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Inflation and Seigniorage in Argentina

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In Argentina, increases in inflation appear to be closely linked to government attempts to increase seigniorage (government revenues from issuing money). The implication? Any serious stabilization effort requires finding an alternative source of revenue to replace the "inflation tax."

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In their model of the relationship between inflation, the inflation tax, and seigniorage, Kiguel and Neumeyer analyze the Argentine experience — for the last decade.

To study the robustness of their model under different regimes, they split the study into three periods — each with distinctive rules about the exchange rate, interest rates, and the mobility of international capital flows.

Argentina — where increases in inflation appear to be closely linked to government attempts to raise seigniorage — is a natural choice for this study because of its persistent high rates of inflation and fiscal imbalance. Monetization of fiscal deficits becomes a major force for creating money and inflation in countries with limited access to domestic and foreign credit.

Kiguel and Neumeyer found that inflation in Argentina played an important role in generating public sector revenues.

At the revenue-maximizing rate of inflation, they found, the government can get seigniorage of about 7.5 percent of GDP in steady state (this was true for the tablita and pre-Austral periods). Between June 1978 and April 1985, there was a clear, positive relation between inflation and the inflation tax for rates of inflation below 18 percent.

Events are more difficult to interpret at inflation rates near and above 20 percent. In the 20 percent range, the inflation tax ranged from 7 to 10 percent of GDP. Steady-state seigniorage is at a maximum 7.5 percent when inflation is around 20 percent a month. Increases in inflation above 20 percent do not give the government more inflation tax revenues. The revenue from inflation seems to fall unambiguously once inflation exceeds 22 percent.

The inflation tax remained close to, and even exceeded, maximum sustainable levels during the first half of the 1980s — and was probably the single most important source of revenue to the government at that time. The implication: any serious stabilization effort requires finding an alternative source of revenue to replace the inflation tax.

This paper is a product of the Macroeconomic Adjustment and Growth Division, Country Economics Department. Copies are available free from the World Bank, 1818 H street NW, Washington DC 20433. Please contact Raquel Luz, room N11-057, extension 61588 (43 pages with figures and tables).

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"Seigniorage is the profit on minting coins, earned by the mint, usually owned or farmed by the sovereign, who has a certain 'droit de seigneur' or monopoly on such profits." "The Contrast ... may well turn on whether the competitors [mints] are interested in short- or long-run gains. In the short run, profits can be maximized by adulteration; in the long-run, by producing to quality standards."[1]

I. Introduction

Public sector deficits occupy a central role in causing inflation in many developing countries. This is especially important in those countries where the government has to rely on the central bank to finance its fiscal imbalance, due to its limited access to domestic and foreign borrowing. Monetization of fiscal deficits thus becomes the major force for money creation and inflation.

Higher rates of inflation, however, do not always provide more resources to the government. There are several reasons for this outcome. First, as we know from the literature on the inflation tax, e.g. Friedman (1971), there is a revenue maximizing rate of inflation which corresponds to the point where the demand for money is unit elastic. Beyond that point, further increases in inflation will actually reduce the inflation tax revenue in the steady state. Second, there could be changes in inflation which are not of a fiscal nature. The balance of payments theory of inflation, as presented in Liviatan and Pitterman (1985), provides an example of such a case. Liviatan and Pitterman found that in Israel

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[1] Charles, P. Kindleberger (1984), A Financial History of Western Europe, London, Allen & Unwin.

inflation accelerated at times when the economy was facing serious external imbalances. Balance of payments problems triggered a maxi-devaluation which very quickly moved the economy to a higher inflationary "plateau". If there is inertia in the inflation process which is accommodated through monetary and exchange rate policies, inflation could remain at the higher plateau even in the absence of a change in the budget deficit.

The relationship between inflation and money financed budget deficits is illustrated in figure 1, where we show data on seigniorage, and inflation rates for Argentina, Bolivia, Brazil, Israel and Mexico. Seigniorage represents the amount of resources that the government gains from printing money and is measured here as a percentage of GDP. These figures indicate that there are two different types of relationships between seigniorage and inflation. In Brazil, Israel and Mexico seigniorage has been relatively stable over the years while inflation has displayed a tendency to rise. In these three countries the fiscal approach does not seem to provide a convincing explanation of the evolution of inflation. In Argentina and Bolivia, on the other hand, increases in inflation appear to be closely linked to attempts by the government to raise seigniorage.

In this paper, we will investigate the relationship between inflation, the inflation tax, and seigniorage on the basis of the Argentine experience of the last decade. The persistent high rates of inflation and the continuously large fiscal imbalances observed in Argentina makes this country a natural choice for a case study on this topic.

The paper will be organized as follows. In section II we present the basic analytical framework and discuss what is the appropriate measure of seigniorage for Argentina. The framework is similar to other models of inflation finance (e.g. Bailey (1956), Friedman (1971), Calvo (1978), Anand and Van Wijnbergen (1989), etc.), but we adjust it to incorporate the major stylized facts of the Argentine financial system. This section establishes that due to the structure of reserve requirements and the charges and compensations that the central bank imposes on the various deposits in the financial system, M1 is the basis for the inflation tax. This discussion is continued in section III where we examine the behavior of the inflation tax and seigniorage in Argentina from 1978 till 1985.

In section IV we conduct an empirical study of the demand for money based on monthly data for the period 1979-85. Our results are of interest for two reasons. First, we split the sample in three different periods for estimation purposes, each of them having distinctive rules for the exchange rate, interest rates and on the mobility of international capital flows. This enabled us to study the robustness of our estimated parameters to regime changes. Second, we were able to overcome the simultaneity bias that arises because of the correlation between the opportunity cost of holding money and monetary shocks. This was possible because during the first period the money stock was truly endogenous and interest rates were determined by the preannounced rate of devaluation and by arbitrage conditions. For the third period we found that the stock of money and rate of inflation were cointegrated and therefore we could obtain consistent estimators of the money demand function's parameters.

We conclude in section V with a discussion of the implications of our empirical results for the inflationary process in Argentina.

II. Financial Arrangements and Inflation Tax

A. Seigniorage and Inflation

Money creation is an important source of public sector revenue in many developing countries. The analytical literature on this subject (e.g. Friedman (1971), Calvo (1978), Bruno (1988), Bruno and Fischer (1986), Dornbusch and Fischer (1986), etc.) usually considers a closed economy, where money creation is driven by fiscal needs.

In this paper we will follow the presentation used in Dornbusch and Fischer (1986), which will be modified to introduce a banking system. The money supply process is captured in equation (1)

$$(1) \quad \Delta H = Pg$$

where H represents the monetary base (i.e. the liabilities of the central bank), P is the price level and g is the monetized portion of the deficit. ΔH denotes the change in the monetary base over time. $\Delta H/P$ denotes the real amount of resources that the government receives from printing money, sometimes referred to as seigniorage.

When there is a banking system, total money supply (M) will be given by

$$(2) \quad M = kH$$

where k is the money multiplier. The monetary base can be held as currency (C) by the public or used to satisfy the reserve requirements on bank deposits (D). Defining the reserve requirement ratio as r, then $k = (1 + c)/(c + r)$, where c is the currency-deposit ratio. The stock of base money is $H = (1/k)M$. Real money balances (m) are defined as

$$(3) \quad m = M/P = kH/P = kh$$

where $h = H/P$. Differentiating (3) with respect to time yields

$$(4) \quad \dot{m} = \Delta M/P - \pi m = k(\Delta H/P - \pi h)$$
$$= k(g - \pi h)$$

where $\dot{m} = dm/dt$, g represents seigniorage and πh is the inflation tax. In the long run equilibrium (i.e. when real money balances are constant) seigniorage is equal to the inflation tax. The monetary base (i.e. the stock of central bank liabilities) represents the base for the inflation tax.

The standard presentation of the inflation tax model is completed with the specification of the money demand function. In Cagan's model it is given by

$$(5) \quad m^d = kh^d = Ae^{-\alpha\mu} \qquad \alpha > 0;$$

where A is a constant, μ is the expected rate of inflation.[2] If we assume that expectations are rational then $\mu = \pi$.

The basic structure of the model is summarized in figure 2. The $\dot{m} = 0$ schedule, from equation (4), is a rectangular hyperbola showing the combinations of π and h such that seigniorage equals inflation tax. The m^d schedule depicts the pairs of h and π such that the money market clears. There are two stationary equilibria, points A and B, at which both conditions are satisfied simultaneously. The characteristics of the model and its stability properties are discussed at some length in Bruno and Fischer (1986), Dornbusch and Fischer (1986), Evans and Yarrow (1981), and Kiguel (1989).

A clear implication of the model is that if the economy starts at the low inflation equilibrium (point A), and that point is stable, an increase in the budget deficit (shown by an upward shift in the $\dot{m} = 0$ schedule) will lead to a permanent increase in the rate of inflation. A second important implication is that there is a maximum amount of seigniorage that the government can extract without destabilizing inflation. This corresponds to point C in figure 2, where the demand for money is tangent to the $\dot{m} = 0$ schedule. Seigniorage in excess of that amount cannot be financed in a stable way. In that case, under plausible assumptions regarding the adjustment in the money market, there will be a continuous acceleration in inflation (see Kiguel (1989)). Notice that the continuous increase in inflation will occur in spite of a constant level of seigniorage.

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[2] Cagan's model represents the traditional way to analyze this problem. One possible extension of the model could be based upon the demand for money recently used in Eckstein and Leiderman (1989).

B. Remuneration of Reserve Requirements and Seigniorage

The analysis needs to be modified in those cases where the central bank pays interest on bank reserves. This practice has been adopted in many high inflation countries (e.g. Argentina, Mexico, etc.) as a way to reduce the costs of financial intermediation.

For simplicity, we can assume that the central bank pays an interest rate (i) on bank reserves, and that $i = \pi$. Under the fractional banking system being considered total deposits (D) are

(6) $D = 1/(c + r)H.$

We define $d = D/P$. In our example, seigniorage will be

(7) $\Delta H/P - \pi rd = \Delta C/P = g;$

in other words, the government collects the inflation tax on currency, while it returns to the private sector the tax on deposits through interest payments on reserves.

An additional difficulty for the interpretation of the results arises if we extend the model to an open economy. In that case seigniorage can be used either to finance the budget deficit or to accumulate international reserves. This element was very important in Mexico during 1987,[3] where seigniorage levels were relatively large, as can be seen from figure 1.E,

[3] A similar phenomenon is observed in Chile and Argentina during the period of the predetermined exchange rates (the Tablita). In both episodes money creation was linked to accumulation of international reserves by the central bank.

while the operational deficit of the consolidated public sector was negligible.

It follows from the above discussion that a correct calculation of the government's revenue from money creation requires a careful examination of the structure of the financial system and of the regulations on reserve requirements.

We now turn to the Argentine case. On June 1, 1977 a financial reform introduced a fractional reserve banking system and liberalized interest rates. The central bank paid interest on the required reserves on time deposits to compensate banks for the cost of these "immobilized" funds. At the same time, it charged commercial banks interest on the fraction of the stock of demand deposits (on which banks did not pay interest) that they were able to lend. In other words, the central bank taxed away the seigniorage levied by commercial banks on demand deposits, while it compensated them for the required reserves on time deposits.[4]

Given that the interest rate paid and charged on reserves was roughly the same, the inflation tax (in steady state) was given by

$$\text{(8)} \quad \pi tax = \pi(cc + r_d dd + r_t dt) + i(1-r_d)dd - ir_t dt$$

[4] This system of taxes and subsidies was recorded through the Monetary Regulation Account (MRA, in Spanish Cuenta de Regulacion Monetaria). Two reasons were invoked for the creation of the MRA in June, 1977: (a) Paying interest on the legal reserves required for time deposits was a mechanism designed to eliminate the distortionary effect of a high legal reserve requirement on interest rates. (b) Taking away the inflation tax on commercial banks demand deposits provided an instrument to avoid an 'unfair' advantage of the latter over other financial institutions (financieras and savings and loans associations), that were not allowed to accept demand deposits. For a complete description of the Monetary Regulation Account, see Ensayos Economicos, No 31, September 1984.

where cc, dd and dt are respectively currency, demand and time deposits in real terms, and r_d and r_t are the reserve requirements on demand and time deposits.

If we assume that the interest rate paid on reserves is equal to the rate of inflation, we can rewrite (8) as

$$(8') \quad \pi tax = \pi(cc + dd) \ .$$

M1, which is usually defined as the sum of currency plus demand deposits, thus becomes the basis for the inflation tax (πtax).

This set up appears to be appropriate in studying the inflation tax in Argentina. A casual look at the evidence indicates that the central bank sets the interest rate on bank reserves at roughly the same levels as the rate of inflation. The choice of M1 appears to be robust to the various institutional changes that took place in the period under study[5].

III. Seigniorage and Inflation Tax in Argentina

In the previous section we established that M1 is the relevant monetary aggregate to measure inflation tax and seigniorage. In this section we will present our estimates of these variables for the period under study and a brief interpretation of the stylized facts.

There are a number of technical difficulties that arise when one

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5 After the July 1982 financial reform the legal reserve requirement for demand deposits was usually above 90%.

attempts to obtain accurate measures of inflation tax and seigniorage. An important part of the problem is that the government obtains seigniorage and collects the inflation tax on a continuous basis while our estimates are based on discrete observations. This concern can be very difficult to overcome when inflation is high (in three digit levels).[6]

In this paper we adopted a methodology to calculate the inflation tax and seigniorage that satisfies some basic consistency criteria and yields results that are compatible with the existing literature and the empirical evidence. In a discrete time version, inflation tax and seigniorage (S) are given by

$$(9) \quad S = (M1_t - M1_{t-1})/GDP_t$$

$$(10) \quad \pi tax = S - (M1_t/P_tY_t - M1_{t-1}/P_{t-1}Y_t)$$

where GDP_t is the nominal gross national product, Y_t is real gross domestic product in period t and P_t is the price level at the end of period t. These definitions ensures that $S = \pi tax$ in the steady state.

The results of our calculations of monthly seigniorage and of the inflation tax using equations (9) and (10) from 1977 to 1987 are presented in figure 3.[7] We also included the corresponding inflation rates to illustrate the relationship between them.

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[6] For an excellent discussion of some of the problems see Rodriguez (1985) and Bressiani-Turroni (1937), Appendix to Chapter 3. Some of the difficulties in measuring seigniorage are also addressed in Cukierman (1988).

[7] A 5 period moving average was calculated for seigniorage to compensate for seasonal fluctuations in the variables.

This figure indicates that seigniorage has been an important source of revenue in Argentina, exceeding 3 percent of GDP for most of the period. There is also a marked increase in seigniorage between 1982 and 1985, which was accompanied by an increase in the rate of inflation. Seigniorage fell from mid-1985 on (after the Austral plan) and basically remained at pre-1982 levels.

Changes in seigniorage were very significant in five occasions. There were two sharp reductions in seigniorage, the first, at the beginning of 1981, resulted from capital outflows in anticipation of large devaluations (i.e. the end of the tablita period); the second, in late 1984, resulted from the implementation of tight money. There were also three large increases in seigniorage, the first, in the second half of 1982, was caused by the monetization of domestic debt under Cavallo; the second, in late 1983 and early 1984 resulted from a large increase in the budget deficit; and the last, in mid-1985, was driven by a remonetization during the early stages of the Austral plan.

Of special interest is the acceleration in inflation that started in 1982 and was brought to a halt by the Austral plan in mid-1985. This acceleration was taking place at a time when seigniorage was relatively high (around 6 percent of GDP) but constant. One plausible interpretation of this episode, consistent with our discussion in section II.A, is that the amount of seigniorage was excessive in the sense that it could not be financed by any stable rate of inflation. Instead, it had to be financed in an unstable fashion through increasingly higher inflation rates.

IV. The Demand for Money and the Inflation Tax Laffer Curve

In this section we will investigate whether seigniorage levels were in effect excessive in Argentina based on an estimation of the demand for money. Using Cagan's demand for money function we will attempt to determine the value of the revenue maximizing rate of inflation and the corresponding level of seigniorage.

There is no agreement, based on the existing literature on the demand for money in Argentina, regarding the revenue maximizing rate of inflation. Fernandez and Mantel (1985), for example, estimated that this rate is in the 20 percent per month range, Rodriguez (1988)[8] calculated numbers that are closer to 30 percent per month, while Demaestri and Dueñas (1978) suggested that the rate is closer to 7 percent. Melnick (1988) incorporates a ratchet effect in the demand for money and estimates the revenue maximizing rate of inflation at 22% when inflation exceeds previous levels and at 29% when it does not.

In this section we will investigate the characteristics of the demand for money in Argentina based on monthly data from 1979 to 1985. For estimation purposes we will divide the sample into three clearly differentiated periods. The first one, from January 1979 to January 1981, corresponds to the interval in which the government preannounced the value of the exchange rate (the "tablita" period). The authorities started the preannouncement of the exchange rate on December 20, 1978 and the regime continued in place until February 1981, when a 10 percent unscheduled devaluation was effected. During this time there were no controls on

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8 in Bruno et al, Inflation and Stabilization ...

capital flows and hence the quantity of money was endogenously determined. Interest rates (which represent the opportunity cost of holding money) were essentially determined by arbitrage conditions and closely followed the international interest rate plus the expected rate of depreciation of the exchange rate (see Blejer 1982).

There was a second transitional period, from February 1981 until June 1982, characterized by continuous changes in the structure of the financial markets and a lack of a rule for the exchange rate. There were two maxi-devaluations in 1981 (30 percent devaluation in April, followed by another of the same size in June) and a dual exchange market was adopted from June to December. The financial markets were also disturbed by the war in the South Atlantic, a period during which financial and foreign exchange markets were tightly regulated.

The third period, from July 1982 till March 1985, is the pre-Austral plan period. During that time interest rates were regulated and there were restrictions on capital flows. The central bank pegged the interest rate on deposits, although interest rates were periodically adjusted according to changes in the rate of inflation. Throughout the period there was a pegged official exchange rate and a parallel unofficial rate.

There was an important difference in the adjustment of the money market after June 1982. Prior to that time, agents could alter their stock of money balances to the desired levels by selling to or buying from the central bank foreign exchange. The introduction of capital controls in June altered the adjustment mechanism and gave more control over the money supply to the central bank. It is important for the reader to keep this difference in mind when looking at the econometric results for the two periods that we estimate.

The estimation of the demand for money will only be done for the first and third periods. We decided to drop the period between February 1981 and June 1982 due to the small number of observations that we had, and to the biases introduced by the frequent changes in regimes that took place during this short interval. In addition, based on simple econometric tests[9], we found that it was not appropriate to include this transition in either the Tablita or the pre-Austral periods.

The money demand function we estimate is the one employed by Cagan (1956) in his classic study of the European hyperinflation.

(11) $m_t^{d} = a_0 + a_1 x_{t+1} + \mu_t$

where $m_t = \ln M1_t^{d} - \ln P_t$

x_{t+1} = opportunity cost of holding money in period t+1.

The a_i's are parameters representing a constant and the semi-elasticity of the demand for money, μ_t is the error term.

I) <u>The "tablita" period: January 1979-January 1981</u>

The financial regime prevailing during the "Tablita" period offered important advantages from an estimation point of view. The nominal interest rate, the independent variable in the regression, can be taken as exogenously determined through the exchange rate rule and the interest rate parity condition. Whereas money supply, the dependent variable, was

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[9] Chow tests reject the null hypothesis of no structural bias in the money demand function's parameters when we extend the "tablita" period to June 1982. If we assume instantaneous market clearing in the money market the null hypothesis of no change in the parameters is rejected when we extend the sample period only until march 1981.

endogenously determined. These represent an ideal set of conditions for estimating the money demand function.

In our model we assume that domestic nominal interest rates were determined by arbitrage conditions. In other words, the following equation is assumed to hold continuously;

$$(12) \qquad i_t = i^*_t + (e_t{}^e{}_{+1} - e_t) + u_t$$

where

i_t = 30 day domestic deposit interest rate (% per month).

i^*_t = international interest rates.

$e_t{}^e{}_{+1}$ = expectation of the (log) exchange rate for t+1.

e_t = (log) exchange rate at the end of period t

u_t = deviations from interest rate parity resulting from risk premium and other sources.

Two alternatives were considered regarding the interest rates and money market shocks. If the shock to interest rates, u_t, is uncorrelated with the money market shock, μ_t, we can substitute (12) into (11) and estimate this equation using OLS. If, on the other hand, u_t is correlated with μ_t, we have to use two stage least squares in order to obtain unbiased and consistent estimators of the parameters. We estimated equation (11) under both assumptions, and we used current and past values of the rate of devaluation (a policy variable) and the prime rate at a New York money center bank as instruments for the TSLS estimation.

We also make two alternative assumptions about the adjustment mechanism in the money market. We consider a model in which there is a lag in the adjustment in the money market (as in Chow (1966), Goldfeld (1973), and Khan and Knight (1984) among others), and a second model where we assume that the money market continuously clears.

For the partial adjustment model we estimated:

$$(13) \quad m_t = \tau a_0 + \tau a_1 \, i_t + (1-\tau) \, m_{t-1} + \tau \, \mu_t$$

where τ = speed of adjustment of the money market.

For the market clearing model ($m_t = m_t{}^d$, for all t) we estimated:

$$(14) \quad m_t = a_0 + a_1 \, i_t + \mu_t$$

The results from estimating (13) and (14) for the "tablita" period are presented in table I[10 11]. The Durbin-Watson statistic is reported for the market clearing model and Durbin's (1970) h-statistic is reported for the partial adjustment model. We observe that the assumptions regarding the correlation of interest rates and money market disturbances as well as the speed of adjustment of the money market do not significantly affect the estimated values of the money demand's structural parameters. However, the

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[10] Two methods were employed to correct the model for seasonal correlation in the residuals. The first one was to assume a seasonal 12^{th} order moving average process. The second one was to introduce a seasonal dummy for the a_0 that is equal to 1 every December and zero otherwise. We did not use a seasonal auto-regressive representation for the μ_t's or a full fledged X-11 method due to the small number of observations (25).

[11] The data employed, all from DATAFIEL, are the end of period interest rates on 30 day deposits in Buenos Aires (measured in percent per month), the end of period real stock of money is the ratio of the end of period stock of nominal M1 to the end of period consumer price index (1974=100). End of period prices were taken to be the mean of the monthly average price (CPI) in t and in t+1 - i.e. $P_t = .5(AvP_t + AvP_{t+1})$.

speed of adjustment of the money market is not robust to the choice of the seasonal correction model or to the assumption on the stochastic contents of interest rates.

In the inflation tax literature, the revenue from inflation is maximized at the point where the demand for money is unit elastic with respect to the rate of inflation. Equations (13) and (14) were estimated using the interest rate as the opportunity cost of holding money. We found that the demand for money was unit elastic at interest rates that ranged from a low estimate of 17.2% (σ=3.27) per month in the seasonal moving average partial adjustment model with instrumental variables, to a high estimate of 22.2% (σ=3.61) in the instrumental variables market clearing model with a dummy variable for December. The corresponding revenue maximizing rate of inflation can be calculated simply by subtracting the real interest rate from these numbers.

2) <u>The "pre-Austral" period: July 1982 - March 1985</u>

There were significant changes in the money supply process and in the determination of interest rates between the third period (July 1982 to March 1985) and the time of the "Tablita". The imposition of restrictions on capital flows limited the degree of "endogeneity" in the money supply. It became more difficult for the private sector to adjust real money balances through changes in the money supply. Consequently, prices played a more important role in the adjusting mechanism of the money market during this period. In addition, interest rates on deposits, which were freely determined during the "Tablita", were fixed by the central bank which determined the regulated interest rate.

The introduction of controls on interest rates complicates the choice regarding the appropriate variable to measure the opportunity cost of holding money during this period. After a careful examination of the possible alternatives we chose the regulated interest rate, the actual rate of inflation, and an indicator of inflationary expectations. The latter was generated by regressing the actual rate of inflation on its own lags and on current and lagged regulated rates.[12]

We first performed tests to determine whether the variables were integrated. We rejected the hypothesis that the logarithm of the real stock and the three opportunity costs of holding money being considered are not co-integrated variables as defined by Engle and Granger (1987)[13]. Cagan's equation then becomes the co-integrating regression and it can be estimated by ordinary least squares (OLS).[14]

We reproduce, for convenience, Engle and Granger's (1987) definition of co-integration.

<u>Definition</u>: The vector $y' = (m_t, x_{t+1})$ is said to be co-integrated of order d, b, denoted $(m_t, x_{t+1}) \sim CI(d,b)$, if (i) $\{m_t\}$ and $\{x_{t+1}\}$ are integrated of

[12] We decided against the use of the interest rate on commercial paper because it was a rate available only to large corporations. We also considered the expected rate of depreciation of the black market exchange rate. However, we found that this rate was very difficult to forecast. We could not reject the null hypothesis that it is a constant plus white noise with a 97.5% significance level and we found that it was uncorrelated with other suitable variables.

[13] Melnick (1988) also finds co-integration in his study of the Argentine demand for money.

[14] Identification results from the fact that, given the bi-dimensionality of our system, there is a unique linear combination of $\{m_t\}$ and $\{x_{t+1}\}$ that is stationary and from assuming that the money market is stable. Consistency is an asymptotic property of the least squares estimators of co-integrating vectors.

order d, I(d); and (ii) there exists a non-zero vector α' so that $z = \alpha' y \sim I(d-b)$; $b>0$. The vector α is called the co-integrating vector.

Since our co-integrated system consists of only two variables the co-integrating vector is unique. There is only one equilibrium relationship between m_t and x_{t+1} that is stationary. This result of co-integration theory is useful for identification purposes. All linear combinations of m_t and x_{t+1}, except the one defined by the co-integrating vector α, will be non-stationary and have infinite variances.

Assume that the demand for money is

(15) $m_t^d = a_0 + a_1 x_{t+1}$

and let the money market equilibrium errors be given by

(16) $z_t = m - a_0 - a_1 x_{t+1}$

If the differences between the quantity of money demanded and the observed one have a tendency to be corrected (i.e. they are stationary with a zero mean) the money market is stable, and then we know that least squares will estimate the parameters of Cagan's equation (the elements of the co-integrating vector). Other linear relations between the (log) stock of money and its opportunity costs will not yield stationary errors.

The estimators of the money demand function parameters will be subject to two sources of bias. First, there is a simultaneity bias that arises whenever the current price level enters into x_{t+1}.[15] A second source of bias is due to an errors in variables problem[16] since during the "pre-Austral" period there was no market measure of the expected cost of holding M1, x_{t+1}. In spite of these small sample biases (of order $O(T^{-1})$) the least square estimators of the money demand function will be consistent because the regressors have a higher order of integration than the error term (Phillips and Durlauf, 1986, Stock 1987, 1988).

There are two steps in testing for co-integration. We first have to test whether the two autoregressive representations of the time series processes $\{m_t\}$, $\{r_t\}$ and $\{\pi_t\}$ have a unit root. If the first condition is satisfied we then need to test the residuals of the co-integrating regression for non-stationarity. If the null hypothesis of non-stationarity is rejected we find co-integration. We employ Dickey-Fuller (DF) and Phillips-Perron (PP)[17] tests to determine if the system has unit roots. (The formulas of the PP statistics and critical values can be found in the appendix).

We use the equations (17.a) to (17.c) to test the first condition for co-integration. Our objective is to select one of the three models to represent the time series behavior of y_t. Under the null hypothesis of a

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15 Sargent and Wallace (1973).

16 This source of bias can be eliminated by estimating the reverse regression (of x_{t+1} on m_t) and assuming that the measurement errors are uncorrelated with m_t.

17 Phillips-Perron propose a set of tests on unit roots that are transformations of those proposed by Dickey-Fuller (1979,1981). The PP statistics converge in distribution to the DF ones under mild conditions on the innovation sequences $\{u_t\}$ in (15), which allow for finite ARMA processes and heteroskedasticity.

unit root, equation (17.a) represents a random walk, (17.b) is a random walk with drift, while (17.c) corresponds to a case that exhibits deterministic non-stationarity[18].

(17.a) $y_t = \alpha\, y_{t-1} + u_t$

(17.b) $y_t = \mu^* + \alpha^*\, y_{t-1} + u^*_t$

(17.c) $y_t = \tilde{\mu} + \beta(t-T/2) + \tilde{\alpha}\, y_{t-1} + \tilde{u}_t$

The selection criteria based on the PP tests are the following. We start using model (17.c) and we use the statistic $Z(\Phi_3)$ to test the null ($\beta=0, \mu=\mu, \alpha=1$) and the statistics $Z(\tilde{\alpha})$ and $Z(t_{\tilde{\alpha}})$ to test the unit root hypothesis. If we do not reject the null hypothesis of a random walk with drift, represented by model (17.b), we proceed with $Z(\Phi_2)$ to test the null of a driftless random walk ($\mu=\beta=0, \alpha=1$). If we do not reject the driftless case based on the statistics obtained from (17.c) we then use equation (17.b) to calculate the statistics $Z(\Phi_1)$, $Z(\alpha^*)$ and $Z(t_{\alpha}*)$ which can then be used to perform additional more powerful tests.[19] The regressions (17.a)-(17.b) are reported in table II.A and the Phillips-Perron tests in

[18] The reader should keep in mind that these tests have low power against the alternative hypothesis that the variables are trend stationary instead of difference stationary (De Jong and Whiteman (1989). The latter hypothesis has the appeal of allowing for the possibility of stabilization plans.

[19] It is important to start with model (17.c) because if the series $\{y_t\}$ is stationary around a linear trend it can be shown that $T(\alpha^*-1)$ and $Z(t_{\alpha}*)$ converge in probability to zero.

the Table II.B.

In the tests for inflation we cannot reject the hypothesis that inflation is a random walk with drift. We first observe in the Phillips-Perron set of tests that $Z(\Phi_3)$ does not reject the hypothesis H_0: $(\beta=0,\mu=\mu,\alpha=1)$ at a 10% significance level. The statistics $Z(\tilde{\alpha})$, $Z(t_{\tilde{\alpha}})$ do not reject the hypothesis of a unit root $(\alpha=1)$ either. We then use the statistic $Z(\Phi_2)$ and we reject the null H_0: $(\beta=\mu=0, \alpha=1)$ at a 5% or 1% significance level depending on the residuals we use for estimating the nuisance parameters σ and σ_u[20]. We therefore conclude that model (17.b) is the more appropriate and $\{\pi_t\}$ follows a random walk with drift[21].

The tests for the time series properties of the log of the real money stock $\{m_t\}$ also do not reject the hypothesis of an I(1) process. In model (17.c) the statistics $Z(\Phi_3)$, $Z(\tilde{\alpha})$ and $Z(t_{\tilde{\alpha}})$ do not reject their respective null hypothesis at a 10% significance level. $Z(\Phi_2)$ rejects the null $(\mu=\beta=0,\alpha=1)$ at a 5% significance level. Again we accept the hypothesis of a random walk with drift[22].

The tests for the regulated deposit interest rate also select the random walk with drift. None of the statistics based on model (17.c),

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20 The PP tests involve the estimation of two nuisance parameters, through the statistics S^2_u, S^2_{Tl};which are sensitive to the estimators we use for the u_t's. Both, the residuals of model (15.a) and the first differences $(y_t - y_{t-1})$ can be used for estimating them under the null of a driftless random walk $(\mu=\beta=0, \alpha=1)$. S^2_{Tl} yields a consistent estimator of σ when l grows at the controlled rate $T^{-1/3}$, which in our case is $33^{-1/3}=3.2$.

21 DF and Augmented Dickey-Fuller (ADF) tests using up to four lagged differences do not reject the unit root hypothesis in model (15.b) for the rate of inflation.

22 DF tests in which the errors are corrected for seasonality fail to reject the unit root hypothesis in model (15.b).

$Z(\Phi_3)$, $Z(\alpha)$ and $Z(t_{\tilde{\alpha}})$, rejects its respective null hypothesis. $Z(\Phi_2)$ rejects the driftless random walk at a 10% significance level[23].

DF tests on the second differences of $\{r_t\}$, $\{\pi_t\}$ and $\{m_t\}$ reject the unit root hypothesis at a 1% significance level, thus suggesting that the first differences are stationary.

The second step in testing for co-integration is to test whether the residuals of the forward (of m_t on x_{t+1}) and of the reverse (of x_{t+1} on m_t) co-integrating regressions are non-stationary. We estimated the co-integrated regressions using regulated deposit interest rates, the actual inflation and a linear projection of the rate of inflation as proxies for x_{t+1}. In all the four possible co-integrating regressions based on the rate of inflation, the ADF(1) test rejected the unit root at a 1% significance level. For the regression with the regulated interest rate the ADF(1) test rejected the null at a 5% significance level. So we can finally conclude that the log of the real stock of money and the expected cost of holding money are co-integrated, $(m_t, x_{t+1}) \sim CI(1,1)$.

The structural parameters of the money demand function are estimated by the co-integrating regression. As mentioned before they are subject to two sources of small sample biases that arise because of a simultaneity problem and because of errors in variables. This last source of bias disappears in the reverse regression[24]. The revenue maximizing rate of

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[23] DF and ADF tests fail to reject the unit root hypothesis for regulated interest rates in model (15.b).

[24] The errors in variables problem biases the estimator of a_1 towards zero. If $x^*_{t+1} = x_{t+1} + \delta_{t+1}$ then

$$m_t = a_0 + a_1(x_{t+1} + \delta_{t+1}) + (z_t - a_1 \delta_{t+1})$$

inflation estimated from the reverse regression is 19.4% (σ=2.02) when we use the regulated deposit interest rate as a proxy for the cost of holding money, 17.99% (σ=3.68) when we use the actual inflation and 18.47% (σ=2.91) when we use the linear projections of inflation[25]. The error in variables bias may explain the difference between our estimate of the revenue maximizing rate of inflation and the one obtained by R. Fernandez and C. Rodriguez[26], since their estimate of 30.5% is similar to those we obtain in the forward regressions. The errors in variables bias may explain why the estimates of the parameters of the forward regressions are more sensitive to the choice of the proxy for the opportunity cost holding money than the estimates derived from the reverse regression. Melnick (1988) estimates the elasticity of a rise of inflation above the previous highest level to be one when the inflation rate is 22% per month.

The similarity between these estimates and those obtained for the "tablita" regime is striking. This is surprising in view of the significant changes in the institutional setting in the two periods. Under the "tablita" regime domestic interest rates were market determined and there was international capital mobility, and during the "pre-austral" regime interest rates were set by the central bank, yielding negative real

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where we see that $-a_1\delta_{t+1}$ is positively correlated with x^*_{t+1}. In the reverse regression this bias disappears because δ_{t+1} is assumed to be independent of m_t.

25 These statistics are not normally distributed, their distributions are skewed and have a small sample bias that lowers the estimated revenue maximizing rate of inflation.

26 See comments by C. Rodriguez in M. Bruno et. al. Inflation Stabilization.

returns, and there was no capital mobility[27].

V. Implications and Final Reflections

The analysis of the previous sections shows that inflation in Argentina had an important role generating public sector revenues. The rate of inflation, however, has exceeded our estimated revenue maximizing rate in many occasions during the pre-Austral period. This in itself presents a number of puzzles. Did the authorities tolerate rates of inflation that are inefficient from a public finance perspective? Did these apparently excessive rates of inflation perform a fiscal role?

The results of section IV imply that at the revenue maximizing rate of inflation the government can obtain seigniorage of about 7.5 percent of GDP in steady state. This is true for the "tablita" and the pre-Austral periods. The actual relationship between inflation and the inflation tax between June 1978 and April 1985 is presented in figure 4 by the small squares. It can be seen there that there is a clear, positive relation between inflation and the inflation tax for rates of inflation below 18 percent. In this respect the results are consistent with our analysis in section IV. The interpretation of the events is more difficult for rates of inflation near and above 20 percent. There is a cluster of observations in the 20 percent range, with the inflation tax ranging from 7 to 10 percent of GDP. For rates of inflation in excess of 20 percent the

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27 If we extend the sample period to July 1982 - May 1988 the reverse regression of money on inflation still estimates the revenue maximizing rate of inflation at 21.84 (σ=1.84) percent per month.

relationship is even less clear. Increases in the rate of inflation are not successful in securing more inflation tax revenues once inflation exceeds that level.

The overall evidence is consistent with the results of our estimation. The solid line in figure 4 corresponds to the fitted relation between inflation and the inflation tax using the estimates of the demand for money from the "tablita" period. Steady state seigniorage is maximized at around 7.5 percent of GDP when inflation is 21.1 percent per month. The diagram suggest that the maximizing revenue could be close to 8.5 percent of GDP, a level that is still within the margin of error of our regressions.[28] The evidence also indicates that in those instances in which this level was exceeded inflation displayed a tendency to accelerate. The revenue from inflation seems to fall unambiguously once inflation exceeds 22 percent.

An important finding of our study is that the inflation tax has remained close to, and even exceeded the maximum sustainable levels during most of the first half of the eighties. Indeed, this appears to have been the single most important source of revenue to the government during this period. This implies that any serious stabilization effort should find an alternative source of revenue to replace the inflation tax.

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[28] Fernandez and Mantel (1988) estimates indicate that the government can get up to 8.5 percent of GDP from the inflation tax.

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TABLE I: Tablita Regime (January 1979 - January 1981)

(1) Partial Adjustment Model: $m_t = (1-\tau)\ m_{t-1} + \tau\ a_0 + \tau\ a\ 1\ i\ t + \mu_t$

(2) Market clearing Model: $m_t = a\ 0 + a_1\ i_t + \mu_t$

	MODEL (1)			MODEL (2)		
	SMA(12)	SMA(12) TSLS	Dec TSLS	SMA(12)	SMA(12) TSLS	Dec MA(1) TSLS
$(1-\tau)$	0.28 (2.22)	0.21 (1.51)	0.39 (4.23)			
τa_0	-2.316 (-5.55)	-2.521 (-5.59)	-1.991 (-6.60)			
τa_1	-0.039 (-4.06)	-0.048 (-4.34)	-0.030 (-4.12)			
a_0	-3.21 (-47.11)	-3.18 (-45.35)	-3.26 (-55.7)	-3.24 (-60.7)	-3.20 (-49.2)	-3.27 (-71.8)
a_1	-.054 (-4.65)	-.06 (-5.06)	-.049 (-5.17)	-.049 (-4.41)	-.056 (-5.11)	-.046 (-6.0)
Q(12)		8.9	4.2		9.25	8.5
F	21.3	18.3	49.7	26.0	15.5	28.8
R^2	.75	.72	.88	0.70	0.58	0.80
h or DW	1.06	.20	.40	1.69	1.69	1.95
$E(1/a_1)$	19.4	17.2	21.1	21.1	18.4	22.2
$\sigma(1/a_1)$	(3.98)	(3.27)	(4.08)	(3.78)	(3.48)	(3.61)

Notes:

i. Number of observations: 25
ii. t-statistics are in parenthesis except for $E(1/a_1)$ where the standard deviation is reported.
iii. t-statistics for structural parameters of the partial adjustment model are based on the variance of the asymptotic distribution.
iv. SMA(12): Seasonal moving average
Dec (Dummy) = 1 in December, 0 otherwise.
v. The first column in each model reports the estimation with no instruments.
vi. TSLS estimates (1) and (2) with instrumental variables using lagged interest rates and current and lagged rates of devaluation as instruments for it.
vii. TSLS in model (2), Dec, is corrected for an MA(1) error process.

TAbLE II.A: Phillips-Perron Rgressions

I. MONEY	μ	β	α	R^2	DW
(17.a)			1.0057 (259)	.73	1.94
(17.b)	-.343 (-.89)		.919 (9.3)	.74	1.82
(17.c)	-1.21 (-2.05)	-.478 (-1.90)	.698 (4.65)	.77	1.66
II. INFLATION					
(17.a)			1.018 (39)	.67	1.62
(17.b)	1.76 (.89)		.919 (8.02)	.67	1.52
(17.c)	7.84 (2.88)	.204 (2.94)	.553 (3.43)	.74	1.46
III. REGULATED INTEREST RATES					
(17.a)			1.031 (56)	.88	1.94
(17.b)	1.07 (1.35)		.950 (15.1)	.88	1.90
(17.c)	4.46 (2.62)	.124 (2.22)	.662 (4.64)	.90	1.69

TABLE II.B: Phillips-Perron Tests

Model (17.c)[1]	$Z(\Phi_3)$	$Z(\alpha)$	$Z(t_\alpha)$	$Z(\Phi_2)$
Money	1.38	-6.46	-1.70	10.70*** [2]
Inflation	5.19	-5.46	-2.16	5.44* [3]
Int. Rate	2.93	-8.88	-2.29	4.91*

Model (17.b)	$Z(\Phi_1)$	$Z(\alpha)$	$Z(t_\alpha)$
Money	12.08*** [4]	.08	.06
Inflation	4.73* [5]	.66	.30
Int. Rate	4.44*	-.99	-.61

* The Null hypothesis is rejected at a 10% significance level.
** The Null hypothesis is rejected at a 5% significance level.
*** The Null hypothesis is rejected at a 1% significance level.

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1 The truncation lag used to compute S^2_{Tl} was l = 3.

2 When the truncation parameter, l, is 6 or 12 $Z(\Phi_2)$ becomes 2.41 and 2.39, implying that we should accept the driftless case.

3 When the residuals of regression (17.a) are used under the null of a random walk, $Z(\Phi_2)$ = 10.28, rejecting the null at a 10% significance level.

4 If we allow the truncation parameter l to be 6 or 12 $Z(\Phi_1)$ becomes 1.56 and 1.59, and we should accept the random walk hypothesis.

5 If we use the first differences of the inflation rate under the null of the random walk this statistic becomes 1.36

TABLE III

Co-Integrating Regressions: July 1982-March 1985

(1) $m_t = a_0 + a_1 x_{t+1} + w_t$; $w_t = z_t - a_1 \delta_{t+1}$; $\delta_{t+1} = x_{t+1} - x^*_{t+1}$

x_{t+1}	a_0	a_1	R^2	DW	DF	ADF(1)	ADF(2)	ADF(3)
π_{t+1}	-3.52	-.024	.43	.79	-.46	-.62	-.60	-.36
	(-39.17)	(4.88)			(-3.03)	(-3.83)	(-2.7)	(-1.47)
$\hat{\pi}^e_{t+1}$	-3.41	-.031	.40	.91	-.50	-.72	-.72	-.51
	(-33.4)	(-5.4)			(-3.33)	(-4.49)	(-3.2)	(-1.92)
r_t	-3.47	-.038	.75	.95	-.43	-.64	-.66	-.64
	(-67.3)	(-9.6)			(-2.89)	(-3.3)	(-2.8)	(-2.26)

(2) $x_{t+1} = -a_0 / a_1 + 1/a_1 m_t + w'_t$ $w'_t = (-1/a_1 z_t + \delta_{t+1})$

x_{t+1}	a_0/a_1	$1/a_1$	R^2	DW	DF	ADF(1)	ADF(2)	ADF(3)
π_{t+1}	-53.42	-17.99	.43	.82	-.43	-.63	-.50	-.41
	(-3.67)	(-4.88)			(-2.92)	(-4.11)	(-2.56)	(-1.82)
π^e_{t+1}	-55.33	-18.47	.57	1.13	-.57	-.76	-.57	-.52
	(-4.82)	(-6.35)			(-3.40)	(-3.9)	(-2.34)	(-1.88)
r_t	-64.31	-19.40	.75	.81	-.42	-.53	-.55	-.64
	(-8.04)	(-9.59)			(-2.84)	(-3.3)	(-2.87)	(-2.90)

$$\hat{\pi}^e_{t+1} = \hat{b}_0 + \hat{b}_1 \pi_t + \hat{b}_2 \pi_{t-1} + \hat{b}_3 \pi_{t-2} + \hat{b}_4 r_t + \hat{b}_5 r_{t-1}$$

Notes: i. t-statistics are between brackets

ii. The forward regression is estimated with TSLS.

iii. The estimators of the co-integrating regression are not normally distributed.

iv. x^*_{t+1} is the true expected opportunity cost of holding money.

APPENDIX

Statistics on model 17.c

$Z(\Phi_3) = (S^2_u/S^2_{T1})\Phi_3 - (S^2_{T1}-S^2_u)/2S^2_{T1}[T(\tilde{\alpha}-1)-(T^6/48D_x)(S^2_{T1}-S^2_u)]$

$Z(\tilde{\alpha}) = T(\tilde{\alpha}-1) - (T^6/24D_x)(S^2_{T1}-S^2_u)$

$Z(t_{\tilde{\alpha}}) = (S^2_u/S^2_{T1})t_{\tilde{\alpha}} - (T^3/4\ (3D_x)S_{T1})(S^2_{T1}-S^2_u)$

$Z(\Phi_2) = (S^2_u/S^2_{T1})\Phi_2 - (S^2_{T1}-S^2_u)/3S^2_{T1}[T(\tilde{\alpha}-1)-(T^6/48D_x)(S^2_{T1}-S^2_u)]$

Statistics on model 17.b

$Z(\alpha^*) = T(\alpha^*-1) - 1/2(S^2_{T1}-S^2_u)[T^{-2}\Sigma(\bar{y}_{t-1}-y_{-1})^2]^{-1}$

$Z(t_{\alpha^*}) = (S^2_u/S^2_{T1})t_{\alpha^*} - (1/2S^2_{T1})(S^2_{T1}-S^2_u)[T^{-2}\Sigma(\bar{y}_{t-1}-y_{-1})^2]^{-(1/2)}$

$Z(\Phi_1) = (S^2_u/S^2_{T1})\Phi_1 -$
$- (1/2S^2_{T1})(S^2_{T1}-S^2_u)\{T(\alpha^*-1)-1/4(S^2_{T1}-S^2_u)[T^{-2}\Sigma(\bar{y}_{t-1}-y_{-1})^2]^{-1}\}$

where $S^2_u = T^{-1}\sum_{t=1}^{t} u^2_t$, u^2_t = residuals from appropriate model.

= consistent estimator of $\sigma_u = \lim_{T\to\infty} T^{-1}\sum_{t=1}^{T} E(u_t^2)$

under the corresponding null hypothesis.

$S^2_{T1} = T^{-1}\sum_{t=1}^{T} u^2_t + 2T^{-1}\sum_{j=1}^{l}\sum_{t=j+1}^{T} u_t u_{t-j}$

= consistent estimator of $\sigma = T^{-1}E(S^2_T)$, $S^2_T=\sum_{t=1}^{T} u_t$

under the corresponding null hypothesis.

$D_x = \det(X'X)$

$\Phi_1 = [T\Sigma(y_t-y_{t-1})^2 - T\Sigma u^{*2}]/(2\Sigma u^{*2})$

$\Phi_2 = [T\Sigma(y_t-y_{t-1})^2 - T\Sigma\tilde{u}^2]/3\Sigma\tilde{u}^2$

$\Phi_3 = [T\Sigma(y_t-y_{t-1})^2 - (\bar{y}-\bar{y}_{-1})^2]/2\Sigma\tilde{u}^2$

$\alpha^*, t_{\alpha^*}, \tilde{\alpha}, t\tilde{\alpha}$ are the standard OLS statistics.

CRITICAL VALUES OF THE STATISTICS

Statistic	Null Hypothesis	T	P[X≤x] = .10	.90	.95	.99
Φ_3	$\beta = 0,\ \alpha = 1,\ \mu = \mu$	25	1.33	5.91	7.24	10.61
	in model 17.c	50	1.37	5.61	6.73	9.31
Φ_2	$\beta = \mu = 0,\ \alpha = 1$	25	1.10	4.67	5.68	8.21
	in model 17.c	50	1.12	4.31	5.13	7.02
Φ_1	$\mu = 0,\ \alpha = 1$	25	0.65	4.12	5.18	7.88
	in model 17.b	50	0.66	3.94	4.86	7.06

Statistic	Null Hypothesis	T	P[X≤x] = .10	.05	.01
$t_{\tilde{\alpha}}$	$\alpha = 1$ in 17.c	25	-3.24	-3.60	-4.38
		50	-3.18	-3.50	-4.15
$\tilde{\alpha}$	$T(\alpha-1) = 0$ in 17.c	25	-15.6	-17.9	-22.5
		50	-16.8	-19.8	-25.7
t_{α^*}	$\alpha = 1$ in 17.b	25	-2.63	-3.00	-3.75
		50	-2.60	-2.93	-3.58
α^*	$T(\alpha-1) = 0$ in 17.b	25	-10.2	-12.5	-17.2
		50	-10.7	-13.3	-18.9

Note: The Phillips-Perron statistics converge in distribution to those whose critical values are reported above.

Source: Fuller (1976), Dickey-Fuller (1981)

Figure 1.A

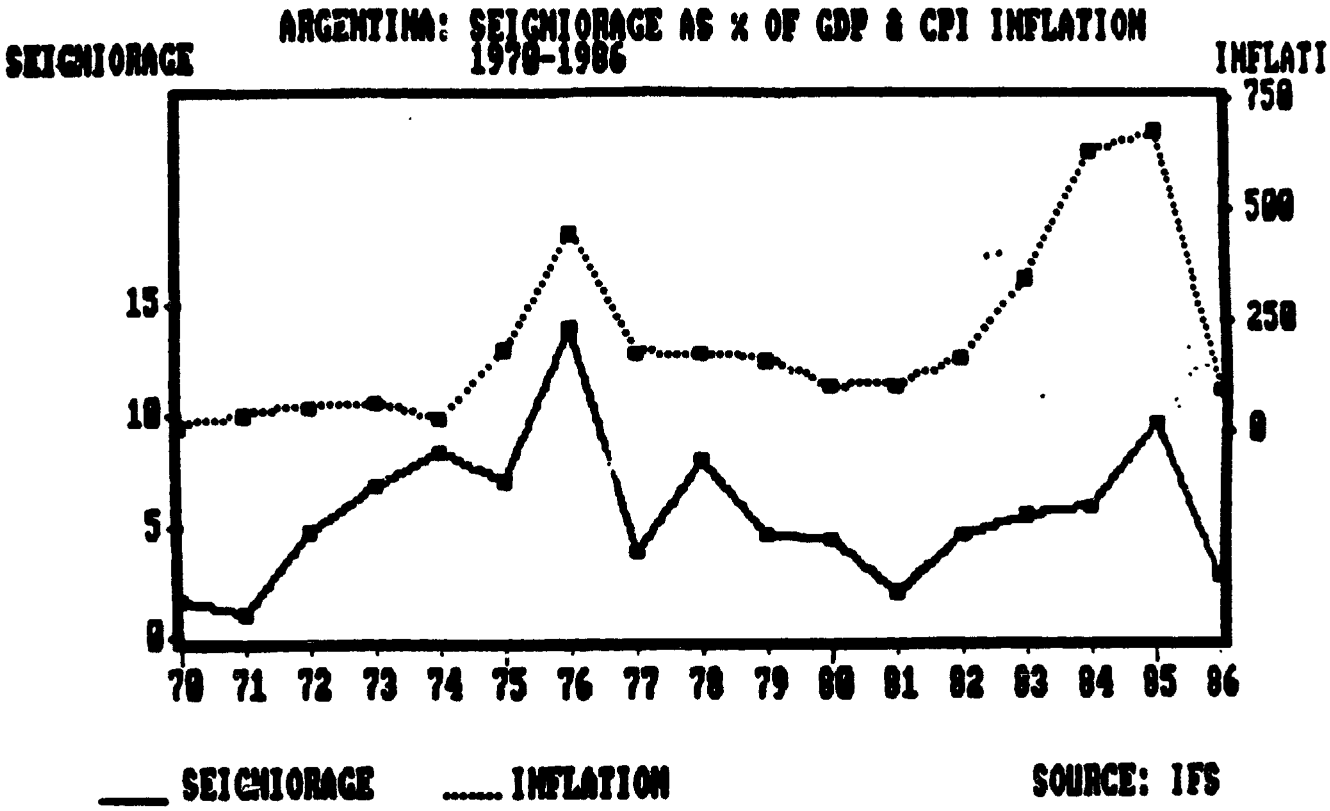

ARGENTINA: SEIGNIORAGE AS % OF GDP & CPI INFLATION
1970-1986
SEIGNIORAGE
INFLATI(
750
500
250
0
15
10
5
0
70
71
72
73
74
75
76
77
78
79
80
81
82
83
84
85
86
SEIGNIORAGE
INFLATION
SOURCE: IFS

Figure 1.8

BOLIVIA: SEIGNIORAGE AS % OF GDP & CPI INFLATION
1970-1985

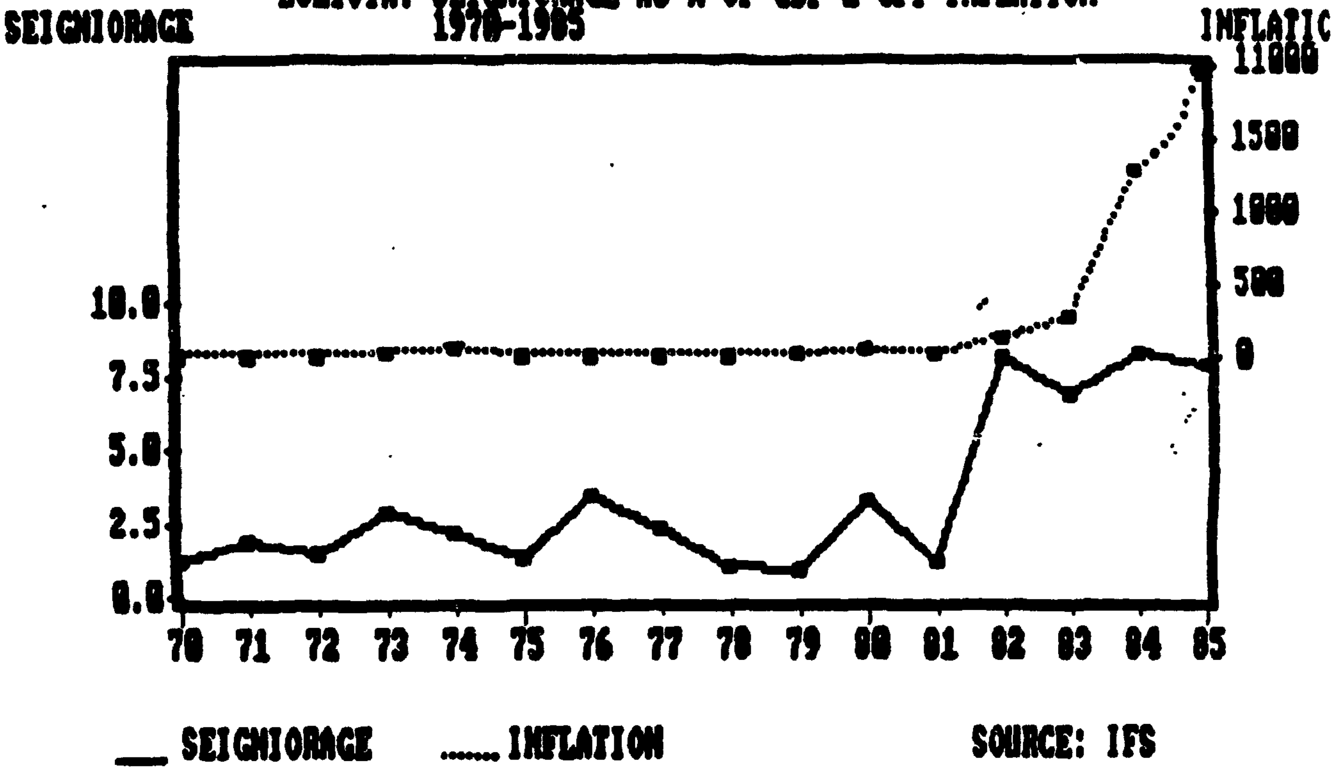
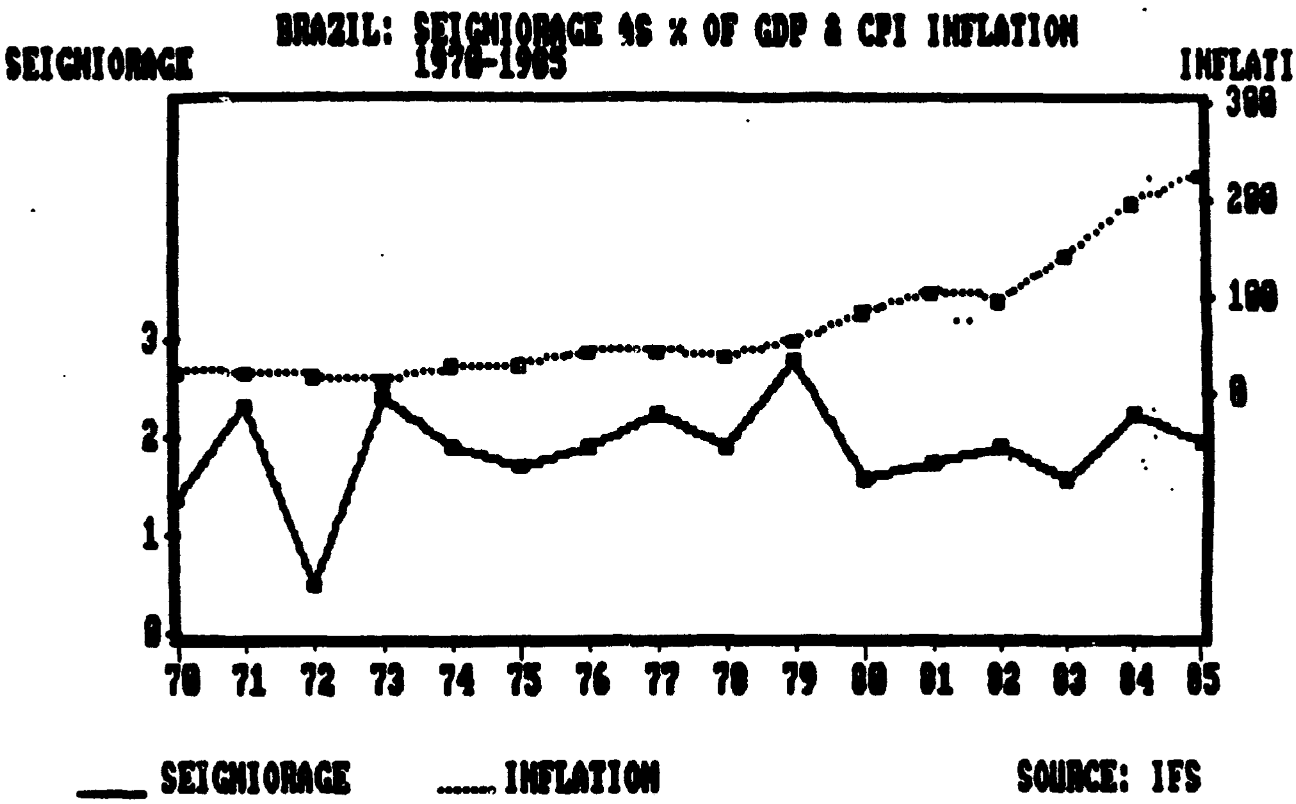


Figure 1.C



BRAZIL: SEIGNIORAGE AS % OF GDP & CPI INFLATION
1970-1985
SEIGNIORAGE
INFLATI
0
1
2
3
0
100
200
300
70
71
72
73
74
75
76
77
78
79
80
81
82
83
84
85
SEIGNIORAGE
INFLATION
SOURCE: IFS

Figure 1.D

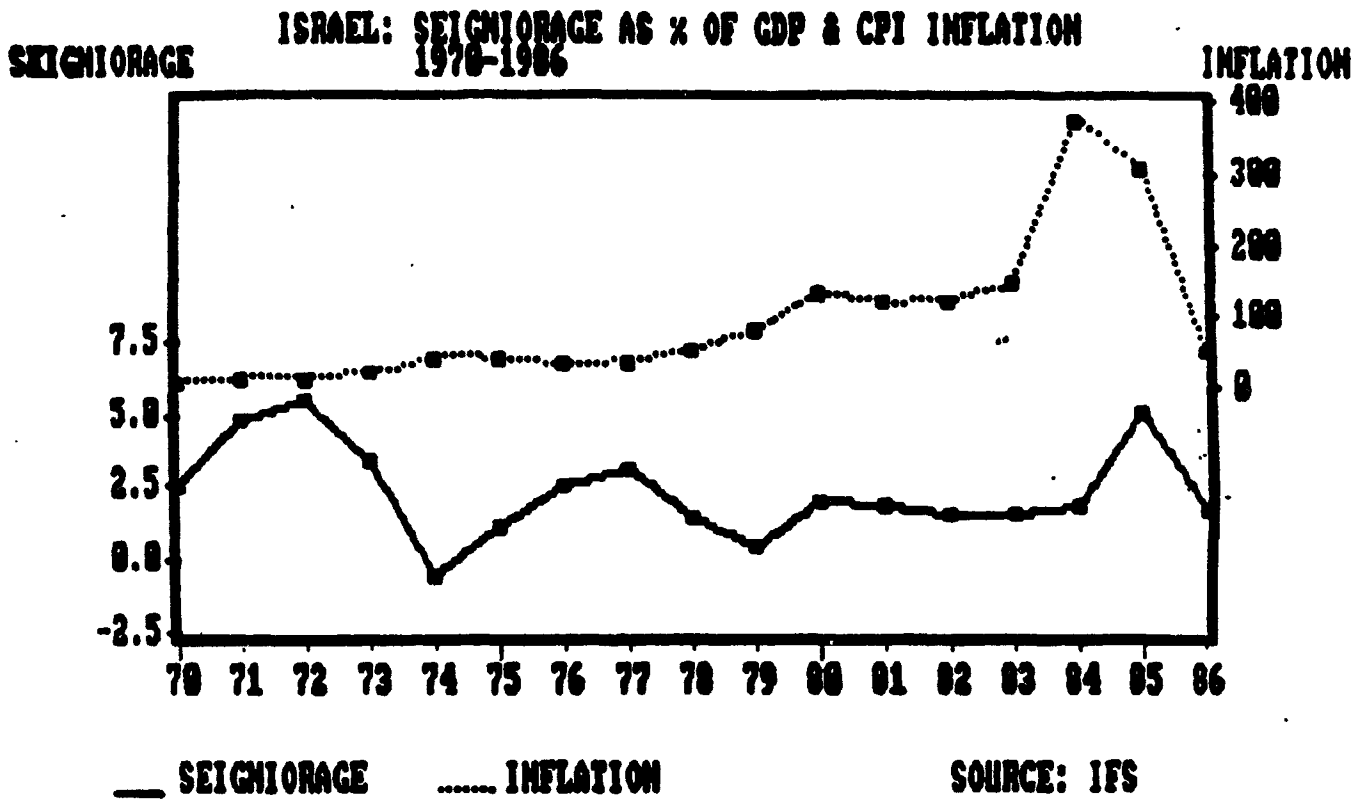

ISRAEL: SEIGNIORAGE AS % OF GDP & CPI INFLATION
1970-1986
SEIGNIORAGE
INFLATION
400
300
200
100
0
7.5
5.0
2.5
0.0
-2.5
70
71
72
73
74
75
76
77
78
79
80
81
82
83
84
85
86
SEIGNIORAGE
INFLATION
SOURCE: IFS

Figure 1.E

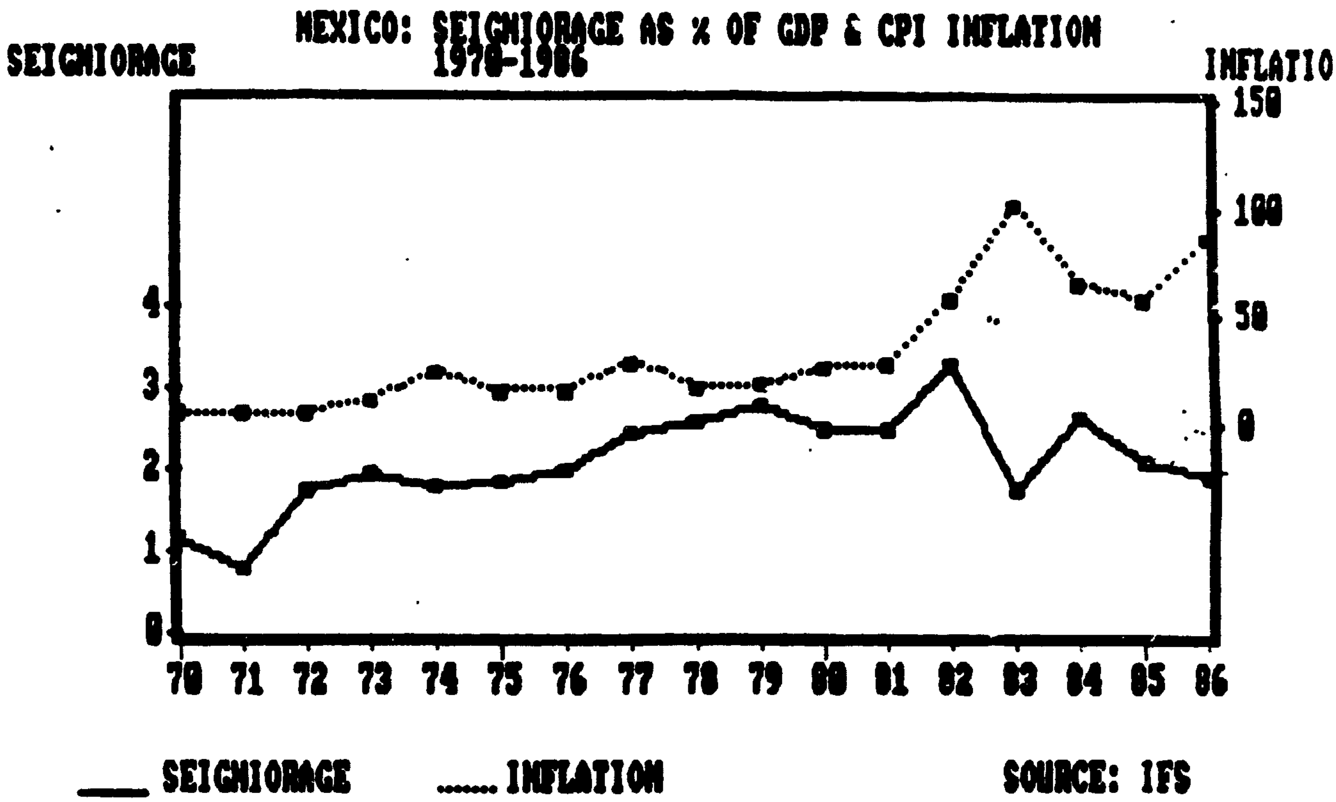

MEXICO: SEIGNIORAGE AS % OF GDP & CPI INFLATION
1970-1986
SEIGNIORAGE
INFLATIO
0
1
2
3
4
0
50
100
150
70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86
SEIGNIORAGE
INFLATION
SOURCE: IFS

Figure 2

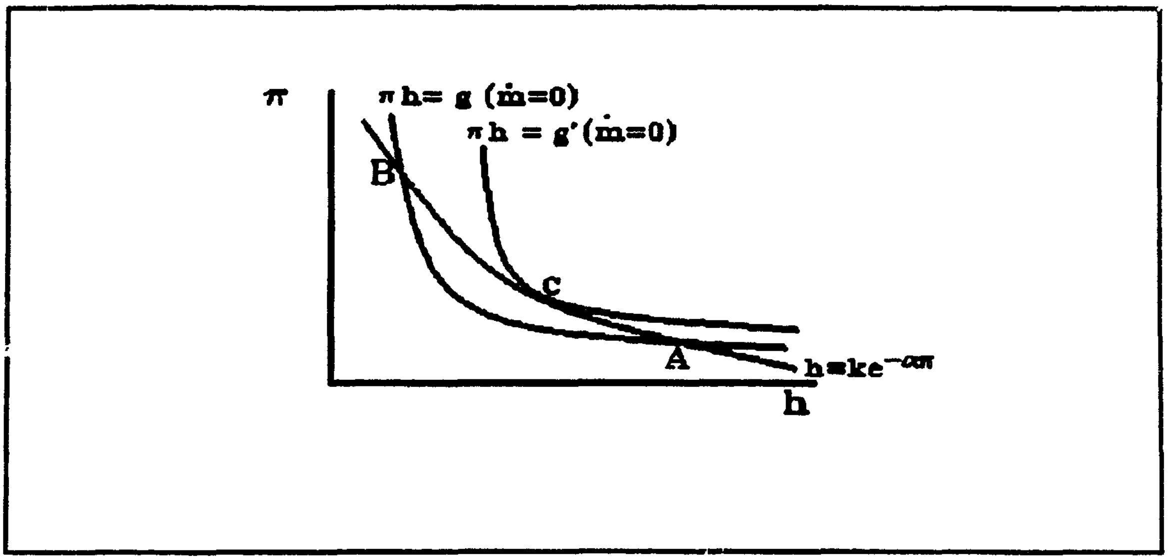


Figure 3

SEIGNORAGE. INFLATION TAX AND INFLATION RATE

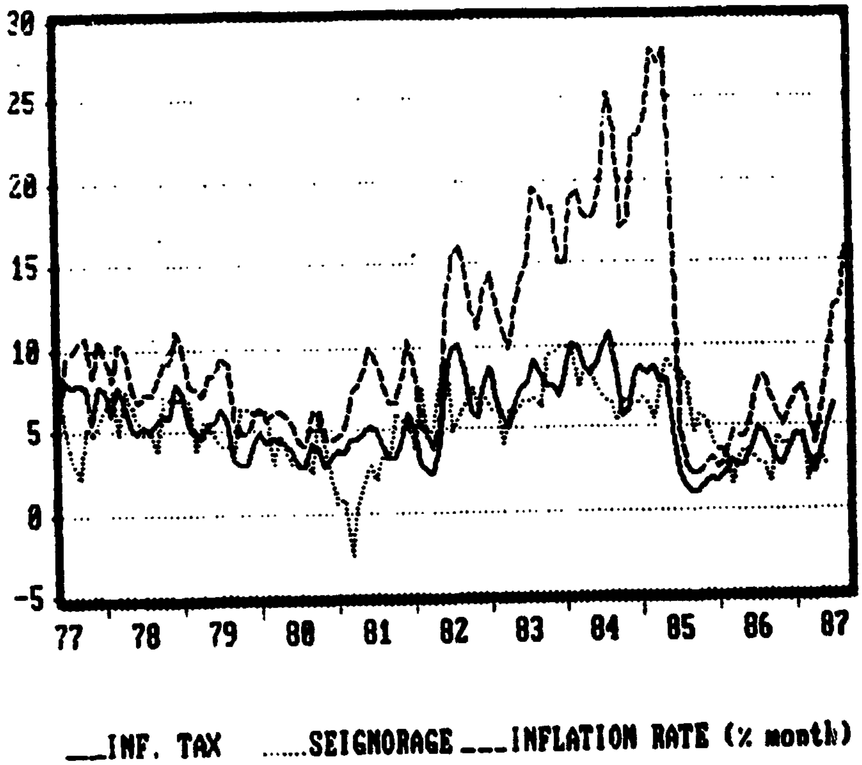
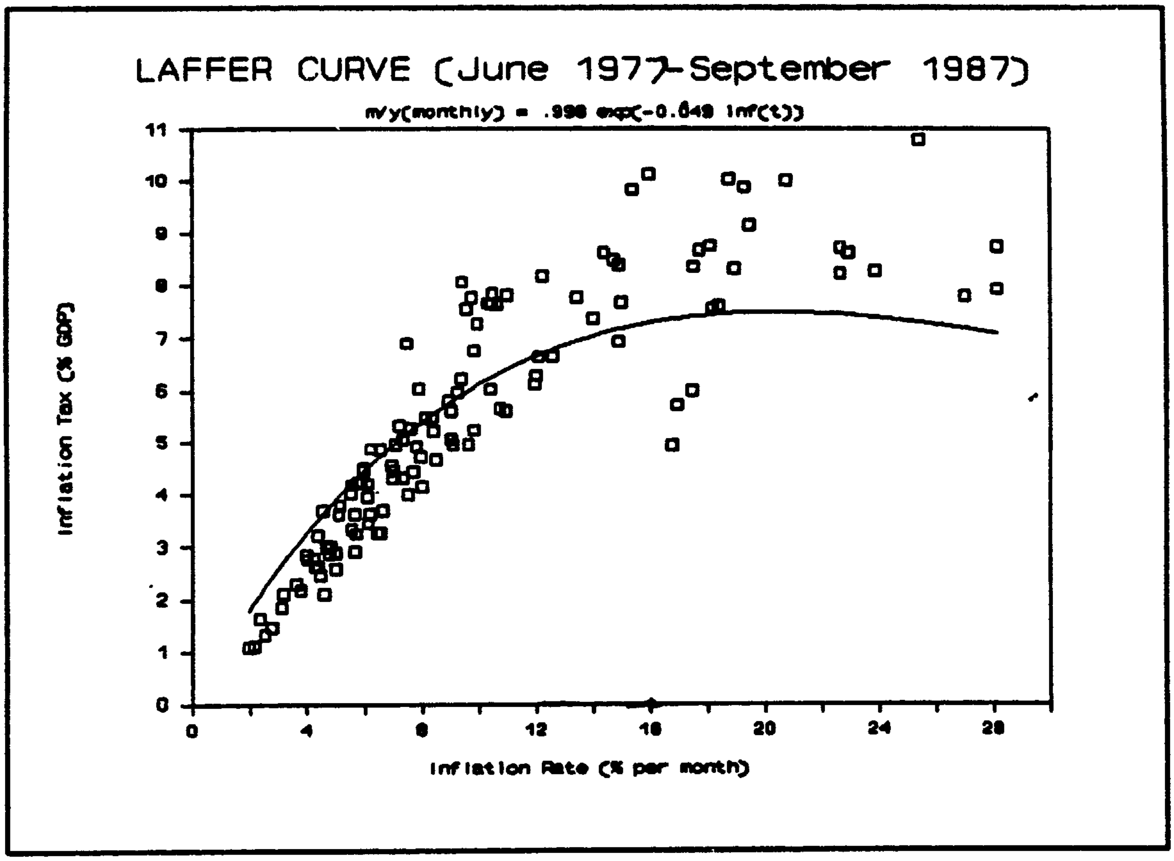


Figure 4


LAFFER CURVE (June 1977-September 1987)
m/y(monthly) = .998 exp(-0.049 inf(t))
Inflation Tax (% GDP)
Inflation Rate (% per month)
0
1
2
3
4
5
6
7
8
9
10
11
0
4
8
12
16
20
24
28

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