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A MONETARY APPROACH TO THE CRAWLING-PEG SYSTEM: THEORY AND EVIDENCE

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With the advent of the modern literature on the monetary approach to the balance of payments and to the exchange rate, and following the seminal contributions of Mundell (1968, 1971), Johnson (1972), and Dornbusch (1973), a large amount of effort has been devoted to emphasizing the role of the money market, and of asset markets, in the determination of the balance of payments and the exchange rate. The long-run impact of monetary shocks in a regime of fixed exchange rates, the effects of devaluations and changes in commercial policy in a monetary setting, and the short-run consequences of monetary imbalance on the inflation rate and on the balance of payments have recently been the object of careful theoretical and empirical study. The importance of monetary variables in the determination of the exchange rate in a regime of floating rates has also been analyzed in detail.1/

1/ A number of important contributions on the topic are collected in Frenkel and Johnson (1976, 1978) and in the IMF (1977) volume. A review of the empirical evidence on the monetary approach to the balance of payments and exchange rates is presented in Magee (1976). Johnson (1977) and Whitman (1975) present comprehensive reviews of the recent contributions to the monetary approach literature, while a critique of some of the central aspects of that approach is elaborated by Hahn (1977). All these deal with fixed-exchange-rate regimes.

Among those dealing with floating rates are Dornbusch (1976), Frenkel (1976), Frenkel and Clements (1978), Kouri (1975), and Mussa (1976).

Most of these studies, however, have dealt either with cases in which the exchange rate has been kept fixed for very long periods, or with cases of free floating in which the exchange rate is predominatly determined by the interaction of market forces without government intervention.2/

Yet in recent years many countries have experienced simultaneous fluctuations in both their exchange rates and international reserves. These fluctuations have occurred either under a managed-float system, characterized by government intervention in the foreign-exchange market, or under a crawling-peg system, in which the authorities completely determine, and periodically change, the country's exchange rate.3/ In order to explicitly analyze the experience of countries with these characteristics, an extension to the previous formulations of the monetary approach is required.

2/ An exception is the study by Girton and Roper (1977). They develop and test a monetary model of exchange-market pressure, which is defined as a composite variable that includes changes in both the exchange rate and international reserves. As will be seen below, our model deals with the simultaneous determination of each of the components of exchange-market pressure.

3/ A theoretical analysis which concludes that the optimal exchange rate regime will correspond to neither of the extremes of a completely fixed or a completely flexible rate is presented by Frenkel (1978, Appendix C). Frenkel, then, concludes that "....for the purpose of empirical work it is useful to design a framework of the adjustment mechanism that can accommodate simultaneously changes in international reserves and changes in the exchange rate." [Frenkel (1978, p. 39, fn. 1)].

In this paper we develop and estimate a framework, which extends the monetary approach, for the analysis of the joint determination of the exchange rate, international reserves, and the rate of inflation when a crawling-peg system is adopted. The basic model is presented in Section I. In the same section, we utilize the model to study the impact of changes in domestic monetary policy on the evolution of these three endogenous variables. The empirical implementation of the model, presented in Section II, uses quarterly data from Brazil for the crawling-peg period: 1968 III-1977 IV. We estimate the parameters of the model simultaneously using a Full-Information Maximum-Likelihood method. Concluding remarks are presented in Section III.

I. THE MODEL

Monetary Equilibrium.

The model here developed is a variant of the monetary approach to the balance of payments. Its main feature is that it accounts for different degrees of exchange-rate flexibility (from a freely floating parity to a totally fixed exchange rate). We take the case of a small country, defined as one the international price of whose traded goods is exogenously determined, and we allow for the existence of nontraded goods defined as goods whose price responds, at least in the short run, to domestic monetary variables.

We also assume that the rate of growth of real income is not affected by monetary variables.

The basic relationships of the monetary sector are:

(1) $M_s \equiv a(R + D)$

(2) $M_d = Pm_d$

(3) $m_d = f(y, \pi^e)$,

where M_s is the nominal supply of domestic money; a is the money multiplier; R is the foreign-exchange reserves held by the Central Bank; D is the domestic-credit component of the monetary base; M_d is the demand for nominal cash balances; P stands for a price index that includes traded and nontraded goods; and m_d is the real demand for money, which is assumed to be a function of real income, y, and of the alternative cost of holding money, proxied by π^e the expected rate of inflation.[4/]

Although it is possible to postulate a mechanism of lagged adjustments,[5/] for simplicity we assume the existence of stock equilibrium during the period of analysis, i.e., that the money market clears in each period so that the nominal stock of money

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4/ As it happens, the results below are valid under a large variety of assumptions about the mechanism for the formation of π^e, provided that the latter depends on lagged variables. In the empirical application, we assume that π^e is formed by a version of rational expectations; see Section II.

5/ Indeed, in Section II we postulate for the empirical analysis a mechanism of lagged adjustments in the money market.

is equalized, ex-post, with the demand for nominal balances. The assumption requires the existence of the flow equilibrium

$$M_s^* = M_d^*, \tag{4}$$

where the asterisk indicates the percentage rate of change of the variable. Differentiating equations (1) and (2) logarithmically, the flow-equilibrium condition can be rewritten as

$$a^* + (1 - \gamma) R^* + \gamma D^* = P^* + m_d^*, \tag{4'}$$

where γ is a factor of proportionality equal to $D/(R + D)$ and P^* is the domestic rate of inflation.

<u>The Domestic Rate of Inflation and the Balance of Payments.</u>

When traded and nontraded goods are both present, the domestic rate of inflation can be measured as a weighted average of the rate of change of the price of both kinds of goods,

$$P^* = \lambda P_T^* + (1 - \lambda) P_{NT}^*, \tag{5}$$

where P_T is the price of traded goods in domestic currency, P_{NT} is the price of nontraded goods, and λ is the share of traded goods in total expenditure. In a small economy P_T^* is determined by the world rate of inflation (P_w^*) and by the variations in the effective exchange rate (ρ^*):

$$P_T^* = P_w^* + \rho^*. \tag{6}$$

The price of nontraded goods, however, may be affected by domestic factors, at least in the short run. Since an ex-ante excess supply of money implies excess demand in the goods market, and if excess demand for nontraded goods varies monotonically with excess demand throughout the economy, we can expect the price of nontraded goods relative to that of traded goods to be a function of imbalance in the money market,

$$(7) \qquad P^*_{NT} = P^*_T + \theta\Omega,$$

where Ω is a measure of monetary imbalance and θ is the elasticity of the relative price with respect to the monetary variable. 6/

Regarding the measure of Ω, it is important to remember that a central conclusion of the monetary approach to the balance of payments is that in a small open economy the nominal supply of money may be beyond the control of the monetary authority. Under fixed exchange rates the monetary authority can only determine the ex-ante quantity of money by changing the domestic-credit component of the base, or to affect the money multiplier by manipulating variables under its control (such as legal reserve requirements). Such actions, in conjunction with the flow demand for real balances generated by adjustments in the desired stock, create an ex-ante excess flow supply of money to which the public reacts by changing the level of the international reserve component of the base through the balance

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6/ θ is a function of the elasticity of substitution between traded and nontraded goods in consumption and production as well as the income elasticity of the nontraded goods. For a detailed description of the dynamics of domestic-price determination in a monetary model with traded and non-traded goods, see for example Blejer (1977) and Parkin (1974).

of payments and by affecting the rate of domestic inflation. The ex-post nominal quantity of money in an open economy is then influenced by the behavior of the public in response to ex-ante conditions in the money market. 7/

It appears, therefore, that the relevant measure to account for the monetary effects on the goods market in an open economy should be an ex-ante measure which does not include the endogenous reaction of the foreign component of the base. For that reason we define Ω in equation (7) as the gap (in percentage terms) between the ex-ante change in the money supply (i.e., a change in the domestic-credit component of the base and in the money multiplier) and changes in demand. Equation (7) can therefore be rewritten as

$$(7') \qquad P^*_{NT} = P^*_T + \theta(\gamma D^* + a^* - M^*_d).$$

Substituting (6) into (7') and then (6) and (7') into (5) we obtain, after some manipulation, the following expression for the rate of domestic inflation: 8/

$$(8) \qquad P^* = \varepsilon(P^*_w + \rho^*) + (1 - \varepsilon)(\gamma D^* - m^*_d),$$

where $\varepsilon = 1/[1 + \theta(1 - \lambda)]$.

7/ For time-series analysis and econometric tests of the interaction between changes in domestic credit and in international reserves implied by the monetary approach using European data, see Blejer (forthcoming), and Leiderman (1978).

8/ Assuming, for simplicity, a constant money multiplier, i.e., $a^* = 0$. In the empirical section, however, changes in the money multiplier are explicitly considered.

In addition to changes in the price level, there are also changes in international reserves operating to restore monetary equilibrium. Therefore an expression for the money account of the balance of payments, which is equal to the change in the international reserves held by the Central Bank, may be obtained by substituting P* in equation (4')--the flow equilibrium condition for the money market--for its value in (8) and rearranging the terms:

$$(9) \qquad (1 - \gamma)R^* = \varepsilon(P^*_w + \rho^* + m^*_d - \gamma D^*).$$

Equations (8) and (9) present the domestic rate of inflation and the balance of payments as functions of world inflation, exchange rate policy, and the rate of ex-ante excess flow supply of money. When nontraded goods are absent ($\bar{\lambda} = 1$) or when their price is not sensitive to monetary imbalance ($\theta = 0$), then $\varepsilon = 1$ and the model is similar to the classical long-run formulation of the monetary approach (see Johnson (1972)). In such case, domestic monetary variables do not affect the domestic rate of inflation which, if the exchange rate is not altered, is fully determined by the world rate, and every ex-ante monetary shock will lead to reserve depletion due to a balance-of-payments deficit.

The Endogeneity of the Exchange Rate in a Crawling-Peg System.

Except in a fully flexible exchange-rate system (or in a managed float), the exchange rate is regarded by governments as a policy instrument, and its fluctuations are generally influenced by policy decisions aimed at one or more policy goals. Unlike under an adjustable-peg regime, under a crawling-peg system the exchange rate is changed frequently according to some set of rules adopted in order to attain the government's objectives. 9/ The variations of the exchange rate can therefore be considered as following a sort of reaction function which reflects policy goals as well as the parameters of the model adopted and the values of the exogenous and endogenous variables considered relevant for the desired goals. These goals, and therefore the crawling rules, may vary from country to country. 10/

With a view towards empirical implementation of the model for the case of Brazil, we shall postulate here that the policy objective is to avoid long-run changes in the real exchange rate and that the nominal rate (ρ) is therefore altered to maintain purchasing power parity. 11/ We assume, in addition, that the full adjustment of the

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9/ A number of porposals for the operation of the crawling-peg as well as analyzes of the stability of the system have recently been presented in the literature. See for example Cooper (1970), Kenen (1975), Levin (1975, 1977), Mathieson (1976), and Williamson (1965).

10/ Kenen (1975) analyzes in detail the relative efficiency of a number of alternative sliding-parity rules. Mathieson (1976) studies the consequences of using a welfare--instead of a balance-of-payments--objective as the guideline for the crawl.

11/ A discussion of the appropriateness of this assumption for the case of Brazil is presented in Section II below.

In a previous version of this paper a number of alternative rules were incorporated into the model, among them maintaining a given level of nominal reserves ($R^* = 0$) and maintaining a given level of real reserves ($R^* - P_W^* = 0$). Although the dynamics of the system change with the policy rule, its basic structure is not affected. For presentational convenience the functioning of the model is here confined to a single rule.

exchange rate may take more than one period and we shall analyze the effects of differences in the speed of exchange-rate adjustment. The reaction function implied by the policy rule is

$$\rho^*_t = \beta \sum_{i=0}^{n} (1 - \beta)^i L^i (P^* - P^*_w)_t, \tag{10}$$

where t is a time subscript; β indicates the portion of the current differential rate of inflation transmitted to the exchange rate in the current period and L is the lag operator (such that $L^i x_t = x_{t-i}$).12/

This formulation specifically assumes that (in addition to the current-period adjustment) the exchange rate will continue to be changed in each subsequent period by a portion β of the still unadjusted differential until the whole differential has been transmitted to the exchange rate. Obviously, the greater is β, the faster will be the adjustment of the rate. If β = 1 our model does not differ conceptually from the monetary-approach model of free floating exchange rates, since the rate of depreciation is then fully determined by the domestic-foreign inflation differential (see Frenkel (1976)).

12/ A reaction function of this type follows the approach of Dean (1974) in the sense that endogenous target variables are functions of the current values of other endogenous variables on the grounds that they are a plausible representation of the structure of the model allowing for the possibility of prior knowledge of the structural-form coefficients. This differs from the approach of earlier works such as Friedlaender (1973) where endogenous variables depend only on exogenous or lagged-endogenous variables.