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Testing for Credibility Effects

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Abstract

This paper examines some recent techniques designed to draw inferences about the credibility of changes in macroeconomic policy regimes. An alternative two-step approach, based on the decomposition between permanent and transitory components of a "credibility variable" is proposed. The methodology is then used to test for the existence of a credibility effect in the Cruzado stabilization plan implemented in Brazil in 1986.

JEL Classification Numbers:

C4, E3, E6

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I. Introduction

The role of credibility factors in the design of a disinflation program has been a major focus of research in macroeconomics over the past decade. 1/ It has been argued that credibility about a future change in the course of policy may be able directly to reduce the costs of disinflation by changing inflationary expectations. To reduce inflationary expectations effectively in accordance with the disinflationary goal, a newly implemented policy must appear credible to the public. Since inflationary expectations have a significant influence on current wage and price decisions, a reduction in actual inflation may result. To the extent that it is quantitatively significant, this "expectations effect" suggests that there is a potential gain (in terms of output and unemployment) in establishing the credibility of a monetary disinflationary program. 2/ By contrast, when policies implemented lack credibility--because, for instance, they are inconsistent with each other--rational agents would eventually recognize that the announced program is not sustainable in the long run, and fears of the program's collapse would become self-fulfilling.

In a world with imperfect information, however, the speed at which the economy will react to a major change in the policy regime may be slow. 3/ Even if a change in regime is sufficiently credible --in the sense that policies are consistent and are believed by agents--the economy may not move quickly to a new equilibrium with lower price expectations. Indeed, instant credibility is unlikely in a stochastic world, and rational individuals would typically learn gradually about the new environment (Taylor, 1975). Ascertaining how quickly economic agents perceive a change in their environment has important implications for the short-run impact of policy changes.

Despite the importance of this issue for the conduct of macro-economic policy, there have been only limited attempts to examine

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1/ See, for instance, Calvo (1989), Calvo and Végh (1991), Dornbusch (1991), and Orphanides (1989). For recent reviews of the literature on credibility in macroeconomics, see Blackburn and Christensen (1989), and Cukierman (1991).

2/ The importance of expectations in a disinflationary process has been emphasized by a number of authors, including Baxter (1985), Lächler (1988), and Sargent (1982, 1983).

3/ Regime changes refer to such events as changes in tax legislation, strikes, the imposition of price controls, etc. These alter the economic environment or institutional rules in which agents pursue economic objectives. Underlying tastes and preferences may remain the same across regimes, but the optimal response is different under the new conditions.

empirically the evidence related to regime changes. 1/ The purpose of this paper is to analyze alternative procedures to estimate the size of, and the diffusion effect of, credibility effects in the context of stabilization policies. The paper focuses on an analysis of the time-series properties of the inflation rate in high-inflation developing economies, using as an example the Cruzado Plan implemented in Brazil during 1986.

The remainder of the paper is organized as follows. Section II examines some basic conceptual issues in analyzing the role of credibility factors in the context of stabilization policies. Section III presents a critical review of existing methods designed to test for credibility factors. Section IV presents an alternative two-step procedure, which is not affected by the drawbacks of some of these methods. Section V applies the methodology to test for the existence of a "credibility effect" in the first phase of the Brazilian Cruzado Plan of 1986. The final section summarizes the main results of the analysis and discusses some possible extensions.

II. Credibility and Disinflation Policies: Analytical Issues

It has long been recognized that when the public lacks confidence in the ability of politicians to carry out a newly-announced stabilization program, disinflation becomes more difficult to achieve. The lack of confidence has been shown to result from a variety of sources. First, the government's stabilization program may be perceived as being inconsistent with other policies being pursued simultaneously, and be recognized as such by the public. For instance, a disinflationary program which does not include measures to limit the public sector budget deficit will lack credibility --irrespective of whether "orthodox" or "heterodox" policies are called for--because the public understands its inconsistent nature. 2/ As discussed below, one of the key reasons why the Brazilian Cruzado Plan implemented in 1986 lost credibility rapidly was because private agents became gradually aware that the public sector budget at the onset of the stabilization was not balanced. 3/

1/ One reason for this relative lack of interest might be the skepticism of many economists regarding the practical relevance of the Lucas critique. See the discussion below.

2/ See Auernheimer (1987) for a formal analysis of the implications of "inconsistent" programs that violate the long-run government budget constraint.

3/ Lächler (1988) has argued that credibility problems may arise independently of whether the macroeconomic policy mix adopted is consistent or not, but rather from the unfavorable dynamic adjustment pattern associated with exchange rate-based stabilization programs in small open economies.

Secondly, the lack of credibility may result from a time-inconsistency dilemma for the government: its optimal ex-post strategy may differ from its ex-ante strategy. For instance, once nominal wages are set by the private sector, the authorities may find it tempting to disinflate less than they had promised to, in order to generate output gains (Barro and Gordon, 1983a). This arises in the context of a model in which a monetary authority is concerned about both inflation and unemployment in a world governed by an expectations-augmented Phillips curve. The policymaker wants everyone to expect low inflation, so that it will face a favorable trade-off between inflation and unemployment. But an announcement of a policy of low inflation is not credible. Once expectations are formed, the authority has an incentive to renege on its announcement in order to reduce unemployment. 1/ Private economic agents understand the incentive to renege and therefore do not believe the policy announcement in the first place. The general implication of this analysis is, therefore, that in circumstances in which a policymaker has an ex-post incentive to renege on its promises, rational agents will discount announcements of future policy actions--or assurances regarding the continuation of present policies.

A third source of credibility problems is incomplete or asymmetric information: private agents may not be able to assess how serious the government really is about stabilizing the economy. Imperfect information of this sort is particularly prevalent in developing countries, where policymakers tend to change rapidly, generating "confusion" about the true policy objectives. 2/

Finally, a fourth source of credibility problems results form the uncertainty regarding the predictability of policy reforms or measures. In a stochastic world, even if a program is coherently formulated and time-consistent--in the sense that policymakers have no incentive to depart from the announced policy measures--exogenous shocks may occur which may be large enough to throw the program "off track". Such shocks may be external in nature (such as, for instance, the behavior of world oil prices or interest rates) but may also result from the policy environment itself, in particular when the authorities have imperfect control over policy instruments. For instance, the announcement of a fiscal target will not be fully credible if the government does not adequately control the level of

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1/ The policymaker's incentive to inflate need not be motivated by employment considerations; it can also arise due to the presence of short-term rigidities in the tax system or because the government wants to reduce the real value of its nominal debt (Cukierman, 1991).

2/ This source of credibility problems is substantially different from the time-inconsistency case discussed above, wherein private agents perceive only too well the policymaker's motivations.

government expenditure. Another example relates to a situation in which the rate of inflation depends on the rate of expansion of domesit credit, which in turn depends on both deterministic and stochastic factors. Private agents will in general be aware of this and will accordingly form a probability that the policy target will not be met. 1/ The lower the degree of precision over policy instruments, the more likely it is that agents will anticipate the possibility of a future collapse of the stabilization effort. 2/ The lack of policy predictability may create, therefore, doubts about the sustainability of the reform process, and will affect the degree of credibility of an otherwise consistent and "viable" program. 3/

An important distinction which has often been blurred in the recent literature is that between reputation and credibility. In general, reputation refers to a government, while credibility refers to a given policy. Clearly, these concepts are related: an "anti-inflationary" reputation can only be established by a track record of continuously low-inflation policies. This distinction is, however, important for empirical analysis and will be examined below.

The analysis in this paper does not focus on any particular source of credibility problems discussed above. It is, in practice, very difficult to test for the existence of one particular type of credibility problem, and few authors have indeed attempted to do so in the past few years. 4/ Rather, most researchers have worked on the general premise that a "credible" disinflationary program will translate into a change in the process driving prices, while a program which lacks credibility will have no discernible effect. We now examine how this general presumption has been implemented in practice.

1/ In a sense, the lack of credibility results from the inability of the policymaker to precommit his actions in response to different states of the environment. Although, in principle, fully contingent mechanisms might eliminate this source of credibility problem, they are hard to formulate in practice.

2/ The anticipation of a future possible abandonment of the stabilization attempt will affect immediately the behavior of private agents. A model of the inflationary process which captures these features is provided by Flood (1982).

3/ The implications of the lack of control over government spending and its effects on the likelihood of collapse of a stabilization program is examined in Agénor and Bhandari (1991).

4/ Bordo and Redish (1990) provide a recent attempt to test for the existence of a time-consistency effect in exchange rate policy. An empirical method for evaluating the credibility of a time-inconsistent policy rule is provided by Masson and Symansky (1990), in the context of a multi-country simulation model.

III. Testing for Credibility Effects: An Overview

This section provides a critical review of recent techniques designed for testing for the presence of credibility effects. 1/ We emphasize both the conceptual and empirical limitations that various tests are faced with. 2/

In testing for credibility effects, it is important to distinguish the immediate effects occuring when a change in policy is announced, which we shall call the announcement effect, and the effects occuring after agents have experienced that the announced policy change really has been pursued, which we shall call the implementation effect. 3/ This is important, since a policy change may gain credibility only gradually. As shown below, some methods have implicitly assumed that credibility is gained instantaneously, and have focused on the announcement effect.

1. Prediction-error method and proxy variables

Most empirical analyses of policy credibility so far have made use of the prediction-error method. 4/ Essentially, the method consists in estimating, over the pre-reform period, a model of the inflationary process and forming predictions over the post-reform period. A disinflationary policy is deemed credible if such predictions

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1/ Because of our focus on high-inflation developing economies, this review excludes recent papers which have attempted to draw inferences about the credibility of policy by examining the stability of the relationship between short- and long-term interest rates; See Andersen and Risager (1988), Christensen (1987b), Driffill (1990), Hamilton (1988), and Mankiw et al. (1987). The last paper aims at assessing the credibility of the regime change involved in the setting-up of the U.S. Federal Reserve in 1914.

2/ The use of dummy variables of the intercept-shift variety for modelling regime changes in time series regressions is widespread but is not examined here. Such a procedure has been shown to lead to substantial misspecification (Corker and Begg, 1985). More importantly, as emphasized by Lucas (1976), if a regime change alters the process that is generating inflation, it would also be expected to alter the way in which expectations are formed and therefore the estimated structure of the economy. Consequently, structural breaks or regime changes cannot be accounted for by a shift dummy alone.

3/ A similar distinction is emphasized by Christensen (1990).

4/ See for instance Blanchard (1984), Christensen (1987a) and Kremers (1990). In the first two papers, the process to be explained relates to the nominal interest rate, instead of the inflation rate.

overestimate actual values of the inflation rate during the "new" regime, simply because the model has proved unable to account for such a regime change. 1/ The precise nature of predictive failure tests used in these applications varies, of course, but quite often are variants of a Chow stability test (see Harvey, 1990).

However, this procedure provides in general an unsatisfactory test of the credibility hypothesis because such prediction errors might explain almost anything not considered explicitly in the model --just as dummy variables would. Only in the case in which the residuals are due solely to the absent credibility variable (that is, if the model is correctly specified) will the prediction error method prove useful in testing for credibility effects.

An alternative procedure which can allow proper identification of a regime break is to define and include in the regression model a "credibility variable" explicitly and to test for its significance and stability over time. Christensen (1987b, 1990), for instance, has used the variability of the exchange rate as a proxy variable for credibility of an exchange rate regime. He argues that a necessary condition to sustain high credibility is that the variability of the exchange rate becomes positively correlated with the nominal interest rate. In the context of a disinflationary program in developing countries, the spread between the parallel market exchange rate and the official rate has often been used as an indicator of the degree of confidence in macroeconomic policies (see, for instance, Dornbusch et al. 1990).

There are, however, difficulties associated with the use of proxy variables for credibility, either because of the largely arbitrary way in which they are defined, or because of the failure to recognize their endogenous nature. For instance, in Christensen's study mentioned above, measuring the credibility variable by the standard deviation of the exchange rate and thereby restricting credibility to be affected equally by appreciations and depreciations of the domestic currency may be inappropriate. In the case of developing countries, the parallel market premium itself may be an inadequate indicator of credibility because it is an endogenous variable, which responds to both the behavior of "fundamentals" (money supply, foreign prices etc.) and the degree of confidence. In our procedure described below, a solution to this problem is proposed.

1/ Structural models have typically been used for this purpose (see, for instance, Kremers, 1990), but some authors have used a vector autoregression procedure (see Giavazzi and Giovannini, 1988). In the latter procedure, evidence of a regime shift is determined by examining the impulse response functions in two sub-samples.

2. Bayesian learning procedure

An alternative procedure, which may be particularly appropriate when agents learn progressively about a change in regime, is to formulate a Bayesian learning procedure and derive explicitly a probability that a disinflationary program will collapse. Credibility, in this context, is high when the probability of failure is low.

Baxter (1985) has provided an application of these ideas in her attempt to measure the evolution of "credibility" after the introduction of a pre-announced exchange rate policy in Argentina and Chile, in the late seventies. In her model, agents observe the pattern of public deficits and domestic money creation, and then estimate, through a Bayesian procedure, whether or not that pattern is compatible with the announced exchange rate rule and thus sustainable in the sense of not violating any steady-state equilibrium conditions. Her findings show that the measure of credibility declines over time for the Argentinian policy but not for that of Chile--which nevertherless experienced the same ultimate fate. Furthermore, her empirical measure of credibility correlates well with various observed economic variables (for instance, interest and inflation rates) in Argentina, and not in Chile, thus suggesting that market participants also rely on sources of information other than domestic money creation and fiscal deficits. 1/

A Bayesian procedure for estimating reputational and credibility effects has also been developed by Weber (1991), who measures an anti-inflation reputation by the probability that policymakers consistently pursue low-inflation policies, that is, the government's resolve to pursue its efforts. This probability is derived by learning over time from the actual behavior of the policymakers. Formally, this probability is estimated by a Bayesian procedure which consists in finding how inflation could be forecasted over a given period under various alternative assumptions about the degree to which inflation shocks are allowed by the central bank to become permanent. The relative success of these forecasts is then evaluated over time. In particular, the procedure determines the probability that a weighted average of the various forecasts predicts inflation better than each of them separately. The weight attached to the "low-inflation" forecast yields the required measure of anti-inflation reputation.

1/ This should not appear surprising, if only because many of the relevant government statistics appear with considerable lags, forcing agents to initially seek other indicators. Moreover, it is questionable whether official statements concerning the deficit and money creation will be fully believed, since they cannot be immediately verified (in contrast to announced exchange rates) and given that the government would have an incentive to be less than candid or withhold information if in fact its policies were inconsistent.

Following Cukierman and Meltzer (1986), Weber defines credibility as the extent to which beliefs concerning a policy conform to official announcements about this policy. To achieve credibility, policymakers must precommit themselves to a particular policy rule. Such a pre-commitment may or may not be binding. Credibility is thus viewed as a measure of the degree to which policymakers "tie their hands" on future policies by issuing policy announcements. Again, following Cukierman and Meltzer (1986), Weber defines two measures of credibility. The first one measures <u>average credibility</u>, and estimates the extent to which private agents expect policy outcomes to deviate from prior policy announcements. The second measure estimates <u>marginal credibility</u>, and focuses on the ability of policy announcements to influence the public's expectations; it measures the impact of a change in the announcement on expectations and may be thought of as the weight placed on the announcement when the public forms its expectations. This weight is equal to unity if the policymaker always makes completely accurate (fully credible) announcements and tends towards zero as the announcements become non-credible.

Weber uses univariate time-series models to evaluate how expectations of the public are affected by policy announcements. 1/ In this approach, however, it is difficult to distinguish between changes in the goodness-of-fit of the time-series model generating

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1/ Weber examines the credibility of money, exchange rate and interest targeting in *EMS* countries. To determine the credibility of monetary announcements for instance, his procedure consists in estimating the following processes:

$$m_t = \alpha m_{t-1} + \epsilon_t, \qquad m_t^a = \beta m_{t-1}^a + \zeta_t,$$

where $E(z_t | \Omega_{t-1}) = 0$; $E(z_t z_t | \Omega_{t-1}) = \sigma_z^2$, $z_t = \epsilon_t$, ζ_t; m_t^a denotes the policy announcement; and m_t actual money growth. The optimal prediction of planned policy conditional on information available up to period t-1 is given by

$$E(m_t | \Omega_{t-1}) = \Theta E(m_t | m_{t-1}, m_{t-2}, \ldots) + (1 - \Theta)E(m_t^a | m_{t-1}^a, m_{t-2}^a, \ldots),$$

or, if a policy announcement is made at the beginning of period t,

$$E(m_t | \Omega_{t-1}, m_t^a) = \Theta E(m_t | m_{t-1}, m_{t-2}, \ldots) + (1 - \Theta)m_t^a,$$

where the optimal weight $0 < \Theta < 1$ is calculated by selecting the value of Θ which minimizes the overall sum of squared deviations from the expectation $E(m_t | \Omega_{t-1})$ given above and the actual outcome m_t.

expectations and changes in the credibility of policymakers, because possibly relevant variables are excluded from the model. This can be a serious problem if policy announcements are correlated with some of the omitted variables. The results can be even more misleading if the relationships between policy announcements and other relevant factors change during the sample period. A multivariate approach system can mitigate this problem, as discussed below. Moreover, Weber's procedure does not allow an explicit examination of the effect of credibility on the persistence of the inflationary process.

3. Time-varying parameters and the Lucas critique

Closely related to the credibility hypothesis is the Lucas critique (see Lucas, 1976) which states that policy regime changes affect the parameters of reduced-form models. 1/ The usual procedure for testing the relevance of the Lucas critique has been to compare regression coefficients across different regime periods, but this method also seems unsatisfactory because parameter instability may be due to general mispecification rather than the Lucas critique. It is therefore important that one allows parameters to vary directly with the policy variable, which has been done by estimating a time-varying parameter model.

Time-varying procedures have been developed and used by several authors to examine the timing of the change in the stochastic process driving inflation and interest rates. 2/ A particularly interesting technique is the method used by Mankiw *et al*. (1987). 3/ The approach allows the determination of the most likely date for the change in regime, conditional on the assumption that the change occurred all at once. It also allows for the possibility of a gradual change in regime--a particularly useful case, when credibility only builds through time.

1/ See, however, Favero and Hendry (1990) and Sims (1987) for a critical evaluation of the Lucas critique.

2/ Corbo and McNellis (1989), for instance, use a time-varying parameter technique to estimate price equations in economies where the degree of openness of the trade account changes during the estimation period.

3/ An alternative technique is the Markov process model for regime shifts, developed by Hamilton (1988). In practice, however, estimation of the Markov switching process has met with considerable difficulties (see for instance Driffill, 1990) and is not discussed here.

Suppose that the process for the inflation rate obeys

$$\pi_{t+1} = \alpha_0 + \alpha_1 \pi_t + \epsilon_{t+1}, \qquad t = 1, \ldots, T_s - 1, \qquad (1a)$$

$$\pi_{t+1} = \beta_0 + \beta_1 \pi_t + \epsilon_{t+1}, \qquad t = T_s, \ldots, T \qquad (1b)$$

where T_s is the switch date (the first period of the new regime). Assuming normal errors, the log-likelihood function for this model is

$$\log L = -(T/2)\log(2\pi) - (T_s - 1)\log(\sigma_o^2) - (T - T_s + 1)\log(\sigma_n^2) \qquad (2)$$

$$- (1/2)\sum_{t=1}^{T_s-1}(\epsilon_{t+1}^2/\sigma_o^2) - (1/2)\sum_{t=T_s}^{T}(\epsilon_{t+1}^2/\sigma_n^2),$$

where σ_o^2 and σ_n^2 are the error variances in the old and new regimes. The maximum likelihood value for T_s can be determined by computing the maximum likelihood estimates of the parameters for all possible T_s's and then choosing the value of T_s with the maximum likelihood. This "switching regression" procedure was suggested by Goldfeld and Quandt (1973).

A second procedure for determining the timing of the change in the inflation process is to estimate a time-varying parameter model that allows the coefficients of the equation to change gradually over time, rather than moving instantaneously from the old to the new values as in the switching regression above. Mankiw *et al*. (1987), assume that the parameters in a model similar to (1) follow a logistic curve. 1/ Their approach allows the calculation of the rate of adjustment between changes in regime. Because the limit of the logistic curve is the step function, this procedure includes the earlier process as a special case.

A difficulty with the switching-regression technique is that, with a single switch point, it is only useful for examining regime shifts which are both credible and permanent within the data sample period. In many cases, stabilization programs may achieve credibility for a limited period before breaking down. Extending the above analysis to allow for such a situation would involve allowing for two or more switch points.

1/ In their analysis, Mankiw *et al*. focus on the short-term interest rate, rather than inflation as in (1).

IV. An Alternative Approach

We now present an alternative technique, which is less vulnerable to the limitations of some of the procedures described earlier. Our analysis rests on two key assumptions. First, inflation is, because of inertial forces (wage contracts, financial indexation, *etc.*) a slow-moving process, which displays considerable persistence. 1/ Second, the transitory component of the parallel market premium and not its level is the appropriate proxy to measure the degree of credibility of a stabilization package. 2/ When a disinflationary program lacks credibility, agents will typically anticipate a resumption in inflation in the future. As a consequence, to avoid the inflation tax on real monetary balances, they switch to foreign-currency denominated assets. For given supply, the parallel market exchange rate depreciates, and the premium rises. The premium captures, therefore, the degree of confidence in existing policies (see Agénor and Bhandari, 1991). However, the premium is an endogenous variable, and its level will also reflect the behavior of "fundamentals"--domestic credit, foreign prices, *etc.* It is therefore important to "purge" the variable to account for this endogenous component, since these will typically be altered at the inception of a stabilization attempt.

To test for the existence of a credibility effect on the behavior of inflation, we then examine the relationship between the coefficients driving the inflationary process, and the transitory component of the premium. Such a relationship is estimated via a Kalman filter procedure.

1/ In the Appendix we demonstrate, using a simple open-economy macroeconomic model with overlapping wage contracts of the Fischer-Taylor variety, that the degree of inflation persistence is positively related to the perceived degree of monetary and exchange rate policy stringency and negatively related to the degree of credibility of a non-accomodative monetary policy. Inflation persistence is shown therefore to result not only from backward-looking elements per se but also from the lack of credibility in disinflation policies.

2/ The parallel market premium is probably the variable most sensitive to market expectations regarding current and future government policies, and as changes in expectations are crucial in attempting to identify credibility effects, it seems natural to concentrate on its behavior. For some industrializing countries, an alternative variable could be the index of stock prices.

1. Estimating the credibility variable

The first step in our procedure is to decompose the the parallel market premium, ρ_t, into a "systematic" (permanent) component and an "error" (transitory) component which will be taken as a measure of credibility. To do so, the procedure suggested here would start by estimating a static regression or a vector autoregression (*VAR*) system, which includes "fundamental factors", captured in the vector of predetermined variables z_t: [1],[2]

$$\rho_t = z_t \delta + u_t,$$ (3a)

$$\begin{bmatrix} \rho_t \\ z_t \end{bmatrix} = \delta(L) \begin{bmatrix} \rho_t \\ z_t \end{bmatrix} + u_t, \qquad \delta(L) = \delta_1 L + \ldots$$ (3b)

where δ and δ_k, $k = 1, \ldots,$ denote vectors of parameters and u_t a white noise process.

A vector autoregression formulation is a natural one to estimate when ρ_t is known to respond to "fundamentals" according to some theory, but the exact form of the relationship is unknown. By focusing on a multivariate time-series representation in which lagged values of the premium as well as other variables affect its current value, we are assuming that agents use all available information in forecasting the premium. The negative of the transitory component can be taken as an indicator of expectations, or, more generally, confidence. In this procedure, therefore, it is not the premium itself but rather its transitory component that is interpreted as the credibility variable. By construction, the residuals from (3a) or (3b) are unbounded and have zero mean over the estimation period. [3] It is therefore important to consider a sample large enough (relative to the period of interest) if one is to avoid imposing inadequate

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[1] An autoregressive formulation for the premium (using, for instance, the Beveridge-Nelson decomposition between permanent and transitory components) would usually be inadequate, because it would not take account of the current behavior of fundamentals.

[2] An instrumental variable procedure is, of course, required to estimate (3a) if some elements of z_t are endogenous variables.

[3] This property does not, however, imply that the credibility variable has no permanent effect on the inflation process, because of the autoregressive nature of equation (4b) given below.

restrictions on the credibility variable. 1/

It is also important to note that any decomposition of an observable variable into a systematic and unsystematic components depends on the choice of information set, that is, on the choice of variables z_t: white noise on one information set can be predictable using another. Thus, there is an inherent lack of uniqueness in using white noise residuals as a criterion for data coherency, although non-random residuals do indicate data "incoherency". 2/ The *VAR* approach allows, however, to control for the environment to some extent without imposing "too many" *a priori* restrictions on parameters.

2. Credibility and inflation inertia

The second step in our procedure is to estimate a backward-looking process for inflation with parameters varying with the transitory component of the parallel market premium, using a Kalman filter approach. Assuming, for simplicity, that inflation, π_t, is driven by a first-order autoregressive process (an assumption which is tested below), and denoting by c_t the credibility variable, the system to be estimated is given by

$$\pi_t = \alpha_t \pi_{t-1} + \epsilon_t, \tag{4a}$$

$$\alpha_t = \alpha_{t-1} + \gamma c_t + \eta_t, \tag{4b}$$

where

$$\begin{pmatrix} \epsilon_t \\ \eta_t \end{pmatrix} \sim N\left\{ \begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma_\epsilon^2 & 0 \\ 0 & \sigma_\eta^2 \end{pmatrix} \right\} \tag{4c}$$

1/ This situation is very similar to the "peso problem" analyzed by Krasker (1980), in which agents attach a non-zero probability to an event which does not occur within the sample period. As in the present case, this is a small sample problem.

2/ Ideally, one would need a more structural framework which incorporates detailed knowledge of policies and institutions. However, unless such a structural model can be viewed as the "true" model of the economy--an implausible assumption--the inherent ambiguity which exists in relating expectations and model predictions (whether these are derived from an "atheoretical" *VAR* system or a structural model) will persist.

and π_t is in mean-deviation form. Equation (4a) represents the measurement equation and equation (4b) the transition equation. The disturbances ϵ_t and η_t are serially uncorrelated disturbances with zero mean and constant variances, and are assumed uncorrelated with each other in all time periods. The Kalman filter allows us to update the estimate of α through time, using a two-step methodology. The first consists in forming the optimal predictor of the next observation, given all information currently available, by means of a prediction equation. The new observation is then incorporated into the estimator of the state vector using the updating equation. The resulting estimates of α_t are "smoothed" over time, because they are based on all information available. 1/

The above discussion suggests that the resulting estimate of γ should be negative: the higher credibility is, the lower the "inertial" effect on inflation. Consequently, the coefficient α_t should fall after the implementation of a credible disinflation program. Although the procedure does not allow to give a precise interpretation to the size of γ, its sign is what matters.

V. Credibility of the Brazilian Cruzado Plan, 1986-87

This Section applies the methodology developed above to a recent stabilization experiment, the Brazilian Cruzado Plan, implemented in 1986-87. We first provide a brief overview of the Plan, before considering the econometric results.

1. An overview of the Cruzado Plan

The Brazilian Cruzado Plan, introduced at the end of February 1986, consisted of a general freeze of prices, the exchange rate, and tariffs for public services. 2/ In addition, the government removed indexation, provided an upward adjustment of wages to their average real value over the previous six months, and established provisions for automatic adjustment of wages to be triggered when accumulated inflation exceeded 20 percent. However, key public sector prices (with the exception of electricity rates) and controlled private sector prices were not adjusted prior to implementation of the Plan, as originally planned.

1/ See Harvey (1989) for an extensive discussion of estimation methods using the Kalman Filter.

2/ In January of 1986, inflation was running at a monthly rate of 17.8 percent. See Cardoso (1991), Kiguel and Liviatan (1988), Helpman and Leiderman (1988), Modiano (1988), and Novaes (1990) for a detailed account of the Plan.

The first months of the plan were highly successful. Monthly inflation rates were between 1 and 2 percent, industrial output increased by 40 percent between February and October of 1986 (while GDP expanded at an annual rate of nearly 8 percent during that period), and in November 1986 real wages were 9 percent higher than the average attained in 1985 (see Figure 1). 1/ But by late August 1986 the plan was becoming unsustainable. The price freeze was not consistent with the increase in domestic demand generated by the initial wage increase and the larger operational deficit of the public sector, which turned out to be 3.7 percent of GDP rather than the 0.5 percent projected early in the year. Excess demand developed in goods and labor markets. Imports rose sharply while exports fell, and the trade surplus diminished substantially in September 1986--turning into a deficit between October and December of that year. 2/ The combination of excess demand with misaligned relative prices (resulting from price controls) and large fiscal deficits led to unsustainable macroeconomic imbalances that finally undermined the stabilization attempt. 3/,4/

When price controls were abandoned in December 1986, inflation rose to monthly rates of between 10 and 15 percent until March 1987 and accelerated even more from April 1987 to reach a monthly rate of 26 percent in May and June of that year. The acceleration of inflation led the government to adopt a new stabilization plan, known as the Bresser Plan. The plan tried to correct some of the errors of the Cruzado Plan, adjusting public sector tariffs and the exchange

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1/ Official reserves, the consumer price index and the official exchange rate (defined as the end-of-period Cruzado-Dollar rate) are taken from the Fund's International Financial Statistics. The index of industrial output is taken from the Fundacao Instituto Brasileiro de Geografia e Estadistica (IBGE). The parallel market exchange rate is taken from the Centro de Estudios Económicos.

2/ The balance of payments deteriorated sharply as a result of the trade deficit and also because of widespread speculation that corrective action would include a major devaluation of the domestic currency. The authorities, however, did not devalue the cruzado until mid-October, and then only by 1.8 percent.

3/ The political cycle also hampered the stabilization effort by encouraging overexpansionary policies intended to increase public support for the government at the time of upcoming elections. The Brazilian economy experienced an expansionary cycle before the parliamentary elections in November 1986, at a time when the Cruzado plan was under way. Corrective action to counteract the consumption boom was delayed until after the elections.

4/ The government introduced fiscal measures to restrain consumption in July (the "Cruzadinho" package) and November 1986 (the "Cruzado II" package), but with little success.

rate at the beginning of the price and wage freeze. This time the freeze was to be temporary, and wage indexation was to be restored three months later. This program too was ultimately a failure: inflation rose rapidly in the last quarter of 1987 (more than 10 percent a month), and by 1988 the annual inflation rate was approaching hyperinflation, at about 1,000 percent.

Table 1 indicates the results of opinion polls conducted immediately after the announcement and during the Cruzado Plan. The evidence suggests that the Cruzado Plan had strong initial popular support. However, support begun to dissipate once the initial success was replaced by a resumption of inflation. During March and June 1986, there was growing awareness that the public sector budget at the onset of the stabilization was not balanced. The situation grew worse as a result of the increase in expenditure of the federal government on the wage bill, subsidies, tax exemptions, and transfers to state enterprises and state and local authorities. The implementation of the plan suffered from three major shortcomings (Modiano, 1988). First, the public sector deficit turned out to be too large to finance without substantial recourse to the inflation tax. Second, consumption demand became excessive because of overly generous wage adjustment when the plan was announced, and because of the failure to realign some key public and private sector prices before the plan was announced and introduced. Third, the price freeze (including the exchange rate) was maintained too long given the excess aggregate demand which was apparent. In view of these increasingly perceived realities, credibility of the plan begun to erode, and inflationary expectations increased. The government was slow to take corrective action, further aggravating the situation. The inflationary spiral was reactivated because agents perceived that recourse to inflationary finance was likely to be renewed, considering the size of the fiscal deficit, and because excess demand developed.

The behavior of the parallel exchange rate and the premium are shown in Figure 2. The figure suggests that the premium fell substantially before the plan was implemented, but started to rise at the end of March 1986. Reflecting excessive monetization--the rate of growth of the broader monetary aggregate M_4 reached 21 percent between the end of February and the end of June--the parallel market premium jumped between March and June 1986 from 26 percent to 50 percent, and reached 90 percent in October 1986. Deteriorating confidence as well as anticipations of a large devaluation of the Cruzado--which turned out to be unfounded--account for this sharp rise. After the announcement of new policy measures in November 1986, the premium fell substantially.

FIGURE 1. BRAZIL
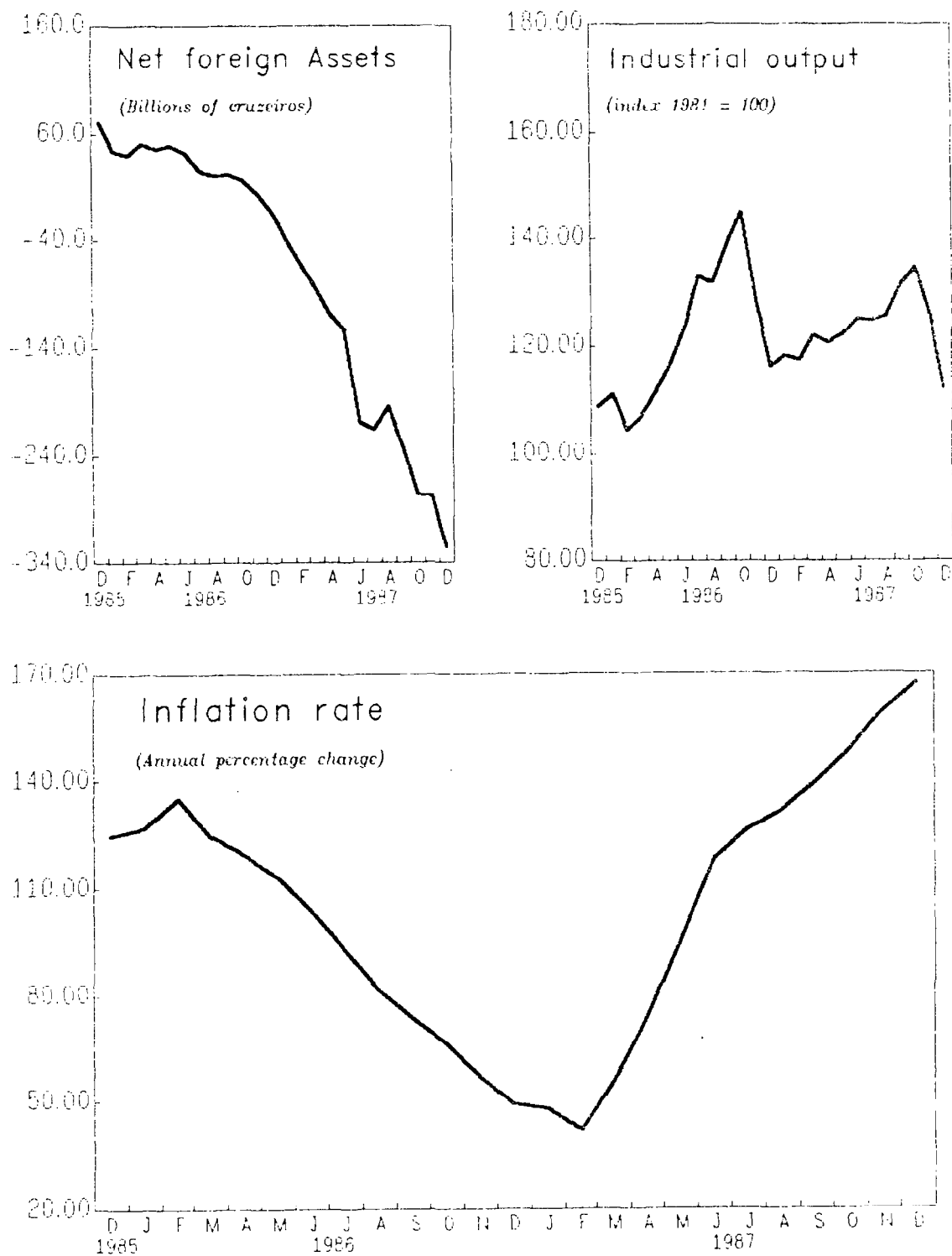## Prices, Output, and Net foreign Assets, 1985/87

Net foreign Assets
(Billions of cruzeiros)

Industrial output
(index 1981 = 100)

Inflation rate
(Annual percentage change)

FIGURE 2. BRAZIL
Exchange Rates and Parallel Market Premia, 1985/87

Official exchange rate
(Cruzeiros per US Dollar)

Parallel exchange rate
(Cruzeiros per US Dollar)

Parallel market premium
(percentage)
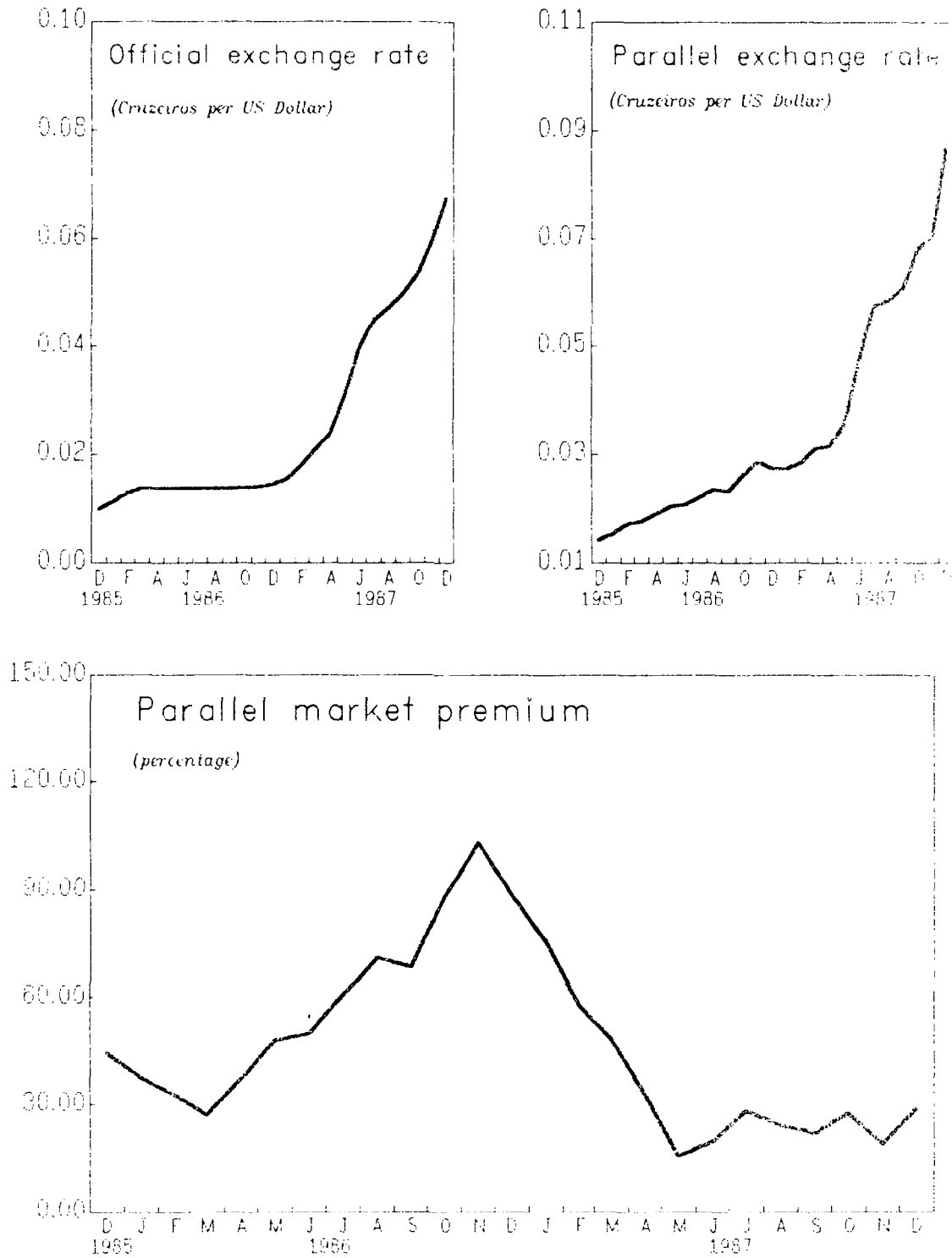
Table 1. Brazil: Public Opinion Polls, 1985-86 1/

		May 1985	March 1986
1.	In the last 12 months the economic situation		
	- improved	25	52
	- worsened	71	47
2.	In the next 12 months the economic situation		
	- will improve	--	91
	- will not improve	--	5
3.	In the next 12 months, Sarney's Administration will		
	- Manage to reduce inflation	--	90
	- Not manage to reduce inflation	--	8
	inflation will remain at its current rate	--	(5)
	inflation will increase	--	(3)
	- Other answers/don't know	--	2
4.	With the new economic measures, inflation		
	- will stop	--	70
	- will continue to grow	--	23
	- Other answers/don't know	--	7
5.	With respect to the changes introduced in the economy by Pres. Sarney, do you		
	- Approve	--	96
	- Disapprove	--	2
	- Other answers/don't know	--	2

Source: Novaes (1990, p. 21).

1/ Results refer only to São Paulo, but a similar pattern was
    observed in Rio de Janeiro.

2. Evaluating the credibility of the Cruzado Plan

Following the methodology described in Section IV, we now examine whether statistical results can account for the "credibility pattern" suggested by survey evidence and casual observation--rapid gains in credibility at the inception of the Cruzado Plan, followed by a rapid erosion in the following months.

The first step of the procedure is to estimate either a static regression or a *VAR* system, which includes "fundamentals". The variables considered here as "fundamentals" are the rate of growth of the money stock, changes in output, domestic and foreign inflation rates, and the rate of depreciation of the official exchange rate. 1/ Seasonal dummy variables were also included as independent variables in the regressions. Figure 3 shows the credibility measures--that is, the negative of the residuals series--derived from a first- and second-order *VAR* systems. 2/ For the period of interest--the period which covers the adoption to the abandonment of the Cruzado Plan-- both measures display a fairly similar pattern: credibility rose sharply at the inception of the program and fell rapidly in the following months.

Maximum likelihood estimates of the parameters of the model (4a)- (4c) using the credibility index derived from the first-order *VAR* system are as follows (asymptotic standard error in parentheses): 3/

$$\hat{\gamma} = -0.00035, \qquad \hat{\sigma}^2_\epsilon = 0.0015, \qquad \hat{\sigma}^2_\eta = 0.0029, \qquad (5)$$
$$(0.00007)$$

while Figure 4 shows the behavior of the coefficient α. The coefficient γ is negative, as predicted by the model, and highly signifi- cant. Also, as suggested by the analysis, the persistence effect

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1/ Data on money supply (narrowly defined) and import prices are taken from Conjunctura Economica. In principle, the budget deficit should also be included in the *VAR* system. Lack of monthly data for the complete period prevented us from using this variable. The impact of fiscal deficits on the premium are, however, captured to a certain extent by the behavior of output and the money stock. Another potentially relevant variable would be the extent of central bank intervention in the foreign exchange market--data for which is not readily available.

2/ Higher-order systems were also estimated. They provided the same picture for 1986-87 as the series reported in Figure 1, but we were unable to derive convergent parameters for the whole sample period using the Kalman filter procedure.

3/ Results obtained with the second measure of credibility were similar to those reported in equation (5). Note also that the potential credibility effect of price controls on the behavior of inflation will be captured by our credibility measure.

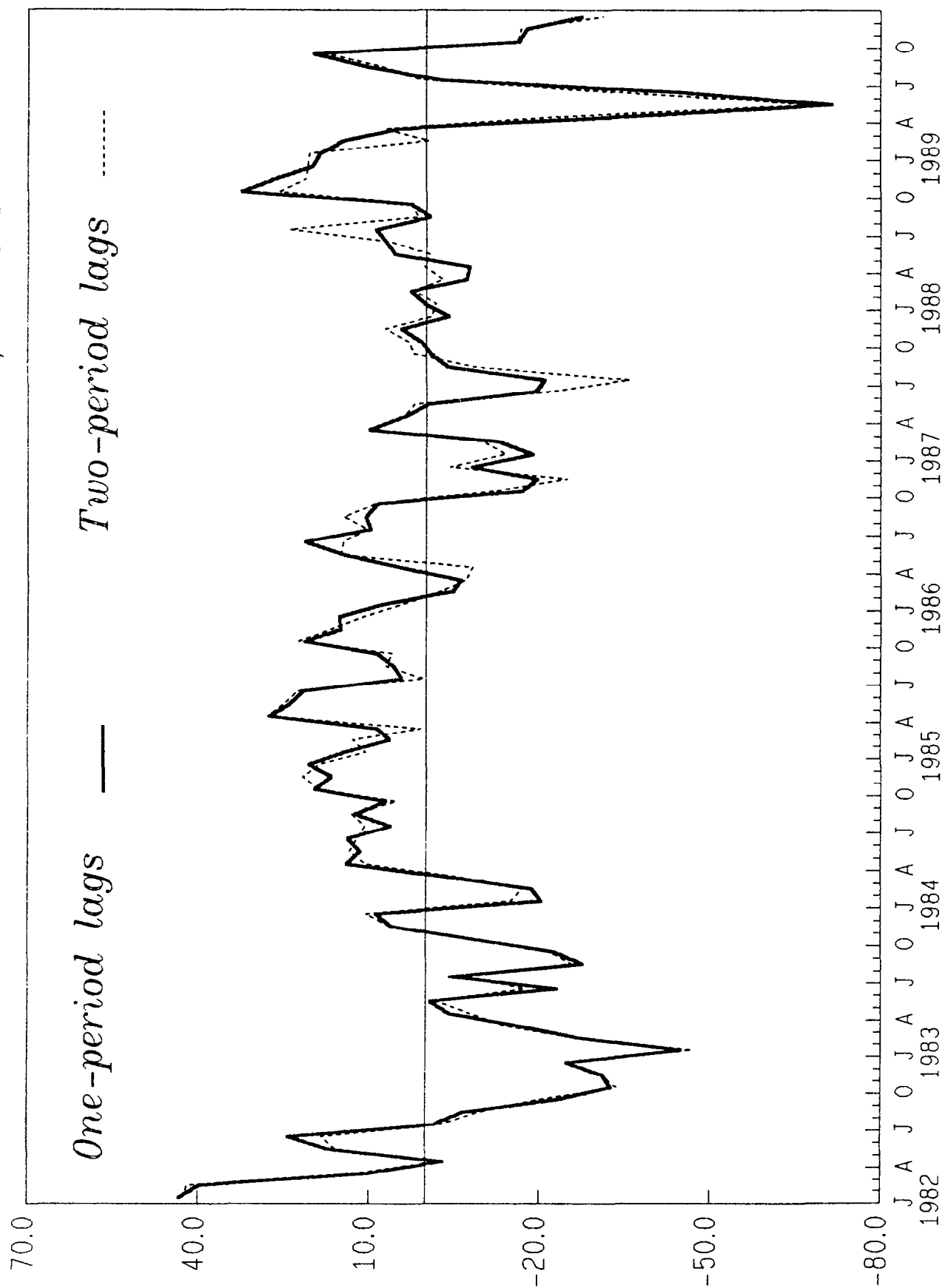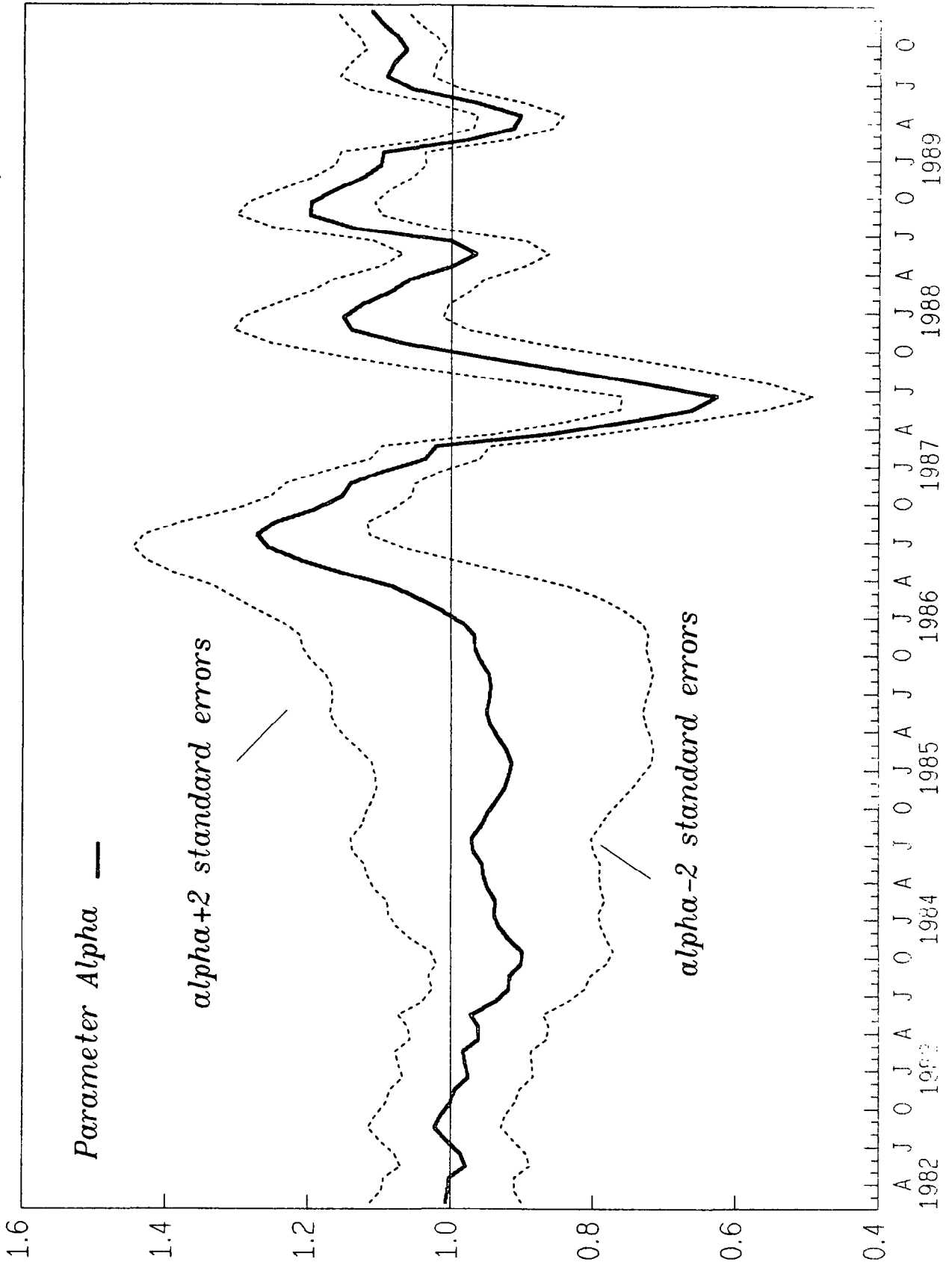FIGURE 3. CREDIBILITY VARIABLES, 1982–89

FIGURE 4. CREDIBILITY AND INFLATION PERSISTENCE, 1982–89

(which increased steadily from the end of 1985 to reach an all-time high in April 1986) started to fall dramatically until approximately June 1987--right after the Plan collapsed--and increased rapidly to its pre-program value, reflecting the explosive behavior of prices when policy credibility is low.

It is interesting to compare the results given in (5) with those obtained when credibility is measured by the inverse of the actual premium--so that $c_t = 1/\rho_t$. Estimation of the model (4a)-(4c) yields in this case

$$\hat{\gamma} = \begin{matrix} 0.058, \\ (0.067) \end{matrix} \qquad \hat{\sigma}^2_\epsilon = 0.0016, \qquad \hat{\sigma}^2_\eta = 0.0031 \qquad (6)$$

The above results indicate that the parameter γ has the wrong sign and is not statistically significant. Using the actual premium would therefore indicate no credibility effect on inflation persistence, in contrast to the results shown in equation (5) which allows for the effect of "fundamentals" on the behavior of the exchange rate spread.

Overall, the results suggest that although the Cruzado Plan seems to have gained credibility rapidly, its impact of the inflationary process has been less dramatic.

VI. Concluding Comments

The purpose of this paper has been to examine alternative procedures to estimate the size of, and the diffusion effect of, credibility factors in the context of disinflation programs. After a brief review of conceptual issues in evaluating the source of credibility problems and an overview of empirical techniques, a two-step methodology has been developed. The method, which may be viewed as particularly suitable for high-inflation developing economies, focuses on an analysis of the time-series properties of the parallel market premium and the inflation rate. It relies on a decomposition of the parallel market premium into a permanent and transitory component and tests for statistical correlations between the transitory component of the premium (which can be viewed as a "credibility variable") and the coefficients characterizing the process driving the inflation rate. To demonstrate its usefulness in analyzing stabilization programs, the technique was applied to the Cruzado Plan implemented in Brazil during 1986.

There are several possible extensions of the analysis developed in this paper that may prove worthwhile. First, the robustness of the proposed two-step procedure should be tested by examining a larger group of case studies. A comparative analysis of the experience of Argentina, Bolivia, Israel and Peru, which have recently pursued

disinflation strategies, would provide considerable insight in the general applicability of our technique. Second, a different approach to the first-step problem (generating a credibility variable) can be implemented. In many developing countries, public or private organizations conduct monthly opinion polls on economic predictions which can prove useful in determining the degree of confidence in the economy. Techniques used to derive quantitative series of expected inflation from qualitative survey data are well developed and could be applied to derive a "credibility index". 1/ The major advantage of this approach is that it would allow one to evaluate the degree of credibility of a policy package ex ante, rather than ex post, as is done here. 2/ More generally, it would make it possible to estimate the extent to which regime changes have been anticipated--without recourse to "constructed" measures of expectations. Finally, even in the case where the credibility variable needs to be somehow "created", it could be useful to consider variables other than the parallel market premium, such as stock prices, the degree of financial intermediation, or the extent of capital flight. Nevertheless, this paper demonstrates that quantification of credibility is essential to explain the empirical aspects of stabilization policies.

1/ These techniques are surveyed by Holden *et al.* (1985), as well as Pesaran (1988). The lack of a sufficiently long time series of survey data prevented the application of these techniques here.

2/ An alternative possibility, which has been followed by Cukierman (1988) in the case of Israel, would be to derive inflation expectations from the market prices of government bonds.

Inflation Inertia and Policy Credibility

In this Appendix we develop a simple open-economy model with overlapping wage contracts in order to demonstrate the link between the perceived degree of policy credibility and the degree of inflation persistence. 1/

Let y_t, p_t and e_t denote the logarithms of domestic output, prices and the exchange rate (the domestic price of foreign currency) respectively. y_t is normalized to zero at full employment and foreign prices are held constant and normalized to zero. Aggregate demand is assumed to be given by

$$y_t = \alpha(m_t - p_t) + \beta(e_t - p_t) + v_t, \qquad \alpha, \beta > 0 \qquad (A1)$$

where v_t is a stochastic demand shock.

As in Taylor's (1980) model, wage setting is staggered so that optimal average current prices are an average of wages (w) set in the current and the previous period, less any productivity shocks (q):

$$p_t = (1/2)(w_t + w_{t-1}) - q_t. \qquad (A2)$$

Wage contracts are set for half the labor force each period and are of two periods duration. Wage negotiators are assumed to attempt to maintain a constant real wage for the duration of the contract. If κ denotes the share of domestic goods in the consumption basket of workers, then the target wage is given by

$$w_t = (1/2)[\kappa p_t + (1 - \kappa)e_t] + (1/2)[\kappa E(p_{t+1}|\Omega_t) \qquad (A3)$$

$$+ (1 - \kappa)E(e_{t+1}|\Omega_t)] + (\gamma/2)[y_t + E(y_{t+1}|\Omega_t)],$$

where $E(.|\Omega_t)$ denotes the mathematical conditional expectation operator and Ω_t denotes the information set available to wage contract negotiators in period t. Equation (A3) thus represents both cost-push

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1/ The analysis in this Appendix is developed from Alogoskoufis' (1990) analysis of inflation persistence and exchange rate regimes.

inflationary factors (the first two terms) as well as demand-pull inflationary factors (the last term). Now consider simple equations relating to the degree of monetary and exchange rate accommodation:

$$e_t = \vartheta p_t, \qquad\qquad 0 \le \vartheta \le 1 \qquad\qquad (A4)$$

$$m_t = \phi p_t + \nu_t, \qquad\qquad 0 \le \phi \le 1 \qquad\qquad (A5)$$

where ν_t represents money supply shocks and ϑ and ϕ are parameters representing the degree of exchange rate and monetary accommodation, respectively.

Solving equations (A1) through (A5) for prices, we obtain the following difference equation:

$$p_t = (\mu/4)[p_t + E(p_{t+1}|\Omega_t) + p_{t-1} + E(p_t|\Omega_{t-1})] + \lambda_t - q_t, \qquad (A6)$$

where

$$\mu = \kappa + (1 - \kappa)\vartheta - \gamma\alpha(1 - \phi) - \gamma\beta(1 - \vartheta), \qquad\qquad (A7)$$

and

$$\lambda_t = (\gamma/4)[\alpha\{\nu_t + E(\nu_{t+1}|\Omega_t) + \nu_{t-1} + E(\nu_t|\Omega_{t-1})\} \qquad (A8)$$

$$+ \upsilon_t + E(\upsilon_{t+1}|\Omega_t) + \upsilon_{t-1} + E(\upsilon_t|\Omega_{t-1})].$$

Solving (A6) forward yields

$$E(p_t|\Omega_{t-1}) = \delta_1 p_{t-1} + (4/\mu\delta_2)\sum_{i=0}^{\infty} \delta_2^{-i} E(\lambda_{t+i} - q_{t+i}|\Omega_{t-1}), \qquad (A9)$$

where δ_1 and δ_2 are the roots of the system, $0 < \delta_1 < 1 < \delta_2$, and δ_1 is given by

$$\delta_1 = (2 - \mu)/\mu - [(2 - \mu)^2 - \mu^2]/\mu. \qquad\qquad (A10)$$

Finally, if we assume that all stochastic shocks affecting aggregate demand, the money supply and productivity are simple random walks then a closed-form solution for inflation may be derived from (A6) and (A9):

$$\Delta p_t = \delta_1 \Delta p_{t-1} + \psi_t, \qquad\qquad (A11)$$

where $E(\psi_t | \Omega_{t-1}) = 0$.

Thus, from $(A11)$, inflation will follow an $AR(1)$ process with an autoregressive parameter δ_1. Moreover, from $(A7)$ and $(A10)$, it can be shown that $\partial \delta_1 / \partial \phi > 0$, and $\partial \delta_1 / \partial \vartheta > 0$, so that the degree of inflation persistence rises with the degree of monetary and exchange rate accommodation. Indeed, with full monetary and exchange rate accommodation ($\phi = \vartheta = 1$) $\delta_1 = 1$; the inflation process contains a unit root and the system is unstable.

To examine the effect of the lack of policy credibility on inflation persistence in the above framework, suppose that the authorities announce a non-accomodative policy of the type $m_t = \overline{m} = 0$, but agents attach a probability $0 < \rho < 1$ that the policy will actually be implemented. 1/ The probability that the accomodative policy $(A5)$ will be adhered to is therefore $(1 - \rho)$. Solving the model as before, it is straightforward to verify that $\partial \delta_1 / \partial \rho < 0$: the higher the credibility of the announced low-inflation policy, the less persistent inflation will be. 2/

1/ For simplicity ρ is treated as constant. See Agénor and Bhandari (1991) for an endogenous treatment of collapse probabilities.

2/ In the basic framework developed by Calvo and Végh (1991) in which price setters are forward looking, price stickiness results essentially from the lack of credibility in macroeconomic policy. They also show, however, in an extension of their analysis, that perfect credibility does not remove inflation inertia in the presence of backward price indexation. The same result obtains here.

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