0.13)	(0.15)	(0.14)	(0.61)	(0.31)	(0.29)
govt. bond yield abroad	1.85***	1.81***	1.86***	5.22*	2.63**	3.14***
	(0.61)	(0.60)	(0.56)	(2.84)	(1.07)	(0.88)
change in terms of trade	-0.44***	-0.25**	-0.13	-0.29	-0.34	-0.25
	(0.15)	(0.13)	(0.16)	(0.34)	(0.14)	(0.14)
R Sq	0.93	0.96	0.91	0.71	0.95	0.90
Adj R Sq	0.92	0.95	0.89	0.67	0.94	0.88
Std. Error	1.99	1.63	1.38	3.98	1.71	1.49
Sum Squared Resid	193.90	84.96	47.74	759.55	93.88	55.22
F Stat	102.15	114.83	44.83	-	-	-
Prob	0.0000	0.0000	0.0000	-	-	-
J Stat	-	-	-	0.0000	0.0000	0.0000
No. of Observations	56	39	32	55	39	32

1/ Instrument list includes lags of dependent variable, lags of observed inflation and lags of explanatory variables

*, ** and *** denote 10%, 5% and 1% significance respectively

Std. Errors in parentheses

[51] This is because there are no available series for inflation expectations before May of 1996, and the nature of the estimation would require lagged information about them.

With respect to OLS with NW standard errors (the first three columns of Table 1.5) there are several interesting results. First, it appears to be some degree of interest rate smoothing in both sub-samples, as the coefficient for the lagged interest rate remains between 0 and 1 and is significant in both cases. Second, a somewhat disappointing result is that the "credibility gap" loses explanatory power in the second sub-sample. One would expect the credibility gap to become more relevant for monetary policy whenever the inflation target is in operation, relative to the case when it is not. On the other hand, one might explain this result through the idea that the central bank has followed a more flexible inflation target as inflation has diminished over time (see Figure 1.2 above).[52] Third, the coefficient for the output gap is positive and remains significant across sub-samples, which is consistent with the theoretical literature on monetary policy behavior, and suggests a stabilizing monetary policy (note that even though the coefficient falls, its implied long run value remains around 1). Fourth, the exchange rate coefficient falls monotonically and ends up becoming statistically insignificant for the sub-sample starting from May 1999, five months after the adoption of the inflation target. The occurrence of the Russian crisis and the exchange rate volatility it generated may to a good extent explain the significance of this variable for the second sub-sample. The higher stability observed since the beginning of 1999 may also explain that the exchange rate is not significant for the third sub-sample. This issue should be taken carefully since, even though the exchange

[52] I would like to thank Alberto Torres for this observation.

rate volatility has indeed fallen over time,[53] it is hard to determine *ex ante* if this is a cause or a consequence of the policy shift, and this brings about the need to take into account endogeneity issues through the use of GMM estimations. Ultimately, the fact that the exchange rate variable is significant for the first sub-sample but not for the second brings about Svensson's point regarding the conditions for inflation targeting to be successful, which include exchange rate flexibility. At the same time, the non-significance of the changes in the exchange rate after May 1999 points toward the idea that fear of floating may be a transitional phenomenon.

The last three columns of Table 1.5 show the results using GMM estimations. These estimations also show that the central bank engaged in some degree of interest rate smoothing towards the adoption of the inflation target, even though the lagged dependent variable is not significant for the full sample. With respect to the coefficient of the "credibility gap" the story is more appealing than that from OLS; this variable *gains* explanatory power after the structural break. This result supports the belief that this indicator becomes more relevant for monetary policy once the explicit inflation target is adopted, even though the coefficient is somewhat smaller and does not change monotonically in any particular direction. Again, as pointed out above, the fact that the coefficient associated to the inflation gap is smaller for the second sub-sample may be explained along the lines of a less strict inflation targeting towards the end of the sample where inflation was much lower than previously, which makes the results from both methods quite consistent.

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[53] See Werner (2001).

The coefficient of the output gap from GMM is always significant, but relatively more stable than from OLS. Even though it reaches its lowest value for the second sub-sample (after the adoption of the inflation target), the implied long run coefficient remains practically equal to 1. But one of the most striking results is perhaps that the coefficient of the exchange rate depreciation rate falls heavily and loses explanatory power even after the first break, that is, regardless of the Russian crisis and its effects during 1998. These results allow to further suspect that fear of floating was a temporary phenomenon for the Mexican experience.[54]

There is an additional matter that deserves some attention. The variables included in the estimations presented here tend to follow a trend over time, and the fact that the R-squared statistics obtained in the estimations presented above are relatively optimistic supports this idea, particularly given the inclusion of the lagged dependent variable as a repressor. For this purpose, equation (2) is estimated under the assumption that all variables are of the same order of integration, that is, they are all stationary.[55] This implies that, aside from the exchange rate depreciation, the change in terms of trade, and the *UMS26* rate, the rest of the variables are expressed in first differences to ensure stationarity.[56] By splitting the sample along the same lines as

[54] It has been argued that exchange rate volatility diminished significantly during the second half of 1999. The measured volatility indeed fell relative to that prior to January of 1999. However, there is no significant difference in the behavior of the exchange rate before the second half of 1998 and after May of 1999 (see Appendix 3). This point becomes relevant below when daily data are considered for similar exercises.

[55] I would like to thank Michael Binder for this suggestion.

[56] See Appendix 1.

before, the results continue to support the idea of a change in the behavior of the monetary authority towards the end of 1998, as shown in Table 1.6.[57]

Table 1.6. Regression in First Differences for Mexico Using Monthly Data

Dependent Variable: D(nominal overnight interest rate)		
OLS with Newey-West standard errors		
	full sample	5/99-12/01
constant	-1.22	-4.58
	(4.41)	(5.04)
D(expected - announced inflation)	2.94***	1.08
	(0.96)	(1.51)
D(output gap) (sa)	-0.23	-0.29*
	(0.30)	(0.16)
exchange rate depreciation	0.66***	0.38**
	(0.22)	(0.14)
govt. bond yield abroad	0.08	0.45
	(0.46)	(0.53)
change in terms of trade	-0.14	0.00
	(0.21)	(0.19)
R Sq	0.51	0.33
Adj R Sq	0.47	0.20
Std. Error	2.47	1.52
Sum Squared Resid	298.75	59.82
F Stat	10.39	2.56
Prob	0.0000	0.0515
No. of Observations	55	32

*, ** and *** denote 10%, 5% and 1% significance respectively
Std. Errors in parentheses

1.3.3.3. Further Analysis of The Mexican Case: Estimations Using Daily Data.

In order to take advantage of the higher frequency data available (the interest rate, the exchange rate, the *UMS26* rate, and the oil prices, which are available daily, and the figures for inflation expectations, which are available biweekly), I combine the high frequency data with lower frequency series by constructing simple approximations (linear interpolations) between the lower frequency observations, and then repeat the

[57] The problem is the limited availability of data and the information loss associated with this specification. Structural change tests for this specification are available upon request.

exercises to further explore the possibility of a change in Mexico's monetary authority's behavior towards the end of 1998.[58]

The first step is to repeat the estimations for the full sample (from May 5, 1996 to December 31, 2001) using daily data. The second step is to test for structural breaks and contrast the corresponding sub-sample estimations derived with those from monthly data. The main advantage here is that it is econometrically feasible to estimate a separate sub-sample prior to August 1998 if a break is found. Finally, in order to account for the robustness of the changes found, some alternative specifications are considered. Among these alternative specifications, the credibility gap is substituted with what is called *performance*, which is the difference between observed inflation and the corresponding inflation target, exactly as in Taylor (1998). The use of lagged observed inflation is explored as well.[59]

The first column of Table 1.7 replicates the estimation presented in column (b) of Table 1.1 but using daily instead of monthly data. The signs and the significance of the coefficients here are almost identical to their monthly counterparts, but not their magnitudes. The problem is that the results using daily data suggests the presence of a

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[58] For example, to proxy for the output gap, I assume that the rate of growth of industrial production is constant within a month, and the daily unobserved data between monthly existing observations are filled up with the implied calculations. For the case of inflation expectations, which are available biweekly, I assume that individuals revise their expectations daily at a constant rate. Therefore the corresponding unobserved series is created also using linear interpolations. The variables affected by this procedure relative to low frequency data are the credibility gap and the output gap; the oil prices for the Mexican mix available daily are used instead of the terms of trade available monthly.

[59] I wish to thank Fernando Broner and John Shea for suggesting these alternative exercises.

unit root; both the coefficient of the lagged dependent variable and the R-squared are practically 1. Also, it can be argued that there is a strong degree of simultaneity between the instrument variable and some of the regressors, and between some regressors themselves, particularly the rate of change of the exchange rate and the country risk variable. To partially address these problems, in column (b) of Table 1.7 the lagged dependent variable on the right-hand side, the exchange rate and the oil price regressors correspond to *monthly* rather than *daily* lags.[60] These results are qualitatively very similar to those in column (d) of Table 1.1, since in both cases the signs are identical and the only variable that is not significant is the lagged exchange rate depreciation which also has the wrong sign. Column (c) in Table 1.7 shows the results excluding the lagged dependent variable. The significance of all the coefficients relative to those in column (b) remains unchanged, but the exclusion of the lagged dependent variable seems to induce an upward bias in the remaining variables except the oil price changes. This probably reflects that observed interest rates affect inflation expectations and the output gap and partially illustrates the need for the use of the GMM method discussed above. The remaining two columns show alternative specifications for expression (2): column (d) includes the lagged observed inflation as an explanatory variable, while column (e) replaces the credibility gap with the difference between observed and announced inflation, labeled as *performance*. It is somewhat surprising that inflation lags remain significant since one would expect this variable to be included in inflation expectations without necessarily contradicting the

[60] It corresponds to the previous monthly average. This is why I explore the alternative specifications of equation (2) presented in Table 1.7.

assumption that they are constructed rationally. The significance of the *performance* variable allows to test for the robustness of the remaining variables. Notice that in both cases the output gap is positive and significant as well as for the case of the government bond yield and the oil price change. An interesting result is that the lagged exchange rate is not significant in any specifications and it is negative in two of them.

Table 1.7. OLS with NW Std. Errors for the Full Sample Using Daily Data for Mexico

Dependent Variable: nominal overnight interest rate					
	(a)	(b)	(c)	(d)	(e)
constant	-1.52***	-24.35***	-22.46***	-21.77***	-16.34***
	(0.58)	(3.19)	(3.60)	(3.23)	(3.76)
lagged nominal overnight interest rate	0.95***	0.56***	-	0.43***	0.57***
	(0.01)	(0.05)	-	(0.06)	(0.07)
lagged observed inflation	-	-	-	0.17***	-
	-	-	-	(0.03)	-
expected - announced inflation	0.30***	1.88***	5.83***	2.53***	-
	(0.08)	(0.37)	(0.40)	(0.37)	-
performance	-	-	-	-	0.28***
	-	-	-	-	(0.09)
output gap (sa)	0.05***	0.46***	0.75***	0.52***	0.20**
	(0.01)	(0.07)	(0.10)	(0.07)	(0.08)
exchange rate depreciation	0.04***	-	-	-	-
	(0.01)	-	-	-	-
lagged exchange rate depreciation	-	-0.05	0.1	-0.01	0.07
	-	(0.05)	(0.06)	(0.04)	(0.06)
govt. bond yield abroad	0.21***	3.07***	3.36***	2.71***	2.44***
	(0.07)	(0.39)	(0.41)	(0.39)	(0.47)
change in oil prices	-0.00	-	-	-	-
	(0.00)	-	-	-	-
lagged change in oil prices	-	-0.04***	-0.04***	-0.05***	-0.03***
	-	(0.01)	(0.01)	(0.01)	-0.01
R Sq	0.99	0.92	0.84	0.93	0.88
Adj R Sq	0.99	0.92	0.84	0.93	0.88
Std. Error	0.70	1.85	2.60	1.77	2.40
Sum Squared Resid	588.77	4061.19	8061.50	3740.72	8368.33
F Stat	17252.00	2331.52	1292.46	2182.38	1707.92
Prob	0.0000	0.0000	0.0000	0.0000	0.0000
No. of Observations	1197	1197	1197	1197	1458

*, ** and *** denote 10%, 5% and 1% significance respectively
Std. Errors in parentheses

The results using GMM presented in Table 1.8 are practically identical to those using OLS. The only difference is that for specification (a) the exchange rate depreciation is not significant using GMM as opposed to OLS where it is. The fact that excluding the lagged dependent variable clearly introduces an upward bias in other regressors (as shown in column (c)), that there are some issues of endogeneity of the exchange rate, and that the performance variable is backward looking, specifications (b) and (d) seem to be plausible for the present purposes.[61]

[61] An additional exercise separating the inflation gap into expected and announced inflation, and including lagged observed inflation was undertaken as well. See Appendix 1.

Table 1.8. GMM Estimations for the Full Sample Using Daily Data for Mexico[1/]

Dependent Variable: nominal overnight interest rate					
	(a)	(b)	(c)	(d)	(e)
constant	-1.54**	-25.52***	-23.75***	-22.95***	-16.75***
	(0.63)	(3.36)	(3.58)	(3.41)	(3.90)
lagged nominal overnight interest rate	0.96***	0.56***	-	0.44***	0.57***
	(0.01)	(0.05)	-	(0.06)	(0.07)
lagged observed inflation	-	-	-	0.16***	-
	-	-	-	(0.04)	-
expected - announced inflation	0.23***	1.77***	5.73***	2.42***	-
	(0.07)	(0.36)	(0.40)	(0.38)	-
performance	-	-	-	-	0.27***
	-	-	-	-	(0.09)
output gap (sa)	0.04***	0.45***	0.75***	0.51***	0.20**
	(0.01)	(0.07)	(0.10)	(0.07)	(0.08)
exchange rate depreciation	0.01	-	-	-	-
	(0.01)	-	-	-	-
lagged exchange rate depreciation	-	-0.07	0.09	-0.03	0.05
	-	(0.05)	(0.06)	(0.05)	(0.07)
govt. bond yield abroad	0.21***	3.20***	3.51***	2.85***	2.48***
	(0.08)	(0.41)	(0.41)	(0.41)	(0.48)
change in oil prices	-0.00	-	-	-	-
	(0.00)	-	-	-	-
lagged change in oil prices	-	-0.05***	-0.04***	-0.05***	-0.03***
	-	(0.01)	(0.01)	(0.01)	(-0.01)
R Sq	0.99	0.92	0.84	0.93	0.88
Adj R Sq	0.99	0.92	0.84	0.93	0.88
Std. Error	0.71	1.85	2.60	1.77	2.40
Sum Squared Resid	595.69	4065.51	8064.20	3738.12	8355.91
J Stat	0.0000	0.0000	0.0000	0.0000	0.0000
No. of Observations	1196	1196	1196	1196	1457

1/ Instrument list includes lags of dependent variable, lags of observed inflation and lags of explanatory variables
*, ** and *** denote 10%, 5% and 1% significance respectively
Std. Errors in parentheses

1.3.3.4. Multiple Endogenous Structural Changes and Sub-sample Results.

As for the case of monthly data, the natural step to test for the presence of structural breaks. All the specifications shown in Table 1.7 (and Table 1.8) were subject to Bai and Perron's procedure.[62] The results with respect to the occurrence of structural breaks remain practically unchanged relative to those obtained for the case of

[62] See Appendix 2: Table A2.1 through Table A2.8.

monthly data presented in Table 1.4A and Table 1.4B previously. For the case where all the coefficients of equation (2) are allowed to change, there is evidence of only one structural break according to the sequential method at the five percent significance level, which corresponds to September 22 of 1998. The confidence interval goes from September 15, 1998 to April 27, 1999, fairly similar to the results using monthly data. This is interesting because the change is identified at the time where exchange rate volatility was relatively high in light of the Russian in August 1998. Whenever the lagged dependent variable is not allowed to change, three breaks are identified, which correspond to the beginning of June 1998, the beginning of February 1999, and the beginning of April 2001.

With the use of *monthly* rather than *daily* lags for the dependent variable on the right-hand side of equation (2) four breaks are identified, both when this coefficient is allowed to change across regimes and when it is not. These breaks correspond to the beginning of June 1998, the beginning of February 1999, mid November 1999, and mid November 2000, all consistent with the confidence intervals of the breaks identified in Table 1.4B above. The tests that correspond to column (e) support the presence of four breaks for OLS and three for GMM, also occurring within the vicinity of the previous ones. The structural break tests for the rest of the specifications of Table 1.7 and Table 1.8 provide similar results. What is key for my purposes is that in all cases one break is identified to occur some time around the third quarter of 1998, while another is identified to occur some time within the first five months of 1999 (see below).

Following the exercises using monthly data, the next step is to estimate the alternative specifications in Table 1.8 for expression (2) for different sub-samples as indicated by the application of Bai and Perron's procedure. In principle, two sub-samples are explored: from May 5, 1996 to the end of July 1998 (to exclude the high volatility episode generated by the Russian crisis in August of that year); and from May 1999 to December 2001.[63] Tables 1.9 through 1.11 repeat the GMM estimation results that correspond to those in columns (b), (d) and (e) of Table 1.8 for the full sample, and their respective *before* and *after* sub-samples.[64] The idea is precisely to illustrate the changes in the magnitude and explanatory power of the variables to infer any possible changes in the behavior of the central bank. As mentioned previously, the credibility gap and the output gap constitute the core variables for monetary policy, standard in the literature about policy rules (the conventional variables, while the rest of the variables may account for external factors possibly relevant in small open economies. It is worth mentioning that the country risk variable is relevant in these economies to the extent that they are dependent on foreign capital. The better the perception of the markets abroad, the more likely for capital to enter these countries. This may affect monetary policy both directly (that is precisely the rationale for the inclusion of this variable explicitly in (2) above) and indirectly through exchange rate changes (the rationale for using GMM estimations).

[63] It will also be interesting to explore the behavior of the coefficients of equation (2) exactly in the period of highest turbulence, that is, between the Asian crisis and the beginning of 1999. Another interesting exercise would be to study the behavior of this specification towards the end of the year 2000, which is where the last break has been identified.

[64] Analogous results using Newey-West standard errors are also available upon request. The results are practically identical to those presented here. Exercises using the real *ex ante* interest rate as the dependent variable were also undertaken with strikingly similar results (also available upon request).

Table 1.9 shows the results (using daily data) for the full sample and the selected sub-samples for specification in (b) of Table 1.8. It is interesting that the lag of the dependent variable is not significant before the adoption of the target, which may suggest that interest rate smoothing was not a priority at the time. The coefficient of the credibility gap remains very stable across samples, increasing only slightly and perhaps not significantly. The coefficient for the output gap falls for the second sub-sample to less than one half of its value during the first one, but it is statistically significant in both. A more stable macroeconomic environment could explain this result, but the behavior of the output gap rejects this conjecture. Instead, the fact that output was above its potential level (see Appendix 3) for the second sub-sample should suggest that the central bank would respond more strongly to this variable. A third possibility is that the central bank was more strict in terms of the applicability of inflation targeting and was more willing to "accommodate" changes in the output gap (relative to the inflation gap). The lagged exchange rate depreciation rate is strongly significant in the first sub-sample (recall that this is not explained by external volatility since the Russian crisis is excluded) but it clearly loses significance for the second part, *i.e.*, after the adoption of the target. A similar pattern is observed for the oil price inflation. Finally, it is worth noting that the government bond yield abroad (the country risk variable) is significant in both sub-samples. This clearly suggests that the perception that investors have about the country is relevant for monetary policy.

Table 1.9. GMM Estimations for the Full Sample and Selected Sub-samples Using Daily Data for Mexico[1/] (specification in (b) of Table 1.8)

Dependent Variable: nominal overnight interest rate			
	Full Sample	Before	After
constant	-25.52***	-2.51	-13.57***
	(3.36)	(3.49)	(2.38)
lagged nominal overnight interest rate	0.56***	-0.10	0.67***
	(0.05)	(0.08)	(0.05)
expected - announced inflation	1.77***	1.34***	1.36***
	(0.36)	(0.28)	(0.41)
output gap (sa)	0.45***	0.99***	0.40***
	(0.07)	(0.23)	(0.07)
lagged exchange rate depreciation	-0.07	0.13***	-0.08
	(0.05)	(0.04)	(0.06)
govt. bond yield abroad	3.20***	2.33***	1.75***
	(0.41)	(0.32)	(0.28)
lagged change in oil prices	-0.05***	-0.04***	-0.01
	(0.01)	(0.01)	(0.01)
R Sq	0.92	0.64	0.92
Adj R Sq	0.92	0.64	0.92
Std. Error	1.85	1.07	1.19
Sum Squared Resid	4065.51	360.53	975.27
J Stat	0.0000	0.0000	0.0000
No. of Observations	1196	304	694

1/ Instrument list includes lags of dependent variable, lags of observed inflation and lags of explanatory variables

*, ** and *** denote 10%, 5% and 1% significance respectively

Std. Errors in parentheses

Since the specification in (c) of Table 1.8 shows the bias introduced by excluding the lagged dependent variable as a regressor, there is no further analysis of the corresponding sub-samples. Instead, Table 1.10 shows the results for the full sample and the selected sub-samples for specification in (d) of Table 1.8, where lagged observed inflation is included as an explanatory variable.

Table 1.10. GMM Estimations for the Full Sample and Selected Sub-samples Using Daily Data for Mexico[1/] (specification in (d) of Table 1.8)

Dependent Variable: nominal overnight interest rate			
	Full Sample	Before	After
constant	-22.95***	4.88	-11.08***
	(3.41)	(4.54)	(3.37)
lagged nominal overnight interest rate	0.44***	-0.12	0.63***
	(0.06)	(0.09)	(0.06)
lagged observed inflation	0.16***	0.01	0.07
	(0.04)	(0.06)	(0.06)
expected - announced inflation	2.42***	1.18***	1.42***
	(0.38)	(0.30)	(0.42)
output gap (sa)	0.51***	0.93***	0.42***
	(0.07)	(0.22)	(0.07)
lagged exchange rate depreciation	-0.03	0.16***	-0.07
	(0.05)	(0.04)	(0.06)
govt. bond yield abroad	2.85***	1.61***	1.46***
	(0.41)	(0.42)	(0.39)
lagged change in oil prices	-0.05***	-0.03***	-0.01*
	(0.01)	(0.01)	(0.01)
R Sq	0.93	0.40	0.92
Adj R Sq	0.93	0.39	0.92
Std. Error	1.77	1.00	1.18
Sum Squared Resid	3738.12	295.41	960.30
J Stat	0.0000	0.0000	0.0000
No. of Observations	1196	304	694

1/ Instrument list includes lags of dependent variable, lags of observed inflation and lags of explanatory variables

*, ** and *** denote 10%, 5% and 1% significance respectively

Std. Errors in parentheses

Qualitatively, the results in Table 1.9 are very similar to those in Table 1.10. Notice that, as for the first case, the lagged dependent variable is significant only after the adoption of the inflation target. Also, despite the fact that lagged inflation is significant for the full sample, it is not so for any of the two sub-samples. The coefficient for credibility gap is significant in both sub-samples and it also tends to be higher for the second, supporting the idea of a more strict regime for that period. The output gap is significant in both sub-samples as well. The reduction in the point estimate also points toward the conjecture of more strict inflation targeting after its adoption in 1999. The loss of significance of the rate of change in the exchange rate allows to speculate about the transitory nature of fear of floating in Mexico. The remaining two variables observe similar results to those in Table 1.9 with the exception that the oil price inflation is (marginally) significant for the second sub-sample in the specification of Table 1.10.

Table 1.11 corresponds to specification (e) of Table 1.8. Instead of using the credibility gap, the *performance* variable is utilized as a regressor (clearly this implies that the lagged observed inflation has to be excluded from the estimation). The reason is, as explained, to test for the robustness of other variables through avoiding the endogeneity of inflation expectations embedded in the inflation gap measure. In this case the lagged interest rate is significant in both sub-samples, but the coefficient for the first is less than one fourth of the coefficient for the second and this difference is statistically significant. The fact that the *performance* variable loses significance for the second sub-sample is consistent with the result for lagged observed inflation in Table 1.10, suggesting that the nature of the policy rule for Mexico is forward rather than backward looking. The rest of the results are qualitatively the same as those from the previous specifications, except for the oil price inflation, which is not significant for any sub-sample.

Table 1.11. GMM Estimations for the Full Sample and Selected Sub-samples Using Daily Data for Mexico[1/] (specification in (e) of Table 1.8)

Dependent Variable: nominal overnight interest rate			
	Full Sample	Before	After
constant	-16.75***	-10.83***	-11.76***
	(3.90)	(2.28)	(3.84)
lagged nominal overnight interest rate	0.57***	0.16**	0.77***
	(0.07)	(0.08)	(0.04)
performance	0.27***	0.30***	0.11
	(0.09)	(0.10)	(0.10)
output gap (sa)	0.20**	0.87**	0.30***
	(0.08)	(0.36)	(0.07)
lagged exchange rate depreciation	0.05	0.41***	-0.10
	(0.07)	(0.08)	(0.06)
govt. bond yield abroad	2.48***	2.77***	1.57***
	(0.48)	(0.35)	(0.41)
lagged change in oil prices	-0.03***	-0.00	-0.01
	(-0.01)	(0.02)	(0.01)
R Sq	0.88	0.80	0.91
Adj R Sq	0.88	0.80	0.91
Std. Error	2.40	1.97	1.23
Sum Squared Resid	8355.91	2155.11	1041.69
J Stat	0.0000	0.0000	0.0000
No. of Observations	1457	565	694

1/ Instrument list includes lags of dependent variable, lags of observed inflation and lags of explanatory variables
*, ** and *** denote 10%, 5% and 1% significance respectively
Std. Errors in parentheses

Overall, the results can be summarized as follows. First, the inflation gap has gained importance for monetary policy in Mexico after the adoption of an explicit inflation target relative to other policy variables. Second, the output gap has remained relevant for monetary policy before and after 1999, but the fall in the coefficient supports the idea of more strict inflation targeting after that year. Third, the rate of change of the exchange rate has lost importance for the central bank of Mexico after

1999. This suggests that the fear of floating phenomenon is temporary or rather transitional, and there is a movement toward greater exchange rate flexibility once the inflation target is in operation.[65,66] Fourth, the government bond yield abroad remains significant both before and after the break, suggesting that country risk factors are taken into account as well. Finally, the terms of trade variable tends to be less relevant after 1999.

The idea that the fear of floating phenomenon is temporary and the highly volatile environment experienced in Mexico during the second half of 1998 allows to believe that there may be a non-linearity in the reaction function of the central bank. In *extremely* difficult times, it is possible that the monetary authority engages in some sort of signaling game where it uses the interest rate to stabilize the foreign exchange market. A simple approach to test for the presence of a non-linearity would be to include a quadratic term of exchange rate depreciation as a regressor. Instead I estimate (2) using a *dummy* variable to distinguish the *before* and the *after* periods interactive with the exchange rate depreciation.[67] Table 1.12 shows that the interactive term is negative and significant, indicating the presence of this non-linearity.

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[65] Alternatively, this may suggest that monetary policy instrumentation took into account some sort of monetary conditions index along the lines of Ball (1999).

[66] It may be argued that this is nothing but a result that the exchange rate not only has been more stable since 1999, but its rate of depreciation has diminished as well (see previous discussion for the monthly data). Despite the fact that there is a difference in the volatility of the exchange rate depreciation rate over time, it appears to be stationary (see Appendix 1 and Appendix 3).

[67] This variable (dummy target) takes values of 1 under inflation targeting and zero otherwise (consistent with the structural change results).

Table 1.12. GMM Estimations for the Full Sample Using Daily Data for Mexico[1/] (testing for non-linearity)

Dependent Variable: nominal overnight interest rate	
constant	-25.33***
	(3.46)
lagged nominal overnight interest rate	0.57***
	(0.06)
expected - announced inflation	1.71***
	(0.36)
output gap (sa)	0.44***
	(0.07)
lagged exchange rate depreciation	0.02
	(0.05)
lagged exch. rate dep. * dummy target	-0.24**
	(0.10)
govt. bond yield abroad	3.17***
	(0.43)
lagged change in oil prices	-0.04***
	(0.01)
R Sq	0.92
Adj R Sq	0.92
Std. Error	1.84
Sum Squared Resid	4010.04
J Stat	0.0008
No. of Observations	1196

1/ Instrument list includes lags of dependent variable,
lags of observed inflation and lags of explanatory variables
*, ** and *** denote 10%, 5% and 1% significance respectively
Std. Errors in parentheses

An alternative approach is to estimate (2) for the highly volatile episode after the Asian crisis in 1997. Table 1.13 shows the results from estimating (2) from the beginning of January to the end of October of 1998. The exchange rate heavily explains the instrument variable, since the coefficient not only is significant at the 1 percent level but it's among the highest for the estimated sub-samples. At the same time, the credibility variable is not significant, and the coefficient for the output gap is also among the highest. Clearly, the idea of a non linearity should be explored in more detail in order to understand this phenomenon and the results obtained.

Table 1.13. GMM Estimations between January and October of 1998 Using Daily Data for Mexico[1/] (testing for non-linearity)

Dependent Variable: nominal overnight interest rate	
constant	-33.86***
	(3.25)
lagged nominal overnight interest rate	0.31***
	(0.06)
expected - announced inflation	-0.25
	(0.80)
output gap (sa)	1.48***
	(0.25)
lagged exchange rate depreciation	0.32***
	(0.11)
govt. bond yield abroad	5.00***
	(0.44)
lagged change in oil prices	-0.03***
	(0.01)
R Sq	0.93
Adj R Sq	0.93
Std. Error	1.74
Sum Squared Resid	633.59
J Stat	0.0000
No. of Observations	217

1/ Instrument list includes lags of dependent variable, lags of observed inflation and lags of explanatory variables
*, ** and *** denote 10%, 5% and 1% significance respectively
Std. Errors in parentheses

The results presented so far constitute clear evidence of a change in the behavior of the central bank of Mexico after the adoption of the inflation target in January 1999. This is reflected by the observed change in the relative importance of different variables for monetary policy. Before 1999, the exchange rate played a key role for monetary policy implementation, and conventional variables such as the inflation gap were relatively less relevant. However, once the inflation target was put in place, conventional variables gained importance and the exchange rate lost relevance. However, it is important to keep in mind that, between 1995 and 1999, Mexico underwent significant changes and was subject to numerous disturbances. Along with the announcement of the adoption of the inflation target, after 1999 international markets observed greater stability, which might have played a role in the observed changes in monetary policy. This might have helped the central bank to gain credibility and, at the same time, to produce an important reduction of the exchange rate passthrough, two factors that may explain part of the results in this paper.

Mexico has nonetheless accumulated more than 50 billion in international reserves in the past years and, despite exchange rate volatility has fallen to levels comparable with those in other inflation targeting economies such as New Zealand and Canada, interest rate volatility remains relatively higher. This brings forward the need to study those countries to put the Mexican case in context in terms of the changes around the implementation of the target.

1.4. Evidence from Canada and New Zealand.

The purpose of this section is to present some preliminary evidence intended to explore whether the adoption of an explicit inflation target in New Zealand and Canada has affected the way their central banks respond to changes in the exchange rate and other external factors. The main reason to exploring these two countries is that both are small open economies that follow an inflation target under (official) exchange rate flexibility. These countries are characterized by currencies that are sensitive to fluctuations of prices of resource-based commodities, and they are highly integrated to financial markets. Consequently the role of fluctuations in external markets is key for monetary policy in these countries. Also, New Zealand and Canada first implemented explicit inflation targets as their monetary policy prescription, and, along with Australia, are considered in the literature as the benchmark or reference case for the analysis of this policy.

1.4.1. The Case of New Zealand From 1985 to 2001.

1.4.1.1. Monetary Policy Overview: Adoption of Inflation Targeting.

New Zealand underwent significant reforms during the second half of the eighties, when inflation reached historical highs and the country suffered from a severe recession that was extended until 1989. In addition to fiscal, trade and other structural reforms, important monetary measures were undertaken, including a comprehensive financial liberalization and the termination of foreign exchange and interest rate controls.

The abandonment of an exchange rate anchor in 1984 created the need for an alternative means to control inflation at the time. By the end of that year, in an attempt to regain inflation control, the Reserve Bank of New Zealand adopted a policy known as the “full funding” rule. The goal was to manage the rate of growth of primary liquidity, where government bonds were issued to offset all other liquidity injections to the economy. In 1986, the central bank first engaged in open market operations to target the liquidity required for large-scale inter-bank operations (the level of settlement cash), and made daily announcements of the rates at which it was willing to provide for extra liquidity whenever necessary. The observed volatility of interest rates and the sharp depreciation that the exchange rate suffered in 1988 proved that the relationship between the primary liquidity target and the velocity of money was highly unstable. Even though this meant that the settlement cash target had limited macroeconomic significance, it remained as the instrument for monetary policy until 1999, since the central bank realized that it was not the level but the ability to change this target what ultimately could influence financial markets.[68]

The adoption of an explicit inflation target in New Zealand was in February of 1990, after the disinflation program that started in 1985 was almost completed; while yearly headline inflation was almost 20 percent in mid 1987, by the end of 1989 it was well below 7.5 percent, as shown in Figure 1.5.[69] The goal was to bring inflation within 3 to 5 percent by the end of 1990, 1.5 to 2.5 percent by the end of 1991 and 0 to 2 percent by the end of 1992. For the first year and a half of the operation of the inflation target, even though disinflation continued, the real economy did not show any signs of recovery since negative rates of growth and increased unemployment were observed. The Iraqi invasion of Kuwait and the continued recession induced the monetary authority to reschedule the timing of the inflation targets one year forward in February of 1991, and the exchange rate received close attention from the monetary authority, since it consistently depreciated until the first half of 1992, when the economy started to recover.

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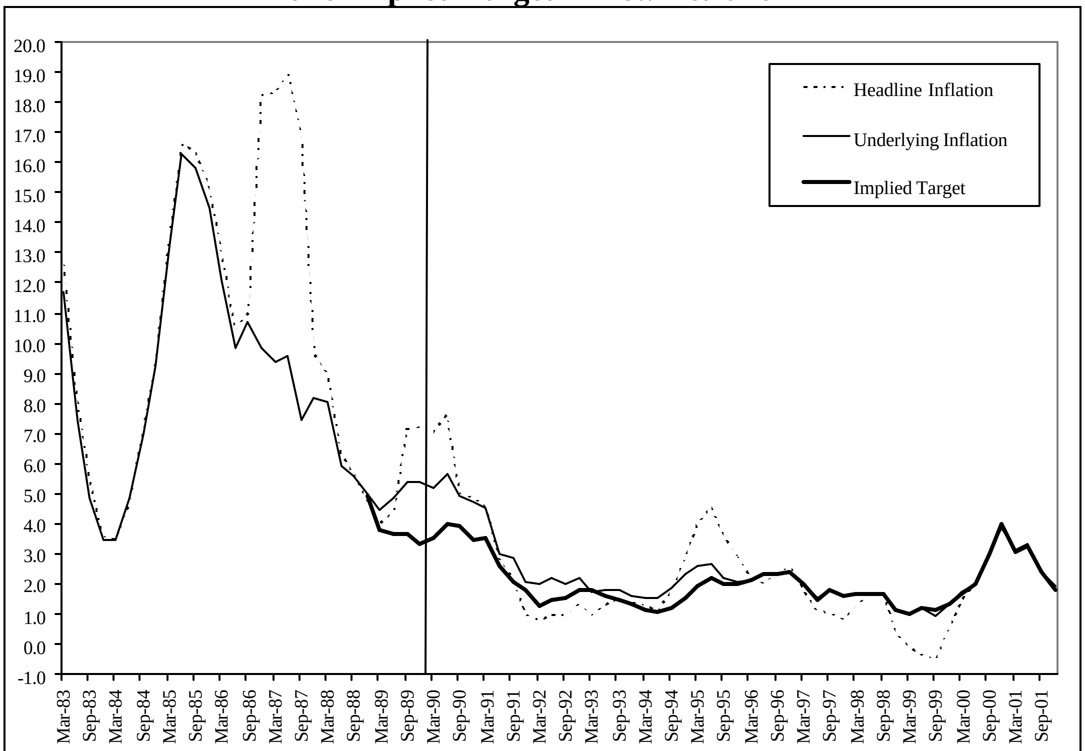
[68] See Reserve Bank of New Zealand, “The Evolution of Monetary Policy Implementation”, www.rbnz.govt.nz

[69] Headline inflation refers to CPI inflation. Core or Underlying inflation excludes from inflation measures the prices of the most volatile products (or services) included in the CPI. The implied target was provided directly from the Reserve bank of New Zealand and it is a measure consistent with the bank’s inflation, output and other variables forecasts and its interest rate projections.

Figure 1.5. Underlying Inflation, Headline Inflation and Implied Target in New Zealand*



*The inflation targets are point targets as noted above. The graph plots an implied target series provided by the Reserve Bank of New Zealand (see footnote 69).

Box 1.2. Monetary Policy in New Zealand from 1985 to 2001

-Floating since 1984 (after collapse of exchange rate regime).
-Liquidity management rule up to 1986 (growth of primary liquidity).
-Settlement cash target from 1986 to 1999.
-Unstable relationship between primary liquidity target and the velocity of money.
-Adoption of scheme: February 1990 (CPI target range).
-External shocks: Iraq-Kuwait (1991).
-Use of MCI since 1997, (currently of secondary importance).
-Instrument: Overnight Cash Rate for inter-bank transactions (adopted in 1999).
-Reduced inflation from around 8% in 1989 to about 2% in 2001.

Around 1995, some signs of overheating emerged, and there was a danger of breaking the established inflation target during the second quarter of 1996. The political arena at the time was such that goals for unemployment and growth were to be added to monetary policy.[70] By the end of that year, the inflation target had to be re-adjusted for the second time to a range from 0 to 3 percent instead of 0 to 2 percent. Starting formally in 1997 and until recently, the stance of monetary policy was

[70] This may suggest that new Zealand went from very strict to less strict inflation targeting.

summarized by what the Bank of New Zealand called the Monetary Conditions Index (MCI), which measured inflationary pressures from interest rate and exchange rate adjustments. The monetary authority established a band for the MCI to serve as a reference to the intended path for monetary policy. However, the observed MCI was consistently off the band due to exchange rate fluctuations and highly volatile interest rates. Arguably, the observed exchange rate fluctuations at the time responded more to structural than portfolio adjustments, and thus there was no need for the excessive interest rate adjustments. These facts finally led the monetary authorities to abandon the cash target and instead adopt the overnight cash rate (OCR) in March of 1999 as the monetary policy instrument. By managing this rate directly, the central bank has been able to provide a range for overnight inter-bank transactions rates and simplify the operational aspect of monetary policy, leaving the MCI to a secondary level.

The OCR remains as the monetary policy instrument and is revised every 6 weeks on pre-announced dates (as opposed to the previous cash target regime, where the adjustments were made at undetermined times), and commercial banks are provided with "standing facilities", allowing them to get extra liquidity from the central bank if necessary at a penalty rate and constitute the reference that limits interbank interest rates. There are also daily liquidity management operations for day-to-day liquidity adjustments in case of forecast errors. It is important to note that some authors argue that the focus of monetary policy in New Zealand went from looking closely to the exchange rate and its effects on inflation to more long-term variables, including the

MCI first (which also included the exchange rate but to a lower extent than before) and the output gap second.[71]

1.4.1.2. Estimating a Policy Reaction Function for New Zealand From 1988 to 2001.

As mentioned before, in this section expression (2) in Section 3 is estimated for the case of New Zealand from 1988 to 2001.[72] The purpose is to offer some preliminary evidence on the possibility of a change in the behavior of the monetary authority before and after the adoption of the inflation target in a similar fashion to the evidence presented for Mexico. There are several considerations to take into account. First, the frequency of the data is quarterly rather than monthly, which prevents for a direct comparison with the experience of Mexico. Second, the dependent variable utilized is the cash rate. Third, Statistics New Zealand provided the observations for the inflation target to generate the credibility gap.[73] Fourth, the exchange rate is the trade weighted exchange rate index available for that country. And fifth, New Zealand does not have a long-term external bond like that of Mexico, so the 10-year external bond is used instead.

Table 1.14 and Table 1.15 show the results from estimating four alternative specifications for expression (2) for New Zealand. Columns (a) and (c) of Table 1.14

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[71] See Brash (1998) and Clinton (2001).

[72] Unfortunately, there is no data for inflation expectations before 1988 and constructing a series is difficult since bonds indexed to inflation were introduced in November 1995. Using long *versus* short term bond yields is a possibility but the results (not shown) are very unstable.

[73] I wish to thank Loretta Dobbs, Ronald Mair and Frank Overend in Statistics New Zealand for their valuable help in obtaining these and other historical data for New Zealand used in these exercises.

show the results for the full sample with and without the lagged dependent variable as a regressor respectively using contemporaneous changes in both the trade weighted exchange rate and the terms of trade. Columns (e) and (g) of Table 1.15 show the results for the full sample with and without the lagged dependent variable as a regressor as well, but use lagged observations for the exchange rate depreciation and the terms of trade changes. Columns (b) and (d) of Table 1.14 and (f) and (h) of Table 1.15 present the corresponding results for each of these specifications for the sub-sample starting at the end of 1991 that corresponds to the inflation targeting period exclusively (see below).

Table 1.14. GMM Estimations for the Full Sample and Selected Sub-samples Using Quarterly Data for New Zealand[1/]

Dependent Variable: nominal overnight cash rate				
	(a)	(b)	(c)	(d)
	Full Sample	Second Part	Full Sample	Second Part
constant	1.84*	1.00	2.50*	2.41
	(1.00)	(1.60)	(1.25)	(2.31)
lagged nominal overnight cash rate	0.23	0.38**	-	-
	(0.16)	(0.15)	-	-
expected - announced inflation	0.63**	0.79*	0.90***	1.34**
	(0.27)	(0.42)	(0.22)	(0.49)
output gap (hp)	0.62***	0.53***	0.72***	0.76***
	(0.16)	(0.17)	(0.15)	(0.17)
trade weighted exchange rate depreciation	0.03	0.01	0.13	0.18
	(0.30)	(0.24)	(0.31)	(0.33)
govt. bond yield abroad	0.44**	0.41**	0.56***	0.54
	(0.19)	(0.18)	(0.17)	(0.33)
change in terms of trade	0.21	0.14	0.27**	0.25
	(0.14)	(0.18)	(0.13)	(0.21)
R Sq	0.87	0.55	0.83	0.22
Adj R Sq	0.85	0.47	0.82	0.10
Std. Error	1.34	1.30	1.49	1.69
Sum Squared Resid	83.08	52.13	104.45	91.12
J Stat	0.0000	0.0000	0.0000	0.0000
No. of Observations	53	38	53	38

1/ Instrument list includes lags of dependent variable, lags of observed inflation and lags of explanatory variables
*, ** and *** denote 10%, 5% and 1% significance respectively
Std. Errors in parentheses

As opposed to the case of Mexico, the structural change tests for New Zealand under these alternative specifications do not identify significant structural changes around the adoption of the inflation target. Instead, the tests identify a change that occurred some time between the second quarter of 1996 and the second quarter of 1997.[74] Unfortunately, the limited availability of data does not allow comparison of New Zealand's proposed Taylor rule for before and after that date, and the purpose of this paper is to explore any possible changes around the adoption of an explicit inflation target. For these reasons the sub-sample explored starts from the last quarter of 1991.[75]

It is worth to note several results. First, for the full sample the credibility gap is positive and significant in all four cases (columns (a) and (c) of Table 1.14 and columns (e) and (g) of Table 1.15), and excluding the lagged dependent variable pushes the value of the estimates upward. Second, the output gap is also positive and significant for the full sample in all four cases, with the omission of the lagged dependent variable having the same "upward" effect as for the credibility gap. Third, the long run interest rate abroad shows the same pattern. Fourth neither the exchange rate nor the terms of trade variable are significant regardless of whether they are contemporaneous or lagged observations.

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[74] See Appendix 5.

[75] The selection of this date is not fully arbitrary. First, it can be argued that during the first few months of operation of the target there was still some "noise". Second, in January of 1991 there was a negative external shock due to the Iraq-Kuwait conflict mentioned previously. Finally, the economy was still suffering from an ongoing recession. Arguably, partially leaving these factors outside the sub-sample makes the comparison against Mexico more plausible.

Table 1.15. GMM Estimations for the Full Sample and Selected Sub-samples Using Quarterly Data for New Zealand[1/] (continued)

Dependent Variable: nominal overnight cash rate				
	(e)	(f)	(g)	(h)
	Full Sample	Second Part	Full Sample	Second Part
constant	1.97*	1.22	2.61**	1.96
	(1.14)	(1.55)	(1.24)	(1.59)
lagged nominal overnight cash rate	0.23	0.35**	-	-
	(0.14)	(0.15)	-	-
expected - announced inflation	0.64**	0.83*	0.90***	1.39***
	(0.30)	(0.42)	(0.22)	(0.37)
output gap (hp)	0.62***	0.53***	0.73***	0.73***
	(0.17)	(0.18)	(0.18)	(0.19)
lagged trade weighted exchange rate depreciation	-0.03	0.00	-0.02	-0.02
	(0.04)	(0.04)	(0.04)	(0.05)
govt. bond yield abroad	0.43**	0.41**	0.55***	0.60**
	(0.19)	(0.19)	(0.18)	(0.24)
lagged change in terms of trade	0.02	0.05	0.06	0.07
	(0.07)	(0.10)	(0.07)	(0.10)
R Sq	0.85	0.53	0.83	0.39
Adj R Sq	0.84	0.44	0.81	0.29
Std. Error	1.40	1.33	1.55	1.49
Sum Squared Resid	91.26	54.88	105.31	71.16
J Stat	0.0000	0.0000	0.0000	0.0000
No. of Observations	53	38	53	38

1/ Instrument list includes lags of dependent variable, lags of observed inflation and lags of explanatory variables
*, ** and *** denote 10%, 5% and 1% significance respectively
Std. Errors in parentheses

Since the lagged dependent variable is significant, it is safe to ignore columns (c) and (d) of Table 1.14 and columns (g) and (h) of Table 1.15. The coefficient for the inflation gap is larger and the coefficient for the output gap is smaller for (b) and (f) than for (a) and (e). The interest rate abroad, however, remains stable around 0.4 across samples. These results are interesting since, for the case of Mexico with monthly data (last three columns of Table 1.5 specifically), both the coefficient for the inflation gap and the coefficient for the output gap are smaller for the second part relative to the full sample.[76] Also, the exchange rate depreciation rate (contemporary or lagged), is not significant at all, regardless of the sample and the specification,[77] which is the case for the change in the terms of trade variable as well. The fact that the terms of trade and the exchange rate variables are not significant is somewhat surprising in the sense that the anecdotal evidence mentioned above suggests that these variables were of great importance for monetary policy in New Zealand (particularly the exchange rate) during the first few years of operation of the (implicit) inflation target. However, as Bernanke *et al* (1999) point out, "… it was unclear [prior to 1997] whether the exchange rate entered policy decisions as a determinant of future inflation or as a goal unto itself".[78] Moreover, the Bank of New Zealand took advantage of an existing "terms of trade escape clause" between 1990 and 1991 to accommodate external shocks that affected output at the time, which partially supports the results presented. Finally, since it is not straightforward to associate a change in the behavior of the Reserve Bank of New Zealand with the adoption of an explicit inflation target in that country, a more gradual policy shift relative to Mexico probably occurred. Alternatively, the fact that inflation was much lower in New Zealand at the time of the adoption may explain these findings.

[76] A similar pattern can be identified for the case of Mexico with daily data (see Table 1.9 through Table 1.11).

[77] The only case where the coefficient for exchange rate depreciation presented a similar behavior to that in Mexico was when the dependent variable was the real *ex-ante* short-term interest rate (not reported).

[78] Bernanke *et al*, p. 98.

1.4.2. The Case of Canada From 1989 to 2001.

1.4.2.1. Monetary Policy Overview: From Money Targeting to Inflation Targeting.

Canada was the second country that adopted an explicit inflation target following New Zealand, but the conditions for its implementation were somewhat different, since the shift was less "institutionalized" than in New Zealand.[79] Towards the end of 1982, the Central Bank of Canada decided to drop *M1* as its intermediate target for monetary policy, and core inflation reached about 12 percent that year. The monetary authority failed to establish an alternative monetary target that could work as a nominal anchor, but nonetheless inflation fell and averaged 5 percent between 1985 and 1990. In 1988, Bank of Canada decided to explicitly promote price-stability as its long-term goal, but it was not until February of 1991 when it decided to formalize the shift towards the pursue of an explicit inflation target. The overnight interest rate for large valued inter-bank transactions became the monetary policy tool; by establishing an operating range for this interest rate, the monetary authority managed to conduct monetary policy in order to meet the policy goal.

Some documents from the Central Bank of Canada itself point out that it is not fully clear why Canada adopted an inflation target in February of 1991. The country entered a deep recession in 1990, allowing inflation to keep its downward trend (reaching 4.2 percent that year), and there were no major events in the foreign

[79] New Zealand's inflation targeting is more "formal" than Canada's in the sense that in the former the institutional framework is relatively more strict in terms of its implementation (see Bernanke *et al* [1999]).

exchange market. Large risk premiums that developed at the time due to increasing public and external debt, and a somewhat unstable political environment along with lack of credibility may have been the spark for the policy shift. The central bank argued that the idea was to make clear to the public the rate of progress made in reducing inflation in order to increase people's confidence in monetary policy.[80]

Along the same lines as New Zealand, rather than adopting point-targets for inflation, the Central Bank of Canada established a target range of 2 percent around a midpoint set at 3 percent at the end of 1992, 2.5 percent in June of 1994 and 2 percent in December of 1995. Despite some inflationary pressures that emerged in 1991 as a consequence of the oil price shock associated with the conflict in Kuwait and an increase in domestic taxes, the inflation target was undershot in 1991 and 1992, as shown in Figure 1.6. These events were considered as one-time price changes and therefore there was no need for interest rate changes. Nonetheless, as of 1993, concerns about increasing unemployment developed and the exchange rate consistently depreciated. Towards the second half of 1995, a heated debate about the lack of recovery of the economy emerged, with some blaming slow growth on excessively aggressive inflation reductions. However, the bank argued that external factors such as the Tequila crisis and increases in international interest rates, along with additional domestic structural changes were key to the observed slow recovery.

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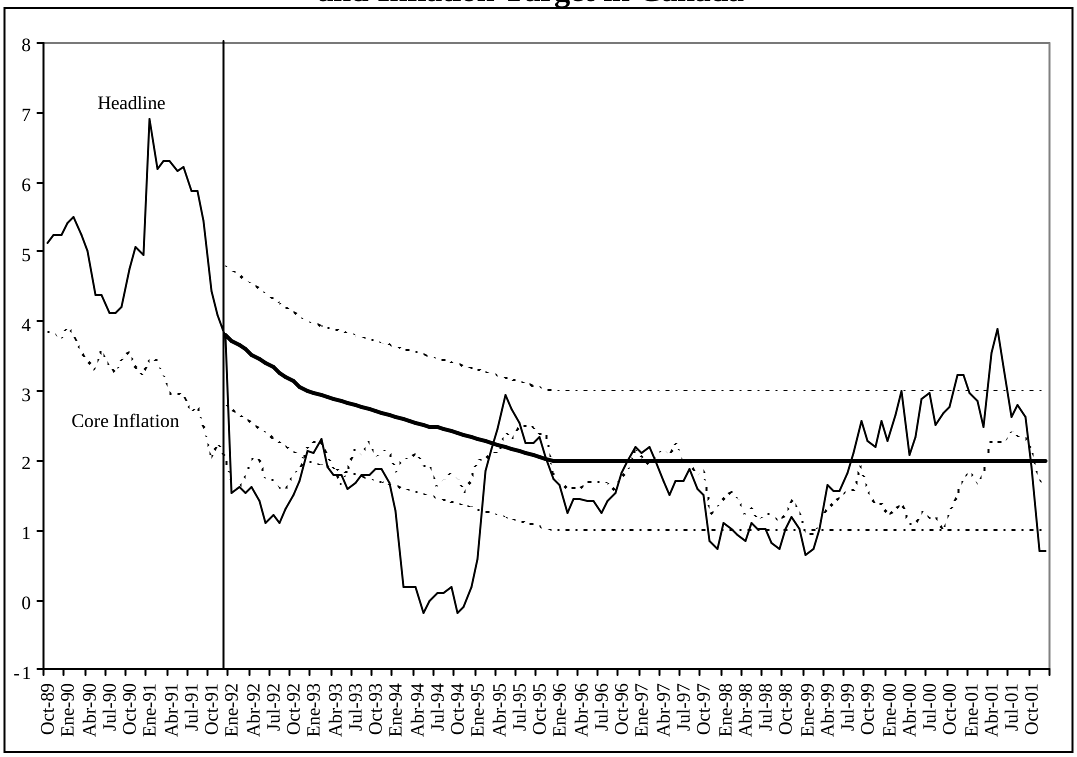
[80] As a signal of commitment, real return government bonds were introduced 3 months after the first target was announced.

Figure 1.6. Headline Inflation, Core Inflation and Inflation Target in Canada*



* The Inflation Target shown is at the end of the year, not at the time of the announcement so that deviations mean failure to meet the target corresponding to the end of the year.

Currently, monetary policy in Canada continues to rely on the overnight money market rate as the policy instrument. The central bank establishes a range of 50 basis points for the overnight target rate on large value transfers among financial institutions. The ceiling for this band is the rate at which the central bank lends additional cash if necessary to financial institutions to cover short-term deficits (overdrafts), while the floor is the rate that the central bank pays for excess cash held by financial institutions. By modifying the target rate, the bank affects other interest rates such as the bank rate and the money rate, and therefore the amount of cash in the system. The central bank also relies on a monetary conditions index similar to that of New Zealand to assess the stance of monetary policy. This index has been considered a short run operational target for monetary policy implementation, but not an anchor in itself or a commitment to alter the exchange rate.[81]

Box 1.3. Monetary Policy in Canada from 1989 to 2001

-Recession in 1990 (no previous exchange rate collapse).

-Monetary policy target *M1* (up to 1982).

-Price stability as long-term goal since 1988.

-Large risk premiums in 1990.

-Adoption of scheme: February 1991 (CPI target range).

-External Shocks: Mexico (1994).

-Instrument: Overnight Money Market Rate (large scale inter-bank transactions).

-Reduced headline inflation from around 7% in 1990 to around 1% in 2001; core inflation from around 4.5% to somewhat below 2%.

1.4.2.2. Estimating a Policy Reaction Function for Canada: From 1989 to 2001.

Following the discussion about monetary policy rules in Section 2, expression (2) is estimated for Canada using monthly data. In the present case, the credibility gap (or inflation gap) has been calculated by subtracting the midpoint of the inflation target range (see Figure 1.6) from the observations for inflation expectations available in

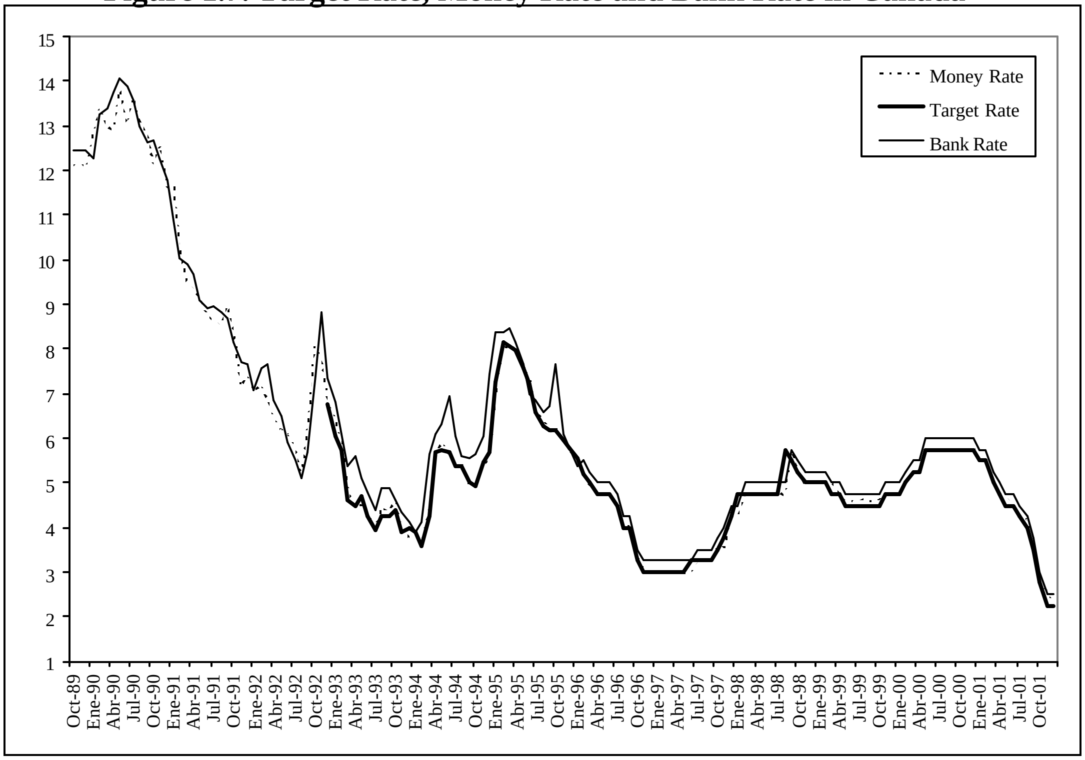
[81] See Bernanke *et al* (1999) and references therein.

Consensus Forecasts from surveys to the private sector.[82] The monthly output gap was interpolated directly from the quarterly series constructed by the Bank of Canada.[83] I use the exchange rate in domestic currency per US dollars, the inflation of the price of commodities and the 10-year external bond return as the remaining explanatory variables. The dependent variable is either the overnight money rate or the bank rate, instead of the target rate, due to limited data availability for the latter; as Figure 1.7 shows, both are closely linked to the target rate.

[82] See Consensus Economics (various volumes).

[83] I would like to thank Brigitte Desroches at the Bank of Canada for sharing these and other data used here.

Figure 1.7. Target Rate, Money Rate and Bank Rate in Canada*



*Source: Bank of Canada. The target rate is the Bank of Canada's official rate or policy rate (for overnight transactions); the bank rate used to be the policy rate (now it constitutes an upper bound to the official rate, and it is the minimum rate at which the Bank of Canada extends short-term advances to financial institutions); the money market rate is the rate at which major participants in the money market borrow and lend one-day funds to each other. See http://www.bankofcanada.ca/en/glossary/glossary.htm

In terms of the validity of equation (2) for the case of Canada, there are several interesting facts to consider. First, according to Armour *et al* (2002), the overall research goal at the Bank of Canada has been to find a Taylor-type rule that is robust across different models. The bulk of the research considers different monetary policy rules and embeds them in different macroeconomic models. In that context, a given rule is said to be robust to the extent that it can replicate or track the observed behavior of inflation and output. One of the most widely cited models is known as the Quarterly Projection Model (QPM), which uses a forecast-based rule. Yetman (2001) argues that credibility can be measured simply as a function of the distance between the expectations of agents (or the perceived target) and the actual target. These facts allow to think that the credibility gap (expected - announced inflation) is a plausible regressor in expression (2) proposed here. This is because a rule that considers the credibility gap is able to replicate the behavior of variables relevant from the point of view of the monetary authority in Canada. Second, as Bernanke *et al* (1999) stress, Canada is a small open economy largely dependent on exports of natural resources (or natural resource based products for that matter), and since the MCI has been used as an indicator of the stance of monetary policy, it seems plausible to include both the inflation rate for commodity prices and the exchange rate depreciation rate as explanatory variables for monetary policy. Third, external indebtedness (public and private) has been crucial in terms of the conduction of monetary policy, so that the interest rate on (long run) external bonds could also be relevant for the analysis.

The results for the full sample using GMM are presented in Table 1.16. For columns (a) and (b) the dependent variable is the bank rate, while for columns (c) and (d) it is the money rate. The coefficients are all of the expected signs, but the exchange rate and the commodity prices are not significant in any of the four cases. With respect to the magnitudes of the estimations, Côté *et al* (2002), Clinton (2001), Armour *et al* (2002) and Yetman (2001) among others find that the coefficients for Taylor-type rules that are robust (as defined above) should oscillate between 1.5 and 2.5 for the inflation gap and around 0.5 for the output gap. The estimates presented here are surprisingly close to these figures: the coefficient for the inflation gap ranges between 1.6 and 2.0, while the coefficient for the output gap ranges from 0.39 to 0.52.

Table 1.16. GMM Estimations for the Full Sample Using Monthly Data for Canada[1/]

Dependent Variable: 2/ (October 1989-December 2001)	(a)	(b)	(c)	(d)
constant	-1.90	-1.54	-1.60	-1.30
	(1.44)	(1.32)	(1.54)	(1.43)
expected - announced inflation	1.65**	1.71**	1.82**	2.00**
	(0.74)	(0.67)	(0.80)	(0.77)
output gap (Bank of Canada)	0.52***	0.46***	0.43**	0.39**
	(0.19)	(0.17)	(0.22)	(0.19)
exchange rate depreciation	1.12	-	0.65	-
	(1.30)	-	(1.31)	-
lagged exchange rate depreciation	-	0.95	-	0.74
	-	(1.07)	-	(1.03)
10 year external bond	1.14***	1.08***	1.06***	1.00**
	(0.20)	(0.20)	(0.23)	(0.22)
change in commodity prices	0.08	-	0.05	-
	(0.11)	-	(0.11)	-
lagged change in commodity prices	-	0.05	-	0.02
	-	(0.10)	-	(0.10)
R Sq	0.62	0.69	0.71	0.70
Adj R Sq	0.61	0.68	0.70	0.68
Std. Error	1.68	1.51	1.50	1.51
Sum Squared Resid	396.03	316.88	315.62	316.66
J Stat	0.0000	0.0000	0.0000	0.0000
No. of Observations	146	145	146	145

*, ** and *** denote 10%, 5% and 1% significance respectively

Std. Errors in parentheses

1/ Instrument list includes lags of dependent variable, lags of observed inflation and lags of explanatory variables

2/ For (a) and (b) is the Bank Rate. For (c) and (d) is the Money Rate

With respect to the insignificance of the coefficient on the exchange rate depreciation, Longworth (2000) argues that "[the Central Bank of Canada has not] relied on the exchange rate passthrough to consumer prices to guide inflation to its target" (p. 39). Although he recognizes that reacting to exchange rate changes could be helpful for reducing inflation, this would be at the expense of higher output variability. Secondly, as Côté *et al* (2002) find, "rules that react exclusively to [the inflation gap and to the output gap] often outperform rules that also include the exchange rate" (p. 31). This is because, they argue, the exchange rate is a shock absorber that helps to stabilize the economy, and any attempt to smooth exchange rate fluctuations introduces more volatility to the (Canadian) economy.[84] This may explain the result here that the exchange rate is not significant. Amano and Wirjanto (1994) on the contrary, find (weak) evidence that the Bank of Canada was pursuing an exchange rate target between 1971 and 1992.[85] This may suggest that the fear of floating phenomenon is purely transitional, as suggested for the case of Mexico above.[86]

The endogenous structural change tests (see Appendix 6) identify four breaks according to the Sequential Procedure criterion. The first break occurred around March 1993 (in late 1993, Canada underwent internal political conflict over whether the central bank was "too aggressive" in pursuing its inflation target); the second break occurred by December 1994 (when the Central Bank announced explicitly that it would keep the target rate within a 50 basis points band); the third around September 1996; and the fourth by August 1999. The fact that no break associated with the adoption of the inflation target was found can be explained, along the lines discussed by Bernanke

[84] See also Bernanke *et al* (1999)

[85] Unfortunately we cannot consider such a sample due to limited data availability. If this were true, the coefficient for the exchange rate depreciation rate could be significant for specific sub-samples.

[86] By no means should one take the results presented here as conclusive evidence about the behavior of the Central Bank of Canada. In fact, the estimations are not fully robust to changes (forward) in the sample. Even though the point estimates remain relatively constant over time, the explanatory power of the regression declines quickly (negative R-squared stats are easily obtained, which suggests that the instruments are perhaps not the most adequate).

et al (1999), by arguing that the Central Bank of Canada was already following an implicit target before February of 1991. From Table 1.14 it seems that the relatively better fit is that in column (c). With this in mind, Table 1.17 reproduces this estimation (labeled as (e)) along with the sample that goes from the second to the fourth break (labeled as (f) in Table 1.17), that is, from April 1993 to October 1999 (see also Figure 1.7). Notice that the coefficient for the inflation gap remains basically unchanged, while the coefficient for the output gap increases by almost one half. The coefficient for the exchange rate depreciation remains insignificant. Overall, these results are in line with those from research conducted at the Bank of Canada (see above). While both the inflation gap and the output gap are key for monetary policy decisions, changes in the exchange rate are not considered to be of direct importance. However, two issues that seem contradictory remain to be explored. The point estimates are surprisingly close to those that replicate Canadian output and inflation behavior in simulated macroeconomic models (2.0 for the inflation gap and 0.5 for the output gap). But at the same time, these coefficients appear to be highly unstable over time, very sensitive to specific episodes and to specific observations.[87]

[87] The second regression in Table 1.17 is not quite robust. The estimations for the different sub-samples identified are somewhat mixed. The coefficients appear to be unstable in the sub-samples that lie between the second and third breaks found. Also, rolling regressions (not reported) show that the coefficients are highly unstable.

Table 1.17. GMM Estimations for the Full Sample and Selected Sub-samples Using Monthly Data for Canada[1/]

Dependent Variable: Money Rate		
	(e) [2/]	(f) [3/]
constant	-1.60	3.99***
	(1.54)	(1.18)
expected - announced inflation	1.82**	1.79**
	(0.80)	(0.78)
output gap (Bank of Canada)	0.43**	0.64***
	(0.22)	(0.22)
exchange rate depreciation	0.65	0.64
	(1.31)	(0.66)
10 year external bond	1.06***	0.26*
	(0.23)	(0.15)
change in commodity prices	0.05	0.04
	(0.11)	(0.07)
R Sq	0.71	0.23
Adj R Sq	0.70	0.18
Std. Error	1.50	1.10
Sum Squared Resid	315.62	88.80
J Stat	0.0000	0.0206 [4/]
No. of Observations	146	79

*, ** and *** denote 10%, 5% and 1% significance respectively
Std. Errors in parentheses
1/ Instrument list includes lags of dependent variable, lags of observed inflation and lags of explanatory variables
2/ Full Sample
3/ April 1993 to October 1999
4/ P-value = 0.20, so that the overidentifying restriction is valid

As for the case of New Zealand, there is no clear evidence of a change in the behavior of the central bank upon the explicit adoption of the inflation target in Canada, which can be explained by the argument above that the policy shift was more gradual and in fact it is difficult to fully determine what led the monetary authority to such change. In contrast, what is striking is that in none of these three countries the does exchange rate depreciation directly affect the monetary policy instrument under inflation targeting. This is not sufficient evidence to conclude that the exchange rate does not matter for monetary policy, but it is sufficient to conclude that these countries to a large extent meet the exchange rate flexibility requirement for inflation targeting to be successful, and focus their attention on more conventional variables such as expectations for future inflation and the output gap, as prescribed by the theory.

1.4.3. Summing Up: The Three Cases Contrasted.

Mexico, New Zealand and Canada, adopted this monetary policy scheme in less than optimal economic circumstances: both Mexico and New Zealand were coming out of collapsed exchange rate regimes while Canada was still under the effects of a recession that started a few years before, and the three countries faced large risk premiums and were subject to external shocks. Also, a key factor is that New Zealand and Canada adopted inflation targets at much lower inflation rates than Mexico, since this might have implied different priorities for each country's monetary authority. In all of them, however, it was possible to bring inflation within the proposed targets, but a "too stringent" monetary policy has been frequently blamed of preventing economic growth, which was particularly relevant in the political arena around 1995 in Canada.

Before the adoption of the inflation target, all three countries pursued a liquidity control policy toward affecting large-scale inter-bank operations: "settlement cash" in New Zealand, *M1* in Canada and domestic credit in Mexico. Currently, Canada and New Zealand use overnight interest rates for this type of inter-bank operations as policy instruments, allowing them to fluctuate within specified limits that are modified regularly. Mexico on the contrary, still relies on affecting quantities rather than interest rates through the use of borrowed reserves (*el corto*). Canada and New Zealand, in turn, continue to take into account a Monetary Conditions Index as an indicator of the stance of monetary policy, although it has been relegated to a secondary role.

With respect to the transition toward inflation targeting, the policy shift was more gradual in Canada, while Mexico and New Zealand adopted inflation targeting in a more "institutionalized" fashion, with more clear goals and guidelines for its operation, at least in the initial stages. In this respect, the structural test results show that only for Mexico is there a clear structural change around the adoption of the explicit target in 1999. Neither Canada nor New Zealand display any structural changes associated with the adoption of this policy. While this result may be consistent with the smooth transition described for Canada, for New Zealand the explanation relies perhaps on the initial pursuit of an implicit target, but since this was also the case for Mexico, one might need to look for alternative arguments.

Table 1.18 summarizes the policy rule estimation results for Mexico (with both monthly and daily data), New Zealand and Canada respectively. Rather than repeating the output from previous sections, this table shows only whether the variables are econometrically significant for two sets of samples: the full sample in the first column, and the inflation target sub-sample in the second; for the case of Mexico with daily data the sub-samples correspond to before and after the adoption of the target. The third and sixth columns show in what direction the coefficient changes under inflation targeting relative to the full sample. One of the most interesting results is that the output gap is always significant in all three countries. Also, the inflation gap is significant whenever the inflation target is in operation in all three cases.

Table 1.18. Summary of Key Results

	Mexico					
	Monthly Data 1/			Daily Data 2/		
Variable	Full Sample 05/96-12/01	Target 10/98-12/01	Coefficient	No Target 05/96-08/98	Target 05/99-12/01	Coefficient
Constant	S	S	higher	NS	S	lower
Lagged Dep. Var.	NS	S	higher	NS	S	higher
Expected - Announced Inflation	NS	S	lower	S	S	higher
Output Gap	S	S	lower	S	S	lower
ER Depreciation Rate	S	NS	lower	S	NS	lower
Govt. Bond Yield Abroad	S	S	lower	S	S	lower
Terms of Trade Changes	NS	NS	higher	S	NS	higher

1/ From Table 5

2/ From Table 9

	New Zealand			Canada		
	Quarterly Data 3/			Monthly Data 4/		
Variable	Full Sample 1988-2001	Target 1991-2001	Coefficient	No Target 1989-1990	Target 1993-2001	Coefficient
Constant	S	NS	lower	NS	S	higher
Lagged Dep. Var.	NS	S	higher	NA	NA	NA
Expected - Announced Inflation	S	S	higher	S	S	higher
Output Gap	S	S	lower	S	S	higher
ER Depreciation Rate	NS	NS	no change	NS	NS	lower
Govt. Bond Yield Abroad	S	S	lower	S	S	lower
Terms of Trade Changes	NS	NS	no change	NS	NS	lower

3/ From Table 12

4/ From Table 17

S = Significant

NS = Not significant

Another interesting result is that in all three cases the exchange rate depreciation does not have explanatory power under inflation targeting. Using daily data for the case of Mexico allows me to split the sample before the target (excluding the Asian and Russian crises) and under the target. The exchange rate variable is empirically relevant for monetary policy in Mexico only before the inflation target was adopted, but not once the target was in operation. This result, and the fact that both the output gap and the inflation gap are empirically relevant for monetary policy under inflation targeting lead me to conclude that the monetary authority in Mexico is converging qualitatively toward responding to conventional variables, as is the case for New Zealand and Canada. Moreover, these results show that the exchange rate is more of a shock absorber than an intended target for the monetary authority, and perhaps more importantly, that fear of floating was a transitional phenomenon in Mexico.

The return on the government bond yield abroad is significant in all cases for the three countries, leading to believe that the perception among investors abroad is relevant for monetary policy decisions. This result is important because it is consistent with the idea that these countries are highly integrated to international markets and to different degrees rely on external capital flows. Interestingly, the value of the coefficient associated with this variable is reduced under inflation targeting in the three countries considered.

Finally, it is worth mentioning that in all three countries there is evidence that the monetary authority engages in some degree of interest rate smoothing. As mentioned earlier in the paper, this may be explained along the lines of avoiding large shifts in the position of borrowers and overstressing a continuously developing financial sector.

1.5. Conclusions.

Arguably, the identification of different phenomena that affect monetary policy is perhaps best addressed by looking at the reaction function of the central bank as in Taylor (1998) and others. Since most empirical studies on the topic tend to focus on large open economies or closed economies, they fail to address the impact of other channels of monetary transmission that are considered relevant for small open economies. The main purpose of this paper was precisely to explore the extent to which the adoption of an explicit inflation target in Mexico could be associated with a *de facto* change in the monetary authority's behavior, in terms of its response to different variables that are considered relevant for monetary policy, including the exchange rate and other variables suggested by Svensson (1998) and others.

Using endogenous structural change tests, a change in the behavior of the monetary authority in Mexico can in fact be associated with the adoption of an explicit inflation target in 1999. Before that, the exchange rate played a key role for monetary policy implementation, and conventional variables such as the inflation gap were relatively less relevant. However, once the inflation target was put in place, these variables gained importance for monetary policy and the exchange rate lost relevance. In this respect, an important issue that must be acknowledged is that the conditions under which these countries adopted inflation targeting were not quite the same: the inflation rate in Mexico, for example, was much higher at the time of adoption than in New Zealand and Canada. Also, international markets were relatively more stable after 1999, and this probably affected monetary policy decisions, since it was perhaps less costly for the Central Bank of Mexico to gain credibility. An additional element is that an important reduction of the exchange rate passthrough was accomplished. Finally, Mexico accumulated more than 50 billion in international reserves in the past years and, despite exchange rate volatility has fallen to levels comparable with those in New

Zealand and Canada, interest rate volatility remains relatively higher, which is an open issue still to be explored.

In general, the estimations for Mexico under inflation targeting are qualitatively more similar to those of New Zealand and Canada: exchange rate and terms of trade changes lose relevance, while conventional variables, along with country risk measures, remain key to monetary policy behavior. Through the use of high frequency data for Mexico, I confirm a change in the central bank's behavior after 1999, where the exchange rate no longer explained the instrument variable. These results may be safely interpreted as evidence of some sort of "convergence", in terms of the variables taken into account for monetary policy in Mexico, toward those in New Zealand and Canada.

The fact that the exchange rate no longer explained the instrument variable suggests that, before the adoption of the target in 1999, Mexico was perhaps using a monetary conditions index to evaluate monetary policy decisions. Alternatively it may suggest a temporary or transitional nature for what has been identified as fear of floating. This transitional nature of fear of floating can be rationalized either by the idea of the central bank trying to build reputation during "hard times", or by the idea that in extreme circumstances policymaking should be comprehensive for the sake of consistency. This might be classified as what is known as constrained inflation targeting, whereby high levels of passthrough, and in some instances lack of credibility, may induce central bankers to react to variables that would otherwise be irrelevant. Therefore fear of floating phenomenon need not be perverse, but instead, could be a response to a set of conditions under which the monetary authority reacts. There is an underlying optimization process that leads a country's central bank to respond in different manners to different shocks, and considering this optimization process is the best possible way to analyze monetary policy as a whole. In fact, monetary policy reports in all three countries express their concern about the importance of exchange rate behavior for the accomplishment of other policy targets.

Finally, one may think of many issues that generate the possibility of changes in the behavior of the central bank. These may be due to changes in the external environment (from high volatility to relative stability) or to changes in the characteristics of the central bank itself. In any case, given the results obtained for Mexico as compared to those for New Zealand and Canada, the central bank's observed actions may be a signal of commitment in difficult times, and a clear indication that in some instances the exchange rate constitutes an additional constraint for policymaking in a small open inflation-targeting economy.

"…countries that appear to behave according to the declared regime during tranquil times may be tempted to change their course of action once the regime is under stress. Thus, a very different picture of exchange rate regime choices may appear once the international context becomes more volatile."[88]

Chapter 2. Reputation and Endogenous Persistence.

2.1. Introduction.

After the crisis of 1995, Mexico not only entered a deep recession, but also observed a rebound in domestic inflation fueled by severe external shocks accompanied by high exchange rate volatility. Nonetheless, since the adoption of an explicit inflation target in January of 1999, not only has inflation diminished consistently, but also the gap between inflation expectations and inflation announcements has been reduced, suggesting that there have been credibility gains. Moreover, the exchange rate pass-through to prices has fallen,[89] and the extent to which the monetary policy instrument reacts to exchange rate changes has diminished significantly.[90]

A more stable external environment, the adoption of an explicit inflation target and the credibility gains, along with a lower pass-through and (arguably) a more cautious external indebtedness may explain the success of monetary policy in that country. However, a recent concern about real-side performance has emerged. Indeed, projected GDP growth has been revised downward since 2000. At the same time, it has

[88] Levy-Yeyati and Sturzenegger (2002), p. 2.

[89] See Garcés (1999). For an international analysis of exchange rate pass-through see Baqueiro *et al* (2002) and references therein.

[90] See Torres (2001) and Chapter 1 here.

been argued that monetary policy is too stringent and has curtailed economic performance.

It may seem irrational for the central bank to continue to pursue a tight monetary policy if that restrains economic growth. In this paper, a reputation model based on Drazen and Masson (1994) (DM) is presented whereby the monetary authority may induce negative spillovers that translate into lower output by not following a stringent monetary policy. Put more simply, a two-period model of reputation shows that, whenever the monetary authority deviates from zero inflation in face of an exogenous output shock, while it may offset the contemporaneous negative effect of such shock on unemployment, it may impose restrictions on producers/investors such that future unemployment increases. This effect reinforces the reputational effect standard in Backus and Driffill (1985) in the sense that no-inflation observations increase reputation, and a higher future output cost from inflating in the present may induce a policymaker not to inflate in the present, making reputation investment more attractive.

The paper is organized as follows. In the next section, a brief exposition of the literature about the role of exchange rates, the importance of explicit over implicit inflation targeting, and the role of exchange rate pass-through and balance sheet effects in inflation targeting countries is presented. In Section 3 a modification to DM's model that allows for endogenous persistence in order to rationalize the role of external factors, credibility concerns and balance-sheet effects in pursuing tight monetary policy is presented. Section 4 concludes.

2.2. Inflation Targeting: Some Important Issues.

2.2.1. Information and Control under Inflation Targeting.

One of the most discussed issues in inflation targeting countries is that of transparency, credibility and accountability of monetary policy. It is argued that an increase in transparency has allowed economic agents to build up an improved perception of monetary policy that has translated into improved inflation expectations for the public and improved inflation control for the policymaker. Faust and Svensson (2000), for example, explore the extent to which policy transparency (measured as the degree to which economic agents can infer the central bank's intentions) is welfare improving whenever output preferences of the central bank are not fully observable. They show that, in general, higher transparency leads to lower output and inflation variability and hence to higher welfare. This is because increased transparency leads a central bank that is concerned about its reputation to a stronger commitment toward the social optimum. Geraats (2001) shows that transparency (measured as the publication of central bank's forecasts) can be beneficial for a central bank to enhance its reputation. Information disclosure allows the public to infer the central bank's objectives and hence avoid biases in their inflation expectations, which in turn allows the central bank to increase its reputation. Yetman (2001) explores the role of learning under implicit inflation targeting and imperfect control. He shows that it is not sufficient to move toward an explicit inflation target framework, but it is also crucial to increase transparency in order to gain credibility and thus increase welfare. Finally, Nolan and Schalling (1996) explore the role of increased accountability and its relationship with central bank independence in reducing inflationary expectations. All these models assume imperfect control over inflation and imperfect knowledge of the central bank's intentions (*i.e.*, the central bank's *type*) with respect to inflation and/or output. The key argument is that information disclosure and, arguably, explicit inflation targeting is welfare improving.

2.2.2. Inflation Targeting in Small Open Economies.

It may be argued that foreign interest rates, country risk, and the exchange rate itself, along with the occurrence of crises in other emerging markets and the extent to which they affect capital flows, play a crucial role in the decision process of policymaking in small open economies. The role of external factors has been considered crucial for economic policy, particularly in emerging markets.[91] This suggests an important distinction in terms of monetary policy between open and closed economies. Recently, a vast literature, both theoretical and empirical, has focused on the distinction between small open economies that pursue an inflation target as the primary objective, and closed economies. Ball (1999, 2000) for example, explores the implications for exchange rate management from adopting an explicit inflation target in small open economies, and attempts to outline how monetary policy should differ between open and closed economies. Ball argues that small open economies that attempt to stabilize inflation and output should also take into account exchange rate fluctuations, and that "[Taylor] rules must be modified to give a role to the exchange rate".[92] Others like Svensson (1998), Agénor (2000) and Clarida *et al* (2001) argue that

[91] See for example Calvo, Leiderman and Reinhart (1993) for Latin America.

[92] Ball (2000), p. 2.

the exchange rate plays a central role for monetary policy transmission and affects inflation and output and, as Agénor points out, "[B]ecause foreign shocks are transmitted through the exchange rate, and the exchange rate affects consumer price inflation, stabilizing exchange rates has remained an important consideration under inflation targeting".[93]

2.2.3. Inflation Targeting and Exchange Rate Fluctuations.

In the past decade, many countries abandoned intermediate exchange rate regimes and officially adopted either hard pegs or free floating, some of them in combination with inflation targeting.[94,95] However, this apparent trend has been challenged by the observation that intermediate exchange rate regimes have not quite disappeared. For example, Levy-Yeyati and Sturzenegger (2002) construct *de facto* classifications for exchange rate regimes and find that neither fixed nor free floating official regimes prevail, but instead, the former observe some degree of flexibility while the latter observe relatively limited exchange rate fluctuations.[96]

To explain this "false" divergence from intermediate exchange rate regimes, on the *fix* side, Levy-Yeyati and Sturzenegger identify a *fear of pegging*, where policymakers announce less-than-fixed regimes in an attempt to minimize speculation

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[93] Agénor (2000), p. 16.

[94] IMF *World Economic Outlook*, October 1997. See also *Annual Report on Exchange Arrangements and Exchange Restrictions*, IMF, various volumes.

[95] This phenomenon can be explained in several manners. For example, the integration of financial markets and the higher degree of capital mobility can negatively affect the performance of managed floating regimes. See for example Eichengreen (1994) and Fischer (2001).

[96] See also Reinhart and Rogoff (2003), forthcoming.

and the likeliness of collapse, but *de facto* follow a fixed regime. On the *float* side, different hypotheses have emerged to explain what Calvo and Reinhart (2002) labeled as *fear of floating*. In an attempt to identify the extent to which managed floating has "disappeared" as an exchange rate policy alternative in practice, they find evidence that many countries that claim to follow a free-floating exchange rate regime are not quite doing so and instead observe relatively stable exchange rate behavior. They illustrate that inflation targeting, in combination with lack of credibility and high exchange rate passthrough to prices, may explain this observation. If lack of credibility is associated with highly volatile risk-premiums, the monetary authority may find it optimal to engage in (some degree of) exchange rate smoothing to offset the effects of exchange rate fluctuations on price inflation, and this incentive will be stronger the higher the commitment to low inflation variations. Others like Hausmann *et al* (2000) find that free-floating countries in fact allow for different degrees of exchange rate flexibility, and argue that this phenomenon may be explained by different degrees of exchange rate pass-through to prices and/or the inability for these countries to borrow in domestic currency. Given a high passthrough and that firms' liabilities are denominated in foreign currency, the monetary authority, concerned that depreciations are inflationary *and contractionary*, acts to avoid excessive exchange rate volatility. Conversely, Lahiri and Végh (2001) attempt to rationalize the fear of floating phenomenon through the existence of an output cost of both nominal exchange rate fluctuations and higher interest rates (to limit such fluctuations), along with a fixed cost of interventions.

This reclassification of exchange rate regimes in general, and the identification of fear of floating in particular, brings attention to countries where inflation constitutes the primary goal of monetary policy. Indeed, Calvo and Reinhart's (2002) hypothesis becomes highly relevant in these countries, since exchange rate flexibility is considered as a necessary condition for inflation targeting to be successful,[97] and their argument gains strength exactly in small open economies where lack of credibility, high levels of exchange rate pass-through and financial market imperfections are more frequent than not.

2.3. Inflation Targeting in Mexico: Some Stylized Facts.

The collapse of the exchange rate band in 1995 translated into high inflation and a considerable output cost. To offset the inflationary effects of the devaluation and regain stability, an explicit domestic credit target was established along with the imposition of a zero-average legal reserve requirement for commercial banks. Also, the Federal Government and the central bank agreed upon pursuing goals for yearly inflation, without considering them as official targets.[98] It was not until January 1999 that an explicit inflation target was announced for the first time. The shift in policy determination was mostly due to the observed weakening of the relationship between the demand for money and the intermediate target used prior to 1999, but also to the difficulties derived from the external environment during the previous two years and the authority's concern about reputational matters. The Asian and Russian crises of 1997 and 1998 affected Mexico's exchange rate behavior to the extent that the

[97] See Taylor (1998).

[98] For a detailed description of the operation of monetary policy since 1995 see Carstens and Werner (1999) and references therein.

monetary authority was forced to revise its (implicit) inflation goals upward and intervene directly in the foreign exchange market. However, despite the Brazilian crisis in early 1999 and the highly volatile prices of oil, higher transparency in monetary policy allowed for inflation expectations to fall considerably, and observed inflation to reach about 4 percent in 2001 from almost 20 percent in 1998, meaning that observed inflation met the announcements consistently (see Figure 2.1) since 1999. In addition to the observed fall in the gap between inflation expectations and inflation announcements (as shown in Figure 2.2), and the success in maintaining inflation below target from 1999 onward, the exchange rate pass-through to prices decreased significantly, both in speed and magnitude,[99] and the fear of floating phenomenon diminished significantly and perhaps entirely disappeared.[100]

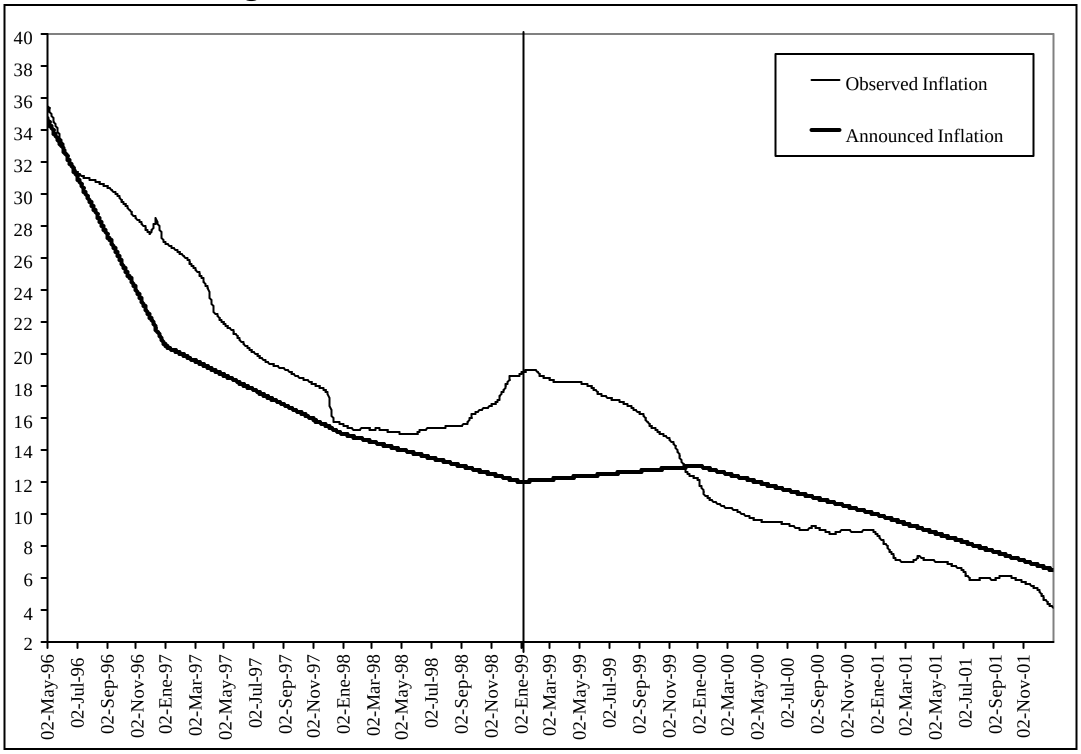
These facts are of particular relevance to the idea that a central bank willing to invest in reputation may be prevented from doing so under extremely adverse circumstances. Specifically, the occurrence of crises abroad might have generated conditions that forced the central bank of Mexico to intervene directly in foreign exchange markets and review its inflation targets upward. This behavior can be

[99] See Garcés (1999). For an international comparison about the behavior of exchange rate pass-through, see Baqueiro *et al* (2002) and references therein.

[100] See Torres (2001). A key result in Chapter 1 is that the monetary authority in Mexico appeared to be moving away from responding to changes in the exchange rate, interrupted by extraordinary conditions in the international markets around 1998.

explained along the lines of escape clauses, where the central bank may abandon its monetary policy rule under extreme circumstances defined in advance.[101]

Figure 2.1. Observed and Announced Inflation*



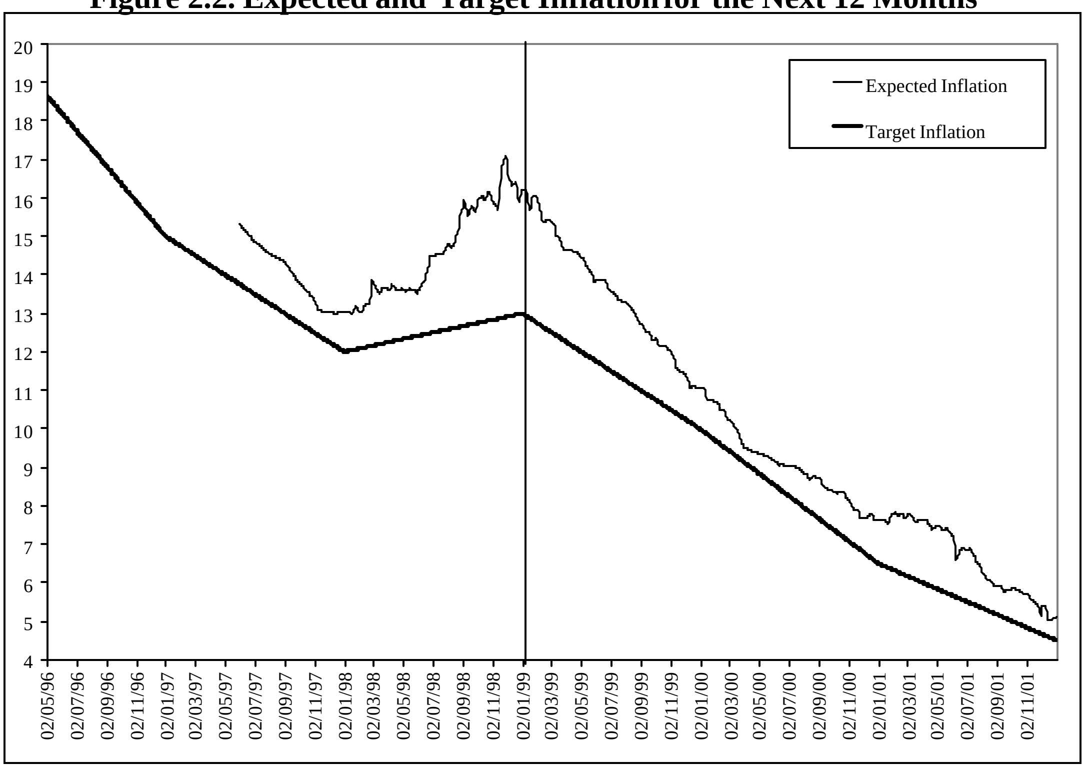
*Source: Banco de Mexico

The fear of floating phenomenon may be explained as a result of lack of credibility and a strong commitment to inflation targeting (to rebuild reputation) as in Calvo and Reinhart (*op cit*), or as a result of exchange rate passthrough to prices and balance sheet effects as in Hausmann *et al* (*op cit*), but the observed temporary nature of this phenomenon would require endogenizing risk, exchange rate pass-through and/or the balance sheets effect: successfully meeting inflation targets not only would

[101] See for example Flood and Isard (1989), Persson and Tabellini (1990) and Drazen and Masson (1993).

enhance reputation and lower subsequent inflation expectations, but it would also lower perceived risks, affect price setting procedures and diminish financial market frictions such that the pervasive effect of exchange rate fluctuations would fade away. This may therefore provide a good explanation for the observations in Mexico mentioned above, namely the fall in the gap between expected and announced inflation (interpreted as credibility gains), and the fall in the speed and magnitude of the exchange rate pass-through. However, the fact that country risk has not continued to fall (see Figure 2.3) may suggest that there is another factor involved in monetary policy decisions that is closely linked to reputation.

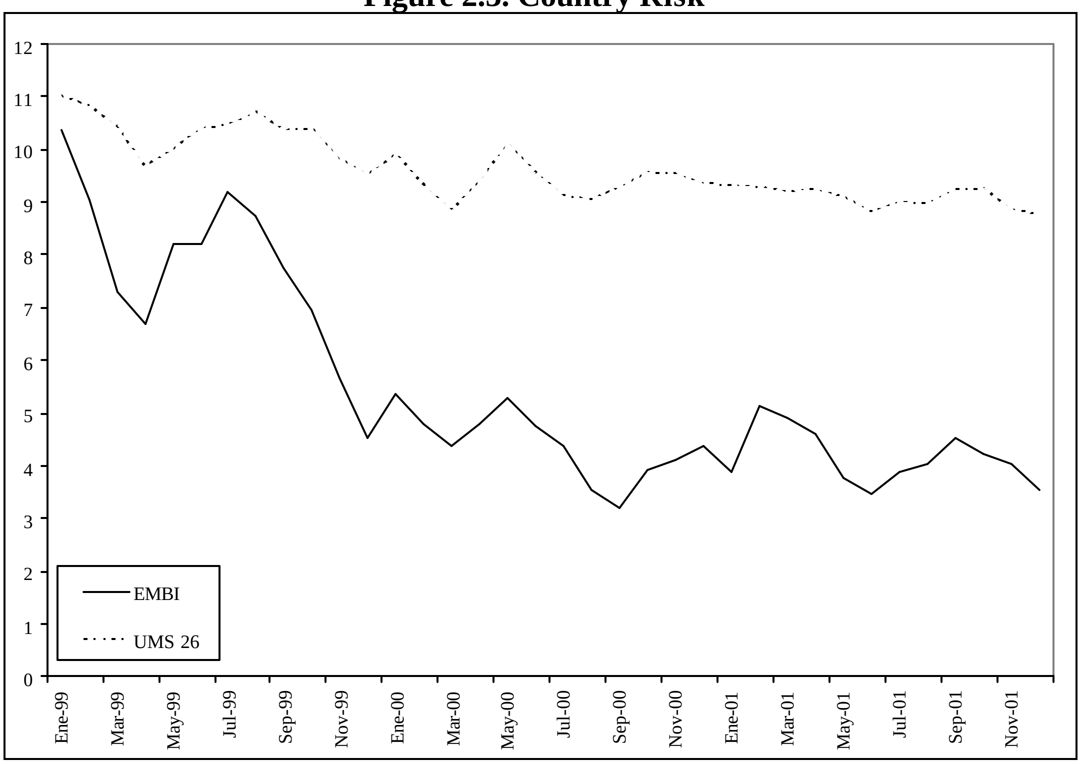
Figure 2.2. Expected and Target Inflation for the Next 12 Months*



*Source: Banco de Mexico

These different arguments may well explain why the central bank decided to move toward an explicit inflation target, why it put such targets under revision and why under some extreme circumstances it decided to intervene directly in the foreign exchange market as well. Lahiri and Végh (*op cit*) may further explain this last matter. However, this literature fails to explain first the temporary nature of the fear of floating experienced in Mexico, and second the continuation of a somewhat stringent monetary policy at an apparently important output cost or, more simply, a somewhat sluggish economic recovery in the past two years, as shown in Figure 2.4.

Figure 2.3. Country Risk*



*Source: JP Morgan and Bloomberg.
EMBI is a measure of country risk based on the returns of different bonds held abroad.
UMS26 is the return on long term government bonds held abroad (in dollars).

In the next section, a modification to Drazen and Masson (1994) model is presented to attempt to explain why a central bank that faces an additional cost to that of losing reputation may continue to follow a stringent monetary policy even if the contemporaneous cost in output is significant. The argument is that by reneging on its inflation promises, the monetary authority generates negative spillovers that impose a greater damage in future unemployment than the potential benefits of generating some (unanticipated) present inflation.[102]

Figure 2.4. Real GDP Growth*

*Source: Banco de Mexico

[102] This is an empirical matter yet to be explored. See Blanchard and Fischer (1989) for a theoretical discussion.

2.4. The Model.

Following Drazen and Masson (1993) (DM), a two-period model of reputation is presented where unemployment persistence will arise *depending* upon the monetary authority's policy choice. The single-period loss function for the monetary authority is given by

$$L_t = (U_t - \tilde{U})^2 + \frac{q^i}{2} p_t^2 \qquad (1)$$

for t=1, 2; i = T (tough), W (weak) such that $q^T > q^W > 0$. q^i is the policymakers preference for inflation or its *type* and $\tilde{U}$ is the target rate of unemployment in any period.[103] This implies that a tough policymaker dislikes inflation more than a weak one. It is assumed that q^i is private information to the policymaker, but the public has prior beliefs on the type of policymaker.[104] A policymaker minimizes the present discounted value of the full horizon loss function given by

$$\Lambda^i = (U_1 - \tilde{U})^2 + \frac{q^i}{2} p_1^2 + bE_1[(U_2 - \tilde{U})^2 + \frac{q^i}{2} p_2^2] \qquad (2)$$

where b is the discount factor, subject to

---

[103] $\tilde{U}$ is the natural rate of unemployment defined as in Kydland and Prescott (1977).

[104] As in Backus and Driffill (1985).

$$U_1 = -a(p_1 - p_1^e) + e_1 \qquad (3)$$

$$U_2 = -a(p_2 - p_2^e) + dp_1 + e_2 \qquad (4).$$

where e_t is a random shock with mean zero and limited variance; d is a positive constant (see below) and p_t^e is expected inflation in period t, taken as given.[105] In DM, unemployment persistence is exogenous since it exists regardless of the policymaker's choice in the first period, but its magnitude can be affected by the policymaker's choice. The key difference from DM is that here the term dp_1 in (4) replaces daU_1, with U_1 given by (3). Therefore, persistence itself is *endogenous* to the policy choice in the first period. The idea is that there are real effects from monetary policy beyond those from the expectations/reputation mechanism that are captured by the term dp_1. In other words, unemployment in the first period will only affect subsequent unemployment whenever $p_1 > 0$ is observed. Suppose that individuals face a cash-in-advance constraint for investment on productive capacity in the future such that positive inflation reduces the real value of their savings, reduces future productive capacity, and raises future unemployment. In the context of an open economy, inflation could also generate currency depreciation that may translate into currency

[105] In a different context, Giannoni and Woodford (2003) use a similar specification for inflation. In their analysis, the presence of lagged inflation (inflation inertia) is explained through price indexation in a Calvo-type model of staggered price setting. See also Orphanides and Williams (2003) and Orphanides and Lengwiler (1999). The interpretation of lagged inflation in equation (4) here is slightly different (see below).

mismatches and balance-sheet effects that may reduce demand and supply of home goods.

It is assumed that the policymaker can only choose between setting $p_t = 0$ or $p_t = \bar{p}$ (exactly as in DM). Choosing positive inflation in the first period would impose an additional future cost in unemployment. Given a first period shock e_1, the monetary authority faces a tradeoff between lowering period 1 unemployment by choosing positive inflation and avoiding higher unemployment in period 2 by keeping inflation at zero in the first period.

Solving backward, we start by determining a critical shock for period 2 for which type *i* policymaker will be indifferent between setting zero and positive inflation ($\hat{e}_2$). Hence in period 2, the policymaker can find e such that $L_2^i(p_2 = \bar{p}) = L_2^i(p_2 = 0)$. As in DM, define $m_2(p_1)$ as the probability that inflation in period 2 is positive given inflation in period 1, so that $p_t^e = m_2(p_1)\bar{p}$. Thus

$$L_2^i(p_2 = \bar{p}) = [-a(\bar{p} - m_2(p_1)\bar{p}) + dp_1 + e_2 - \tilde{U}]^2 + \frac{q^i}{2}\bar{p}^2 \qquad (5)$$

and

$$L_2^i(p_2 = 0) = [am_2(p_1)\bar{p} + dp_1 + e_2 - \tilde{U}]^2 \qquad (6).$$

Setting (5) equal to (6) and solving for e_2 we obtain

$$\hat{e}_2^i(p_1) = \frac{2a^2 + q^i}{4a}\overline{p} + \widetilde{U} - am_2(p_1)\overline{p} - dp_1 \qquad (7),$$

which is analogous to equation (4) in DM. $\hat{e}_2^i(p_1)$ is the critical shock to unemployment in period 2 such that a policymaker of type *i* is indifferent between setting positive and zero inflation in that period given its past action. If $e_2 > \hat{e}_2^i(p_1)$, then the policymaker will find it optimal to set $p_2 = \overline{p}$. Notice that, all else equal, whenever $p_1 > 0$, then the magnitude of the shock necessary to set $p_2 > 0$ is lower since the last term in (7) disappears.

In a similar fashion, one can solve for period 1's $\hat{e}_1^i(P)$ such that $\Lambda^i(p_1 = 0) = \Lambda^i(p_1 = \overline{p})$, where:

$$\Lambda^i(p_1 = 0) = [am_1(P)\overline{p} + e_1 - \widetilde{U}]^2 + bE_1L_2^i(p_1 = 0) \qquad (8)$$

$$\Lambda^i(p_1 = \overline{p}) = [-a(\overline{p} - m_1(P)\overline{p}) + e_1 - \widetilde{U}]^2 + \frac{q^i}{2}\overline{p}^2 + bE_1L_2^i(p_1 = \overline{p}) \qquad (9)$$

where *P* defines a set of prior beliefs about the policymaker's type ($prob(q = q^i)$) and the distribution of e.

By setting (8) equal to (9) one can obtain $\hat{e}_1^i(P)$ as

$$\hat{e}_1^i(P) = \frac{2a^2 + q^i}{4a}\overline{p} + \widetilde{U} - am_1(P)\overline{p} + \frac{1}{2a\overline{p}} bE_1[L_2^i(p_1 = \overline{p}) - L_2^i(p_1 = 0)] \quad (10),$$

and if $e_1 > \hat{e}_1^i(P)$, then the policymaker will find it optimal to set $p_1 = \overline{p}$.

Assuming that e_t is uniformly distributed between $-v$ and v, then the term in brackets in (10) can be calculated as follows:

$$E_1 L_2^i(p_1) = \frac{1}{2v}\int_{-v}^{\hat{e}_2^i(p_1)} [am_2(p_1)\overline{p} + dp_1 + e_2 - \widetilde{U}]^2 \, de_2 + \\ \frac{1}{2v}\int_{\hat{e}_2^i(p_1)}^{v} \{[-a(\overline{p} - m_2(p_1)\overline{p}) + dp_1 + e_2 - \widetilde{U}]^2 + \frac{q^i}{2}\overline{p}^2\} de_2 \quad (11)$$

Following DM, define $m(p_1)=am_2(p_1)\overline{p} - \widetilde{U}$ such that (11) can be recalculated as:

$$E_1 L_2^i(p_1) = \frac{1}{2v}\int_{-v}^{v} [m(p_1) + dp_1 + e_2]^2 \, de_2 + \\ \frac{1}{2v}\int_{\hat{e}_2^i(p_1)}^{v} \{-2a\overline{p}[m(p_1) + dp_1 + e_2] + \frac{2a^2 + q^i}{2}\overline{p}^2\} de_2 \quad (12)$$

which can be evaluated as

$$E_1 L_2^i(p_1) = \{\frac{1}{2v}[m(p_1)+dp_1]^2 e_2 + \frac{1}{v}[m(p_1)+dp_1]\frac{1}{2}e_2^2 + \frac{1}{6v}e_2^3\}\Big|_{-v}^{v} + \{-\frac{a\overline{p}}{v}[m(p_1)+dp_1]e_2 - \frac{a\overline{p}}{v}\frac{1}{2}e_2^2 + \frac{2a^2+q^i}{2}\overline{p}^2 e_2\}\Big|_{\hat{e}_2^i(p_1)}^{v} \tag{13}$$

Using the fact that $\hat{e}_2^i(p_1) = -[m(p_1) + dp_1] + \frac{2a^2+q^i}{4a}\overline{p}$, equation (13) can be expressed as

$$E_1 L_2^i(p_1) = [m(p_1)+dp_1]^2 + \frac{1}{3}v^2 - \frac{a\overline{p}}{2v}[v-\hat{e}_2^i(p_1)]^2 \tag{14}$$

Note that, as opposed to DM, we have that

$E_1 L_2^i(\overline{p}) = [m(\overline{p})+d\overline{p}]^2 + \frac{1}{3}v^2 - \frac{a\overline{p}}{2v}[v-\hat{e}_2^i(\overline{p})]^2$, while

$E_1 L_2^i(0) = [m(0)]^2 + \frac{1}{3}v^2 - \frac{a\overline{p}}{2v}[v-\hat{e}_2^i(0)]^2$. Since setting inflation equal to zero in the first period does not generate any distortions that affect unemployment in the second period, the term $d\overline{p}$ is eliminated from the first term in brackets for $E_1L_2^i(0)$. It can be shown that $E_1[\,L_2^i(\overline{p}) - L_2^i(0)\,]$ is equal to

$$[1-\frac{a\overline{p}}{2v}]\{[m(\overline{p})+d\overline{p}]^2 - m(0)^2\} - \frac{a\overline{p}}{v}[v - \frac{2a^2+q^i}{4a}\overline{p}]\{[m(\overline{p})+d\overline{p}] - m(0)\} \tag{15}$$

and so long as d = 0, equation (15) would be analogous to equation (A4) in DM.

To determine the sign of (15), we first need to determine the sign of $m_2(\bar{p}) - m_2(0)$. For that purpose, as in DM, we define $m_2(p_1) = p_2(p_1)\, q_2^T(p_1) + [1-p_2(p_1)]\, q_2^W(p_1)$ as the probability that positive inflation is observed in period 2 given observed inflation in period 1 (p_1), where $p_2(p_1)$ is the probability that the policymaker is of type T and $q_2^i(p_1)$ is the probability that a monetary authority of type i will inflate in period 2 given $p_1 = p$. Notice that, by (7) and the uniform distribution of e_t, the latter will be given by

$$q_2^i(p_1) = prob\ [e_2 > \hat{e}_2^i(p_1)\,] = \frac{[v - \hat{e}_2^i(p_1)]}{2v} \qquad (16)$$

and

$$q_1^i = prob\ [e_1 > \hat{e}_1^i(P)\,] = \frac{[v - \hat{e}_1^i(P)]}{2v} \qquad (17).$$

Note that $p_2(p_1 = 0) = \dfrac{1 - q_1^T}{2 - q_1^T - q_1^W}$ and $p_2(p_1 = \bar{p}) = \dfrac{q_1^T}{q_1^T + q_1^W}$, where q_1^i is the probability that a policymaker of type i will set $p_1 = p$.

The key result is that, as opposed to DM, the sign of $m_2(\bar{p}) - m_2(0)$ will be unambiguously positive (assuming d in equation (4) is positive):

$$m_2(\bar{p}) - m_2(0) = (1 - \frac{a\bar{p}}{2v})^{-1}[\frac{d\bar{p}}{2v} + \frac{(q_1^W - q_1^T)(q^T - q^W)\bar{p}}{(q_1^W + q_1^T)(2 - q_1^W - q_1^T)8av}] \quad (18).$$

Equation (18) is analogous to equation (7) in DM. However, if $d > 0$, then there would be an additional *benefit* to the policymaker to set $p_1 = 0$ other than the signaling (reputation) effect given by the second term in brackets. Conversely, if positive inflation is observed in the first period, not only there is a cost on reputation, but also a future unemployment cost due to the negative spillover explained previously. If $d = 0$, the result is the standard Backus and Driffill (1985) result, where observing zero inflation in the first period increases the probability of observing zero inflation in the second period (given a set of shocks $\{e_1, e_2\}$) and hence increases reputation.

An interesting implication of this modification to DM's model is that whenever a policymaker is "forced" to inflate in the first period, it will find it more costly to reach a zero-inflation target in the second period. This implies that even a weak policymaker will have a greater incentive not to inflate in the first period, and the shock required for a policymaker to inflate in that period should be higher. The existence of this negative spillover in the second period that depends on the actions observed in the first period will benefit a weak type in the sense that the return to investment in reputation is higher than if this effect was not present. Moreover, for the tough policymaker it would be harder to reach its goal of zero inflation in the second period if it inflates in the first period. The inclusion of this type of effect may explain why the monetary authorities in Mexico still follow a stringent monetary policy and the gap between inflation expectations and inflation announcements has continued to close, at the cost of sluggish economic recovery.

2.5. Conclusions.

Part of the literature on inflation targeting has focused on the role of exchange rate variations in small open economies. While fear of floating can be explained as a result of high exchange rate passthrough to prices, balance sheet effects and country risk volatility associated with lack of credibility, its temporary nature has not yet been explored in depth in theoretical or empirical work. A modification of Drazen and Mason's (1994) paper, where unemployment persistence plays a key role in determining the credibility of a policy separated from the concept of reputation, has been explored. In this paper, the idea is that, under asymmetric information about policymaker's types, a government's reaction to an exogenous shock that seems optimal in the short run may introduce negative spillovers to economic agents such that there are future costs to such reactions over and above the negative effect on the government's reputation.

In Mexico, for example, the central bank continues to follow a stringent monetary policy in the sense that it signals a high commitment to setting low inflation. Even though this strong commitment may translate into short run output costs, at the same time the central bank may be aiming at avoiding harmful effects from deviating from its promises by not only losing reputation but introducing additional distortions that may be more costly in the long run.

Appendix 1. Unit Root Tests.

Unit Root Tests (monthly frequencies)

	ADF Statistic		Critical Value		Order of Integration
	Level	1st Difference			
Overnight Interbank Interest Rate	-2.53	-7.45	1%	-4.10	
			5%	-3.48	1
			10%	-3.17	
Credibility Gap	-1.19	-3.79	1%	-3.55	
			5%	-2.92	1
			10%	-2.60	
Output Gap	-1.39	-5.34	1%	-4.10	
			5%	-3.48	1
			10%	-3.17	
Nominal Exchange Rate	-1.62	-8.09	1%	-3.97	
			5%	-3.42	1
			10%	-3.13	
UMS26	-3.67	-7.59	1%	-4.10	
			5%	-3.48	0-1
			10%	-3.17	
Terms of Trade	-1.67	-5.69	1%	-4.10	
			5%	-3.48	1
			10%	-3.17	
Oil Prices	-1.61	-5.79	1%	-3.97	
			5%	-3.42	1
			10%	-3.13	

Appendix 1. (continued)

Result for Mexico Using Daily Data with Credibility Gap Decomposed

Dependent Variable: nominal overnight interest rate		
	OLS-NW	GMM 1/
constant	-21.97***	-23.17***
	(3.03)	(3.16)
lagged nominal overnight interest rate	0.41***	0.41***
	(0.06)	(0.06)
expected inflation	2.42***	2.33***
	(0.35)	(0.37)
announced inflation	-1.72***	-1.63***
	(0.34)	(0.36)
lagged observed inflation	-0.22**	-0.22**
	(0.10)	(0.10)
output gap (sa)	0.42***	0.42***
	(0.06)	(0.06)
lagged exchange rate depreciation	-0.04	-0.06
	(0.04)	(0.05)
govt. bond yield abroad	2.61***	2.75***
	(0.36)	(0.37)
lagged change in oil prices	-0.04***	-0.05***
	(0.01)	(0.01)
R Sq	0.93	0.93
Adj R Sq	0.93	0.93
Std. Error	1.70	1.70
Sum Squared Resid	3419.69	3421.18
F Stat	2101.04	-
Prob	0.0000	-
J Stat	-	0.0000
No. of Observations	1197	1196

1/ Instrument list includes lags of dependent variable, lags of observed inflation and lags of explanatory variables

*, ** and *** denote 10%, 5% and 1% significance respectively

Std. Errors in parentheses

Appendix 2. Endogenous Structural Change Tests Using Daily Data.

This output corresponds to the test for the regressions in column (a) of Table 1.7 and Table 1.8. The lagged dependent variable is the observation in *t*-1 (*daily* lag). In this case p=0 and q=7 since all variables are allowed to change across regimes. There is evidence of at least 1 structural break, which is supported by using the sequential procedure result.

Table A2.1. Daily Lagged Dep. Var. Allowed to Change

Set of regressors: RHS of Equation (2)						
Max number of breaks allowed (M): 5						
$SupF_T(k)$ test for (fixed) number of structural breaks						
k=1	*k=2*	*k=3*	*k=4*	*k=5*	*UDMax*[1/]	*WDMax*[1/]
34.10*	34.09*	32.46*	28.53*	26.65*	34.10*	43.50*
$SupF(i+1,i)$ test for i vs. i+1 structural breaks						
i=1	*i=2*	*i=3*	*i=4*	*i=5*		
16.32	20.20	19.19	19.19	-		
	Number of breaks selected					
Sequential Procedure	1*					
LWZ Procedure	0					
BIC Procedure	2					
Estimated dates[2/]						
$\hat{T}_1$	$\hat{T}_2$	$\hat{T}_3$	$\hat{T}_4$	$\hat{T}_5$		
9/22/98**	-	-	-	-		
(9/15/98-4/27/99)	-	-	-	-		

[1/] UDMax and WDMax tests for unknown number of structural breaks.

[2/] Intervals reported are significant at 5% level.

* Indicates 5% significance level.

** Selected estimated break(s).

Appendix 2. (continued)

This output *also* corresponds to the test for the regressions in column (a) of Table 1.7 and Table 1.8. The lagged dependent variable is the observation in t-1 (*daily* lag). However, in this case p=1 and q=6 since the lagged dependent variable is *not* allowed to change across regimes. There is evidence of at least 1 structural break as indicated by the *UDmax* and *WDmax* tests. 3 structural breaks are significant at the 5 percent level using the sequential procedure result.

Table A2.2: Daily Lagged Dep. Var. Not Allowed to Change

Set of regressors: RHS of Equation (2) except lagged dep. var.						
Max number of breaks allowed (M): 5						
$SupF_T(k)$ test for (fixed) number of structural breaks						
k=1	*k=2*	*k=3*	*k=4*	*k=5*	*UDMax*[1/]	*WDMax*[1/]
43.42*	33.80*	28.12*	19.56*	17.54*	43.42*	43.42*
$SupF(i+1,i)$ test for i vs. i+1 structural breaks						
i=1	*i=2*	*i=3*	*i=4*	*i=5*		
34.53*	28.90*	19.44	-	-		
		Number of breaks selected				
Sequential Procedure		3*				
LWZ Procedure		0				
BIC Procedure		0				
		Estimated dates[2/]				
$\hat{T}_1$	$\hat{T}_2$	$\hat{T}_3$	$\hat{T}_4$	$\hat{T}_5$		
6/1/98**	2/5/99**	4/24/01**	-	-		
(5/19/98-6/9/98)	(2/2/99-3/6/99)	(4/19/01-4/26/01)	-	-		

[1/] UDMax and WDMax tests for unknown number of structural breaks.

[2/] Intervals reported are significant at 5% level.

* Indicates 5% significance level.

** Selected estimated break(s).

Appendix 2. (continued)

This output corresponds to a similar specification for the regressions in column (a) of Table 1.7 and Table 1.8. The difference is that the lagged dependent variable is the observation in t-20 (*monthly* lag). In this case p=0 and q=7 since the lagged dependent variable is allowed to change across regimes. 4 structural breaks are identified as supported by the sequential method.

Table A2.3: Monthly Lagged Dep. Var. Allowed to Change

Set of regressors: RHS of Equation (2)						
Max number of breaks allowed (*M*): 5						
$SupF_T(k)$ test for (fixed) number of structural breaks						
k=1	*k=2*	*k=3*	*k=4*	*k=5*	*UDMax*[1/]	*WDMax*[1/]
35.96*	138.49*	151.43*	142.78*	208.43*	208.43*	340.18*
$SupF(i+1,i)$ test for i vs. i+1 structural breaks						
i=1	*i=2*	*i=3*	*i=4*	*i=5*		
75.37*	144.85*	24.89	-	-		

	Number of breaks selected
Sequential Procedure	4*
LWZ Procedure	3
BIC Procedure	4

Estimated dates[2/]				
$\hat{T}_1$	$\hat{T}_2$	$\hat{T}_3$	$\hat{T}_4$	$\hat{T}_5$
6/3/98**	2/9/99**	11/17/99**	11/9/00**	-
(5/29/98-6/8/98)	(1/13/99-3/5/99)	(11/11/99-12/15/99)	(11/6/00-11/30/00)	-

[1/] UDMax and WDMax tests for unknown number of structural breaks.

[2/] Intervals reported are significant at 5% level.

* Indicates 5% significance level.

** Selected estimated break(s).

Appendix 2. (continued)

This output corresponds to a similar specification for the regressions in column (a) of Table 1.7 and Table 1.8. The difference is that the lagged dependent variable is the observation in t-20 (*monthly* lag). In this case p=1 and q=6 since the lagged dependent variable is *not* allowed to change across regimes. 4 structural breaks are identified as supported by the sequential method.

Table A2.4: Monthly Lagged Dep. Var. Not Allowed to Change

Set of regressors: RHS of Equation (2) except lagged dep. var.						
Max number of breaks allowed (M): 5						
$SupF_T(k)$ test for (fixed) number of structural breaks						
k=1	*k=2*	*k=3*	*k=4*	*k=5*	*UDMax*[1/]	*WDMax*[1/]
53.25*	179.24*	219.66*	121.66*	196.62*	219.66*	330.67*
$SupF(i+1,i)$ test for i vs. $i+1$ structural breaks						
i=1	*i=2*	*i=3*	*i=4*	*i=5*		
72.03*	64.61*	26.55*	-	-		
	Number of breaks selected					
Sequential Procedure	4*					
LWZ Procedure	3					
BIC Procedure	4					
Estimated dates[2/]						
$\hat{T}_1$	$\hat{T}_2$	$\hat{T}_3$	$\hat{T}_4$	$\hat{T}_5$		
6/3/98**	2/9/99**	11/17/99**	11/10/00**	-		
(5/27/98- 6/8/98)	(1/8/99- 3/9/99)	(11/8/99- 12/17/99)	(10/30/00- 11/22/00)	-		

[1/] UDMax and WDMax tests for unknown number of structural breaks.

[2/] Intervals reported are significant at 5% level.

* Indicates 5% significance level.

** Selected estimated break(s).

Appendix 2. (continued)

This output corresponds to the test for the regressions in column (b) of Table 1.7 and Table 1.8. In this case *p*=0 and *q*=7 since the lagged dependent variable is allowed to change across regimes. 4 breaks are identified following the sequential method.

Table A2.5: Lagged Dep. Var. Allowed to Change

Set of regressors: RHS of Equation (2).						
Max number of breaks allowed (*M*): 5						
$SupF_T(k)$ test for (fixed) number of structural breaks						
k=1	*k=2*	*k=3*	*k=4*	*k=5*	*UDMax*[1/]	*WDMax*[1/]
55.86*	169.42*	156.06*	156.47*	234.05*	234.05*	381.99*
$SupF(i+1,i)$ test for *i* vs. *i*+1 structural breaks						
i=1	*i=2*	*i=3*	*i=4*	*i=5*		
116.49*	100.07*	721.00	-	-		
		Number of breaks selected				
Sequential Procedure		4*				
LWZ Procedure		3				
BIC Procedure		5				

Estimated dates[2/]				
$\hat{T}_1$	$\hat{T}_2$	$\hat{T}_3$	$\hat{T}_4$	$\hat{T}_5$
6/4/98**	2/10/99**	11/18/99**	11/8/00**	-
(6/1/98-6/15/98)	(2/1/99-3/11/99)	(11/8/99-12/8/99)	(11/3/00-12/11/00)	-

[1/] UDMax and WDMax tests for unknown number of structural breaks.

[2/] Intervals reported are significant at 5% level.

* Indicates 5% significance level.

** Selected estimated break(s).

Appendix 2. (continued)

This output *also* corresponds to the test for the regressions in column (b) of Table 1.7 and Table 1.8. In this case p=1 and q=6 since the lagged dependent variable is *not* allowed to change across regimes. 4 breaks are identified using the sequential method.

Table A2.6: Lagged Dep. Var. Not Allowed to Change

Set of regressors: RHS of Equation (2) except lagged dep. var.						
Max number of breaks allowed (*M*): 5						
$SupF_T(k)$ test for (fixed) number of structural breaks						
k=1	*k=2*	*k=3*	*k=4*	*k=5*	*UDMax*[1/]	*WDMax*[1/]
82.72*	81.74*	152.70*	208.62*	323.19*	323.19*	543.52*
$SupF(i+1,i)$ test for i vs. $i+1$ structural breaks						
i=1	*i=2*	*i=3*	*i=4*	*i=5*		
108.76*	108.76*	22.41	-	-		
	Number of breaks selected					
Sequential Procedure	4*					
LWZ Procedure	3					
BIC Procedure	5					
Estimated dates[2/]						
$\hat{T}_1$	$\hat{T}_2$	$\hat{T}_3$	$\hat{T}_4$	$\hat{T}_5$		
6/4/98**	2/10/99**	11/18/99**	11/10/00**	-		
(5/27/98-6/8/98)	(2/1/99-3/12/99)	(11/11/99-12/6/99)	(11/2/00-11/21/00)	-		

[1/] UDMax and WDMax tests for unknown number of structural breaks.

[2/] Intervals reported are significant at 5% level.

* Indicates 5% significance level.

** Selected estimated break(s).

Appendix 2. (continued)

This output corresponds to the test for the regressions in column (d) of Table 1.7 and Table 1.8, where the *monthly* lagged observed inflation is included as a regressor. In this case p=0 and q=8 since all variables are allowed to change across regimes. 4 breaks are selected as shown by the sequential procedure.

Table A2.7: Lagged Observed Inflation

Set of regressors: as in column (d) of Table 1.7 and Table 1.8						
Max number of breaks allowed (M): 5						
$SupF_T(k)$ test for (fixed) number of structural breaks						
k=1	*k=2*	*k=3*	*k=4*	*k=5*	*UDMax*[1/]	*WDMax*[1/]
55.83*	148.92*	382.00*	365.54*	337.46*	382.00*	550.76*
$SupF(i+1,i)$ test for i vs. $i+1$ structural breaks						
i=1	*i=2*	*i=3*	*i=4*	*i=5*		
294.67*	260.61*	32.77*	-	-		
		Number of breaks selected				
Sequential Procedure		4*				
LWZ Procedure		3				
BIC Procedure		5				
		Estimated dates[2/]				
$\hat{T}_1$	$\hat{T}_2$	$\hat{T}_3$	$\hat{T}_4$	$\hat{T}_5$		
6/16/98**	3/8/99**	11/18/99**	11/13/00**	-		
(6/11/98-6/17/98)	(2/18/99-3/5/99)	(11/15/99-12/9/99)	(11/6/00-11/21/00)	-		

[1/] UDMax and WDMax tests for unknown number of structural breaks.

[2/] Intervals reported are significant at 5% level.

* Indicates 5% significance level.

** Selected estimated break(s).

Appendix 2. (continued)

This output corresponds to the test for the regressions in column (e) of Table 1.7 and Table 1.8, where the *monthly* lagged observed inflation is omitted from the set of regressors. In this case p=0 and q=7 since all variables are allowed to change across regimes. Evidence supports the presence of 3 structural breaks using the same criterion as for previous tests.

Table A2.8: Endogenous Structural Change Tests

Set of regressors: as in column (e) of Table 1.7 and Table 1.8						
Max number of breaks allowed (M): 5						
$SupF_T(k)$ test for (fixed) number of structural breaks						
k=1	*k=2*	*k=3*	*k=4*	*k=5*	*UDMax*[1/]	*WDMax*[1/]
200.52*	230.55*	404.48*	494.26*	504.58*	504.58*	848.58*
$SupF(i+1,i)$ test for i vs. $i+1$ structural breaks						
i=1	*i=2*	*i=3*	*i=4*	*i=5*		
54.29*	318.82*	18.16	-	-		

	Number of breaks selected
Sequential Procedure	3*
LWZ Procedure	3
BIC Procedure	5

Estimated dates[2/]				
$\hat{T}_1$	$\hat{T}_2$	$\hat{T}_3$	$\hat{T}_4$	$\hat{T}_5$
8/27/98**	5/5/99**	11/10/00**	-	-
(8/21/98- 8/31/98)	(4/30/99- 5/11/99)	(11/2/00- 11/23/00)	-	-

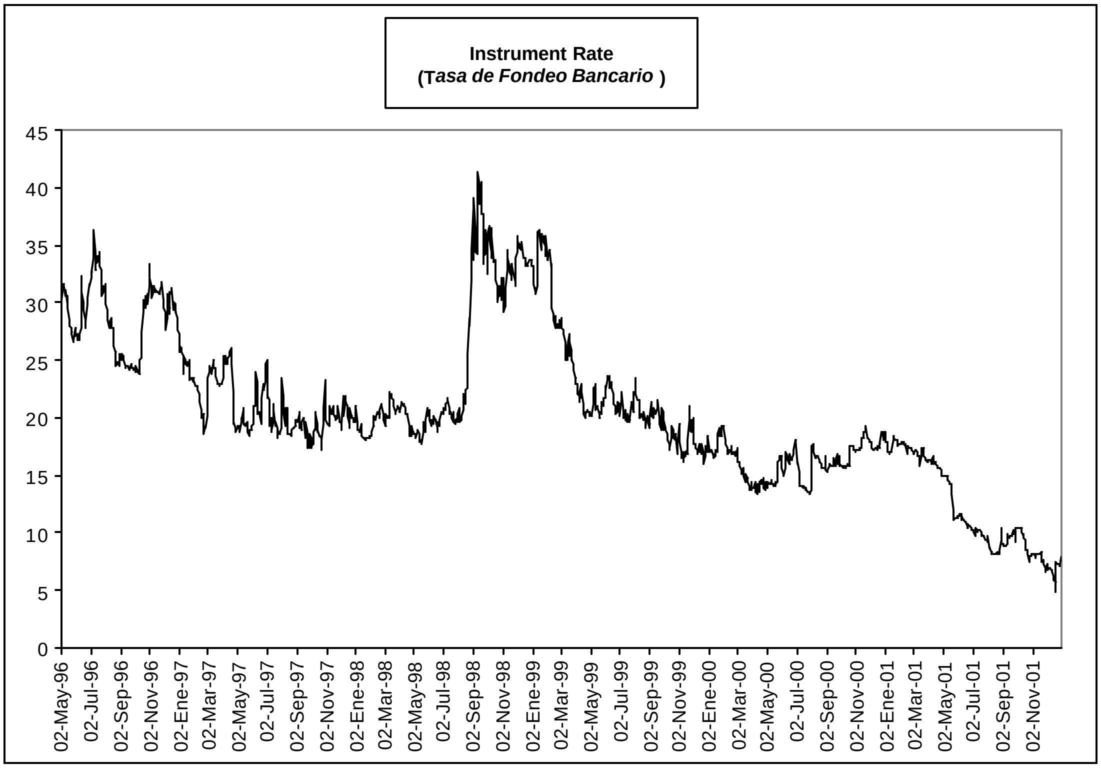
[1/] UDMax and WDMax tests for unknown number of structural breaks.

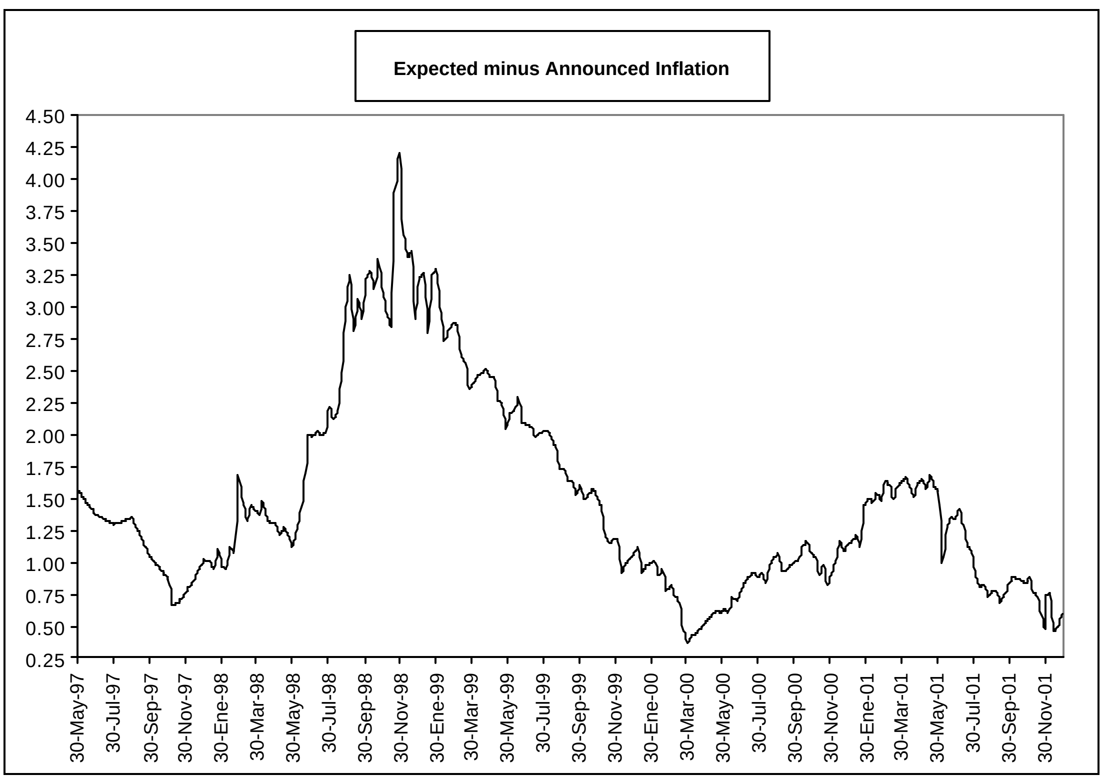
[2/] Intervals reported are significant at 5% level.

* Indicates 5% significance level.

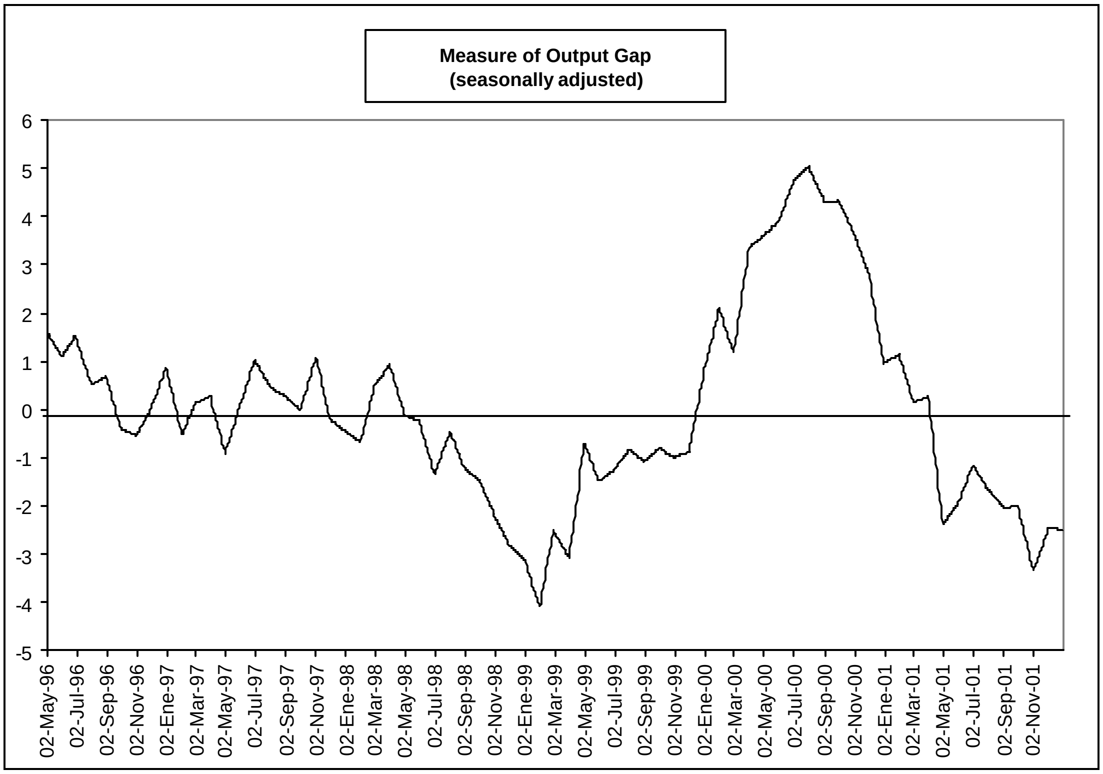
** Selected estimated break(s).

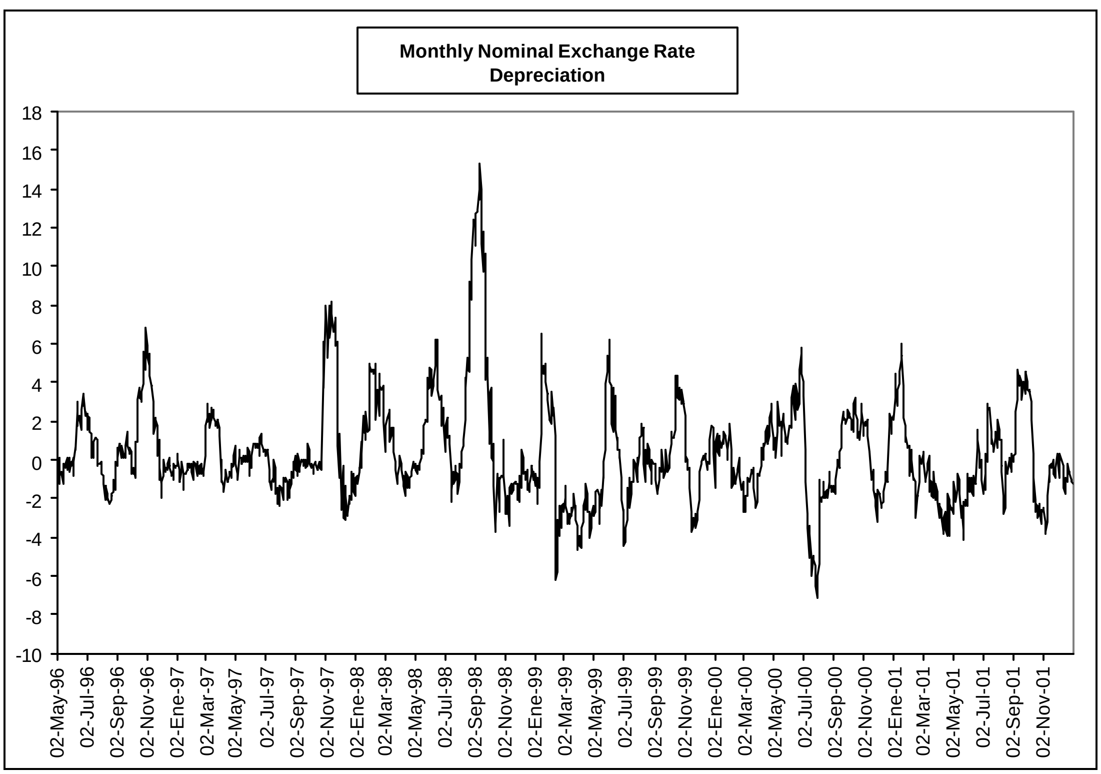
Appendix 3. Variables Included in Equation (2) for Mexico.



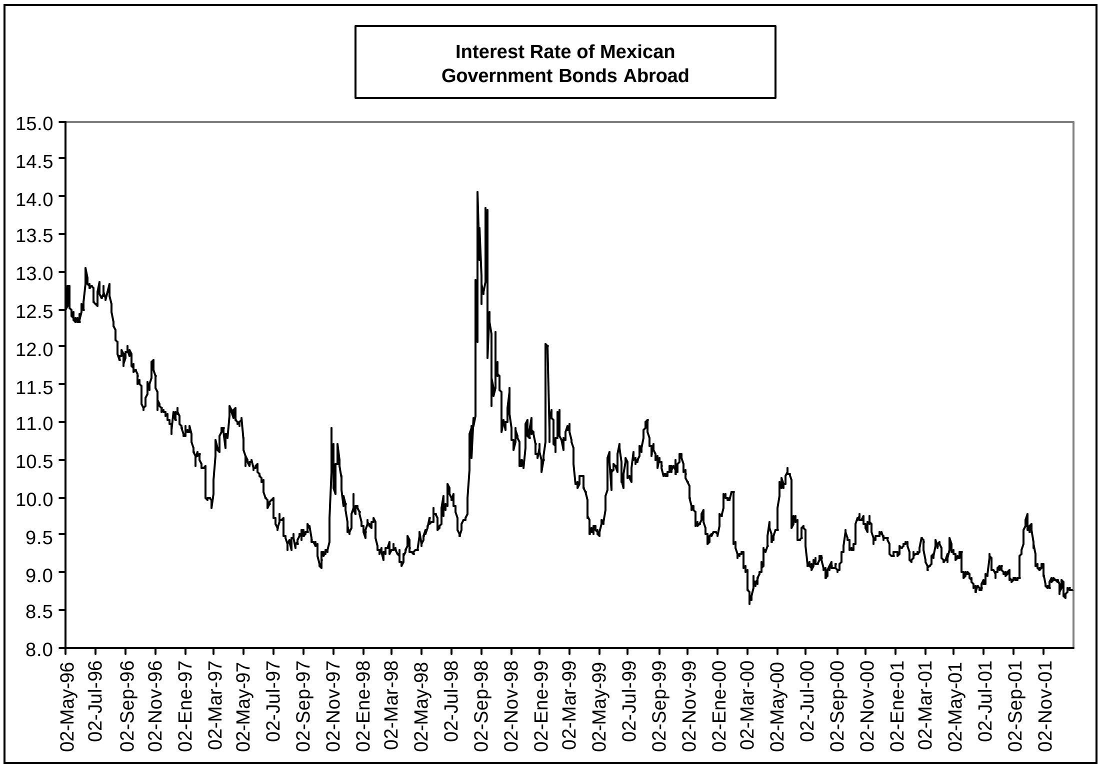


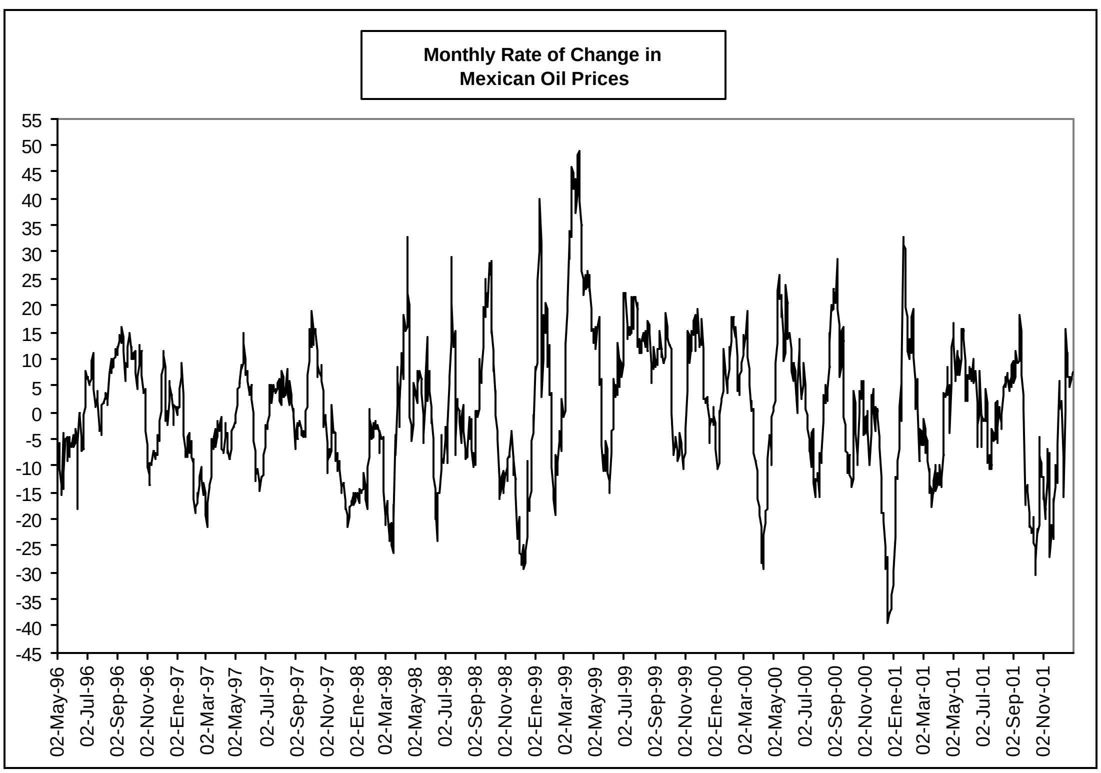
Appendix 3. (continued)



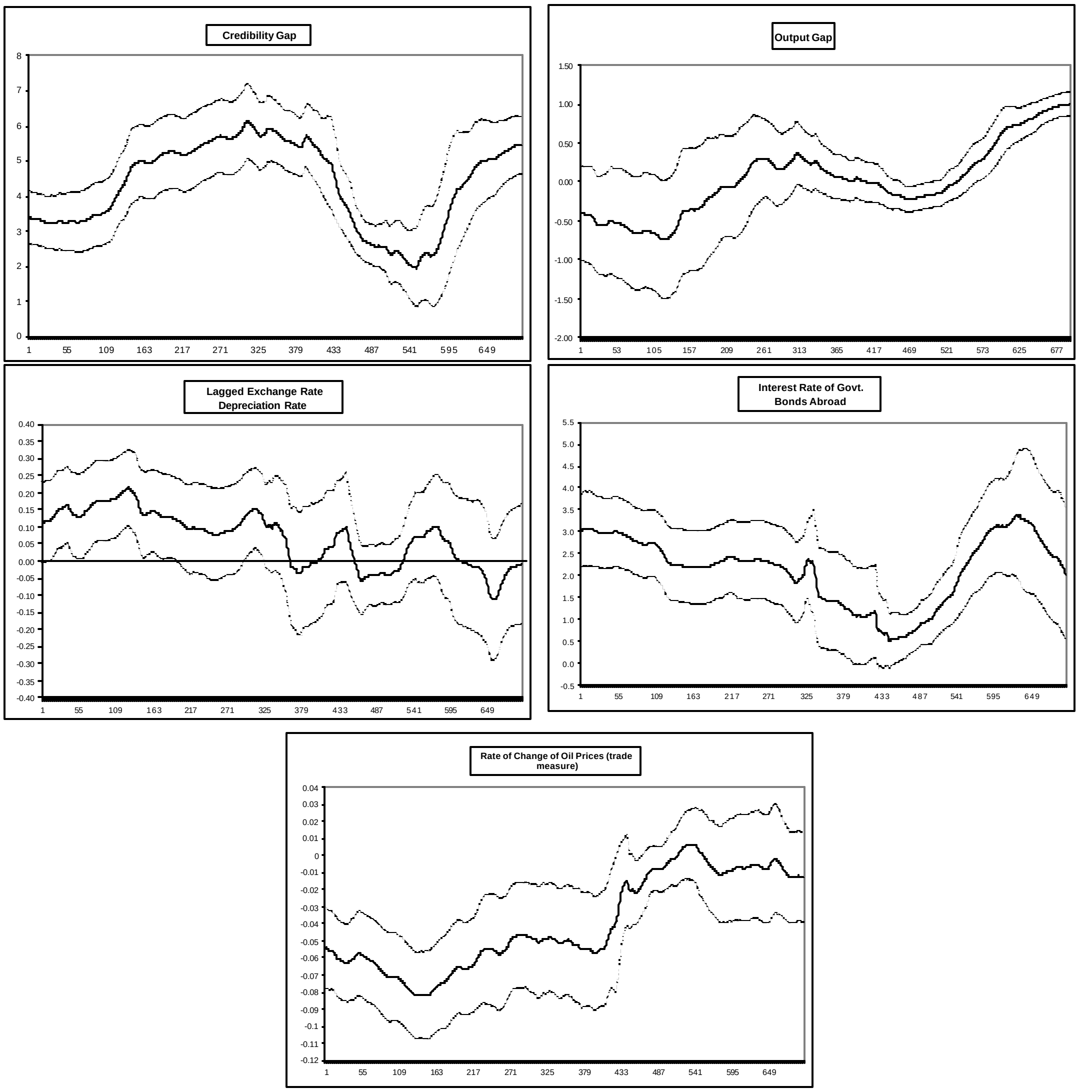


Appendix 3. (continued)





Appendix 4. Recursive Regression Coefficients).



Appendix 5. Endogenous Structural Change Tests for New Zealand (Quarterly Data).

Table A5[3/] Endogenous Structural Change Tests for New Zealand using quarterly data

Max number of breaks allowed (*M*): 5						
$SupF_T(k)$ test for (fixed) number of structural breaks						
k=1	*k=2*	*k=3*	*k=4*	*k=5*	*UDMax*[1/]	*WDMax*[1/]
28.73*	29.58*	102.46*	171.61*	186.83*	186.83*	314.19*
$SupF(i+1,i)$ test for *i* vs. *i*+1 structural breaks						
i=1	*i=2*	*i=3*	*i=4*	*i=5*		
13.34	23.62*	15.90	11.22	-		

	Number of breaks selected
Sequential Procedure	1*
LWZ Procedure	0
BIC Procedure	0

Estimated dates[2/]				
$\hat{T}_1$	$\hat{T}_2$	$\hat{T}_3$	$\hat{T}_4$	$\hat{T}_5$
1997:1**	-	-	-	-
(1996:2-1997:2)	-	-	-	-

[1/] UDMax and WDMax tests for unknown number of structural breaks.
[2/] Intervals reported are significant at 5% level.
[3/] All coefficients allowed to change (no lagged dep var).
* Indicates 5% significance level.
** Selected estimated break(s).

Interpretation follows from previous examples.

Appendix 6. Endogenous Structural Change Tests for Canada (Monthly Data).

Table A6[3] Endogenous Structural Change Tests for Canada using monthly data

Max number of breaks allowed (*M*): 5						
$SupF_T(k)$ test for (fixed) number of structural breaks						
k=1	*k=2*	*k=3*	*k=4*	*k=5*	*UDMax*[1/]	*WDMax*[1/]
466.53*	1221.23*	444.69*	381.98*	487.26*	1221.23*	1411.76*
$SupF(i+1,i)$ test for *i* vs. *i*+1 structural breaks						
i=1	*i=2*	*i=3*	*i=4*	*i=5*		
424.43*	80.22*	62.25*	-	-		

	Number of breaks selected
Sequential Procedure	4*
LWZ Procedure	2
BIC Procedure	4

Estimated dates[2/]				
$\hat{T}_1$	$\hat{T}_2$	$\hat{T}_3$	$\hat{T}_4$	$\hat{T}_5$
3/93**	12/94**	9/96**	8/99**	-
(1/93-4/93)	(10/94-1/95)	(7/96-10/96)	(6/99-9/99)	-

[1/] UDMax and WDMax tests for unknown number of structural breaks.

[2/] Intervals reported are significant at 5% level.

[3/] All coefficients allowed to change (no lagged dep var).

* Indicates 5% significance level.

** Selected estimated break(s).

Interpretation follows from previous examples.

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