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# Four Essays on the 1994 Mexican Crisis

by

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To Rogelio

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## Declaration

All the material in this thesis is my own work. The thesis has not been submitted for a degree at another university, and no part of it has been published or used in other academic or professional project.

## Summary

Most of the thesis is devoted to studying the collapse of the Mexican peso in December 1994 using empirical methods that allow shifts in regimes, as well as a small theoretical model based on the escape clause approach. Also, we present a study of the consumption boom observed in Mexico in the period 1989-1994 to highlight the importance of taking into account structural breaks in cointegration modelling.

We use a series of realignment expectations, as well as linear and non-linear methods, to look for evidence that helps to characterise the Mexican crisis. Contrary to the predictions of first-generation models of currency crises, we find that the credibility of the peso did not experience any steady deterioration before its devaluation, and there was no stable relationship between realignment expectations and economic fundamentals. By using a Markov-switching regression model, we show that realignment expectations shifted over time between regimes of relatively high and low credibility, and that these shifts were more frequent during the troubled 1994. This evidence makes it problematic to endorse explanations of the collapse of the peso based on models of speculative attacks, and suggests using the approach of second-generation models of currency crises to study the Mexican experience.

The theoretical model is designed to illustrate some specific features of the Mexican experience. We argue that the substitution of peso denominated assets for dollar denominated and indexed assets in investors' portfolios helped policymakers to resist recurrent periods of confidence crisis during 1994, but it also made it more difficult to eliminate a potential self-fulfilling devaluation. In particular, the sterilisation of reserve losses during 1994 seems to be more important in the onset of the devaluation of the peso than the increase in the stock of dollar indexed bonds.

We use an index of pressure in the foreign exchange market and mean-variance Markov-switching models to study the timing and causes of the shifts of the Mexican economy between states of calm and crisis. Models with time-varying transition probabilities do not yield conclusive results. Hence, we adopt a two step approach to obtain the probability of the state of crisis at each date in the sample, and then model this series as a function of economic fundamentals and political events. We find that the reduction of the debt-output ratio and positive political events maintained the economy in the state of calm up to 1994, despite a continuous real appreciation of the peso. However, the end of the declining path of the debt-output ratio and negative political shocks produced a shift towards the state of crisis for most of 1994 that finally led to the collapse of the peso.

The study of the consumption boom observed in Mexico in the period 1989-1994 illustrates that structural breaks in long run relationships can be dated and evaluated if we allow regime shifts in cointegration modelling. The available data rejects a stable cointegration relationship between consumption and income. Meanwhile, using Markov-switching models, we find that there was a marked shift in the cointegration vector after the implementation of the program for stabilisation and economic reform in December 1987. The program caused the former unitary income elasticity of consumption to increase by almost 30 per cent, but later the shift was reversed when the currency and financial crisis erupted at the end of 1994.

# Chapter 1

## Introduction

In December 1987 the Mexican government implemented a program whose aim was stabilisation and economic reform. This program seemed to be very successful, and was praised by many institutions and scholars. The exchange rate-based stabilisation program reduced the inflation rate from 159 per cent in 1987 to 7 per cent in 1994. And the economic reform led to a considerable reduction in the government's participation in the economy, the privatisation of the banking system, and was crowned with the North American Free Trade Agreement (NAFTA).<sup>1</sup> However, during 1994 the peso became under pressure and collapsed in December 21st.

The Mexican currency crisis and the financial crisis that followed confronted many investors, officials and academics with an enormous surprise that gained instantaneous attention around the world and motivated a massive, unprecedented international loan package backed by the US government and the IMF worth 48 billion dollars. In academic circles, the collapse of the peso called for a better understanding of sudden currency crises that has continued growing due to the turmoil in Latin America that followed the Mexican crisis, and more recently due to the chain of devaluations and financial crises in East Asia.

The recent precedent for sudden, strong currency crises was the experience of the European Exchange Rate Mechanism in the fall of 1992, whose effects continued until 1993, and led to the widening of the currency bands. The crisis of

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<sup>1</sup>See Aspe (1993) and Lustig (1992) for detailed expositions of the stabilisation and economic reform program.

the ERM encouraged new hypotheses and explanations for currency crises and a new generation of models started to develop. The development of new models resulted primarily from the fact that this experience did not fit with the existing paradigm used to study balance of payments crises, which was based on the seminal contribution of Krugman (1979).

Obstfeld (1997b, 1996, 1995, 1994, and 1986) pioneered a new strand of the theoretical literature of currency crises that explicitly incorporates the strategic interplay of speculators and economic authorities. Obstfeld postulates that under some conditions, determined by macroeconomic fundamentals, there may be multiple equilibria in foreign exchange markets and self-fulfilling currency crises. The theoretical literature based on the escape clause approach, also called second-generation models for currency crises, grew rapidly in the mid 1990s and is now part of the indispensable knowledge for studying currency crises. However, the empirical analysis of the currency crises of the 1990s is still insufficient.

Most of the literature based on second-generation models has been theoretically oriented and the discussion of real events is somewhat tentative, and restricted to qualitative reviews of the conditions and variables that were the likely causes of crises. While the implementation of econometric models to discern the nature of recent devaluations (due to bad fundamentals, as in Krugman's mode, or with self-fulfilling elements, as with Obstfeld) and able to study systematically the effects of sudden shifts in speculators' expectations has lagged behind a large collection of theoretical propositions. Modern econometric studies of recent currency crises are scarce, and the best-known papers have focused on the experience of the French franc in 1992-93 (Jeanne and Masson (2000), Jeanne (1997)) and the crisis of the ERM (Dahlquist and Gray (2000) and Gomez-Puig and Montalvo (1997)).

Most of the present study is a contribution to the empirical literature on currency crises that focuses on the nature and causes of the collapse of the Mexican peso in December 1994. The purpose of this work is to offer, at least, a partial answer to a key issue raised by Garber and Svensson (1994) some time ago: "It is widely understood [...] that it is difficult to distinguish between situations in which multiple equilibria may be present and situations in which exogenous policies inevitably lead to a collapse of a fixed exchange rate. The development of methods to distinguish between these two models of speculative attacks in the data is an

important open issue of the field" (page 1901).

On the theoretical side, we present a small model based on the escape clause approach, the purpose of which is to illustrate some specific features of the Mexican crisis. The model considers the financing needs of a consolidated government (that includes the central government and the Central Bank) and the effects of investors' expectations on the decision of policymakers whether to devalue or not. We use this model to illustrate the policies pursued in Mexico during 1994 to resist recurrent confidence crises, and their role in the onset of the devaluation at the end of that year.

The thesis also includes an analysis of one of the most noticeable effects of the program for stabilisation and economic reform implemented in Mexico at the end of 1987: the boom in private consumption observed in the period 1989-1994. In this work we argue that long run relationships can be subject to regime shifts that can be accurately identified and evaluated if we allow shifts in the parameters of cointegration relationships. With this work we aim to contribute to the growing literature on modelling structural breaks in cointegration relationships.

Throughout the thesis, intensive use is made of the Markov-switching models introduced in the econometric literature by Hamilton (1996, 1994, 1989) which enable us to analyse shifts in regimes by allowing changes over time in the parameters governing stochastic processes.

The plan of the thesis is as follows. Chapter 2 presents an overview of the theoretical and empirical literature relating to currency crises. We review the different theoretical approaches existing in the literature, and stress the mechanisms that can lead to devaluations and their implications for the analysis of data. For obvious reasons, we give considerable attention to the empirical studies of the devaluations of the Mexican peso that occurred in the past three decades. And, in contrast to other surveys, we include in our review papers that have used the drift adjustment method of Bertola and Svensson (1993) to construct a series of realignment expectations that are used as indicator of the credibility of target zones, as well as empirical works that are close in spirit to the so-called second generation models of currency crises.

In Chapter 3 we make use of empirical techniques to discern whether the collapse of the Mexican peso was a conventional currency crisis caused by erroneous

macroeconomic management, or rather, a sudden crisis in which self-fulfilling elements were present. We construct a series of realignment expectations using the drift adjustment method and analyse their relationship to macroeconomic fundamentals using linear methods and a non-linear Markov-switching regression model. This model generalises the one used by Jeanne and Masson (2000) since we consider shifts not only in the constant term but also in all the remaining coefficients. This is so because we are interested not only in shifts in the level of realignment expectations over time, but also in the changes of the relationship between those expectations and macroeconomic fundamentals.

We find that neither the path nor the relationship of realignment expectations with macroeconomic fundamentals predicted by first generation models of currency crises was present before the devaluation of the peso. Using a Markov-switching regression model we show that the credibility of the Mexican peso shifted between states of relatively low and high credibility in the period 1988-1993 but tended to stay in one regime or another for long periods. And these shifts in credibility became erratic during 1994, a year marked by recurrent political and financial turmoil. Also, we also find that in the months immediately before the devaluation of the peso the expectations of a realignment were relatively low, and linked only to the changes in the Central Bank's international reserves.

In view of these results, we suggest that it is hard to endorse explanations of the Mexican crisis that attribute the collapse of the peso to imbalances resulting from persistent macroeconomic mismanagement. Rather, we advance the hypothesis that to understand the Mexican experience in 1994 and the collapse of the peso at the end of that year, we have to consider shifts in speculators' expectations and the reaction of policymakers.

In Chapter 4 we present a model inspired by the escape clause approach to illustrate our ideas regarding the Mexican experience in 1994. This is a model with two periods in which under certain conditions, determined by macroeconomic fundamentals, the effects of speculators' expectations on interest rates and the government's financing needs can produce more than one equilibrium, and a self-fulfilling currency crisis may occur as the result of changes in investors' expectations.

This model allows us to discuss the mechanisms used by policymakers to cope with the recurrent confidence crises observed in 1994. In particular, we advance

the view that policymakers resisted periods of confidence crises by encouraging investors to substitute assets denominated in pesos for assets denominated in or indexed to the dollar, and in this way promoted the coordination of speculators' expectations in the no-devaluation equilibrium. However, this did not eliminate completely the possibility of a self-fulfilling devaluation. Indeed, we argue that the government may have contributed to open the possibility of a self-fulfilling crisis by following a policy of sterilisation of reserve losses.

Based on our model, we suggest that some macroeconomic fundamentals and political factors may have put the Mexican economy in a situation in which a self-fulfilling crisis was a possibility, and the periods of confidence crisis observed during 1994 were successfully confronted thanks to massive substitutions of assets in investors' portfolios. Recurrent confidence shocks, however, had the effect of exhausting this mechanism of defence and the final round of financial turmoil resulted in the devaluation of the peso at the end of the year.

Chapter 5 presents an empirical investigation of the origins of the devaluation of the peso, which is designed to be close in spirit to the approach of second-generation models of currency crisis. An index of pressure in the foreign exchange market is used to measure the credibility of the peso over time and mean-variance Markov-switching models are employed to identify both the timing and causes of confidence crises. We find that the Mexican economy shifted over time between a state of calm – with a slight pressure for peso depreciation – and a state of crisis – with stronger and more volatile pressure for peso depreciation. And these shifts were related to some macroeconomic fundamentals and political events.

Markov-switching models with time-varying transition probabilities suggest that fiscal matters and political events caused the shifts of the economy between the periods of calm and crisis but these results are not conclusive. This is why we adopt an alternative approach, using a model with constant transition probabilities to obtain the probability of the crisis state at each date in the sample and model this series as a function of macroeconomic fundamentals and political news.

The two step approach yielded robust results. These indicate that despite a real appreciation of the peso, the continuous reduction of the debt to output ratio and positive political news helped to maintain the economy in the state of calm until the end of 1993. However, the definitive change in the path of the public debt



relative to output and an unprecedented series of negative political shocks shifted the economy towards the state of crisis during most 1994, in spite of a modest real depreciation of the peso. In such a state of crisis, reserve losses accumulated over the year, leading finally to the collapse of the peso. These results are confirmed when we estimate a model in which the transition probabilities depend on the variables mentioned.

Chapter 6 focuses on one of the most noticeable consequences of the program for stabilisation and economic reform introduced in Mexico in December 1987: the boom in private consumption observed in the period 1989-1994. Here, we highlight the importance of taking structural breaks into account, not only when testing for unit roots but also when modelling long run relationships. Specifically, we argue that structural breaks in long run relationships can be accurately dated and evaluated if we allow regime shifts in cointegration modelling.

Using standard cointegration modelling procedures, we find that a long run relationship with stable parameters between private consumption and income is rejected by the available data. Hence, we propose modelling the long run relationship taking into account shifts in regime.

Our estimates show that the implementation of the stabilisation and economic reform program at the end of 1987 led to a sharp change in consumption behaviour. Such a change implied a shift from a cointegration vector with unitary income elasticity to another with a much larger elasticity: during the boom, private consumption was growing 30 per cent faster than income. And later, when the currency and financial crises erupted at the end of 1994, the vector with unitary elasticity was re-established.

Chapter 7 presents the conclusions of our work and discusses prospective future research. The Appendix details the series used.

## Chapter 2

# Review of the Literature on Currency Crises

### 2.1 Models of speculative attacks

First generation models of currency crises explain these events as the result of the maintenance of fiscal and monetary policies that are inconsistent with a fixed exchange rate regime. The seminal contribution of Krugman (1979) portrays a small open economy in which a speculative attack against the currency is preceded by a period of money creation, needed to monetize persistent fiscal deficits, that exceeds the growth of money demand and produces continuous reserve losses which will inevitably deplete reserves at some future date. The speculative attack occurs before reserves have been totally exhausted and consists of a massive exchange of domestic money for the remaining international reserves in the Central Bank. Without reserves to maintain the official rate, the Central Bank allows the exchange rate to float and the nominal interest rate adjusts upwards to a level consistent with a continuous depreciation of the domestic currency because the monetization of fiscal deficits will continue. The timing of the attack cannot be determined using Krugman's model due to non-linearities but the log-linear version of Flood and Garber (1984) allows the exact determination of the time of the attack. This occurs when the shadow exchange rate, the one that is consistent with the path of money supply, is equal to the fixed exchange rate.

Extensions of the basic speculative attack model have made it more realistic

and permitted the identification of some general features of the behaviour of the economy in the run up to a currency crisis. In what follows, we present a review that focuses on some features that have been stressed in interpretations of the Mexican crisis based on the speculative attack approach, such as Dornbusch and Werner (1994), Dornbusch, Goldfajn and Valdes (1996), Edwards (1997), and Warner (1997). Other reviews of those extensions can be found in Agenor and Flood (1994) and Blackburn and Sola (1993).

Flood and Garber (1984) and Dornbusch (1987) present versions of the speculative attack model that incorporate uncertainty about the growth of domestic credit and show that there is an upward trend in domestic nominal interest rates prior to the speculative attack due to an increasing probability of devaluation, and also increasing rates of reserve losses that exceed the growth of domestic credit because money demand decreases. Also, Willman (1989) has shown that a pattern of rising interest rates will emerge if there is uncertainty about the reserve limit that triggers the abandonment of the fixed parity.

A very complete account of the empirical regularities that we should expect to observe before a currency crisis is obtained in a model that incorporates sticky prices and predetermined but forward looking wages. According to Willman (1988), an anticipated collapse affects current wages because of its forward looking nature, and this in turn affects prices (which are determined as a mark-up on wages), the real exchange rate, the trade balance and output. The rise of wages and prices lowers the real interest rate, which exerts an expansionary effect on output, and the trade balance deteriorates continuously before the official exchange rate is abandoned due to the loss of competitiveness. However, the steady rise in domestic prices results in real appreciation of the domestic currency, which dampens the initial expansive effect of the real interest rate. When the abandonment of the fixed exchange rate occurs, the real interest rate falls because the expected rate of depreciation jumps upwards in order to be consistent with the persistent creation of money in a floating regime, which makes output increase, and there is a further deterioration of the trade balance. Later, the trade balance will return gradually to its steady state level due to the continuous depreciation of the domestic currency. These stylised facts can also be found in the extensions of Krugman's model suggested in Flood and Hodrick (1986) and Conolly and Taylor (1984).

This general description of the regularities we should expect to find in the run up to a currency crisis is compatible with two other central notions about rational responses to an anticipated devaluation. Vegh (1992) and Calvo (1996b) use models in which money demand is motivated by a cash-in-advance constraint to show that a large current account deficit emerges in anticipation of a future balance of payments crisis because agents reallocate future consumption to the present. And Penati and Pennacchi (1989) show that the growth of the current account deficit is reinforced when private agents hedge themselves against the risk of devaluation by accumulating assets denominated in foreign currency.

In sum, according to the approach of models of currency crises *à la* Krugman, a general syndrome in the economy prior to a crisis should be identifiable: expansionary fiscal policy, fast output growth, overvaluation of the domestic currency, large trade and current account deficits, rapid money creation and continuous reserve losses. And this should be accompanied by a steady increase in realignment expectations, expressed as a rising pattern of interest rate differentials. In the empirical analysis of Chapter 3, we will investigate whether these implications of the speculative attack approach were present in the collapse of the Mexican peso in December 1994.

## **2.2 New approaches to currency crises**

### **2.2.1 Second-generation models of currency crises**

Largely because the predictions and implications of the speculative attack approach did not fit with the crisis of the European Exchange Rate Mechanism of 1992-93, models using the escape clause approach, or second-generation models of currency crises, have been proposed. The main principles guiding these models are: *a)* the abandonment of an exchange rate parity is not necessarily the result of unsustainable macroeconomic policies, but a decision taken by an optimizing policymaker that weighs the costs and benefits of such a decision; *b)* the expectations of speculators affect the decision of the government to exercise the escape clause and abandon the parity; and *c)* due to the circularity implied above, there can be multiple equilibria and self-fulfilling currency crises.

In second-generation models of currency crises, there is no need for fiscal, monetary or external imbalances to accumulate over time and hence no evident reason for the eventual abandonment of the exchange rate regime. However, currency crises may happen as one of the outcomes of multiple equilibria, which arises because economic policy is contingent on speculators' expectations. The government has to weigh the cost of abandoning the exchange rate regime and the cost of defending the actual parity, and it may be forced to opt out if devaluation expectations feed into interest rates, prices and wages in order to pursue some other policy objectives such as the growth of output, the level of employment, the size and cost of public debt, the competitiveness in international trade or the health of the domestic financial system (Obstfeld, 1996, 1994). In models with multiple equilibria, the key component of the dynamics is the set of beliefs of investors, which may synchronize in a way that makes it preferable for the government to abandon the parity. That is, a change in market sentiment may trigger the abandonment of the exchange rate parity, and hence, the expectation of a devaluation becomes self-fulfilling.

It is important to state clearly some ideas concerning second-generation models. First, on the one hand, there are models of currency crises with an optimizing policymaker and escape clauses that do not involve the possibility of multiple equilibria, as the one by Isard (1995, chapter 9). We can label his model a pure escape clause model since the decision to abandon the parity cannot be due to changes in market sentiment. There is the need for a strong enough shock to provoke the conditions that make preferable for the government to abandon the exchange rate parity. On the other hand, there are models in which the role of self-fulfilling expectations is stressed. For instance, the early work of Obstfeld (1986) presents a model of pure self-fulfilling balance of payments crises in which the currency crisis can occur if monetary policy is expected to be looser after the abandonment of a fixed exchange rate, and such an expectation may itself push the government to relax monetary discipline. In the review of second-generation models presented below we stress the role of multiple equilibria.

Second, in models with multiple equilibria, the timing of the speculative attack is rather arbitrary because of the sunspot nature of the equilibria, but it does not mean that a crisis can occur at any moment or under any circumstance. For

subjective changes in market sentiment to provoke a self-fulfilling currency crisis, certain conditions on the fundamentals of the economy are necessary. In other words, shifts in market sentiment cannot produce a crisis in an economy with strong fundamentals. This is a very important point that has been stressed in Obstfeld (1997b, 1996, 1994), Obstfeld and Rogoff (1996), Jeanne (1999, 1997) and Jeanne and Masson (2000).

Third, in accordance with the above, we may expect the concerns of investors about the likelihood of a potential currency crisis to have some effect on domestic interest rates when fundamentals deteriorate. Krugman (1996) and Sutherland (1997) have suggested that the mere possibility of a sudden crisis affects interest rates.

In what follows we review several second-generation models of currency crises and stress the mechanisms and macroeconomic fundamentals that can make a self-fulfilling crisis possible.

Drazen and Masson (1994) and Masson (1995) have suggested that the rate of unemployment may play a dual role in a country with a fixed or semi-fixed exchange rate parity. Increasing unemployment may enhance the reputation of the government by signalling its commitment to incur output and employment losses when the objective is to maintain the exchange rate parity, but it may also raise doubts about the ability of the government to defend the domestic currency since there should be some limit to the level of unemployment that can be tolerated. That is, increasing rates of unemployment may end up damaging the credibility of the exchange rate regime. Unemployment also plays a key role in the model of Ozkan and Sutherland (1998), who show that a government may find it optimal to renege on the exchange rate parity in order to boost aggregate demand, output and employment. Since investors are aware of this temptation, they incorporate the expectations of a devaluation into interest rate differentials when economic activity slows down, which may bring forward the abandonment of the parity by depressing economic activity further. Therefore, we should expect to find a positive relationship between realignment expectations and the rate of unemployment, as did Drazen and Masson (1994) and Masson (1995) in their empirical analysis.

The level of international reserves available to defend the domestic currency has been postulated as a variable linked to the likelihood of a sudden speculative

attack. In the model for the Mexican crisis of Sachs et al (1996a) and that of Velasco (1996), a reduction of international reserves increases the net debt of the consolidated government (the federal government and the Central Bank), which produces a temptation to abandon the current parity and deflate the portion of gross debt denominated in domestic currency. Hence, when the net government debt is in a certain critical range, the expectation of a devaluation produces higher interest rates and can make the devaluation happen. Also, it can be argued that the lower the amount of reserves the higher the probability that a negative shock to competitiveness will exhaust the remaining reserves, and hence, a small amount of reserves may trigger strategic behaviour by speculators, making it optimal for each of them to acquire as many international reserves as possible, which unchains the speculative attack. Therefore, increases in the stock of international reserves should decrease the likelihood of a sudden crisis.

The level of public debt has been indicated as fertile ground for self-fulfilling speculative attacks and debt crisis by Calvo and Mendoza (1996), Sachs et al (1996a,b), Velasco (1996), and Cole and Kehoe (1996), because, as mentioned above, the higher the government debt the greater the temptation to deflate the portion of debt denominated in domestic currency. Also, Obstfeld (1994) has shown that the higher the level of public debt, the higher the costs in terms of interest payments when the domestic currency is attacked and hence the greater the probability that the government will prefer to renege on the existing exchange rate parity and relax its budget constraint by deflating the real debt service in order to avoid further increases of public debt and higher costs of financing. Therefore, we should expect a positive effect of increases in the ratio of public debt to GDP on the likelihood of a self-fulfilling devaluation.

A short maturity of public debt has been proposed by Giavazzi and Pagano (1990) as a potential cause of sudden speculative attacks. These authors stress the fact that shorter maturities imply increasing borrowing needs in the near future that should be faced by either rolling over the existing debt at increasing interest rates or by expanding the domestic credit of the Central Bank, which implies the abandonment of the exchange rate parity. In their model, the interaction between the private sector's expectations and the reaction of the government can lead to a self-fulfilling crisis by increasing the costs of rolling over public debt and

forcing the government to resort to financing from the Central Bank. Therefore, we should expect a reduction in the average maturity of public debt to increase the probability of a crisis.

Calvo (1996c) and Calvo and Mendoza (1996) have argued that a precarious financial position of the banking system can make a sudden crisis more likely. The argument is that if the currency crisis passes through a bank run, in the sense that the domestic money that is exchanged for international reserves is withdrawn from the banking system, the expectation of domestic credit creation by the Central Bank to support commercial banks produces the conditions for a self-fulfilling currency crisis. In this case, the abandonment of monetary discipline occurs because the Central Bank tries to avoid the credit squeeze and bankruptcies that would occur if the domestic credit to the banking system were not expanded. Hence, a precarious financial position of the banking system should increase the likelihood of a self-fulfilling crisis.<sup>1</sup>

The increase in the share of short term debt indexed to foreign currency has been suggested by many authors as one of the causes of the Mexican currency crisis. This argument has been best portrayed by Calvo and Mendoza (1996). They suggest that the increase of dollar indexed debt during 1994 reduced the net availability of reserves because in case of a run on Mexican bonds, the Central Bank would need to spend international reserves to repurchase such a debt. Then, as the share of short term debt indexed to the dollar increased rapidly during 1994, the credibility of the peso came under serious doubts and this helped prepare the ground for a sudden crisis. Following their argument, we should expect to find a positive relationship between realignment expectations and the fraction of government debt indexed to the dollar.

Finally, it has been argued that the position of the exchange rate within a currency band can reinforce speculative behaviour and increase the likelihood of a devaluation. Caramazza (1993) argues that the position of the exchange rate in the band may be interpreted as capturing the actual market sentiment or the credibility of the target zone – this interpretation can be derived also from Bertola and Caballero (1992). Hence, the closer the exchange rate to the upper limit of

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<sup>1</sup>This argument is similar to the central hypothesis of the so-called third-generation models for financial and currency crises that are commented below.



the band the higher the probability of a realignment. Another reason to consider a positive effect of the position of the exchange rate within the band on realignment expectations is that since intervention is costly for the Central Bank in the sense of using a scarce resource to defend the parity, the prospect of costly intervention when the exchange rate is close to the upper limit may reinforce speculation – see Chen and Giovannini (1997). Hence, the higher the position of the nominal exchange rate in a currency band, the more likely should be a sudden speculative attack.

### **2.2.2 Third-generation models for financial and currency crises**

The recent crises in East Asia have stressed the connection between banking and currency crises and the contagion of crises between countries (see, for instance, the collective volume edited by Agenor et al (1999)). And following these experiences, a third-generation of models for financial and currency crises has started to develop. These models are often based on the literature on bank runs initiated by Diamond and Dybvig (1983) and consider currency crises as part of broader crises rooted in the financial fragility of domestic financial systems. That is, third-generation models are not focused on speculative attacks, currency crises are considered a by-product of a massive run of investors and creditors away from domestic financial assets, both financial and real estate. In the words of Paul Krugman (1998, p. 73): "The Asian story is really about a bubble in – and subsequent collapse of – asset values in general, with currency crises more a symptom than a cause". Examples of this recent literature are: Chang and Velasco (1998), Goldfjan and Valdes (1997), Corsetti et al (1998) and Edison et al (2000).

This literature often focuses on the conditions that generate financial fragility, such as the mismatch of maturities, riskiness and currency denomination of the financial intermediaries' assets and liabilities (especially the banking system), the problem of moral hazard in banking that emerges because of (explicit or implicit) deposit guarantees extended by governments, and the poor regulation of banking activities.

The economy portrayed in third-generation models is one in which an exag-

generated expansion of risky credit supported by capital inflows generates a phase of accelerated growth and a self-sustaining bubble in the prices of financial and housing assets that make the conditions of the economy appear sounder than it actually is. However, when a negative shock or contagion from another economy in trouble stops the flow of resources, the asset price bubble bursts, and a run away from the financial assets of the country is initiated and produces a currency crisis.

It is worth mentioning that some authors, as Jeanne (1999) and Chang and Velasco (1998), have suggested that existing second-generation models of currency crises can be extended to model the banking sector and, hence, there is no real need for a third-generation of models. This idea can be illustrated with the models of Calvo (1996c) and Calvo and Mendoza (1996) mentioned above. These models have the same basic logic of third-generation models in the sense that a fragile financial position of the banking system can result in a sudden self-fulfilling currency crisis because the bank run is transformed into a run away from the domestic currency when investors withdraw their resources.

In the empirical analysis of Chapters 3 and 5 we will consider a key variable reflecting the degree of fragility of the banking system. We use the share of non-performing loans to total loans as a measure of the health of the banking system and examine its relationship with the credibility of the peso. We expect to find a negative relationship between the fraction of non-performing loans to total loans and investors' confidence on the peso, since, according to the arguments above, the more fragile the banking system the more likely a potential currency crisis.

### **2.3 Review of the empirical literature**

We classify the empirical literature on currency crises into five categories. Our classification contrasts with the one contained in the extensive review of Kaminsky et al (1997) because they include papers presenting informal evidence to argue for the likely causes of some crises and ignore most recent papers that use the drift adjustment method to measure the credibility of currency bands, papers in the vein of second-generation models and other original works. We include these works and constrain the review only to papers containing econometric analysis.

The first category considers papers containing explorations of the behaviour of

several economies before and after realignments and periods of extreme pressure in the foreign exchange market that are aimed towards the identification of early warning signals of crises. The second category includes empirical applications of the conventional model of balance of payments crisis in which the estimation of the probability of a devaluation plays the central role. The third category includes papers that use the so-called drift adjustment method to construct an indicator of realignment expectations for currency bands and relate them to the behaviour of macroeconomic fundamentals in order to look for the likely causes of realignments. The fourth category includes works that are close in spirit to second-generation models of currency crises and allow regime shifts in order to capture sudden changes in market sentiment. Finally, a less well-defined category includes studies that do not share a specific method but contain original approaches and interesting results.

*Broad data explorations.* In this category, we include the work of Eichengreen et al (1995)<sup>2</sup> which uses macroeconomic data from 20 industrialized countries for the period 1959-1993 and an approach based on the event studies methodology to identify empirical regularities before and after crises, devaluations and other changes of exchange rate regimes. The final objective of their analysis is to look for early warning signals of crises and devaluations by comparing the behaviour of a large set of macroeconomic variables two years before and after crises and devaluations with the one observed in periods of 'tranquillity' in which no changes in regime took place or there was no pressure in the foreign exchange market. The empirical regularities identified by the authors are that devaluations tend to occur after periods of expansionary monetary policy, wage and price inflation, deteriorating competitiveness, weak external accounts and increasing unemployment. The authors considered not only episodes of devaluation but also periods of confidence crisis that did not end in realignments, so they propose the construction of an index of pressure in the foreign exchange market. Their index is the weighted sum of the changes in international reserves as a proportion of the monetary base, changes in the domestic-foreign interest rate differential and the rate of depreciation of the domestic currency. The weights given make equal the individual conditional volatilities of the three summed series, and reserve changes enter the index with a negative sign. Increases of the interest rate differential, reserve losses and a higher

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<sup>2</sup>A very similar analysis is found in Eichengreen et al (1994).

price of the foreign currency produce increases of the index. Crises are identified as periods in which the index is above its mean by two or more standard deviations. The authors found that the signals before crises are similar to those of devaluations but the empirical regularities are weaker. Therefore, they find it more difficult to establish generalized facts about confidence crises.

The study of Kaminsky et al (1997) is also aimed at the identification of early warning signals of currency crises and considers both industrialized and developing countries. They propose monitoring several macroeconomic variables that tend to exhibit unusual behaviour (exceed a certain threshold) in a two-year period before currency crises. They also use an index of foreign exchange market pressure but this involves only the changes in reserves and the nominal depreciation of the domestic currency. Crises are identified as positive deviations of the index of at least three standard deviations from its mean value. And signals of currency crises are identified as variations of macroeconomic variables that belong to the extreme percentiles of the individual distributions. For instance, if an observation of the rate of growth of domestic credit inside the two years window is in the upper ten or twenty percent of its distribution, it is considered to be a signal. The optimal percentile fractions used to establish the thresholds for the macroeconomic variables considered were those rendering the lowest noise-to-signal ratio, that is the ones that minimize the fraction of misleading signals (those that were not followed by a crisis in the following two years) as a proportion of total signals. The results of their study indicate that real appreciation of the domestic currency is the most common and reliable signal of crises, followed at some distance by changes in the ratios of domestic credit and monetary aggregates to output, reductions in the rates of growth of output and exports, reserve losses, increases in the interest rate of domestic deposits and reductions in the ratio of international reserves to monetary aggregates such as M2.

The work of Frankel and Rose (1996) uses annual data for over a hundred developing countries and defines currency crashes as episodes in which there are depreciations of the domestic currency of at least 25 percent and the rate of depreciation increased at least 10 percent when compared to the one observed in the previous year.<sup>3</sup> First, they analysed the behaviour of a set of macroeconomic

<sup>3</sup>The second criteria was introduced because there are some countries that suffered hyperin-

variables in a period of three years before and after currency crashes using an event study methodology similar to the two papers mentioned above and then corroborate their main results using a Probit model in which the data for all countries and periods was pooled and the regressand was a bivariate series indicating crises. Their results indicate that currency crashes tend to occur when there are reductions of foreign direct investment and reserves, the growth of domestic credit accelerates, the domestic currency appreciates, interest rates in industrialized countries increase and output growth slows down.

*Empirical works based on Krugman's approach.* The second category of empirical literature includes works that have implemented the approach of first-generation models of currency crises and focus on modelling the shadow exchange rate in order to estimate the probability of this rate being equal to or above the official rate in the next period, which is equal to the probability of a speculative attack. Since the Mexican experience in recent decades has been a fertile ground for empirical applications of this model, we consider here these studies.<sup>4</sup>

Blanco and Garber (1986) analysed the recurrent devaluations of the Mexican peso in the period 1973-1982. The fundamental determining the path of the shadow exchange rate was modelled as a composite variable involving estimates of the money demand equation, and estimated paths for real income and domestic credit creation. They assumed a fixed devaluation rule (the theoretical floating exchange rate was multiplied by an arbitrary constant) and estimated the trigger level of reserves at which the fixed rate would be abandoned. The objective was to calculate three-month ahead expected exchange rates and the probability of a devaluation. Their work delivered probabilities of devaluation that increased in advance of the major devaluations of September 1976, February and December 1982. The probabilities estimated reached levels between 20 and 30 percent on the dates of the devaluations and then vanished. Remarkably, the last two devaluations were out of the sample used to estimate the model. Also, their estimated expected exchange rates conditional on devaluation were close to the values observed.

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flation and hence the first criteria was commonly met.

<sup>4</sup>Conolly and Fernandez (1987) used Mexican data as well but with a very short sample period in which no major devaluation occurred. Conolly (1986) and Cumby and van Wijnbergen (1989) focus on Argentina and Otker and Pazarbasioglu (1997) present an application for European currencies.

Goldberg (1994) applied a similar model to Mexican data for the period 1980-1986. She expanded the list of determinants of the shadow exchange rate by including real exchange rate movements and foreign credit disturbances, and estimated the model for a range of different threshold levels of international reserves. The computed one month ahead probabilities of devaluation reached very high levels in the months in which devaluations occurred, although some false signals were also produced. According to this study, domestic fiscal and monetary shocks determined the timing of speculative attacks on the Mexican peso in this period.

The application of the traditional model of balance of payments crises to Mexican data of Melick (1996) covers the period 1975-1994 using monthly data and compares the ability of the model to predict earlier crises and the one of December 1994. The results show probabilities of speculative attacks that track closely actual realignments in part of the sample. The model performs well up to the devaluation of July 1985, then shows a modest increase in the probability of realignment for the one observed in November 1987, and offers no signal for the devaluation of December 1994.

The author's explanation for the failure of the model to predict the most recent crisis is that this experience differs in several aspects from the case portrayed in first-generation models of currency crises. First, the mechanism of reserve exhaustion postulated in Krugman's model was not present in the Mexican case since there was not a persistent fiscal deficit needing to be monetized and no continuous reserve losses. Second, the conventional model does not take into account the possibility of sterilization of reserve losses and its effects in the case of an attack, something observed in Mexico during 1994. Third, the log-linear structure of the conventional model does not allow domestic credit to be negative, and in Mexico domestic credit was negative prior to the devaluation of the peso. Hence, the author used a broader measure of 'domestic credit' that included the credit extended by official development banks to the private sector. And fourth, the conventional model is not able to take into account the effects of factors that played an important role in the Mexican crisis, such as the financial position of the banking system and unprecedented political instability. In sum, Melick concluded that the conventional model failed to predict the crisis of December 1994 because this was not a typical situation of inconsistent fiscal, monetary and exchange rate policies.

Otker and Pazarbasioglu (1997) also estimated a model with a sample containing the devaluation of December 1994. They estimated one-month ahead probabilities of crises as a function economic fundamentals, and also made an analysis of the likely determinants of the timing of crises, which was represented by the length of the periods between devaluations. The method used incorporated an estimation of the probability of crises and survival analysis. Their results suggest that the level of international reserves in the Central Bank, output growth, real appreciation of the real exchange rate, inflation differentials and fiscal deficits or the expansion of domestic credit to the banking system significantly affected the likelihood of crises.<sup>5</sup> And, on the other hand, they found that reductions in foreign reserves and increases in the share of dollar indexed debt as a fraction of short term debt were significant determinants of the timing of crises.<sup>6</sup>

*Empirical studies on the credibility of currency bands.* As a result of the proliferation of currency bands in Europe and the wave of crises in 1992-93 it was necessary to design a method aimed at capturing the credibility of target zones. Bertola and Svensson (1993) and Svensson (1993) amended the original target zone model of Krugman (1991) and proposed such a method. The essence of the so-called drift adjustment method consists of subtracting the expected depreciation of the exchange rate inside the band from the domestic-foreign interest rate differential in order to obtain a series of the expected realignment of the central parity, which is used as the indicator of the credibility of the currency band. The drift adjustment method can be used with a double objective. On the one hand, the path of realignment expectations gives an account of the credibility of the regime through time and allows us to identify if credibility was gradually eroded or suddenly lost (this is the only objective in Rose (1993) and Svensson (1993)). And, on the other hand, an investigation of the likely causes of crises can be conducted by

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<sup>5</sup>It is worth noting that the positive sign of the parameter corresponding to output growth is contrary to the one predicted by traditional models, so the authors argue that perhaps external balance considerations dominated the traditional money demand argument.

<sup>6</sup>Note that neither the share of dollar indexed debt nor the credit to the banking system are variables suggested by traditional models of currency crises, but they have been widely mentioned as particular features of the Mexican 1994 crisis. Hence, it seems that Otker and Pazarbasioglu introduced to obtain better results for the crisis of December 1994. These issues will be discussed in length in Section 3.5, where we compare their results with the evidence obtained in this work.

studying the relationship between realignment expectations and macroeconomic fundamentals using econometric methods.

The most well known empirical analysis of the credibility of the currency bands of the European Exchange Rate Mechanism before its crisis is the one by Rose and Svensson (1994). They calculated realignment expectations for a set of European currencies and tried to relate them to the behaviour of macroeconomic fundamentals in order to look for the causes of the crisis. Their results indicate that the credibility of the system varied considerably over time but there was no clear loss of confidence before the crisis of September 1992. They used both vector autoregression and regression analysis and found it difficult to identify significant and meaningful relationships between realignment expectations and economic fundamentals. Among a large set of macroeconomic variables (all measured as differences with respect to Germany) only inflation, reserve changes and a measure of monetary independence (the standard deviation of the exchange rate within each month) showed a significant relationship with realignment expectations. These findings and the difficulties in finding meaningful relationships between fundamentals and realignment expectations carries on in others papers.<sup>7</sup>

Caramazza (1993) found that in addition to inflation differentials and changes in international reserves, export price competitiveness, unemployment, the government financing requirements as fraction of GDP and the position of the exchange rate inside the band have a significant relationship with realignment expectations in the case of the French franc. The role of the position of the exchange rate inside the band is confirmed by Thomas (1994) whose results render the unemployment rate as not significant, although he found that labour costs relative to Germany are significant in the case of France and the ratio of public debt to GDP for Italy. The position of the exchange rate in the band is significant as well in the work of Chen and Giovannini (1997) who also found significant effects from other variables, such as the length of time since last realignment (the longer the period of time the less the expected realignment due to improved reputation) and the Basle-Nyborg agreements, which involved the establishment of a financial facility to support countries facing liquidity squeezes in the short term.

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<sup>7</sup>Except for the measure of monetary independence, which is commonly not considered in other papers.



In sum, the empirical analysis of realignment expectations has found it difficult to unveil signals for incoming crises and a clear relationship between realignment expectations with macroeconomic fundamentals. Apart from inflation differentials, reserve changes and the position of the exchange rate inside the band, the set of significant variables seems to vary across countries and even across periods – see Thomas (1994).

*Empirical studies based on the approach of second-generation models.* In the category of empirical works that are close in spirit to second-generation models of currency crises and allow shifts in regimes in order to capture sudden changes in investors' expectations, we include the following.

Jeanne and Masson (2000) propose a model that explicitly allows for multiple equilibria in order to test for self-fulfilling elements in the episodes of speculation against the French franc in the period February 1987 - July 1993. They estimated a Markov-switching regression with constant transition probabilities in which the constant term, but not the slope coefficients, is allowed to change between two regimes, and the dependent variable is the probability of a realignment.<sup>8</sup> The changes of the constant term are interpreted as shifts in market sentiment and the fundamentals they considered are the real exchange rate, the rate of unemployment and the trade balance. The results of the model with regime shifts yielded a better account of the episodes of speculation against the franc than a linear regression. Also, they found that the effects of the real exchange rate, the rate of unemployment and the trade balance as fraction of GDP on the probability of devaluation have the wrong signs and are not significant in the linear regression, but in the model with a switching constant term the same variables take the right sign and the rate of unemployment is significantly different from zero.

Jeanne (1997) presents a general theoretical model in which both fundamentals and changes in market sentiment have a role in the onset of a crisis and tests its implications using French data. In his model, the possibility of multiple equilibria arises due to bifurcation in the paths of fundamentals. The model is estimated using a Markov switching model with constant transition probabilities and some restrictions on the transition probabilities are imposed a priori in order to ensure

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<sup>8</sup>The probability of a realignment was obtained using a series of expected realignment, obtained using the drift-adjustment method, and assuming a constant rate of devaluation.

sensible results. The dependent variable is the probability of devaluation (obtained as in Jeanne and Masson (2000)) and the macroeconomic fundamentals considered are the real exchange rate, the trade balance to GDP ratio and the rate of unemployment. In order to test for self-fulfilling elements, he calculated a composite fundamental and the threshold level after which the fundamental produces multiple equilibria. According to his results, after 1992 there was a bifurcation of fundamentals and self-fulfilling elements in the periods of speculation against the franc. His estimation with regime shifts also describes better the credibility of the franc in the period 1992 than a linear regression.

Gomez-Puig and Montalvo (1997) applied the switching-regimes model to interest rate differentials to obtain an alternative indicator of the credibility of the EMS. The authors estimated interest rate differentials of various European countries with respect to Germany as autoregressive processes of order one and allow the mean and the variance to shift between two alternative regimes. The autoregressive term is the same in both regimes and the transitions are governed by a Markov chain with constant transition probabilities. The authors interpret the prevalence of the regime with higher mean and variance as indicating lack of credibility, but did not attempt to relate interest rate differentials to macroeconomic fundamentals. Their results show that few months before the realignments in the fall of 1992 the probability of the volatile regime increased considerably in the case of the Spanish peseta, the Portuguese escudo and the Italian lira, and that for most European currencies the volatile regime prevailed after September 1992 and disappeared after August 1993, when the width of the ERM bands were increased.

The work of Dahlquist and Gray (2000) presents a description of the behaviour of the short term interest rates of EMS currencies. They found that the volatility, the level and the speed of adjustment of the mean-reverting process generating short term rates were higher in periods of speculative attacks and crises. And when the transitions between regimes are modelled as depending on the interest rate differential with Germany and the position of the exchange rates inside their bands, the weight given to these series are larger in the regime of crisis.

Martinez-Peria (1999) also focused on the crises of the European Monetary System using switching-regime models. She pooled the data of various countries

and estimated an autoregressive model of the percentage deviations of European currencies with respect to the German Mark, as well as a vector autoregressive model with regime switches for those deviations, changes in reserves and interest rates. Both models involved time-varying transition probabilities that depend on the growth of domestic credit, the ratio of imports to exports, the unemployment rate, the fiscal deficit, the real exchange rate and expectations of exchange rates and interest rate differentials. Her estimations serve to identify the periods of tranquillity and crises, but are less successful in identifying the causes of shifts between regimes. According to her results, macroeconomic fundamentals and expectations determine *jointly* the likelihood of shifts the state of tranquillity to the state of crisis, but no single variable is individually significant, except for the fiscal deficit when dummies for country fixed effects are included.

Finally, Piard (1998) used an index of pressure in the French foreign exchange market as the dependent variable and estimated Markov-switching models in which the transitions between the states of calm and crisis depend on macroeconomic fundamentals. She found that the effects of macroeconomic fundamentals on the transitions between regimes are asymmetric. The transition from the stable regime to the crisis regime was affected by unemployment, domestic inflation, competitiveness, the trade balance and domestic industrial production, but the probability of staying in the crisis state appears to be insensitive to macroeconomic fundamentals.

*Other interesting empirical works.* In this category we include original works that do not share a common approach but present interesting results.

Kaminsky and Reinhart (1997) start from the observation that many countries have had banking crises around the time of currency crises and hence their work investigates if these crises have common causes, and if they precede each other with a regular pattern. They analyse data for 6 industrialized countries and 15 developing countries in a sample period including the beginning of the 1990s and the previous two decades. Currency crises are identified using an index of pressure in the foreign exchange market, and banking crises are identified on the basis of reports found in other studies or the specialized press about bank closures, mergers, and governmental takeovers, interventions and support programs in the banking industry. The method of analysis is similar to the event study methodology and

signals approach used in Kaminsky et al (1997). The authors found that the set of empirical regularities observed before the two types of crises is rather similar: crises occur as the economy enters a recession after a boom in economic activity that was accompanied by real exchange rate appreciation, large capital inflows, slow export growth, worsening trade terms, reserve losses and expansion of monetary aggregates. Perhaps the most interesting results of their work are that, using probit models, they show that banking crises are significant in predicting balance of payments crisis and that financial liberalization helps to predict banking problems. They also identified a change in the profile of currency crises over time: in the 1970s, current account problems (real exchange rate overvaluation, worsening trade terms and low export growth) played the main role in predicting currency crises, while in the 1980s and 1990s capital account variables (mainly reserve losses) played the central role. Also, they found that the pattern of precedence is more pronounced in recent times.

Another original work is that of Sachs et al (1996b) who focused on the effects of the Mexican crisis on other 20 emerging markets. The authors constructed an index of pressure in the foreign exchange market for several emerging countries and used panel data analysis to investigate the characteristics of the countries that suffered most the so-called Tequila effect. The index used is a weighted sum of nominal exchange rate and reserve changes between November 1994 and each month in the first half of 1995, and the weights in the index were given by the inverse of their respective standard deviations in the last 10 years. The fundamentals used to explain the strength of the Tequila effect in each country are the real appreciation of the domestic currency and the growth of credit observed in the recent past. In order to allow for differentiated effects of those fundamentals in different countries, the authors attached dummy variables to those countries whose fundamentals were 'weak' (that is, the appreciation of their real exchange rates and the growth of the ratio of claims by banks and the monetary authorities on the private sector as fraction of GDP were in the extreme quartiles of the sample) and to those that showed the lowest ratios of international reserves to M2 in November 1994 (a measure of reserve adequacy).<sup>9</sup> Their results show that countries with

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<sup>9</sup>The growth of credit was taken as a proxy for the weakness the banking system under the argument that the higher the growth, the less able are the banks to monitor the quality of their

overvalued currencies, weak banking systems and low reserve availability suffered more in the turmoil generated by the Mexican crisis.<sup>10</sup>

Finally, Esquivel and Larrain (1998) estimated a Probit model with random effects using annual data of 30 countries for the period 1975-1996. Their results indicate that high rates of seigniorage, current account imbalances, real exchange rate appreciation, negative trade shocks, low output growth, low levels of reserves relative to monetary aggregates and a measure of regional contagion explain and predict well most of the currency crises in the sample.

## 2.4 Summary and comments

In a very brief summary of the literature on currency crises, we can say that there are two main theoretical positions. The one associated to Krugman treats currency crises as the result of macroeconomic mismanagement, and the one associated to Obstfeld puts forward the idea of sudden shifts in speculators' expectations that may result in a devaluation of an otherwise viable exchange rate parity. In the empirical field, there are many works and of most of them seem to adopt (explicitly or implicitly) the approach of first-generation models. Few empirical works are close in spirit to the approach of second-generation models, and these have focused on European experiences.

Our analysis of the collapse of the peso will share some features of the works just reviewed, but it will also present some new elements. We present an analysis of the credibility of the peso using a series of realignment expectations based on the drift adjustment method, linear methods and a non-linear Markov-switching regression in which we are interested not only in the shifts of credibility over time but also in the changes of the relationship between realignment expectations and macroeconomic fundamentals. We use a small theoretical model based on the escape clause approach to study some specific features of the Mexican experience

portfolios, and hence the weaker their financial situation.

<sup>10</sup>The role of the financial position of the banking system is not a feature exclusive to emerging markets. The survey among foreign traders reported in Eichengreen and Wyplosz (1995) shows that around 69 percent of the traders surveyed considered the destabilizing effects of high interest rates on the banking system as important or very important factors in the decisions of some European central banks to stop defending their currencies in the crisis of September 1992.

that, in contrast to other works, considers a consolidated government (involving the federal government and the Central Bank) and the effects of the currency composition of the public debt and the sources of the monetary base. And finally, we use mean-variance Markov-switching models to investigate the causes of the shifts of the Mexican economy between states of calm and crisis. In this work, we consider the effects of political factors, and also we present a two step approach aimed at overcoming some difficulties that may be found when using Markov-switching models with time-varying transition probabilities.

## Chapter 3

# Realignment Expectations, Macroeconomic Fundamentals and the Collapse of the Peso

### 3.1 Introduction

This chapter participates in the debate about the characterization of the Mexican currency crisis of December 1994 as either a conventional currency crisis caused by bad fundamentals or a sudden crisis with self-fulfilling features.

More specifically, the issue we study is the following. On the one hand, if devaluation expectations were increasing gradually before the devaluation of the Mexican peso and their behaviour can be explained by the macroeconomic fundamentals that play the central role in first-generation models currency crises, interpretations of the devaluation of the peso a la Krugman can be preferred. On the other hand, if there was not a continuous loss of credibility of the exchange rate regime before its abandonment and the behaviour of realignment expectations show marked changes in credibility that can be related to variables of theoretical models of currency crises with self-fulfilling features, interpretations based on second-generation models may be preferred. We address this issue by means of the empirical analysis of realignment expectations and their relationship with the macroeconomic fundamentals that according to the theoretical models reviewed in Chapter 2 play the central role in the generation of currency crises.

Our empirical analysis shares the features of some of the categories considered in the review of the empirical literature above. First, the credibility of the exchange rate regime in Mexico is measured using a series of realignment expectations based on the drift adjustment method because the exchange rate-based stabilisation program implemented at the end of 1987 involved currency bands in certain periods. Second, we are interested in the relationship between realignment expectations and the macroeconomic fundamentals considered in models of currency crises in order to shed some light on the causes of the collapse of the peso. And third, we use a non-linear Markov switching model to study the shifts of credibility of the peso over time, and also the shifts in the relationship between realignment expectations and macroeconomic fundamentals. This Markov-switching regression with regime shifts encompasses the approach of first-generation models of currency crises as a special case of no changes in regimes, and it also generalizes the model postulated by Jeanne and Masson (2000) because we allow not only the constant term, but also all the remaining coefficients to shift over time.

We find that before the collapse of the peso, the series of realignment expectations does not show an upward trend and their relationship with macroeconomic fundamentals is not stable over time, which contradicts the predictions of the traditional speculative attack approach a la Krugman. Hence, we estimate a Markov-switching regression that allows for regime shifts in order to have a more detailed account of the credibility of the peso and its relationship with other macroeconomic variables over time.

The results of the model with regime shifts shows that in the period 1988-1993 the credibility of the peso shifted between two equally persistent regimes of high and low credibility but tended to stay in one regime or another for long periods. And this alternation became erratic during 1994, a year marked by a series of political shocks and turmoil in the financial and foreign exchange markets. Surprisingly, the period immediately before the devaluation of the peso in December 1994 belongs to the regime of relatively *low* realignment expectations and their behaviour was affected only by the changes in the international reserves held by the Central Bank.

Since neither the upward trend of realignment expectations before the devaluation of December 1994 nor the close relationship with economic fundamentals



predicted by first-generation models of currency crisis is found to be present, we consider our evidence as counting against interpretations of the Mexican currency crisis based on the traditional speculative attack approach. Also, although our results do not constitute conclusive support an explanation of the collapse of the peso based on the approach of second-generation models of currency crises, we consider the evidence of shifts in credibility over time as a suggestion that a framework that considers the interaction of speculators and economic authorities in an environment marked by unpredictable shocks and changes in market sentiment may be more appropriate to explain the collapse of the peso.

The rest of the chapter is organized as follows. Section 3.2 explains the construction of the series of realignment expectations used, which is based on the drift adjustment method. Section 3.3 identifies the determinants of realignment expectations. Section 3.4 presents a Markov-switching regression model that allows the construction of a detailed account of the behaviour of realignment expectations over time, and the changes in their relationship with macroeconomic fundamentals. Section 3.5 discusses the results obtained and compares them with those of other studies. Section 3.6 summarizes and concludes.

## **3.2 Measuring realignment expectations**

A common measure of the total expected depreciation of the currency in a fixed or semi-fixed exchange rate regime is, under the assumption of uncovered interest rate parity, the difference between the interest rates of financial instruments that differ only in their currency of denomination. For instance, in the case of European currencies the difference between the interest rates of eurodeposits or government bonds of any country and Germany is commonly used. For Mexico, it would tempting to measure the expected depreciation of the peso as the difference between the interest rates of peso denominated discount bonds issued by the Mexican government and instruments issued by the US government denominated in dollars with similar maturity and characteristics. However, such a measure can be misleading since the Mexican debt is subject to a non-zero risk of repudiation and hence the interest rate differential involves both the expected rate of depreciation of the Mexican peso and a premium due to repudiation risk. Nevertheless, we can

take advantage of the variety of instruments issued by the Mexican government in order to construct a measure of the expected depreciation of the peso that avoids such a problem.

The total expected depreciation of the Mexican peso will be identified as the difference between the interest rates of Cetes, discount bonds issued by the Mexican government denominated in pesos, and other discount bonds issued by the Mexican government denominated in pesos as well but *indexed* to the dollar. Using this indicator and assuming that both instruments are subject to the same risk of repudiation we eliminate the default risk premium.<sup>1</sup>

The dollar-indexed bonds are Pagafes and Tesobonos. Pagafes were indexed to the controlled exchange rate and Tesobonos were indexed to the market exchange rate. Nevertheless, the interest rates of Pagafes are used in order to increase the sample considered and to take advantage of the fact that the controlled and market exchange rates deviated only slightly from each other in the period in which the interest rates of Pagafes are used (this is shown in Hoe and Rojas-Suarez (1991)). The interest rate differential is calculated with annual rates of three-month bonds divided by four, which yields the expected depreciation of the peso in the following quarter. As explained below, these interest rate differentials will be adjusted in order to obtain the expected realignment of the peso, that is, the unannounced or unplanned expected change of the exchange rate in the next quarter.

We will correct the interest rate differential because of the different exchange rate regimes that prevailed in Mexico in the period studied, which covers the stabilisation program initiated in December 1987 and abandoned in December 1994. As shown in Table 3.1, there was a fixed exchange rate between weeks 10 and 52 of 1988, and three regimes of preannounced rates from week 1 of 1989 to week 45 of 1991. From week 46 of 1991 to week 51 of 1994 two peculiar exchange rate bands were announced, which involved a fixed floor and a crawling ceiling, but there was systematic intramarginal intervention.

For the periods of fixed and crawling rates, the expected realignment is ob-

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<sup>1</sup>Both bonds are denominated in pesos, so there is no reason in principle to attach different default risks to them. That would not be case if instead of being indexed to the dollar, these instruments were denominated in dollars, in which case there could be a default risk related to the availability of reserves for repayment. Tesobonos were not paid in dollars until February 1995.

Table 3.1: Exchange rate regimes 1988-1994

Regime	Characteristics	Period (weeks)
Fixed rate		88.10 - 88.52
Crawling peg	Crawl: 0.001 pesos daily	89.01 - 90.21
Crawling peg	Crawl: 0.0008 pesos daily	90.22 - 90.45
Crawling peg	Crawl: 0.0004 pesos daily	90.46 - 91.45
Target Zone	Fixed floor. Ceiling crawl: 0.0002 pesos daily	91.46 - 92.43
Target Zone	Fixed floor. Ceiling crawl: 0.0004 pesos daily	92.44 - 94.51

Sources: Aspe (1993) and Schwartz (1994).

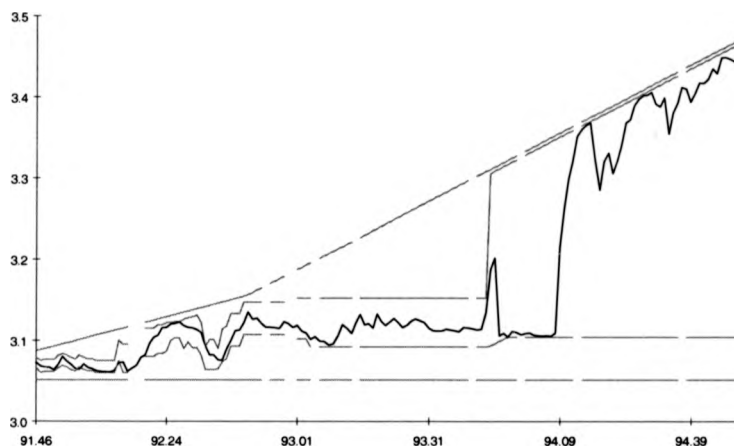
tained by subtracting the announced rate of depreciation from the interest rate differential.<sup>2</sup>

In the period of target zones there was systematic intramarginal intervention, as documented in Schwartz (1994). This is shown in Figure 3.1, which contains daily observations of the nominal exchange rate, the limits of the announced bands and the limits resulting from intramarginal intervention. As the policy of systematic intramarginal intervention was easily identified, in what follows the exchange rate bands resulting from such intervention are considered the relevant ones.

To calculate realignment expectations for the periods of exchange rate bands we use the drift adjustment method suggested in Svensson (1993) and Bertola and Svensson (1993) and decompose the total expected rate of change of the exchange rate into two terms, the expected depreciation within the band and the expected realignment of the central parity. We can express the log of the exchange rate within the band as  $s_t = x_t + c_t$ , where  $x_t$  denotes the deviation of the log of the spot rate from the central parity and  $c_t$  the log of the central parity. Hence, the expectation made at time  $t$  of the rate of change of the exchange rate in the following  $m$  periods is, assuming uncovered interest rate parity,

<sup>2</sup>This period includes 192 weekly observations; auctions of government bonds take place weekly. In this period there are 52 rates corresponding to three-month Tesobonos and 62 rates of three-month Pagafes. For 78 observations the three-month interest rates of dollar indexed bonds were obtained by calculating an equivalent interest rate using the formula:  $i^{m=12} = (1 + i^{m=4})^{(12/4)} - 1$ , where  $m$  represents maturity in weeks, and  $i^{m=4}$  the available annual rate of one-month bonds divided by twelve; 25 of these 78 observations involve one-month Tesobonos.

Figure 3.1: Exchange rate bands (weeks 91.46 - 94.51)



$$i^{p(m)} - i^{d(m)} = E_t [\Delta s_{t+m}] = E_t [\Delta c_{t+m}] + E_t [\Delta x_{t+m}] \quad (3.1)$$

where  $i^{p(m)}$  is the interest rate of peso denominated bonds and  $i^{d(m)}$  is the interest rate of dollar indexed bonds, both with maturity of  $m$  periods.

The expected realignment is obtained by subtracting from the interest rate differential the expected depreciation of the exchange rate within the band,  $E_t [\Delta x_{t+m}]$ , which in turn is estimated using equation (3.2), where  $j$  denotes the different target zones implemented, so that using this equation is tantamount to fitting individual regressions for each target zone.

$$x_{t+m} - x_t = \alpha_j + \gamma_j \cdot x_t + \delta_j \cdot (i^{p(m)} - i^{d(m)}) + \epsilon_{t+m} \quad (3.2)$$

Three currency bands resulting from intramarginal intervention are identified in Figure 3.1: a band following the movements of the exchange rate; a horizontal band; and a band with a fixed floor and a crawling ceiling. The database consists of 163 weekly observations of the spot exchange rate, the centre of the intramarginal

bands and the interest rate differential.<sup>3</sup> Since the expected depreciation within the band is estimated under the assumption of no realignment, the weeks in which changes in the characteristics of the bands took place were eliminated, as well as the previous twelve observations, hence, 124 observations were available for the estimation of equation (3.2).<sup>4</sup>

The results of the estimation of the expected depreciation within the band are shown in Table 3.2 (after the elimination of insignificant variables) and indicate that there was strong mean reversion of the exchange rate in the three periods considered ( $\gamma_1, \gamma_2, \gamma_3 < 0$ ), that in the period of the horizontal band higher interest rate differentials were associated with an appreciation of the peso ( $\delta_2 < 0$ ), and that there is a positive constant in the period of the widening band ( $\alpha_3 > 0$ ).<sup>5</sup>

Finally, for the period in which the ceiling and the centre of the band were crawling, the announced rate of depreciation of the central parity is subtracted as well. That is, the expected realignment is:

$$E_t [\Delta c_{t+m}] = (i^{p(m)} - i^{d(m)}) - \hat{\Delta} x_{t+m} - \Delta c_{t+m}^a \quad (3.3)$$

where  $\hat{\Delta} x_{t+m}$  denotes the estimated depreciation within the band and  $\Delta c_{t+m}^a$  the announced depreciation of the central parity.<sup>6</sup>

Joining the expected realignment for the crawling peg periods and the result of equation (3.3) for the periods of currency bands, we obtain the series of realignment expectations shown in Figure 3.2, in which we can observe the following features.

<sup>3</sup>Since the frequency of the data (weekly) is higher than the time horizon of the expectation (three months), the error term in (3.2) is correlated, so we used the Newey-West (1987) method with truncation lag equal to 12 to obtain robust standard errors.

<sup>4</sup>The additional twelve observations were eliminated in order to avoid using observations of the deviation of the exchange rate from the center of the band that belong to different target zones.

<sup>5</sup>Note that the positive constant in the third period cannot be interpreted as due to the gradual depreciation of the central parity since we are estimating the expected change of the deviation with respect to the central parity. Also, note that we do not use a recursive estimation of the expected depreciation within the band, but we allow for different parameters in each band. This is, we assume that agents obtained a clear idea about the behaviour of the exchange rate inside the band as soon as the central parity and the limits of the bands were identified.

<sup>6</sup>Bufman et al (1994) suggest this further correction for the case of bands with a crawling central parity.

Table 3.2: Estimated expected depreciation within the band

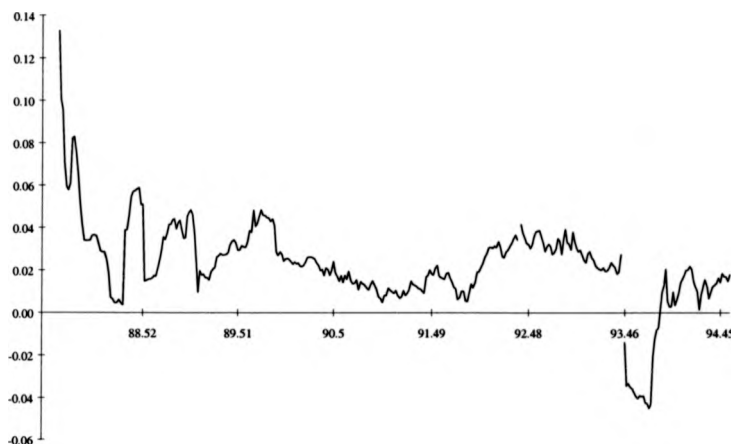
Parameter	Coefficient	Standard errors and p-values
$\alpha_3$	0.02718	0.00619 (0.000)
$\gamma_1$	-1.42872	0.18749 (0.000)
$\gamma_2$	-1.27709	0.19221 (0.000)
$\gamma_3$	-0.62005	0.15947 (0.000)
$\delta_2$	-0.08985	0.03043 (0.003)
124 Observations	Adjusted $R^2$	0.678
Mean of dependent variable	0.007424	
Standard Error of Regression	0.011073	
F-Statistic	61.74 (0.000)	

Standard errors obtained with the Newey-West (1987) method.

There was a considerable reduction of realignment expectations during 1988, which means that the stabilisation program and the exchange rate regime gained credibility relatively quickly after its introduction. From the end of 1988 and until the end of 1993, there were periodic gains and losses of credibility. Realignment expectations varied considerably during 1989 and later credibility improved between 1990 and until mid-1991. In the second half of 1992 and 1993 the credibility of the peso decreased. And at the end of 1993 and the beginning of 1994 there were expectations of an appreciation of the peso. Realignment expectations became negative in this period because the exchange rate was on the floor of the band and the interest rate differential decreased considerably. This unique and short episode was due to the effects of the approval of the North American Free Trade Agreement (NAFTA) by the US Congress, which unchained a flow of foreign investment that was waiting for the approval. Finally, during 1994 realignment expectations varied considerably but, surprisingly, remained at low levels.

As it is evident from the plot of the series, the first important observation to be made is that the pattern of increasing realignment expectations predicted by first-generation models of currency crises is absent, and there seems to be marked changes in credibility during 1994, although this year shows mainly low realignment expectations.

Figure 3.2: Expected realignment (three month horizon)



### 3.3 Realignment expectations and macroeconomic fundamentals

Once the measure of realignment expectations has been constructed, our task is to identify the macroeconomic fundamentals determining their behaviour. The frequency of the fundamentals that potentially determine realignment expectations is monthly, so the weekly observations in Figure 3.2 were averaged over each month. The fundamentals considered are those appearing in models of exchange rate determination, conventional models of speculative attacks and models for currency crises with self-fulfilling elements.<sup>7</sup> The sample used contains monthly observations for the period May 1988 to November 1994.

The group of variables associated with first-generation models includes the monthly rates of growth of the monetary aggregate M2; output (approximated by

<sup>7</sup>In empirical applications of first generation models the probability of a devaluation is equal to the probability that the theoretical exchange rate under floating is equal to or exceeds the fixed rate. Hence, the list of potential determinants from models of exchange rate determination and conventional models is basically the same. Classical papers focusing on exchange rate determination are: Meese and Rogoff (1983), Meese (1990), and Meese and Rose (1991).

the growth of the index of industrial production), OUT; the real exchange rate, RER;<sup>8</sup> monthly changes in the ratio of the six-month cumulated trade balance to industrial production, CTBO; the interest rate on three-month certificates of deposit in the US, CDUS; and the monthly changes in the ratio of public sector borrowing requirement to industrial production, PSBRO.

And the variables associated with models of self-fulfilling crises are the monthly changes in the rate of unemployment, UNE; the monthly rate of change of international reserves in the Central Bank, RES; monthly changes of the ratio of public debt to industrial production, PDO; monthly changes in the log of the average maturity of public debt, MAT; and the monthly changes of the share of short term government debt indexed to the dollar, SH. Finally, as a measure of the health of the banking system, we use the monthly changes in the ratio of non-performing loans to total loans, BL

The econometric methods used require the series to be stationary, hence, unit root tests were applied to the variables following the testing strategy proposed in Perron (1988). The model of equation (3.4), which contains a deterministic trend and  $p$  lags, was estimated for each series, and the hypothesis  $H_t : (\rho_t - 1) = 0$  was tested (test statistic  $\tau_t$ ).<sup>9</sup> The rejection of this hypothesis meant that there is not a unit root in the series. That was the case for most of the variables. And when the hypothesis  $H_t$  was not rejected, the hypothesis  $H_3 : \gamma_t = (\rho_t - 1) = 0$  was tested to check the validity of using a model without trend (test statistic  $\Phi_3$ ).

$$\Delta Y_t = \mu_t + t\gamma_t + (\rho_t - 1)Y_{t-1} + \sum_{i=1}^p \Delta Y_{t-i} + \varepsilon_t \quad (3.4)$$

As  $H_3$  was not rejected in any case, the hypothesis  $H_2 : \mu_t = \gamma_t = (\rho_t - 1) = 0$  was tested to check the validity of testing for a unit root in a model without trend term (test statistic  $\Phi_2$ ), and provided  $H_2$  was not rejected, the hypothesis  $H_\mu : (\rho_b - 1) = 0$  was tested in model (3.5) (test statistic  $\tau_\mu$ ).<sup>10</sup>

<sup>8</sup>The real exchange rate is defined as the ratio of the product of the price of dollars in terms of pesos and the index of consumer prices in the US on the index corresponding to Mexico. Hence, negative rates of growth denote appreciation of the peso.

<sup>9</sup>The number of lags was determined according to the minimum Akaike information criteria.

<sup>10</sup>Testing  $H_2$  in model (3.4) is necessary because the critical values to test  $H_\mu$  in model (3.5) are generated assuming that the constant term is zero.



Table 3.3: Augmented Dickey-Fuller unit root tests

Variable		Lags	Test statistics			
			$\tau_t$	$\Phi_3$	$\Phi_2$	$\tau_\mu$
Realignment expectations	ER	15	-4.13**			
Monetary aggregate	M2	17	-3.05	4.89	3.34	-1.00
Output	OUT	10	-4.36**			
Real exchange rate	RER	0	-6.58**			
Trade Balance	CTBO	8	-4.37**			
Foreign interest rate	CDUS	12	-0.78	5.58	3.76	-3.31*
Public deficit	PSBRO	3	-8.78**			
Unemployment	UNE	10	-4.95**			
International reserves	RES	7	-2.71	5.80	3.93	-2.96*
Public debt	PDO	0	-13.52**			
Average maturity	MAT	20	-3.55*			
Non-performing loans	BL	16	-3.51*			
Dollar-indexed debt	SH	5	-0.58	1.56	1.33	-0.32

\* and \*\* denote significance at 5 and 1 percent levels respectively.

$$\Delta Y_t = \mu_b + (\rho_b - 1)Y_{t-1} + \sum_{i=1}^p \Delta Y_{t-i} + \varepsilon_t \quad (3.5)$$

Table 3.3 shows that realignment expectations and their potential determinants are stationary series, with the exception of the rate of growth of the monetary aggregate (M2) and the share of indexed debt (SH).<sup>11</sup> However, we will still consider M2 and SH in the empirical analysis since M2 has been found relevant in some of the papers reviewed in Chapter 2, and the share of short term debt indexed to the dollar has attracted considerable attention in the debate about the causes of the Mexican crisis (see, Calvo and Mendoza (1996) and Otker and Pazarbasioglu (1997)).

<sup>11</sup>The presence of unit roots was also found in the rates of growth of the monetary base and M1.

The identification of the determinants of realignment expectations was conducted by initially estimating a very general specification and then reducing it to obtain a parsimonious model. The initial regression considered three lags of the potential determinants and tests of zero cumulated effects were applied. As noted above, in the period November 1993 - March 1994, realignment expectations show negative values due to the approval of the NAFTA by the US Congress in November 1993, hence, five dummy variables were included in order to capture this unique one-off effect.

The time horizon of the expected realignment is one quarter and the frequency of the data is monthly, so the error term of the regression is serially correlated. For this reason the standard errors are calculated using the Newey-West (1987) method with three lags. The tests for cumulated effects are Wald tests, and the test statistics are distributed as a  $\chi^2$  with 1 degree of freedom. Table 3.4 shows that the null of no cumulated effects is strongly rejected for the case of the changes in non-performing loans in the banking system and the sign of the effect is as expected. The hypothesis of no cumulated effects is also rejected in the case of the fraction of short term debt denominated in dollars and changes in international reserves, but the sign of the cumulated effect of the fraction of indexed debt is contrary to expected. The hypothesis is not rejected for the case of changes of the real exchange rate and the foreign interest rate but the cumulated effects have the correct sign.

After insignificant variables were eliminated, we obtained a much more parsimonious model in which the determinants of realignment expectations are the second lag of the changes in the real exchange rate, the first lag of the changes in international reserves and the second and third lags of the changes in the ratio of non-performing loans in the banking system, see Table 3.5.<sup>12</sup> That is, realignment expectations increased when there were problems in the banking system, when the peso appreciated in real terms and there were less international reserves to defend the peso.

The inclusion of the position of the exchange rate inside the band as an additional explanatory variable was attempted in this final model without good results.

<sup>12</sup>In the initial estimation, the variables with associated p-values of 10% or less were:  $RER_{t-1}$ ,  $PSBRO_{t-1}$ ,  $RES_{t-1}$ ,  $MAT_{t-3}$ ,  $BL_{t-2,t-3}$  and  $SH_{t-1,t-2}$ .

Table 3.4: Cumulated effects on realignment expectations

Variable	Sign of cumulated effect	Statistics and p-values $\chi^2(3)$
M2	+	0.016 (0.898)
OUT	+	0.074 (0.785)
RER	-	1.728 (0.189)
CTBO	+	1.197 (0.274)
CDUS	+	1.776 (0.183)
PSBRO	+	1.335 (0.248)
UNE	-	0.181 (0.671)
RES	-	3.106 (0.078)
PDO	+	0.054 (0.816)
MAT	+	0.012 (0.913)
BL	+	6.606 (0.010)
SH	-	2.830 (0.093)

Table 3.5: Determinants of realignment expectations

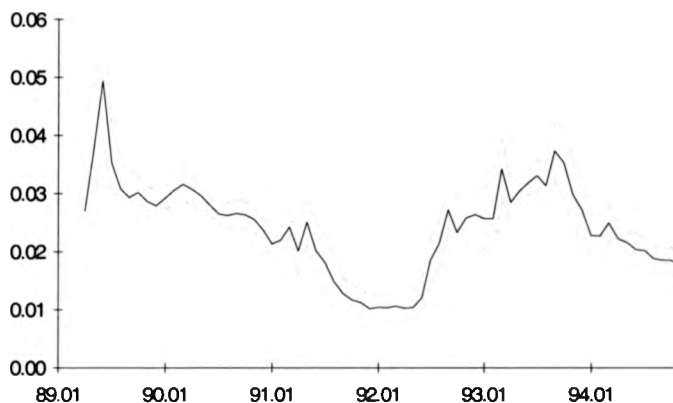
Variable	Coefficient	Standard errors and p-values
Constant	0.02155	0.00222 (0.000)
RER <sub>t-2</sub>	-0.37727	0.15609 (0.018)
RES <sub>t-1</sub>	-0.02022	0.01068 (0.063)
BL <sub>t-2</sub>	0.56668	0.22830 (0.015)
BL <sub>t-3</sub>	0.80334	0.28358 (0.006)
Nafta 93.11	-0.03115	0.00227 (0.000)
Nafta 93.12	-0.06085	0.00288 (0.000)
Nafta 93.01	-0.05844	0.00398 (0.000)
Nafta 94.02	-0.06653	0.00277 (0.000)
Nafta 94.03	-0.03146	0.00310 (0.000)
79 Observations	$R^2$ 0.630	Adjusted $R^2$ 0.581
Mean of dependent variable	0.021081	
Standard error of regression	0.011608	
Log likelihood	-245.28	F-Statistic 13.026 (0.000)
Test of functional form	F(1, 68)	0.118 (0.732)
Test of normality of errors	$\chi^2(2)$	2.325 (0.313)
Test of parameter stability	$\chi^2(5)$	3.102 (0.684)

Tests of autocorrelation and heteroscedasticity of errors are redundant due to the use of Newey-West robust standard errors.

The series of the position of the exchange rate inside the band contained the deviation of the spot exchange rate from the central parity as a fraction of the width of the band for the periods of currency bands and zeros in the periods of predetermined exchange rates. The *t*-ratio and *p*-value associated with contemporaneous observations of this variable were 0.662 and 0.42 respectively, and when one lag is used the values obtained were -0.495 and 0.66.

The significant effects of the changes in the real exchange rate and international reserves is similar to that obtained by Rose and Svensson (1994) and others for the case of European currencies. The difference being that instead of real exchange rate appreciation, those authors identified inflation differentials as a significant

Figure 3.3: Rolling constant coefficient



determinant of realignment expectations. However, such a difference is immaterial if we consider that in our work the changes in the real exchange rate reflect mainly inflation differentials since the nominal exchange rate had only small variations.

The role of the changes in the ratio of non-performing loans in the banking system is something relatively innovative since only a few empirical exercises have considered this variable. The significant positive effect of the ratio of non-performing loans to total loans on realignment expectations means that when the banking system is in trouble, the stability of the exchange rate may be in doubt because of the potential need of the Central Bank to abandon monetary discipline and expand domestic credit in order to support the banking system. As mentioned in the survey of the literature, the study of Kaminsky and Reinhart (1997) found that problems in the banking system help to predict balance of payments crises, and the work of Sachs et al (1996b) shows that countries with weak banking systems are more likely to succumb in periods of stress in their foreign exchange markets.<sup>13</sup>

The test of parameter stability did not reject the null when the last 20 observa-

<sup>13</sup>Moreover, the results in Table 3.5 are in general similar to the findings of these authors for the case of other emerging markets.

Figure 3.4: Rolling coefficient of RER(-2)

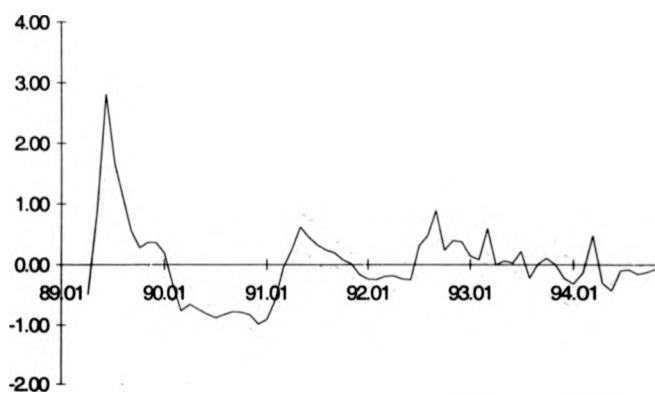


Figure 3.5: Rolling coefficient of RES(-1)

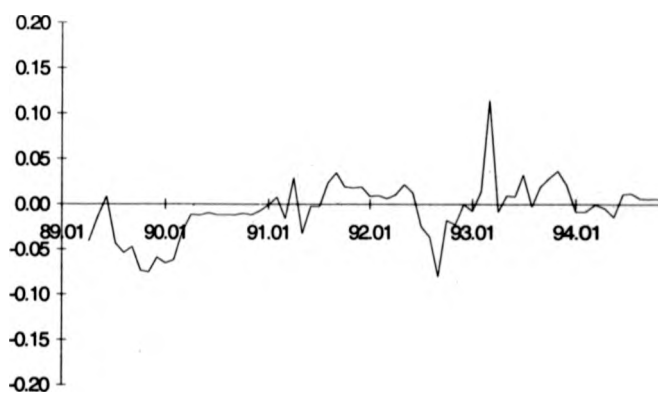


Figure 3.6: Rolling coefficient of BL(-2)

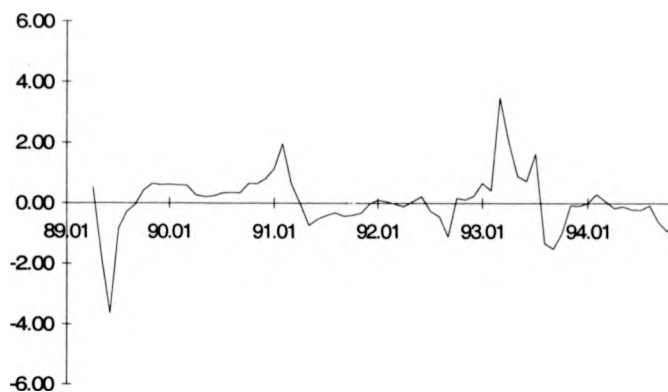
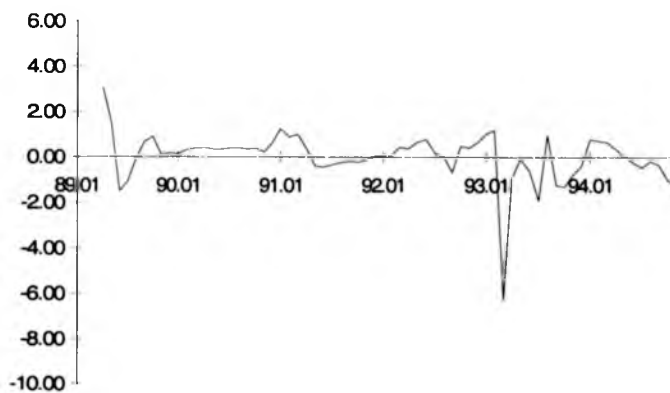


Figure 3.7: Rolling coefficient of BL(-3)



tions were left out of the sample. However, the coefficients of the macroeconomic fundamentals seem to vary over time. This is shown in Figures 3.3 – 3.7 which contain the plots of the rolling coefficients obtained with a window size of 12 months. As can be observed, the coefficients seem to experience changes at the beginning of 1991, in mid-1992 and at the end of 1993. And these variations seem to coincide with the changes in the level of realignment expectations observed in Figure 3.2 above.

Given the changes of credibility over time and the instability of the regression coefficients, the next section is devoted to obtain a more accurate description of the changes in realignment expectations and the shifts in the relationship between realignment expectations and macroeconomic fundamentals.

### **3.4 A Markov-switching model of realignment expectations**

The analysis of the last section has permitted the identification of the determinants of realignment expectations using a linear model. And in this section, a further step is taken to analyse the behaviour of these expectations and their relationship with macroeconomic fundamentals by means of a non-linear Markov-switching regression model that allows shifts in regimes.

Regime-switching models have been applied in various fields of the econometric literature, for instance, Dagsvik and Jovanovic (1994) used this approach to investigate if the Great Depression was the result of multiple equilibria and a coordination failure; Ruge-Murcia (1995) studied the changes in credibility after the introduction of stabilisation programs in Israel; Akram (1998) investigated if unemployment in Norway has shifted between multiple equilibria over time; and Driffill and Sola have applied models with regime shifts to study the deviations of stock prices from what is dictated by fundamentals (1998) and to test some hypotheses about the term structure of interest rates (1994).

However, although the number of empirical studies of currency crises using the approach of regime shifts has been growing recently, the literature is still scarce. Gomez-Puig and Montalvo (1997) applied the Markov-switching model to interest rate differentials in EMS countries with the only objective of obtaining an indicator



of credibility, Dahlquist and Gray (2000) present a description of the behaviour of short term interest rates in EMS countries, and the works of Jeanne and Masson (2000), Piard (1998) and Jeanne (1997) have focused on the episodes of speculation against the French franc during the crisis of the ERM in 1992-93.

We propose a Markov-switching regression to identify the dates of the shifts in the credibility of the peso and also the shifts in the parameters relating macroeconomic fundamentals and realignment expectations. This model encompasses the analysis of the previous section as the special case of no shifts in regimes and generalizes the model of Jeanne and Masson (2000) by allowing not only the constant term but all the parameters of the regression to shift over time because we want to evaluate the effects of macroeconomic fundamentals on realignment expectations in the different regimes. Also, the model with regime shifts allows us to capture appropriately non-linear relations between realignment expectations and their determinants.

The method of estimation is the one pioneered by Hamilton (1996, 1994, 1993, and 1989), in which the transition between different regimes is assumed to be governed by a first order Markov chain and the transition probabilities are constant. We will allow the level of realignment expectations and their relationship with macroeconomic fundamentals to shift between two possible regimes or states over time. The regime prevailing at each date is not observable but can be inferred.<sup>14</sup>

A Markov-switching regression model is characterized by the following parameters:

$$y_t \sim N(E[\mathbf{x}'_t \beta_s], \sigma_s^2); \quad s = i, j$$

$$[p_{ij}] = [p(s_t = j \mid s_{t-1} = i)] = \begin{bmatrix} p_{ii} & p_{ji} = 1 - p_{jj} \\ p_{ij} = 1 - p_{ii} & p_{jj} \end{bmatrix} \quad (3.6)$$

where  $y_t$  represents the series of realignment expectations,  $\mathbf{x}'_t$  is the vector of explanatory variables (and includes a constant),  $\beta_s$  is the vector of coefficients,  $s_t$

<sup>14</sup>Detailed expositions of Markov-switching models can be found in Kim and Nelson (1999), Krolzig (1997) and Hamilton (1994).

denotes the state prevailing at each date  $t$ ,  $\sigma_s^2$  is the variance of the error term of the regression in regime  $s$ , and  $[p_{ij}]$  is the matrix containing the probabilities of transition between regimes. The estimation is conducted using the EM algorithm, and the set of explanatory variables used is the same as in the previous section. The estimation and reduction of a general model containing all the potential determinants of realignment expectations cannot be performed due to the large number of parameters that would be involved and the size of the sample.

The results of the estimation are presented in Table 3.6, and Figure 3.8 shows the filter and smoothed probabilities of Regime 1 prevailing at each date of the sample. The filter probability at date  $t$  is calculated using information up to that date, while the series of smoothed probabilities is calculated using the information of the entire sample.<sup>15</sup>

Regime 1 corresponds to periods of relatively high realignment expectations, or low credibility, and the set of determinants in this regime is the same as in the linear regression. In this regime investors evaluated their prospects of a realignment taking into account the real appreciation of the peso observed in the recent past, the financial health of the banking system and the availability of reserves to defend the peso. Regime 2 corresponds to periods of high credibility. In this regime only the availability of international reserves matters when determining the expectations of a realignment. The error term in the regime of high credibility shows a higher variance, meaning that this regime was more volatile. The two regimes are almost equally persistent according to the estimated transition probabilities. The period of time the economy was expected to stay in the regime of low credibility is  $(1/(1 - 0.863)) \cong 7$  months, and the average time spent in the regime of high credibility is  $(1/(1 - 0.876)) \cong 8$  months. And given that the inferred transition probabilities are very similar, the unconditional probabilities of finding each regime in any date in the sample are similar as well:  $\pi_1 = 0.475$ , and  $\pi_2 = 0.525$ .

In order to test the validity of the estimation assuming two regimes, some specification tests were conducted, as recommended in Hamilton (1996). The

<sup>15</sup>In the estimation of the regression with regime shifts the dummy variables for the outliers related to the approval of NAFTA cannot be series valued only in a single observation since in that case the standard errors (calculated with the average outer product estimator) could not be calculated. Hence the variable *Nafta* refers to a dummy with value of one in the period 1993.11 - 1994.03 and zeros elsewhere.

Table 3.6: Estimates of Markov-switching regression

	Regime 1			Regime 2		
	Coefficient	Standard errors and p-values		Coefficient	Standard errors and p-values	
Constant	0.02751	0.00144	[0.00096]	0.01880	0.00183	[0.00201]
		(0.000)	(0.000)		(0.000)	(0.000)
RER <sub>t-2</sub>	-0.64741	0.06798	[0.08428]	0.21715	0.19393	[0.13778]
		(0.000)	(0.000)		(0.267)	(0.119)
RES <sub>t-1</sub>	-0.01478	0.00817	[0.00532]	-0.05637	0.01163	[0.02097]
		(0.075)	(0.007)		(0.000)	(0.009)
BL <sub>t-2</sub>	0.55530	0.23092	[0.25265]	-0.53057	0.75995	[0.44277]
		(0.019)	(0.031)		(0.487)	(0.234)
BL <sub>t-3</sub>	0.55532	0.30245	[0.20974]	-0.03781	0.70769	[0.24141]
		(0.071)	(0.010)		(0.957)	(0.873)
Nafta	-0.06946	0.00553	[0.00257]	-0.02213	0.01581	[0.00248]
		(0.000)	(0.000)		(0.166)	(0.000)
$\sigma_1^2$	0.00004	0.00001	[0.00001]	0.00006	0.00001	[0.00002]
		(0.006)	(0.000)		(0.000)	(0.001)
$p_{ii}$	0.863	0.072	[0.048]	0.876	0.078	[0.038]
		(0.000)	(0.000)		(0.000)	(0.000)

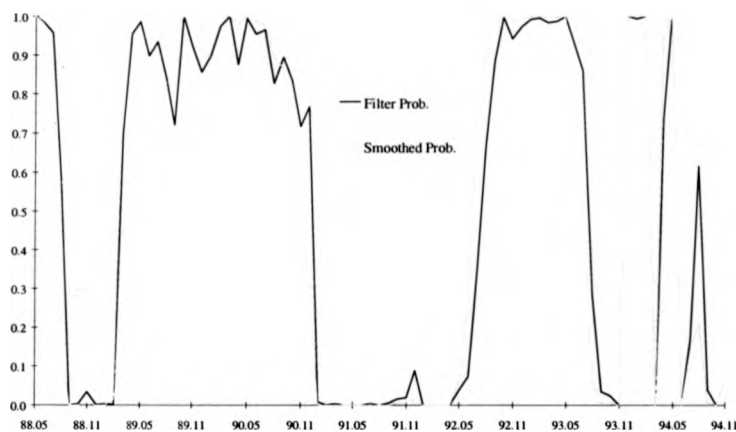
Log likelihood -113.09

The vector of coefficients,  $\sigma_1^2$  and  $p_{ii}$  are as in (6.1).

White (1982) robust standard errors in brackets.

Nafta refers to a dummy unit value in the period 1993.11 - 1994.03.

Figure 3.8: Regime 1. Filter and smoothed probabilities.



results are found in Table 3.7. To test if a specification with three regimes instead of two is needed, the Andrews (1993) test for parameter stability was performed. This test is nonstandard since the potentially missing parameters are present only under the alternative hypothesis. The number of potentially missing parameters is at least six: four transition probabilities, a coefficient for the recursive dummy variable involved in the test and the variance of the error term in the third regime. Critical values for this test can be found in Andrews (1993), and the  $p$ -value is obtained as proposed by Hansen (1997).<sup>16</sup> According to this test, there is no evidence that a third regime is needed. The other specification tests indicate that there is no serial correlation in the residual, but there is evidence of ARCH effects, and a closer look reveals that these effects are present in the error term of regime 2. The rejection of the null of no ARCH effects make it necessary to use standard errors that are robust to specification problems. Hence, robust standard errors were calculated as proposed by White (1982), and they are shown in square brackets in Table 3.6. The results of the estimation do not change when the robust

<sup>16</sup>In Andrews (1993), use Table I, entries  $p = 6$ ,  $\pi_0 = 0.15$ . And for the  $p$ -value use formula (8) and the values in Table 2 of Hansen (1997) corresponding to  $m = 6$  and  $\pi_0 = 0.15$ ;  $\eta$  was taken as 10.

Table 3.7: Specification tests

Andrews test	11.278 (0.617)	
	$\chi^2(1)$	$F(1, 64)$
Correlated errors	0.068 (0.794)	0.054 (0.823)
ARCH effects:		
in both regimes	30.740 (0.000)	24.514 (0.000)
in regime 1	3.206 (0.073)	2.557 (0.114)
in regime 2	28.578 (0.000)	22.790 (0.000)

standard errors are used to judge the significance of the parameters estimated.

Figure 3.8 shows the filter and smoothed probabilities of Regime 1 prevailing at each date in the sample. We can observe that the period 1988-1993 was characterized by an alternation between periods of low and high credibility, but the regimes were quite persistent. Realignment expectations fell from very high levels after the introduction of the stabilisation plan at the end of 1987. Nevertheless, confidence was rapidly eroded and from mid 1989 and until the end of 1990 the regime of low credibility prevailed. Credibility was recovered between the end of 1990 and mid 1992, but afterwards realignment expectations returned to relatively high levels during most of 1993. The year 1994 shows quite dramatic changes in credibility. And, although the effects of the approval of the NAFTA and its modelling with a dummy variable may have produced probabilities for the last two months of 1993 and the first quarter of 1994 that do not support an interpretation, it is clear that the alternation of the two regimes was much more frequent in this year, which reflects the political and financial turbulence observed.

The probability of the volatile regime jumps upwards in April and May, then drops in June, reaches a peak in August and falls again. At the end of the sample, the probability of the regime of high realignment expectations takes negligible values. That is, the regime of relative high credibility was prevailing in the months immediately before the collapse of the peso, and realignment expectations were affected only by the changes in the international reserves held by the Central Bank.

### 3.5 Discussion of results

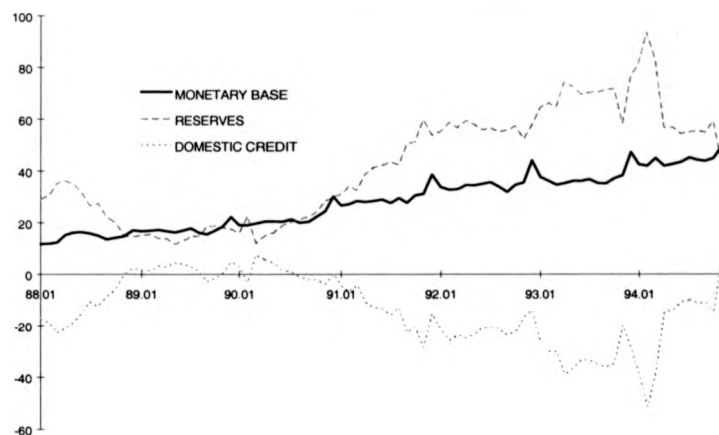
The results obtained in the previous section point in the same direction as those obtained by Melick (1996) in terms of the ability of the speculative attack approach to explain the collapse of the peso. As mentioned in section 2.3, this author found that his application of the traditional model of balance of payments crisis to Mexican data is not able to predict the crisis of December 1994. In contrast, we find no evidence of an upward trend of realignment expectations before the devaluation of the peso and they are not closely linked to the economic fundamentals stressed in traditional models of speculative attacks.

The results of Otker and Pazarbasioglu (1997), at first glance, appear to contradict the evidence of both Melick (1996) and sections 3.3 and 3.4, however, a closer look at their results reveals points of coincidence. Otker and Pazarbasioglu report that when the fiscal deficit is used as one of the determinants of the likelihood of crises, their results are rather poor for the crisis of December 1994 (the probability of a crisis is only 10 percent), but if the fiscal variable is substituted by the Central Bank's domestic credit to the banking system, the performance of the model is much better (the probability of a devaluation increases to 70 percent). Hence, taking into account the policy of sterilisation of reserve changes followed by the Mexican Central Bank during 1994 (see Banco de Mexico (1995) and Mancera (1995)) we can argue that the extension of domestic credit to the banking system in 1994 may be considered a variable reflecting shocks to reserves instead of deliberate increases of domestic credit to finance fiscal deficits. Figure 3.9 shows the policy of sterilization followed by the Mexican Central Bank. As can be observed, the accumulation of international reserves that began in early 1990 was accompanied by a reduction of the domestic credit of the Central Bank, and the sudden reserve losses observed after March 1994 were accompanied by equivalent changes in domestic credit.<sup>17</sup> That is, the significance of the credit to the banking system in the work of Otker and Pazarbasioglu can be interpreted as the counterpart of the significant effects of the changes in international reserves in determining the likelihood of a crisis. In fact, this argument can explain why the estimated coef-

<sup>17</sup> Sterilization during 1994 took the form of credit to the banking system and the credit to the public sector remained almost unchanged.

ficient for international reserves decreased by about 20 percent when the authors used the credit to the banking system in place of the public sector deficit.

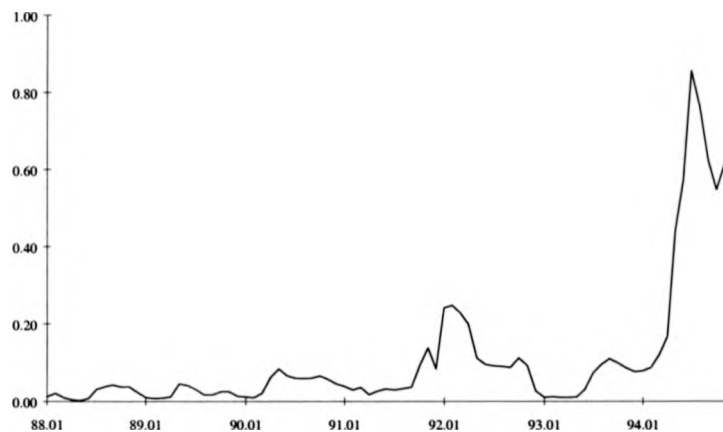
Figure 3.9: Monetary base (billions of pesos)



With respect to the significance of the share of dollar indexed debt in total short term government debt as a determinant of the *timing* of crises (the length of the period since the last devaluation), we can consider that it is likely that this variable is acting as a sort of dummy for the devaluation of 1994. As can be observed in Figure 3.10, during 1994 the share of short-term debt indexed to the dollar (one and three month government bonds) increased considerably and it was negligible in previous years. It shows a sustained upward trend in 1994 and hence it is likely to be significant in duration models. In our estimations, changes in the share of dollar indexed government bonds did not affect realignment expectations or have an effect contrary to expected.

Therefore, if we disregard the significance of output growth in the results of Otker and Pazarbasioglu (because it has a sign contrary to expected), if we consider the significance of the domestic credit extended to the banking system as the counterpart of the significance of the changes in international reserves, and consider the inclusion of the share of dollar indexed debt as an ad-hoc modification, we are left with the conclusion that the determinants of the probability of a currency crisis

Figure 3.10: Share of short-term bonds indexed to the dollar



in Mexico after 1991 were the real appreciation of the peso and the availability of international reserves. This is compatible with the empirical evidence we have found.

### 3.6 Conclusions

In this chapter we have constructed a measure of realignment expectations based on the drift adjustment method, analysed its behaviour over time, and investigated its relationship with the macroeconomic fundamentals considered in models of currency crises.

Contrary to the predictions of first-generation models, we found that credibility did not deteriorate steadily before the collapse of the peso in December 1994. Actually, the level of realignment expectations in the months immediately before the devaluation was relatively low when compared to that observed in previous periods.

Using linear methods, the set of variables determining realignment expectations in the period considered was found to be similar to those identified for other countries with respect to the real exchange rate (which reflects mainly inflation



differentials) and the changes in international reserves held by the Central Bank. An innovative finding is that the health of the banking system was a significant determinant of realignment expectations. However, the relationship between realignment expectations and its determinants is not stable, according to the results of rolling estimations. Hence, we postulated a Markov-switching regression model that allows shifts in regimes.

We found that the credibility of the peso shifted between two equally persistent regimes of high and low credibility, and before 1994 it tended to stay in one regime or another for long periods. However, in 1994 the turbulence in Mexican financial markets resulted in dramatic regime shifts. The credibility of the peso varied markedly during 1994, but in the months immediately before the devaluation of the peso, realignment expectations belonged to the regime of relatively high credibility. In the periods of low credibility, realignment expectations were determined by the changes in the international reserves available to defend the exchange rate, the real appreciation of the peso observed in the recent past, and the conditions of the banking system. And in periods of relatively high credibility the expectations of a realignment were linked only to changes in international reserves.

The instability of the relationship between realignment expectations and their determinants, and the results of the Markov-switching model indicate that the pattern of a tight relationship between realignment expectations and the macroeconomic fundamentals predicted by first-generation models of currency crises is absent. From the set of economic fundamentals stressed by those models, only the real exchange rate plays a role in the determination of realignment expectations in certain periods, but fiscal deficits, money supply, output growth and the trade balance do not show a systematic relation with realignment expectations.

Since neither the pattern nor the relationship of realignment expectations with the macroeconomic variables stressed by first-generation models of currency crises is present, we consider that there is no empirical support for an interpretation of the collapse of the peso based on the traditional model of balance of payments crises *à la* Krugman.

The results of the Markov-switching regression show that the credibility of the peso shifted over time between regimes of high and low high credibility and that during 1994 those shifts in credibility were much more marked. We consider this

frequent alternation of regimes as a suggestion to study the collapse of the peso using the approach of second-generation models of currency crises. However, we do not regard our results as conclusive about the causes of the currency crises because immediately before the devaluation of the peso realignment expectations belonged to the regime of high credibility and were affected only by international reserves, a result that does not allow us to argue for a particular cause of the collapse of the peso.

In sum, the absence of evidence in favour of an interpretation of the collapse of the peso based on the speculative attack approach a la Krugman and the finding that credibility shifted over time and these shifts were more pronounced during the troubled 1994, leads us to conclude that a sensible interpretation of the Mexican currency crisis may be based on the theoretical framework of second-generation models of currency crises. Such an approach will allow us to consider the effects of the abnormal political events that occurred in Mexico during 1994 on the decisions of both investors and policymakers, and analyse the results of their interaction on the viability of the exchange rate regime.

## Chapter 4

# Government Finance, Multiple Equilibria and Currency Crises

### 4.1 Introduction

This chapter presents a model in which the interaction of speculators' expectations and government's optimal decisions can produce multiple equilibria in the foreign exchange market, and a self-fulfilling currency crisis may occur as the result of sudden changes in investors' expectations because the optimal decision of the policymaker is to validate those expectations and alleviate its budget constraint by deflating the public debt denominated in domestic currency.

This model allows us to discuss some features that are specific to the Mexican experience in 1994, as the effects of the reaction of the economic authorities to the periods of confidence crisis that preceded the devaluation of the peso in December 1994. In particular, we analyse the effects of the substitution of peso denominated assets for dollar denominated and dollar indexed assets in investors' portfolios that occurred before the collapse of the peso.

Our model is based on the work of Obstfeld (1994) but we consider a *consolidated* government that involves the central government and the Central Bank, an interest rate elastic money demand, the maturity structure of public debt, and the currency composition of this debt and the sources of the monetary base. The model can be regarded as close to those in Sachs et al (1996a), Velasco (1996) and Calvo (1996a).

Based on our model, we suggest the following account of the events experienced by the Mexican economy during 1994 that finally led to the devaluation of the peso on December 21st. The level of public debt, its short maturity and possibly political conditions might have put the economy in a situation in which a self-fulfilling crisis was possible, and the political shocks that produced periods of confidence crisis during 1994 repeatedly threatened to coordinate expectations in an equilibrium with devaluation. These periods of confidence crisis were resisted without increases in domestic interest rates by means of massive substitutions of peso denominated assets for dollar denominated and indexed assets in investors' portfolios. However, at the same time, the substitution of assets increased the depreciation rate in the equilibrium with devaluation. And the sterilisation of reserve losses made it more difficult to eliminate a potential self-fulfilling crisis. The collapse of the peso occurred when the resource of asset substitution was exhausted and the market coordinated in the equilibrium with devaluation at the end of the year.

The rest of the chapter is organized as follows. In section 4.2 we set up the model. Its equilibria and the possibility of self-fulfilling currency crises are discussed in section 4.3. In section 4.4 we study some means to avoid self-fulfilling crises. Section 4.5 focuses on the particular features of the Mexican experience. And section 4.6 presents the conclusions and final comments.

## 4.2 The model

The model focuses on the interaction of an optimizing consolidated government, that includes the central government and the Central Bank, and private investors in a two period setting. We assume that no devaluation occurs in period 1, so that the domestic nominal interest rate ( $i$ ) is equal to the international interest rate ( $i^*$ ) in this period, and focus on the conditions in which a self-fulfilling crisis may occur in period 2. Also, we assume that purchasing power parity holds, and hence the exchange rate,  $e_t$ , can be equated to the price level,  $p_t$ , in any period:  $e_t = p_t$ .

The central government enters period 1 with total nominal liabilities, including interest payments, equal to  $D$ . A fraction  $\gamma$  of these liabilities is short term debt and is due in period 1, and the rest is long term debt that will be due in period 2

(a higher  $\gamma$  means a shorter average maturity of debt). Real government spending,  $g$ , is the same in both periods. The central government taxes real output,  $y$ , in each period at the rate  $\tau_t$ , and real output is assumed constant. The tax rate of period 1,  $\tau_1$ , is given, so that decisions about the tax rate concern only the second period.

We consider a consolidated government, hence we include among its sources of revenues the interest earnings obtained from the international assets held by the Central Bank and the domestic credit extended to the banking system. Also, we assume that the operating cost of the Central Bank is zero and it does not extend credit to the central government.

The cash flow constraint of the consolidated government in nominal terms in period 1 is expressed in equation (4.1), where  $N^T$  represents the total issues of debt in period 1 that will be repaid in period 2.  $\gamma D$  is the nominal debt service in period 1,  $e_1$  is the price of foreign currency in period 1,  $g$  is the public spending in real terms, and  $\tau_1 y e_1$  represents nominal tax revenues. We use a Cagan type real money demand function that increases with output and decreases with the nominal interest rate. The Central Bank charges the domestic nominal interest rate to the domestic credit granted to the banking system and receives the international interest rate from international reserves. Then, since the domestic interest rate is equal to the international interest rate in the first period, the term  $e_1 i^* (k y \exp(-\delta i^*))$  in equation (4.1) represents the total nominal interest revenues that the Central Bank obtains from the sources of the monetary base.

$$N^T = \gamma D + e_1 g - \tau_1 y e_1 - i^* (k y \exp(-\delta i^*)) e_1 \quad (4.1)$$

We express the total nominal liabilities of the central government as a fraction of nominal output as  $\eta$ , that is,  $D = \eta y e_1$ . And the composition of the debt issued in period 1 is as follows. A fraction  $f$  of the debt issued is *indexed* to the foreign currency and yields the international interest rate, while the fraction  $(1 - f)$  is denominated in domestic currency and pays the domestic interest rate,  $i$ . Then, we denote  $f * N^T = T$  and  $(1 - f) * N^T = N^d$ .

The cash flow of the consolidated government in *real* terms in period 1 is:

$$(1 - f) * n^T + f * n^T = n^d + t = \gamma\eta y + g - i^*(ky \exp(-\delta i^*)) - \tau_1 y \quad (4.2)$$

where  $n^T = \frac{N^T}{e_1}$ ,  $n^d = \frac{N^d}{e_1}$ ,  $t = \frac{T}{e_1}$ , and  $\gamma\eta y = \frac{D}{e_1}$  denote real magnitudes.

The nominal money demand in period 1 can be written as:

$$(ky \exp(-\delta i^*))e_1 = R_1 e_1 + C \quad (4.3)$$

where  $R_1$  is the value of the international assets held by the Central Bank expressed in foreign currency and  $C$  is the amount of nominal domestic credit granted to the banking system.

Monetary policy is implemented by means of open market operations involving international assets, so that if the domestic credit remains constant between periods 1 and 2, any change in the value of the international assets held by the Central Bank expressed in domestic currency results from changes in the real money demand and the exchange rate.

In period 2 the government has to finance the debt service and public expenditure in nominal terms with the following sources of income: taxes on output, the increase in the nominal money holdings of the private sector, and the interest earnings obtained from international reserves and domestic credit. Therefore, the cash flow constraint of the consolidated government in period 2 in nominal terms is as in equation (4.4).

$$te_2(1 + i^*) + N^d(1 + i) + (1 - \gamma)\eta y e_1 + e_2 g = e_2 \tau_2 y + e_2 \frac{ky}{\exp \delta i} - e_1 \frac{ky}{\exp \delta i^*} + i^* e_2 R_2 + i C \quad (4.4)$$

We can write the real money demand in periods 1 and 2 as:  $m_1 = \frac{ky}{\exp \delta i^*}$  and  $m_2 = \frac{ky}{\exp \delta i}$ , respectively, and express the domestic value of the stock of international reserves in foreign currency in period 2 as  $R_2 e_2 = e_2 m_2 - C$ , hence equation (4.4) can be rewritten as:

$$te_2(1+i^*) + n^d e_1(1+i) + (1-\gamma)\eta y e_1 + e_2 g =$$

$$e_2 \tau_2 y + e_2 m_2 - e_1 m_1 + i^*(e_2 m_2 - C) + iC \quad (4.5)$$

Now we introduce a definition that will allow us to obtain a meaningful expression of the cash flow constraint of the government in period 2, and an assumption that summarizes the behaviour of speculators. The rate of depreciation of the domestic currency is defined as the change in the exchange rate between periods 1 and 2 divided by the exchange rate of period 2, as in equation (4.6).<sup>1</sup>

$$\varepsilon = \frac{e_2 - e_1}{e_2} \quad (4.6)$$

And we assume that rational risk neutral investors require uncovered interest rate parity to hold, that is,

$$1+i = (1+i^*)(1+\pi) = \frac{1+i^*}{1-\varepsilon} \quad (4.7)$$

where  $\pi$  is the rate of growth of prices between periods 1 and 2, and  $\varepsilon$  is as above. Hence, the depreciation rate implied by the interest rate parity condition is:

$$\varepsilon = 1 - \frac{1+i^*}{1+i} \quad (4.8)$$

The cash flow constraint of the government in *real* terms in period 2 is:

$$t(1+i^*) + (1-\varepsilon)(n^d(1+i) + (1-\gamma)\eta y) + g =$$

$$\tau_2 y + m_2 - (1-\varepsilon)m_1 + i^* \left[ m_2 - \frac{C}{e_2} \right] + i \frac{C}{e_2} \quad (4.9)$$

<sup>1</sup>Similar definitions of the depreciation rate are used in Obstfeld (1997), Herrendorf (1997), and Calvo (1996a).

where  $(1 - \varepsilon) = \frac{\varepsilon_1}{\varepsilon_2}$ , and it can be called the 'depreciation factor', it represents the share of debt that is not repudiated through inflation (Calvo (1996a)).

Finally, we define the fraction of the monetary base backed by domestic credit in period 1 as  $w = \frac{C}{\varepsilon_1 m_1}$ , and rewrite the last equation as:

$$n^d(1 + i) + (1 - \gamma)\eta y + t(1 + i^*) + g =$$

$$\tau_2 y + \varepsilon [n^d(1 + i) + (1 - \gamma)\eta y] + (1 - \varepsilon)m_1 + (1 + i^*)m_2 + (i - i^*)(1 - \varepsilon)wm_1 \quad (4.10)$$

The left hand side of (4.10) represents total real spending in period 2, which includes the real service payments of the public debt denominated in domestic currency, the service of the debt indexed to the foreign currency and the constant real expenditure. The right hand side includes real taxes on output in period 2 and *total* seigniorage revenues. Total seigniorage revenues means, as in Herrendorf (1997), the sum of all sources of real revenues for the consolidated public sector resulting from the monopoly to issue money. It includes the depreciation of the real service of public debt denominated in domestic currency, the change in real money demand, the depreciation of the real balances carried by the private sector from period 1 to 2, the international interest rate times all the assets of the Central Bank (since domestic credit pays at least the international interest rate), and the excess of the domestic interest rate over the international interest rate times the real value of the domestic credit granted to the banking system.

The government determines the tax rate and the rate of depreciation of the domestic currency for period 2 by minimizing the social loss produced by these taxes subject to its real cash flow constraint. The social loss function is quadratic in both the tax rate and the depreciation rate, as in equation (4.11) where  $\theta$  represents the relative importance given to the depreciation rate in the preferences of the government; that is,  $\theta$  indicates the degree of conservatism of the government with respect to inflation.<sup>2</sup>

<sup>2</sup>At this point, it is clear that the present model, as well as the ones mentioned in the introduction, could be considered in some extent as belonging to the literature on optimal taxation. A



$$L = \frac{\tau_2^2 + \theta \varepsilon^2}{2} \quad (4.11)$$

Acting with full discretion, the optimal depreciation and tax rates from the viewpoint of the government are determined by equations (4.12) and (4.13), where  $I = (1 + i)$  and  $I^* = (1 + i^*)$  are the domestic and international interest factors, respectively. These two equations are the reaction functions of the government.

$$\varepsilon^* = \frac{[fnI + (1 - \gamma)\eta y + m_1(1 - (i - i^*)w)]}{[fnI + (1 - \gamma)\eta y + m_1(1 - (i - i^*)w)]^2 + \theta y^2} \times$$

$$[fnI + \gamma\eta y + m_1(1 - (i - i^*)w) + tI^* + g - m_2(1 + i^*)] \quad (4.12)$$

$$\tau_2^* = \frac{\theta y [fnI + (1 - \gamma)\eta y + m_1(1 - (i - i^*)w) + tI^* + g - m_2(1 + i^*)]}{[fnI + (1 - \gamma)\eta y + m_1(1 - (i - i^*)w)]^2 + \theta y^2} \quad (4.13)$$

Equation (4.12) represents the optimal depreciation rate as a function of the nominal interest rate given the total public debt as a fraction of output, the maturity structure and currency composition of this debt, and the currency composition of the monetary base.

The equilibria of the model is determined where the depreciation rate implied by the interest rate parity condition (equation 4.8) is equal to the optimal depreciation for the government (equation 4.12). The equilibria are shown in figure 4.1 in the  $(i, \varepsilon)$  plane. In the figure, the vertical axis measures the depreciation rate, the horizontal axis measures the nominal interest rate, the grey line shows equation (4.8), and the black one corresponds to equation (4.12). Figure 4.1 was obtained with the following parameter values:  $y = 1.3$ ,  $k = 0.1$ ,  $\delta = 0.8$ ,  $\gamma = 0.9$ ,  $f = 0.2$ ,  $\eta = 0.6$ ,  $w = 0.1$ ,  $g = 0.0$ ,  $\tau = 0.1$ ,  $i^* = 0.04$  and  $\theta = 1.2$ . These values are intended to describe the conditions of an economy that resembles what was observed in Mexico at the beginning of 1994: the debt to output ratio was

survey on optimal seigniorage collection can be found in Herrendorf (1997), and a model focusing on seigniorage and inflation in which there may be multiple equilibria can be found in Obstfeld (1997).

considered as relatively low, the public debt had a short average maturity, most of the monetary base was backed by international reserves and only a small fraction of the public debt was indexed to foreign currency. Later, we will modify these parameters to describe the developments observed in Mexico during 1994.

### 4.3 Equilibria and self-fulfilling crises

Figure 4.1 shows that there are two equilibria in the model, one with low expected depreciation and interest rates and another with a higher expected depreciation accompanied by a higher nominal interest rate. Two features of the equilibria are worth noting. The equilibria are self-fulfilling: once the market has settled in one of the two equilibria the government will necessarily validate investors' expectations. And the model per-se says nothing about which equilibrium will be chosen by the private sector: the coordination of market expectations in one of the two equilibria depends on sunspots or unpredictable exogenous news.

Figure 4.2 shows the value of the loss function (on the vertical axis) for different interest rates (on the horizontal axis). The grey line shows the value of the loss function that is obtained when the government acts with full discretion when determining the depreciation and tax rates. The thin black line shows the loss function that would be obtained if the government would be able to pre-commit itself to maintain a zero depreciation rate and to act only on the tax rate. Comparing these two curves we can observe that there is a time consistency problem. The private sector will not believe a government's announcement of a zero depreciation rate because in that case the government will act with discretion and set a positive rate of depreciation (and taxes) given that the loss under discretion is less than the loss under pre-commitment for any interest rate. Pre-commitment is not credible and the private sector will not expect a zero depreciation rate, but one of the two depreciation rates that imply equilibrium in Figure 4.1. Which of the two interest rates will be chosen depends on sunspots or exogenous news.

The thick black line in Figure 4.2 shows the value of the loss function when a depreciation of the domestic currency implies a fixed cost  $Z$  which is added to the loss of the government. This fixed cost represents a political punishment in terms of loss of credibility or reputation; in the figure  $Z = 0.2$ . As can be observed,

if the market coordinates in the low depreciation equilibrium, there will be no depreciation because the loss under discretion plus the reputational cost is higher than the pre-commitment loss without depreciation. That is, the reputational cost is enough to insure a zero depreciation rate if the market coordinates in the low depreciation equilibrium. However, if the market coordinates in the high depreciation equilibrium the government will find it optimal to act with discretion and depreciate the domestic currency.

The model has a unique equilibrium with devaluation if, for instance, the debt to output ratio,  $\eta$ , raises to 0.68. Figures 4.3 and 4.4 show that for this level of public debt a devaluation must occur because the government's loss under discretion plus the reputational cost are below the loss without depreciation. Also, as we will see later, the model can have a unique equilibrium without devaluation, that occurs if the ratio of government debt to output is reduced to 0.30 or less.

The model shows three regions for the debt to output ratio in which we find different sets of equilibria. For a strong fundamental, a low debt to output ratio, there is a single equilibrium without devaluation; if the fundamental is in an intermediate zone, there are multiple equilibria and one of them implies a devaluation; and for a very bad condition of the fundamental there is a unique equilibrium in which the currency is devalued. Such a partition of the space for the fundamental and its relationship with the number of equilibria can be found also in other models of self-fulfilling crises, for instance in Sachs et al (1996a), Obstfeld (1996) and Jeanne (1997), who calls bifurcation the expansion of the set of equilibria when the fundamental enters in the zone where a self-fulfilling crisis may occur. In the next section we discuss some means to avoid a situation with multiple equilibria or the coordination of speculators' expectations in the equilibrium with devaluation.

#### **4.4 Means to avoid self-fulfilling crises**

The different ways to avoid a currency crisis involve changes in the conditions of the economy, changes in the preferences of the government, and announcements or policy actions that promote the coordination of expectations in the equilibrium

Table 4.1: Summary of results

	Low	High	Min $Z$	Min $\theta$
MULTIPLE EQUILIBRIA			0.91	17.0
Depreciation rates	0.21	0.68		
Interest rates	0.35	2.30		
EQUILIBRIUM WITH DEVALUATION			0.30	3.0
Depreciation rate		0.44		
Interest rate		0.80		
DEBT REDUCTION				
Depreciation rate	0.02			
Interest rate	0.06			
LONGER AVERAGE MATURITY				
Depreciation rate	0.17			
Interest rate	0.24			
INCREASE OF DOMESTIC CREDIT			1.10	14.0
Depreciation rates	0.20	0.75		
Interest rates	0.17	2.90		
INCREASE OF INDEXED BONDS			0.65	1.62
Depreciation rates	0.12	0.73		
Interest rates	0.31	2.88		

without depreciation.<sup>3</sup> For all the cases discussed in this section, the parameter values of Section 4.2 constitute the initial situation or the benchmark case. Table 4.1 contains the quantitative summary of all the experiments performed.

*Debt reduction.* The possibility of a currency crisis can be eliminated if the debt to output ratio is under a certain threshold because the set of equilibria is determined by the level of public debt. According to Figure 4.1, a self-fulfilling currency crisis may happen even for a debt to output ratio of  $\eta = 0.60$ , but if this ratio is reduced to 0.30, no crisis can happen since only the low interest rate equilibrium remains and the reputational cost is enough to insure a zero depreciation rate (see figures 4.5 and 4.6). This result is similar to some of the hypotheses that have been put forward about the causes of the Mexican crisis. Sachs Tornell and Velasco (1996a), Atkeson and Rios-Rull (1996) and Cole and Kehoe (1996) have all suggested that the collapse of the peso may be interpreted using models with multiple equilibria in which investors' expectations about the

<sup>3</sup>See Cooper (1999) for an exposition of the role of strategic complementarities in macroeconomics. It includes a discussion of the role played by the government in avoiding a situation with multiple equilibria and the coordination of private sector's beliefs in the bad equilibrium.

temptation of the government to deflate outstanding public debt or about its ability to honor such debt can create the conditions in which the coordination in the 'bad' equilibrium produces a self-fulfilling crisis.

*Longer average maturity of public debt.* The equilibrium with devaluation can also be eliminated with an increase in the average maturity of public debt. Given the parameter values used, if  $\gamma$ , the share of debt maturing in the first period, decreases from 0.9 to 0.3, the equilibrium with devaluation is again eliminated, and in the remaining low interest rate equilibrium the fixed cost insures that there is no depreciation of the domestic currency. See figures 4.7 and 4.8. The average maturity of debt playing the role of the key fundamental is also suggested in Giavazzi and Pagano (1990) and Alesina, Prati and Tabellini (1990).

*Change in government's preferences.* A government facing a situation with a potential currency crisis may appoint a new central banker who is known as an inflation fighter in order to signal to the market its determination not to devalue. In this case the change in the government's preferences implies an increase in  $\theta$ , the weight given to the depreciation rate in the loss function. A high enough  $\theta$  can eliminate the equilibrium with depreciation. With the parameter values used, the value of  $\theta$  that can eliminate the possibility of a self-fulfilling crisis is at least 17.0. This option goes in line with the suggestion of Rogoff (1985) to appoint a conservative central banker in order to reduce the inflation bias that arises from the time inconsistency problem.

*Increase in the reputational cost.* This option involves an increase in the political or reputational cost such that even for the high interest rate equilibrium the government loss plus  $Z$  is above the loss under pre-commitment for the interest rates that imply equilibrium. Given the parameter values used above, the value of  $Z$  necessary to eliminate the possibility of a devaluation is at least 0.91. As an example of this kind of mechanism, we can recall the agreement of several European governments to accomplish the so-called convergence criteria (which included limits to the depreciation of their currencies) that led to the European single currency. Later, we will comment on a simple experiment that illustrates how a change in the reputational or political cost can also open the possibility of a self-fulfilling crisis.

*Focal points.* Another way to elude a self-fulfilling crisis is to manage investors'

expectations in order to avoid the coordination of the market in the bad equilibrium. That is, the government can promote the coordination of speculators' expectations in the equilibrium without depreciation. Such an option was mentioned, but not discussed, by Calvo (1996b) some time ago. Miller et al (1990) also mention briefly the importance of the government's information policy to shape market expectations, as do Giavazzi and Pagano (1990) and Alesina et al (1990). Cooper (1999) presents an interesting exposition of the role of strategic complementarities in macroeconomic issues, which includes a discussion of the influence of the government on the coordination of market expectations.

Some actions and/or announcements by the government can play the role of signals that promote the coordination of the market in the equilibrium without devaluation when facing a confidence crisis, which is a period in which the expectations of speculators may shift to the equilibrium with devaluation. For instance, the announcements of plans of a contingent tightening of fiscal policy, or an agreement with the governments of countries that are willing to support the domestic currency by intervening in their exchange markets, or to lend resources in case of a confidence crisis, may help to coordinate the market in the equilibrium without devaluation. In this respect, Chen and Giovannini (1997) present empirical evidence suggesting that the Basle-Nyborg agreements of 1987, which extended the use of short term financing to European countries pursuing intervention in the foreign exchange market, contributed significantly to reduce realignment expectations of the French franc and the Italian lira.

Another option to avoid the coordination of expectations in the bad equilibrium, which is of special importance in the Mexican case, is the substitution in investors' portfolios of assets denominated in domestic currency for assets denominated in or indexed to the foreign currency when a confidence crisis occurs.

Asset substitution allows investors to hedge against a potential depreciation of the domestic currency and it also allows the government to resist periods of confidence crisis without noticeable increases in interest rates. This mechanism was heavily exercised by the Mexican government during 1994 (March, April, June and November) and was triggered by a series of negative political shocks.<sup>4</sup> Between

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<sup>4</sup>In January, a rebellion broke out in the south and peace talks were held until the end of February. At the end of March the presidential candidate of the ruling party was assassinated.

February and December of 1994, the international reserves in the Banco de Mexico decreased by 23.5 billion dollars, and the share of government bonds indexed to the dollar increased from 3.7 per cent to 55.3 per cent. During 1994 the total change in investors' portfolios towards dollar denominated and dollar indexed assets amounted to 45.6 billion dollars.

In the next section, we will concentrate on the effects of changing political conditions and the substitution of assets in the equilibria of our model.

#### **4.5 Some specific features of the Mexican experience**

In this section we perform some experiments to illustrate features of the Mexican experience that deserve close attention. The first experiment is related to the role of changing political conditions, and the other two are related to the substitution of peso denominated assets for dollar denominated and dollar indexed assets in investors' portfolios.

The first experiment, although being a conjecture, is useful to illustrate that changing political conditions may affect the set of equilibria in the model. The experiment is as follows. Suppose that the economy is in a situation like that described in Section 4.2 but the reputational cost is above its critical value 0.91, so that a depreciation cannot occur. However, in such a situation a decrease in the political cost can make a self-fulfilling crisis possible.

For the Mexican case, we can argue that if the prospect of no approval of the NAFTA in the US Congress in November 1993 and the prospect of a defeat for the ruling party in the general elections of mid 1994 was part of the reputational cost that the government would have faced in case of a devaluation, then  $Z$  should have decreased after the agreement was approved and after the ruling party won the presidential elections and maintained control of the upper chamber of the national Congress in August 1994. Therefore, we conjecture that both the approval of

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In June the Minister of the Interior attempted to resign. At the end of September, the General Secretary of the ruling party was assassinated, and in November, the Deputy General Attorney claimed that some leaders of the ruling party were putting obstacles to the investigation of this murder and resigned from his post and the party.

NAFTA and the outcome of the general elections might have reduced the political cost. This could have made feasible a self-fulfilling crisis, or at least could have created such a perception among speculators.

The bases for this conjecture are the pressure against the peso observed some days before the approval of NAFTA by the US Congress in November 1993 due to the bad prospects for the vote, and the public testimonies of a crucial meeting of the recently elected President, the President, the Minister of Finance and the Governor of the Central Bank in November 1994 in which the prospect of a devaluation was discussed. The newly elected President argued in favour of a devaluation but the opposition of the Minister of Finance was more influential on the existing President. Also, it is worth noting that the conjecture of a reduction in the political cost after the elections may answer a key question put forward by Sachs et al (1996a): why was a devaluation not allowed in March 1994 when the assassination of the presidential candidate of the ruling party unchained the first and biggest round of financial turmoil of the year.<sup>5</sup>

The substitution of assets in investors' portfolios during the periods of confidence crisis in 1994 took two forms. The first and most important was the substitution of bank deposits for assets denominated in dollars, that resulted in large reductions of the international reserves in the Central Bank. And the second was the increase in the issue of short term dollar indexed bonds (Tesobonos) that substituted peso denominated bonds (Cetes) that were maturing. These massive asset substitutions were allowed by the economic authorities in order to avoid increases of domestic interest rates. On the one hand, the Central Bank decided to sterilize the reserve losses by increasing the credit to the banking system in order to avoid the credit squeeze and the increases of interest rates on bank loans because that would have further damaged the already weak banking system and economic activity in general. And, on the other hand, the substitution of peso denominated bonds for dollar indexed bonds in investors' portfolios allowed a roll-over of the maturing public debt without substantial increases in the interest rates paid by

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<sup>5</sup>A somewhat similar argument has been suggested by Garcia (1999) in his interpretation of the crisis of the EMS. In his view, the prospect of no monetary union the future, given the results of the Danish referendum and the bad prospects of the French referendum, decreased the cost of realignments of European currencies and in this way contributed to create the conditions for the crisis of the ERM in September 1992.



government bonds. The official statements of these policies can be found in Banco de Mexico (1995) and Mancera (1995). Werner (1996a) presents empirical evidence of the effects of the substitution of bonds on interest rates, and Calvo and Mendoza (1996) and Agenor and Masson (1994) of the sterilisation policy.<sup>6</sup>

The first experiment concerning the effects of asset substitution is the following. Suppose that the parameters used remain the same as in Section 4.2, but in period 1 there is a confidence crisis and investors withdraw deposits from the banking system that are exchanged for international reserves. Also, in accordance with the Mexican experience in 1994, suppose that such a reduction of the international assets in the Central Bank is completely sterilized by equivalent increases of the domestic credit granted to the banking system. In that case, the money supply and the interest rate do not change in period 1, but there is a new composition of the monetary base. What are the consequences for the equilibria described?

Figure 4.9 shows the equilibria of the model when  $w$ , the fraction of the monetary base backed by domestic credit, increases from 0.1 to 0.7, and Figure 4.10 shows the corresponding loss functions. As can be observed, the most noticeable change is that both the nominal interest rate and the rate of depreciation in the bad equilibrium are higher. This is because a depreciation reduces the real revenues that the Central Bank obtains from the domestic credit granted to the banking system, and hence a higher depreciation rate is needed to compensate for such a decrease by means of a larger reduction in the real service of public debt. The effects of the increase of domestic credit can be also recognized by noting that the bad equilibrium is eliminated by an increase of the reputational cost for the government:  $Z$  must increase at least to 1.10. And if the possibility of a self-fulfilling crisis is eliminated by taking a harder position against inflation,  $\theta$  must be at least to 14.

The second experiment of asset substitution involves the composition of the

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<sup>6</sup>Werner (1996a) as well as Flood and Marion (1996) considered risk averse speculators and a currency risk premium, so that the effect of an increase in the probability of a devaluation on the interest rate differential can be offset by a reduction in the share of peso denominated bonds in the portfolio of speculators. In our model we assume risk neutral investors, which eliminates the effects of the composition of public debt on the domestic interest rate. However, we argue that changes in the currency composition of public debt serve to coordinate expectations in the low interest rate equilibrium, which yields the same result.

debt issued in period 1. Suppose that the fraction of the monetary base backed by international reserves is as in the benchmark case,  $w = 0.1$ , but due to a confidence crisis in period 1 the government allows a fraction  $f = 0.65$  of the new debt issued to be indexed to the exchange rate. Again, total indebtedness, money supply and the interest rate do not change in period 1, but there are important consequences for the equilibria of the model. Figures 4.11 and 4.12 show these effects.

The bad equilibrium is characterized by a higher nominal interest rate and a higher depreciation rate. The reason for this effect is that the real value of the dollar indexed debt is not affected by the depreciation of the domestic currency, hence a higher depreciation rate is needed to ensure balance in the real resource constraint of the government through seigniorage revenues, which include the reduction of the real service of non-indexed debt. The effects of a higher share of dollar indexed debt can also be recognized by noting that in this case the bad equilibrium can be eliminated if  $\theta$  increases at least to 1.62 or the reputational cost  $Z$  is at least 0.65.

It is important to note that the values of  $Z$  and  $\theta$  necessary to eliminate the equilibrium with devaluation when the share of indexed debt increases are both lower than in the initial situation even when the interest rate in the bad equilibrium is higher. The reason is that by issuing dollar indexed debt, the government has internalized to some extent the consequences of a depreciation because the real value of a larger share of debt is not affected by a depreciation, and this makes the depreciation of the domestic currency less tempting. Such a result can be considered as supporting the suggestion of Calvo (1996a), who argues in favour of indexed debt.

A very important implication of the experiments just discussed is the following. Say that the initial situation is the one described in Section 4.2 and there is no possibility of a depreciation because the reputational cost  $Z$  is above 0.91 but below 1.10 and  $\theta$  does not have a big magnitude but is above 1.62. If a confidence crisis occurs in period 1 and investors substitute deposits in the banking system for assets denominated in foreign currency, and the reduction of international reserves is sterilized by increases of domestic credit, the government ends in a situation in which a self-fulfilling crisis may occur. However, that would not be the case if the government substitutes bonds denominated in domestic currency for dollar indexed

bonds, because the reputational cost is already above 0.65 and  $\theta$  is above 1.62, and these magnitudes are enough to eliminate the possibility of a self-fulfilling crisis. Hence, by allowing the substitution of domestic deposits for international assets and sterilizing reserve losses instead of allowing an increase in the share of indexed debt, the economic authorities are in fact opening the room for a potential self-fulfilling crisis. Therefore, despite the attention given by many analysts to the role of indexed debt in the genesis of the Mexican crisis, we argue that the sterilisation of reserve losses during 1994 should be considered as more important in the onset of the collapse of the peso than the increase of the stock of Tesobonos.

The results of our experiments, and the observation of repeated political shocks and asset substitution during 1994, suggest that the conditions that made possible a self-fulfilling currency crisis were cumulating during the year, and the collapse of the peso occurred when the resource of asset substitution was exhausted and the market coordinated in the equilibrium with depreciation in December 21st, again in connection with political shocks and following the announcement of a prospective 15 per cent increase in the ceiling of the currency band.<sup>7</sup>

#### 4.6 Conclusions and comments

In this chapter we presented a model in which the interaction of investors' expectations and the optimal decision of policymakers may lead to self-fulfilling currency crises, that is useful to investigate some features of the Mexican experience in 1994.

The central feature of the model is that there may be multiple equilibria in the foreign exchange market, and a self-fulfilling crisis triggered by exogenous unpredictable news or sunspots may occur for certain values of macroeconomic fundamentals. This model is useful to study the effects of the substitution of peso denominated assets for dollar denominated or indexed assets that was observed in Mexico during 1994.

We found that the interest and depreciation rates in the bad equilibrium is

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<sup>7</sup>In December 1994, fears of a renewed outbreak of hostilities in Chiapas followed the controversial inauguration of a new governor of the ruling party in this province because the Zapatista Army dismissed the results of the elections and a considerable number of peasants broke through an army cordon and took control of 38 municipalities.

higher after the substitution of assets, and also it is more difficult to eliminate the possibility of a self-fulfilling crisis by means of a higher reputational cost or a more conservative position against inflation when the asset substitution takes the form of a reduction in the international reserves that is sterilized. Even more, in some circumstances the substitution of public debt towards indexed bonds may eliminate the possibility of a self-fulfilling devaluation. Hence, we consider the sterilisation of reserve losses during 1994 as much more important in the genesis of the devaluation of the peso than the increase of the stock of indexed bonds.

Based on the results of our model, we can suggest the following account of the Mexican experience in 1994 and the collapse of the peso in December 21st. The level of public debt and its short average maturity, together with a likely decrease of the political cost of a depreciation after the approval of NAFTA and later after the general elections, might have put the economy in a situation in which a self-fulfilling crisis was possible, and the political shocks observed during 1994 triggered periods of confidence crisis that threatened to coordinate speculators' expectations in the equilibrium with devaluation. These periods of confidence crisis were resisted without substantial increases of interest rates thanks to the substitution of peso denominated assets for dollar denominated or indexed assets in investors' portfolios, but the substitution of assets increased the depreciation rate in the bad equilibrium and made it more difficult to avoid a self-fulfilling crisis. Finally, the devaluation of the peso occurred when the resource of asset substitution was exhausted and the market coordinated in the bad equilibrium at the end of the year, when political shocks resumed and the government announced a prospective widening of the currency band.

In this chapter we have adopted the approach of second-generation models of currency crises, but such an approach has received some criticism and it is worth commenting on that. Morris and Shin (1998a,b) argue that multiple equilibria are the result of the assumption of common knowledge of the level of the macroeconomic fundamentals, and propose a model in which individual speculators base their decisions whether or not to attack only on private noisy signals about the conditions of the economy and the assumption that other speculators are rational. In their model, strategic behaviour determines that a speculator decides not to attack only if she receives a very good signal of the level of the fundamental

because only in this way she can be sure that no speculator could have received information indicating that the exchange rate is not sustainable. And also, strategic behaviour makes the share of speculators attacking the currency increase when the fundamental weakens. Given that the cost of defending the currency also increases as the share of speculators attacking grows, there is a critical level of the fundamental that produces the mass of speculators necessary to provoke the collapse of the currency. Hence, in their model there is a unique equilibrium in which a devaluation occurs, and it is linked to the level of the fundamental.<sup>8</sup>

On the one hand, we consider that the assumption of private information about economic fundamentals postulated by Morris and Shin is hard to accept in the case of the foreign exchange market since it is one in which the information is most public (see also Jeanne (1999)). And on the other hand, if it is true that there is a threshold level for the fundamental, a trend towards such a threshold would allow one to determine the timing of the speculative attack in advance. Or, in the absence of a definite trend, given that the fundamental cannot reach the threshold in a single dramatic jump and it is usually considered a stochastic variable, there should be some signals of an incoming crisis when the fundamental approaches the trigger value. However, it is widely accepted that the timing of the ERM crises in 1992-93, the Mexican crisis, and the recent crises in East Asia has been rather arbitrary, and it seems to be linked to exogenous shocks such as political events or contagion. There have been no definitive trends or dramatic changes in fundamentals that could explain the eruption of the crises, and there were no evident signals of incoming devaluations. Therefore, we consider that the hypothesis of self-fulfilling crises resulting from multiple equilibria and sudden changes in speculators' expectations triggered by exogenous unpredictable news is plausible.

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<sup>8</sup>Other arguments used to criticize the hypothesis of multiple equilibria that rely on the assumption of private information and focus on modelling the strategic behaviour of speculators can be found in Caplin and Leahy (1994), Banerjee (1992), and Bikhchandani, Hirshleifer and Welch (1992).

Figure 4.1: Multiple equilibria

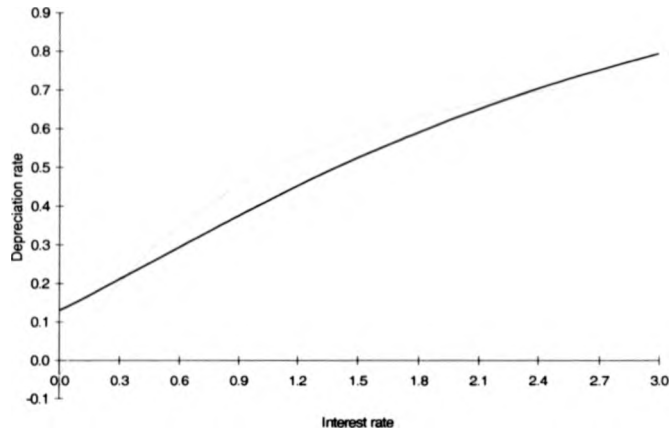


Figure 4.2: Government loss

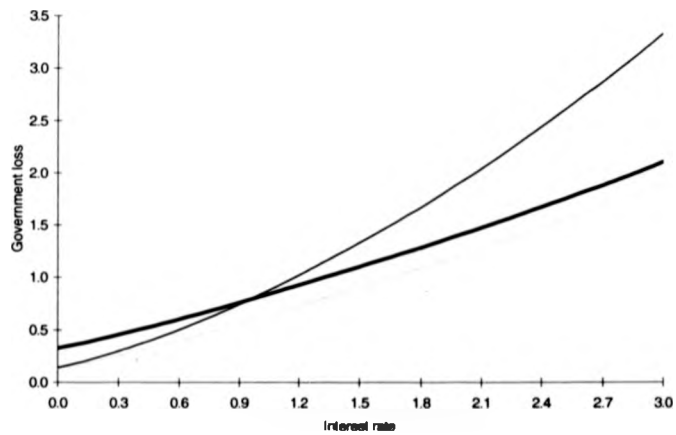


Figure 4.3: Unique equilibrium

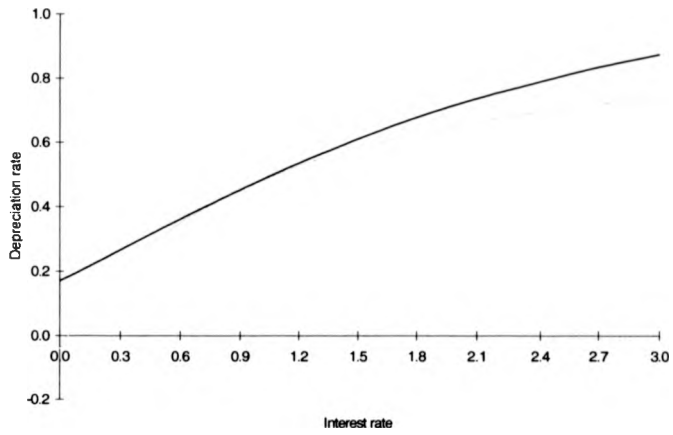


Figure 4.4: Unique equilibrium. Government loss

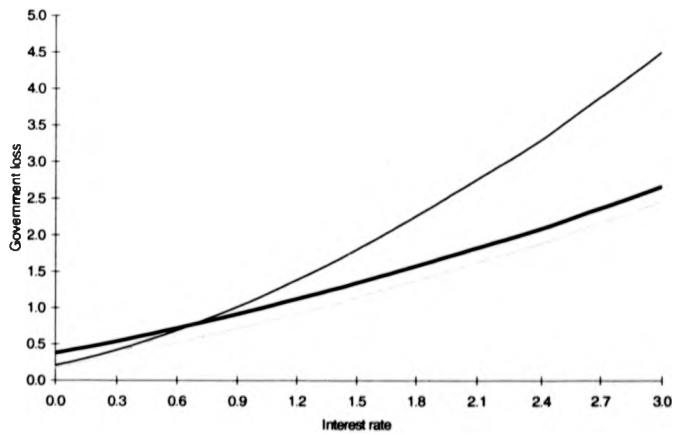


Figure 4.5: Debt reduction

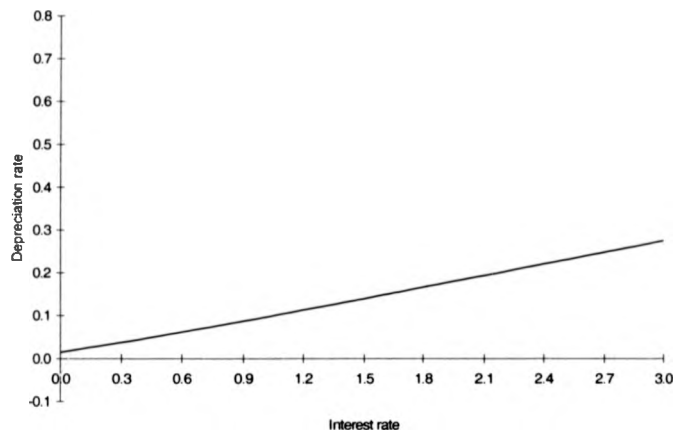


Figure 4.6: Debt reduction. Government loss

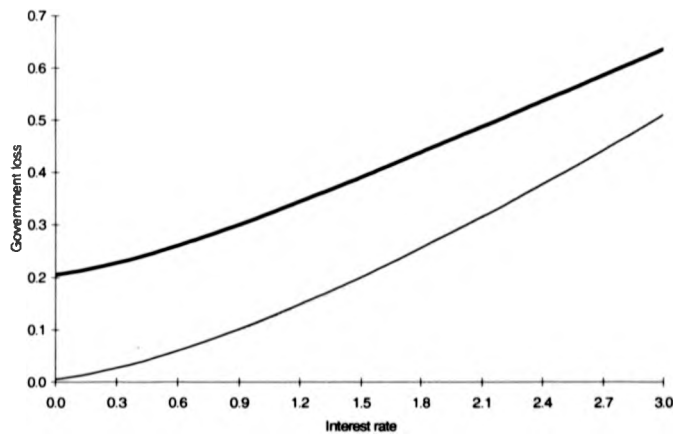




Figure 4.7: Increase of average maturity

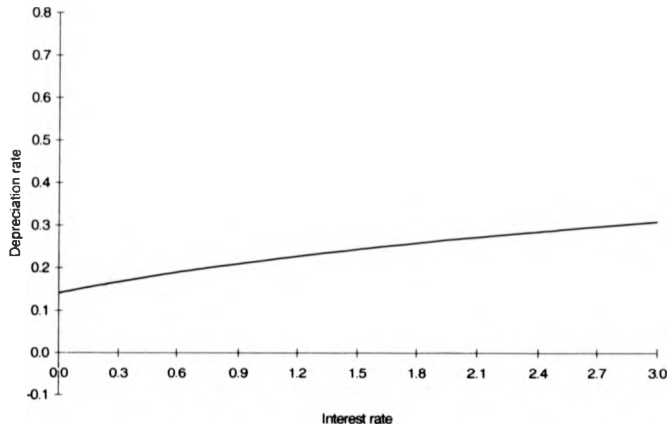


Figure 4.8: Increase of average maturity. Government loss

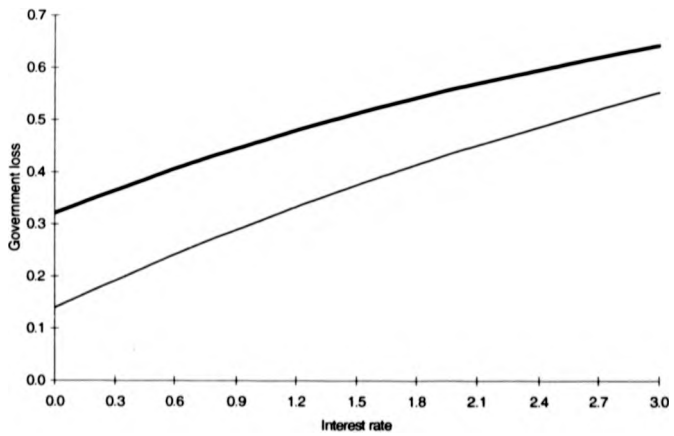


Figure 4.9: Increase of domestic credit

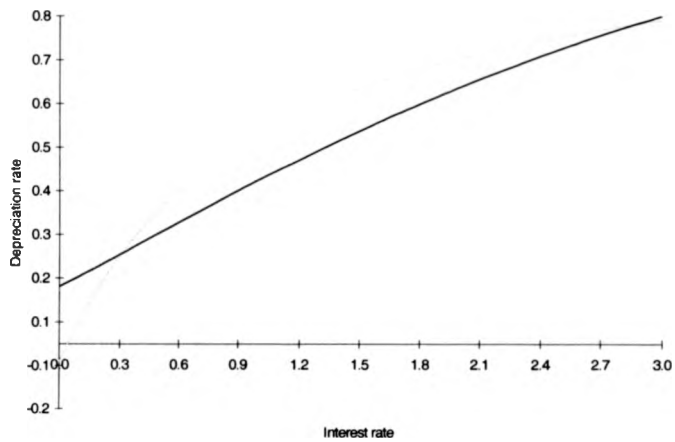


Figure 4.10: Increase of domestic credit. Government loss

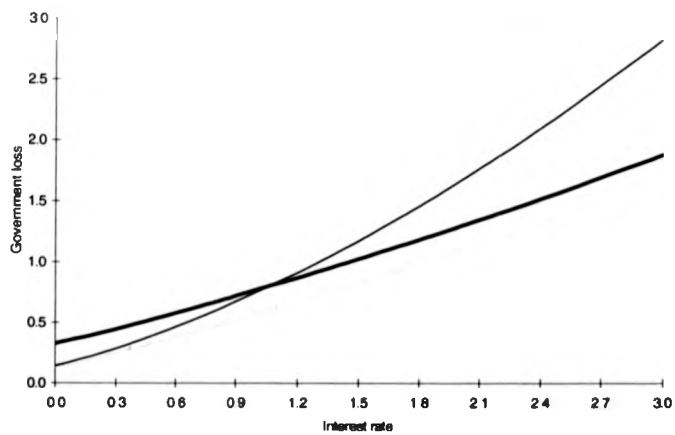


Figure 4.11: Increase of indexed bonds

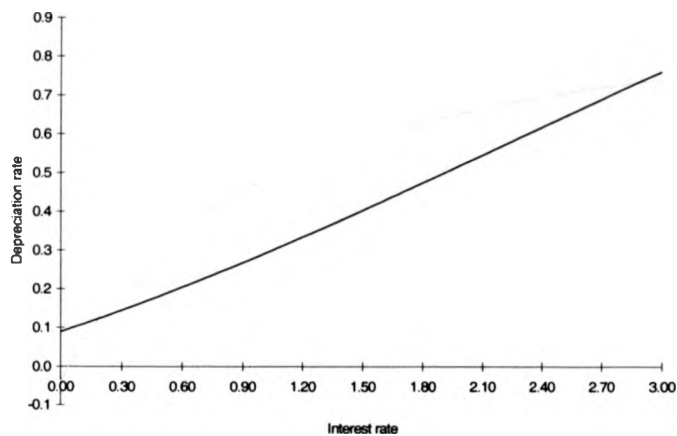
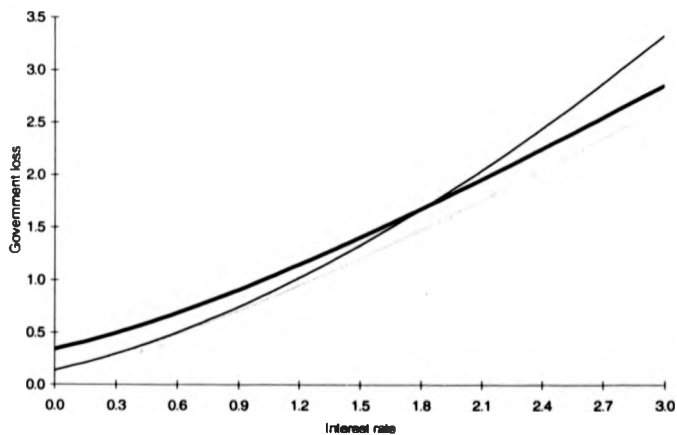


Figure 4.12: Increase of indexed bonds. Government loss



## Chapter 5

# Pressure in the Foreign Exchange Market and the Collapse of the Peso

### 5.1 Introduction

This chapter builds on the results obtained in the previous two and presents an empirical analysis of the causes of the shifts of the Mexican economy between states of calm and crisis in the foreign exchange market that led to the collapse of the peso in December 21st 1994.

In Chapter 3, we performed various corrections to interest rate differentials to construct a series of realignment expectations that was used as an indicator of the credibility of the peso. And its empirical analysis suggested that the predictions of the traditional approach to balance of payments crises a la Krugman were not present in the Mexican case. Also, we found that realignment expectations shifted over time between two regimes of relatively high and low credibility, especially during 1994, but in the months immediately before the collapse of the peso realignment expectations were relatively low. In Chapter 4 we presented a model in which a self-fulfilling currency crisis may occur and argued that the periods of confidence in the foreign exchange market observed in 1994 were resisted without noticeable increases in domestic interest rates thanks to the substitution of assets in speculators' portfolios. Based on these results, in this chapter we introduce an

alternative indicator of the credibility of the peso that is not based on interest rate differentials, and adopt empirical methods that allow the identification of the causes of shifts between states of calm and crisis in the foreign exchange market.

The main ingredients of this chapter are the following. First, since it is likely that interest rate differentials and realignment expectations did not reflect accurately the pressure in favour or against the peso, we use an index of pressure in the foreign exchange market as indicator of the credibility of the exchange rate instead of realignment expectations. Second, we use a different type of Markov-switching model. Instead of a Markov-switching regression, we estimate mean-variance Markov-switching models for the index of pressure and model the transition probabilities and the probabilities of the regimes prevailing at each date in the sample as functions of macroeconomic fundamentals. Third, we consider an indicator of political news in our estimations in order to formalize the widespread notion among academics and official institutions that political events had a considerable effect on the confidence in the Mexican peso.

The results obtained using Markov-switching models with time-varying transition probabilities and different lags of macroeconomic fundamentals and political news, point to fiscal matters and political events as the triggers of the shifts of the economy between states of calm and crisis. We use a two step approach consisting of the use of a Markov-switching model with constant transition probabilities and the subsequent modelling of the probability of the crisis state. We show that real peso appreciation, the changes in the public debt relative to output and political events drove the shifts of the economy between long periods of a slight pressure in favour of a revaluation of the peso and shorter periods of stronger and more volatile pressure for peso depreciation. These results are confirmed using a model in which the transition probabilities depend on the variables identified with the two step approach.

Our results suggest that before 1994 the reduction of the debt-output ratio and positive political shocks maintained the economy in a state of calm for long periods despite a considerable real appreciation of the peso. However, the termination of the declining path of the debt to output ratio and a series of negative political shocks shifted the economy towards a state of crisis for most of 1994, and the real depreciation of the peso observed in this year was not enough to return the economy

to a state of calm. In such a state of crisis, large reserve losses accumulated over the year and the last period of confidence crisis in late December resulted in the collapse of the peso.

The rest of the chapter is organized as follows. In section 5.2 we discuss the reasons why interest rates differentials, which are the basis of the drift adjustment method, may have not reflected accurately the credibility of the peso. In section 5.3 we construct an index of pressure in the foreign exchange market. In Section 5.4 we use mean-variance Markov-switching models with time varying and constant transition probabilities to study the behaviour of the index over time. Also, we use a logistic transformation of the probability of the crisis state obtained with our preferred model and linear methods to study the causes of the shifts of the economy between the states of calm and crisis. Section 4.5 presents the conclusions and final comments.

## **5.2 Pressure in the foreign exchange market and interest rates**

Interest rate differentials are the basic indicator of the credibility of exchange rates, and Svensson (1993) and Bertola and Svensson (1993) proposed the drift adjustment method to measure the credibility of currency bands. Both interest rate differentials and realignment expectations have been used extensively in works devoted to investigating the causes of currency crises, but often these indicators seem to be silent alarms for incoming devaluations and do not show strong and stable links with macroeconomic fundamentals predicted by models of currency crises a la Krugman. The Mexican experience appeared to be similar in this respect and many analysts have remarked that it is puzzling that although the peso was known to be under severe pressure in some periods during 1994, the usual indicators of exchange rate credibility did not show dramatic increases before the devaluation of the peso in December. Various hypotheses have been proposed to explain why domestic interest rates did not accurately reflect the pressure against the peso prior to its devaluation, and we have illustrated two of them using the model of Chapter 4.

The main reason why domestic interest rates in Mexico did not show dramatic

increases during 1994 is that the monetary authorities were reluctant to reduce the monetary base when recurrent confidence crises provoked reductions in international reserves. Reserve losses were sterilised increasing the domestic credit to the banking system in order to avoid large increases in interest rates that would have further damaged the already fragile banking system and economic activity. See Banco de Mexico (1995) and Mancera (1995), and the empirical studies of Calvo and Mendoza (1996) and Agenor and Masson (1999).<sup>1</sup>

A second explanation indicates that the substitution of peso denominated bonds for dollar indexed bonds during 1994 helped investors to hedge against a potential devaluation of the peso and hence allowed a roll-over of the maturing debt without considerable increases in the interest rates of government bonds. This hypothesis was proposed by Flood and Marion (1996) who considered risk averse investors in order to allow portfolio reallocation to have a role in the determination of interest rates. Werner (1996a) presents empirical evidence indicating that during 1994 the reduction of the share of peso denominated bonds in total government bonds prevented substantial increases in the interest rates of peso denominated bonds.

A third reason for the modest response of interest rates is that the currency band mitigated the effects of confidence shocks on interest rates because the movement of the exchange rate inside the band took part of the pressure against the peso. The empirical evidence for this hypothesis is presented by Werner (1996b), who shows that the target zones used in Mexico and Israel contributed to reducing the variability of interest rates thanks to the movement of the exchange rates inside their bands.

In sum, there is a strong case to consider that interest rate differentials and realignment expectations may not have accurately reflected the situation of the foreign exchange market in Mexico in 1994. Therefore, in the next section we introduce an alternative device to measure the credibility of the peso.

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<sup>1</sup>Here, it is worth recalling that the sterilization of reserve losses when domestic and foreign assets are close substitutes insures small effects of confidence crises on interest rates but at the cost of *larger* reductions of international reserves. This result has been illustrated since some time ago with simple monetary models of a small open economy with a fixed exchange rate, see Roubini (1989), Boyer (1979) and Argy and Kouri (1974).

### 5.3 The index of pressure in the foreign exchange market

The original idea of the index of pressure in the foreign exchange market comes from Mirton and Roper (1977), later Weymark (1998) introduced further developments, and recently the index has been used in various empirical analyses of currency crisis. The aim of the index is to summarize the information about the excess demand for foreign currency that can be reflected in three different series: the difference between domestic and foreign interest rates, changes in international reserves and changes in the nominal exchange rate.

The series we use to construct the index are the monthly changes in foreign reserves as a percentage of the monetary base (CRE/MB), changes in the difference between the average cost of funds for banks in Mexico and the prime rate in the US (CBRD), and monthly changes in the log of the nominal exchange rate (CLNER). The period considered starts in May 1988 and ends in December 1994.<sup>2</sup> Graph 5.1 shows these series. The figure contains the negative of the changes in foreign reserves as a fraction of monetary base and there is a spike in the change of reserves in March 1990, which is produced by the disbursement of around 7 billion dollars due to the operations related to the renegotiation of the external debt under the Brady Plan.<sup>3</sup>

Table 5.1 shows some statistics of the series used. The Kaiser-Meyer-Olkin measure of sampling adequacy is not close to one, which indicates that the correlations cannot be considered small, and the Bartlett test indicates that the joint hypothesis of zero correlations is rejected. The correlations of the series have the expected signs: reserve losses accompany a nominal depreciation of the peso, and the correlations of CBRD and the other two series are not significant.

<sup>2</sup>For the case of the variation in reserves and interest rate differentials, the observation for December 1994 corresponds to the values of the whole month. The depreciation of the exchange rate corresponds to that observed before the abandonment of the exchange rate band on December 21st. The nominal depreciation of the peso is set to zero in the period 1998.05 - 1991.10 because the peso was subject to a predetermined depreciation which did not reflect the conditions of the foreign exchange market.

<sup>3</sup>In the figure, the right axis corresponds to CBRD and CLNER and the left axis to -CRE/MB. The observations of CLNER prior to 91.11 were set to zero and are not shown in the figure.



Figure 5.1: Input series for PC analysis

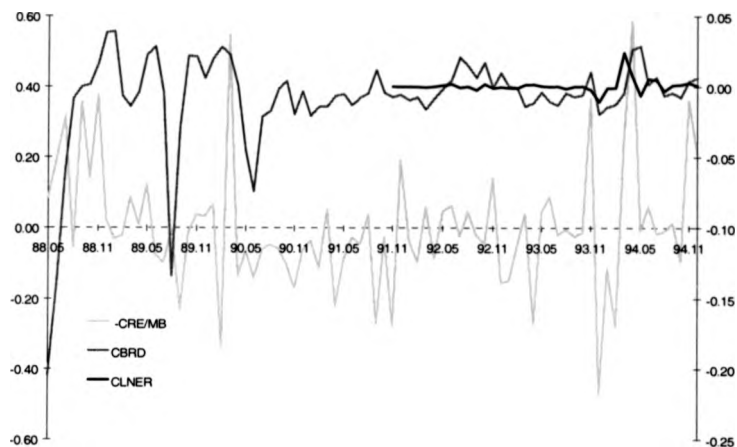


Table 5.1: Basic statistics for PC analysis

Basic Tests	Correlations (p-values)	
K-M-O of sampling adequacy:	CRE/MB	CBRD
0.0503	CRE/MB	—
Bartlett test of sphericity:	CBRD	—
9.54138 (0.023)	CLNER	-0.33903 (0.001) 0.03513 (0.378)

Table 5.2: Principal components

	Eigenvalues	% of Variance		Correlations (p-values)	Coefficients
PC1	1.344	44.8	CRE/MB	-0.81241 (0.000)	-0.60407
PC2	0.994	78.0	CBRD	0.15008 (0.184)	0.11159
PC3	0.660	100.0	CLNER	0.81386 (0.000)	0.60514

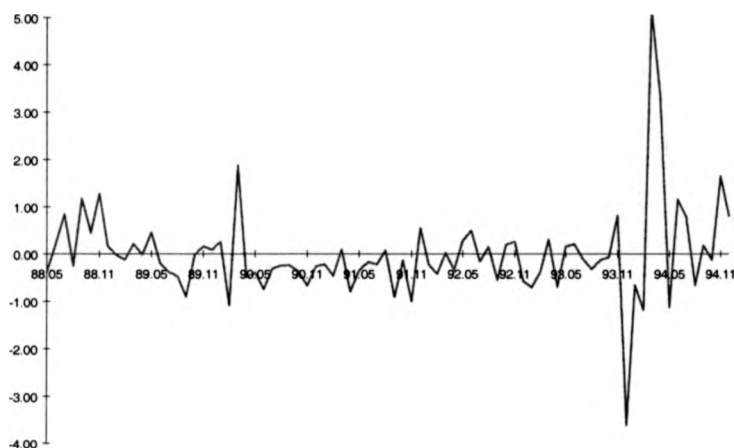
The summary of the conditions prevailing in the foreign exchange market is obtained by means of principal component analysis. This way of summarizing the information is preferred to those used by Eichengreen et al (1996a,b, 1995, 1994), Sachs et al (1996b) and Kaminsky et al (1988) because in this way we avoid arbitrary decisions about the signs and the weights given to the original series to construct the index.<sup>4</sup>

The results of the principal components analysis are shown in Table 5.2. The eigenvalue of the first principal component is well above one and the second one is close to one. The first principal component explains 45 per cent of the variance of the series and the second one adds only 33 percent. The correlation between the first principal component and the interest rate differential is rather small when compared to the other two correlations, and it is not statistically different from zero at conventional levels. The principal component is a linear combination of the standardized variables, which ensures that the index is not dominated by the series with the largest variations. The coefficients used to construct the first principal component have the right signs and, not surprisingly, the one corresponding to the interest rate differential is about one sixth of the other two.

Figure 5.2 shows the plot of the first principal component, which is our index of pressure in the foreign exchange market. Positive values of the index indicate pressure against the peso, that is, periods in which there were reserve losses, increases in the interest rate differential and nominal depreciation of the peso, while negative values indicate pressure in favour of the peso. In the figure, we can identify informally the following features. There was an initial period of pressure against the peso at the end of 1988, the first year of the stabilisation program, that disappeared in 1989. In March 1990 there is a positive spike in the index due

<sup>4</sup>For instance, Eichengreen et al impose the negative sign on reserve changes and give weights to the series such that the individual conditional variances are equal.

Figure 5.2: Index of pressure in the foreign exchange market



to the operations related to the debt renegotiation mentioned above. And after the conclusion of the debt renegotiation, there was a period of pressure in favour of the peso that vanished later. From the beginning of 1992 and up to November 1993 the pressure remained somewhat neutral, although mainly negative. In November 1993 there was an increase in the pressure against the peso due to the uncertainty surrounding the approval of the NAFTA in the US Congress, and immediately after that there was a short period with strong pressure in favour of the peso due to the flow of capital that was awaiting the approval. The negative pressure diminished considerably in January and February of 1994 and was followed by a dramatic change towards strong positive pressure in March, April, June and July. In May and August the pressure diminished considerably but came back in November and December. The aim of the next section is to identify systematically the shifts of the economy between states of pressure in favour and against the peso and the causes of those shifts.

## 5.4 Markov-switching models and regime shifts

The empirical analysis of time series subject to sudden shifts is based on the Markov-switching model introduced by Hamilton (1989) in the econometric literature. This estimation method seems to be the natural counterpart in the empirical field of the hypothesis of regime shifts suggested by second-generation models of currency crises because the aim of the method is the identification of different regimes in the behaviour of a series by allowing changes in the parameters governing its process. In what follows we use models that allow regime shifts to identify systematically in which periods the Mexican foreign exchange market was in calm or in a confidence crisis and the factors causing those shifts.

### 5.4.1 Models with time-varying transition probabilities

Hamilton's work has concentrated on a class of models in which the probabilities of transition between the states or regimes are constant. Later there has been a further development of his estimation method by Diebold, Lee and Weinbach (1994) involving time-varying transition probabilities that depend on exogenous time series.

A mean-variance Markov switching model with time varying transition probabilities (MS-TVTP) can be stated as follows. A variable  $y_t$  is assumed to be made up of a mean that changes between states and a white-noise error with a different variance in each state. Suppose the number of states is two. Then, the distribution of the series is represented as in expression (5.1), where  $\mu_s$  and  $\sigma_s^2$  denote the mean and variance of the series in state  $s = i, j$ . The transitions between regimes are state dependent, that is, the first order Markov process governing the transitions is assumed to be affected by some explanatory variable by means of an exponential function, as in expression (5.2), where  $x_t$  is the variable affecting the shifts between regimes;  $r$  denotes the lags of the explanatory variable used (up to  $q$ );  $\beta_{s,0}$  are 'constant' parameters and  $\beta_{s,r}$  are 'slope' parameters. The model is estimated using the EM algorithm and the vector of  $(6 + 2q)$  parameters is  $\Theta' = (\mu_s, \sigma_s^2, \beta_{s,0}, \beta_{s,1}, \dots, \beta_{s,q})$ .

$$y_t \sim N(\mu_s, \sigma_s^2); \quad s = i, j. \quad (5.1)$$

$$[p_{ij}] = [p(s_t = j \mid s_{t-1} = i)] =$$

$$\left[ \begin{array}{cc} p_{11} = \frac{\exp(\beta_{1,0} + \sum_1^q \beta_{1,r} \cdot x_{t-r})}{1 + \exp(\beta_{1,0} + \sum_1^q \beta_{1,r} \cdot x_{t-r})} & p_{21} = 1 - p_{22} \\ p_{12} = 1 - p_{11} & p_{22} = \frac{\exp(\beta_{2,0} + \sum_1^q \beta_{2,r} \cdot x_{t-r})}{1 + \exp(\beta_{2,0} + \sum_1^q \beta_{2,r} \cdot x_{t-r})} \end{array} \right] \quad (5.2)$$

We estimated the model represented in expressions (5.1) and (5.2) with the index of pressure in the foreign exchange market as the dependent variable and the lags of the changes of macroeconomic fundamentals and political news as the variables determining the transitions between regimes. Two sets of estimations were obtained. In the first one, the independent variables are a constant and single lags (alternatively the first, second or third lag) of the potential trigger that causes the shifts between regimes, that is  $q = 1$ . The results are contained in Tables 5.3, 5.4, 5.5 and 5.6. In the second set of estimations, a constant and three lags of the changes in the macroeconomic fundamentals were introduced simultaneously ( $q = 3$ ). These results are contained in Tables 5.7 and 5.8.

The list of potential triggers causing the shifts is the same as in Chapter 2, but excludes the changes in international reserves. Here, we use the lags of annual rates of growth or annual changes of the macroeconomic fundamentals because we assume that it takes some time to collect information about the state of the economy and the changes in the conditions of the economy that may trigger a shift from one state to the other occur in a period of one year. We can be confident that the series used are stationary given the results of the unit root tests of Chapter 2. The index of pressure is also a stationary series: the  $\tau_t$  test statistic takes the value -7.94 and rejects the hypothesis of a unit root at the one per cent level of significance.

A variable intended to represent political events was constructed to capture the effects of political events on the shifts between regimes. The variable POL

takes the value of one for positive political shocks, that is, events that contributed to maintain political stability, it takes the value of zero in those months in which there were no major political news, and has value of minus one in the months in which a political event diminishes the stability or strength of the political system. The compilation of political news was based on the information contained in Kessing's Record of World Events (Appendix 7.2 presents the political news and the associated values of POL).<sup>5</sup>

Two regimes are identified in most of our estimations, that is, both the mean and the variance of the index are significant in each regime. One regime has a positive mean, which denotes pressure against the peso, and another regime has a negative mean, which denotes pressure in favour of peso appreciation. Also, the positive mean is often larger in absolute value than the negative one, and its corresponding error term has a larger variance. That is, the pressure against the peso was stronger and more volatile.

Using one lag of the macroeconomic fundamentals (Table 5.3), we find that the changes in the ratio of the public debt to output ratio (PDO) have significant effects on the transitions between regimes, but the signs are not consistent since they mean that the probability of staying in either of the two regimes increases when the debt-output ratio increases. Instead of that, we would expect to find opposite signs: positive for the regime of positive mean and negative for the regime with negative mean (note that  $sign\ of\ (\partial p_{ii}/\partial x_{t-r}) = sign\ of\ \beta_{s,r}$ ). The sign of the coefficient corresponding to the changes in the ratio of public deficit to output (PSBRO) in the regime of negative pressure is contrary to expected. Using the second lag of the fundamentals (Table 5.4), we find a significant positive effect of increases of the public deficit and the public debt on the probability of staying in the unstable regime, which means that worsening fiscal conditions made more

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<sup>5</sup>Although it is natural to consider that political events affect economic issues, the study of those effects is often difficult due to problems in obtaining indicators of the political sphere that can be used formally. A recent paper considering the effects of political factors on exchange rates is the one by Blomberg and Hess (1997). These authors amended standard exchange rate models and included variables representing the partisan characteristics of the government, election periods, and approval ratings. They found that their model yields better out sample forecasts than the random walk model, which in turn has been largely considered as better than standard models in terms of forecasting.

Table 5.3: MS-TVTP. 1st lag

	M2	OUT	RER	CTBO	CDUS	PSBRO	UNE	PDO	MAT	HL	SH
$\mu_1$	0.496	0.546	0.529	0.436	0.562	0.520	0.532	0.452	0.519	0.536	0.016
s.e.	2.554	0.279	0.607	0.158	2.365	0.296	2.204	0.180	0.177	1.657	0.361
t		1.959		2.768		1.758		2.515	2.939		
$\sigma_1^2$	3.285	3.352	4.736	2.819	3.409	4.122	3.309	3.171	3.272	3.362	0.001
s.e.	1.005	0.343	0.805	0.106	2.938	0.315	3.054	0.089	0.140	4.181	1.001
t	3.268	9.764	5.885	26.656		13.096		35.765	23.373		
$\beta_{10}$	1.232	1.636	1.603	2.698	1.131	1.039	1.500	-41.762	1.539	1.395	-19.780
s.e.	191.410	16.122	32.725	2.454	41.227	3.465	50.741	0.349	1.029	29.170	1.0x10 <sup>7</sup>
t								-119.749			
$\beta_{11}$	-35.653	-60.974	-3.252	0.584	19.214	0.235	162.146	29.396	-1.365	21.345	-3.889
s.e.	1.7x10 <sup>3</sup>	1.8x10 <sup>3</sup>	440.436	1.366	7.1x10 <sup>3</sup>	0.292	5.4x10 <sup>3</sup>	0.351	2.141	3.2x10 <sup>3</sup>	12x10 <sup>5</sup>
t								83.757			
$\mu_2$	-0.174	-0.182	-0.113	-0.191	-0.181	-0.133	-0.180	-0.171	-0.180	0.178	-0.031
s.e.	0.321	0.011	0.044	0.003	0.112	0.019	0.251	0.003	0.007	0.572	5.376
t		-16.738	-2.574	-58.137		-7.089		-58.653	-24.930		
$\sigma_2^2$	0.140	0.139	0.211	0.137	0.143	0.183	0.143	0.136	0.142	0.144	0.441
s.e.	0.319	0.024	0.012	0.003	0.118	0.026	0.409	0.006	0.006	0.378	10.260
t		5.726	18.223	49.148		7.171		21.612	23.467		
$\beta_{20}$	2.654	2.648	3.981	3.772	2.667	2.549	2.664	2.249	2.693	2.788	-1.065
s.e.	6.590	4.154	13.484	3.225	10.164	0.338	6.036	0.454	0.478	18.877	46.049
t						7.548		4.959	5.630		
$\beta_{21}$	-8.109	14.522	-29.072	-2.922	-48.203	0.006	-15.005	0.177	0.405	-42.355	0.202
s.e.	85.934	278.322	211.038	5.856	2.2x10 <sup>3</sup>	0.002	1.1x10 <sup>3</sup>	0.058	1.507	1.9x10 <sup>3</sup>	109.048
t						3.935		30.061			
Lik	-3.170	-3.707	-6.389	-5.707	-5.115	-6.527	-5.296	-2.873	-5.610	-5.423	-65.743

t-statistics shown for significance of at least 10 per cent.

Table 5.4: MS-TVTP, 2nd lag

	M2	OUT	RER	CTBO	CDUS	PSBRO	UNE	PDO	MAT	HL	SH
$\mu_1$	0.487	0.542	0.533	0.453	0.528	0.510	0.580	0.552	0.513	0.518	0.016
s.e.	5.818	0.394	0.659	0.365	8.374	0.265	29.746	0.205	0.178	3.421	0.001
t						1.923		2.700	2.884		
$\sigma_1^2$	3.070	3.380	4.790	2.904	3.276	3.195	3.328	3.712	3.230	3.238	0.001
s.e.	1.114	0.373	1.194	0.409	9.845	0.344	39.486	0.123	0.143	5.723	0.000
t	2.754	9.081	4.010	7.098		9.293		30.215	22.582		
$\beta_{10}$	4.712	1.065	2.519	2.334	0.982	1.807	3.106	-59.863	1.550	1.584	-5.861
s.e.	176.398	15.358	40.590	5.222	28.711	3.717	$1.5 \times 10^3$	0.423	1.078	42.922	3.453
t								-141.385			
$\beta_{11}$	-109.304	-31.061	-15.556	0.509	74.591	0.048	$1.1 \times 10^3$	22.810	-1.689	9.126	-42.247
s.e.	$2.9 \times 10^3$	$1.8 \times 10^3$	558.412	1.721	$1.5 \times 10^3$	0.023	$6.9 \times 10^5$	0.925	2.878	$2.7 \times 10^3$	1.002
t						2.114		24.656			
$\mu_2$	-0.167	-0.179	-0.113	-0.190	-0.182	-0.183	-0.188	-0.168	-0.181	-0.182	-0.034
s.e.	0.041	0.148	0.035	0.017	0.546	0.021	1.665	0.006	0.011	0.662	0.009
t	-4.095		-3.232	-10.866		-8.598		-28.709	-16.685		
$\sigma_2^2$	0.132	0.141	0.210	0.137	0.142	0.142	0.151	0.148	0.141	0.142	0.427
s.e.	0.024	0.110	0.049	0.004	0.642	0.004	0.816	0.007	0.004	0.371	0.052
t	5.439		4.268	33.792		33.514		20.187	36.510		
$\beta_{20}$	2.833	2.697	4.406	3.506	2.638	2.755	2.805	2.609	2.696	2.831	-0.715
s.e.	23.970	15.432	18.860	6.374	7.396	1.419	55.007	0.340	0.483	27.385	0.167
t						1.941		7.681	5.587		
$\beta_{21}$	-12.022	25.339	-33.854	-2.671	-33.133	-0.009	3.204	0.060	0.387	-44.854	0.149
s.e.	214.002	488.665	293.104	12.870	$3.2 \times 10^3$	0.033	$1.5 \times 10^4$	0.056	1.712	$2.6 \times 10^3$	0.736
t											
Lik	-1.636	-4.584	-5.844	-5.421	-5.091	-4.385	-4.475	-3.499	-5.499	-5.536	-67.416

t-statistics shown for significance of at least 10 per cent.



Table 5.5: MS-TVTP. 3rd lag

	M2	OUT	RER	CTHO	CDUS	PSHRO	UNE	PDO	MAT	BL	SH
$\mu_1$	0.507	0.504	0.564	0.491	0.557	0.527	0.589	0.449	0.500	0.491	0.016
s.e.	4.389	0.175	1.733	0.214	0.531	0.205	25.974	0.159	0.170	5.226	0.000
t		2.874		2.299		2.564		2.817	2.949		
$\sigma_1^2$	3.284	3.104	4.908	3.064	3.431	3.161	3.450	3.085	3.155	3.089	0.001
s.e.	1.259	0.701	1.387	0.243	1.938	0.123	11.254	0.088	0.164	7.983	0.002
t	2.608	4.426	3.540	12.624	1.770	25.750		35.222	19.192		
$\beta_{10}$	-0.420	1.868	2.808	1.857	1.912	6.666	1.438	-825.815	1.846	1.844	-15.436
s.e.	127.492	19.287	40.212	2.294	62.922	18.171	10.260	0.506	2.537	58.786	1.2x10 <sup>5</sup>
t								1.6x10 <sup>3</sup>			
$\beta_{11}$	-36.849	1.023	-22.595	0.473	-79.764	-0.160	404.397	257.329	-2.979	1.191	-5.201
s.e.	1.8x10 <sup>3</sup>	806.644	628.2*3	0.736	7.5x10 <sup>3</sup>	0.456	1.3x10 <sup>5</sup>	0.506	5.769	2.3x10 <sup>3</sup>	3.8x10 <sup>4</sup>
t								508.082			
$\mu_2$	-0.177	-0.187	-0.114	-0.188	-0.179	-0.190	-0.184	-0.176	-0.183	-0.186	-0.043
s.e.	0.618	0.163	0.063	0.020	0.084	0.003	2.098	0.003	0.014	0.728	0.113
t			-1.802	-9.489	-2.130	-62.9510		-59.571	-12.682		
$\sigma_2^2$	0.140	0.145	0.213	0.138	0.142	0.135	0.145	0.133	0.140	0.139	0.445
s.e.	0.632	0.157	0.142	0.010	0.271	0.008	2.625	0.004	0.007	0.521	0.147
t				14.134		16.297		34.798	20.998		
$\beta_{20}$	2.609	3.095	4.848	3.159	2.689	3.222	2.608	2.233	2.785	3.022	-1.372
s.e.	2.817	21.258	26.963	2.770	5.572	0.671	25.064	0.455	0.628	53.391	0.554
t						4.803		4.906	4.432		
$\beta_{21}$	-7.039	30.129	-39.989	-2.205	-63.937	-0.029	-14.677	0.218	0.334	-61.839	0.118
s.e.	19.257	837.262	426.567	6.317	2.6x10 <sup>3</sup>	0.010	1.7x10 <sup>6</sup>	0.060	2.158	4.1x10 <sup>3</sup>	0.549
t						-2.874		3.650			
Lik	-2.686	-5.581	-5.151	-5.117	-4.980	-3.680	-4.331	-1.974	-4.828	-5.292	-75.971

t-statistics shown for significance of at least 10 per cent.

Table 5.6: MS-TVTP. Effects of political events.

	POL	POL <sub>t-1g</sub>	POL <sub>t-2</sub>	POL <sub>t-3</sub>
$\mu_1$	0.652	1.140	1.229	1.251
s.e.	0.466	0.998	0.015	0.987
<i>t</i>			80.761	
$\sigma_1^2$	3.258	0.088	0.100	0.119
s.e.	0.114	2.249	0.006	1.306
<i>t</i>	28.579		14.708	
$\beta_{10}$	1.318	-33.577	-348.267	-17.061
s.e.	4.537	19.1x10 <sup>5</sup>	36.969	16.2x10 <sup>5</sup>
<i>t</i>			-9.420	
$\beta_{11}$	-7.285	-34.841	-995.597	1.404
s.e.	424.401	19.7x10 <sup>5</sup>	7.699	1.7x10 <sup>5</sup>
<i>t</i>			-129.307	
$\mu_2$	-0.209	-0.171	-0.190	-0.183
s.e.	0.013	0.608	0.004	0.207
<i>t</i>	-16.077		-52.246	
$\sigma_2^2$	0.141	0.146	0.183	0.159
s.e.	0.007	0.487	0.003	0.295
<i>t</i>	20.143		55.980	
$\beta_{20}$	3.594	1.545	2.249	2.175
s.e.	1.402	10.047	0.274	5.098
<i>t</i>	2.563		8.216	
$\beta_{21}$	4.357	-0.126	0.966	0.075
s.e.	2.429	12.370	0.837	74.763
<i>t</i>	1.794			
Lik	-0.038	-9.687	-8.680	-12.432

t-statistics shown for significance of at least 10 per cent.

Table 5.7: MS-TVTP. 3 lags simultaneously (first part)

	M2	OUT	RER	CTBO	CDUS	PSBRO
$\mu_1$	0.486	0.556	0.458	0.568	0.607	0.498
s.e.	0.171	1.342	1.474	0.504	8.720	18.019
t	2.844					
$\sigma_1^2$	3.246	3.438	3.152	3.558	3.447	3.434
s.e.	0.103	1.485	0.860	0.606	7.061	8.614
t	31.602	2.315	3.667	5.870		
$\beta_{10}$	119.960	1.870	-0.477	-554.233	2.348	-76.988
s.e.	0.868	84.451	1455.385	$7.3 \times 10^6$	784.052	$3.5 \times 10^4$
t	138.188					
$\beta_{11}$	-901.797	-73.944	1657.960	94.186	78.436	-0.395
s.e.	0.868	3199.074	71.968	$1.4 \times 10^6$	$1.9 \times 10^5$	$3.8830.870$
t	-1038.841		23.037			
$\beta_{12}$	-1091.040	-18.925	1190.362	-274.772	929.586	44.701
s.e.	0.868	1219.451	24.684	$3.5 \times 10^6$	$8.1 \times 10^5$	$1.8 \times 10^5$
t	-1256.843		48.223			
$\beta_{13}$	-881.303	20.246	631.477	1113.463	-1106.653	55.434
s.e.	0.868	2546.381	251.885	$1.4 \times 10^7$	$7.2 \times 10^5$	$1.0 \times 10^5$
t	-1015.232		2.507			
$\mu_2$	-0.175	-0.179	-0.174	-0.176	-0.188	-0.160
s.e.	0.003	0.137	0.050	0.088	4.537	1.354
t	-70.102		-3.508	-2.041		
$\sigma_2^2$	0.132	0.138	0.131	0.131	0.141	0.170
s.e.	0.002	0.315	0.035	0.108	2.556	2.205
t	58.807		3.762			
$\beta_{20}$	2.820	2.693	3.511	2.107	2.704	3.018
s.e.	0.348	8.208	11.845	2.504	78.650	124.781
t	8.095					
$\beta_{21}$	14.480	5.257	116.497	8.091	-100.582	0.136
s.e.	0.883	449.751	691.485	73.001	$4.2 \times 10^4$	6.692
t	16.394					
$\beta_{22}$	-26.546	24.308	-244.434	-6.560	124.851	-0.302
s.e.	0.929	533.376	495.525	129.243	$7.8 \times 10^4$	27.780
t	-28.563					
$\beta_{23}$	4.959	-8.200	122.997	-1.073	-86.785	0.046
s.e.	0.875	504.787	1311.290	60.612	$4.0 \times 10^4$	12.439
t	5.667					
Lik	-1.152	-2.797	-1.745	-1.117	-1.233	-4.444

Table 5.8: MS-TVTP. 3 lags simultaneously (second part)

	UNE	PDO	MAT	BL	SH	POL
$\mu_1$	0.705	0.428	0.562	0.424	0.561	0.490
s.e.	181.125	2.597	0.453	29.021	12.900	0.342
$t$						
$\sigma_1^2$	3.812	4.058	3.161	2.685	3.417	3.545
s.e.	70.341	2.821	0.525	66.283	12.163	1.848
$t$			60.025			1.919
$\beta_{10}$	5.796	-1.780	5.013	5.089	0.817	-8.31
s.e.	$3.8 \times 10^4$	$9.8 \times 10^4$	82.353	3627.693	97.554	$1.7 \times 10^6$
$t$						
$\beta_{11}$	-2783.054	7.123	-0.890	988.001	24.582	25.913
s.e.	$2.4 \times 10^7$	$7.0 \times 10^5$	1081.073	$7.9 \times 10^5$	$1.2 \times 10^4$	$5.4 \times 10^5$
$t$						
$\beta_{12}$	3327.032	0.017	38.203	-1019.316	-0.286	-80.794
s.e.	$2.7 \times 10^5$	$9.4 \times 10^4$	2085.617	$9.0 \times 10^5$	$2.2 \times 10^4$	$1.6 \times 10^7$
$t$						
$\beta_{13}$	7811.275	0.918	-42.832	84.202	-53.604	-306.298
s.e.	$6.7 \times 10^7$	$2.0 \times 10^5$	2236.948	$2.0 \times 10^5$	6745.836	$6.2 \times 10^7$
$t$						
$\mu_2$	-0.185	-0.114	-0.196	-0.199	-0.181	-0.157
s.e.	4.907	0.121	0.084	8.229	0.275	0.022
$t$			-2.394			-7.172
$\sigma_2^2$	0.151	0.205	0.144	0.138	0.140	0.150
s.e.	6.319	0.020	0.092	0.781	1.567	0.020
$t$						7.692
$\beta_{20}$	2.544	8.293	3.536	5.641	2.016	3.179
s.e.	382.911	383.354	14.682	2435.540	32.770	1.768
$t$						1.798
$\beta_{21}$	-73.906	1.069	4.082	35.350	-4.322	3.293
s.e.	$6.7 \times 10^4$	334.353	131.395	$4.8 \times 10^4$	263.265	7.077
$t$						
$\beta_{22}$	101.914	-0.982	-11.366	-102.851	8.838	2.252
s.e.	$9.0 \times 10^4$	429.108	229.565	$1.7 \times 10^5$	504.774	5.653
$t$						
$\beta_{23}$	-40.442	-1.903	9.177	-123.997	-7.695	0.138
s.e.	$5.0 \times 10^4$	216.418	125.276	$1.2 \times 10^5$	346.363	13.349
$t$						
Lik	-2.412	-1.489	-2.230	-3.354	-3.744	-1.442

persistent the state of crisis. And using the third lag of the fundamentals (Table 5.5), we observe that the effect of increases of public deficit is significant and has the expected sign in the stable regime: higher public deficits made this regime less persistent, whereas the signs of changes in public debt are inconsistent. Note that in all the cases in which a variable was found to be a significant determinant of the transitions between regimes, the regimes are well identified.

Table 5.6 shows the results using contemporaneous and three lags of political news as the determinants of the transitions between regimes. Contemporaneous political events have the expected effect in the stable regime: positive political shocks increase the persistence of this regime, and negative political shocks decrease its persistence. And also, using the second lag of POL we find that political events affect the probability of staying in the unstable regime with the expected signs since negative political shocks make this regime more persistent. Again, in both cases the regimes identified have significant mean and variance.

In order to look for cumulated effects of the macroeconomic fundamentals on the transitions probabilities, we estimated models using three lags simultaneously. These results are shown in Tables 5.7 and 5.8. The growth of M2 seems to have significant cumulated effects: the  $\chi^2$  with 6 degrees of freedom of the likelihood ratio test has a value of 11.654 and a  $p$ -value of 0.0701, but the signs of the effects are not consistent. And the effect of the real exchange rate (RER) in the unstable regime has a sign contrary to expected, the means are not identified and the likelihood ratio test takes the value of 10.468 with a  $p$ -value of 0.106. No other variable has cumulated effects and often the standard errors calculated took excessively large values.

In sum, using models with time-varying transition probabilities we find that most macroeconomic fundamentals do not have significant effects on the transition between regimes. However, the results suggest that fiscal and political matters drove the transitions between regimes since the changes in the ratio of the public deficit to output, the public debt to output ratio and political news have significant effects when the regimes are well identified.<sup>6</sup>

<sup>6</sup>Using lags of the changes in the ratio of the consolidated public debt (which includes the net debt of the central government, the public enterprises, the official development banks and the central bank) to output yielded the following results. Using two lags, the regimes are well

These results may have two causes. The first is the spike of the index related to the renegotiation of the external debt in March 1990. The plot of the probabilities of the regimes in each date often changes dramatically and behaves erratically after March 1990. And the second is that given that the estimation method is quite sophisticated, proposing a general model containing all the fundamentals and their lags (that would be subsequently reduced) is intractable. As a result of this, only one fundamental was related to the transition probabilities at a time. In the next section we adopt an alternative approach aimed to avoid these two problems.

#### 5.4.2 A two step approach to model regime shifts

The first step of an alternative approach to model the shifts between regimes consists of identifying the different states over time and obtaining the probabilities of each state prevailing at each date in the sample, using a mean-variance Markov-switching model with constant transition probabilities. And the second step consists of modelling the inferred probability separately as a function of macroeconomic fundamentals and political news. Using this approach, the spike related to the debt renegotiation can be isolated using a simple dummy variable and a general model involving the lags of the macroeconomic fundamentals that potentially affect the transitions between regimes can be estimated and reduced.

##### Models with constant transition probabilities

A two-state mean-variance Markov-switching model with  $p$  autoregressive terms and constant transition probabilities (MS-AR( $p$ )) can be stated as follows. The series  $y_t$  is modelled as an AR( $p$ ) process in which the mean and variance are allowed to change between states, but the AR coefficients are the same in both states, as in expression (5.3). And the matrix containing the constant transition probabilities that describes the first order Markov process governing the shifts between regimes is as in expression (5.4). Hence, the vector of  $(6 + p)$  parameters to be estimated with the EM algorithm is  $\Theta' = (\mu_s, \sigma_s^2, \phi_1, \dots, \phi_p, p_{ii}, p_{jj})$ .

identified and the variable has the right sign and is significant in the unstable regime, and the other lags are insignificant. Using three lags simultaneously, the regimes are not identified and the variable is not significant.

$$y_t - \mu_s = \sum_{r=1}^p \phi_r (y_{t-r} - \mu_s) + \varepsilon_t \sim N(\mu_s, \sigma_s^2); \quad s = i, j \quad (5.3)$$

$$[p_{ij}] = [p(s_t = j \mid s_{t-1} = i)] = \begin{bmatrix} p_{ii} & p_{ji} = 1 - p_{jj} \\ p_{ij} = 1 - p_{ii} & p_{jj} \end{bmatrix} \quad (5.4)$$

MS-AR( $p$ ) models with  $p = 0, 1, 2, 3$  were applied to the index of pressure in the foreign exchange market. Table 5.9 shows the results. According to the Schwarz criteria, the model with three lags may be preferred. And a likelihood ratio test suggests that we cannot use two lags only (the value of the test statistic is 3.596 and it is distributed as a  $\chi^2$  with one degree of freedom, so that the corresponding  $p$ -value is 0.058). However, we note that none of the means are significant when using three lags.

A direct comparison of the model with three lags with the most parsimonious model indicates that the simplest mean-variance model with no autoregressive terms may be preferred: the value of the test statistic, distributed as a  $\chi^2$  with 3 degrees of freedom, is 5.364 and its  $p$ -value is 0.147. And comparing the plots of the probabilities obtained with 0 and 3 lags, Figures 5.3 and 5.4, we observe that the MS-AR(0) model seems to distinguish more adequately the different periods of negative and positive pressure in the foreign exchange market. In particular, the MS-AR(3) model does not capture completely the positive pressure observed in 1988 and mid-1994.

We prefer the simplest mean-variance model without autoregressive terms to characterize the periods of pressure against to and in favour of the peso because the result of the likelihood ratio test favours this model, the characterization of the different periods of positive and negative pressure is less sharp with the MS-AR(3) model, and none of the means estimated in the model with three lags is significant. The only remarks to make about the simplest model are that the mean in the crisis state is not significant at conventional levels (although the associated  $p$ -value is not too big and this problem is shared with the other models) and the model does not assign the months of December 1993, and January and February of 1994 to the stable state.

Table 5.9: Markov-switching AR(p) models

MS-AR(3)	$\mu_1$	$\sigma_1^2$	$p_{11}$	$\mu_2$	$\sigma_2^2$	$p_{22}$	AR(1)	AR(2)	AR(3)
Estimate	0.75989	6.5137	0.5400	-0.1338	0.1681	0.9245	0.0950	0.1835	0.1863
s. e.	0.52824	3.4020	0.2188	0.1077	0.0410	0.0420	0.0797	0.0758	0.0718
t	1.439	1.915	2.468	-1.242	4.096	22.008	1.192	2.420	2.594
p-value	(0.155)	(0.060)	(0.016)	(0.218)	(0.000)	(0.000)	(0.237)	(0.018)	(0.012)
			d.f. 71	Llik -4.997			Schwarz C. -24.179		
MS-AR(2)	$\mu_1$	$\sigma_1^2$	$p_{11}$	$\mu_2$	$\sigma_2^2$	$p_{22}$	AR(1)	AR(2)	
Estimate	0.5173	3.0248	0.8926	-0.1892	0.1364	0.9421	-0.0142	0.034	
Standard error	0.3915	0.9818	0.0902	0.0518	0.0277	0.0347	0.116	0.0109	
t	1.321	3.081	9.896	-3.653	4.924	27.150	-0.123	0.313	
p-value	(0.191)	(0.003)	(0.000)	(0.001)	(0.000)	(0.000)	(0.902)	(0.755)	
			d.f. 72	Llik -6.795			Schwarz C. -24.081		
MS-AR(1)	$\mu_1$	$\sigma_1^2$	$p_{11}$	$\mu_2$	$\sigma_2^2$	$p_{22}$	AR(1)		
Estimate	0.5178	2.9679	0.8710	-0.1845	0.1393	0.9393	-0.0214		
s. e.	0.3776	0.9845	0.1078	0.0513	0.0288	0.0361	0.1134		
t	1.371	3.015	8.080	-3.596	4.837	26.019	-0.189		
p-value	0.175	0.004	0.000	0.001	0.000	0.000	0.910		
			d.f. 73	Llik -7.309			Schwarz C. -22.326		
MS-AR(0)	$\mu_1$	$\sigma_1^2$	$p_{11}$	$\mu_2$	$\sigma_2^2$	$p_{22}$			
Estimate	0.53055	3.08127	0.83436	-0.18170	0.14104	0.93600			
s. e.	0.40299	1.05545	0.11698	0.05196	0.02947	0.03684			
t	1.317	2.919	7.133	-3.497	4.787	25.408			
p-value	(0.191)	(0.005)	(0.000)	(0.001)	(0.000)	(0.000)			
			d.f. 74	Llik -7.679			Schwarz C. -20.591		



Figure 5.3: MS-AR(0). Filter and smoothed probabilities.

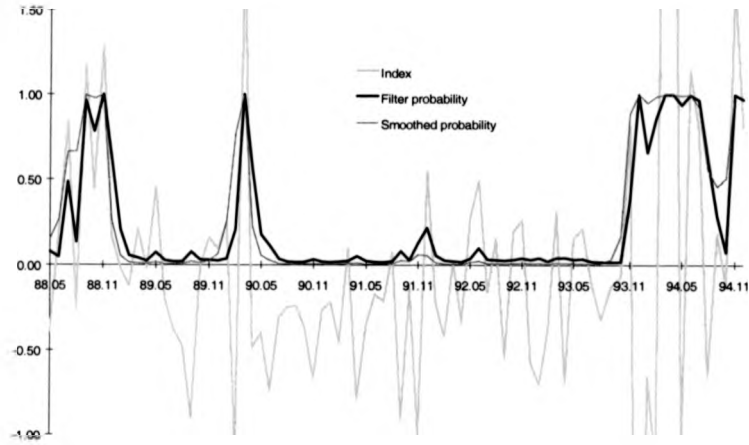


Figure 5.4: MS-AR(3). Filter and smoothed probabilities.

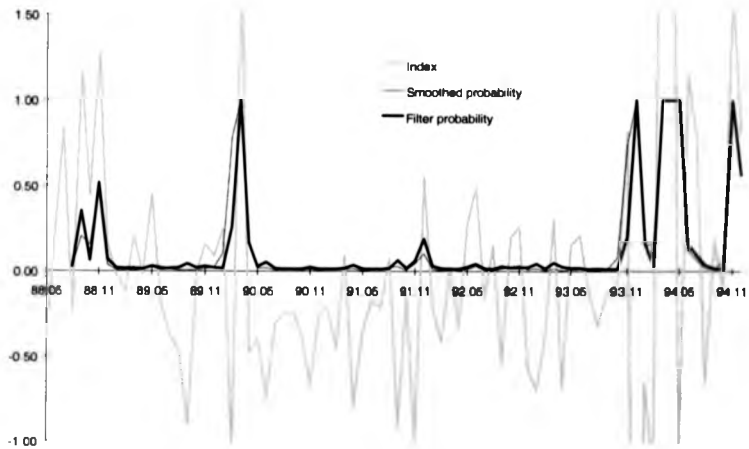
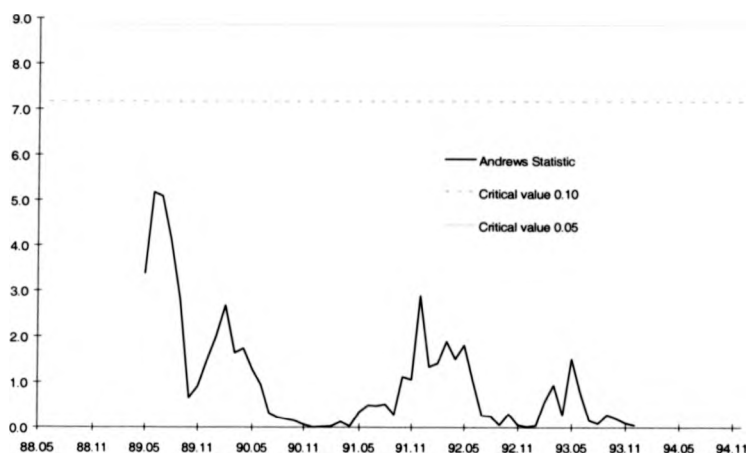


Figure 5.5: Andrews test of parameter stability.



In order to check our preferred model, a series of specification tests was performed, as suggested in Hamilton (1996). The results of the Andrews (1993) test for an additional shift in the mean of the series shown in Figure 5.5 do not indicate that a model with three regimes is needed. And the rest of the specification tests, shown in Table 5.10, indicate that there are no major specification errors, although there may be some doubts about the presence of crossed ARCH effects, because the White test rejects the null of no effects while the same hypothesis is not rejected in the Lagrange multiplier version of the test. Given this latter result, standard errors robust to specification problems were calculated, as proposed in White (1982). Table 5.11 shows again the estimates of the MS-AR(0) model, the robust standard errors, and the corresponding values of the  $t$ -statistics and  $p$ -values. The conclusions about the significance of the parameters estimated do not change and the  $p$ -value corresponding to the mean of the crisis state remains between 0.15 and 0.20.

As in the previous subsection, two states or regimes showing pressure against and in favour of the peso are identified. The absolute value of the mean in the crisis state is more than twice that of the mean in the other regime, which denotes considerable asymmetry in the pressure, and also the pressure in the state of crisis

Table 5.10: Specification tests

White Tests			
Serial correlation in both regimes	F(2, 76)	0.202	(0.818)
Serial Correlation in and across regimes	F(4, 78)	0.887	(0.476)
ARCH effects in both regimes	F(2, 76)	2.156	(0.122)
ARCH effects in and across regimes	F(4, 78)	2.614	(0.042)
LM Tests			
Serial correlation in regime 1	F(1, 75)	0.055	(0.815)
Serial correlation in regime 2	F(1, 75)	0.035	(0.852)
Serial correlation across regimes	F(1, 75)	0.014	(0.906)
ARCH effects in regime 1	F(1, 75)	0.042	(0.838)
ARCH effects in regime 2	F(1, 75)	1.749	(0.190)
ARCH effects in each regime and across regimes	F(1, 75)	0.479	(0.491)
Tests of Markov Specification			
$p_{ii}$ depends on own lagged values and own scores of mean	F(4, 76)	0.389	(0.852)
$p_{ii}$ depends on own lagged values	F(2, 76)	0.636	(0.532)
$p_{11}$ depends on own lagged values and own scores of the mean	F(2, 76)	0.017	(0.983)
$p_{22}$ depends on own lagged values and own scores of the mean	F(2, 76)	0.769	(0.549)

Table 5.11: Robust standard errors of the MS-AR(0) model

	$\mu_1$	$\sigma_1^2$	$p_{11}$	$\mu_2$	$\sigma_2^2$	$p_{22}$
Estimate	0.53055	3.08127	0.83436	-0.18170	0.14104	0.93600
Standard error	0.38476	1.45901	0.10965	0.05647	0.03399	0.03073
t-statistic	1.379	2.112	7.609	-3.217	4.150	30.459
p-value	(0.172)	(0.038)	(0.000)	(0.002)	(0.000)	(0.000)

is much more volatile: its variance is 21 times the other. The crisis state was much less persistent than the stable one: the expected time the crisis regime is expected to last is  $(1/(1 - 0.83)) \cong 6$  months, while the stable regime is expected to last more than one year;  $(1/(1 - 0.93)) \cong 15$  months. These results indicate that the Mexican peso had a slight favourable pressure for long periods, but during short periods the economy shifted into a crisis state with stronger and more volatile pressure for peso depreciation. Not surprisingly, the periods of pressure against the peso were present before the fixed rate regime was substituted by a regime with predetermined rates at the end of 1988 and during the troubled 1994.

### Modelling the shifts between regimes

In this section we estimate the filter probability of the crisis state inferred with the MS-AR(0) as a function of macroeconomic fundamentals and political news in order to investigate the causes of the shifts between regimes. We use a logistic transformation of the probability as the dependent variable of a linear regression, which ensures that the estimated probability remains between zero and one and the effects of the fundamentals on the probabilities of each state are symmetric by construction.<sup>7</sup> We prefer to model the series of the filter probability because it is calculated at each date using the information available up to that date, in contrast, the smoothed probabilities are calculated using the information of the entire sample.

The hypothesis of a unit root in the process of the transformed probability using standard ADF tests cannot be rejected. This is due to the shifts in the probability, not, of course, due to any trend in the series. The variable represents a probability that shifts in certain periods, so it is expected to exhibit breaks along time, and we know that in such a situation the ADF test tends not to reject the null. Hence, unit root tests with breaks in the constant and/or trend were performed as suggested by Perron (1989, 1990). The results in Table 5.12 confirm the idea that the series is stationary with breaks.<sup>8</sup>

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<sup>7</sup>See Wallis (1987).

<sup>8</sup>In the regressions of Table 5.12, the trend coefficient is not significant in models A and C and all the proposed deterministic components are significant in model B. The significance of the change of the trend coefficient in model B can be considered dubious because the series is expected to show shifts not trends. Hence, the preferred model is D since this model considers

Table 5.12: Unit root tests for the transformed probability

Variable	Test statistics				
	Lags	$\tau_t$	$\Phi_3$	$\Phi_2$	$\tau_\mu$
$TProb_t$	6	-2.84	5.16	3.44	-2.17
Tests with structural breaks					
Alternative processes:					
A: I(0) with trend and change in mean					-9.37**
B: I(0) with mean and and change in trend					-8.10**
C: I(0) with changes in mean and trend coefficient					-8.28**
D: I(0) without trend and change in mean					-9.32**

\*\* denotes significance at 5 percent level.

The initial and most general estimation of the transformed probability ( $TProb_t$ ) included as explanatory variables one lag of itself, three lags of the set of macroeconomic fundamentals, a dummy that takes the value of one in March 1990 and zero elsewhere (DUM), and the contemporaneous observation and three lags of the variable representing political events. After the elimination of insignificant lags and variables the results in Table 5.13 were obtained.

The lagged value of the transformed probability, included to capture the persistence in the series after it shifts from one regime to another, has the expected sign and is significant; also, its coefficient is not close to one, which reinforces the idea that the transformed probability is a stationary series. The cumulated and long run effects of both output growth and changes in the ratio of the six-month cumulated trade balance relative to output are not significant. The effects of and increase in the debt-output ratio have the correct sign and are significant, which means that higher public indebtedness increased the probability of the crisis state both in the short and long runs. A real depreciation of the peso also increased the probability of the crisis state in the short and long runs. Political events have the expected effects as well: positive political shocks reduced the probability of the crisis state and negative news increased its persistence, and their cumulated and changes in the mean only and is estimated without a trend term. The breaks considered are given by the classification of each date as belonging to the state of crisis or calm using the filter probability and the value of 0.5 as threshold.

long run effects are significant. The specification tests indicate the failure of the functional form test and non-normal errors (the statistics of skewness and kurtosis take high values). However, there is no evidence of first (or higher) order serial correlation of errors or heteroscedasticity, and the residuals are stationary, which suggests that the changes in the level of the dependent variable over time are well described by the linear combination of regressors.

To check the robustness of our results, other estimations were obtained as well. The first alternative regression was estimated and reduced using the annual changes of the ratio of the public debt consolidated with the central bank instead of PDO (which considers only the net debt of the central government, the public enterprises and the official development banks). The results obtained were almost identical given that the paths of both definitions of debt are very similar. Also, when the dependent variable in the regression is the transformed filter probability of the crisis state obtained with the MS-AR(3) model, we find similar results. The lag of the transformed probability has the correct sign and is significant. Output growth has neither cumulated nor long run effects, and the lags of the changes in the cumulated trade balance are eliminated when reducing the set of regressors. The cumulated and long run effects of the changes in the debt to output ratio and political news have the expected signs and are significant. The only difference is that the cumulated and long run effects of the real appreciation exchange rate have the expected signs, but turn out to be marginally insignificant: their  $p$ -values are (0.131) and (0.137), respectively.

The results in Table 5.13 together with the series in Figures 5.6 and 5.7 suggest that the reduction of public indebtedness relative to output and positive political shocks helped to maintain the economy in a state of calm for most of the sample period, despite a continuous real appreciation of the peso. However, the definitive end of the declining path of the debt to output ratio in 1994 and recurrent negative political shocks kept the economy in a state of crisis during most of 1994. The real depreciation of the peso observed during 1994 was not enough to counterbalance these effects.

The two step approach proposed can be considered as a method for model reduction. That is, after reducing a general model using the two step approach, we can estimate a reduced model with time-varying transition probabilities using

Table 5.13: Estimation of the probability of the crisis state

	Coefficient	s. e.	t (p-values)	Wald tests statistics (p-values)	
				Cumulated effect	Long-run effect
Constant	0.7189	0.7782	0.924 (0.359)		
TProb <sub>t-1</sub>	0.2939	0.0959	3.064 (0.003)		
OUT <sub>t-2</sub>	-17.9041	10.2897	-1.740 (0.086)		
OUT <sub>t-3</sub>	37.2005	13.4320	2.769 (0.007)	(+) 1.4632 (0.226)	1.3937 (0.238)
RER <sub>t-3</sub>	-34.1368	12.2550	-2.786 (0.007)		7.4596 (0.006)
CTBO <sub>t-1</sub>	-6.2670	2.8260	-2.218 (0.030)		
CTBO <sub>t-2</sub>	6.8233	2.7521	2.479 (0.016)	(+) 0.4099 (0.522)	0.3974 (0.528)
PDO <sub>t-3</sub>	0.0088	0.0023	3.713 (0.000)		15.8479 (0.000)
POL <sub>t</sub>	-1.4735	0.6034	-2.442 (0.017)		
POL <sub>t-1</sub>	-1.1695	0.6835	-1.711 (0.092)	(-) 7.9698 (0.005)	8.3146 (0.004)
DUM	12.4575	2.6781	4.651 (0.000)		
79 observations					
R squared	0.63228		Adjusted R squared 0.57820		
Mean of TProb <sub>t-1</sub>	-1.4148		F(10, 68) 11.6922 (0.000)		
Standard deviation of TProb <sub>t-1</sub>	3.8911		Standard error of regression 2.5271		
Residual sum of squares	434.2703		Log likelihood -179.4128		
Specification tests					
First order serial correlation (h-test): -1.2712 (0.204)					
Serial correlation F(12, 56): 0.6986 (0.746)					
Heteroscedasticity F(1, 77): 0.00397 (0.950)					
Functional form F(1, 67): 11.3671 (0.001)					
Normality of errors $\chi^2(2)$ : 57.0473 (0.000)					
Skewness: 1.4064 Kurtosis - 3 : 3.0689					
ADF test for unit root in residuals -4.98** No. of lags: 6					

Figure 5.6: Changes in debt-output ratio and political news

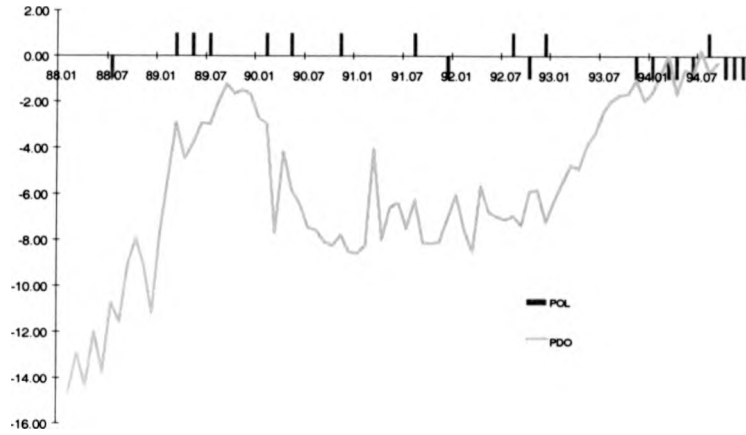


Figure 5.7: Annual changes of the real exchange rate

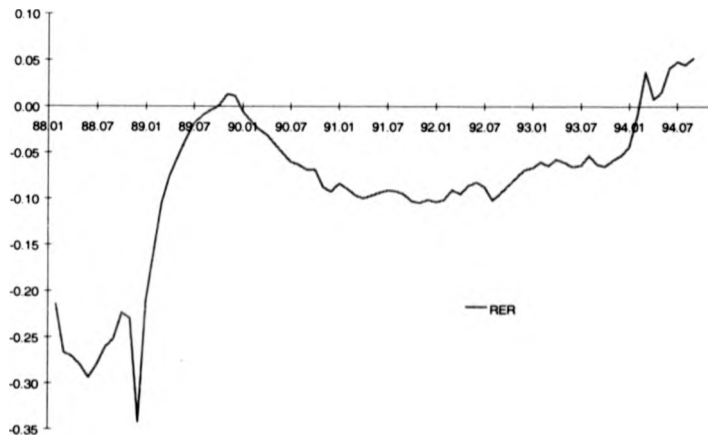




Table 5.14: Reduced model with TVTP

	$\mu_s$	$\sigma_s^2$	<i>Const.</i>	$PDO_{t-3}$	$POL_t$	$RER_{t-3}$
	State of Crisis					
Estimate	0.702	3.812	32.549	31.991	-2155.466	-549.423
s.e.	0.258	0.208	3364.895	769.862	89.400	42.062
t-statistic	2.721	18.345			-24.110	-13.062
	State of Calm					
Estimate	-0.179	0.154	6.661	-1.999	96.589	5.326
s.e.	0.005	0.005	5.548	0.665	32.827	7.221
t-statistic	-36.095	32.536		-3.007	2.942	
	Log likelihood: -5.729					

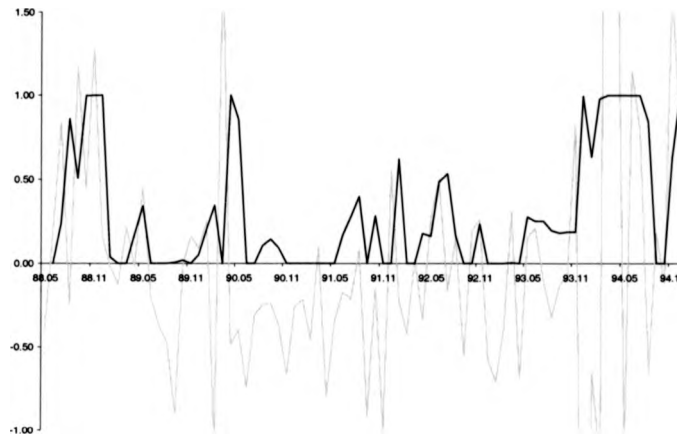
t-statistics shown for significance of at least 10 per cent.

the variables that have significant effects. Hence, we estimated a mean-variance model in which the transitions between regimes depend on the debt-output ratio, political news and the real exchange rate. Both the parameters and the probability estimates add to the robustness of our results. Table 5.14 shows the parameters estimated.

As before, we find that the pressure was asymmetric: the state of pressure shows a positive mean which has absolute value and variance larger than in the state of calm. And the parameters of the transition probabilities estimated indicate that the public debt to output ratio made the state of calm more persistent while real peso appreciation affected negatively the persistence of this state. Negative political shocks made the state of crisis more persistent, and a real depreciation of the peso had the opposite effect.

The plot of the probability of the crisis state estimated (shown in Figure 5.8) tells us the same history as before. The state of crisis prevailed in the last part of 1988, and reached a peak in March 1990 due to the disbursement of reserves for the renegotiation of the external debt. The economy remained in calm until the end of 1993. In November of this year the probability estimated increased due to

Figure 5.8: Reduced model. Probability estimated



the pressure that surrounded the approval of NAFTA, and then decreased after its approval. In 1994, the state of crisis prevails most of the year. After March the economy shifted to the state of crisis and remained there several months. The state of calm returned in September and October, but the economy shifted again to the state of crisis in November and December.

Given that the two step approach yielded robust results that are confirmed using a model with time-varying transition probabilities, we can be confident about the identification of the variables causing the transitions of the economy between the states of calm and crisis.

## 5.5 Conclusions and comments

This chapter proposes an index of pressure in the foreign exchange market as an indicator of the credibility of the Mexican peso, and using Markov-switching models to describe the shifts of the economy between states of calm and crisis. Also, we propose modelling the transitions between regimes and the probabilities of each regime at each date in the sample as functions of macroeconomic fundamentals and political news in order to investigate the causes of those shifts.

Two states were identified using Markov-switching models with constant or time varying transition probabilities. The state of calm is characterized by a slight pressure for peso appreciation and the crisis state by stronger and more volatile pressure for peso depreciation.

The results of models with time varying transition probabilities suggest that fiscal matters and political shocks significantly affected the transitions between regimes, but the results are not conclusive. Hence, we adopted a two step approach to obtain the probability of the state of crisis at each date in the sample and model this series as a function of macroeconomic fundamentals and political events.

The preferred model with constant transition probabilities indicates that the magnitude of the pressure for peso depreciation was more than twice the favourable pressure in the state of calm, and it was also much more volatile: the variance in the crisis state was 21 times the other. The state of calm had an expected duration of 15 months, and the unstable regime an expected duration of 6 months. According to the series of the filter probabilities, the economy remained in the state of calm most of the time, but shifted to the state of crisis in the last months of 1988, when the fixed exchange rate regime changed to predetermined rates, and most of 1994, a year marked by political and financial turmoil.

The logistic transformation of the probability of the crisis state was modelled as a function of macroeconomic fundamentals and political news. We found robust results indicating that political events, the changes in the debt-output ratio and the movements of the real exchange rate directed the shifts of the economy between the states of calm and crisis. These results were confirmed using a model with time-varying transition probabilities involving the variables mentioned.

During most of the sample, the reduction of public indebtedness and positive political events contributed to maintaining the economy in a state of calm, despite a considerable real appreciation of the peso. However, the ratio of public debt to output stopped its declining path before 1994 and a series of negative political shocks followed. This shifted the economy towards the state of crisis for most of the year. A real depreciation of the peso was not enough to return the economy to the state of calm. In the state of crisis, reserve losses accumulated along the year, and the last period of confidence crisis in late December resulted in the collapse of the peso.

Based on this evidence, we conclude that the periods of confidence crisis observed in 1994 and the collapse of the peso on December 21st should be considered as the product of a combination of weakening fundamentals, that were not necessarily fatal, and a series of unpredictable shocks that shifted the economy towards the state of crisis and exhausted the mechanisms of defence used by the government during that year.

The plots of the probabilities of the crisis state obtained indicate that before the devaluation of the peso, the economy spent some months in a state of crisis in which recurrent reserve losses undermined the future defence of the peso. We may consider such a pattern as consistent with the hypothesis proposed by Bensaïd and Jeanne (1997), who suggest that a currency crisis may be a protracted period during which there is a war of attrition between monetary authorities and speculators before the final speculative attack and the devaluation of the currency.

We found that during 1994 the macroeconomic fundamentals that determined the prevalence of the different states acted in opposite directions but most of the time the economy stayed in a crisis state. Such a finding is similar to that reported by Jeanne (1997) in his study of the speculation against the French franc in 1992-93. According to his results, the rise in the rate of unemployment maintained the French economy in the zone of multiple equilibria despite the improvement of other economic fundamentals. Hence, as Jeanne notes, "One may conjecture that the difference between the French franc [or the peso] and other currencies, if it exists, probably lies more in the nature of the determining fundamentals than in the presence of animal spirits [sudden shifts towards the state of crisis]"<sup>9</sup>.

Therefore, when studying other currency crises in which self-fulfilling elements may be present, one should not expect to find a typical pattern of fundamentals leading the economy to a crisis state, but different configurations of fundamentals and shocks for different countries. A clear example of this is the role of contagion in the recent crises in East Asia, and probably in the crisis of the ERM as well, although this is not the case for Mexico.

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<sup>9</sup>Page 283.

## Chapter 6

# The 1989-94 Consumption Boom in Mexico: An analysis of Cointegration using Regime Shifts

### 6.1 Introduction

One of the most noticeable consequences of the program for stabilisation and economic reform introduced in Mexico in 1987 was a considerable reduction in domestic savings and an increased dependence on external savings to finance capital formation.<sup>1</sup> The ratio of domestic savings to gross domestic product (GDP) decreased from 21.3 per cent in 1988 to 14.7 per cent in 1994 while the ratio of foreign savings increased from 1.3 per cent in 1988 to 7.1 per cent in 1994. And later, after the eruption of the financial crisis at the beginning of 1995 and a short period of recovery, the savings ratio has returned to values similar to those observed before the program. In 1998 domestic savings amounted to 20.6 per cent of GDP, and in 1999 this figure was 20.3 per cent.

In this chapter we analyse the changes in consumption behaviour that contributed to such a reduction in domestic savings using cointegration modelling methods that allow shifts in regimes. We will argue that the introduction of the program for economic stabilisation and reform implied a temporary structural break in the long run relationship between aggregate private consumption and in-

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<sup>1</sup>See Buirra (1994) and Banco de Mexico (1995) for brief discussions of this issue.

come that led to a consumption boom of considerable magnitude. We will illustrate this by modelling the cointegration relationship between consumption and income taking into account shifts in regime, which will enable us to date and evaluate the structural break.

Structural breaks in economic relationships have long been a subject of study (early works include Quandt (1958) and Chow (1960)) because economies are often subject to shocks or institutional changes that may change the dynamics of economic variables and the pattern of their inter-relationships.<sup>2</sup> However, although the study of the effects of structural breaks on unit roots tests (Perron (1988), (1989), (1990)) came soon after the start of the revolution of unit roots and cointegration (Engle and Granger (1987), Johansen (1988)), the effects of structural breaks on cointegration modelling have taken longer to become a focus of the research agenda. See Hansen (1992), Quintos and Phillips (1993), the January 1996 issue of the *Journal of Econometrics*, Hoa and Inder (1996), and Seo (1998). Even now, there is no well-established approach in the literature to tackle the problem of structural breaks in long-run cointegrating relationships.

The focus of our analysis is the change in the cointegrating relationship between aggregate private consumption and income that resulted in the consumption boom observed in Mexico during the period 1989-1994. Specifically, we will argue that structural breaks should be taken into account not only in unit root testing, but also in cointegration modelling in order to identify and evaluate accurately the consumption boom. We achieve this by postulating Markov-switching models for the cointegrating relationship that allow shifts in regimes.

Our modelling indicates that the implementation of the program for stabilisation and economic reform at the end of 1987 and its abandonment at the end of 1994 produced institutional change-induced structural breaks in the series of private consumption and income and also in their cointegrating relationship. Before the program was implemented, the long run relationship between consumption and income was characterized by the unitary elasticity often found in empirical research. However, the introduction of the program soon led to a sharp regime shift

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<sup>2</sup>For instance, the stability of money demand equations often receives considerable attention given its critical role in the implementation of monetary policy. See for instance, Lutkepohl et al (1999), Raj (1995) and Hendry and Ericsson (1991).

in the cointegrating relationship. In the period of the boom, the income elasticity of consumption increased considerably: private consumption was growing almost 30 percent faster than income. And later, when the program was abandoned at the end of 1994, the unitary elasticity was re-established in the middle of a currency and financial crisis.

The rest of the chapter is organized as follows. Section 6.2 presents the theoretical background for the proposition of a cointegration relationship between consumption and income, a review of the main findings in the empirical literature, and a brief theoretical background supporting the case of regime shifts in their long run relationship. Section 6.3 focuses on the characteristics of the series used and highlights the importance of taking into account the effects of structural breaks when testing for unit roots. Section 6.4 estimates the cointegrating vector of the log of per capita private consumption and the log of income using seasonally unadjusted and adjusted data and investigates the stability of its parameters over time. Section 6.5 estimates long run relationships that allow shifts in the cointegration vectors using Markov-switching models, and tests for the existence of cointegrating relationships with shifts. Section 6.6 summarizes and concludes.

## 6.2 Income, consumption and structural breaks

The theoretical basis of the proposition for a cointegrating relationship between aggregate consumption and income is a result of the rational expectations-permanent income hypothesis (RE-PIH) introduced by Friedman (1957). The representative individual maximizes a concave twice differentiable utility function which depends on consumption, as in equation (6.1), and discounts future utility with the rate of time preference  $\delta$  ( $0 < \delta < 1$ ). The accumulation of assets by the individual is constrained in each period by the budget constraint in equation (6.3), where  $r$  is the (assumed constant) real interest rate.  $A_{k+1}$  is the stock of assets at the end of period  $k$ , and  $Y_k^d (= rA_k + Y_k)$  and  $Y_k$  denote disposable and labour income in period  $k$ , respectively.

$$U_t = \sum_{k=t}^{\infty} \left( \frac{1}{1+\delta} \right)^{k-t} U_k(C_k) \quad (6.1)$$

$$C_k \geq 0; U_c > 0; U_{cc} < 0; \lim_{c \rightarrow 0} U_c = \infty; \lim_{c \rightarrow \infty} U_c = 0 \quad (6.2)$$

$$A_{k+1} = Y_k^d + A_k - C_k = (1+r)A_k + Y_k - C_k \quad (6.3)$$

The period by period budget constraint gives rise to the intertemporal budget constraint in equation (6.4), where the no-Ponzi game condition in expression (6.5) has been imposed with equality because of the characteristics of the utility function.

$$\sum_{k=t}^{\infty} \left(\frac{1}{1+r}\right)^{k-t} C_k = (1+r)A_t + \sum_{k=t}^{\infty} \left(\frac{1}{1+r}\right)^{k-t} Y_k \quad (6.4)$$

$$\lim_{k \rightarrow \infty} \left(\frac{1}{1+r}\right)^{k-t} A_k \geq 0 \quad (6.5)$$

Assuming that the rate of time preference equals the real interest rate yields a constant level of consumption,  $C_t$ . Substituting this result into expression (6.4) and solving for  $C_t$  yields an expression in which consumption at period  $t$  equals the annuity value of the consumer's total discounted wealth.

$$C_t = \left(\frac{r}{1+r}\right) \left[ (1+r)A_t + \sum_{k=t}^{\infty} \left(\frac{1}{1+r}\right)^{k-t} Y_k \right] \quad (6.6)$$

Then, subtracting disposable income from both sides of (6.6) and rearranging yields:

$$C_t - Y_t^d = -Y_t - rA_t + \left(\frac{r}{1+r}\right) \left[ (1+r)A_t + \sum_{k=t}^{\infty} \left(\frac{1}{1+r}\right)^{k-t} Y_k \right] \quad (6.7)$$

$$C_t - Y_t^d = -Y_t + \left(\frac{r}{1+r}\right) \left[ \sum_{k=t}^{\infty} \left(\frac{1}{1+r}\right)^{k-t} \left( Y_t + \sum_{j=t+1}^k \Delta Y_j \right) \right] \quad (6.8)$$



$$C_t - Y_t^d = \left(\frac{r}{1+r}\right) \sum_{k=t}^{\infty} \left(\frac{1}{1+r}\right)^{k-t} \sum_{j=t+1}^k \Delta Y_j \quad (6.9)$$

Assuming that labour income,  $Y_k$ , follows a random walk,  $Y_j - Y_{j-1} = \Delta Y_j = \varepsilon_j$  has an expected value of zero and constant variance. Hence, the factors on the right hand side of expression (6.9) are a constant, a summation that converges to  $(1/r)$  and sums of covariance stationary terms. As a result, consumption and disposable income are cointegrated with a cointegrating vector  $(1 \ -1)$ .<sup>3</sup>

Cointegration between consumption and disposable income has been extensively tested and often confirmed. In particular, cointegration vectors with unitary marginal propensity to consume and unitary income elasticity are often found (for instance, see King et al (1991), later revised by Han and Ogaki (1997) and Villagomez (1994)), or assumed, as in any error correction model containing the lagged ratio of consumption to income (see Davidson et al (1978) and some of the works reviewed in Church et al (1995)). In fact, it is the absence of cointegration between consumption and income that calls for attention: see Hall et al (1997a), Cooley and Ogaki (1996), Fuchun (1995) and Engle et al (1993).

The instability of the cointegrating vector due to structural changes is considered the main cause of a failure to find cointegration where economic theory predicts its existence, and this issue has gained considerable attention recently. However, there is no single approach in the literature to tackle the issue of unstable cointegrating vectors, and hence no definitive answer in terms of a complete and well defined framework for inference and testing. For instance, Granger and Siklos (1997) have suggested that structural breaks may result in a cointegrating

<sup>3</sup>Note that the result of a constant level of consumption over time  $C_t = C_{t-1}$  in the deterministic version of the model is compatible with the finding that consumption is integrated of order one when a random error term is introduced to obtain the stochastic representation of the series and  $Y_t^d$  is integrated of order one regardless of the order of integration of the stock of assets. Also note that other cointegrating vectors may result, depending on the specific form of the utility function and different assumptions about the rate of time preference, the real interest rate and the shape of the stream of labor income along the life cycle of the consumers (see, Graham and Himarios, (1996)), but we will not elaborate further on this theoretical issue since the cointegrating vector which is usually found or assumed to achieve cointegration is the one illustrated above.

relationship existing during some periods but not in others; Hall et al (1997a) have proposed a model that allows shifts in the cointegrating vector; Krolzig (1997) studied the case of switching constant terms in a vector error correction model; Hall et al (1997b) have suggested a switching error correction model; and Hansen and Johansen (1993) have studied the case of a change in the number of cointegrating vectors over time.

Structural breaks in time series or economic relationships may be due to large shocks or institutional changes. The latter case is the one studied in this chapter. In what follows, we present empirical evidence indicating that the implementation of the program for stabilisation and economic reform in Mexico at the end of 1987 and its abandonment at the end of 1994 resulted in a temporary change in the long run relationship between aggregate private consumption and income that led to the consumption boom.

At a theoretical level, the proposition that the relationship between consumption and income may show shifts due to the implementation of a program for stabilisation and economic reform is supported by various models and hypotheses. Such is the conclusion of Rebelo and Vegh (1995) who made a comparative study of the explanatory power of different theoretical hypotheses aimed at explaining the stylized facts observed in countries that have implemented exchange rate-based stabilisation programs. They concluded that a consumption boom, as well as other empirical regularities, can be produced under different, and sometimes opposite, theoretical hypotheses. For instance, a model with forward looking expectations in which money demand is motivated by a cash-in-advance constraint that considers the issue of lack of credibility of the stabilisation program (as in Calvo and Vegh (1993)) can be used to explain the consumption boom after the implementation of a stabilisation program. However, a model with inflation stickiness due to backward looking expectations that in addition takes into account the positive supply side effects of the permanent (or at least perceived as such) reduction of the inflation rate can also be used to explain a strong surge in private consumption when an exchange rate-based stabilisation program is implemented (see, Rodriguez (1982), Dornbusch (1982) and Roldos (1995)).

Pill (1995) reached a similar conclusion in his study of the pegging of the British Pound to the German Mark between 1986 and 1992 and the economic reforms im-

plemented during the Thatcher government. Pill concluded that two theoretical hypotheses put forward in the literature were able to explain the boom-bust cycle and the consumption boom observed in the UK during that period. One of those hypotheses, the one postulated by Muellbauer and Murphy (1990a,b), suggested that the deregulation and liberalization of the financial system and ill designed regulations in the housing market made the UK economy enter in a self enforcing spiral of credit expansion, inflation of asset prices, increases of wealth, consumption growth and expansion of domestic demand that was unsustainable. While the other hypothesis, associated with King (1994, 1990), argued that the credit financed consumption was generated by the expectation of increases in future income generated by the economic reforms implemented. Like Rebelo and Vegh, Pill remarks that in many respects, including the consumption boom, different theoretical hypotheses about exchange rate based stabilisation programs are observationally equivalent.

One of the explanations of boom-bust cycle in the UK reviewed by Pill – that suggested by King – is based on the rational expectations-permanent income hypothesis, and can be illustrated with the modelling outlined in section 6.2. Suppose that the stabilisation of the inflation rate and the economic reforms are credible and make consumers revise their expectations of future income upwards because of a future increase in productivity. Since individuals smooth consumption over time, the result is that current consumption will rise above current income. Then, if after some time it is revealed that, perhaps due to a large unanticipated negative shock, the increase in future productivity and income will not occur, consumption will adjust downwards. And the result is that the time series of aggregate consumption and income show a temporary change in their cointegrating relationship.

As in other countries, financial liberalization was one of the main ingredients of the economic reform program implemented in Mexico,<sup>4</sup> and such a policy is often suggested as a factor that contributes to generate a boom in consumption, see for example, Chan and Hu (1997), Agell and Berg (1996), Bayoumi (1993), Miles

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<sup>4</sup>Financial liberalization in Mexico started in the fall of 1988. It included the abolition of controls on interest rates, the obligatory lines of credit to the public sector and priority sectors and continuous reductions in reserve requirements. The last stage of the liberalization involved the privatization of the banking system and the abolition of reserve requirements. See Aspe (1993).

(1992), Lehmussaari (1990), and the works of Muellbauer and Murphy mentioned above.

Consider two types of consumers: a fraction  $(1 - \lambda)$  of the population has access to financial markets, behaves as stated in equation (6.6) and consumes  $C_{n,t}$  at period  $t$ . Whereas the fraction  $\lambda$  of the population is constrained to consume each period the amount of the total labour income they receive:  $C_{c,t} = \lambda Y_t$ . Total consumption at time  $t$  is  $C_t = C_{n,t} + \lambda Y_t$ , while total disposable income is as before ( $Y_t^d = rA_t + Y_t$ ) since unconstrained individuals hold all the assets of the economy. Hence, total consumption can be expressed as in equation (6.10), and subtracting total disposable income from both sides and rearranging yields expression (6.11), where the right hand side is a random stationary series with an expectation of zero, and the vector  $(1 - 1)'$  is the cointegrating vector.

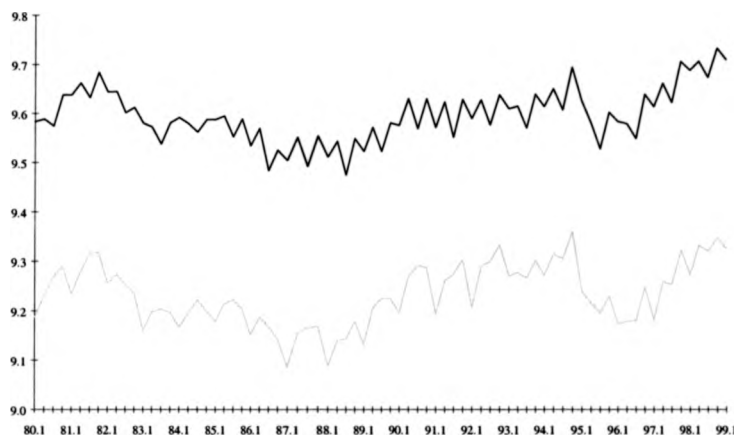
$$C_t = \left( \frac{r}{1+r} \right) \left[ (1+r)A_t + \sum_{k=t}^{\infty} \left( \frac{1}{1+r} \right)^{k-t} (1-\lambda)Y_k \right] + \lambda Y_t \quad (6.10)$$

$$C_t - Y_t^d = (1-\lambda) \left( \frac{r}{1+r} \right) \sum_{k=t}^{\infty} \left( \frac{1}{1+r} \right)^{k-t} \sum_{j=t+1}^k \Delta Y_j \quad (6.11)$$

Now suppose that the temporary expectation of a future increase in labour income mentioned above is accompanied by a decrease in  $\lambda$  due to financial liberalization. In that case, the increase of expected future income will have a stronger effect on current consumption. That is, the temporary gap between consumption and income will be larger because those consumers who were previously excluded from financial markets will incur debt to smooth their consumption over time, and hence financial liberalization contributes to increase the magnitude of the consumption boom.

In the following sections, we show that the program for stabilisation and economic reform implemented in Mexico at the end of 1987 and abandoned at the end of 1994 provoked structural breaks in the time series of consumption and income and a considerable change in their cointegration relationship.

Figure 6.1: Logs of per capita GDP and consumption expenditure.



### 6.3 Preliminary analysis of the series

Prior to the cointegration analysis, it is necessary to check the order of integration of the series involved. The logs of real per capita consumption expenditure and gross domestic product (GDP) shown in Graph 6.1 have a marked pattern of seasonality, hence we check for the order of integration at the zero frequency and seasonal frequencies using the unit roots tests proposed in Osborn (1990).<sup>5</sup>

According to the results in panel a) of Table 6.1, the series of per capita GDP,  $y_t$ , contains a unit root at the zero frequency, but not at the seasonal frequency; while the series of per capita consumption expenditure,  $c_t$ , is integrated at both frequencies. The non-stationarity of the series at the zero frequency and stationarity of their first differences is confirmed with the results of the Augmented Dickey Fuller tests in panel b).

The results in panel c) of Table 6.1 confirm the presence of a seasonal unit

<sup>5</sup>We used total consumption expenditures because there are no disaggregated series for non-durables and durables. The income variable is Gross Domestic Product because quarterly series of disposable income are not available. Population data are reported at annual frequency, so the figure for each year was assumed to apply to middle of the year and a log-linear extrapolation was used to obtain the series at quarterly frequency.

Table 6.1: Unit root tests

a)

Tests for unit roots at zero and quarterly frequencies

Variable	lags	$\beta_1$	$\beta_2$	F-test
$y_t$	1	-0.8769	-4.6394	6.0153(0.000)
$c_t$	4	-0.9487	-3.4086	3.0266(0.012)
		(-2.11)	(-3.75)	(3.79)

b)

ADF tests

Variable	lags	$\tau_t$	$\Phi_3$	$\Phi_2$	$\tau_\mu$
$y_t$	1	-1.1769	1.4338	1.1703	-0.7398
$c_t$	2	-2.3055	3.0395	2.0574	-1.9355
$\Delta y_t$	1	-6.0367**			
$\Delta c_t$	1	-7.4856**			

c)

Test for unit roots at all frequencies

Variable	lags	$\pi_1$	$\pi_2$	$\pi_3 \cap \pi_4$	$\alpha_0 \cap \pi_1$
$c_t$	4	-2.5038	-2.5210	3.4776	3.1547
		(-3.56)	(-3.49)	(8.92)	(6.70)

Critical values at 0.05, in parentheses, taken from Osborn (1990).

\*\*Denotes significance at 5 per cent level.

root in the process of  $c_t$  and also reveal a disturbing result: it seems that  $c_t$  contains a unit root at all frequencies, which would mean that there are no long run relationships between different seasons since the individual series for each quarter drives away from the others (Osborn, 1993). However, we know that the failure to reject the null of non-stationarity in unit root tests may be due to structural changes in the means or the growth rate of a series (Perron, 1989), its seasonal pattern (Otero and Smith, 1995), or all three components (Hall et al, 1997a). Therefore, unit root tests that allow for a structural break in the constant, the trend and the seasonal pattern were applied to  $c_t$  in order to explore further the conclusion obtained above.

By inspection, it seems that the series  $c_t$  contains two changes, one in 1988 and the other at the end of 1994. The unit root tests and critical values suggested in Hall et al (1997a) are designed for the case of one structural break in the sample, hence, we used two sub-samples in which we assume there is only one structural break. The first sub-sample starts in 1980 and ends in 1994. We assume that in this sub-sample there is a break due to the implementation of the stabilisation program and the economic reforms. The second sub-sample starts in 1988 and ends in the first quarter of 1999. In this sub-sample, the structural break is due to the currency and financial crisis that started in December 1994. The tests were also applied to the entire sample available (1980.1-1999.1) although the critical values are not strictly applicable for the case of two structural breaks.

The results in Table 6.2 show that  $c_t$  is not integrated at all frequencies. It contains a unit root at the zero frequency, but not at the semiannual frequency and there are doubts about its order of integration at the annual frequency since the null of a unit root is rejected for the period 1980-1994 but not in the period 1988-1999. In what follows, we will consider  $c_t$  and  $y_t$  to be integrated of order one at the zero frequency only and concentrate on their cointegrating relationship at this frequency.

## 6.4 Stability of the cointegration vector

The analysis of cointegration and constancy of parameters is performed using the Fully Modified estimators of the cointegration vector suggested in Phillips and

Table 6.2: Seasonal unit root tests with breaks

Sample	lags	$\pi_1$	$\pi_2$	$\pi_3 \cap \pi_4$	$\pi_2 \cap \pi_3 \cap \pi_4$
1980.1 - 1994.1	none	-2.8060	-3.3619	21.4510	46.4439
1988.1 - 1999.1	1	-3.0497	-3.2179	10.7115	27.2114
1980.1 - 1999.1	none	-3.3313	-3.7334	16.9222	25.8258
		(-4.07)	(-3.10)	(13.6)	(10.80)

Critical values at significance 0.05, in parentheses, taken from Hall et al (1997a).

Hansen (1990), the Augmented Dickey-Fuller test for cointegration suggested in Engle and Granger (1987), and the tests of parameter constancy of Gregory and Hansen (1996), and Hansen (1992).

Table 6.3 shows the results of the estimation of the cointegrating vector for different subperiods and the entire sample in panel a), and the results of the tests of cointegration and parameter constancy in panels b) and c). According to the results in panel a), the estimate of the income elasticity of consumption varies with the sample used. For the first subsample (1980-1994) the elasticity is above one; in the second subsample (1988-1999) it is below one; and using the entire sample available yields an elasticity close to one.

In panel b), the Augmented Dickey-Fuller test rejects the null of no cointegration and favours the alternative of cointegration and its implicit assumption of constant parameters. But on the other hand, the tests suggested by Gregory and Hansen (1996) reject the same null in favour of the alternative of cointegration with a shift in parameters (both the constant and the income elasticity) when applied to the first subsample ( $ADF^*$  and  $Z_t^*$ ) and the entire sample ( $ADF^*$  and  $Z_t^*$ ,  $Z_a^*$ ). That is, the tests in panel b) yield conflicting evidence about the constancy of parameters. Therefore, in order to determine if there is a cointegrating vector with constant parameters or shifts in those parameters, panel c) presents the results of the tests proposed in Hansen (1992). In these tests the null hypothesis is cointegration with constant parameters and the alternatives indicate a structural break in parameters (in the *SupF* test) or gradual changes in parameters over time (in the *MeanF* and  $L_c$  tests). The results suggest that the null of cointegration with constant parameters cannot be accepted.



Table 6.3: FM estimators and tests.

		1980.1 - 1994.4		1988.1 - 1999.1		1980.1 - 1999.1	
		Const	$y_t$	Const	$y_t$	Const	$y_t$
a)							
estimates		-1.824	1.153	0.032	0.959	-0.504	1.014
s.e.		1.049	0.109	1.433	0.149	0.869	0.090
t-statistic		-1.737	10.528	0.022	6.434	-0.578	11.193
p-values		(0.087)	(0.000)	(0.983)	(0.000)	(0.565)	(0.000)
b)							
		lags	statistic	lags	statistic	lags	statistic
ADF		0	-5.983**	0	-3.399**	0	-5.429**
ADF*		0	-5.260**	0	-4.520	0	-5.931**
$Z_t^*$			-6.005**		-4.458		-6.564**
$Z_{\alpha}^*$			-40.324		-27.791		-51.631**
c)							
		statistic	p-values	statistic	p-values	statistic	p-values
SupF		14.062	(0.030)	8.420	(>0.200)	11.624	(0.082)
MeanF		5.763	(0.023)	3.296	(0.139)	3.504	(0.119)
$L_c$		0.720	(0.010)	0.474	(0.047)	0.593	(0.023)

p-values in parentheses. Critical values at significance 0.05: -4.95 for tests ADF\* and  $Z_t^*$ , and -47.04 for test  $Z_{\alpha}^*$ ; taken from Gregory and Hansen (1996). >0.200 means a p-value equal or larger than 0.2

The same conclusion about the stability of the cointegrating vector is obtained when seasonally adjusted series are used.<sup>6</sup> Table 6.4 shows the Fully Modified estimators of the cointegrating vector and the relevant tests. Panel a) of the table shows that the estimate of the income elasticity is above one in the first subsample, below one in the second and close to one when using the entire sample. In contrast to the results obtained with seasonally unadjusted data, the ADF test in panel b) of the table does not favour the alternative of cointegration.<sup>7</sup> This result may be considered as an indication of shifts in the cointegrating vector because the non-rejection of the unit root hypothesis in the residuals of a cointegrating relationship using ADF tests may be due to the presence of shifts in the cointegrating vector, as documented by Gregory et al (1996). And such an indication can be confirmed by testing the null of no cointegration against an alternative that allows for shifts in parameters. In effect, the  $Z_t^*$  and  $Z_a^*$  tests indicate that the results of the ADF tests are due to the instability of parameters. For the three samples used, the null of no cointegration is rejected if the alternative allows shifts in both the constant term and the income elasticity.<sup>8</sup>

From the results above, we conclude that the long run relationship between consumption and income cannot be characterized by a cointegrating vector with constant parameters. If there is a cointegrating relationship it appears to shift over time.

## 6.5 Cointegration and regime shifts

In this section we deal with the issue of stability of parameters by allowing the cointegration relationship to shift over time using a Markov-switching model.

The estimation of Markov-switching models pioneered by Hamilton (1989, 1994, 1996) typically assumes that the variables are stationary. And no theoretical elaboration of the distribution theory exists for a Markov-switching regression with  $I(1)$  variables. Nevertheless, Hall et al (1997a) have performed Monte Carlo exper-

<sup>6</sup>The seasonal adjustment was performed using the linear approximation of the X11 filter.

<sup>7</sup>The same conclusion is obtained when the cointegrating vector is estimated using ordinary least squares or if it contains the theoretically plausible values  $(1 - 1)^2$ .

<sup>8</sup>Note that the tests of Hansen (1992) were not performed on seasonally adjusted data because there is no conflict between the ADF tests and the  $Z^*$  tests of Gregory and Hansen (1996).

Table 6.4: FM estimators and tests. Seasonally adjusted data

a)	1980.1 - 1994.4		1988.1 - 1999.1		1980.1 - 1999.1	
	Const	$y_t$	Const	$y_t$	Const	$y_t$
estimates	-3.289	1.306	0.725	0.887	-1.224	1.089
s.e.	1.277	0.133	2.325	0.242	1.682	0.175
t-statistic	-2.574	9.796	0.311	3.665	0.727	6.215
p-values	(0.013)	(0.000)	(0.7570)	(0.0010)	(0.469)	(0.000)
b)						
	lags	statistic	lags	statistic	lags	statistic
ADF	6	-1.607	2	-1.112	6	-1.369
ADF*	6	-3.577	2	-4.500	6	-4.152
$Z_t^*$		-39.970**		-50.881**		-54.290**
$Z_{\alpha}^*$		-128.178**		-95.486**		-187.221**

p-values in parentheses. Critical values at significance 0.05: -4.95 for tests ADF\* and  $Z_t^*$ , and -47.04 for test  $Z_{\alpha}^*$ ; taken from Gregory and Hansen (1996).

iments in order to explore the distribution of the Maximum Likelihood estimates of a Markov-switching cointegration vector for the bivariate case. Their results indicate that for models such as those used here,  $t$ -statistics can be used if we also use a heteroscedasticity and autocorrelation robust estimator of the covariance matrix.<sup>9</sup>

The Markov-switching cointegration model allows the estimates of the constant term, the income elasticity, the coefficients of the seasonal dummies and error variance to shift between the two regimes. Hence, the model for seasonally unadjusted data with two regimes involves the following vector of 14 parameters  $\theta = (\alpha_s, \beta_s, \delta_{q,s}, \sigma_s^2, p_{ss})$ , where  $\alpha_s$  is the constant coefficient,  $\beta_s$  the income elasticity,  $\delta_{q,s}$  the coefficient of the quarterly dummy variable,  $d_{q,t}$ , corresponding to quarter  $q = 2, 3, 4$ , and  $\sigma_s^2$  is the variance of the error term. All these parameters depend on the regime prevailing at date  $t$ ,  $s_t (= i, j)$ , as stated in equation (6.1), and the transition between regimes is governed by a first order Markov-chain with constant transition probabilities,  $p_{ss}$ , as in expression (6.2).

$$c_t = \alpha_s + \beta_s y_t + \sum_{q=2}^4 (\delta_{q,s} d_{q,t}) + \varepsilon_t; \quad s = i, j. \quad (6.1)$$

$$[p_{ij}] = [p(s_t = j \mid s_{t-1} = i)] = \begin{bmatrix} p_{ii} & p_{ji} = 1 - p_{jj} \\ p_{ij} = 1 - p_{ii} & p_{jj} \end{bmatrix} \quad (6.2)$$

Note that in contrast to the analysis in Sections 6.3 and 6.4, here we do not make any assumption about the dates of the structural breaks. Instead, they will be determined in the estimation. The dates of the breaks will be given by the shifts in the series of filter and smoothed probabilities of each regime prevailing at each date in the sample that are calculated in the iterations of the EM algorithm used to maximize the likelihood function.

<sup>9</sup>In particular, the authors report that the estimates have a negligible bias in samples of 100 and 200, and the empirical size of tests based on conventional  $t$ -statistics or  $N(0,1)$  do not deviate significantly from the nominal test size.

Table 6.5: Markov-switching cointegration

Regime 1	$\alpha_1$	$\beta_1$	$\delta_{2,1}$	$\delta_{3,1}$	$\delta_{4,1}$	$\sigma_1^2$	$p_{11}$
estimate	-0.48799	1.00837	0.02399	0.07114	0.02833	0.00022	0.97607
s. e.	0.39693	0.04134	0.00621	0.00550	0.00860	0.00005	0.01757
t-statistic	1.230	24.391	3.864	12.925	3.292	4.163	55.543
p-value	0.223	0.000	0.000	0.000	0.002	0.000	0.000
Regime 2	$\alpha_2$	$\beta_2$	$\delta_{2,2}$	$\delta_{3,2}$	$\delta_{4,2}$	$\sigma_2^2$	$p_{22}$
estimate	-3.02977	1.27746	0.01002	0.08507	0.02160	0.00020	0.95384
s. e.	1.29769	0.13497	0.00931	0.00955	0.00938	0.00009	0.07456
t-statistic	-2.335	9.465	1.076	8.904	2.301	2.107	12.793
p-value	0.023	0.000	0.286	0.000	0.025	0.039	0.000

Log-likelihood: -209.31

Robust standard errors as in White (1982).

Table 6.5 presents the results of the estimation using seasonally unadjusted series.<sup>10</sup> In regime 1 we find a unitary elasticity, while regime 2 has an elasticity well above one (1.28), which means that during the years of the boom consumption was growing almost 30 per cent faster than income. Plots of the filter and smoothed probabilities, shown in Graph 6.2, indicate that the change of regime started in 1988 and regime 2 prevailed from the beginning of 1989 until the end of 1994.<sup>11</sup> That is, soon after the stabilisation program was implemented the economy entered a consumption boom, and the unitary elasticity was reinstalled at the beginning of 1995, when the currency and financial crisis erupted.

It is important to note the coincidence of the dating of the shifts indicated by the filter and smoothed probabilities of the Markov-switching model shown in Graph 6.2 with the shifts in the paths of the standardized residuals obtained with

<sup>10</sup>We used robust standard errors as the ones suggested in White (1982) because they can overcome the effects of serial correlation and heteroscedasticity in the error term.

<sup>11</sup>The filter probabilities of each regime prevailing at date  $t$  are calculated using the information up to that date, while the smoothed probabilities take into account the information of the entire sample.

Figure 6.2: Filter and smoothed probabilities.

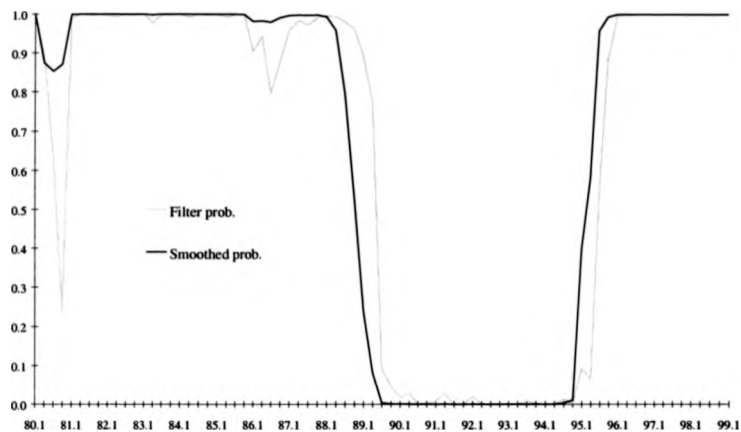
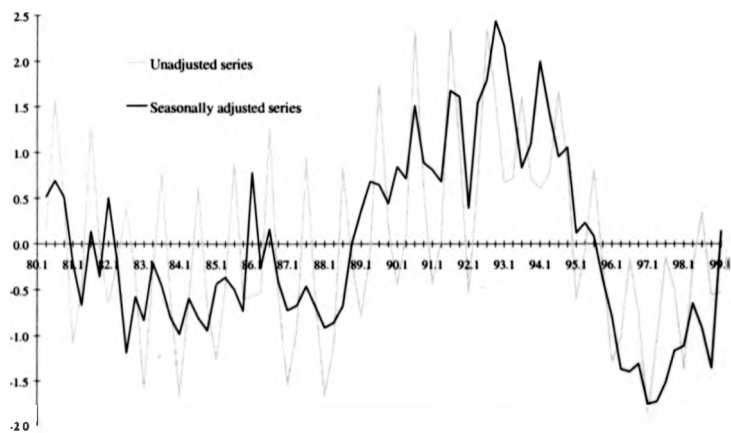


Figure 6.3: Fully modified residuals.



the Fully Modified estimators in Graph 6.3. The shifts in regimes coincide with the step changes of the residuals.

We notice that the variance of the error term is somewhat smaller in the regime of the boom. Such a result may be explained by noting that the left hand side of equation (6.11) can be rewritten as  $C_{n,t} + \lambda Y_t - Y_t^d = C_t - Y_t^d$ . Hence, if the variances of the consumption of non-constrained individuals and total disposable income remain the same, the variance of total consumption may decrease when  $\lambda$  decreases, because the random error contained in the series of labour income affecting current consumption will have a smaller weight attached.

In order to check if a third regime should be considered, a model with three regimes was estimated. The most noticeable results were that one of the elasticities estimated was not significant, and during the period 1989-1994 the estimate of the elasticity was similar to the one shown above and significant. A likelihood ratio test applied to the model with three regimes, to test if the additional parameters could be considered zero, yielded an adjusted *p*-value of 0.060, hence the hypothesis of two regimes is rejected at the 10 per cent level of significance, but not at the 5 per cent level.<sup>12</sup>

Very similar income elasticities and patterns of the filter and smoothed probabilities are obtained if we apply the Markov-switching cointegration model with two regimes to seasonally adjusted data. Table 6.6 presents the results of the estimation and Graph 6.4 the plots of the inferred probabilities. Again, the income elasticity of consumption was above one during the period 1989 - 1994, and the unitary elasticity that prevailed before 1989 was re-established at the beginning of 1995. The shifts of the cointegration relationship described by the filter and smoothed probabilities coincide with the marked changes in the series of Fully Modified residuals shown in Graph 6.3, and the variance of the error term is again smaller in the regime of the consumption boom.<sup>13</sup>

<sup>12</sup>In this test, there are ten nuisance parameters that are not identified under the null hypothesis of two regimes, hence, the *p*-value corresponding to the test statistic, a  $\chi^2$  with ten degrees of freedom, was corrected as suggested in Davies (1987).

<sup>13</sup>It is worth noting that the preferred tests and estimations are the ones using seasonally unadjusted series because the effects of structural breaks in the series on the efficiency of seasonal filters are uncertain, and filtering may have undesirable consequences for some tests we use here (see Ghysels and Perron (1996), Otero and Smith (1996) and Franses and McAleer (1998)). Also, note that obtaining so similar results using unadjusted and adjusted data is not guaranteed

Table 6.6: Markov-switching cointegration. Seasonally adjusted data

Regime 1	$\alpha_1$	$\beta_1$	$\sigma_1^2$	$p_{11}$
estimate	-0.48666	1.01150	0.00020	0.97812
s. e.	0.39969	0.04157	0.00004	0.01795
t-statistic	1.218	24.327	4.093	54.482
p-value	0.227	0.000	0.000	0.000
Regime 2	$\alpha_2$	$\beta_2$	$\sigma_2^2$	$p_{22}$
estimate	-3.13913	1.29194	0.00015	0.95591
s. e.	1.09663	0.11410	0.00004	0.07112
t-statistic	-2.863	11.323	3.426	13.439
p-value	0.006	0.000	0.001	0.000

Log-likelihood: -215.86

Robust standard errors as in White (1982).

Figure 6.4: Filter and smoothed probabilities. Seasonally adjusted data.

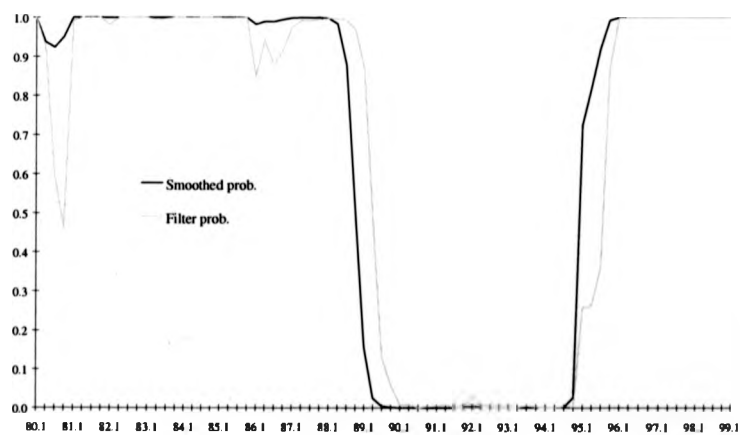
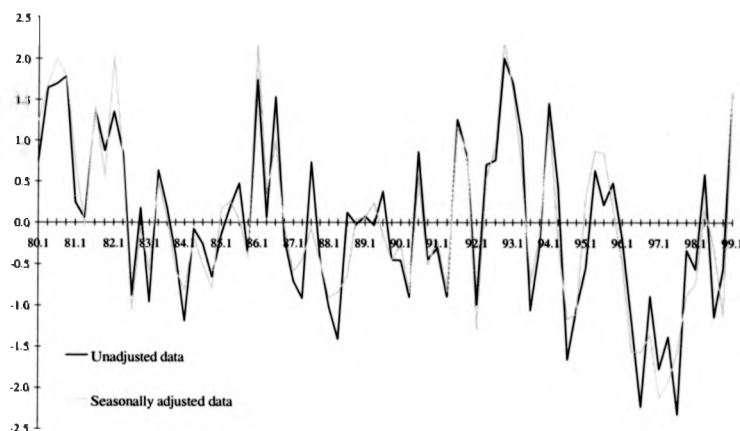




Figure 6.5: Standardized residuals of regime switching models.



To test the null of no cointegration against the alternative of cointegration (both with regime shifts) we apply an ADF test to the standardized weighted residuals of the switching cointegration relationship. The weights are given by the smoothed probabilities shown in Graphs 6.2 and 6.4 and the weighted residuals are shown in Graph 6.5. The outcome of the tests is reported in Table 6.7, and the critical values were obtained from Hall et al (1997a).<sup>14</sup> The models postulating a cointegration relationship with shifts in regimes yield stationary residuals.

## 6.6 Conclusions

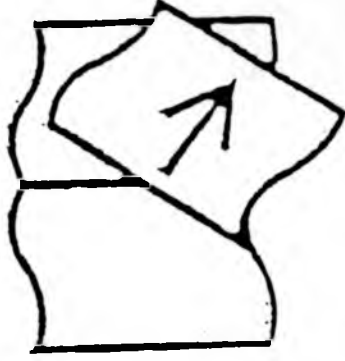
This chapter highlights the importance of taking into account structural breaks when testing for unit roots and the modelling of long run cointegrating relationships. This has been illustrated with an analysis of the consumption boom observed

a priori, as is clear from the analysis of the stability of the German money demand function using a smooth transition regression model of Lutkepohl et al (1999).

<sup>14</sup>We follow the recommendation made in Hall et al (1997a) of leaving in the auxiliary regression of the ADF test only the lagged differences of the residuals that have significant t-ratios, because the inclusion of redundant terms decreases the power of the test.

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the years of the boom. And later, when the program was abandoned at the end of 1994 in the middle of a currency and financial crisis, the cointegrating vector with unitary income elasticity was re-established.

The results obtained cannot be used to support any particular hypothesis put forward in the theoretical literature to explain the effects on consumption of stabilisation and economic reform programs because they are observationally equivalent in terms of a consumption boom, as well as other empirical regularities. However, we can state that the regime with an income elasticity larger than one can not be considered an equilibrium relationship in the sense that such an income elasticity can not be sustained in the long run, since it would imply a violation of the no-Ponzi game condition.

In summary, this chapter shows that shifts in long run relationships that can be rationalized without problems as the result of an optimal decision of consumers (or at least a decision that was considered optimal at the time it was made) can be accurately dated and evaluated if we allow regime shifts in cointegration models.

## Chapter 7

### Conclusions

The empirical analysis of the currency crises of the nineties remains insufficient in itself, and the collapse of the Mexican peso in December 1994 opened a debate in which there are different explanations based on the theoretical literature, but scarce empirical evidence. This is why most of the thesis was devoted to formulating an interpretation of the collapse of the peso using empirical methods.

We started the empirical analysis of the devaluation of the peso using a series of realignment expectations based on the drift adjustment method and linear and non-linear methods. The objective was to find empirical evidence that helps to characterise the Mexican crisis as either due to bad fundamentals a la Krugman or a crisis with self-fulfilling elements a la Obstfeld.

Contrary to the predictions of first generation models of currency crises, we found that the series of realignment expectations do not show a noticeable deterioration of the credibility of the peso before its collapse.

Using linear methods, we found that the set of variables determining realignment expectations was similar to those identified for other countries. In particular, the real exchange rate and the changes in international reserves were found to be significant. Moreover, an innovative finding was that a worsening of the financial health of the banking system significantly affected realignment expectations.

Rolling estimations of the linear model suggested that the relationship between realignment expectations and their determinants did not remain stable over time. In view of this finding and the apparent shifts in the level of realignment expectations over time, we postulated a non-linear model that allows shifts in regimes.

Using a Markov-switching regression model, we found that the credibility of the peso shifted over time between two equally persistent regimes of high and low credibility but up to 1993 realignment expectations tended to stay in one regime or another for long periods. During 1994, a year marked by political and financial turmoil, the alternation between regimes was much more marked, and, surprisingly, immediately before the devaluation of the peso realignment expectations belonged to the regime of relatively high credibility.

In periods of relatively high credibility, realignment expectations were affected only by the changes in international reserves. While in periods of relatively low credibility realignment expectations were affected by the real appreciation of the peso, the health of the banking system and the changes in international reserves.

The instability of the relationship between realignment expectations and macroeconomic fundamentals, identified with the rolling estimations and the Markov-switching model, indicates that the pattern of a tight relationship between them predicted by first generation models of currency crises was absent in the Mexican case. And from the set of macroeconomic fundamentals stressed in first generation models, only real exchange rate appreciation played a significant role in the determination of realignment expectations in certain periods.

In Chapter 3 we found that neither the pattern nor the relationship of realignment expectations with macroeconomic fundamentals predicted by first generation models of currency crises was present in the Mexican case. We did not regard the results obtained in this chapter as sufficiently significant to claim the identification of the origins of the collapse of the peso. However, we considered these results as a suggestion to study the devaluation of the peso using the approach of second-generation models of currency crises in order to take into account sudden shifts in market sentiment.

In Chapter 4, we presented a small theoretical model, based on the escape clause approach, to discuss some specific features of the Mexican experience. In particular, we studied the effects on the equilibria of the model of the substitution of peso denominated assets for dollar denominated and indexed assets that allowed policymakers to cope with the periods of confidence crisis observed during the troubled 1994 and avoid large increases in domestic interest rates.

We found that the depreciation rate in the equilibrium with devaluation is

higher after the substitution of assets, and it is more difficult to eliminate the possibility of a self-fulfilling devaluation when asset substitution takes the form of reductions in international reserves that are sterilised. Hence, we argued that the sterilisation policy pursued in Mexico during 1994 was much more important in the onset of the devaluation at the end of the year than the increase in the stock of dollar indexed bonds.

In this chapter, we suggested the following account of the Mexican experience in 1994. The level of public debt and its short average maturity (together with a likely decrease of the political cost of a devaluation after the approval of NAFTA in the US Congress and the general elections in Mexico) may have put the economy in a situation in which a self-fulfilling crisis was possible. And a series of political shocks provoked periods of confidence crisis in which investors' expectations threatened to switch towards the equilibrium with devaluation. These periods of confidence crisis were resisted without noticeable increases in interest rates thanks to the substitution of peso denominated assets for dollar denominated or indexed assets in investors' portfolios. However, the substitution of assets increased the depreciation rate in the bad equilibrium and made it more difficult to avoid the possibility of a self-fulfilling devaluation. Finally, the devaluation of the peso occurred when the resource of asset substitution was exhausted at the end of the year, and the market coordinated in the bad equilibrium, again in connection with political shocks and the announcement of a prospective increase in the ceiling of the currency band.

In Chapter 5 we proposed an index of pressure in the foreign exchange market as an indicator of the credibility of the Mexican peso and the use of mean-variance Markov-switching models to investigate the relationship between the shifts of the economy from calm to crisis and macroeconomic fundamentals and political events.

We found that the pressure was asymmetric: in all our estimations the state of calm was characterised by a slight pressure for peso appreciation and the crisis state by stronger and more volatile pressure for peso depreciation.

Modelling the transition probabilities dependent on lags of several macroeconomic fundamentals and political news suggested that fiscal matters and political shocks caused the transitions between regimes, but these results were not conclusive. Hence, we adopted a two-step approach to obtain the probability of the crisis state prevailing in each date in the sample using a mean-variance Markov-switching

model with constant transition probabilities and then modelled this series as a function of macroeconomic fundamentals and political events.

The preferred model with constant transition probabilities indicates that the pressure for peso depreciation was more than twice the favourable pressure in the state of calm, and its variance was 21 times the other. The state of calm had an expected duration of 15 months and the unstable regime an expected duration of 6 months. That is, the foreign exchange market remained in calm for long periods but shifted to the state of crisis for shorter periods. The series of the filtered probabilities obtained indicated that the economy shifted to the state of crisis in the last part of 1988, when the fixed exchange rate regime changed to predetermined rates, and most of 1994.

Modelling the logistic transformation of the probability of the crisis state as a function of macroeconomic fundamentals and political news yielded robust results indicating that political events, the changes in the debt-output ratio and the movements of the real exchange rate directed the shifts of the economy between the states of calm and crisis.

During most of the sample period examined, the reduction of public indebtedness and positive political news maintained the economy in a state of calm, despite a considerable real appreciation of the peso. Nevertheless, the ratio of public debt to output stopped its declining path before 1994 and a series of negative political shocks followed. This shifted the economy towards a state of crisis for most of that year, and a modest real depreciation of the peso was not enough to return the economy to a state of calm. The state of crisis involved large reserve losses that accumulated over the year, and the last period of confidence crisis in December resulted in the collapse of the peso.

In sum, the empirical evidence we have found suggests that the periods of confidence crisis observed in 1994 and the collapse of the peso on December 21st should be considered as the product of a combination of weakening fundamentals – that was not necessarily fatal – and a series of unpredictable shocks. These shifts triggered recurrent shifts in investors' confidence that finally exhausted the mechanisms of defence used by the government.

In Chapter 6 we presented a further application of models with regime shifts, devoted to study one of the main consequences of the program for stabilisation

and economic reform introduced in Mexico in December 1987: the boom in private consumption observed in the period 1989-1994. Here, we illustrated how changes in long run relationships can be accurately identified and evaluated if we allow regime shifts in cointegration relationships.

Using standard cointegration modelling methods, we found that the available data rejects a long run relationship with constant coefficients between private consumption and income. Hence, we proposed modelling the cointegration relationship taking into account shifts in regimes.

Using Markov-switching models, we found considerable shifts in the long run relationship between consumption and income. These shifts were due to an institutional change-induced structural break produced by the introduction of the program for stabilisation and economic reform at the end of 1987 and its abandonment at the end of 1994.

Before the program, the cointegration relationship between consumption and income was characterised by the unitary income elasticity often found in the literature. However, the program induced a shift in the cointegration vector that resulted in a consumption boom of considerable magnitude: per capita consumption expenditure was growing almost 30 per cent faster than gross domestic product in the period 1989-1994. And later, at the beginning of 1995, the unitary income elasticity was re-established in the middle of a currency and financial crisis.

## **7.1 Prospective future research**

The present analysis of the Mexican currency crisis has been based on empirical evidence, a feature that should be desired in the explanations of other currency crises, such as the recent crises in Asia. The application of empirical methods that allow shifts in regimes to the episodes of speculation in other countries is an obvious research agenda for the near future.

The analysis of realignment expectations in Chapter 3 shows that the share of non-performing loans in the banking system affected the credibility of the peso in certain periods. And a similar argument has been put forward repeatedly in the case of Asia. Hence, we expect that future empirical research ought to give more attention to the conditions of the domestic financial system. The availabil-



ity of indicators of the conditions of financial systems may be a problem for the applied researcher, but such a restriction can be relaxed if international financial institutions and domestic authorities encourage the publication of information on a regular basis.

The two step approach we used in Chapter 5 may be considered a way to tackle the issue of model reduction for models with regime changes that involve a large number of parameters. However, the empirical analysis of other currency crises of the nineties should not be restricted to the use of Markov-switching models to study shifts in regimes. Probit and duration models may be used to complement the analysis of the causes of shifts in the confidence of speculators on exchange rates.

We also found that political events played a major role in the collapse of the peso, and the use of indicators of political conditions has proven to be useful in other empirical works on exchange rates. Hence, considering systematic indicators of political conditions – perhaps not elaborated by economists – is another element that seems to be part of the research agenda in the near future.

In addition, one should stress that when studying other currency crises, it cannot be expected that a typical pattern of fundamentals leading the economy to a crisis can be found. Rather, different configurations of fundamentals and perhaps other factors in different countries are of relevance. This was neatly illustrated by the significant role played by political factors in the Mexican experience and the absence contagion effects in our analysis. These two elements should receive considerable attention in the case of Asian crises.

With respect to the application of models of cointegration relationships with regime shifts, we think that models for the bivariate case may have a rather narrow future. However, as we have mentioned, there is no general distributional theory for the case of Markov-switching cointegration relationships (single equation models or systems of equations). Hence, the use of multivariate models to study cointegration relationships with regime shifts seems to depend on the development of Monte Carlo studies that can support reliable inference. We expect that the necessity of modelling structural breaks in more general cointegration relationships will encourage the production of the required Monte Carlo studies.

# Appendix

## Appendix A. Data and sources

- Consumption. Private consumption expenditures in pesos at 1995 prices. Source: OECD (Economic Indicators).
- Income. Gross Domestic Product in pesos at 1995 prices. Source: OECD (Economic Indicators).
- Indexes of Consumers Prices in Mexico and the US. Sources: Banco de Mexico and IMF (IFS).
- Interest Rates in the US. Interest rate of Certificates of Deposit and Prime Rate. Source: IMF (IFS).
- Interest Rates of Mexican bonds (Cetes, Pagafes and Tesobonos). Source: Banco de Mexico.
- Interest Rate in Mexico. Average cost of funds for commercial banks (CPP). Source: Banco de Mexico.
- Maturity of Public Debt. Average maturity of government bonds. Source: Banco de Mexico.
- Monetary Base and International Reserves minus gold. Source: Banco de Mexico.
- M2. Notes and coins held by the public plus cheque accounts and liquid instruments in the banking system. Source: Banco de Mexico.
- Output. Index of the volume of industrial production. Source: Instituto Nacional de Estadística Geografía e Informática.
- Political Events. Discrete variable elaborated with information contained in the Kessings' Records of World Events.
- Population. Source: Instituto Nacional de Estadística Geografía e Informática.
- Public Sector Borrowing Requirements. Source: Banco de Mexico.

- Public debt. Broad Economic Debt (net debt of the federal government, public enterprises and official development banks) and Debt Consolidated with the Central Bank. Source: Banco de Mexico.
- Trade Balance. Source: Instituto Nacional de Estadística Geografía e Informática.
- Share of non-performing loans. Non-performing loans as a fraction of total loans of the banking system. Source: Banco de Mexico.
- Share of dollar indexed bonds (Pagafes and Tesobonos) in total short term government bonds (1 and 3 month maturity). Source: Banco de Mexico.
- Spot Interbank Exchange Rate, pesos per dollar. Source: Banco de Mexico.
- Unemployment Rate. Source: Instituto Nacional de Estadística Geografía e Informática.

## Appendix B. Political events 1988 - 1994

### 1988

*May (0)*. The stabilisation program Pact of Economic Solidarity (PSE) is renewed, it is planned to last until the end of August.

*June (0)*. The biggest opposition demonstration of the last 20 years takes place in Mexico City. The leader is Cuauhtemoc Cardenas, a former member of the Party of the Institutionalised Revolution, PRI, (the ruling party) and now the presidential candidate of the National Democratic Front (FDN), an alliance of five small opposition parties.

*July (-1)*. Francisco Ovando, a close collaborator of the opposition candidate Cardenas is shot dead together with an assistant. Ovando was on charge of the group aimed to supervise balloting in the imminent elections. The minister of the interior announces that there was no political motive in the crime. Presidential and Congressional elections took place in the middle of an enormous controversy about its legitimacy and results. Due to an alleged computer failure, the government-dominated Federal Electoral Commission failed to make public partial results within hours of the polling stations closing, as it has been promised. The main opposition candidates delivered a joint protest to the Minister of the Interior and president of the electoral commission warning that they would not accept the election results or recognize the resulting authorities unless the fraud was investigated and legality restored. The PRI's presidential candidate, Carlos Salinas, wins with the smallest ever margin. Large groups claim that Cuauhtemoc Cardenas was the real winner.

*August (0)*. The definitive results of the elections are announced and charges of a massive fraud are made by the opposition parties. The stabilisation program is renewed, now it is planned to last until the end of November.

*September (0)*. The recently elected Chamber of Deputies, dominated by the PRI, endorsed Carlos Salinas as the elected president.

*October (0)*. More than 100,000 people marched in Mexico City to mark the 20th anniversary of the Army's massacre of hundreds of student protesters in 1968 and to protest for the

resurgence of political violence. Since July there had been more than 12 murders which suggested political motives. The largest of the two state owned airlines is sold to a consortium of private investors. This was the first significant privatisation in Latin America. A further renewal, to the end of the year, of the Economic Solidarity Pact is announced. The US government agreed to lend an unprecedented short-term bridging loan of 3.5 billion dollars linked to loan programs by the IMF and the World Bank that was negotiated in secret. The loan was the largest offered to a debtor country since the start of the Latin American debt crisis. The formation of the Party of the Democratic Revolution (PRD) is announced, this party will be the formalized version of the FDN. The formal constitution is planned for early 1989.

*November (0).* Elections of Governor and municipal councils in the state of Tabasco. Voting took place amid the heavy presence of troops and paramilitary police. The FDN protested for the climate of violence that surrounded the elections and police fired onto a crowd of protesters. Official results give the victory to the PRI.

*December (0).* Carlos Salinas inaugurates his six-year presidential term but the entire parliamentary opposition walked out during the inauguration. In his speech, Salinas states that the most urgent political need is openness in the electoral process and announces his intentions to liberalize the economy and to conform to international economic expectations. Salinas announces a new anti-inflationary program which is planned to last until July of the next year.

## 1989

*January (0).* Joaquin Hernandez, president of the country's powerful oil workers union is arrested and charged with illegal possession of arms, gun smuggling, homicide and resisting arrest. The arrest was widely interpreted as a movement of President Salinas to break the power of the union and because Hernandez showed some preference for Cardenas, the former most important contender for the Presidency. Some 50 union leaders were arrested as well.

*February (0).* President Salinas ordered the amnesty of 403 prisoners held for political and social offences in a move considered as aimed to improve Mexico's human rights image. On the same day, Miguel Nazar the chief of the intelligence of the Mexico City police requested a leave of absence.

*March (1).* Nicholas Brady, the US Treasury Secretary introduced a fresh strategy to deal with the debt crisis that encourages voluntary debt reductions schemes. The Brady Plan replaced the (James) Baker Plan (former US Treasury Secretary) which considered fresh lending and economic growth as the key to the solution of the debt crisis.

*April (0).* Miguel Gallardo, a leading drug trafficker is arrested together with 5 senior policemen. A letter of intent is sent by the Mexican government to the IMF asking for financial assistance of 3,635 million dollars over the next three years under the IMF's extended fund facility. A considerable proportion would be used to reduce external debt. Mexico began negotiations with commercial bank creditors, seeking a comprehensive agreement which would allow to reduce the annual debt service burden from 6 to 2 per cent of GNP.

*May (1).* The IMF approved the extended fund facility to support Mexico's economic program. The IMF also authorized financing to offset the decline in Mexico's exports earnings during 1988. The main package incorporated a support program for debt reduction. Mexico signed an agreement with the official creditors of the Club of Paris that considers debt reductions. President Salinas unveils the national development plan, which contains the political and

economics objectives of his mandate. The restriction of a maximum of 49 per cent of foreign ownership of companies is lifted as well as restrictions on foreign investment.

*June (0)*. The world Bank approved three structural adjustment loans to support reforms in the fields of finance, industry and public enterprise management. The loans also contained a provision for debt reduction (up to 25 per cent of the loans). Japan agreed to provide loans to Mexico for 2 billion dollars in order to co-operate with the debt strategy of Mexico, the IMF and the World Bank. The economic program is extended until March 1990. Jose Zorrila (former chief of agency of the police intelligence agency who resigned in 1985 amid allegations of drug trafficking) and other four men are detained in connection with the unsolved killing in 1984 of Manuel Buendia, a well known journalist.

*July (1)*. For the first time, the PRI loses a gubernatorial election; the right wing National Action Party (PAN) wins in the state of Baja California Norte. A governments spokesman remarked that this illustrated the commitment of the government to greater democracy and clean elections. The official results were known 4 days after the official deadline. In another six states the PRI wins in the elections of state legislators and mayors. Supporters of the Party of the Democratic Revolution (PRD) blocked several main roads and occupied municipal buildings in the state of Michoacan to protest for alleged electoral fraud. It is announced that Spain proposed to cancel half of Mexico's debt to Spanish banks (863 million dollars) and the remainder would be transformed into bonds. Mexico and 15 of its main commercial creditors reached the first ever agreement under the Brady Plan. The agreement contemplated a reduction of up to 35 per cent of the country's 54 billion dollars of long and medium term debt.

*August (0)*. Its is announced that foreign investment would be allowed in the state-controlled oil sector for the first time in order to modernize this industry, and a three year plan to privatize the country's second largest airline, Mexicana, was initiated.

*September (0)*. No relevant news.

*October (0)*. No relevant news.

*November (0)*. No relevant news.

*December (0)*. PRD supporters occupied town halls in the state of Michoacan, protesting for a fraud in the July elections. The stabilisation program is renewed well in advance of its end (March of the next year). Its is announced that it will last until July of 1990.

## 1990

*January (0)*. No relevant news.

*February (1)*. A debt reduction agreement is signed between the Mexican government and representatives of its 450 foreign commercial creditor banks. The agreement marked the first application of the Brady Plan; 49 per cent of the creditor banks chose to convert existing loans into par bonds and the conversion to discount bonds was chosen by 41 per cent, the remaining chose fresh lending. The World Bank, the IMF and the US Export-Import Bank complemented the Mexican resources needed to provide the collateral needed for the new bonds issued.

*March (0)*. Troops bring to an end the occupation of town halls by militants of the PRD. The transactions involved in the debt agreement signed in February took place in this month. The Mexican central bank lends the government around 7 billion dollars to constitute the collateral debt bonds, which resulted in a considerable fall in international reserves.

*April (0)*. The government authorized and estimated of 10,000 troops, supported by tanks,

to bring forcibly to an end the occupation of 19 town halls in the state of Michoacan by supporters of the PRD.

*May (1).* President Salinas presents an initiative to privatize the banking system that is approved by the Congress. Business leaders, traders and trade unions expressed support for the move. The economic program is renewed in advance. It is planned to last until January of the next year.

*June (0).* No relevant news.

*July (0).* Electoral reforms proposed by Salinas are approved by the Congress. With this reform, the President would choose the head of the new electoral commission, and any party receiving 35 per cent of the national vote would be guaranteed the majority (50 per cent plus one seat) in the Chamber of Deputies. A further provision banned electoral alliances and coalitions, a move designed against the PRD. A debt for equity auction worth 1 billion dollars takes place; this mechanism involved issuing bonds at a discount that are exchanged for external debt.

*August (0).* No relevant news.

*September (0).* The PRI announces modifications to its statutes. These reforms were interpreted as an attempt to transform the image of the PRI and domestic and international credibility.

*October (0).* A debt for equity auction is announced and attracted bids for 2.5 billion dollars; 85.8 per cent included bonds issued at a 35 per cent discount in exchange for bank loans. The Deputy attorney General responsible for the enforcement of antidrug laws is removed from his post due to allegations of torture and extortion.

*November (1).* President Salinas met US President Bush and an agreement to proceed with negotiations to achieve an US-Mexico free trade treaty was reached. Bush claimed that such a treaty would change the history of North America and would be an example for all nations. Bush guaranteed a credit of 1.5 billion dollars for improvements to Mexican oil installations. The economic program is renewed for a further year; now it is planned to last until December of 1991. Official results of the state and local elections in the State of Mexico gave an overwhelming majority of seats to the PRI. The opposition claims fraud.

*December (0).* The very late results of state elections in Hidalgo gave the victory to the PRI. The two main opposition parties, PAN and PRD, claimed a scandalous fraud and called for mass protests.

## 1991

*January (0).* Meeting of Central American leaders: the presidents of Guatemala, Honduras, Salvador, Nicaragua, Costa Rica and the foreign ministers of Colombia, Venezuela and Mexico agreed to accelerate negotiations for free trade for 1996 at latest. Mexico and Venezuela agree to continue supplying oil to the region in favourable terms.

*February (0).* The Canadian, Mexican and US governments announced that Canada was to join the negotiations of the free trade zone.

*March(0).* President Salinas visits the US and Canada for talks about the free trade agreement. A commercial agreement is signed with the European Community.

*April (0).* President Salinas visited seven United States states and Canadian cities in a tour aimed at allaying doubts over the inclusion of Mexico in North American free trade bloc. Bush promises to work for an extension of the period in which fast track could apply to a free

trade agreement.

*May (0)*. No relevant news.

*June (0)*. Opening round of official negotiations of NAFTA.

*July (0)*. President Salinas' tour in Europe. Salinas signed in Italy trade and oil agreements worth 1 billion dollar, and German companies pledged 3 billion dollars in new investments in Mexico.

*August (1)*. PRI's overwhelming victory in mid term congressional and gubernatorial elections restored PRI's dominance to levels observed prior 1988. The elections were followed by claims of fraud and intimidation. Local elections in six states with close contests in Guanajuato and San Luis Potosi. Under domestic and international pressure, President Salinas compelled Ramon Aguirre to make the unprecedented announcement that he would not take up office as Guanajuato's Governor and designated Carlos Medina, militant of the PAN, as interim governor. The government announced the sale of the largest bank for 3.2 billion dollars.

*September (0)*. A free trade agreement with Chile is signed. The growth of GDP is reported to be above previous year but declining. Amnesty International called the US and the international community to stop ignoring human rights abuses in Mexico.

*October (0)*. Resignation of the elected governor of San Luis Potosi after a meeting with President Salinas. The elected governor was replaced with another PRI member until new elections could be held. The government announced the sale of the second largest bank for 2.5 billion dollars. This was the eighth commercial bank sold.

*November (0)*. In his annual report to the nation, President Salinas proposed radical reforms in agriculture, the education system and the status of the Catholic Church. The economic program is extended to the end of January 1993. As one of the final stages in the governments privatization program, three major state owned steel companies were sold for a total price of 885 million dollars.

*December (-1)*. A significant delay in the signing of the NAFTA occurred after disagreements on specifics, specially about the opening up of the oil industry to US competition. Talks between both presidents took place in the US. The US representative for trade negotiations cautioned that the US had no intentions of substituting speed for substance. The week before shares on the Mexican stock exchange had fallen sharply on fears that the NAFTA would be postponed.

## 1992

*January (0)*. Annulment of Tabasco elections, some generals are imprisoned. The Congress approved radical constitutional reforms to end the land distribution system called the Ejido (a type of communitary property established after the revolution at the beginning of the century); other constitutional reforms conferred legal status to the Catholic Church and changed the educational system. Talks with Canada and the US about the trade agreement resumed.

*February (0)*. The Congress approves reforms to the pensions and housing funds aimed to boost domestic savings by an estimated 1 billion dollars. The financial sector welcomes the changes but employers express disagreement with the higher labour costs implied.

*March (0)*. No relevant news.

*April (0)*. A series of explosions due to petrol leakages from a pipeline of the state owned oil company that filled the sewages killed at least 200 people in Guadalajara.

*May (0)*. Guadalajara's governor resigns and another PRI official is elected by the state

Congress as interim governor. Four local executives of the oil company and 5 government officials are taken to jail. The IMF extended the for one year the three-year extended agreement granted in May 1989. The extension amounts to 653 million dollars.

*June (0)*. A 3.0 billion dollar road privatisation program is approved by the Congress. It is announced that 7.17 billion dollars of foreign debt have been cancelled using second market operations in the near future.

*July (0)*. Elections for governors, state legislatures and town majors in Chihuahua and Michoacan. The PRI's candidate for governor in Michoacan wins with a landslide and the PAN's in Chihuahua. Elections were particularly tense in Michoacan. The debate centred on the expenses of the PRI in the campaigns. Some days later Salinas said to the Financial Times that he would seek to have ceilings placed on campaign spending. After a meeting of Bush and Salinas, the Mexican press announced that Mexico agreed to open up its oil sector to performance contracts. This was reported as a concession which US companies had been seeking for some time. The last of 18 state-owned banks is privatised. The total sale is worth 12.9 billion dollars.

*August (1)*. A draft of the North American Free Trade Agreement (NAFTA) is agreed with the US and Canada. The NAFTA is planned to take place since January 1994. Elections of legislators and majors in Durango, Veracruz, Oaxaca, Aguascalientes, Zacatecas and Baja California.

*September (0)*. In Veracruz, protesters of the PRD demonstrate against electoral fraud and corruption. The demonstration coincided with the inauguration of the PRI's elected governor, a ceremony attended by President Salinas and protected by 2,000 police and federal troops. Diplomatic relations with the Vatican are restored.

*October (-1)*. After months of demonstrations and clashes by supporters of the PRD, the governor of Michoacan resigns and is replaced by another PRI member. The economic program, planned to expire in January of the next year, is renewed in advance. The extension is for one year; now it is planned to last until December 1993. After some weeks of relative pressure on the peso, the crawl of the ceiling of the exchange rate band increases from 0.002 to 0.004 pesos per day. Analysts considered that the measure averted the danger of a future large one step devaluation.

*November (0)*. In his report to the nation, President Salinas proposes that the sources of parties financing should be made public in the future, that electoral expenses should have a ceiling and that impartiality in the media should be encouraged. The speech is interpreted to ease NAFTA ratification in the US Congress. The PRI wins 2 state disputed local elections and there are clashes in Oaxaca for the results of the August elections.

*December (1)*. The NAFTA agreement is signed. The forecast of economic growth for 1992 is lowered from 4.0 to 2.8 per cent. The forecast of the current account deficit in 1992 is also revised (from 14 to 20 billion dollars), now it is expected to represent 6 per cent of GDP. A currency reform takes place, the new peso equals a thousand old pesos.

## 1993

*January (0)*. Cabinet reshuffle to strength the control over the political system in the run up to the denomination of the PRI's candidate for the 1994 presidential elections. Violent clashes are reported in the states of Oaxaca and Michoacan in protests for electoral fraud. PRI's militants evicted PRD members from municipal offices occupied for 18 days; it was reported that



7 people died.

*February (0)*. No relevant news.

*March (0)*. The PRI announces limits to individual donations to political parties. The announcement came in the wake of sustained protests by opposition parties following the disclosure that 30 business leaders were asked contributions of 25 million dollars per head to help finance the 1994 presidential election campaign. Many of those requested had benefited from the privatisation policies. The results of an unofficial plebiscite in Mexico City showed that 85 per cent of the participants were in favour of the direct election of the Governor in the capital, a post designated by the President. The PRI wins elections in Guerrero and Baja California. Abstention reached an unprecedented 67 per cent in Guerrero. According to official figures, the GDP growth in 1992 was 2.6 per cent, one percentage point below the observed in 1991 and the current account deficit in 1992 was 85 per cent higher than in the previous year.

*April (0)*. The PRI claims a landslide victory in the extraordinary election held in San Luis Potosi. The PAN organized a referendum and a protest in the capital of the state Yucatan to protest for the PRI decision to postpone until May 1995 the gubernatorial elections which had been set for November. Six of the seven members of the PRI's executive committee are dismissed by the president of the party for involvement in corrupt practices.

*May (0)*. The archbishop of Guadalajara, Jesus Posadas' (second in seniority in the Mexican Roman Catholic hierarchy) is shot dead. The authorities stated initially that Posadas was caught in crossfire in a battle between drug rings. But the fact that Posadas was 20 years older than the allegedly targeted drug trafficker and that he received 14 shots from a distance less than 4 feet provoked doubts on this explanation. The Church hierarchy demanded a credible explanation. Another theory proposed that drug traffickers had colluded to kill Posadas to show his strength. Annual shipments of drugs, mostly from Colombia, across the Mexican border into the US were reported to be worth thousands of millions of dollars. Humberto Tirado, a judge who was noted for investigating and prosecuting drug traffickers is shot dead in Mexico City. A constitutional amendment is submitted to the Congress by President Salinas to make the Central Bank independent.

*June (0)*. President Salinas announced the creation of the National Institute to Combat Drugs, an independent body dependent of the Attorney General. The institute was the centrepiece of a new drive against drug traffickers. The attorney general insists on his explanation of the killing of Cardinal Posadas.

*July (0)*. President Salinas unveiled a package of electoral reforms. The reforms came after the PRI won by a landslide the governor elections in the state of Mexico, the one with the largest population.

*August (0)*. No relevant news.

*September (0)*. The electoral reforms introduced in July are approved by the Congress. The reforms are said to be designed to bring the country's antiquated political system in line with economic modernisation. The main change consists in separating the organisation and supervision of elections from the government and put it on the hands of an independent body. The Central Bank announced international reserves of 22.6 billion dollars.

*October (0)*. The economic program two months in advance; now it is planned to last until the end of December 1994. A plan for agricultural development is announced. In the capital,

a demonstration in Mexico City marks the 25 anniversary of the 1968 massacre of university students by the Army.

*November (-1).* The PRI designates Luis Colosio as its candidate for the Presidency. Colosio's candidature was carefully prepared by President Salinas. Manuel Camacho, in charge of the government of Mexico City, resigns because he hoped to be the presidential candidate. Camacho later accepted the Foreign Relations Portfolio. The PAN designates Diego Fernandez as its candidate. The PRI wins with a large minority the local elections in the State of Mexico. In the state of Yucatan elections produced controversy and demands for annulment of the poll. The uncertainty regarding the NAFTA vote in the US Congress resulted in considerable pressure on the peso. As a result, the crawling of ceiling of the target zone was increased from 0.002 to 0.004 pesos per day, and the horizontal intramarginal band was eliminated.

*December (0).* Jesus Silva is appointed Tourist Minister. His appointment put an end to speculation that he might leave the PRI after centre-left deputies of the PRD asked him to run as an opposition presidential candidate in August 1994. Economic growth reaches its worst record in the Salinas administration, it is reported that the GDP grew 1.2 percent from September 1992 to the same month in 1993.

#### 1994

*January (-1).* The first day of the year, a rebellion broke out in the southern State of Chiapas. The Zapatista Army for National Liberation, an armed group of indians, took control of four towns and issued a series of demands calling for major social and economic change in the region. This action coincided with the entry into force of the NAFTA. This was the first incidence of guerrilla in two decades and caused considerable embarrassment to the PRI. Two power lines are blown up in the states of Puebla and Michoacan and a there is a bomb attack in Mexico City. The guerrilla also kidnapped a former governor of Chiapas. Ten days after the broke up of the rebellion, the government announced a unilateral cease-fire. Manuel Camacho leaves the Foreign Portfolio Ministry and becomes the Commissioner for Peace and Reconciliation in Chiapas. The Minister of the Interior is replaced. At the end of the month, an agenda for peace talks was agreed between the Government and the Zapatista Army. The conflict had a considerable impact on the confidence of the PRI.

*February (0).* Popular support for the Zapatista Army grows. Peace talks with the Zapatista Army took place at the end of the month; particular attention is given in the talks for proposals of political reform. The Zapatista army demanded the resignation of President Salinas. In Chiapas, hundreds of peasants occupied peacefully 10 towns. The National Army backed the peace process.

*March (-1).* Mexico's political system is plunged into crisis in March 23rd due to the assassination of the PRI's presidential candidate, Luis Colosio. Rumours of a plot by sectors within the PRI that worried at signs that Colosio might show greater respect for democratic procedures or move away from the free market economic policies widespread. President Salinas favoured Ernesto Zedillo, Colosio's campaign manager, as substitute for the candidature. The selection has said to have been taken place in stressed negotiations within the PRI. As a further sign of turbulence, Jose Cordoba, Salinas' powerful chief of staff, was suddenly removed and sent to Washington as envoy to the Inter-American Development Bank. It was said that the sacrifice of Cordoba was the condition of PRI's officials to accept Zedillo as the new candidate.

A preliminary agreement for peace with the Zapatista Army was reached in Chiapas at the beginning of the month but after the assassination of Colosio, the Zapatista Army remained in red alert. The killing of Colosio prompted a sharp fall in Mexican shares and bonds in New York and London and pressures against the peso grew dramatically. Bill Clinton announced that the US Treasury would be prepared to lend Mexico up to 6.0 billion dollars to stabilise the peso. The president of Banamex-Accival, the largest financial group in the country was kidnapped. In an attempt to boost the confidence on the economy, it is announced that Mexico would be accepted as a member of the OECD next month.

*April (-1).* The federal judge in charge of the investigation of Colosio dismissed charges against the allegedly partners of the murderer of Colosio. The investigations turned obscure when the main charge of the confessed assassin, Mario Aburto, was changed from premeditated murder to murder with malicious intent. Legal experts and the media considered that by ruling out premeditation, the government prepared the ground for the argument that Aburto acted impulsively and alone. Opinion polls suggested that most Mexicans believed that the murder was organised and had a political motive. The government resorted to an independent commission to investigate the assassination. Jose Benitez, the police chief of Tijuana, the city in which Colosio was assassinated, was murdered by unidentified gunmen. Benitez was reported to have information on the assassination of Colosio.

*May (0).* The government announced that it had requested the UN to provide technical assistance to national observers in the forthcoming presidential election of August. Mexico's first televised presidential campaign debate took place with an estimated audience of 30 million people. The candidate of the PAN was considered as the winner of the debate but showed a very low profile in the weeks that followed the debate, which caused widespread criticism.

*June (-1).* Interior Minister, Jorge Carpizo, submitted his resignation but withdrew it days later after President Salinas refused to accept it. Carpizo was persuaded to stay following unprecedented cross-party support and backing from non-partisan groups. The episode highlighted the division between hard-liners and moderates within the PRI. Carpizo had reportedly already threatened to resign before because of hard-line opposition to electoral reforms. The Zapatista Army announced its rejection of the governments peace plan and Manuel Camacho, the Commissioner for Peace in Chiapas, resigned. Zedillo criticised his peace efforts and said that protracted negotiations with the Zapatista Army had only produced a prolonged truce. The Zapatista Army called for a new dialogue with all progressive forces in the country and the holding of a national democratic convention to create a provisional or transitional government.

*July (0).* President Salinas designated Olga Islas a the new special prosecutor in the investigation of the murder of Colosio. Islas substituted Miguel Montes who reversed his preliminary findings of a conspiracy, presented in television, and later concluded that the confessed murderer of Colosio had been a lone gunman.

*August (1).* Presidential and congressional elections took place. The PRI wins the Presidency and the majority in the Congress. Reports of electoral irregularities in the presidential and congressional elections emerge. Senior executives of a financial corporation are sentenced in connection with loans granted by a group of banks and small investors to the corporation which were to support companies which turned out to be non-existent.

*September (0).* Two days before the end of the month, the Secretary General of the PRI,

Jose Ruiz, was is killed in Mexico City. The murderer was arrested at the scene of the crime. It was nor immediately clear whether the killing was connected with moves to reform the party, or with opposition to the governments fight against drug trafficking because Mario Ruiz, brother of Jose Ruiz, was in charge of anti-drug law enforcement. The Minister of Finance announced that federal regulators had taken over the running another financial group and auditors were investigating alleged irregularities; arrest orders are issued against the head of the group and other four executives.

*October (-1).* Investigations of the killing of the Secretary General of the PRI suggested links both with drug cartels and members of the PRI which opposed reforms to the party. But there was not a clear resolution of the issue. A drug cartel issued a statement claiming responsibility for the assassination of the Jose Ruiz but the same day the Attorney General requested that the PRI deputy Manuel Muñoz be stripped of his parliamentary immunity in order to bring criminal proceedings against him because he was connected to the killing. Manuel Muñoz alleged the following day that the assassination had been masterminded by telephone by Abraham Rubio, a tourism developer connected with the drug cartel who was serving a sentence in prison. The Zapatista Army announced its withdrawal from talks with the government, which were stalled since June.

*November (-1).* Mario Ruiz resigned from the PRI and from his post as Deputy Attorney General and accused senior party officials of hindering the investigation of his brother murder. Mario Ruiz, brother of the murdered PRI's Secretary General assassinated in September claimed to have evidence implicating senior members of the PRI in a cover-up to protect the assassins. PRD deputies disrupted the last speech to the Chamber of Deputies of President Salinas. A simultaneous demonstration by PRD supporters in Mexico City protesting at alleged PRI involvement in the deaths of more than 300 PRD activists in the previous six years led to violent clashes with the police.

*December (-1).* Ernesto Zedillo inaugurates his presidential term. In his speech Zedillo promised to guarantee the independence of the judiciary and to ensure the separation of the government from the PRI. He also proposed a reform of the electoral system to end the controversy fuelled by opposition parties which, he said, were intent on denying the PRI's legitimate success in recent elections. Fears of a renewed outbreak of hostilities in Chiapas followed the controversial inauguration of a new PRI governor. The Zapatista Army dismissed the official results of the elections and demanded the installation of the candidate of the PRD as governor. A shadow government was established by Zapatista and PRD supporters. Members of the Zapatista Army broke through an army cordon and gained control of 38 municipalities. There were no reports of violence when the federal troops recaptured the municipalities. On December 20th the government announced that the ceiling of the target zone of the peso would be increased by 15 per cent. This was taken by financial markets as a surrender to defend the peso-dollar parity and the price of the dollar was hitting the new ceiling hours after the announcement. On December 21st the government announced that the peso was to float freely. The recently appointed Minister of Finance was substituted. At the end of the month, the government reached an agreement with the Zapatista Army to end military operations and begin negotiations.

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