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Dollarization and Credibility: an analysis of the Mexican experience

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1. Introduction

The widespread belief on the part of the private sector that the course of policy pursued by the authorities may be unsustainable is probably the main factor behind balance of payments crises and speculative attacks on the domestic stock of foreign reserves. While a number of authors have investigated the timing of these speculative runs[1], most of them have been concerned with the collapse of the exchange rate regime in a deterministic environment or have devoted little attention to the process of formation of agents' subjective beliefs. Most notably, very little empirical work has been attracted to the modelling of the determinants of ‘confidence’ and to the assessment of its role in the portfolio decisions that ultimately precipitate balance of payments crises[2].

In this essay we examine these questions by formulating and constructing a measure of agents' confidence in the viability of the policy regime. As in the models of Baxter (1985) or Flood and Garber (1980), individuals are assumed to use Bayesian learning procedures to make subjective judgements about the probability that the course of policy be consistent with the existing exchange rate regime. The resulting measure of ‘confidence’ – that we will also label ‘credibility’ – is then applied by individuals to their portfolio decision between domestic and foreign currency denominated assets. We use a currency substitution framework to model this second stage; thus in the complete model the optimal currency composition of agents’ money holdings depends – among other factors – on credibility, and the latter is in turn determined by present and past policy actions as well as by the public’s prior beliefs. By relating the subjective probability of a (maxi)devaluation to the subjective beliefs about the sustainability of the current policy, declines in credibility induce in our model shifts away from domestic currency denominated assets.

The model is empirically tested by applying it to the Mexican experience of the late seventies. The latter constitutes on its own an interesting framework for the credibility issue. During this period, the Mexican economy combined unrestricted capital mobility with a formally floating, but practically fixed, exchange rate policy. An uncommon feature of the Mexican financial system was the existence of domestically issued assets denominated in dollars (‘mexdollars’). The latter provided a mechanism that absorbed short-term capital flows without endangering the Central Bank’s stock of foreign reserves. As runaway fiscal deficits reduced the publics’ confidence in the sustainability of the exchange rate regime, a sizeable portfolio shift towards dollar denominated assets started to develop in 1981. By the end of that year, a sharp increase in the political risks perceived by the public added a new dimension to the problem by inducing massive capital flight. These circumstances eventually

[1] Krugman (1979) is the classical reference. See also Connolly and Taylor (1982) and Flood and Garber (1984).
[2] Baxter (1985) and Cumby and Van Wijnbergen (1983) are two exceptions; however, they analyse only the formation of expectations without trying to evaluate their impact on the course of events. See also Kaminsky (1981).

led in August of 1982 to the elimination of the Mexdollar System and the introduction of exchange Controls.

The empirical results reported in this paper are very supportive of our modelization. The currency substitution-credibility framework is applied to the holdings by Mexican residents of peso, mexdollar, and U.S. dollar denominated demand deposits. Both the constructed credibility measure and the complete model explain satisfactorily the events described above. An important by-product of the estimation of the model is the finding of a significant degree of substitutability between the three alternative monies to which Mexican investors had access.

The remainder of the paper is organized as follows. Section 2 briefly describes the evolution of the Mexican economy in the late seventies and the events that led to the financial crisis of 1982. The model is discussed in section 3. Section 4 describes the data set employed in the estimation of the model, the results of which are reported in section 5. Finally, some concluding remarks appear in section 6.

2. The Mexican economy, 1977-1982

The year 1982 was critical for the Mexican economy. The country suffered one of its worst economic and political crises, that led to a massive real depreciation of the peso and to the introduction, for the first time in México's modern history, of a system of exchange Controls. Real GDP fell also for the first time in five decades, while the request by the Mexican authorities of a moratorium in their foreign debt payments ignited the Latin American debt crisis.

The behaviour of the economy in 1982 contrasts sharply with its performance in the previous years. As shown in Table 2.1, during 1977-81 real GDP grew at an average annual rate above 7 percent, fuelled by runaway public spending well above the increased revenues granted by the oil bonanza of the seventies. The public deficit expanded steadily to reach gigantic proportions in 1981-82, financed to a large extent by growing foreign indebtedness. Meanwhile, as Figure 2.1 shows, the peso was becoming increasingly overvalued. As a result, the current account gap gradually widened.

When the oil market started weakening in the second half of 1981 and world interest rates rose to historically high levels – adding substantial weight to the burden of foreign debt – the public sector failed to adopt the necessary adjustment measures. Stimulated by the inconsistency of the policies being pursued, speculation against the peso reached sizeable proportions, both in terms of 'dollarization' (see below) and in terms of capital flight.

The gestation of the crisis of 1982 can be better understood by looking at the developments that took place in Mexican financial markets during this period. For several decades, the Mexican Banking System had offered to domestic investors deposits denominated in dollars ('mexdollars'). In an environment of unrestricted capital mobility, the mexdollar market provided an effective insulation device from short-term capital flows, absorbing a large part of the pressure that otherwise would have affected the foreign exchange market during times of financial turmoil, as in the months immediately before and after the 1976 devaluation. Mexdollars offered investors an alternative to U.S. dollars (or other foreign currencies) held abroad, and after the liberalization of 1977 both assets became perfect substitutes except for political uncertainty factors[3]. Starting in that date, interest rates on Mexdollar deposits were pegged at a two percent premium to the Eurodollar rates. The premium was later reduced and finally eliminated in November of 1978.

This system worked quite well for years. The degree of 'dollarization' – that is, the share of dollar denominated deposits in the total deposits of the banking system – became an indicator of the public's confidence in the course of economic policy. As Figure 2.2 shows, dollarization kept a roughly stable profile from 1977 until the first half of 1981, declining at first from the high levels reached in the 1976 crisis and slowly rising after 1977. As the economic environment deteriorated in late 1981 and confidence in the policy being pursued weakened, dollarization accelerated. Capital flight also acquired sizeable proportions. Eventually, the peso was devalued 65 percent in February of 1982, and the government announced the adoption of an austerity program. However, the inability of the public sector to follow the proposed measures became immediately patent, as reflected by the substantial wage increases granted during the first quarter of 1982 (30 percent in January plus an additional 34 percent in March). The financial environment continued to worsen; most notably, massive capital flight was now associated with a stagnant or decreasing degree of dollarization (see Figure 2.2). As emphasized by Ize and Ortiz (1983, 1985a), the political uncertainty factor became so strong that it dominated exchange rate considerations, inducing the private sector to transfer the bulk of its assets abroad. The mexdollar market had ceased to serve its purpose, and the authorities – fearing a generalized run on mexdollars that would have exhausted the stock of foreign reserves – eventually decreed in August of 1982 the inconvertibility of mexdollar deposits and the establishment of exchange Controls.

The generalized shift of investors into foreign assets held abroad despite the availability of mexdollar deposits is a remarkable feature of the final months of the mexdollar market, that seems to indicate a substantial change in the political uncertainty perceived by the public. While a thorough analysis of this phenomenon is beyond the scope of this essay, we shall briefly mention two of the explanations – not mutually exclusive – that have been proposed. It has been argued that the private sector may have foreseen oncoming social and political turmoil, as the government's postponement

[3] A good historical description of the mexdollar System can be found in Ortiz (1982). See also Ize (1981) and Ortiz and Solis (1982).

of the required austerity measures was in fact making the4 eventual adjustment more costly[4]. Alternatively, the growing budget deficit of the public sector may have triggered off expectations of default on its domestic debt commitments[5], leading eventually to a speculative attack on the stock of foreign reserves[6].

3. The model

In this section we develop a model that describes how the subjective beliefs of domestic investors about the sustainability of the current policy regime affect their portfolio decisions in a multiple currency environment. We proceed in two steps: first, we construct a model of the formation and updating of agents' subjective beliefs. Then we develop a model of currency substitution to represent investors' decisions concerning their holdings of the alternative monies. These two building blocks forms the complete model that is empirically tested in section 5.

3.1. A simple model of credibility

It is well known that the feasibility of a fixed exchange rate or crawling peg regime depends on the willingness of the authorities to follow the associated monetary growth rule. In an uncertain environment, however, the key requirement for the viability of the regime concerns the private sector's perception of the degree to which monetary discipline is being enforced. If the public's 'confidence' declines, in the sense that higher rates of monetary expansion – above those compatible with the exchange rate regime – are persistently anticipated, asset holders will shift towards foreign assets and eventually stage a run on the Central Bank's foreign assets. Thus the sustainability of the policy crucially depends on the public's subjective beliefs, simply because the set of viable policy choices is ultimately determined by the private sector's optimizing decisions.

To analyse this issue, we draw on earlier work by Baxter (1985) and Flood and Garber (1980). We define the 'credibility' of the current policy as the subjective probability held by the public that the policy is feasible. This probability is updated as new information becomes available. We assume that agents' learning proceeds in Bayesian fashion; hence when the policy is first implemented the knowledge of the representative individual is summarized by a prior probability distribution. The latter is then combined with subsequent observations of the actions actually followed by the

[4] This view is emphasized by Ize and Ortiz (1983, 1985b), who actually take the level of the real wage as an indicator of the degree of adjustment required and, therefore, of the expected political turmoil.
[5] See Blanco and Garber (1984) and Ize and Ortiz (1985a).
[6] Another indication of the public's perception of political uncertainty is provided by the persistent rumours that spread in 1982, according to which punitive measures against the domestic assets of Mexican investors who held assets abroad were being considered by the authorities.

authorities to form a posterior distribution that determines the credibility attached at each moment of time to the current policy.

To develop an operative concept of monetary discipline we look at long-run monetary equilibrium conditions. Demand for domestic money balances in nominal terms can be written

$$M_t^d = h(R_t', Y_t)P_t \tag{1}$$

where R' is a vector of asset returns, Y is real income, h denotes real money demand and P is the domestic price level. In the long run, the rate of growth of money demand is given by

$$m^{LR} = M_t^d / M_{t-1}^d - 1 = p + h_y x \tag{2}$$

where p is the domestic rate of inflation, x is the long run rate of growth of real income, and h_y is the (long run) income elasticity of money demand. With a given nominal exchange rate and purchasing power parity holding in the long run, it follows that $p = p^*$, the foreign rate of inflation. Hence we have that

$$m^{LR} = p^* + h_y x \tag{3}$$

Denoting by dc the rate of growth of the domestic component of the money stock, it follows that if $dc > m^{LR}$ then the Central Bank will suffer a continuous loss of reserves, rendering the exchange rate regime infeasible. Thus, feasibility of the policy regime requires that $dc < m^{LR}$. We therefore define the credibility of the current policy at time t as

$$\Pr(dc < m^{LR} / I_t) \tag{4}$$

where I_t denotes the set of available information at the time the probability is computed.

To give empirical content to this credibility measure, we follow Cumby and Van Wijnbergen (1983), Flood and Garber (1984) and Baxter (1985) and assume that domestic money creation follows the simple rule

$$DC_t = (1 + dc + u_t)DC_{t-1} \tag{5}$$

where u_t is an independent normally distributed error term with mean 0 and variance s^2, and dc is the target (or long run) rate of domestic money creation.

The process by which subjective beliefs are updated can be summarized along the lines of Zellner (1971). At time 0, beliefs are described by a prior p.d.f. $f_0(dc, 1/s^2)$ for the parameter dc – that characterizes monetary policy – and the precision $1/s^2$. As time passes, and observations on the policy variable are collected, individuals combine their prior density with the likelihood function of the sample $L(DC_t/dc\,, 1/s^2)$ according to Bayes' rule to yield a posterior p.d.f. for dc and $1/s^2$ which can be expressed as

$$f_{1t}(dc, 1/s^2/DC_t) = KL(DC_t/dc\,, 1/s^2)f_0(dc, 1/s^2) \tag{6}$$

where K is a factor of proportionality. Integrating out $1/s^2$, the marginal posterior p.d.f. for dc can be used to draw inferences about the true value of dc. Denoting this p.d.f. by $f_{1t}(dc/DC_t)$, it follows from (4) that credibility will be given by

$$q_t = \int_{-\infty}^{m^{LR}} f_{1t}(dc/DC_t)d(dc) \tag{7}$$

where q_t stands for the measure of credibility that the public attaches to the current policy regime as of time t. Computation of q_t requires the evaluation of the integral in (7), that can be accomplished using standard numerical integration methods. Having thus completed the description of the credibility model, the next step will be to introduce individuals' subjective beliefs in their decision-making process.

3.2. A simple model of currency substitution

The issue of currency substitution has received increased attention in recent years. Its basic postulate that individuals will move between alternative currencies when their relative returns change has been shown to have some important implications from the point of view of economic policy making: increased currency substitutability tends to undermine monetary stability and independence, increases the sensitivity of domestic prices to exogenous disturbances and renders conventional money demand equations unstable[7].

[7] These results are discussed in Girton and Roper (1981). See also Miles (1978) and Cuddington (1983).

A number of empirical facts have contributed to raise the interest in the currency substitution problem. With the generalized adoption of flexible exchange rates, the expected return on foreign currency holdings is typically nonzero, giving investors a speculative – or hedging – motive to hold foreign money. In addition, some Latin American countries – including, in particular, Mexico – have experienced important episodes of 'dollarization' or, in other words, substantial increases in 'the degree to which real and financial transactions are actually performed in dollars relative to those performed in domestic currency'[8]. Our purpose in this subsection is to develop a simple model that can be used to explain the evolution of the dollarization process in México in recent years, as well as the shift away from domestic assets that led to the financial crisis of 1982.

Several approaches have been used to model the currency substitution phenomenon. A number of studies (e.g., Miles (1978), Miles and Stewart (1980), Schembri (1984), Saurman (1983)) directly postulate a 'money Services production function' or a transactions technology and study the money portfolio decision in isolation from other financial choices. These models, however, have been criticized because they may tend to exaggerate the magnitude of currency substitutability (see e.g. Cuddington (1982, 1983) and Thomas (1985)). More recently, some authors have re-examined the issue of diversification across monies from a broader perspective by introducing a transactions technology in conventional dynamic portfolio balance models. Along this line, Stulz (1984) and Thomas (1985) conclude that, if individuals are allowed to borrow in all currencies, then their optimal holdings of each money are independent of the degree of risk aversion and of the asset composition of their overall portfolio. In other words, the construction of the optimal portfolio of net assets is a separate problem from that of the selection of the optimal holdings of the alternative monies. The basic rationale behind this result is that since money is held only for transactions purposes, agents can retain the transaction Services that money of a certain denomination provides without bearing the associated exchange (or purchasing power) risks by borrowing in that same currency. A key assumption for this result to hold is that individuals be allowed to issue liabilities (e.g., bonds) in each currency having exactly the same risk characteristics as the associated money. As long as this condition is met[9], the relative holdings of each money are just determined by their relative holding costs, while the degree of currency substitutability – or, more precisely, the elasticity of relative currency balances with respect to relative holding costs – depends only on the characteristics of the transactions technology. Simple transactions-based models may therefore provide a better approximation than portfolio-balance models to the currency substitution problem.

[8] This is the definition provided by Ortiz (1982).

[9] Incidentally, it may be noted that this condition is unlikely to hold in our case. While individuals had unrestricted access to mexdollar deposits and also to credit in the same denomination, it does not follow that the perceived risks on both assets were symmetrical. In fact, after the events of August of 1982 mexdollar assets and liabilities were converted into pesos at different exchange rates, imposing a huge capital loss to lenders in mexdollars.

The model that we develop below is both an extension and a reinterpretation of the transactions-based approach to currency substitution. We follow the literature in adopting a sequential approach to portfolio formation. Throughout we adopt a two-currency framework; extension of the analysis to the n-currency case is a straightforward exercise.

We consider an individual who selects his/her optimal holdings of domestic and foreign currencies in order to minimize transactions costs. The transactions technology is described by a function $T(Y, M/P_y, EM^*/P_y)$, where T and Y denote respectively real transaction costs and the real volume of transactions to be carried out, M and M^* are nominal holdings of domestic and foreign currency, E is the exchange rate, and nominal currency holdings have been divided by the transactions deflator (P_y). It is assumed that $@T/@Y > 0$, $@T/@(M/P_y) < 0$, $@T/@(EM^*/P_y) < 0$ and that T is convex in for given Y. The representative individual minimizes T subject to the constraint

$$M\,(1+R)/(1+r) + EM^*\,(1+R)/(1+r^*) < M_0 \tag{8}$$

where R denotes the interest rate at which the individual can borrow, and r and r^* represent the expected rates of retum on domestic and foreign currency holdings, respectively. The basic rationale behind equation (8) is given by Miles (1978): if the amounts M and EM^* are borrowed in order to be held as money balances, the total money assets that the individual must hold in order to repay the loan at the end of the period will be given by (8). The optimal values of M and M^* are thus determined by maximizing the savings in transaction costs that can be attained with a given amount of total money holdings M_0. Hence, the representative individual solves the problem

$$\min T(Y, M/P_y, EM^*/P_y)$$
$$s.t. M\,(1+R)/(1+r) + EM^*\,(1+R)/(1+r^*) < M_0$$

The corresponding first order conditions are simply:

$$\begin{gathered} @T/@M + \lambda\,(1+R)/(1+r) = 0 \\ @T/@(EM^*) + \lambda\,(1+R)/(1+r^*) = 0 \end{gathered} \tag{9}$$

or, more compactly,

$$(@T/@M)/(@T/@(eM^*)) = (1+r)/(1+r^*) \tag{10}$$

In order to arrive at an expression suitable for empirical use, we specialize the transactions technology to

$$T = AY^a[k(Y)(M/P)^{-\rho} + k^*(Y)(EM^*/P)^{-\rho}]^{1/\rho} \tag{11}$$

which closely resembles the specification adopted by Miles (1978), Schembri (1984) or Stulz (1984). It should be noted that all these studies implicitly impose separability of the transactions technology in Y and $(M/P, EM^*/P)$, which effectively implies that the marginal efficiency of each currency in the transaction process is identical to its average value. Hence this assumption automatically rules out the possibility of different fixed and/or marginal transaction costs for the different currencies, which a priori does not appear too implausible. If the assumption does not hold in reality, then the optimal relative holdings of the two currencies would depend on the volume of transactions carried out. Omission of this effect in empirical work would lead to biased and inconsistent estimates. This is in fact one of the arguments offered by Bordo and Choudri (1982) to show that Miles' (1978) empirical model is misspecified; in their estimation results they find a significant association between the relevant transactions variable and the currency composition of money holdings in Canada. In view of these facts, we choose to retain the flexibility of the specification in (11) without imposing separability. Using together with (10), defining $\sigma = 1/(1+\rho)$ and after some manipulation we get

$$\ln\frac{EM^*}{M} = \sigma\ln\frac{k^*(Y)}{k(Y)} + \sigma\ln\frac{1+r^*}{1+r} \tag{12}$$

In (12) the degree of substitutability between domestic and foreign currency is given by σ – the elasticity of substitution –, while their relative efficiency in reducing transaction costs is measured by $k^*(Y)/k(Y)$. Hence if both currencies are easily substitutable in the transactions process, $k(Y)$ and $k^*(Y)$ should be relatively close, and σ should be a large number. We shall further assume that $k(Y) = kY^g$, $k^*(Y) = (1-k)Y^{g^*}$. With these modifications[10], we have:

$$\ln\frac{EM^*}{M} = \sigma\ln\frac{1-k}{k} + \sigma(g^* - g)\ln Y + \sigma\ln\frac{1+r^*}{1+r} \tag{13}$$

Note that if for a given k we have that $g > g^*$, then the relative transactions efficiency of domestic currency increases with the volume of transactions, and therefore the composition of money

[10] Notice that for total costs to rise with the volume of transactions it must be the case that $a + (\sigma/(1-\sigma))sg + (1-s)g^* > 0$, where s is the share of domestic currency holdings in the total.

holdings will tend to shift towards domestic currency as transactions grow. The opposite would happen for $g < g^*$. Separability would in tum imply that $g = g^*$, and $\ln Y$ would cancel in (13).

Finally, to concentrate in our problem, we extend (13) to the case in which individuals have access to three currencies: domestic currency (pesos), domestically issued dollars (mexdollars), and (true) dollars. Using p, md, and d to distinguish them, we rewrite in (14) the alternative pairings of the first-order conditions (10):

$$\ln\frac{ED}{PS} = \ln\frac{1 - k_{md} - k_p}{k_p} + \sigma\left(g_d - g_p\right)\ln Y + \sigma\ln\frac{1 + r_d}{1 + r_p} \tag{14a}$$

$$\ln\frac{EMD}{PS} = \ln\frac{k_{md}}{k_p} + \sigma\left(g_{md} - g_p\right)\ln Y + \sigma\ln\frac{1 + r_d}{1 + r_{md}} \tag{14b}$$

$$\ln\frac{D}{MD} = \ln\frac{1 - k_{md} - k_p}{k_{md}} + \sigma(g_d - g_{md})\ln Y + \sigma\ln\frac{1 + r_d}{1 + r_{md}} \tag{14c}$$

where now PS, MD and D stand for peso, mexdollar and dollar holdings, respectively. We still have to specify the returns r_i that investors anticipate on their holdings of currency i. For narrow definitions of the respective monies, the nominal interest rate paid on holdings of either currency can be taken to be 0. Therefore, the expected yield on dollars (in terms of pesos) is just given by the anticipated rate of depreciation of the peso. On the other hand, the expected return on domestically issued dollars depends on people's beliefs about the Central Bank’s commitment to free convertibility of domestic into true dollars. As long as this commitment is fully believed, the anticipated returns on both types of dollars will be the same. However, if it is believed that with some probability the Central Bank may not honour its domestic dollar liabilities – or, equivalently, that a tax or partial default may be levied on holdings of domestic dollars – then the expected return on the latter will be smaller than the anticipated depreciation of the peso. In addition, the expected nominal return on both domestic assets is affected by the perception of political uncertainty that can be modelled similarly as the anticipation with nonzero probability of a one-time tax on peso and mexdollar holdings. In summary, we have:

$$\begin{gathered} r_{p,t} = -G_{p,t} \\ r_{md,t} = ({}_t e_{t+1} - e_t) - G_{md,t} \\ r_{d,t} = ({}_t e_{t+1} - e_t) \end{gathered} \tag{15}$$

where $G_{i,t}$ is the expected one-time tax (or equivalent fiscal measure) on holdings of currency i that investors anticipate as of period t, we have defined $e = \log E$, and ${}_t e_{t+1}$ is the expectation held at time t of the one-period ahead value of e. Note that an increase in the anticipated rate of exchange depreciation would, *ceteris paribus*, cause a shift in the composition of investors' money holdings towards *both* domestically issued dollars and (true) dollars, while an increase in G_p and G_{md} should result in a move away from domestic assets and into (true) dollars *only*. Our model can therefore allow for two different types of 'dollarization' processes.

The final step is to integrate the currency substitution model with the credibility model developed earlier. We do so by relating the anticipated rate of exchange depreciation to the sustainability of the policy regime. Specifically, we assume that if the current policy regime has to be abandoned, then a substantial devaluation of the peso – along with other possible measures – will be carried out[11]. Hence the evolution of the expected future spot rate is governed by the probability of a (maxi)devaluation taking place, posing the well-known 'peso problem'. The expected spot rate one period ahead can be written as

$$ {}_{e}t_{t+1} = z_t e^{D}_{t+1} + (1 - z_t) e^{ND}_{t+1} \tag{16} $$

where e^{D}_{t+1} is the expected logarithm of the exchange rate conditional on devaluation taking place between t and $t + 1$ – which happens with probability z_t – and e^{ND}_{t+1} is the expected value of e conditional on no devaluation.

Empirical models of the type described in (16) typically pose the identification problem of distinguishing between the subjective probability of devaluation happening and its conditional magnitude. This difficulty is usually solved by assuming that the magnitude is determined either by a switch to flexible exchange rates or by some form of PPP. We follow the second option and assume that the conditional magnitude of the devaluation is proportional to the percentage deviation of the real exchange rate from its equilibrium value:

$$ e^{D}_{t+1} - e_t = a_1[RE^{*}_{t} - C(L)RE_t] \tag{17} $$

where a_1 is a constant, $RE_t = \log(EP^{*}/P)$ is the logarithm of the real exchange rate, RE^{*}_{t}. is its equilibrium counterpart, and $C(L)$ is a polynomial in the lag operator L, with $C(1) = 1$. Hence, the size of the pending depreciation is assumed to be determined by the deviation of a weighted average of current and past real exchange rates from the current equilibrium real exchange rate. We further assume that $e^{ND}_{t+1} = e_t$; so that with probability $(1 - z_t)$ no exchange rate variations are anticipated[12] between t and $t + 1$.

[11] An alternative assumption commonly encountered in the literature is that of a shift to a flexible exchange rate system.
[12] This assumption is made only for convenience. In our case, as Figure 2.1 shows, it appears rather plausible.

The subjective probability of a devaluation taking place between t and $t+1$ – z_t – remains to be specified. In section 3.1 we have obtained a measure for the (subjective) probability held by the public that the course of the policy is unsustainable – q_t –. In the long run, an unsustainable policy will render the fixed exchange rate regime infeasible, and therefore an exchange collapse or a (maxi)devaluation will occur. Hence q_t may be identified with the *long run* probability of devaluation. To find the probability of *immediate* devaluation, however, we must take into account the fact that the authorities may temporarily sustain an infeasible (in the long run) course of policy by relying on the Central Bank's stock of foreign reserves. Thus, it should be the case that for a given degree of 'credibility', immediate devaluation will be regarded as more likely the lower are foreign reserves. In summary, we shall assume that the (subjective) probability of a devaluation taking place between t and $t+1$ is given by the joint probability of the policy course being infeasible and the level of reserves falling below a critical threshold. Specifically, we assume,

$$z_t = (1 - q_t)v_t \tag{18}$$

where v_t is the probability that the Central Bank's reserves fall below the critical level[13]. To specify v_t we follow Cumby and Van Wijnbergen (1983) and assume that individuals do not know with certainty the threshold level – that we shall denote F^* – beyond which reserve depletion triggers devaluation. The public has instead a prior distribution for F^*, that for simplicity is assumed to be uniform between zero[14] and an upper bound F^{max}. If prior beliefs are diffuse, the public will over time update its F^{max} by setting it equal to the *minimum* level of reserves observed up to the present, provided no devaluation has yet occurred. In other words, as long as reserves keep falling and the exchange rate stays unchanged the range within which F^* is believed to lie will be shrinking. Notice, however, that all the learning is concentrated on one end of the distribution even if the lower bound is also unknown (instead of zero), since the fact that no devaluation has taken place gives no information about its value.

Putting all these pieces together, we can use (16), (17) and (18) to rewrite expected depreciation as

$$Prem_t = {}_t e_{t+1} - e_t = a_1(1 - q_t)v_t(RE_t^* - C(L)RE_t) \tag{19}$$

[13] We are implicitly assuming that both events are independent. While this is clearly restrictive, it allows us to simplify considerably the modelling of the learning process. In essence, (18) implies that a low level of reserves need not trigger devaluation expectations if there exists public confidence in the course of policy.

[14] As Cumby and Van Wijnbergen (1983) argue the lower bound for F^* could in principle be negative, as the Central Bank has access to the international lending market.

Equations (5), (7) and (19) together with the subsystem (14) and (15) completely characterize the portfolio decision in the three-currency economy. For a given path of the policy variable, (5) and (7) determine the degree of public 'confidence'. The latter – along with the level of reserves – determines the anticipated rate of exchange depreciation, for given real conditions, in equation (19). Finally, for given G_{jt}, (14) and (15) characterize the optimal allocation of money holdings between the different available currencies.

4. Data

All the data series used in the estimation of the model are quarterly and seasonally unadjusted. For this reason, seasonal dummies were included in the relative money demand equations. Unless otherwise indicated, all variables are expressed as end of period values. The data sources are described in Appendix A.

In order to keep homogeneity in the definition of the money holdings variables, and since no data on Mexican holdings of U.S. currency outside banks is available, the model is estimated using the ratio of demand deposits denominated in the respective currencies as the relevant measure of the dependent variable. Thus, holdings of U.S. dollars by Mexicans are measured by the demand deposits of unaffiliated Mexican residents in chartered U.S. banks[15]. This variable excludes deposits held by the Mexican government and its agencies. Peso and mexdollar holdings are given by the respective volumes of demand deposits in the Mexican banking system.

To compute the anticipated return on dollar denominated money holdings, a series for the future expected spot rate is needed. We follow the conventional procedure and use exchange rate quotations from the futures market[16]. The return on mexdollars, however, has to be adjusted to reflect the developments in the mexdollar market. As described above, prior to November of 1978, interest rates on mexdollar deposits of different maturities were set by the authorities at a premium above the corresponding Eurodollar rates. Because demand deposits in different currencies can be regarded to some extent as complementary with other less liquid deposits of the same denomination, a dummy that takes a value of 1 prior to November 1978 was included in the equations that involve Mexdollar holdings. On the other hand, the variables $G_{i,t}$ that reflect the expectations of government default or fiscal action against domestic assets, or the perceived political risk, are unobservable. However, in view of the discussion in section 2, it seems reasonable to think that the major shift in people's

[15] Prior to 1978, the data do not distinguish between demand and time deposits. Since the ratio between both remained fairly stable in the next three years, it was used to construct the observation for 1977-IV.

[16] During most of our sample, futures trade in pesos involved only contracts of four maturities each year. However, the trading was fairly active, averaging about 28 thousand contracts per year, with each. contract amounting at least to fifty thousand dollars.

perceptions may have occurred at the end of 1981 or the beginning of 1982, when the unwillingness of the public sector to adjust its finances or to reduce real wages became patent. A dummy variable is used to represent this fact, thus imposing identical timing but allowing for different magnitudes of the terms $G_{i,t}$.

The volume of transactions would probably be best described by real GDP, as conventionally assumed. In Mexico, however, this variable is recorded only on an annual basis. As a reasonable alternative, we adopted a quarterly average of the monthly industrial production index.

Mexican monetary statistics underwent major changes in 1977. As a result, the reported measures of several key monetary aggregates correspond to different definitions before and after that date. This poses a problem for the estimation of equation (7), that was resolved by extrapolating the new domestic credit series (available from December of 1977) using the rate of growth of the old magnitude in order to obtain observations for the previous three quarters. The empirical results reported below are robust to alternative extrapolation procedures.

The real exchange rate is constructed as the ratio of U.S. to Mexican Wholesale industrial prices, expressed in common units. Attempts to introduce dependence between the 'equilibrium' real exchange rate and the relative price of oil proved unsuccessful; the former was instead specified as an (unknown) constant, of which a point estimate can in fact be obtained.

The data for foreign reserves published by the Bank of Mexico is to a great extent unreliable. In the period preceding the debt crisis of 1982, several heavily indebted Latin American countries – México among them – resorted to short-term borrowing (for which usually no information is ever published) as well as to Creative accounting practices to artificially inflate the ratio of foreign reserves to long and medium term liabilities. In view of these facts, we decided to adopt an alternative procedure. We neglect published reserve figures and focus instead on the cumulative current account deficit. Hence the critical value F^* will refer to the maximum cumulative deficit permissible over the period. This presents the problem that the right-hand end of the distribution of F^* about which no learning occurs – has to be specified arbitrarily – analogously to setting the limiting value for reserves[17] at zero. In some sense this amounts to a choice of units, that we solve by making the right-hand end equal to the actual cumulative current account deficit from the beginning of the period of analysis until the third quarter of 1982. Observe that this is equivalent to setting $v_t = 1$ for $t = 1982 - III$, while at the same time it makes v_t arbitrarily small at the initial observation. To allow for a different pattern of beliefs at the extremes of the sample, we shall introduce a constant term in our measure of the probability of devaluation[18].

[17] In principle it may be possible to estimate this parameter along with the rest. However, this approach would increase substantially the nonlinearity of the model, and therefore we shall proceed as indicated in the text.
[18] To clarify matters, let us define C^{max} as the upper (right-hand) end of the subjective distribution of F^* (the maximum reserve loss), and C^{min} as the lower end of the same distribution. As time passes, the public may be able to update C^{min}

Finally, construction of the subjective credibility measure q_t requires the specification of the parameter m^{LR} in equation (5). To compute the latter, we use the average quarterly rate of U.S. inflation over our sample period, plus 1.5 times the average quarterly rate of growth of industrial production in Mexico. The figure 1.5 is roughly equal to conventional estimates of the long run elasticity of money demand for Mexico[19]. Again, our empirical results proved remarkably insensitive to alternative values of m^{LR}.

With these variable definitions, the model is estimated using quarterly data for 1977-82. Despite the simplicity of our model, this short sample severely limits the available degrees of freedom. While the terminal date is dictated by the disappearance of the Mexdollar market, several reasons prevented the extension of the sample to the years prior to 1977. First, the unavailability of some series[20] during that period. Second, and more important, our approach makes the year 1977 a natural starting date. As described above, the Mexican economy went through a major financial crisis in 1976, due to both political and economic reasons. The crisis was temporarily closed with a maxi devaluation of the peso, the first change of parity in more than twenty years. The exchange rate then stayed practically unmoved until the second half of 1981. Thus, it appears reasonable to consider the post-1976 period as the scene of a 'new' policy, involving also changes in financial markets like the liberalization of the Mexdollar market in 1977. All these circumstances make the year 1977 a sound starting point for the analysis.

5. Empirical results

Estimation of the model proceeds in two stages. We first estimate equation (5) iteratively, find the marginal posterior distribution for dc and compute the associated series for the credibility measure q_t by repeated evaluation of the integral in (7), all for alternative assumptions about the public's prior beliefs. This procedure actually implies that for *each* prior p.d.f. a number of OLS regressions and numerical integrations equal to the number of data points (minus two) have to be performed. The alternative credibility measures thus obtained are then employed, along with the remaining variables, to estimate[21] equations (14) and (19).

(but not C^{max}, which we set exogenously) if the cumulative deficit is growing and devaluation has not yet occurred. With a uniform prior distribution, the probability that the cumulative current account deficit be greater than the threshold level will be given by: $v_t = Prob(\sum_{i=0}^{t} CA_{t-i} < F^*) = \frac{CA_t}{C^{max} - C_{t-1}^{min}}$ (20), where CA is the current account deficit, and C_{t-1}^{min} is the maximum cumulative current account deficit from the beginning of the analysis until period $t-1$. Hence, the equation for the forward premium will then be given by (19) with v_t substituted for the above expression.

[19] See, for example, Ortiz (1982).

[20] In particular, domestic credit statistics, as noted in the text. See also note 13.

[21] Thus, the estimates will be conditional on the assumed value of m^{LR}, as well as on the specification of the threshold for reserve losses. While a full information procedure could in principle be applied, it would result in an intractable nonlinear problem. We shall therefore limit ourselves to this two-stage procedure, at the possible cost of some efficiency

5.1. Credibility

We use priors of the normal-gamma conjugate family. As is well known (Zellner, (1971)), prior beliefs in the normal-gamma specification are summarized by the prior mean dc_0 and variance s^2/T_0 of the normal p.d.f. for dc given $(1/s^2)$, and by the prior mean $(1/s_0^2)$ and variance $(1/(DF^0 s_0^4))$ of the marginal gamma p.d.f. for $(1/s^2)$.

Although the estimation procedure was carried out for a number of alternative prior beliefs, only three different parameterizations are reported here. These are described in Table 5.1. The priors are respectively labelled 'diffuse', 'data-based' and 'neutral'. The diffuse prior conveys no information; hence posterior beliefs reflect only the sample information. The data-based prior is constructed by computing dc_0 from pre-sample data; observations for 1976 were used for this purpose[22]. The neutral prior is constructed, as in Baxter (1985), so as to yield a prior credibility of exactly 1/2.

Given these prior beliefs, equation (5) is estimated using data for the period 1977-1 1982-11 (observe that the first posterior estimate is thus obtained for 1977-III, yielding only 20 observations on 'credibility'). The resulting credibility measures are depicted in Figure 5.1.

The pattern of credibility appears roughly similar in the three cases. Although the probabilities initially attached to the feasibility of the current policy differ substantially. according to the pre-sample information, the three curves tend to approach each other rather quickly, due to the fact that pre-sample beliefs are not held with too much strength. Increasing DF_0 and T_0 would of course result in more persistent divergences between the three sets of posterior beliefs.

The posterior associated with the diffuse prior shows the nature of the sample information. Thus, the measure of credibility declines abruptly at the end of 1977 from its initial levels due to monetary acceleration induced by a government deficit of record proportions. Subsequent monetary moderation helps restore confidence, and the latter is maintained through 1978 and the first half of 1979. Later, continuous monetary acceleration due to uncontrolled government spending forces all credibility measures down, in monotonic fashion since the third quarter of 1980. By the second quarter of 1981, none of the posteriors attaches more than 10 percent probability to the sustainability of the current policy, a result that seems to agree well with the observed facts. Recall that this lack of confidence stimulated speculation against the peso in late 1981 and early 1982, eventually leading to a financial crisis and a maxi devaluation in this latter year.

The relevance of the credibility measure and its usefulness in summarizing agents' expectations

loss.

22 The resulting average rate of growth of domestic credit, used as the prior mean, tums out to be unexpectedly low. The extrapolation becomes of course less reliable as we move further into the past. For these reasons, the interpretation of the data-based prior as reflecting 'backward-looking' behaviour should not be overemphasized.

are illustrated in Table 5.2, which reports the correlation of the alternative credibility measures with several economic variables. Higher credibility is in all cases strongly associated with lower inflation, lower nominal and real interest rates, and a lower anticipated rate of depreciation of the peso, as measured either by the interest rate differential or the discount in the futures market. In summary, these findings strongly suggest that as confidence in the course of policy was reduced individuals required a higher rate of return in order to hold domestic assets, to compensate for the capital gains that foreign assets would yield should the authorities have to abandon their current policy. Estimation of the complete model, reported below, provides a test of this hypothesis.

5.2. The complete model

The complete structural model consists of equations (14) and (19). Preliminary single-equation experiments showed that lagged effects of the return variable could not be ruled out. As a result, both the current and one-period lagged expected depreciation of the peso is introduced in the right hand side of the relevant equations in (14). The constraint that both carry the same coefficient was not rejected by the data; thus the empirical equations can be compactly written as follows:

$$Prem_t = a_1[(1-q_t)v_t + a_2](RE^* - C(L)RE_t) \tag{5.1}$$

$$\ln\frac{ED}{PS} = \ln\frac{1-k_{md}-k_p}{k_p} + \sigma(g_d - g_p)\ln Y + \sigma\frac{Prem_t - Prem_{t-1}}{2} + b_1\, D1 \tag{5.2}$$

$$\ln\frac{EMD}{PS} = \ln\frac{k_{md}}{k_p} + \sigma(g_{md} - g_p)\ln Y + \sigma\frac{Prem_t - Prem_{t-1}}{2} + c_1\, D1 + c_2 D2 \tag{5.3}$$

$$\ln\frac{D}{MD} = \ln\frac{1-k_{md}-k_p}{k_{md}} + \sigma(g_d - g_{md})\ln Y + d_1\, D1 + d_2 D2 \tag{5.4}$$

where $D1$ and $D2$ are dummy variables equal to zero prior to 1982-1 and after 1978-IV, respectively, and a_2 is that adjusts for the choice of units for v_t as discussed earlier. Observe that the model involves the cross-equation restriction that the two estimates of the elasticity of substitution obtained in equations (5.2) and (5.3) be equal. Rejection of this constraint by the data could be a symptom of model misspecification. The hypothesis that political risk perceptions affect both domestic assets symmetrically can be formulated as $b_1 = d_1$; observe that this hypothesis will imply $c_1 = 0$ in our model. To test these restrictions, we use the quasi-likelihood ratio test discussed by Gallant and Jorgenson (1979). Because the constraints are never rejected by the data, the results reported below correspond to the respective constrained models; the relevant test statistics are also presented.

The model in its alternative specifications was estimated by nonlinear iterative three-stage least squares. Since the linear dependence between the asset demand equations makes the covariance matrix of the four-equation model singular, we could arbitrarily drop one of the asset demand equations and estimate the rest by three-stage least squares. However, the estimates thus obtained may not be invariant to the choice of which equation to exclude. To avoid this problem, an iterative procedure must be used (see Berndt and Savin (1975)). Estimation of the lag polynomial $C(L)$ in equation (5.1) encountered the usual problem of a strong autocorrelation of the real exchange rate series; to avoid it a simple two-lag average was imposed.

Estimation results for equations (5.1), (5.2), and (5.3) – we have excluded equation (5.4) – appear in Table 5.3. On the whole, the results are quite good and very supportive of the theoretical specification of the model. The explanatory power of the equations is rather satisfactory, and the Durbin-Watson and Box-Pierce statistics show no evidence of serial correlation in the residuals. It can also be seen that the parameter estimates of the asset demand equations are fairly insensitive to changes in the prior beliefs.

All the coefficients in Table 5.3 are highly significant and carry the expected signs. In equation 5.1, the mixed credibility-PPP formulation captures more than 90 percent of the variation in the anticipated rate of depreciation of the peso. Using q, v and the estimate of a_2 we can compute the subjective probability of immediate devaluation. Its time path tums out to be very similar for the three alternative sets of prior beliefs, and so it is reported only for the diffuse prior in Figure 5.2. Although its pattern is qualitatively similar to that of the credibility measure, its value is substantially lower in the early portion of the sample – as should be expected – but approaches the latter in the final observations. This suggests that the effects of low credibility only became dominant in the last few quarters of the period. Equation 5.1 also yields an estimate of RE^*, the implicit equilibrium real exchange rate. Its value turned out to be somewhat high; the hypothesis that it be equal to the level attained after the August 1982 devaluation cannot be rejected at conventional significance levels.

Equations 5.2 and 5.3 explain the movements of the relative currency holdings rather satisfactorily; more than 90 percent of the variation in the dependent variable is accounted for in each case. The point estimate of the elasticity of substitution is around 1.7, significantly greater than one in all cases. In our specification, this implies that the short run elasticity of substitution is about 0.85. The estimate of b_1 is positive and significant, confirming that political uncertainty may have induced a shift towards U.S. dollars in the final periods of the sample; the 'liberalization dummy $D2$ is also significant in equation 5.3. The estimates of the g_1 and k_1 coefficients can be used to obtain an idea about the properties of the implied transactions technology; evaluating the $k_i(Y)$ terms of equation (12) at the sample mean of Y the relative 'transactions efficiency' of each currency can be computed. The resulting values (relative to the efficiency of dollars held in the U.S.) appear also in Table 5.3. Not surprisingly, local currency enjoys a clear advantage in this sense, while mexdollars are also superior to holdings of dollars abroad. It is interesting to note that some results reported by Ortiz (1982) can be interpreted in a similar manner: he finds a positive income elasticity for peso balances but zero elasticity for the combined holdings of pesos and mexdollars.

The test statistic for the joint hypothesis that (i) $c_1 = 0$ and (ii) both equations yield identical estimates of σ appears also in Table 5.3. Under the null, it is asymptotically distributed as a Chi-squared with two degrees of freedom. The test fails to reject overwhelmingly.

6. Concluding remarks

A collapse of the public's confidence in the feasibility of the current course of policy is the typical detonant of balance of payments crises. In this paper we have used a Bayesian framework to model the way in which subjective beliefs are formed and updated. By incorporating over time the realizations of government policies to their information sets, individuals are able to form at each moment a subjective judgement about the sustainability of the policy regime. This analysis has been applied to the case of México in 1977-82, where Progressive relaxation of the fiscal discipline combined with unrestricted capital mobility and a (practically) fixed exchange rate eventually led to the collapse of the external payments mechanism and its replacement by a system of exchange Controls. Using a credibility measure constructed in Bayesian fashion from Mexican data under alternative prior beliefs, higher credibility was shown to be associated with lower nominal and real interest rates, and also with lower interest rate differentials and future discounts in the foreign exchange market. In short, the maintenance of an incredible course of policy requires that investors be payed a premium for holding domestic assets.

In order to verify the usefulness of this approach, we went one step further by integrating the credibility analysis into a model of currency substitution that was empirically tested using Mexican data. To do this, an optimizing model was formulated in which individuals are allowed to hold multiple currencies to reduce transaction costs, with alternative currencies being characterized by their different transactions efficiencies and pecuniary returns. The model's first order conditions provide testable implications for the pattern of relative currency holdings as function of relative returns and transactions efficiencies, with credibility, reserves and PPP being the essential determinants of the return differential on foreign currency denominated money balances.

The complete model was estimated using Mexican data for 1977-82. The results are very supportive of the theoretical specification; in particular, a sizeable elasticity of substitution between holdings of the three alternative currencies accessible to Mexican investors – pesos, mexdollars and dollars – is found, along with reasonable characteristics for the implied transactions technology. The role of credibility in determining optimal asset holdings is also validated by the data. The results suggest that the public's belief that the course of economic policy was unsustainable, together with the perception of political risks affecting domestic assets, were the major explanatory factors behind the commotion that Mexican financial markets experienced in 1981-82.

In summary, the approach to the formation and updating of subjective beliefs adopted in this paper appears to agree well with the data. The empirical results, on the other hand, seem also to confirm the crucial importance of these beliefs for the viability of economic policy.

Table 2.1

Selected Economic Indicators, 1977-82

	1977	1978	1979	1980	1981	1982
Real GNP[a]	3.4	8.2	9.2	8.3	7.9	-0.5
Public deficit[b]	6.8	6.7	7.3	7.5	14.5	17.9
Current account[c]	-2.0	-2.6	-3.6	-3.9	-5.2	-1.7
Capital flight[d]	.0	-.1	.7	-3.6	-8.3	-8.3

[a]Annual rate of growth
[b]As percentage of GNP
[c]As percentage of GNP
[d]Errors and omissions of the dollars
Source: Banco de Mexico

Table 5.1

Alternative prior beliefs

Prior	dc_0	T_0	s_0^2	DF_0
Diffuse	-	-	-	-
Data based	.075	4	.010	3
Neutral	.098	4	.010	3

Table 5.2

Correlation between the subjective credibility measure and some economic variables

	Prior		
Variable	Diffuse	Data based	Neutral
Nominal interest rate	-.86	-.89	-.91
Inflation rate	-.50	-.56	-.54
Forward discount	-.68	-.74	-.74
Interest differential	-.69	-.74	-.74
Real interest rate	-.86	-.89	-.90

Notes: The nominal interest rate is the yield on 90-day CD's. The forward discount is the 90-day discount on the peso. The interest differential is measured against Eurodollar rates. The real interest rate is measured using the CPI inflation rate.

Table 5.3

Estimation results for equations 5.1, 5.2 and 5.3 (Prior beliefs)

Parameter	Diffuse	Prior beliefs Neutral	Data-based
a_1	.224 (.106)	.261 (.109)	.231 (.106)
a_2	.168 (.025)	.166 (.024)	.164 (.025)
k_m	.029 (.012)	.029 (.012)	.028 (.012)
k_p	.023 (.008)	.023 (.009)	.023 (.009)
$g_{md} - g_p$	-.315 (.064)	-.315 (.063)	-.313 (.064)
$g_d - g_p$	-1.051 (.078)	-1.049 (.077)	-1.051 (.078)
b_1	.048 (.021)	.048 (.021)	.048 (.021)
c_2	-.091 (.023)	-.091 (.023)	-.091 (.023)
σ	1.655 (.111)	1.661 (.111)	1.651 (.111)
RE^*	3.857 (.572)	3.702 (.428)	3.822 (.541)
Relative efficencies:			
Peso	6.282	6.238	6.304
Mexdollar	1.468	1.464	1.470
Dollar	1.00	1.00	1.00
Test of the restrictions[a]:			
$X^2(2)$	.030	.036	.028

Table 5.3 (continued)

Summary Statistics

	Diffuse	Neutral	Data-based
Equation 5.1			
R^2	.925	.926	.925
$S.D.$	.061	.061	.061
$S.E.E$	.017	.017	.017
DW	2.20	2.17	2.20
$X_{BP}^2(10)$	4.23	2.83	4.32
Equation 5.2			
R^2	.913	.913	.913
$S.D.$	.199	.199	.199
$S.E.E$	.059	.058	.059
DW	2.14	2.14	2.14
$X_{BP}^2(10)$	4.37	4.33	3.90
Equation 5.3			
R^2	.944	.944	.944
$S.D.$	.162	.162	.162
$S.E.E$	.038	.039	.038
DW	2.25	2.17	2.25
$X_{BP}^2(10)$	3.95	3.89	3.85

Notes: [a]Joint test of the constraint $c_1 = 0$ in eq. 5.3 and the cross-equation constraint on σ.
$R - squared$ is computed as $1 - SSE/SST$
$S.D.$ = standard deviation of the dependent variable
$S.E.E$ = standard error of the regression 2
X_{BP}^2= Box-Pierce Statistic

Mexico

Nominal and Real Effective Exchange Rate Indices

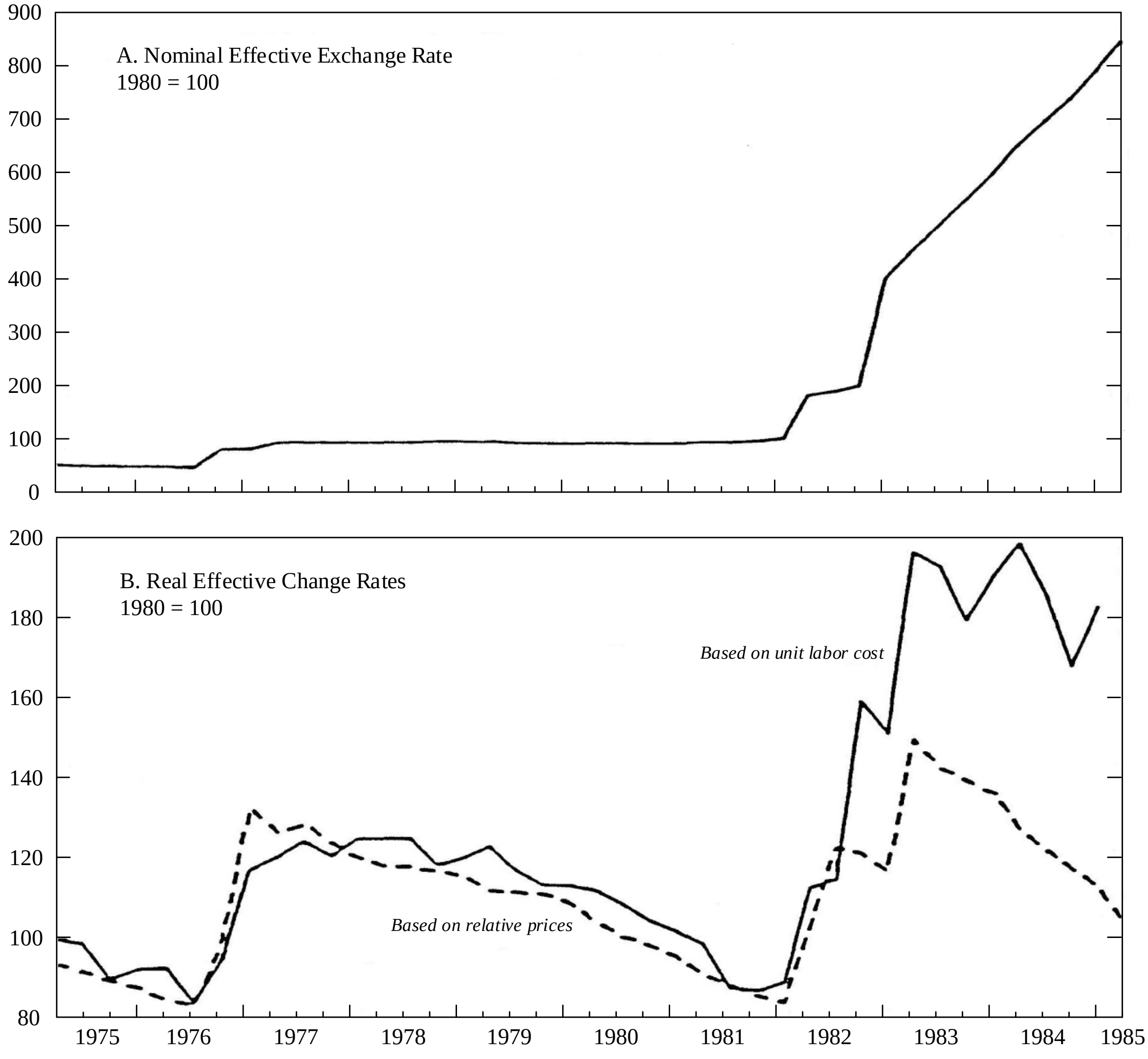
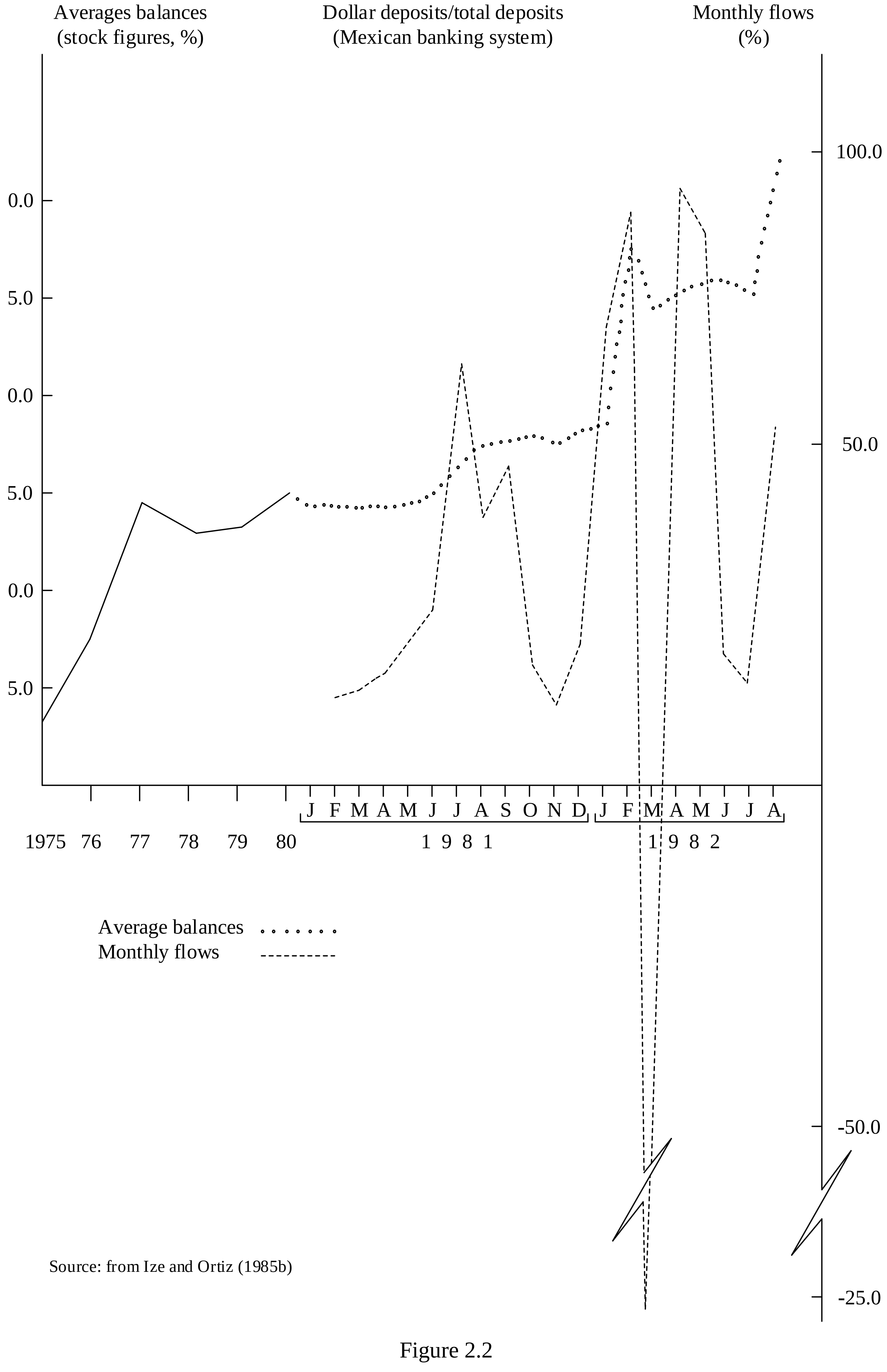


Figure 2.1

Source: from Ize and Ortiz (1985b)



Source: from Ize and Ortiz (1985b)

Figure 2.2

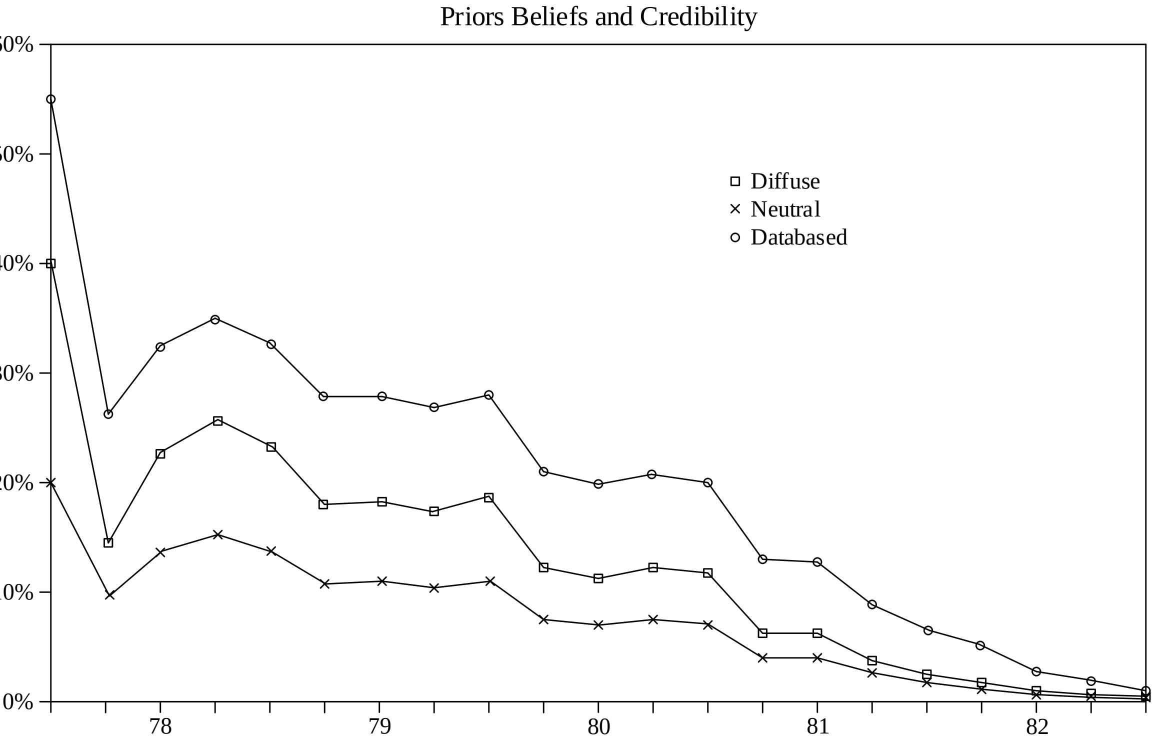


Figure 5.1

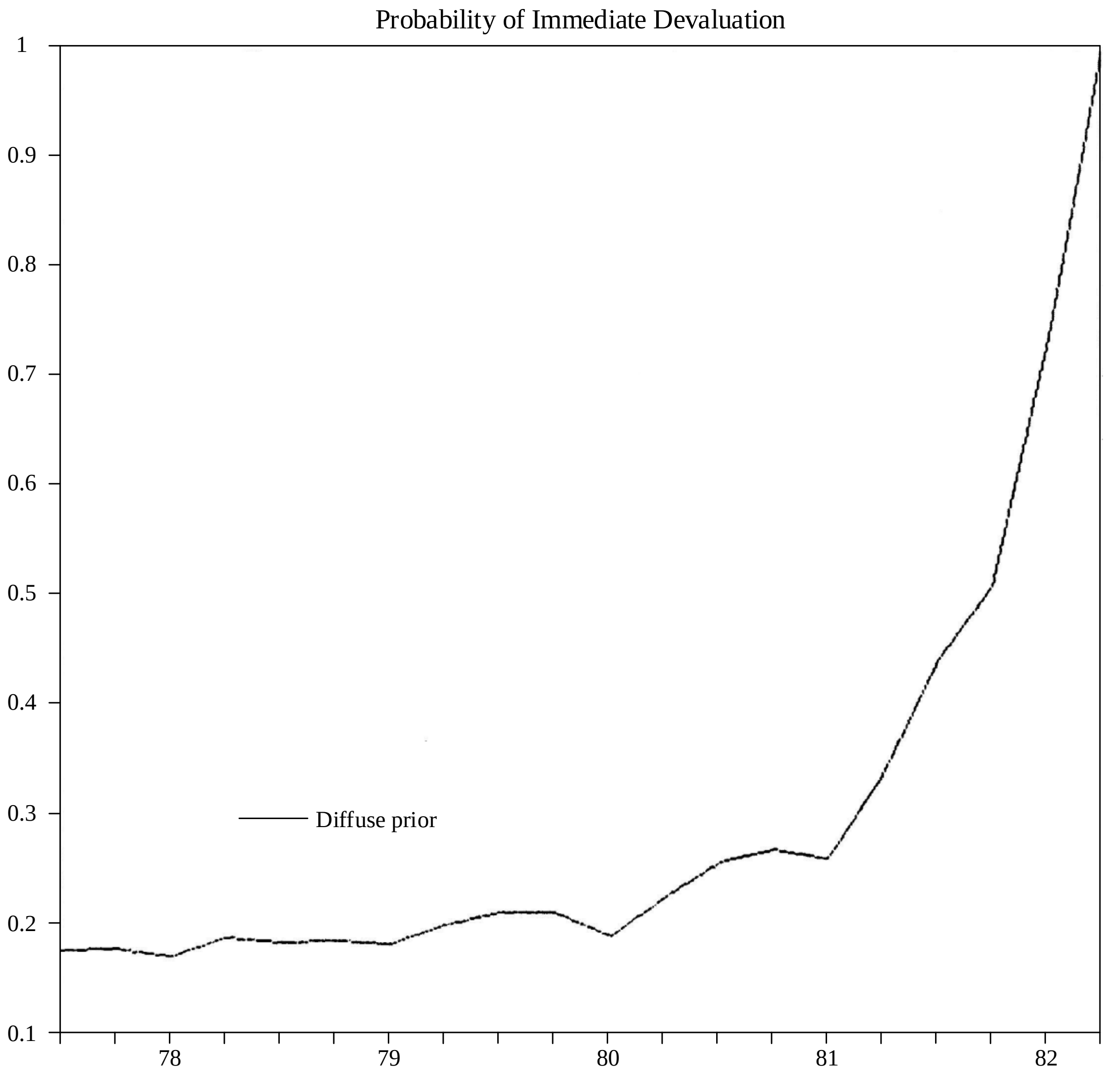


Figure 5.2

Data Appendix

Data for peso and mexdollar demand deposits, the nominal exchange rate, domestic credit, Mexican Wholesale prices and industrial production were obtained from various issues of the monthly publication “Indicadores de Actividad Economica”, published by Banco de Mexico.

Data for foreign reserves held by Mexican monetary authorities, the current account and U.S. Wholesale prices were obtained from International Financial Statistics.

Data on demand deposits held by non-affiliated Mexican residents in U.S. chartered Banks are from the U.S. Treasury Bulletin (monthly).

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