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Exchange Rate Economics

A Survey

RONALD MACDONALD and MARK P. TAYLOR*

Two main views of exchange rate determination have evolved since the early 1970s: the monetary approach to the exchange rate (inflexible-price, sticky-price, and real interest differential formulations); and the portfolio balance approach. The literature on these views is surveyed, followed by a discussion of the empirical evidence and likely future developments in the area of exchange rate determination. The literature on foreign exchange market efficiency, exchange rates and "news," and international parity conditions is also reviewed. [JEL F30, F41]

THE PAST two decades have seen an enormous growth in the literature on exchange rate economics. Given the importance attached to the exchange rate in the success or failure of an open economy, it is not surprising that exchange rate economics is one of the most heavily researched areas of the discipline. The period since the advent of generalized floating exchange rates in 1973 has generated a wealth of data on exchange rates and on the factors that supposedly determine them, giving econometricians and applied economists an unprecedented opportunity to test

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a number of propositions relating to foreign exchange markets. Despite this extensive research, a large number of unresolved issues remain, and exchange rate economics continues to be an extremely challenging area.

This paper surveys the vast literature that this intense research activity has generated. In particular, we examine the two main views of exchange rate determination that have evolved since the early 1970s: the monetary approach (in flexible-price, sticky-price, and real interest differential formulations) and the portfolio balance approach. We then examine the empirical evidence on these models and conclude by speculating how the future research strategy is likely to develop. We also discuss the literature on foreign exchange market efficiency, exchange rates and "news," and international parity conditions.

This contribution may be viewed as an extension and update of earlier surveys of empirical work on exchange rates by, among others, Kohlhagen (1978), Levich (1979, 1985), and Isard (1988), and as a simplification and synthesis of surveys of exchange rate theory by Mussa (1984), Frenkel and Mussa (1985), and Obstfeld and Stockman (1985).

I. Theories of Exchange Rate Determination

Early contributions to the postwar literature on exchange rate economics include Nurkse (1945) and Friedman (1953). Both of these contributions are to a large extent concerned with the role of speculation in foreign exchange markets. Nurkse warns against the dangers of "bandwagon effects," which may generate market instability.[1] Friedman's classic apologia for floating exchange rates (Friedman (1953)) is remarkable in its anticipation of much of the literature of the following two decades and is still cited as the seminal article on stabilizing speculation.

Meade (1951a, Part III) laid the foundations for simultaneous analysis of internal and external balance in an open economy, which were built upon a decade later in the pathbreaking contributions of Mundell (1961, 1962, 1963, 1968) and Fleming (1962). In the verbal exposition of his capital account theory, Meade worked through the stock equilibrium implications of a movement in international interest rate differentials, but did not faithfully represent this feature in his mathematical exposition (Meade (1951b, p. 103)). Mundell (1961, 1962, 1963, 1968) and Fleming (1962) followed Meade's mathematical representation and thus abstracted from the stock-flow implications of interest rate differential

[1] See Bilson (1981), Frankel and Froot (1987), and Allen and Taylor (1990) for recent discussions of bandwagon effects in foreign exchange markets.

changes. Therefore, although the integration of asset markets and capital mobility into open economy macroeconomics was an important contribution of the Mundell-Fleming model, the model was largely rejected on a priori grounds as a serious contender for the explanation of exchange rate movements at the beginning of the recent float. This was because it was judged to contain a fundamental flaw—it is cast almost entirely in flow terms. In particular, the model allows current account imbalances to be offset by flows across the capital account, without any requirement of eventual stock equilibrium in the holding of net foreign assets.

Other papers dating from the 1950s—Polak (1957) and Johnson (1958)—had stressed the distinction between stock and flow equilibria in the open economy context, and this was to become a hallmark of the monetary approach to balance of payments analysis (see, for example, Frenkel and Johnson (1976)), and subsequently, the monetary approach to the exchange rate (see, for example, Frenkel and Johnson (1978)). More generally, work done in the late 1960s by Oates (1966), McKinnon and Oates (1966), McKinnon (1969), and Ott and Ott (1965) began to integrate analyses of open economy macroeconomics and financial portfolio balance by imposing stock equilibrium constraints. Later work by Branson (1968), Willet and Forte (1969), and Kouri and Porter (1974) built on this work by incorporating more general features of financial portfolio choice (Tobin (1965)).[2]

Flexible-Price Monetary Model

Since an exchange rate is, by definition, the price of one country's money in terms of that of another, it makes sense to analyze the determinants of that price in terms of the outstanding stocks of and demand for the two monies. This is the basic rationale of the monetary approach to the exchange rate (Frenkel (1976), Kouri (1976), and Mussa (1976, 1979)).

The early, flexible-price monetary model relies on the twin assumptions of (continuous) purchasing power parity (PPP) and the existence of stable money demand functions for the domestic and foreign economies. The (logarithm of the) demand for money may be assumed to depend on (the logarithm of) real income, y, the (logarithm of the) price level, p, and the level of the interest rate, r (foreign variables are denoted by an asterisk). Monetary equilibria in the domestic and foreign country, respectively, are given by

[2] Taylor (1990) analyzes in detail the evolution of thinking on open economy macroeconomics.

$$m_t^s = p_t + \phi y_t - \lambda r_t \tag{1}$$

and

$$m_t^{s*} = p_t^* + \phi^* y_t^* - \lambda^* r_t^* . \tag{2}$$

Equilibrium in the traded goods market ensues when there are no further profitable incentives for trade flows to occur—that is, when prices in a common currency are equalized and PPP holds. The PPP condition is

$$s_t = p_t - p_t^* , \tag{3}$$

where s_t is the logarithm of the nominal exchange rate (domestic price of foreign currency). Thus, if PPP holds continuously, the logarithm of the real exchange rate, q_t, say $(q_t \equiv s_t - p_t + p_t^*)$, is a constant. The world price, p_t^*, is exogenous to the domestic economy, being determined by the world money supply. The domestic money supply determines the domestic price level, and hence, the exchange rate is determined by relative money supplies. Algebraically, substituting equations (1) and (2) into (3) yields, after rearranging

$$s_t = (m^s - m^{s*})_t - \phi y_t + \phi^* y_t^* + \lambda r_t - \lambda^* r_t^* , \tag{4}$$

which is the basic flexible-price monetary model equation. Equation (4) says that an increase in the domestic money supply, relative to the foreign money stock, will lead to a rise in s_t—that is, a fall in the value of the domestic currency in terms of the foreign currency. This seems intuitive enough. An increase in domestic output, as opposed to the domestic money supply, *appreciates* the domestic currency (s_t falls). Similarly, a rise in domestic interest rates depreciates the domestic currency (in the Mundell-Fleming model; this would lead to capital inflows and, hence, an *appreciation*).

In order to resolve these apparent paradoxes, one has to remember the fundamental role of relative money demand in the flexible-price model. A relative rise in domestic real income creates an excess demand for the domestic money stock. As agents try to increase their (real) money balances, they reduce expenditure and prices fall until money market equilibrium is achieved. As prices fall, PPP ensures an appreciation of the domestic currency in terms of the foreign currency. An exactly converse analysis explains the response of the exchange rate to the interest rate—an increase in interest rates reduces the demand for money and so leads to a depreciation.

It is instructive to write the equation for the flexible-price monetary model in two alternative but equivalent formulations. Assuming that the

domestic and foreign money demand coefficients are equal ($\phi = \phi^*$, $\lambda = \lambda^*$), equation (4) reduces to

$$s_t = (m - m^*)_t - \phi(y - y^*)_t + \lambda(r - r^*)_t. \tag{5}$$

A further assumption underlying the flexible-price model is that uncovered interest parity holds continuously—that is, the domestic-foreign interest differential is just equal to the expected rate of depreciation of the domestic currency. Thus, using a superscript e to denote agents' expectations formed at time t, we may substitute Δs^e_{t+1} for $(r - r)^*_t$ in equation (5) to get

$$s_t = (m - m^*)_t - \phi(y - y^*)_t + \lambda \Delta s^e_{t+1}. \tag{6}$$

Thus, the expected change in the exchange rate and the expected change in the interest differential, both of which reflect inflationary expectations, are interchangeable in this model. Some researchers relax the constraint that the income and interest rate elasticities are equal:

$$s_t = (m - m^*)_t - \phi y_t + \phi^* y^*_t + \lambda \Delta s^e_{t+1}. \tag{7}$$

Note also that equation (7) can be expressed as

$$s_t = (1 + \lambda)^{-1}(m - m^*)_t - (1 + \lambda)^{-1} \phi y_t + (1 + \lambda)^{-1} \phi^* y^*_t + \lambda(1 + \lambda)^{-1} s^e_{t+1}. \tag{8}$$

If expectations are assumed to be rational,[3] then by iterating forward, it is easy to show that equation (7) can be expressed in the "forward solution" form:

$$s_t = (1 + \lambda)^{-1} \sum_{i=0}^{\infty} \left[\frac{\lambda}{1 + \lambda}\right]^i [(m - m^*)^e_{t+i} + \phi y^e_{t+i} + \phi^* y^{*e}_{t+i}], \tag{9}$$

where it is understood that expectations are conditioned on information at time t. Equation (9) makes clear that the monetary model, with rational expectations, involves solving for the expected future path of the "forcing variables"—that is, relative money and income. As is common in rational expectations models, the presence of the discount factor, $\lambda/(1 + \lambda) < 1$, in equation (9) implies that expectations of the forcing variables need not, in general, be formed into the *infinite* future—so long as the forcing variables are expected to grow at a rate less than $(1/\lambda)$.

[3] The application of rational expectations to exchange rates was first considered by Black (1973).

Sticky-Price and Real Interest Differential Monetary Models

A problem with the early, flexible-price variant of the monetary approach, however, is that it assumes *continuous* PPP—equation (3). Under continuous PPP, the real exchange rate—that is, the exchange rate adjusted for differences in national price levels—cannot vary, by definition. Yet, a major characteristic of the recent experience with floating has been the wide gyrations in the real rates of exchange between many of the major currencies, bringing with them the very real consequences of shifts in international competitiveness (see, for example, Dornbusch (1987)). Clearly, therefore, the simple, flexible-price monetary approach does not fit the observable facts. An attempt to rehabilitate the monetary model led to the development of a second generation of monetary models, beginning with Dornbusch (1976). The sticky-price monetary model allows for substantial overshooting of both the nominal and the real price-adjusted exchange rates beyond their long-run equilibrium (PPP) levels, because the jump variables in the system—exchange rates and interest rates—compensate for sluggishness in other variables—notably goods prices.[4]

The intuition behind the overshooting result in the sticky-price monetary model is relatively straightforward. Imagine the effects of a cut in the nominal U.K. money supply. Sticky prices in the short run imply an initial fall in the real money supply and a consequent rise in interest rates in order to clear the money market. The rise in domestic interest rates then leads to a capital inflow and an appreciation of the nominal exchange rate (that is, a rise in the value of the domestic currency in terms of the foreign currency), which, given sticky prices, also implies an appreciation of the real exchange rate.

Foreign investors are aware that they are artificially forcing up the exchange rate and that they may therefore suffer a foreign exchange loss when the proceeds of their investment are reconverted into their local currency.[5] However, so long as the *expected* foreign exchange loss (ex-

[4] In fact, the main features of the sticky-price model would be captured in a framework in which the domestic currency prices of domestic goods are sticky but domestic currency prices of foreign goods can move with the exchange rate.

[5] Even if investors effect forward cover—that is, sell the proceeds of their investment against their local currency in the forward market—the cost of this cover will be close to the expected rate of depreciation of the domestic currency (and exactly equal if the forward market is efficient and agents are risk neutral; see below).

pected rate of depreciation) is less than the *known* capital market gain (that is, the interest differential), risk-neutral investors will continue to buy sterling assets. A short-run equilibrium is achieved when the expected rate of depreciation is just equal to the interest differential (uncovered interest parity holds). Since the expected rate of depreciation must then be nonzero for a nonzero interest differential, the exchange rate must have overshot its long-run equilibrium (PPP) level. In the medium run, however, domestic prices begin to fall in response to the fall in money supply. This alleviates pressure in the money market (the real money supply rises), and domestic interest rates begin to decline. The exchange rate then depreciates slowly in order to converge at the long-run PPP level. This model thus explains the paradox that countries with relatively high interest rates tend to have currencies whose exchange rate is expected to depreciate. The *initial* rise in interest rates leads to a step appreciation of the exchange rate, after which a slow depreciation is expected in order to satisfy uncovered interest parity.

The Dornbusch overshooting model was further developed by Buiter and Miller (1981), who allowed for a nonzero rate of core inflation and considered the impact of natural resource discoveries on output and the exchange rate.

Frankel (1979a) argued that a shortcoming of the Dornbusch (1976) formulation of the sticky-price monetary model was that it did not allow a role for differences in secular rates of inflation. His model was an attempt to allow for this defect, and the upshot was an exchange rate equation that included the real interest rate differential as an explanatory variable.

The sticky-price monetary model is clearly an advance over the simple (continuous PPP) monetary model, in that it more accurately explains the observable facts. It is, however, fundamentally monetary, in that attention is focused on equilibrium conditions in the money market. Monetary models of the open economy are able to maintain this focus by assuming perfect substitutability of domestic and foreign nonmoney assets (but *non*substitutability of monies—see Calvo and Rodriguez (1977) and Girton and Roper (1981), for a relaxation of this assumption). The markets for domestic and foreign nonmoney assets can then be aggregated into a single extra market ("bonds") and excluded from explicit analysis by application of Walras' law. This "perfect substitutability" assumption is relaxed in the portfolio balance model of exchange rate determination. In addition, the portfolio balance model is stock-flow consistent, in that it allows for current account imbalances to have a feedback effect on wealth and, hence, on long-run equilibrium.

Portfolio Balance Model

In common with the flexible-price and sticky-price monetary models, the level of the exchange rate in the portfolio balance model is determined, at least in the short run, by supply and demand in the markets for financial assets. The exchange rate, however, is a principal determinant of the current account of the balance of payments. Now, a surplus (deficit) on the current account represents a rise (fall) in net domestic holdings of foreign assets, which in turn affects the level of wealth, which in turn affects the level of asset demand, which again affects the exchange rate. Thus, the portfolio balance model is an inherently dynamic model of exchange rate adjustment, which includes in its terms of reference asset markets, the current account, the price level, and the rate of asset accumulation. Although, as we noted above, a number of researchers had, in the late 1960s, discussed the implications of open economy portfolio balance in an open economy in the context of a fixed exchange rate, the seminal contributions to the literature on the portfolio balance approach to exchange rate determination were Kouri (1976), Allen and Kenen (1980), Branson (1977, 1983, 1984), Dornbusch and Fischer (1980), and Isard (1983).

The portfolio balance model, like the sticky-price model, allows one to distinguish between short-run equilibrium (supply and demand equated in asset markets) and the dynamic adjustment to long-run equilibrium (a static level of wealth and no tendency of the system to move over time). Unlike the sticky-price model, it also allows for the full interaction between the exchange rate, the balance of payments, the level of wealth, and stock equilibrium.

In the short run (on a day-to-day basis), with the portfolio balance model the exchange rate is determined solely by the interaction of supply and demand in asset markets. During this period, the level of financial wealth (and the individual components of that level) can be treated as fixed. In its simplest form, the portfolio balance model divides net financial wealth of the private sector (W) into three components: money (M), domestically issued bonds (B), and foreign bonds denominated in foreign currency (F); B can be thought of as government debt held by the domestic private sector, and F is the level of net claims on foreigners held by the private sector. Since, under a free float, a current account surplus on the balance of payments must be exactly matched by a capital account deficit (that is, capital outflow and, hence, an increase in net foreign indebtedness to the domestic economy), the current account must give the rate of accumulation of F over time.

With domestic and foreign interest rates given by r and r^* as before,

we can write down our definition of wealth and the simple domestic demand functions for its components as follows:[6]

$$W = M + B + SF \tag{10}$$

$$M = M(r, r^*)W \qquad M_r < 0, \quad M^*_r < 0 \tag{11}$$

$$B = B(r, r^*)W \qquad B_r > 0, \quad B^*_r < 0 \tag{12}$$

$$SF = F(r, r^*)W \qquad F_r < 0, \quad F^*_r > 0. \tag{13}$$

Relation (10) is an identity defining wealth. Two noteworthy characteristics of equations (11)–(13) are that, as is standard in most expositions of the portfolio balance model, the scale variable is the level of wealth, W, and the demand functions are homogeneous in wealth; they can thus be written in nominal terms (assuming homogeneity in prices and real wealth, prices cancel out) (see Tobin (1969)).

The model thus provides a simple framework for analyzing the effect of, for example, monetary and fiscal policy on the exchange rate. Thus, a contractionary monetary policy (a fall in M) reduces nominal financial wealth (through equation (10)), and so reduces the demand for both domestic and foreign bonds (through equations (12) and (13)). As foreign bonds are sold, the exchange rate appreciates (the foreign price of domestic currency rises). The effects of fiscal policy (operating through changes in B) on the exchange rate are more ambiguous, depending on the degree of substitution between domestic and foreign bonds.

Masson (1981), Branson (1983, 1984), and Dooley and Isard (1982) have also extended this model to incorporate rational expectations. Branson (1984), for example, demonstrates that under rational expectations, real disturbances will generate monotonic adjustment of the exchange rate in the portfolio balance model, while monetary disturbances will generate exchange rate overshooting. Masson (1981) and Buiter (1984) also consider the stability of the portfolio balance model when net domestic holdings of foreign assets are negative.

II. Empirical Evidence on Exchange Rate Models

In this section the empirical evidence on exchange rate models is looked at from three perspectives: the monetary exchange rate models using interwar data and data from the recent float before 1978; monetary models including more recent data from the current float; and the portfolio balance model.

[6] We use the notation, $X_j = \partial X / \partial j$.

First-Period Tests of Monetary Models

The empirical evidence on the three formulations of the monetary exchange rate model—the flexible-price, sticky-price, and real interest differential specifications—can be divided into two periods. The first-period evidence relates to studies of the interwar period and of the recent float up until about 1978 and is largely supportive of the monetary model. The second-period evidence, which covers the period of the recent float extending beyond the late 1970s, is not so supportive of the monetary model.

One of the first tests of equation (7) was conducted by Frenkel (1976) for the deutsche mark-U.S. dollar exchange rate over the period 1920-23. Since this period corresponds to the German hyperinflation, Frenkel argued that domestic monetary impulses will overwhelmingly dominate equation (7), and, thus, the domestic income and foreign variables can be dropped, and attention focused simply on the effects of German money and the expected inflation (operating through expected depreciation). Frenkel reported results supportive of the flexible-price model during this period.

A number of researchers have estimated flexible-price model equations for the more recent experience with floating exchange rates. For example, Bilson (1978) tested for the deutsche mark-pound sterling exchange rate (with the forward premium, fp_t, substituted for Δs^e_{t+1}, and without any restrictions on the coefficients on domestic and foreign money) over the period January 1972 through April 1976. Bilson incorporated dynamics into the equation and used a Bayesian estimation procedure; his results were in broad accordance with the monetary approach. Hodrick's (1978) tests of the flexible-price model for the U.S. dollar-deutsche mark and pound sterling-U.S. dollar over the period July 1972 to June 1975 were also highly supportive. Putnam and Woodbury (1979) estimated equation (5) for the sterling-dollar exchange rate over the period 1972–74, and reported that most of the estimated coefficients were significantly different from zero at the 5 percent significance level, and all were correctly signed according to the flexible-price model. However, the money supply term was significantly different from unity.

Dornbusch (1979) reported results broadly supportive of the flexible-price model for the mark-dollar exchange rate over the period March 1973 to May 1978, in a specification incorporating the *long-term* interest rate differential. Although Dornbusch introduced this differential as an econometric expedient, an interpretation may be placed on this term that is consistent with Frankel's real interest differential equation, which we discussed above. Thus, Frankel (1979a), in his implementation of the real

interest differential model for the mark-dollar exchange rate over the period July 1974–February 1978, used a long bond interest differential as an instrument for the expected inflation term, on the assumption that long-term real rates of interest are equalized. Frankel argued that since the coefficients on the interest rate and expected inflation terms were both significant, both the flexible- and sticky-price models were rejected in favor of the real interest differential model.

Second-Period Tests of the Monetary Models

Although the monetary approach appears reasonably well supported for the period up to 1978, the picture alters dramatically once the sample period is extended. For example, estimates of the real interest differential model reported by Dornbusch (1980), Haynes and Stone (1981), Frankel (1984), and Backus (1984) cast serious doubt on its ability to track the exchange rate in-sample: few coefficients were correctly signed (many were wrongly signed); the equations had poor explanatory power as measured by the coefficient of determination; and residual autocorrelation was a problem. In particular, estimates of monetary exchange rate equations for the deutsche mark-U.S. dollar for the post-1978 period often report coefficients that suggest that a relative increase in the domestic money supply leads to a rise in the foreign currency value of the domestic currency (exchange rate appreciation). Frankel (1982a) called this phenomenon—the price of the mark rising as its supply is increased—the "mystery of the multiplying marks."

How can one explain this poor performance of the monetary approach equations for the second half of the floating sample? Rasulo and Wilford (1980) and Haynes and Stone (1981) have suggested that the root of the problem may be traced to the constraints imposed on relative monies, incomes, and interest rates. The imposition of such constraints may be justified on the grounds that if multicollinearity is present, constraining the variables will increase the efficiency of the coefficient estimates. However, Haynes and Stone showed that the subtractive constraints used in monetary approach equations were particularly dangerous because they could lead to biased estimates and sign reversals.

Frankel (1982a) provided an alternative explanation for the poor performance. He attempted to explain the mystery of the multiplying marks by introducing wealth into the money demand equations. Germany, he argued, was running a current account surplus in the late 1970s, which was redistributing wealth from U.S. residents to German residents, thus increasing the demand for marks and reducing the demand for dollars independently of the other arguments in the money demand functions.

By including home and foreign wealth (defined as the sum of government debt and cumulated current account surpluses) in his empirical equation, and by not insisting on the constraint that the domestic and foreign income, wealth, and inflation terms had to have equal and opposite signs, Frankel came up with a monetary approach equation that fit the data well and in which all variables, apart from the income terms, were correctly signed and most were statistically significant.

As noted by Boughton (1988a), a further explanation for the failure of the monetary approach equations may be traced to the relative instability of the underlying money demand functions and the simplistic functional forms that are normally implicitly assumed for money demand. Indeed, a number of single-country money demand studies strongly indicate that there have been shifts in velocity for the measure of money used by the above researchers (see Artis and Lewis (1981) for a discussion). In Frankel (1984), shifts in money demand functions were incorporated into the empirical equation by the introduction of a relative velocity shift term, $(v - v^*)$, which was modeled by a distributed lag of $[(p + y - m) - (p^* + y^* - m^*)]$. Including the $(v - v^*)$ term in the estimating equation for five exchange rates led to most of the monetary variable coefficients becoming statistically significant and with the correct signs. However, significant first-order residual autocorrelation remained a problem in all of the reported equations.

Driskill and Sheffrin (1981) argued that the poor performance of the monetary model could be traced to a failure to account for the simultaneity bias introduced by having the expected change in the exchange rate (implicitly) on the right-hand side of the monetary equations. One potential method of circumventing such simultaneity is offered by the rational expectations solution of the monetary model, which effectively yields an equation purged of the interest differential-forward exchange rate effect. A number of researchers have begun to test this version of the model, with some success. For example, Hoffman and Schlagenhauf (1983) implemented a version of the "forward solution" flexible-price model formulation (equation (9)) by specifying a time-series model for the stochastic evolution of the fundamentals. The equation is estimated jointly with time-series models for relative money and income for the franc, the deutsche mark, and the pound sterling against the U.S. dollar. Hoffman and Schlagenhauf computed likelihood ratio tests for the validity of the rational expectations hypothesis and the validity of this hypothesis plus the coefficient restrictions implied by the flexible-price model (such as the unit coefficient on relative money supplies). Although the expectations restrictions are not rejected for any of the countries, the coefficient restrictions are rejected for Germany. Kearney and MacDonald (1990)

carried out a similar procedure for the Australian dollar-U.S. dollar and could not reject the restrictions implied by the rational expectations hypothesis.

MacDonald and Taylor (1991a), using multivariate cointegration techniques (see Engle and Granger (1987) and Johansen (1988)), tested the validity of the monetary model as a long-run equilibrium relationship for the U.S. dollar-deutsche mark, U.S. dollar-pound sterling, and U.S. dollar-yen exchange rates over the period January 1976 through December 1990. They found that an unrestricted version of equation (4) could not be rejected as a long-run equilibrium for these exchange rates and that, for the U.S. dollar-deutsche mark rate, none of the coefficient restrictions implicit in equation (5) could be rejected. Note that, since all of the monetary models collapse to an equilibrium condition of the form equation (4) or (5) in the long run, these tests have no power to discriminate between them. They do suggest, however, that while short-run exchange rate behavior may be difficult to model, economic fundamentals should not be rejected out of hand as a description of long-run exchange rate behavior.

The rational expectations solution to the flexible-price model has spawned further empirical work that tests for the presence of speculative bubbles. It is well known from the rational expectations literature that equation (9) is only one solution to equation (7) from a potentially infinite sequence (see, for example, Blanchard and Watson (1982)). If we denote the exchange rate given by equation (9) as $\hat{s}_t$, then it is straightforward to demonstrate (see MacDonald and Taylor (1989b)) that equation (7) has multiple rational expectations solutions, each of which may be written in the form

$$s_t = \hat{s} + b_t, \tag{14}$$

where b_t—the "rational bubble" term—satisfies

$$b^e_{t+1} = \lambda^{-1}(1 + \lambda)b_t.$$

Meese (1986) tested for bubbles by applying a version of the Hausman (1978) specification test suggested by West (1986) for present value models. The test involves estimating a version of equation (7) (which produces consistent coefficient estimates regardless of the presence or otherwise of rational bubbles) and a closed-form version of equation (9) (which produces consistent coefficient estimates only in the absence of bubbles). Hausman's specification test is used to determine if the two sets of coefficient estimates are significantly different. Such a difference would suggest the existence of a speculative bubble. For the dollar-yen, dollar-mark, and dollar-sterling exchange rates (monthly data over the

period October 1973 to November 1982), Meese in fact found that the two sets of coefficient estimates were significantly different and therefore rejected the hypothesis of no bubbles. Kearney and MacDonald (1986) applied a version of this methodology to the Australian dollar-U.S. dollar exchange rate and could not reject the hypothesis.

An alternative way of testing for bubbles is to adopt the variance-bounds test methodology originally proposed by Shiller (1979) in the context of interest rates. This may be illustrated in the following way. If we define the ex post rational or perfect foresight exchange rate as what results from replacing expected future values of money and income in equation (9) with their actual values:

$$s_t^* = (1 + \lambda)^{-1} \sum_{i=1}^{\infty} \left[\frac{\lambda}{1 + \lambda}\right]^i [(m - m^*)_{t+i} - \phi y_{t+1} + \phi^* y_{t+i}],$$

then s_t^* will differ from $\hat{s}_t$ given by (9) by a rational forecast error, u_t (that is, $s_t^* = \hat{s}_t + u_t$). Given that u_t is a rational expectations forecast error, $\hat{s}_t$ and u_t must be orthogonal to one another; thus, we have

$$\text{var}(s_t^*) = \text{var}(\hat{s}_t) + \text{var}(u_t), \tag{15}$$

which implies

$$\text{var}(s_t^*) \geq \text{var}(\hat{s}_t). \tag{16}$$

In the absence of bubbles, the inequality given by equation (16) should hold. However, in the presence of bubbles, (16) is likely to be violated since, on usingequation (14), we have $s_t^* = s_t - b_t + u_t$, and the relationship corresponding to (15) is

$$\text{var}(s_t^*) = \text{var}(s_t) + \text{var}(b_t) + \text{var}(u_t) - 2\,\text{cov}(s_t, b_t). \tag{17}$$

Since, in the presence of bubbles, s_t and b_t may be positively correlated, we cannot derive equation (16) from equation (17). Thus, violation of (16) (excess volatility) could be taken as evidence of the presence of rational bubbles.

Huang (1981) tested versions of equation (16) for the dollar-mark, dollar-sterling, and sterling-mark exchange rates for the period March 1973 to March 1979. His results were supportive of excess volatility and, by inference, he rejected the no-bubbles hypothesis. Kearney and MacDonald (1986) implemented tests of equation (16) for the Australian dollar-U.S. dollar over the period January 1984–December 1986 and generally found in favor of the no-bubbles hypothesis.

There are, however, a number of problems with this kind of approach. First, it is conditional on an assumed model of the exchange rate: violation could be due to an inappropriate choice or specification of model. Sec-

ond, and perhaps more important, there may be other possible explanations for the presence of bubbles, such as measurement error in computing the perfect foresight exchange rate, inappropriate stationary-inducing transformations, or small-sample bias.

Evans (1986) tested for bubbles in the U.S. dollar-pound sterling exchange rate over the period 1981–84 by testing for a nonzero median in excess returns from forward market speculation (the forward rate forecasting error adjusted for risk). Evans designed and applied nonparametric tests for a nonzero median in returns that are similar to runs tests. He decisively rejected the zero-median hypothesis and inferred that this result provided evidence of speculative bubbles. Note, however, that Evans may have been detecting peso problems;[7] moreover, there is no guarantee that his method of risk adjusting the excess returns (based on real interest differentials) is correct.

We now turn to the empirical evidence on the reduced form of the sticky-price model. Driskill (1981) presented an estimate of an equation representative of the Dornbusch (1976) overshooting model for the Swiss franc-U.S. dollar rate for the period 1973–77 (quarterly data) and reported results largely favorable to the sticky-price model. Other tests have been conducted by Backus (1984), Hacche and Townend (1981), and Wallace (1979). Wallace reported results supportive of the model for the float of the Canadian dollar against the U.S. dollar during the 1950s. However, Backus, who tested the model for the float between the two currencies during the recent floating experience (from the first quarter of 1971 to the fourth quarter of 1980), reported different estimation results. Unlike Wallace, he found few statistically significant coefficients.

Estimates of a more dynamic version of the sticky-price model, provided by Hacche and Townend (1981) for the effective exchange rate of the pound sterling from May 1972 to February 1980, do suggest exchange rate overshooting. But in other respects the estimated equation is unsatisfactory: many coefficients are insignificant and wrongly signed, and the equation does not exhibit sensible long-run properties.

Papell (1988) argued that the price and exchange rate dynamics underlying the Dornbusch sticky-price model cannot be captured by single-equation estimation methods. To capture such dynamics, he argued, it is necessary to use a systems method of estimation that incorporates the

[7] The peso problem (Krasker (1980)) refers to the situation where agents attach a small probability to a large change in the economic fundamentals, which does not occur in-sample. This will tend to produce a skew in the distribution of forecast errors even when agents are rational, and thus may generate evidence of nonzero excess returns from forward speculation. See MacDonald and Taylor (1989b) for further analysis of the peso problem.

cross-equation constraints derived from the structural equations and the assumption of rational expectations. His procedure allows domestic income and interest rates to be modeled endogenously, but not the money supply. Effectively, Papell reduced the structural model to a reduced-form, vector-autoregressive, moving-average model with nonlinear parameter constraints. He estimated this jointly with equations for income and the interest rate, for the effective exchange rates of Germany, Japan, the United Kingdom, and the United States for the period 1973:1 to 1984:4. Papell found that most of the estimated structural coefficients had the expected sign, were of reasonable magnitude, and were statistically significant. He thus concluded that his results supported Dornbusch's model.

Barr (1989) and Smith and Wickens (1988, 1990) empirically implemented a version of the sticky-price model formulated by Buiter and Miller (1981) for the pound sterling exchange rate. All reported favorable in-sample estimates of the model. The results reported in these papers are likely to be fairly robust since both sets of authors took care in specifying the model dynamics; also, Smith and Wickens estimated the model structurally. In simulating their model, Smith and Wickens (1988) found that the exchange rate overshoots by 21 percent in response to a 5 percent change in the money supply.

Wadhwani (1984) used the sticky-price model to generate s^* and to test for excess volatility; he found that the inequality (16) is violated for the U.S. dollar-pound sterling rate over the period 1973:1 to 1982:3. His results are therefore supportive of those generated by Huang (1981) using the flexible-price model.

Empirical Evidence on the Portfolio Balance Model

Compared to the monetary approach to the exchange rate, less empirical work has been conducted on the portfolio balance model, perhaps due to the limited availability of good disaggregated data on nonmonetary assets. The research that has been done may be broadly divided into two types of tests. The first concentrates on solving the short-run portfolio model as a reduced form (assuming expectations are static), in order to determine its explanatory power. The second, indirect test exploits the fact that the portfolio balance model rests on the assumption of imperfect substitutability between domestic and foreign assets. An alternative way of expressing this assumption is to view the return on domestic and foreign assets as being separated by a risk premium. Thus, an indirect test of the portfolio balance model is to test for the significance of such risk premia. In addition, Branson (1984) examined the time-series behavior

of a number of financial variables for several countries to see if they were consistent with the predictions of the model.

The reduced-form exchange rate equation derived from a system such as equations (10)–(13) may be written as (see Branson, Halttunen, and Masson (1977); the assumed short-run nature of the relationship allows income and prices to be assumed exogenous and constant):

$$S_t = g(M_t, M_t^*, B_t, B_t^*, fB_t, fB_t^*), \tag{18}$$

where fB and fB^* denote foreign holdings of domestic and foreign bonds, respectively. Branson, Halttunen, and Masson (1977) estimated a log-linear version of an equation similar to this for the deutsche mark-U.S. dollar exchange rate over the period August 1971–December 1976. However, they dropped the terms relating to domestic and foreign bond holdings because of their ambiguous effect on the exchange rate, depending on the degree of substitutability between traded and nontraded bonds. But as Bisignano and Hoover (1982) pointed out, this rather arbitrary exclusion will generally result in biased regression coefficients.

Although the estimates reported by Branson, Halttunen, and Masson (1977) were supportive of the portfolio balance model, once account is taken of acute first-order residual autocorrelation, only one coefficient, that on the U.S. money supply, is statistically significant. After specifying a simple reaction function that is purported to capture the simultaneity between the exchange rate and the money supply, Branson, Halttunen, and Masson re-estimated their equation using two-stage least squares and reported more satisfactory estimates of the portfolio balance empirical model; however, residual autocorrelation remained a problem (the estimated first-order autocorrelation coefficient was 0.87, which suggests that unexplained shocks have persistent effects on the exchange rate and, hence, that this version of the portfolio balance model does not fully explain the mark-dollar exchange rate).

In Branson, Halttunen, and Masson (1979), a log-linear exchange rate equation was estimated for the longer period August 1971–December 1978, for the mark-dollar, but the results did not differ significantly from the earlier ones; again, persistent autocorrelation was a problem. In another paper, Branson and Halttunen (1979) estimated the equation for five currencies (the yen, the French franc, the lira, the Swiss franc, and the pound sterling) against the deutsche mark for a variety of different sample periods over the 1970s. Although their results seemed supportive of the portfolio balance model, in terms of statistically significant and correctly signed coefficients, a note of caution must again be sounded, since the residuals in their ordinary-least-square equations were all highly autocorrelated.

One problem with the Branson, Halttunen, and Masson (1977, 1979)

implementation of the portfolio balance model lies in their use of cumulated current accounts for the stock of foreign assets. Such an approximation will, of course, include *third-country* items that are not strictly relevant to the determination of the *bilateral* exchange rate in question. Bisignano and Hoover (1982) picked up on this point, arguing that the portfolio balance approach should be implemented using only bilateral data for foreign assets, and, to be consistent, domestic and foreign bond holdings should be included in the reduced form of the model (see above). Incorporating such modifications in their estimates of the portfolio balance equation for the Canadian dollar-U.S. dollar over the period March 1973 to December 1978, Bisignano and Hoover reported moderately successful econometric results; in particular, they showed that it is wrong to neglect domestic and foreign nonmonetary asset stocks in exchange rate reduced forms.

Dooley and Isard (1982) were the first to attempt to construct data on domestic and foreign bond holding without assuming that the current account deficit is financed entirely in one of the two currencies under consideration. For example, in an analysis of the U.S. dollar-deutsche mark exchange rate, the U.S. demand for U.S. bonds is viewed as one component of the total demand (the other demand components being attributed to private German wealth holders, private and official OPEC[8] residents, and private and official residents of the rest of the world). The total demand is then assumed equal to the supply of outside dollar-denominated bonds, viewed as equal to the cumulative U.S. budget deficit, less the stock of bonds removed from private circulation through Federal Reserve open market operations, and less cumulative U.S. and foreign official intervention purchases of dollar-denominated bonds. Dooley and Isard estimated their model for the dollar-mark exchange rate over the period May 1973 through June 1977, using an iterative estimation procedure to impose model-consistent (that is, broadly speaking, rational) expectations, and compared the predictions of the model to naive forecasts using the forward rate and the lagged spot rate. They summarized the performance of the model as follows:

> The model is better than the forward rate as a predictor of the change in the exchange rate. . . . [H]owever . . . the model fails to explain the major portion of observed changes in exchange rates: the coefficient of correlation between predicted and observed changes is 0.4, and the model incorrectly predicts the direction of one out of every three changes (p. 273).

Dooley and Isard pointed out that the ability of the model to outperform the forward rate as a spot rate predictor challenged the view that exchange risk premia were nonexistent. However, the empirical short-

[8] That is, oil producing and exporting countries.

comings of the model suggest either that their simplifications of the theoretical model were too severe or that observed exchange rate movements were predominantly unexpected.

Boughton (1988b) introduced term-structure effects into an empirical portfolio balance model and estimated jointly a "semireduced form" consisting of a real exchange rate portfolio balance equation that includes long- and short-term interest rates, an equation for the short-term rate (essentially an inverted *LM* curve), and a forecasting equation for the long- and short-term interest rate spread. He used data on the real effective exchange rates for the U.S. dollar and on real bilateral dollar-yen and dollar-mark exchange rates for the period May 1973 through December 1985. His estimation results were broadly satisfactory in terms of the sign and statistical significance of the estimated coefficients. Boughton then used these results in a number of counterfactual simulations to analyze the strong appreciation of the dollar over the 1980–85 period. He concluded that a major contributory factor to the rise of the dollar over the period, according to his model, was a failure of the "rest of the world" (Germany, Japan, the United Kingdom, and France) to tighten monetary policy sufficiently, as measured by the significance of the short-term interest rate differential in explaining the swings in the dollar: in December 1980 the weighted average, short-term rate for the four countries outside the United States would have had to have risen from 11.2 percent to 21.3 percent in order to have prevented the subsequent appreciation of the dollar.

In an attempt to improve on the estimates of monetary approach and portfolio balance equations and, in particular, to overcome the model misspecification suggested by the typically high value of the first-order residual autocorrelation coefficient in such equations, a number of researchers have attempted to combine features of both the monetary and portfolio balance approaches into a reduced-form exchange rate equation. Thus, if risk is important the reduced-form monetary approach will be misspecified to the extent that it ignores the imperfect substitutability of nonmoney assets. In the portfolio balance model with rational expectations, agents would be expected to revise their estimates of the expected real exchange rate as new information about the future path of the current account reached the market: the spot exchange rate in a reduced-form portfolio balance should include news about the current account as an explanatory variable.

We now turn to some empirical attempts to synthesize the portfolio and monetary approaches, with emphasis on the modeling of the risk premium and news about the current account. Versions of hybrid models with characteristics such as these have been estimated by a number of researchers (Hooper and Morton (1982), Frankel (1983, 1984), Isard

(1983), and Hacche and Townend (1981)). In Hooper and Morton's implementation, the risk premium was assumed to be a function of the cumulated current account surplus net of the cumulation of foreign exchange market intervention. Their equation was estimated for the U.S. dollar effective exchange rate 1973:2 to 1978:4, using an instrumental variables estimator. Hooper and Morton reported mixed results, with only some of the coefficients (mainly those relating to the monetary approach variables) significant and of the correct sign.

Using Hooper and Morton's specification, Hacche and Townend (1981) tested the portfolio balance model with an additional term to allow for the impact of oil prices on the sterling effective exchange rate over the period June 1972 to December 1981. The results were largely disappointing: few coefficients were significant and of those that were, the estimated risk premium coefficient was wrongly signed and the point estimate of the oil price coefficient was correctly signed.

In his implementation of the hybrid reduced-form model, Frankel (1984) did not consider the current account news term, and he derived the risk premium as the solution to the portfolio balance model. He estimated a hybrid equation for five currencies against the dollar for the period 1974–81 (monthly data, with the exact beginning and end points currency specific). In general, Frankel found that the estimated coefficients of the monetary approach variables were statistically insignificant, and some wrongly signed.

As noted earlier, an alternative, indirect method of testing the portfolio balance model is to model the exchange risk premium—the deviation from uncovered interest rate parity—as a function of the relative stocks of domestic and foreign debt outstanding. The Dooley and Isard (1982) study discussed above can be interpreted as a test of this kind. Direct attempts to model deviations from uncovered interest parity as a function of relative international debt outstanding have been made by Frankel (1982b, 1983) for the deutsche mark-U.S. dollar rate, and by Rogoff (1984) for the Canadian dollar-U.S. dollar exchange rate. In each case, however, statistically insignificant relationships were reported. Fisher and others (1990) formulated an exchange rate equation, in which the deviation from uncovered interest rate parity (for the pound sterling effective rate, with both the exchange rate and interest rate expressed in real terms) was modeled as a function of the ratio of the current account balance to gross domestic product; this formulation outperformed other exchange rate equations used in major econometric models of the U.K. economy, beating a random walk in out-of-sample forecast tests.[9]

[9]See the next section. Note that this study used quarterly data, as does Boughton (1984b).

Out-of-Sample Forecasting Performance of Exchange Rate Models

So far, we have considered only the *in-sample* properties of the asset approach reduced forms. A stronger test of the models' validity would be to determine how well they perform *out-of-sample*, compared to an alternative. Meese and Rogoff (1983) conducted such a study for the dollar-pound sterling, dollar-mark, dollar-yen, and trade-weighted dollar exchange rates using data running from March 1973 through June 1981. The exchange rate models they tested correspond to the flexible-price, the real interest differential, and the portfolio-monetary synthesis of Hooper and Morton (1982). Meese and Rogoff compared the out-of-sample performance of these equations to the forecasting performance of the random walk model, the forward exchange rate, a univariate autoregression of the spot rate, and a vector autoregression. They computed their forecasts as follows. First, the equations were estimated using data from the beginning of the sample to November 1976, and four forecasts were made for 1, 3, 6, and 12 months ahead. The data for December 1976 were then added to the original data set, the equations were re-estimated, and a further set of forecasts were made for the four time horizons. This "rolling regression" process was then repeated continually. The statistics used to gauge the out-of-sample properties of the models are the mean error (ME), mean absolute error (MAE), and the root mean-square error (RMSE). A sample of Meese and Rogoff's RMSE results (for the six-month forecast and excluding the forward rate, univariate, and vector autoregression forecasts) are reported in Table 1, where the reduced forms derived from structural models have been estimated using the Fair (1970) procedure.

The conclusion that emerges from the Meese-Rogoff study is that none of the exchange rate models using the asset approach outperforms the

Table 1. *Root Mean-Square Forecast Errors for Selected Exchange Rate Equations*

Exchange Rate	Random Walk	Flexible-Price Model	Real Interest Differential	Monetary/Portfolio Synthesis
US$/DM	8.71	9.64	12.03	9.95
US$/yen	11.58	13.38	13.94	11.94
US$/£ stg.	6.45	8.90	8.88	9.08
Trade-weighted U.S. dollar	6.09	7.07	6.49	7.11

Source: Meese and Rogoff (1983).
Note: The forecast horizon is six months.

simple random walk model—a result that was seen as devastating for research on these models. Moreover, this result is all the more striking when it is remembered that the reduced-form forecasts were computed using *actual* values of the various independent variables.

In an attempt to improve on the poor performance of the asset models, Meese and Rogoff attempted a number of alternate approaches: estimating the models in first differences; allowing home and foreign magnitudes to enter unconstrained; including price levels as additional explanatory variables; using different definitions of the money supply; and replacing long-term interest rates with other proxies for inflationary expectations. But all to no avail: the modified reduced-form equations still failed to outperform the simple random walk.

In a later paper, Meese and Rogoff (1984) considered possible explanations for the failure of the reduced-form asset models to beat the random walk model out-of-sample. In particular, they showed—using the vector autoregressive methodology—that the instruments used in simultaneous estimates of reduced-form asset models may not be truly exogenous, and thus the estimated parameter estimates may be extremely imprecise. To overcome this problem, Meese and Rogoff imposed coefficient constraints, culled from the empirical literature on money demand equations, and re-estimated the RMSEs for the same period, as in their 1983 paper. They found that although the coefficient-constrained reduced forms still failed to outperform the random walk model for most horizons up to a year, in forecasting beyond a year (which had not been possible with the unconstrained estimates in Meese and Rogoff (1983) because of problems with degrees of freedom), the asset reduced forms did outperform the random walk model in terms of RMSE. As Salemi (1984) pointed out, this finding suggests that the exchange rate acts like a pure asset price in the short term (that is, approximately a random walk—see, for example, Samuelson (1965)), but that in the longer term its equilibrium is systematically related to other economic variables.

A large segment of the literature has been devoted to determining whether Meese and Rogoff's specification of the asset reduced-form equations, their estimation strategy, or the models themselves are at fault. Woo (1985) and Finn (1986) estimated versions of the rational expectations form of the flexible-price model (equation (9)), with the addition of a partial adjustment term in money demand, and performed a Meese-Rogoff forecasting exercise. Finn reported that this model forecast as well as the random walk model (but failed to *outperform* it); while Woo's formulation outperformed the random walk model, in terms of both the MAE and RMSE, for the deutsche mark-U.S. dollar exchange rate. Somanath (1986) also used a partial adjustment term in his formu-

lation of various asset reduced-form equations for the mark-dollar exchange rate. Interestingly, for the period studied by Meese and Rogoff, he found that the structural exchange rate models outperformed the random walk model in terms of the standard criteria, and that for a sample period extending beyond that of Meese and Rogoff, the basic (that is, without any additional dynamics) flexible-price, real interest differential, and hybrid equations outperformed the random walk.[10]

Wolff (1987) and Schinasi and Swamy (1989) used a time-varying parameter model as the preferred estimation technique for econometric implementation of the real interest differential and flexible-price equations. Both Wolff and Schinasi and Swamy argued that the poor forecasting performance noted by Meese and Rogoff may have been due to their failure to account for parameter instabilities. There are, in fact, a number of reasons why the parameters in empirical exchange rate equations are unlikely to be constant for the recent floating experience. For example, instabilities in the underlying structural equations (money demand and PPP equations), changes in policy regime (see Lucas (1976)), and heterogeneous beliefs by agents (leading to a diversity of responses to macroeconomic developments over time) could all impart parameter instabilities.

Using the Kalman filter methodology, Wolff (1987) reworked Meese and Rogoff's results (same currencies and time period), for the reduced forms of the flexible-price and real interest differential models, assuming that the parameters followed a random walk process. However, the two models won out over the random walk only in the case of the U.S. dollar-deutsche mark exchange rate (for both the dollar-yen and the dollar-pound sterling exchange rates the random walk performed better across all forecast horizons; and, indeed, if one takes the *average* across all currencies and forecast horizons, the random walk model dominates).

Schinasi and Swamy (1989) used a less restrictive time-varying model than Wolff, and their model resulted in consistently better forecasts (than a random walk) for the flexible-price, real interest differential, and hybrid equations (for the mark-, yen-, and pound-dollar bilateral exchange rates). However, it is not entirely clear if the improved performance of the structural models was due to the use of time-varying parameters or simply to the fact that Schinasi and Swamy used a multistep random walk forecast, rather than the one-step forecast used by Meese and Rogoff. In a further experiment, Schinasi and Swamy added a lagged dependent variable to the various reduced forms of the monetary equations and

[10] The forecasting performance of these equations is even better for the extended sample period when money market dynamics are allowed for.

compared their forecasting performance to a one-step-ahead random walk. For all cases the time-varying parameter version was always superior to the fixed coefficients version and, furthermore, it outperformed the random walk in almost all cases.

Finally, Boughton (1984b) tested the out-of-sample forecasting performance of a preferred habitat version of the portfolio balance model (using fixed coefficient methods) for a variety of currencies against a random walk model. In every case, this model outperformed the random walk model. However, this result most likely reflects Boughton's use of quarterly data (all the other studies use monthly data), since his estimates of the hybrid equation also generally outperformed the random walk model.

Empirical Exchange Rate Models: New Directions

The broad conclusion that emerges from our survey is that the asset-approach models have performed well for some time periods, such as the interwar period, and, to some extent, for the first part of the recent floating experience (that is, 1973–78); but they have provided largely inadequate explanations for the behavior of the major exchange rates during the latter part of the float.

The failure of simple asset-approach equations may be due to misspecification. This misspecification may be of an econometric nature, insofar as the dynamic properties of the asset equations have (in relation to the Hendry, Pagan, and Sargan (1984) dynamic modeling methodology) been very poorly specified (the persistent indication of first-order autocorrelation is supportive of this view). Simple asset-approach equations may also be misspecified from an economic point of view. Thus, the "breakdown" in the performance of the monetary model could be a consequence of the omission of important variables such as the current account, wealth, and risk factors. However, even when these additions are made to the simple asset models, little improvement in equation performance is reported.

Some authors (for example, Papell (1988) and Isard (1988)) have argued that a useful way of ensuring that exchange rate models are correctly specified is to estimate the models structurally, and this seems to be a useful avenue for future research.[11] Examples of existing studies that

[11] Thus, Isard (1988, p. 197) writes: "Strong support exists for the view that simultaneous-equation frameworks are preferable to single-equation semi-reduced-form models for capturing the associations between exchange rates, interest differentials, and actual or expected inflation differentials in response to different types of exogenous shocks."

have applied this approach to modeling the exchange rate—with some degree of success—include Kearney and MacDonald (1985), Blundell-Wignall and Masson (1985), Masson (1988), Papell (1988), and Smith and Wickens (1988, 1990). Note, however, that the systems approach raises a further set of issues concerning the assumed structure of the whole economy (see, for example, Fisher and others (1990) on the econometric evaluation of the exchange rate in large-scale models of the U.K. economy).

In attempting to explain the poor empirical performance of the asset approach, some authors have suggested that foreign exchange rates may have consistently deviated from their underlying "fundamental" levels (that is, as predicted by economic theory), due to the presence of rational bubbles, as discussed above (see, for example, Flood and Hodrick (1989)). Other researchers have concentrated on the influence of foreign exchange analysts who base their predictions not on economic theory but on the identification of supposedly recurring patterns in graphs of exchange rate movements—that is, "technical" or "chart" analysts. Frankel and Froot (1986, 1990), for example, suggested a model of the foreign exchange market in which traders based their expectations partly on the advice of fundamentalists (that is, economists) and partly on the advice of nonfundamentalists (that is, chartists). They argued that such a model could explain the heavy overvaluation of the U.S. dollar during the mid-1980s.

Some support for the view that nonfundamentalist advice may be an important influence in foreign exchange markets is provided by Taylor and Allen (1992) who conducted a survey of chief foreign exchange dealers in the London foreign exchange market; they found that a high proportion of these dealers used some form of chart analysis in forming their trading decisions, particularly at the shorter horizons. At the shortest horizons (intraday to one week), Taylor and Allen found that over 90 percent of their survey respondents reported using some form of chart analysis, and about 60 percent judged charts to be at least as important as fundamentals at this horizon. As the time horizon was lengthened, however, the weight given by dealers to fundamental analysis increased. At the longest forecast horizons considered (one year or longer), nearly 30 percent of chief dealers reported relying on pure fundamental analysis and 85 percent judged fundamentals to be more important than chart analysis at this horizon.

In addition, Allen and Taylor (1990) analyzed the accuracy of a number of individual chart analysts' one-week and four-week ahead forecasts of the U.S. dollar-pound sterling, U. S. dollar-deutsche mark, and U.S. dollar-yen exchange rates and found that some of them consistently outperformed a whole range of alternative forecasting procedures, in-

cluding the random walk model, vector autoregressions, and univariate autoregressive moving average time-series models.

Given this evidence, it is hardly surprising that empirical models based on pure, fundamental economic theory fail to provide an adequate explanation of short-term movements in exchange rates. However, the revelation that foreign exchange participants focus more on fundamentals at longer horizons suggests that more attention might fruitfully be paid to modeling the fundamental determinants of *long-term* exchange rates. This is consistent with evidence in favor of the monetary model as a long-run equilibrium condition reported by MacDonald and Taylor (1991a).

Masson and Knight (1986, 1990) and Frenkel and Razin (1987) emphasized the role of shifts in fiscal policy stance among the major Organization for Economic Cooperation and Development (OECD) countries as important determinants of exchange rate behavior (see also Dornbusch (1987)). These authors have argued that the large autonomous changes in national saving and investment balances—in particular, those influenced by shifts in public sector fiscal positions in the largest industrial countries—must exert a very strong influence on current account positions, real interest rates, and, hence, exchange rates.

Dooley and Isard (1991) focused their attention on factors affecting the choice of where to locate tangible assets and other "taxable" forms of wealth. In support of this view, Dooley and Isard pointed to the experience of a number of debt-burdened developing countries during the 1980s that experienced substantial depreciations of their real exchange rate around the time of the outbreak of the international debt crisis in 1982. Dooley and Isard (1991) argued that these depreciations could be attributed primarily to a set of events that considerably reduced the attractiveness of owning assets located in the debt-burdened countries, thus giving rise to a "'transfer problem' in which real depreciation played an important role in the adjustment to substantially smaller net capital inflows and current account deficits" (p. 163). Dooley, Isard, and Taylor (1991) suggested that changes in relative country preferences should be systematically reflected in the price of gold, which can be viewed as "an asset without a country." Hence, if the effects of monetary shocks on gold prices can be isolated, evidence that residual changes in the price of gold are capable of explaining or predicting residual changes in exchange rates might be regarded as indirect evidence that exchange rate behavior largely reflects changes in country preferences. Dooley, Isard, and Taylor, in fact, provided econometric evidence that is largely supportive of this view for a number of major exchange rates. They also demonstrated that the price of gold is a crucial factor in beating a random walk in post-sample prediction tests.

Dornbusch (1987) stressed the importance of analyzing a country's industrial structure in any attempt to explain the behavior of its exchange rate. For example, the effect of an exchange rate change on a firm's pricing decisions (and, hence, on further changes in the exchange rate) will depend on whether the industry faces competition from imports that are close substitutes for its goods and whether the market is characterized by, for example, oligopoly or imperfect competition; another important determinant is the functional form of the specific market demand curve. Although conceding the absence of clear-cut results, Dornbusch nevertheless found this approach promising as an avenue for further research.

Which of these directions is likely to lead us toward a better understanding of exchange rate behavior? In our view, the rational bubbles explanation is perhaps the least attractive, not least because a growing amount of empirical research now suggests that asset market participants may not be endowed with fully rational expectations (Frankel and Froot (1987) and Taylor (1988a)).

The Taylor and Allen (1992) evidence on the prevalence of nonfundamentalist analysis in foreign exchange markets suggests that, as a guide to the *short-run* behavior of exchange rates, the fundamentals versus nonfundamentals approach seems promising. Unfortunately, this road may be rocky because of the difficulties involved in developing reliable models of exchange rate behavior from this approach. For example, Allen and Taylor (1990), after analyzing survey data on chartists' exchange rate forecasts, reported a significant degree of heterogeneity among chartist forecasts—not all chartists see the same patterns (or draw the same conclusions from them) at the same points in time. They argued, moreover, that the degree of consensus is likely to shift significantly over time in a fashion that may be hard to model empirically. Thus, while this approach may help us to rationalize the *past* behavior of exchange rates (for example, Frankel and Froot (1990)), it may prove rather more difficult to apply it to predicting *future* short-term exchange rate behavior.

Given the Taylor-Allen evidence that foreign exchange market participants rely more on fundamental economic analysis at longer horizons, it would seem that more attention ought to be focused on modeling the *long-run equilibrium* exchange rate. It is perhaps in this area that the new approaches that take into account fiscal policy stance, locational decisions, and industrial organization might be most fruitfully applied. In addition, the development of econometric techniques that aid in the identification of long-run relationships using short-run data (see, for example, Engle and Granger (1987)) is likely to provide a further impetus in this direction (see MacDonald and Taylor (1991a)).

III. The Efficient Markets Hypothesis

In this section we present a brief review of the literature on the efficient markets hypothesis as applied to the spot and forward markets for foreign exchange.

Under the hypothesis of market efficiency, it should be impossible for a trader to earn excess returns to speculation. In order to test this hypothesis, it is necessary to have a model of the equilibrium expected return. Early tests of spot market efficiency (for example, Poole (1967)) tested for randomness of exchange rate changes. As pointed out by Levich (1985), however, efficiency only implies randomness of returns if the equilibrium expected return is constant. If the fundamental determinants of the exchange rate (such as relative money and output according to the monetary approach) are serially correlated, then so will the equilibrium exchange rate be. Thus, contrary to popular belief, efficiency does not necessarily imply that the exchange rate should follow a random walk. This is most easily seen by recalling the uncovered interest parity condition: under risk neutrality and rational expectations, the expected rate of depreciation of one currency against another will be just equal to the interest rate differential between the currencies of appropriate maturity, so that the expected profit from arbitraging between them is zero. Thus, only if the interest differential is identically zero will the spot rate follow a random walk.[12] The analysis of Cumby and Obstfeld (1981) can be seen as a logical extension of the literature on the randomness of exchange rate changes, since they test for randomness of deviations from uncovered interest rate parity (see the section on international parity conditions below).

Another method of testing spot market efficiency is to test for the profitability of filter rules (for example, Poole (1967) and Dooley and Shafer (1983)). A simple x percent filter rule implies the following trading strategy: buy a currency whenever it rises x percent above its most recent trough; sell the currency and take a short position whenever the currency falls x percent below its most recent peak. If the market is efficient and uncovered interest rate parity holds, the interest rate costs of such a strategy should on average eliminate any profit. Poole's study did not, in fact, allow for interest rate costs, but Dooley and Shafer's analysis not only included interest rate costs but also allowed for transactions costs using bid and asked exchange rate quotations. After examining a number of filter rules using daily data on nine exchange rates for the 1970s, they

[12] If the interest differential were identically equal to a constant, the logarithm of the spot rate would follow a random walk with drift.

reported that small filters—1, 2, and 3 percent—would have systematically generated profit for all exchange rates over the sample period. As noted by Levich (1985), however, it is not clear that the optimal filter size could have been chosen ex ante, and there also appears to be an important element of riskiness, in that substantial subperiod losses are often generated.

The literature on forward foreign exchange market efficiency has generally used some form of regression-based analysis of spot and forward exchange rates. As is clear from the preceding discussion, the efficient market hypothesis can be seen as a joint hypothesis of a view of equilibrium returns and the contention that agents are endowed with rational expectations. For our purposes, the latter proposition can be stated as

$$\Delta s_{t+k} = \Delta s^e_{t+k} + \eta_{t+k}, \qquad \Delta s^e_{t+k} = E[\Delta s_{t+k} \mid I_t], \tag{19}$$

where $\Delta s_{t+k} = s_{t+k} - s_t$, $\Delta s^e_{t+k} = s^e_{t+k} - s_t$; s denotes the logarithm of the spot rate (home currency price of foreign currency); s^e_{t+k} denotes the expected value of s_{t+k} at time t; E is the mathematical conditional expectation operator; I_t is the information set on which agents base their expectations; and η_{t+k} is a random forecast error, orthogonal to the information set. Relationship (19) is normally expressed in logarithms in order to circumvent the so-called Siegel paradox (Siegel (1972)).[13] This problem does not arise if agents are assumed to form expectations of the *logarithm* of exchange rates, since $E(-s) = -E(s)$. McCulloch (1975), however, investigated the empirical importance of this phenomenon (using 1920s data) and showed the operational importance of the Siegel paradox to be slight. Nevertheless, the literature has continued to work with logarithmic transformations of the data.

If agents are risk neutral, then, since a profit can be expected to be made when the forward rate differs from the expected future spot rate (by taking open forward positions), one might expect the forward rate for maturity k periods ahead to be forced into equality with the market's expectations of the spot rate at time $t + k$:

$$f_t = s^e_{t+k}. \tag{20}$$

If agents are risk averse, however, then the forward rate will not be driven to full equality with the expected future spot rate because of the risk involved in taking open forward positions. Thus, a risk premium, λ_t,

[13] Because of a mathematical relationship known as Jensen's inequality, one cannot have, simultaneously, an unbiased expectation of, say, the deutsche mark-U.S. dollar exchange rate (marks per dollar) and of the U.S. dollar-deutsche mark exchange rate (dollars per mark) because $1/E(S) \neq E(1/S)$.

say, might be expected to drive a wedge between f_t and s^e_{t+k}. Under this assumption, equation (20) can be rewritten, after subtracting s_t from both sides as

$$fp_t = \Delta s^e_{t+k} + \lambda_t, \tag{21}$$

where fp_t denotes the logarithm of the forward premium ($fp_t = f_t - s_t$), and λ_t represents a risk premium that is required to compensate agents from exposure to the risk involved in running open positions in the currency in question.

From equations (19) and (21) we can obtain a statement of the efficient markets hypothesis under risk aversion as follows:

$$fp_t = \Delta s_{t+k} + \epsilon_{t+k} + \lambda_t, \tag{22}$$

where $\epsilon_{t+k} = -\eta_{t+k}$. As we shall see, in trying to interpret the often-quoted finding that the forward premium is a biased predictor of the exchange rate depreciation, researchers tend either to assume that λ_t is zero and conclude that rejection is attributable to "irrationality," or that agents are rational and conclude that rejection is due to the presence of a statistically significant risk premium.

A popular way of testing the joint efficient markets hypothesis is to regress the actual change in the exchange rate on the forward premium:

$$\Delta s_{t+k} = \alpha + \beta fp_t + u_{t+k}, \tag{23}$$

and if agents are risk neutral and rational, we would expect $\alpha = 0$, $\beta = 1$, and if nonoverlapping data are being used ($k = 1$), we would expect the disturbance term to be serially uncorrelated. If, however, agents are either risk averse or "irrational" (or both), then such conditions will be violated.

An alternative test of the optimality of the forward rate as a predictor of the exchange rate change is to conduct orthogonality tests of forecast errors. More specifically, an equation is estimated of the form

$$s_{t+k} - f_t = \Gamma X_t + \omega_{t+k}, \tag{24}$$

where X_t is a vector of variables known at time t, which is the econometricians' observed portion of the "true" information set, I, available to agents; Γ is a vector of parameters; and ω_{t+k} is an error term. The null hypothesis of rational expectations and risk neutrality is equivalent to the hypothesis that Γ should equal the null vector, so that the error in forecasting the exchange rate using the current forward rate cannot be forecast using current information—that is, it should be orthogonal to elements of the information set available at time t. If this condition is significantly violated, then information available to agents at time t has remained unexploited, contradicting rationality.

Tests of Forward Premium as Optimal Predictor of Rate of Depreciation

Many researchers have implemented equation (23) using a variety of currencies and time periods for the recent floating experience, and report results unfavorable to the efficient markets hypothesis under risk neutrality. For example, Bilson (1981), Longworth (1981), Fama (1984), Gregory and McCurdy (1984), Taylor (1988b), and Kearney and MacDonald (forthcoming) all reported a result suggesting a resounding rejection of the unbiasedness hypothesis: a significantly negative point estimate of β. This result seems particularly robust given the variety of estimation techniques used by researchers and the mix of overlapping and nonoverlapping data sets. Equation (25) below (from Fama (1984)) is a typical example of the result obtained by these researchers (standard errors are in parentheses):

$$\underset{}{\Delta s_{t+k}} = \underset{(0.42)}{0.81} - \underset{(0.50)}{1.15}(f-s)_t \tag{25}$$

Currency: Swiss franc-U.S. dollar; August 1973–December 1982.

Considerable research effort has been expended in trying to rationalize this finding. Perhaps the most popular explanation is that there is a nonzero, time-varying risk premium that drives a wedge between the forward rate and future spot rate (see Fama (1984) and Hodrick and Srivastava (1986)).

Error Orthogonality Tests of Efficient Markets Hypothesis

Alternative tests of the efficiency hypothesis have relied on testing the orthogonality of forward rate forecasting errors to information available at the time of the forecast. Orthogonality tests of efficiency may be split into those that include only lagged forecast errors in the conditioning information set (in terms of Fama's 1976 taxonomy, such tests are weak form tests, categorized as A-tests) and those that include information additional to lagged forecast errors in the information set (semistrong form tests, labeled B-tests).

A-tests have been conducted by, among others, Cumby and Obstfeld (1984), Geweke and Feige (1979), Frankel (1979b), Gregory and McCurdy (1984), MacDonald (1983), and MacDonald and Taylor (1991b). These authors used a variety of sample periods (that is, recent float and interwar float), exchange rates (usually bilateral dollar rates), and estimation techniques—ordinary least squares (OLS), generalized least squares (GLS), Zellner's "seemingly unrelated regressions" technique, and gen-

eralized method of moments (GMM). Their basic finding was that the efficient markets hypothesis is rejected for a number of currencies for the recent and interwar floating experiences. For example, Hansen and Hodrick (1980) estimated equation (24) using a weekly data base for part of the recent float and found that the orthogonality property was violated for three currencies (the Swiss franc, the lira, and the deutsche mark). Hansen and Hodrick estimated their version of equation (24) using OLS (since it is consistent), but corrected the covariance matrix of standard errors for the implied moving average error structure, which is implied by overlapping data ($k > 1$) using Hansen's (1982) GMM procedure.[14] MacDonald and Taylor (1991b) also used Hansen's GMM technique to conduct A-tests for the interwar period, but, in contrast to Hansen and Hodrick, they used the GMM procedure to correct for both the implied moving average error *and* conditional heteroscedasticity (Hansen and Hodrick assumed conditional homoscedasticity); the null hypothesis was strongly rejected for dollar-pound sterling, franc-pound sterling, and franc-dollar exchange rates (this result contrasts with other tests of the efficient markets hypothesis for this period).

Given the rejections of the null hypothesis reported when researchers conduct A-tests, it is hardly surprising to find that B-tests result in even stronger rejections. Geweke and Feige (1979), Hakkio (1981), Hansen and Hodrick (1980), Hsieh (1984), and MacDonald and Taylor (1991b) all tested the orthogonality of the forward rate forecast error with respect to own lagged forecast errors and lagged forecast errors from other foreign exchange markets; in each case, the null hypothesis $\Gamma = 0$ was resoundingly rejected.

Rationalizing Inefficiency Findings

The rejection of the efficient markets hypothesis is usually explained in one of two ways. As noted above, it is a joint null hypothesis of rational expectations and an assumption concerning the attitude of agents toward risk. It has often been tested under the assumption of risk neutrality. Thus, the first, and by far the most popular, explanation of the inefficiency finding is that agents are risk averse and, therefore, λ_t is nonzero in equation (21). For examples of attempts to model or test for the foreign exchange risk premium econometrically, see, among others, Fama (1984), Hansen and Hodrick (1983), Domowitz and Hakkio (1985), Wolff (1987),

[14] See MacDonald and Taylor (1989a) for an explanation and discussion of the moving average structure of overlapping forecast errors.

and Taylor (1988b, 1991a). By and large, however, the risk premium has proved elusive.[15]

Alternatively, researchers have sought to explain rejection in terms of a failure of the expectations component of the joint hypothesis. Examples include the peso problem suggested by Krasker (1980) (see footnote 7 above); the rational bubbles phenomenon, originally suggested by Flood and Garber (1980); and inefficient information processing, as suggested by Bilson (1981) (see MacDonald and Taylor (forthcoming) for a more detailed survey).

A problem with each of these rationalizations is that in order to test for a failure in one leg of the efficient markets hypothesis, the researcher must normally *assume* that the other component of the joint hypothesis is valid. For example, all of the investigations of foreign exchange risk premia cited above were conducted conditional on the assumption of rational expectations. Clearly, one would like to be able to conduct tests of each component of the joint hypothesis. The recent availability of survey data on exchange rate expectations from a variety of sources has allowed researchers to do just that. For example, Frankel and Froot (1987, 1990), MacDonald and Torrance (1988b, 1990), and Taylor (1989a) all used the median of various exchange rate surveys. The broad conclusion emerging from this research is that the joint hypothesis fails both because agents are risk averse and because their expectations do not conform to the rational expectations hypothesis (Takagi (1991) and MacDonald and Taylor (forthcoming)). Furthermore, Ito (1990) demonstrated, using a highly disaggregated survey data base, that exchange rate expectations appear to be highly heterogeneous.[16]

The Efficient Markets Hypothesis: Anything Left?

There is now overwhelming evidence to suggest that the forward foreign exchange rate is a biased and inefficient predictor of the future spot rate. The simpler version of the efficient markets hypothesis (that is, assuming risk neutrality) thus seems to have been decisively rejected for the foreign exchange market. This result is commonly explained either

[15] For extensive surveys of this issue see Hodrick (1987) and MacDonald and Taylor (forthcoming).

[16] Froot and Ito (1988) tested the "consistency" of the median response of survey data by testing whether the long-term forecast *implied* by a short-term forecast is consistent with the survey-based long-term forecast. Such a test is effectively an application of the cross-equation restrictions tested in the context of a vector autoregressive model of the forward and spot rates. Froot and Ito demonstrated that the survey forecasts are inconsistent.

in terms of a time-varying risk premium or some problem with the expectations leg of the joint hypothesis of market efficiency. The time-varying risk premium story, although intuitively extremely plausible, receives rather mixed support from the data, and at best we must conclude that the jury is still out on it. Furthermore, a number of researchers have argued that the use of a time-varying risk premium is a vacuous device whose only function is to provide a tautological safe house for the theory (Mankiw and Summers (1984)).[17]

Perhaps, the failure of the joint efficiency hypothesis should be traced to the expectations leg of the joint hypothesis. The reported profitability of some simple trading rules would certainly seem to point in this direction. Indeed, MacDonald and Young (1986), Frankel and Froot (1987), Goodhart (1988), and Allen and Taylor (1990) have argued that combining a chartist view of exchange rate determination with an equilibrium, or fundamentalist, view, offers a much more realistic view of how exchange rates are actually determined and helps to explain why the forward rate is such a poor predictor of the future exchange rate.[18] Combining this view with a fresh approach to the underlying fundamentals (for example, Dooley, Isard, and Taylor (1991)) is an approach that we believe offers much potential for future research on exchange rate economics.

IV. "News" and Exchange Rates

One important implication of the rational expectations hypothesis is that unanticipated events or news drive asset prices like the exchange rate. For example, although the strict efficient markets hypothesis requires the forward exchange rate to be an unbiased forecast of the future spot rate, it does not predict that the forward rate will be a particularly good forecast (although it may be the best available) of the future spot rate in periods that contain a great deal of new information. Thus, in the preceding discussion, the error made in forecasting the spot rate at time $t + k$ using information at time t(that is, η_{t+k} in equation (19)) can be thought of as due to new information arriving in periods $t + 1$ through $t + k$. If such news elements are small and insignificant, then clearly the

[17] Frankel and Froot (1990) present the most complete and formal statement of this view.

[18] Both Hakkio (1984) and MacDonald (1988) reported some success in estimating PPP relationships for the recent floating experience using systems estimators; however, certain features of the estimation strategy adopted by these authors (in particular their use of a serial correlation correction) indicate that PPP deviations are important.

efficient markets hypothesis predicts that s_{t+k} should be very close to $f_t^{\cdot}$, but if a researcher is examining an equation such as (23) during a period in which there has been a great deal of new information, the sample variance of the prediction error could be substantial.

Let the vector z_t include all variables relevant for the process of exchange rate determination; our equation for the determination of the exchange rate is thus

$$s_t = \gamma' z_t + \eta_t, \tag{26}$$

where η_t is a white-noise error. Under the rational expectations hypothesis, agents use the true model in forming their exchange rate expectations agents, so

$$s_t^e = \gamma' z_t^e, \tag{27}$$

where $s_t^e = E(s_t \mid I_{t-1}), z_t^e = E(z_t \mid I_{t-1})$. Thus, subtracting equation (27) from (26) and assuming risk neutrality (so that $s_t^e = f_{t-1}$), we can see that the forward rate forecast error is composed of a news term and a purely random term:

$$s_t - f_{t-1} = \gamma(z_t - z_t^e) + \eta_t, \tag{28}$$

where the term in parentheses represents the news.

This highlights two factors that a researcher faces in attempting to test the news approach empirically. First, a specific model of the process of exchange rate determination must be chosen. In terms of equation (28), a choice has to be made as to which variables should enter the z_t vector. Second, having decided on the appropriate model of exchange rate determination, the researcher must decide on an appropriate method of generating the expected values of the determining variables. As we demonstrate below, researchers have used three methods to generate expected values: regression analysis, time-series analysis, and survey data.

Frenkel (1981) used time-series methods (univariate autoregressions) to generate news on nominal interest rate differentials, which he then used to explain the forward rate forecast error for the U.S. dollar-pound sterling, U.S. dollar-franc, and U.S. dollar-deutsche mark exchange rates over the period June 1973 through June 1979. Although he found that all of the estimated news coefficients had signs in accordance with the monetary model of the exchange rate, this coefficient was statistically significant only for the U.S. dollar-pound sterling.

Edwards (1982) and MacDonald (1983) provided similar mixed support for the flexible-price news approach, using a seemingly unrelated regressions estimation technique. MacDonald (1983) extended this anal-

ysis to the interwar period. Copeland (1984) incorporated oil price surprises into his news analysis of the pound sterling-U.S. dollar exchange rate. Bomhoff and Korteweg (1983), using a multistate Kalman filter technique to generate news on relative money, output, and oil prices, tested the news approach for six exchange rates over the period 1973–79. Again, their results provided some support for the approach. Branson (1984) tested the implications of the rational expectations, portfolio balance model for the effect of news on current account balances and other variables on the exchange rate using a vector autoregressive technique to generate news terms. His results were broadly in accordance with the predictions of the portfolio balance model. In contrast to the above researchers, Dornbusch (1980) generated the news variables from OECD survey data (a survey-based news approach has also been adopted by Engel and Frankel (1984) and MacDonald and Torrance (1988b)).

Other researchers have also used survey data on money supplies and other variables to test for the effect of news on exchange rates (see MacDonald and Taylor (forthcoming) for a discussion).

V. International Parity Conditions

In this survey we have repeatedly referred to various international parity conditions. In this section we bring together these parity conditions and briefly survey the empirical evidence on their validity (a comprehensive account is given in MacDonald and Taylor (1990, forthcoming); see also Isard (1988)).

If foreign exchange markets are operating efficiently, then arbitrage should ensure that the covered interest differential on similar assets be continuously equal to zero—covered interest parity (CIP) should hold:

$$(i - i^*)_t - (f - s)_t = 0. \tag{29}$$

In any computation of CIP, it is clearly important to consider home and foreign assets that are comparable in terms of maturity, as well as other characteristics such as default and political risk (Aliber (1973), Dooley and Isard (1980), and Frankel and MacArthur (1988)).

Essentially, two types of tests of CIP have been conducted. The first relies on computing the actual deviations from interest parity to see if they differ "significantly" from zero. The significance is usually defined with respect to the neutral band, which is determined by transactions costs. For example, Frenkel and Levich (1975, 1977) demonstrated that for a selection of currencies, about 80 percent of apparent profit opportunities lay within the neutral band when treasury bills were used, and almost 100

percent when Eurorates were considered. Furthermore, in Frenkel and Levich (1977) it is demonstrated that in periods of turbulence a much smaller percentage of deviations from CIP may be explained by transactions costs; this is interpreted as reflecting higher financial uncertainty in such periods. Clinton (1988) demonstrated that deviations from CIP should be no greater than the minimum transactions costs in one of three markets: the two underlying deposit markets (for example, Euromarks and Eurodollars), and the foreign exchange swap market (that is, the market in which a currency can be simultaneously bought spot and sold forward against another currency). Based on an analysis of data for five major currencies against the U.S. dollar, which he took from midmorning quotes on the Reuter Money Rates Service for the six-month period from November 1985 to May 1986, Clinton found that the neutral band should be within ±0.06 percent a year from parity and that although the hypothesis of zero profitable deviations from parity could be rejected, "empirically, profitable trading opportunities are neither large enough nor long-lived enough to yield a flow of excess returns over time to any factor" (p. 369).

In questioning the quality of the data used by Frenkel and Levich (1975, 1977), various researchers have arrived at different conclusions. For example, using higher quality data, McCormick (1979) found that most of the deviations from CIP (70-80 percent) lay *outside* the neutral band for U.K.-U.S. Treasury bills. Taylor (1987b, 1989b), however, went further than McCormick, arguing that in order to provide a true test of CIP it is important that data on the appropriate exchange and interest rates be recorded at the same instant at which a dealer could have dealt. Using high-quality, high-frequency, contemporaneously sampled data for spot and forward dollar-pound sterling and dollar-mark exchange rates and corresponding Eurodeposit interest rates for a number of maturities, Taylor found, among other things, that there were few profitable violations of CIP, even in periods of market uncertainty and turbulence. One interesting finding of Taylor's work was a maturity effect—the frequency, size, and persistence of arbitrage opportunities appeared to be an increasing function of the length of maturity of underlying financial instruments. A rationale is offered for this in terms of banks' prudential credit limits. This finding received further support in Taylor and Fraser (1991), in which high-frequency, contemporaneous data sampled around a series of news releases (such as trade figures) were employed to test CIP.

A second method for testing the validity of CIP is the use of regression analysis. Thus, if CIP holds, and in the absence of transactions costs, estimation of the following equation:

$$f_t - s_t = \alpha + \beta(i - i^*)_t + u_t, \tag{30}$$

should result in estimates of α and β differing insignificantly from zero and unity, respectively, and a nonautocorrelated error. Equation (30) has been tested by researchers for a variety of currencies and time periods (see, for example, Branson (1969), Marston (1976), Cosander and Laing (1981), and Fratianni and Wakeman (1982)). Broadly speaking, CIP is supported; although there were significant deviations of α from zero (reflecting perhaps nonzero transactions costs), the estimates of β differed insignificantly from unity in the majority of cases. As noted by Taylor (1987b, 1989b), however, it is not clear what regression-based analyses of CIP are actually testing. For example, it may be that the hypothesis that $\alpha = 0$ and $\beta = 1$ in equation (30) cannot be rejected, but that the fitted residuals themselves represent substantial arbitrage opportunities. Put another way, such a test may strongly suggest that CIP held *on average* over a period, when in fact it did not hold at *any instant* during the period. Thus, although regression-based tests may be useful for testing the broad stylized fact of CIP (which may be of interest, for example, in exchange rate modeling), they can say virtually nothing about market efficiency. In spite of this caveat, we summarize the above evidence as suggesting that CIP does appear to be reasonably well supported by the data, especially if Eurodeposit interest rates are considered.

Uncovered interest parity (UIP) is the proposition that the interest differential should be exactly equal to the expected rate of depreciation of the exchange rate:

$$(i - i^*)_t = \Delta s^e_{t+k}. \tag{31}$$

Given CIP, this means that the forward premium should, in fact, be equal to the expected currency depreciation—a condition that will only hold if agents are risk neutral. In the absence of a direct measure of expectations, it is necessary to formulate an auxiliary hypothesis concerning expectations formation before UIP becomes testable, and it is usual to assume that expectations are formed rationally. In this case, given CIP, UIP implies that the forward rate should act as an optimal predictor of the future spot rate. But this, of course, takes us back to the literature on forward market efficiency, which is discussed in the previous section. Thus, tests of efficiency of the forward exchange market can be viewed as *indirect* tests of UIP—*indirect* because they rely on a maintained hypothesis of CIP.

For reasons not immediately clear, direct tests of UIP occur relatively infrequently in the literature. Under rational expectations and risk neutrality, such a test would amount to testing the interest differential as an optimal predictor of the rate of depreciation. Such a test might, for example, involve estimating an equation of the form

$$s_t = \alpha_0 s_{t-k} + \alpha_1 (r - r^*)_{t-k} + \varphi_t, \tag{32}$$

where the joint hypothesis of risk neutrality and rational expectations implies that α_0 and α_1 should equal minus and plus unity, respectively, and that φ_t should be orthogonal to past information.

Equation (32), or variants thereof, has been tested by, among others, Hacche and Townend (1981), Cumby and Obstfeld (1981), Davidson (1985), Loopesko (1984), and Taylor (1987a); in all instances, UIP was very strongly rejected. In common with the literature on the optimality of the forward rate as a predictor of the future spot rate, such rejection is usually interpreted as indicating the presence of a (time-varying) risk premium. MacDonald and Torrance (1990), however, demonstrated, using survey expectations data, that rejection was most likely caused by both risk and expectations factors. Interestingly, several papers that attempted to model deviations from UIP in terms of a risk premium have been largely unsuccessful (see, among others, Dooley and Isard (1982), Frankel (1982b, 1983, 1985b), and Rogoff (1984)).

Another international parity condition that has received attention in the literature is real interest rate parity. This may be derived using UIP (equation (31)), ex ante PPP (equation (33)), and Fisher closed conditions for the home and foreign country (equations (34) and (35)):

$$\Delta s^e_{t+k} = \Delta p^e_{t+k} - \Delta p^e_{t+k} \tag{33}$$

$$i_t = r_t - \Delta p^e_{t+k} \tag{34}$$

$$i^*_t = r^*_t - \Delta p^{e*}_{t+k}, \tag{35}$$

where i denotes the real interest rate; r, the nominal interest rate; and p, the logarithm of the price level. Combining equations (31) and (33)–(35), yields

$$i_t = i^*_t . \tag{36}$$

Thus, given the stated assumptions, real interest rates must be equalized across countries, and the scope for the policymaker to alter real economic activity by changing the real interest rate is limited. Is condition (36) supported empirically? The real interest rate parity condition has been tested by a number of researchers for the United States against other OECD countries (see, for example, Mishkin (1984a, 1984b), Friedman and Schwartz (1982), Cumby and Obstfeld (1984), Cumby and Mishkin (1984), MacDonald and Taylor (1990), and Fraser and Taylor (1990)), and the results indicate a resounding rejection of real interest rate parity. For example, Cumby and Obstfeld (1984) empirically implement (33) by running the following regression:

$$\Delta p_{t+1} - \Delta p_{t+1} = \alpha + \beta(r - r^*)_t + \nu_{t+1}, \tag{37}$$

which is obtained by using equations (33)–(35) in (31) and by assuming expected inflation rates are formed rationally. A test of $\alpha = 0, \beta = 1$ (the null hypothesis) is a test of the equality of expected real interest rates. A sample of Cumby and Obstfeld's results is reported here:

$$\Delta p_{t+1} - \Delta p^*_{t-1} = \underset{(0.01)}{0.028} + \underset{(0.23)}{0.503}(r - r^*)_t \tag{38}$$

United States-Germany; January 1976–September 1981,

where standard errors are in parentheses, the price terms are consumer price indices, and the interest rates are Eurodeposit interest rates. For this equation, and for others reported by Cumby and Obstfeld, the null hypothesis of ex ante real interest rate parity is easily rejected.

Tests of PPP have often involved estimates of the following equations:

$$s_t = \alpha + \beta p_t - \beta^* p^*_t + \varphi_t \tag{39}$$

$$\Delta s_t = \beta \Delta p_t - \beta^* \Delta p^*_t + \varphi_t. \tag{40}$$

Thus, a test of equation (39) would be interpreted as a test of absolute PPP—the hypothesis that the level of the exchange rate is determined by relative price levels—while a test of equation (40) would be interpreted as a test of relative PPP—the proposition that the rate of exchange rate depreciation is driven by relative inflation differentials. Frenkel (1978, 1981) provided estimates of equations (39) and (40) for the interwar floating experience and for the recent floating experience, respectively. Frenkel's interwar estimates were highly supportive of PPP; his results for a variety of currencies for the recent floating experience were not (PPP in both its absolute and relative forms was resoundingly rejected by the data). In further tests of PPP for the interwar and recent floating experience, Krugman (1978) reported estimates of (39) and (40) that were largely unfavorable to PPP (he used a longer sample period for the interwar period than Frenkel (1978)). Krugman's results pointed to large and persistent deviations of exchange rates from PPP, especially in countries with an unstable monetary policy.

Further evidence against the traditional view of PPP has been provided by the efficient markets view of PPP, which posits that the real exchange rate should follow a random walk. This may be seen in the following way. From the Fisher equations, equations (34) and (35), and the UIP condition (equation (31)), we have

$$i_t - i^*_t = \Delta p^{e*}_{t+k} - \Delta p^e_{t+1} + \Delta s^e_{t+1}, \tag{41}$$

and by assuming the expected values in equation (41) are formed rationally, we have

$$i_t - i_t^* = \Delta p_{t+1}^* - \Delta p_{t+1} + \Delta s_{t+1} + a_{t+1}, \tag{42}$$

where a_{t+1} is the rational forecast error. Thus, if the real interest rate differential is constant over time, the logarithm of the real exchange rate should follow a random walk. As is well known, if a variable follows a random walk process, any change in the variable will be permanent, and mean-reverting behavior is ruled out. Such a view is disturbing to a proponent of PPP, because although few would deny that there are shocks that may lead to a change in the real exchange rate in the short run, such shocks are generally thought to be temporary phenomena: over time the real exchange rate eventually returns to its equilibrium value. The majority of evidence reported so far does in fact favor the efficient markets view of PPP (see, for example, Roll (1979), Darby (1980), Frenkel (1981), Adler and Lehmann (1983), Mishkin (1984b), and MacDonald (1985a, 1985b)). However, some research has led to rejection of the hypothesis (see, for example, Cumby and Obstfeld (1984), Frankel (1985b), and Frankel and Froot (1986)).

Further evidence in favor of the efficient market PPP may be gleaned from studies that use cointegration analysis (Engle and Granger (1987)) to test for mean reversion in the real exchange rate or in the residual of an equation (equation (39)). Such studies (see, for example, Taylor (1988c)) report a failure of significant mean reversion of the exchange rate toward PPP for the recent floating experience (see also Huizinga (1987)). In a recent paper, however, Abuaf and Jorion (1990), using systems estimation methods in which the first-order autoregressive coefficient of the real exchange rate is constrained to be equal across a range of real exchange rates, were able to reject the unit-root (random walk) hypothesis. A similar finding for the recent float is reported by MacDonald (forthcoming). For the interwar period, the unit-root hypothesis may be rejected for the major exchange rates using univariate unit-root tests, implying that this period is characterized by long-run PPP (Taylor and McMahon (1988) and Taylor (1991b)).

Other tests of PPP are more descriptive in their nature. Thus, a number of researchers (for example, Dornbusch and Krugman (1976), Dornbusch (1979), and MacDonald and Taylor (1990)) have sought to gauge the validity of PPP by plotting the real exchange rate alongside the nominal rate for a number of currencies: if PPP holds, the real exchange rate should be independent of the nominal rate. Such plots clearly indicate that both real and nominal rates are closely tied together. All the

above studies have utilized aggregate price indices in their tests of PPP. Given that the absolute PPP condition is simply the sum of parity conditions for individual goods, it may be more appropriate to test PPP at a disaggregated level. This, in fact, has been the strategy of Isard (1977), Kravis and Lipsey (1978), and Fraser, Taylor, and Webster (1990). All of these studies reported strong rejections of the PPP hypothesis.

Of the international parity conditions covered in this section, covered interest parity receives fairly strong support from the data, especially when it is implemented with Eurodeposit interest rates and data that properly reflect the trading opportunities open to arbitrage. A less sanguine conclusion, however, emerges from the discussion of uncovered interest parity: UIP is resoundingly rejected for the recent experience with floating exchange rates. This conclusion clearly has important implications for exchange rate models that rely on UIP in their derivation. A major challenge facing researchers is to determine whether this failure is due to a violation of risk neutrality or a failure of rational expectations. Studies that have attempted to capture a risk premium by regressing the deviation from UIP on determinants of risk have not been successful, and this perhaps suggests that it is the expectations leg of the joint hypothesis that is at fault. Indeed, single hypothesis tests using survey data indicate that both components of the null are at fault (see, for example, MacDonald and Torrance (1988b)).

In common with tests of UIP, empirical tests of real interest rate parity have most often tended to reject the null hypothesis. Our summary of the battery of tests that have been used to test for the existence of PPP supports the view that *continuous* PPP has not held for the recent floating period, while the evidence in favor of *long-run* convergence of real exchange rates toward PPP is at present mixed. Taylor and McMahon (1988) produced evidence strongly suggesting that a form of *long-run* PPP may have held during the interwar period. Perhaps the difference in performance of PPP between the two periods reflects the greater number of factors (such as productivity changes) requiring equilibrium real exchange rate changes for the recent experience with floating.

The findings in this section are important since they suggest that at least three types of international parity conditions used by a number of researchers to build the exchange rate models discussed previously are not unequivocally validated by the data. Future modeling should therefore be aware of this inconsistency and, at the very least, should take proper account of the time-series properties of UIP and PPP. Proper recognition of the limitations of certain parity conditions should help to improve our understanding of how foreign exchange rates are determined.

REFERENCES

(In addition to the sources cited in this article, this list includes items that may be of interest to readers wishing to pursue the subject further.)

Abauf, Niso, and Philip Jorion, "Purchasing Power Parity in the Long Run," *Journal of Finance*, Vol. 45 (March 1990), pp. 157–74.

Adler, Michael, and Bruce Lehman, "Deviations from Purchasing Power Parity in the Long Run,*Journal of Finance*, Vol. 38 (December 1983), pp. 1471–83.

Aliber, Robert Z., "The Interest Rate Parity Theorem: A Reinterpretation," *Journal of Political Economy*, Vol. 81 (November/December 1973), pp. 1451–59.

Allen, H.L., and M.P. Taylor, "Chart Analysis and the Foreign Exchange Market," *Bank of England Quarterly Bulletin*, Vol. 29 (November 1989), pp. 548–51.

———, "Charts, Noise and Fundamentals in the Foreign Exchange Market," *Economic Journal*, Vol. 100, Supplement (1990), pp. 49–59.

Allen, Polly Reynolds, and Peter B. Kenen, *Asset Markets, Exchange Rates, and Economic Integration: A Synthesis* (Cambridge; New York: Cambridge University Press, 1980).

Artis, Michael J., and Mervyn K. Lewis, *Monetary Control in the United Kingdom* (Oxford: Philip Allan, 1981).

Artus, Jacques, and John H. Young, "Fixed and Flexible Exchange Rates: A Renewal of the Debate," *Staff Papers*, International Monetary Fund, Vol. 26 (December 1979), pp. 654–98.

Backus, David, "Empirical Models of the Exchange Rate: Separating the Wheat from the Chaff," *Canadian Journal of Economics*, Vol. 17 (November 1984), pp. 824–46.

Barr, David G., "Exchange Rate Dynamics: An Empirical Analysis," in *Exchange Rates and Open Economy Macroeconomics*, ed. by Ronald MacDonald and Mark P. Taylor (New York: B. Blackwell, 1989).

Bilson, John F.O., "Rational Expectations and the Exchange Rate," in *The Economics of Exchange Rates: Selected Studies*, ed. by Jacob A. Frenkel and Harry G. Johnson (Reading, Massachusetts: Addison-Wesley, 1978).

———, "The 'Speculative Efficiency' Hypothesis," *Journal of Business*, Vol. 54 (October 1981), pp. 435–51.

Bisignano, J., and K. Hoover, "Some Suggested Improvements to a Simple Portfolio Balance Model of Exchange Rate Determination with Special Reference to the U.S. Dollar/Canadian Dollar Rate, *Weltwirtschaftliches Archiv*, Vol. 118, No. 1 (1982), pp. 19–38.

Black, Stanley W., International Money Markets and Flexible Exchange Rates, Princeton Studies in International Finance No. 32 (Princeton, New Jersey: Princeton University Press, 1973).

Blanchard, Olivier J., and Mark W. Watson, "Bubbles, Rational Expectations,

and Financial Markets," in *Crises in the Economic and Financial Structure*, ed. by Paul Wachtel (Lexington, Massachusetts: Lexington Books, 1982).

Blundell-Wignall, Andrew, and Paul R. Masson, "Exchange Rate Dynamics and Intervention Rules," *Staff Papers*, International Monetary Fund, Vol. 32 (March 1985), pp. 132–59.

Bomhoff, Eduard J., and Pieter Korteweg, "Exchange Rate Variability and Monetary Policy Under Rational Expectations," *Journal of Monetary Economics*, Vol. 11 (March 1983), pp. 169–206.

Boothe, Paul, and Debra Glassman, "The Statistical Distribution of Exchange Rates: Empirical Evidence and Economic Implications," *Journal of International Economics*, Vol. 22 (May 1987), pp. 297–319.

Boughton, James M. (1984a), "Exchange Rate Movements and Adjustment in Financial Markets: Quarterly Estimates for Major Currencies," *Staff Papers*, International Monetary Fund, Vol. 31 (September), pp. 445–68.

——— (1984b), "Tests of the Performance of Reduced-Form Exchange Rate Models," *Journal of International Economics*, Vol. 31 (September 1984), pp. 41–56.

——— (1988a), *The Monetary Approach to Exchange Rates: What Now Remains?* Princeton Essays in International Finance, No. 171 (Princeton, New Jersey: Princeton University Press).

——— (1988b), "Exchange Rates and the Term Structure of Interest Rates," *Staff Papers*, International Monetary Fund, Vol. 35 (March), pp. 36–62.

Branson, William H., *Financial Capital Flows in the U.S. Balance of Payments* (Amsterdam: North-Holland, 1968).

———, "The Minimum Covered Interest Differential Needed for International Arbitrage Activity," *Journal of Political Economy*, Vol. 77 (November/December 1969), pp. 1028–35.

———, *Asset Markets and Relative Prices in Exchange Rate Determination*, Reprints in International Finance, No. 20 (Princeton, New Jersey: Princeton University Press, June 1980); reprinted from *Sozialwissenschaftliche Annalen*, Band 1 (1977).

———, "Macroeconomic Determinants of Real Exchange Risk," in *Managing Foreign Exchange Risk*, ed. by Richard J. Herring (Cambridge; New York: Cambridge University Press, 1983).

———, "Exchange Rate Policy After a Decade of 'Floating,'" in *Exchange Rate Theory and Practice*, ed. by John F.O. Bilson and Richard C. Marston (Chicago: University of Chicago Press, 1984).

———, and Hannu Halttunen, "Asset-Market Determination of Exchange Rates: Initial Empirical and Policy Results," in *Trade and Payments Adjustments Under Flexible Exchange Rates*, ed. by John P. Martin and Alasdair Smith (London: Macmillan, 1979).

Branson, William H., Hannu Halttunen, and Paul Masson, "Exchange Rates in the Short Run: The Dollar-Deutschemark Rate," *European Economic Review*, Vol. 10 (December 1977), pp. 303–24.

———, "Exchange Rates in the Short Run: Some Further Results," *European Economic Review*, Vol. 12 (October 1979), pp. 395-402.

Buiter, Willem H., "Comment on Branson," in *Exchange Rate Theory and Practice*, ed. by John F.O. Bilson and Richard C. Marston (Chicago: University of Chicago Press, 1984).

———, and Marcus H. Miller, "Monetary Policy and International Competitiveness: The Problem of Adjustment," in *The Money Supply and the Exchange Rate*, ed. by W.A. Eltis and P.J.N. Sinclair (New York: Oxford University Press, 1981).

Calvo, Guillermo A., and Carlos A. Rodriguez, "A Model of Exchange Rate Determination Under Currency Substitution and Rational Expectations," *Journal of Political Economy*, Vol. 85 (June 1977), pp. 617–25.

Clinton, Kevin, "Transactions Costs and Covered Interest Arbitrage: Theory and Evidence," *Journal of Political Economy*, Vol. 96 (April 1988), pp. 358–70.

Copeland, Laurence S., "Oil, News and the Petropound: Some Tests," *Economics Letters*, Vol. 16, No. 1/2 (1984), pp. 123–27.

Cornell, Bradford, "Money Supply Announcements and Interest Rates: Another View," *Journal of Business*, Vol. 56 (January 1983), pp. 1–23.

Cosander, Pierre-Alexis, and Bruno R. Laing, "Interest-Rates Parity Tests: Switzerland and Some Major Western Countries," *Journal of Banking and Finance*, Vol. 5 (June 1981), pp. 187–200.

Cumby, Robert E., and Frederic Mishkin, "The International Linkage of Real Interest Rates: The European Connection," NBER Working Paper No. 1423 (Cambridge, Massachusetts: National Bureau of Economic Research, 1984).

Cumby, Robert E., and Maurice Obstfeld, "A Note on Exchange-Rate Expectations and Nominal Interest Differentials: A Test of the Fisher Hypothesis," *Journal of Finance*, Vol. 36 (June 1981), pp. 697–703.

———, "International Interest-Rate and Price Level Linkages Under Flexible Exchange Rates: A Review of Recent Evidence," in *Exchange Rate Theory and Practice*, ed. by John F.O. Bilson and Richard C. Marston (Chicago: University of Chicago Press, 1984).

Darby, Michael R., "Does Purchasing Power Parity Work?" NBER Working Paper No. 607 (Cambridge, Massachusetts: National Bureau of Economic Research, December 1980).

Davidson, James E.H., "Econometric Modelling of the Sterling Effective Exchange Rate," *Review of Economic Studies*, Vol. 52 (April 1985), pp. 231–50.

de Grauwe, Paul, "The Exchange Rate in a Portfolio Balance Model with a Banking Sector," *Journal of International Money and Finance*, Vol. 1 (December 1982), pp. 225-39.

Dominguez, Kathryn, "Are Foreign Exchange Forecasts Rational? New Evidence from Survey Data," *Economics Letters*, Vol. 21, No. 3 (1986), pp. 277–81.

Domowitz, Ian, and Craig S. Hakkio, "Conditional Variance and the Risk Premium in the Foreign Exchange Market," *Journal of International Economics*, Vol. 19 (August 1985), pp. 47–66.

Dooley, Michael P., and Peter Isard, "Capital Controls, Political Risk,

and Deviations from Interest-Rate Parity," *Journal of Political Economy*, Vol. 88 (April 1980), pp. 370–84.

———, "A Portfolio-Balance Rational-Expectations Model of the Dollar-Mark Exchange Rate," *Journal of International Economics*, Vol. 12 (May 1982), pp. 257–76.

———, "Country Preferences, Currency Values, and Policy Issues," *Journal of Policy Modeling*, Vol. 9 (Spring 1987), pp. 65–81.

———, "A Note on Fiscal Policy, Investment Location Decisions, and Exchange Rates," *Journal of International Money and Finance*, Vol. 10 (March 1991), pp. 161–88.

———, and M.P. Taylor, "Exchange Rates, Country Preferences, and Gold" (unpublished; Washington: International Monetary Fund, January 1991).

Dooley, Michael P., and Jeffrey Shafer, "Analysis of Short-Run Exchange Rate Behavior, in *Exchange Rate and Trade Instability: Causes, Consequences, and Remedies*, ed. by David Bigman and Teizo Taya (Cambridge, Massachusetts: Ballinger, 1983).

Dornbusch, Rudiger, "Expectations and Exchange Rate Dynamics," *Journal of Political Economy*, Vol. 84 (December 1976), pp. 1161–76.

———, "Monetary Policy Under Exchange Rate Flexibility," in *Managed Exchange-Rate Flexibility: The Recent Experience*, Federal Reserve Bank of Boston Conference Series No. 20 (Boston: Federal Reserve Bank of Boston, 1979).

———, "Exchange Rate Economics: Where Do We Stand?" *Brookings Papers on Economic Activity: 1* (Washington: The Brookings Institution, 1980), pp. 143–85.

———, "Exchange Rate Economics," *Economic Journal*, Vol. 97 (March 1987), pp. 1–8.

———, and Stanley Fischer, "Exchange Rates and the Current Account," *American Economic Review*, Vol. 70 (December 1980), pp. 960–71.

Dornbusch, Rudiger, and Paul Krugman, "Flexible Exchange Rates in the Short Run," *Brookings Papers on Economic Activity: 3* (Washington: The Brookings Institution, 1976).

Driskill, Robert A., "Exchange-Rate Dynamics: An Empirical Investigation," *Journal of Political Economy*, Vol. 89 (April 1981), pp. 357–71.

———, and Steven M. Sheffrin, "On the Mark: Comment," *American Economic Review*, Vol. 71 (December 1981), pp. 1068–74.

Edwards, Sebastian, "Exchange Rates and 'News': A Multi-Currency Approach," *Journal of International Money and Finance*, Vol. 1 (December 1982), pp. 211–24.

Engel, Charles, and Jeffrey A. Frankel, "Why Interest Rates React to Money Announcements: An Explanation from the Foreign Exchange Market," *Journal of Monetary Economics*, Vol. 13 (January 1984), pp. 31–39.

Engle, Robert F., and C.W.J. Granger, "Cointegration and Error Correction: Representation, Estimation, and Testing," *Econometrica*, Vol. 55 (March 1987), pp. 251–76.

Evans, George W., "A Test for Speculative Bubbles in the Sterling-Dollar Exchange Rate: 1981–84," *American Economic Review*, Vol. 76 (September 1986), pp. 621–36.

Fair, Ray C., "The Estimation of Simultaneous Equation Models with Lagged Endogenous Variables and First Order Serially Correlated Errors," *Econometrica*, Vol. 38 (May 1970), pp. 507–16.

Fama, Eugene F., *Foundations of Finance: Portfolio Decisions and Securities Prices* (New York: Basic Books, 1976).

———, "Forward and Spot Exchange Rates," *Journal of Monetary Economics*, Vol. 14 (November 1984), pp. 319–38.

———, and André Farber, "Money, Bonds, and Foreign Exchange," *American Economic Review*, Vol. 69 (September 1979), pp. 639-49.

Finn, Mary G., "Forecasting the Exchange Rate: A Monetary or Random Walk Phenomenon?" *Journal of International Money and Finance*, Vol. 5 (June 1986), pp. 181–93.

Fisher, P.G., S.K. Tanna, D.S. Turner, K.F. Wallis, and J.D. Whitley, "Econometric Evaluation of the Exchange Rate in Models of the U.K. Economy," *Economic Journal*, Vol. 100 (December 1990), pp. 1230-44.

Fleming, Marcus, "Domestic Financial Policies Under Fixed and Floating Exchange Rates," *Staff Papers*, International Monetary Fund, Vol. 9 (November 1962), pp. 369–80.

Flood, Robert P., and Peter M. Garber, "Market Fundamentals versus Price-Level Bubbles: The First Tests," *Journal of Political Economy*, Vol. 88 (August 1980), pp. 745–70.

Flood, Robert P., and Robert J. Hodrick, "Testable Implications of Indeterminacies in Models with Rational Expectations," NBER Working Paper No. 2903 (Cambridge, Massachusetts: National Bureau of Economic Research, March 1989).

Frankel, Jeffrey A. (1979a), "On the Mark: A Theory of Floating Exchange Rates Based on Real Interest Differentials," *American Economic Review*, Vol. 69 (September), pp. 610–22.

——— (1979b), "Test of Rational Expectations in the Forward Exchange Market," *Southern Economic Journal*, Vol. 46 (April 1980), pp. 1083–1101.

——— (1982a), "The Mystery of the Multiplying Marks: A Modification of the Monetary Model," *Review of Economics and Statistics*, Vol. 64 (August), pp. 515–19.

——— (1982b), "In Search of the Exchange Risk Premium: A Six-Currency Test Assuming Mean-Variance Optimization," *Journal of International Money and Finance*, Vol. 1 (December), pp. 255–74.

———, "Monetary and Portfolio-Balance Models of Exchange Rate Determination," in *Economic Interdependence and Flexible Exchange Rates*, ed. by Jagdeep S. Bhandari, Bluford H. Putnam, and Jay H. Levin (Cambridge, Massachusetts: MIT Press, 1983).

———, "Tests of Monetary and Portfolio Balance Models of Exchange Rate Determination," in *Exchange Rate Theory and Practice*, ed. by John

F.O. Bilson and Richard C. Marston (Chicago: University of Chicago Press, 1984).

——— (1985a), "The Dazzling Dollar," *Brookings Papers on Economic Activity: 1* (Washington: The Brookings Institution).

——— (1985b), *Six Possible Meanings of 'Overvaluation': The 1981-85 Dollar*, Essays in International Finance No. 159 (Princeton, New Jersey: Princeton University Press).

———, and Kenneth A. Froot, "Understanding the Dollar in the Eighties: The Expectations of Chartists and Fundamentalists," *Economic Record*, Supplement (1986), pp. 24-38.

———, "Using Survey Data to Test Standard Propositions Regarding Exchange Rate Expectations," *American Economic Review*, Vol. 77 (March 1987), pp. 133–53.

———, "Interpreting Tests of Forward Discount Bias Using Survey Data on Exchange Rate Expectations," *Quarterly Journal of Economics*, Vol. 104 (February 1989), pp. 139–61.

———, "Chartists, Fundamentalists, and the Demand for Dollars," in *Private Behavior and Government Policy in Interdependent Economies*, ed. by Anthony S. Courakis and Mark P. Taylor (Oxford: Clarendon Press, 1990).

Frankel, Jeffrey A., and Alan T. MacArthur, "Political vs. Currency Premia in International Real Interest Differentials: A Study of Forward Rates for 24 Countries," *European Economic Review*, Vol. 32, No. 4 (1988), pp. 1083–1112.

Fraser, Patricia, and Mark P. Taylor, "Some Efficient Tests of International Real Interest Rate Parity," *Applied Economics*, Vol. 22 (August 1990), pp. 1083-92.

———, and A. Webster, "Long-Run Purchasing Power Parity as a Theory of International Commodity Arbitrage" (unpublished; Washington: International Monetary Fund, 1990).

Fratianni, Michele and Lee MacDonald Wakeman, "The Law of One Price in the Eurocurrency Market," *Journal of International Money and Finance*, Vol. 1 (December 1982), pp. 307–23.

Frenkel, Jacob A., "A Monetary Approach to the Exchange Rate: Doctrinal Aspects and Empirical Evidence," *Scandinavian Journal of Economics*, Vol. 78, No. 2 (1976), pp. 200–24.

———, "Purchasing Power Parity Doctrinal Perspective and Evidence from the 1920s," *Journal of International Economics*, Vol. 8 (May 1978), pp. 169-91.

———, "Flexible Exchange Rates, Prices, and the Role of 'News': Lessons from the 1970s," *Journal of Political Economy*, Vol. 89 (August 1981), pp. 665–705.

———, and Harry G. Johnson, eds., *The Monetary Approach to the Balance of Payments* (London: Allen and Unwin, 1976).

———, *The Economics of Exchange Rates: Selected Studies* (Reading, Massachusetts: Addison-Wesley, 1978).

Frenkel, Jacob A., and Richard M. Levich, "Covered Interest Arbitrage: Un-

supported Profits?" *Journal of Political Economy*, Vol. 83 (April 1975), pp. 325–38.

———, "Transaction Costs and Interest Arbitrage: Tranquil Versus Turbulent Periods," *Journal of Political Economy*, Vol. 85 (December 1977), pp. 1209–26.

Frenkel, Jacob A., and Michael M. Mussa, "The Efficiency of Foreign Exchange Markets and Measures of Turbulence," *American Economic Review, Papers and Proceedings*, Vol. 70 (May 1980), pp. 374–81.

———, "Asset Markets, Exchange Rates, and the Balance of Payments," in *Handbook of International Economics*, Vol. 2, ed. by Ronald B. Jones and Peter B. Kenen (New York; Amsterdam: North-Holland, 1985).

Frenkel, Jacob A., and Assaf Razin, "Stochastic Prices and Tests of Efficiency of Foreign Exchange Markets," *Economics Letters*, Vol. 6, No. 2 (1980), pp. 165–70.

———, *Fiscal Policies and the World Economy: An Intertemporal Approach* (Cambridge, Massachusetts: MIT Press, 1987).

Friedman, Milton, "The Case for Flexible Exchange Rates," in *Essays in Positive Economics* (Chicago: University of Chicago Press, 1953).

———, and Anna J. Schwartz, *Monetary Trends in the United States and United Kingdom, Their Relation to Income, Prices, and Interest Rates, 1867–1975* (Chicago: University of Chicago Press, 1982).

Froot, Kenneth A., and Takatoshi Ito, "On the Consistency of Short-Run and Long-Run Exchange Rate Expectations," NBER Working Paper No. 2577 (Cambridge, Massachusetts: National Bureau of Economic Research, 1988).

Girton, Lance, and Don Roper, "Theory and Implications of Currency Substitution," *Journal of Money, Credit and Banking*, Vol. 12 (February 1981), pp. 12–30.

Goodhart, Charles A.E., "The Foreign Exchange Market: A Random Walk with a Dragging Anchor," *Economica*, Vol. 55 (November 1988), pp. 437–60.

Gregory, Allan, and Thomas H. McCurdy, "Testing the Unbiasedness Hypothesis in the Forward Foreign Exchange Market: A Specification Analysis," *Journal of International Money and Finance*, Vol. 3 (December 1984), pp. 357-68.

Geweke, John, and Edgar Feige, "Some Joint Tests of the Efficiency of Markets for Forward Foreign Exchange," *Review of Economics and Statistics*, Vol. 61 (April 1979), pp. 334–41.

Haache, Graham, and John Townend, "Exchange Rates and Monetary Policy: Modeling Sterling's Effective Exchange Rate, 1972–80," in *The Money Supply and the Exchange Rate*, ed. by W.A. Eltis and P.J.N. Sinclair (New York: Clarendon Press, 1981).

Hakkio, Craig S., "A Re-Examination of Purchasing Power Parity: A Multi-Country, Multi-Period Study," *Journal of International Economics*, Vol. 17, No. 3 (1984), pp. 265–77.

———, "The Term Structure of the Forward Premium," *Journal of Monetary Economics*, Vol. 8 (July 1981), pp. 41–58.

Hansen, Lars Peter, "Large Sample Properties of Generalized Method of Moments Estimators," *Econometrica*, Vol. 50 (July 1982), pp. 1029–54.

———, and Robert J. Hodrick, "Forward Exchange Rates as Optimal Predictors of Future Spot Rates: An Econometric Analysis," *Journal of Political Economy*, Vol. 88 (October 1980), pp. 829–53.

———, "Risk-Averse Speculation in the Forward Foreign Exchange Market: An Econometric Analysis of Linear Models," in *Exchange Rates and International Macroeconomics*, ed. by Jacob A. Frenkel (Chicago: University of Chicago Press, 1983).

Hausman, Jerry A., "Specification Tests in Econometrics," *Econometrica*, Vol. 46 (November 1978), pp. 1251–71.

Haynes, Stephen E., and Joe A. Stone, "On the Mark: Comment," *American Economic Review*, Vol. 71 (December 1981), pp. 1060-67.

Hendry, David F., Adrian R. Pagan, and Denis Sargan, "A Dynamic Specification," in *Handbook of Econometrics*, Vol. II, ed. by Zvi Griliches and Michael D. Intriligator (New York; Amsterdam: North-Holland, 1984).

Hodrick, Robert J., "An Empirical Analysis of the Monetary Approach to the Determination of the Exchange Rate," in *The Economics of Exchange Rates*, ed. by Jacob A. Frenkel and Harry G. Johnson (Reading, Massachusetts: Addison-Wesley, 1978).

———, *The Empirical Evidence on the Efficiency of Forward and Futures Foreign Exchange Markets* (New York: Harwood Academic Publishers, 1987).

———, and Sanjay Srivastava, "The Covariation of Risk Premiums and Expected Future Spot Exchange Rates," *Journal of International Money and Finance*, Vol. 5, Supplement (March 1986), pp. S5–S22.

Hoffman, Dennis, and Don E. Schlagenhauf, "Rational Expectations and Monetary Models of Exchange Rate Determination: An Empirical Examination," *Journal of Monetary Economics*, Vol. 11 (March 1983), pp. 247-60.

Hooper, Peter, and John Morton, "Fluctuations in the Dollar: A Model of Nominal and Real Exchange Rate Determination," *Journal of International Money and Finance*, Vol. 1 (April 1982), pp. 39–56.

Hsieh, David A., "Tests of Rational Expectations and No Risk Premium in Forward Exchange Markets," *Journal of International Economics*, Vol. 17 (August 1984), pp. 132–84.

Huang, Roger D., "The Monetary Approach to Exchange Rates in an Efficient Foreign Exchange Market: Tests Based on Volatility," *The Journal of Finance*, Vol. 36 (March 1981), pp. 31–41.

Huizinga, John, "An Empirical Investigation of the Long-Run Behavior of Real Exchange Rates," in *Empirical Studies of Velocity, Real Exchange Rates, Unemployment, and Productivity*, ed. by Karl Brunner and Allan H. Meltzer, Carnegie-Rochester Conference Series on Public Policy, Vol. 27 (1987), pp. 149–214.

Husted, Steven, and John Kitchen, "Some Evidence on the International Transmission of U.S. Money Supply Announcement Effects," *Journal of Money, Credit and Banking*, Vol. 17 (November 1985), pp. 456–66.

Isard, Peter, "How Far Can We Push the 'Law of One Price'?" *American Economic Review*, Vol. 67 (September 1977), pp. 942–48.

———, "Expected and Unexpected Changes in Exchange Rates: The Roles of Relative Price Levels, Balance of Payments Factors, Interest Rates, and Risk," International Finance Discussion Papers, No. 156 (Washington: Board of Governors of the Federal Reserve System, 1983).

———, "Exchange Rate Modeling: An Assessment of Alternate Approaches," in *Empirical Macroeconomics for Interdependent Economies*, ed. by Ralph C. Bryant, Dale W. Henderson, Gerald Holtham, Peter Hooper, and Steven A. Symansky (Washington: The Brookings Institution, 1988).

Ito, Takatoshi, "Foreign Exchange Rate Expectations: Micro Survey Data," *American Economic Review*, Vol. 80 (June 1990), pp. 434–39.

Johansen, Søren, "Statistical Analysis of Cointegration Vectors," *Journal of Economic Dynamics and Control*, Vol. 12 (June/September 1988).

Johnson, Harry Gordon, "Towards a General Theory of the Balance of Payments," in *International Trade and Economic Growth*, ed. by Harry Gordon Johnson (London: Allen and Unwin, 1958).

Jones, Ronald W., and Peter B. Kenen, eds., *Handbook of International Economics*, 2 vols. (New York; Amsterdam: North-Holland, 1985).

Kearney, Colm, and Ronald MacDonald, "Asset Markets and the Exchange Rate: A Structural Model of the Sterling-Dollar Exchange Rate, 1972–1982," *Journal of Economic Studies*, Vol. 12, No. 3 (1985), pp. 3–20.

———, "Intervention and Sterilisation Under Floating Exchange Rates: The UK, 1973–1983," *European Economic Review*, Vol. 30 (April 1986), pp. 345–64.

———, "Exchange Rate Volatility, News and Bubbles," *Australian Economic Papers*, Vol. 70 (June 1990), pp. 1–20.

———, "Tests of Efficiency in the Australian Forward Foreign Exchange Market," *Economic Record* (forthcoming).

Kohlhagen, Steven W., *The Behavior of Foreign Exchange Markets—A Critical Survey of the Empirical Literature*, Monograph Series in Finance and Economics, 1978-3 (New York: New York University, Graduate School of Business Administration, 1978).

Kouri, Pentti J.K., "The Exchange Rate and the Balance of Payments in the Short Run and in the Long Run: A Monetary Approach," *Scandinavian Journal of Economics*, Vol. 78, No. 2 (1976), pp. 280–304.

———, and Michael G. Porter, "International Capital Flows and Portfolio Equilibrium," *Journal of Political Economy*, Vol. 82 (May/June 1974), pp. 443–67.

Krasker, William S., "'The Peso Problem' in Testing the Efficiency of Forward Exchange Markets," *Journal of Monetary Economics*, Vol. 6 (April 1980), pp. 269–76.

Kravis, Irving B., and Robert E. Lipsey, "Price Behavior in the Light of Balance of Payment Theories," *Journal of International Economics*, Vol. 8 (May 1978), pp. 193–246.

Krugman, Paul R., "Purchasing Power Parity and Exchange Rates: Another Look at the Evidence," *Journal of International Economics*, Vol. 8 (August 1978), pp. 397–407.

Levich, Richard M., "On the Efficiency of Markets for Foreign Exchange," in *International Economic Policy: of Theory and Evidence*, ed. by Rudiger Dornbusch and Jacob A. Frenkel (Baltimore: Johns Hopkins University Press, 1979).

———, "Empirical Studies of Exchange Rates: Price Behavior, Rate Determination, and Market Efficiency," in *Handbook of International Economics*, Vol. II, ed. by Ronald W. Jones and Peter B. Kenen (New York; Amsterdam: North-Holland, 1985).

Levy, E., and A.R. Nobay, "The Speculative Efficiency Hypothesis: A Bivariate Analysis," *Economic Journal*, Vol. 96, Supplement (March 1986), pp. 109–21.

———, "Using Bivariate Autoregressive Representations in Testing Exact Expectations Relations," *Economics Letters*, Vol. 28, No. 4 (1988), pp. 343–49.

Loopesko, Bonnie E., "Relationships Among Exchange Rates, Intervention, and Interest Rates: An Empirical Investigation," *Journal of International Money and Finance*, Vol. 3 (December 1984), pp. 257–78.

Longworth, David, "Testing the Efficiency of the Canadian-U.S. Exchange Market Under the Assumption of No Risk Premium," *Journal of Finance*, Vol. 36 (March 1981), pp. 43–49.

Lucas, Robert E., "Econometric Policy Evaluation: a Critique," in *The Phillips Curve and Labor Markets*, ed. by Karl Brunner and Allan H. Meltzer, Carnegie-Rochester Conference Series, Vol. 1 (New York; Amsterdam: North-Holland, 1976).

MacDonald, Ronald, "Tests of Efficiency and the Impact of 'News' in Three Foreign Exchange Markets: The Experience of the 1920s," *Bulletin of Economic Research*, Vol. 35 (November 1983), pp. 123–44.

——— (1985a), "Do Deviations of the Real Exchange Rate Follow a Random Walk?" *Economic Notes*, Vol. 14, No. 1, pp. 63–97.

——— (1985b), "Are Deviations from Purchasing Power Parity Efficient? Some Further Answers," *Weltwirtschaftliches Archiv*, Vol. 121, No. 4, pp. 638-45.

———, *Floating Exchange Rates: Theories and Evidence* (London; Boston: Allen and Unwin, 1988).

——— (1990a), "Are Foreign Exchange Market Forecasters 'Rational'? Some Survey-Based Tests," *The Manchester School of Economic and Social Studies*, Vol. 58 (September), pp. 229–41.

——— (1990b), "Exchange Rate Economics: An Empirical Perspective," in *The International Financial Regime*, ed. by Graham Bird (Guilford: Surrey University Press).

———, "Long-Run Purchasing Power Parity: Is It for Real?" *Review of Economics and Statistics* (forthcoming).

——— (1989a), and Mark P. Taylor, "Foreign Exchange Market Efficiency and Cointegration: Some Evidence from the Recent Float," *Economics Letters*, Vol. 29, No. 1, pp. 63–68.

——— (1989b), eds., *Exchange Rates and Open Economy Macroeconomics* (Oxford; New York: Basil Blackwell).

———, "International Parity Conditions," in *Private Behavior and Government Policy in Interdependent Economies*, ed. by Anthony S. Courakis and Mark P. Taylor (Oxford: Oxford University Press, 1990).

——— (1991a), "The Monetary Approach to the Exchange Rate: Long-Run Relationships and Coefficient Restrictions" (unpublished; Washington: International Monetary Fund).

——— (1991b), "Risk, Efficiency and Speculation in the 1920s Foreign Exchange Market: An Overlapping Data Analysis," *Weltwirtschaftliches Archiv*, Vol. 127, No. 3, pp. 500–23.

———, *Exchange Rates, Risk and Efficiency* (Oxford: Basil Blackwell, forthcoming).

MacDonald, Ronald, and Thomas S. Torrance (1988a), "Exchange Rates and the 'News': Some Evidence Using U.K. Survey Data," *The Manchester School of Economic and Social Studies*, Vol. 56 (March), pp. 69–76.

——— (1988b), "On Risk, Rationality and Excessive Speculation in the Deutschemark-US Dollar Exchange Market: Some Evidence Using Survey Data," *Oxford Bulletin of Economics and Statistics*, Vol. 50 (May), pp. 107–23.

———, "Expectations Formation and Risk in Four Foreign Exchange Markets," *Oxford Economic Papers*, Vol. 42 (July 1990), pp. 544–61.

MacDonald, Ronald, and Robert Young, "Decisions, Rules, Expectations and Efficiency in Two Foreign Exchange Models," *De Economist*, Vol. 134, No. 1 (1986), pp. 42–60.

Mankiw, N. Gregory, and Lawrence H. Summers, "Do Long-Term Interest Rates Overreact to Short-Term Interest Rates?" *Brookings Papers on Economic Activity: 1* (Washington: The Brookings Institution, 1984), pp. 223-47.

Marston, Richard C., "Interest Arbitrage in the Euro-Currency Markets," *European Economic Review*, Vol. 7 (January 1976), pp. 1–13.

Masson, Paul R., "Dynamic Stability of Portfolio Balance Models of the Exchange Rate," *Journal of International Economics*, Vol. 11 (November 1981), pp. 467–77.

———, "Strategies for Modeling Exchange Rates and Capital Flows in Multi-country Models," *Journal of Policy Modeling*, Vol. 10 (Summer 1988), pp. 209–28.

———, and Malcolm Knight, "International Transmission of Fiscal Policies in Major Industrial Countries," *Staff Papers*, International Monetary Fund, Vol. 33 (September 1986), pp. 387–438.

———, "Economic Interactions and the Fiscal Policies of Major Industrial Countries: 1980–1988," in *Private Behavior and Government Policy in Interdependent Economies*, ed. by Anthony S. Courakis and Mark P. Taylor (Oxford: Oxford University Press, 1990).

McCormick, Frank, "Covered Interest Arbitrage: Unexpected Profits? Comment," *Journal of Political Economy*, Vol. 87 (April 1979), pp. 411–17.

McCulloch, J. Huston, "Operational Aspects of the Siegel Paradox," *Quarterly Journal of Economics*, Vol. 89 (February 1975), pp. 170–72.

McKinnon, Ronald T., "Portfolio Balance and International Payments Adjustment," in *Monetary Problems of the International Economy*, ed. by Alexander K. Swoboda and Robert A. Mundell (Chicago: University of Chicago Press, 1969).

———, "Floating Foreign Exchange Rates 1973–1975: The Emperor's New Clothes," in *Institutional Arrangements and the Inflation Problem*, ed. by Karl Brunner and Allan H. Meltzer, Carnegie-Rochester Series on Public Policy, Vol. 3 (1976), pp. 79–114.

———, and Wallace E. Oates, *The Implications of International Economic Integration for Monetary, Fiscal, and Exchange-Rate Policy*, Princeton Studies in International Finance, No. 16 (Princeton, New Jersey: Princeton University Press, 1966).

Meade, James E. (1951a), *The Balance of Payments*, Vol. 1 in *The Theory of International Economic Policy* (London; New York: Oxford University Press; reprinted 1965).

——— (1951b), *The Balance of Payments* (supplement), Vol. 1 in *The Theory of International Economic Policy* (London; New York: Oxford University Press; reprinted 1965).

Meese, Richard A., "Testing for Bubbles in Exchange Markets: A Case of Sparkling Rates?" *Journal of Political Economy*, Vol. 94 (April 1986), pp. 345–73.

———, and Kenneth Rogoff, "Empirical Exchange Rate Models of the Seventies: Do They Fit Out of Sample?" *Journal of International Economics*, Vol. 14 (February 1983), pp. 3–24.

———, "The Out-of-Sample Failure of Empirical Exchange Rate Models: Sampling Error or Misspecification?" in *Exchange Rates and International Macroeconomics*, ed. by Jacob A. Frenkel (Chicago: University of Chicago Press, 1984).

Meese, Richard A., and Kenneth J. Singleton, "On Unit Roots and the Empirical Modeling of Exchange Rates," *Journal of Finance*, Vol. 37 (September 1982), pp. 1029–35.

Mishkin, Frederic S. (1984a), "The Real Interest Rate: A Multi-Country Empirical Study," *Canadian Journal of Economics*, Vol. 17 (May), pp. 283–311.

——— (1984b), "Are Real Interest Rates Equal Across Countries? An Empirical Investigation of International Parity Conditions," *Journal of Finance*, Vol. 39 (December), pp. 1345–57.

Mundell, Robert A., "Flexible Exchange Rates and Employment Policy," *Canadian Journal of Economics and Political Science*, Vol. 27 (November 1961), pp. 509–17.

———, "The Appropriate Use of Monetary and Fiscal Policy for Internal and External Stability," *Staff Papers*, International Monetary Fund, Vol. 9 (March 1962), pp. 70–79.

———, "Capital Mobility and Stabilization Policy Under Fixed and Flexible Exchange Rates," *Canadian Journal of Economics and Political Science*, Vol. 29 (November 1963), pp. 475–85.

———, *International Economics* (New York: MacMillan, 1968).

Mussa, Michael L., "The Exchange Rate, the Balance of Payments, and Mone-

tary and Fiscal Policy Under a Regime of Controlled Floating," *Scandinavian Journal of Economics*, Vol. 78, No. 2 (1976), pp. 229–48.

———, "Empirical Regularities in the Behavior of Exchange Rates and Theories of the Foreign Exchange Market," in *Policies for Employment, Prices, and Exchange Rates*, ed. by Karl Brunner and Allan H. Meltzer, Carnegie-Rochester Conference Series on Public Policy, Vol. 11 (New York; Amsterdam: North-Holland, 1979).

———, "The Role of Intervention," Occasional Paper No. 6 (New York: Group of Thirty, 1981).

———, "The Theory of Exchange Rate Determination," in *Exchange Rate Theory and Practice*, ed. by John F.O. Bilson and Richard C. Marston (Chicago: University of Chicago Press, 1984).

Nurkse, Ragnar, *International Currency Experience: Lessons of the Interwar Period* (Geneva: League of Nations, 1945).

Oates, Wallace E., "Budget Balance and Equilibrium Income: A Comment on the Efficacy of Fiscal and Monetary Policy in an Open Economy," *Journal of Finance*, Vol. 21 (September 1966), pp. 489–98.

Obstfeld, Maurice, and Alan C. Stockman, "Exchange Rate Dynamics," in *Handbook of International Economics*, Vol. 2, ed. by Ronald W. Jones and Peter B. Kenen (Amsterdam; New York: North-Holland, 1985).

Officer, Lawrence H., "The Purchasing Power Parity Theory of Exchange Rates: A Review Article," *Staff Papers*, International Monetary Fund, Vol. 23 (March 1976), pp. 1–60.

Ott, David J., and Attiat F. Ott, "Budget Balance and Equilibrium Income," *Journal of Finance*, Vol. 20 (March 1965), pp. 71–77.

Papell, David H., "Expectations and Exchange Rate Dynamics After a Decade of Floating," *Journal of International Economics*, Vol. 25 (November 1988), pp. 303-17.

Pentecost, Eric J., "The Out-of-Sample Forecasting Performance of Exchange Rate Models: An Appraisal of the Recent Evidence" (unpublished; Loughborough: University of Loughborough, 1988).

Pigott, Charles, and Richard J. Sweeney, "Testing the Exchange Rate Implications of Two Popular Monetary Models," in *Exchange Rates, Trade, and the U.S. Economy*, ed. by Sven W. Arndt, Richard J. Sweeney, and Thomas D. Willett (New York: Ballinger, 1985).

Poole, Walter, "Speculative Prices as Random Walks: An Analysis of Ten Time Series of Flexible Exchange Rates," *Southern Economic Journal*, Vol. 33 (April 1967), pp. 468–78.

Polak, J.J., "Monetary Analysis of Income Formation and Payments Problems," *Staff Papers*, International Monetary Fund, Vol. 6 (November 1957), pp. 1–50.

Putnam, B.H., and J.R. Woodbury, "Exchange Rate Stability and Monetary Policy," *Review of Business and Economic Research*, Vol. 15, No. 2 (1979), pp. 1–10.

Rasulo, James A., and D. Sykes Wilford, "Estimating Monetary Models of the Balance of Payments and Exchange Rates: A Bias," *Southern Economic Journal*, Vol. 47 (July 1980), pp. 136-46.

Rogoff, Kenneth, "On the Effects of Sterilized Intervention: An Analysis of Weekly Data," *Journal of Monetary Economics*, Vol. 14 (September 1984), pp. 133–50.

Roll, R., "Violations of Purchasing Power Parity and Their Implications for Efficient International Commodity Markets," in *International Finance and Trade*, ed. by Marshall Sarnat and Giorgio P. Szego (Cambridge, Massachusetts: Ballinger, 1979).

Rose, Andrew K., and Jack G. Selody, "Exchange Market Efficiency: A Semi-Strong Test Using Multiple Markets and Daily Data," *Review of Economics and Statistics*, Vol. 66 (November 1984), pp. 669-72.

Salemi, Michael K., "Comment on Meese and Rogoff," in *Exchange Rates and International Macroeconomics*, ed. by Jacob A. Frenkel (Chicago: University of Chicago Press, 1984).

Samuelson, P.A., "Proofthat Properly Anticipated Prices Fluctuate Randomly," *Industrial Management Review*, Vol. 6 (Spring 1965), pp. 41-49.

Schinasi, Gary, and P.A.V.B. Swamy, "The Out-of-Sample Forecasting Performance of Exchange Rate Models when Coefficients Are Allowed to Change," *Journal of International Money and Finance*, Vol. 8 (September 1989), pp. 375–90.

Shiller, Robert J., "The Volatility of Long-Term Interest Rates and Expectations Models of the Term Structure," *Journal of Political Economy*, Vol. 87 (December 1979), pp. 1190–1219.

Siegel, Jeremy, "Risk, Interest Rates, and the Forward Exchange," *Quarterly Journal of Economics*, Vol. 86 (May 1972), pp. 303–312.

Smith, P., and M. Wickens, "A Stylised Econometric Model of an Open Economy: U.K. 1973–1981" (unpublished; Southampton: University of Southampton, 1988).

———, "Assessing Monetary Shocks and Exchange Rate Variability with a Stylized Econometric Model of the U.K.," in *Private Behavior and Government Policy in Interdependent Economies*, ed. by A.S. Courakis and Mark P. Taylor (Oxford: Oxford University Press, 1990).

Somanath, V.S., "Efficient Exchange Rate Forecasts: Lagged Models Better than the Random Walk," *Journal of International Money and Finance*, Vol. 5 (June 1986), pp. 195–220.

Takagi, Shinji, "Exchange Rate Expectations: A Survey of Survey Studies," *Staff Papers*, International Monetary Fund, Vol. 38 (March 1991), pp. 156–83.

Taylor, Mark P. (1987a), "Risk Premia and Foreign Exchange: A Multiple Time Series Approach to Testing Uncovered Interest Parity," *Weltwirtschaftliches Archiv*, Vol. 123, No. 4, pp. 579–91.

——— (1987b), "Covered Interest Parity: A High-Frequency, High-Quality Data Study," *Economica*, Vol. 54 (November), pp. 429–38.

——— (1988a), "What Do Investment Managers Know? An Empirical Study of Practitioners' Predictions," *Economica*, Vol. 55 (May), pp. 185–202.

——— (1988b), "A DYMIMIC Model of Forward Foreign Exchange Risk, with Estimates for Three Major Exchange Rates," *The Manchester School of Economic and Social Studies*, Vol. 56 (March), pp. 55–68.

——— (1988c), "An Empirical Examination of Long-Run Purchasing Power Parity Using Cointegration Techniques," *Applied Economics*, Vol. 20 (October), pp. 1369–81.

——— (1989a), "Expectations, Risk and Uncertainty in the Foreign Exchange Market: Some Results Based on Survey Data," *The Manchester School of Economic and Social Studies*, Vol. 57 (June), pp. 142–53.

——— (1989b), "Covered Interest Arbitrage and Market Turbulence," *Economic Journal*, Vol. 99 (June), pp. 376-91.

———,*The Balance of Payments: New Perspectives on Open Economy Macroeconomics* (Aldershot, Hants.: Edward Elgar, 1990).

——— (1991a), "The Hyperinflation Model of Money Demand Revisited," *Journal of Money, Credit and Banking*, Vol. 23 (August, part 1), pp. 327–51.

——— (1991b), "The Dollar-Sterling Exchange Rate During the 1920s: Long-Run PPP and the Norman Conquest of $4.86" (unpublished; Washington: International Monetary Fund).

———, and Patrick C. McMahon, "Long-Run Purchasing Power Parity in the 1920s," *European Economic Review*, Vol. 32 (January 1988), pp. 179–97.

Taylor, Mark P., and Helen L. Allen, "The Use of Technical Analysis in the Foreign Exchange Market," *Journal of International Money and Finance* (forthcoming, April 1992).

Taylor, Mark P., and Patricia Fraser, "Some 'News' on Covered Interest Arbitrage," in *Money and Financial Markets*, ed. by Mark P. Taylor (Cambridge, Massachusetts: Basil Blackwell, 1991).

Tobin, James, "The Theory of Portfolio Selection," in *The Theory of Interest Rates*, Proceedings of a Conference Held by the International Economic Association, ed. by F.H. Hahn and F.P.R. Brechling (London: Macmillan, 1965).

———, "A General Equilibrium Approach to Monetary Theory," *Journal of Money, Credit and Banking*, Vol. 1 (February 1969), pp. 15–29.

Wadhwani, Sushil B., "Are Exchange Rates 'Excessively' Volatile?" Centre for Labour Economics Discussion Paper No. 198 (London: London School of Economics and Political Science, July 1984).

Wallace, Miles S., "The Monetary Approach to Flexible Exchange Rates in the Short Run: An Empirical Test," *Review of Business and Economic Research*, Vol. 15 (Spring 1979), pp. 98–102.

West, Kenneth D., "A Specification Test for Speculative Bubbles," NBER Working Paper No. 2067 (Cambridge, Massachusetts: National Bureau of Economic Research, November 1986).

Willett, Thomas D., and Francesco Forte, "Interest Rate Policy and External Balance," *Quarterly Journal of Economics*, Vol. 83 (May 1969), pp. 242-62.

Wolff, Christian P., "Forward Foreign Exchange Rates, Expected Spot Rates, and Premia: A Signal-Extraction Approach," *Journal of Finance*, Vol. 42 (June 1987), pp. 395–406.

Woo, Wing T., "The Monetary Approach to Exchange Rate Determination Under Rational Expectations," *Journal of International Economics*, Vol. 18 (February 1985), pp. 1–16.

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Real Exchange Rate Targeting Under Capital Controls

Can Money Provide a Nominal Anchor?

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The issue of whether the money supply can serve as a nominal anchor for the domestic price level under real exchange rate targeting is examined. When capital controls are perfect, so that there is complete separation between official and unofficial foreign exchange markets, the domestic inflation rate can be stabilized, but only at the expense of a widening gap between official and parallel market exchange rates. When cross-transactions between the two markets are permitted, the domestic inflation rate cannot be stabilized either in the short run or the long run. [JEL E52, E61, F31, F41]

ACTIVE EXCHANGE rate management has become increasingly prevalent among developing countries in recent years. With a view toward preserving competitiveness, these countries have frequently adopted rules under which the nominal exchange rate is depreciated continuously to offset differences between domestic and foreign inflation rates. Because such rules, which effectively target the real exchange rate, establish a feedback from domestic inflation to the nominal exchange rate, countries adopting them sacrifice the role of the exchange rate as

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the nominal anchor for the price level. Since price level stability remains an important macroeconomic goal in such countries, the question naturally arises as to whether the role of nominal anchor can instead be provided by a policy-controlled financial aggregate, such as the money supply.

In an earlier paper (Montiel and Ostry (1991)), we investigated the effects of real shocks on price level stability under real exchange rate targeting.[1] We found that the stock of domestic credit could not replace the exchange rate in the role of nominal anchor under such a regime. While the money supply may represent a more obvious candidate for this role, our previous paper incorporated the assumption of perfect capital mobility, which prevented the authorities from treating the money supply as a policy variable. To examine the implications of money supply targeting under a real exchange rate rule, we now consider the case in which capital controls are imposed, thereby making sterilization feasible, and ask whether fixing the money supply can stabilize the price level in response to shocks. The analysis leads naturally to a consideration of the case in which the effectiveness of capital controls is less than perfect, and we examine the implications of money supply targeting in this case as well. We find that using money as a nominal anchor is problematic in both cases.

The paper is organized as follows: the next section presents an abbreviated description of our previous model, modified for the presence of effective capital controls, and demonstrates the inflationary consequences of a real—specifically, a terms of trade—shock in the absence of money supply targeting. The money supply is then fixed through a policy of active sterilization in Section II, and the macroeconomic implications of the terms of trade shock are reexamined under these circumstances. Section III considers how the analysis is affected when capital controls are imperfect. Our findings regarding the role of money as a nominal anchor are summarized in a brief concluding section.

I. The Basic Model Under Capital Controls and No Leakages

We consider a small open economy in which competitive firms combine labor (available in fixed supply) and a sector-specific factor to produce home goods and exportables, using a standard concave technology. All prices are flexible, ensuring that full employment is continuously maintained.

[1] Other papers dealing with the issue of real exchange rate targeting include Dornbusch (1982), Adams and Gros (1986), and Lizondo (1991).

The income generated from production of the two goods is received by consumers who use it to buy home goods and importables. Consumers have Cobb-Douglas utility, which implies that they allocate a constant fraction of their total expenditures to each of the two goods in every time period. The real value of aggregate consumption expenditures is assumed to depend upon the real value of factor income net of taxes, the real interest rate, and real financial wealth. Real factor income, which we denote by y, is the value of output of exportables and home goods, deflated by the consumer price index. As shown in Khan and Montiel (1987), under the assumption that the external trade surplus is zero in the initial steady-state equilibrium, real factor income depends only on the terms of trade (the price of exports relative to imports), denoted by ρ, with $y'(\rho) > 0$.

Real household financial wealth consists of real money balances ($m = M/P$), plus the real value of foreign securities (vF_p/P), less the real value of loans extended to households by the banking system ($d_p = D_p/P$), where P is the domestic price level. To permit it to control the domestic money supply, the central bank in this economy refrains from engaging in foreign exchange transactions for financial purposes. We assume that, as a result of this policy, a parallel foreign exchange market emerges in which private individuals trade foreign exchange at the market-determined exchange rate, v. The central bank continues to operate an official exchange market, however, for all commercial transactions. Since trade in the official market is limited to commercial transactions, interest earnings on foreign securities are converted into domestic currency at the parallel market exchange rate.

To simplify the analysis, it is assumed that the foreign inflation rate is equal to the nominal interest rate on foreign securities and, therefore, that the foreign real interest rate is zero. This implies that inflows into the parallel market (in the form of interest earnings on the stock of foreign securities) are just sufficient to offset the rate at which the real value of the stock of foreign securities is eroded by foreign inflation, and therefore, that the real stock of foreign securities (in terms of traded goods), denoted f_p, is constant when capital controls are perfect.

For the composition of the household portfolio, we assume that uncovered interest rate parity holds continuously:

$$i = i^* + \hat{v}, \tag{1}$$

where i is the domestic cost of borrowing, and i^* is the return on foreign securities. The demand for money depends on the nominal interest rate and on real income:

$$m = L[i^* + \hat{v}; y(\rho)]; \quad L_1 < 0, \quad L_2 > 0, \tag{2}$$

where subscripts denote partial derivatives with respect to the corresponding arguments. For the purposes of this section, we shall assume that monetary policy takes the form of holding the real stock of credit to the private sector (d_p) constant.

Under real exchange rate targeting, the authorities continuously adjust the commercial exchange rate, denoted by s, in order to keep the real exchange rate (the relative price of importables to home goods) constant at a base period level. Therefore, the rate of devaluation of the commercial exchange rate is adjusted according to the difference between the rate of inflation of home goods and the foreign currency rate of inflation of importables, which we denote as π^*.[2] Because the domestic price index is a weighted average of the domestic price of importables and home goods, under this rule the domestic rate of inflation, denoted by π, will be equal to the rate of inflation of home goods. Thus, the real exchange rate targeting rule can be expressed as

$$\hat{s} = \pi - \pi^*. \tag{3}$$

We assume that the real exchange rate rule is implemented from an initial steady state characterized by a fixed nominal exchange rate (that is, $\hat{s} = 0$) with no capital restrictions. The resulting equilibrium real exchange rate (see Khan and Montiel (1987)) represents the base period value for the application of the real exchange rate rule. From equation (3), therefore, domestic inflation will be equal to π^* in the initial equilibrium. The description of the financial sector is completed by using the Fisher equations, $r = i - \pi$ and $r^* = i^* - \pi^*$, together with equations (1) and (3), to write the following expression for the domestic real interest rate:

$$r = i^* - \pi^* + \hat{b} = \hat{b}, \tag{4}$$

where $b = v/s$ represents (1 plus) the premium between the financial and commercial exchange rates, $\hat{b}$ is the proportional change of b, and we have used the previous assumption that $r^* = 0$.

An equilibrium for this economy requires, first, that the supply of nontraded goods, denoted y_n, equal the sum of the demand for such goods from the private and public sectors, $c_n + g_n$ (internal balance). Denoting by θ the share of total private expenditure devoted to home goods, the internal balance condition may be written as

$$y_n(\rho) = \theta c[y(\rho) - t, \hat{b}, m + bf_p - d_p] + g_n, \tag{5}$$

[2] In the absence of terms of trade shocks, π^* is the foreign currency rate of inflation of traded goods, which will be referred to in what follows simply as the foreign inflation rate.

where t represents the real value of taxes and where units are chosen so that the value of the real exchange rate is unity in the base period.[3] In equation (5), p and f_p are exogenous variables, while g_n, t, and d_p are policy determined. The real money supply, m, however, is an endogenous variable. Its behavior over time can be derived from the household budget constraint.[4] This yields the following expression for the accumulation of real money balances:

$$\dot{m} = y(\rho) - t - c[y(\rho) - t, r^* + \hat{b}, m + bf_p - d_p] + r^*(bf_p - d_p) - \hat{b}d_p - \pi m - b\dot{f}_p + \dot{d}_p. \tag{6}$$

Since $\dot{f}_p = 0$ when $r^* = 0$, and since monetary policy holds $\dot{d}_p = 0$ in this section, we can rewrite equation (6) more simply as

$$\dot{m} = y(\rho) - t - c[y(\rho) - t, \hat{b}, m + bf_p - d_p] - \hat{b}d_p - \pi m. \tag{7}$$

Using equation (3) and the definition of $\hat{b}$, the money market equilibrium condition (2) can be expressed as

$$m = L[\hat{b} + \pi, y(\rho)]. \tag{8}$$

Solving this expression for the domestic inflation rate, π, yields

$$\pi = \pi(\hat{b}, m; \rho), \quad \pi_1 = -1 < 0; \quad \pi_2 = 1/L_1 < 0; \quad \pi_3 = -L_2 y'/L_1 > 0. \tag{9}$$

Finally, equation (9) can be substituted into equation (7), permitting us to express the model as a system of two differential equations in b and m. It can readily be shown, however, that the equilibrium defined by $\dot{m} = \hat{b} = 0$ is unstable (that is, both roots of the system are positive). Since m and b are both "jumping" variables, therefore, the system will move instantaneously to the steady-state position, $\dot{m} = \hat{b} = 0$, which represents the unique perfect foresight solution.[5]

[3] We have suppressed the real exchange rate as an argument from the supply of nontradables function, since, under the real exchange rate rule, this relative price does not change.

[4] The private sector budget constraint assumes that inflation tax revenues that accrue in the first instance to the central bank are not handed back to the private sector. This assumption was necessary to ensure the existence of a unique steady state in our previous paper (Montiel and Ostry (1991)), and is also necessary under the assumption of imperfect capital mobility. A related point is made by Woodford (1988) in his discussion of the macroeconomic effects of pegging the interest rate.

[5] The instability of the system defined by $\dot{m} = \hat{b} = 0$ requires that the interest elasticity of money demand be less than unity in absolute value. This assumption was also required in signing results in our previous paper (Montiel and Ostry (1991)) and is maintained throughout the present paper.

Imposing the conditions $\dot{m} = \hat{b} = 0$ in equations (5), (7), and (9) yields a system of three equations in m, b, and π, which can be used to determine the effects of real shocks on the equilibrium values of these variables. Since our primary interest in this section is in the inflation rate, it is convenient to rewrite the system as a two-equation system in π and b, which can be analyzed graphically. To do so, note from equation (3) that $\hat{v} = \pi - \pi^*$ when $\hat{b} = 0$ (since $\hat{b} = \hat{v} - \hat{s}$). We can therefore rewrite the money market clearing condition (2) as

$$m = L[\pi, y(\rho)]. \tag{10}$$

Substituting this equation into equations (5) and (7) (with $\hat{b} = \dot{m} = 0$) yields the following two-equation system in π and b:

$$y_n(\rho) = \theta c\{y(\rho) - t, 0, L[\pi, y(\rho)] + bf_p - d_p\} + g_n \tag{11}$$

$$0 = y(\rho) - t - c\{y(\rho) - t, 0, L[\pi, y(\rho)] + bf_p - d_p\} - \pi L[\pi, y(\rho)]. \tag{12}$$

The combinations of b and π that satisfy equations (11) and (12) are portrayed in Figure 1. The schedule labeled NN is the locus of combinations of b and π that clear the market for home goods (equation (11)). The slope of the NN schedule is

$$d\pi/db|_{NN} = -f_p/L_1 > 0, \tag{13}$$

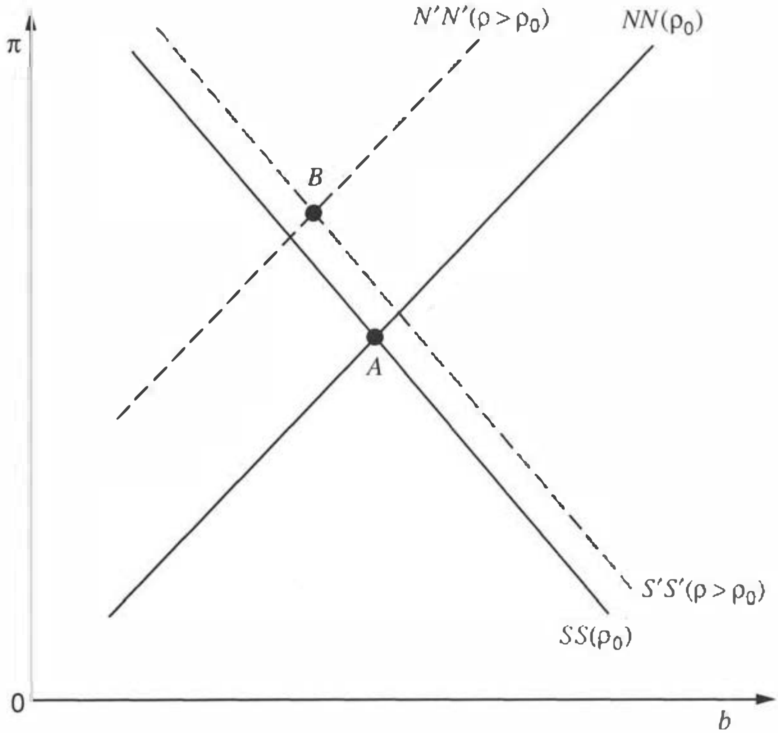
where a subscripted number denotes a partial derivative, so that L_1 is the partial derivative of money demand with respect to its first argument (namely, the interest rate), which is negative. The intuition underlying equation (13) is that a rise in b raises the real value of the private sector's financial wealth and creates an incipient excess demand for home goods. To restore market clearing, a rise in the inflation rate, which reduces real wealth by lowering real money balances, is required.

The schedule labeled SS is the locus of combinations of b and π that maintain the rate of growth of real money balances equal to zero (equation (12)). Its slope is given by

$$d\pi/db|_{SS} = -c_3 f_p/[m(1 - \epsilon) + c_3 L_1], \tag{14}$$

where ϵ is the absolute value of the interest elasticity of money demand, which is taken to be less than unity in the initial steady state. The numerator of equation (14) is negative, since a rise in b raises wealth, increasing consumption expenditures ($c_3 > 0$) and reducing monetary accumulation. The denominator, however, may be positive or negative, since the first term, $m(1 - \epsilon)$, is positive but the second term, $c_3 L_1$, is negative. The sign of the denominator is ambiguous because an increase

Figure 1. *Macroeconomic Equilibrium Under Capital Controls*



Note: ρ_0 is the initial terms of trade defined as the price of exports relative to imports.

in inflation has an ambiguous effect on the accumulation of real money balances, $\dot{m}$. On the one hand, an increase in π raises the inflation tax on the assumption that $\epsilon < 1$, thereby reducing $\dot{m}$; on the other hand, higher inflation reduces real balances, and hence wealth, which causes consumption to decline and saving and $\dot{m}$ to rise. For sufficiently inelastic money demand, however, the effect of inflation on consumption will be dominated by the effect on the inflation tax. This is the assumption underlying the negative slope of the *SS* schedule in Figure 1.[6]

Consider now the effect of an improvement in the terms of trade—that is, a rise in ρ. An improvement in the terms of trade raises the value

[6] Our comparative statics results with respect to inflation do not, however, depend on the assumption that the *SS* schedule is negatively sloped. If the slope of *SS* is positive, then the result requires only that *SS* be steeper than *NN*, which is assured by previous assumptions.

of the marginal product of labor in the exportables sector and causes employment to shift from home goods production to export production.[7] In addition, the rise in ρ raises real income and, hence, the demand for home goods. For both reasons, an incipient excess demand for nontradables develops, the elimination of which requires a reduction in real wealth and, hence, in private spending on all goods, including nontradables. This is brought about by the adverse real balance effect of a rise in inflation. Thus, the *NN* schedule in Figure 1 shifts vertically upwards to *N'N'*, with the magnitude of the displacement given by

$$d\pi/d\rho|_{NN} = [y_n' - \theta y'(c_1 + c_3 L_2)]/(\theta c_3 L_1) > 0. \tag{15}$$

Turning to the *SS* schedule, a rise in ρ raises real factor income, y, which by itself would tend to raise the rate of money accumulation. However, it also raises real consumption spending, both directly through the marginal propensity to consume, and indirectly by increasing real wealth (through a positive real balance effect). In addition, the positive effect of an improvement in the terms of trade on money demand increases the inflation tax, πL, thereby reducing $\dot{m}$. Figure 1 is drawn on the assumption that the marginal saving propensity, $[1 - c_1 - (c_3 + \pi^*)L_2]$, is positive—that is, the increase in real income associated with the improvement in the terms of trade raises income net of the inflation tax by more than it raises consumption.[8] In this case, the *SS* schedule shifts up to a position such as *S'S'* in Figure 1, by a magnitude that is given by

$$d\pi/d\rho|_{SS} = y'[1 - c_1 - (c_3 + \pi^*)L_2]/[m(1 - \epsilon) + c_3 L_1] > 0. \tag{16}$$

As can be seen, the shifts in both curves contribute to a rise in the inflation rate, although they have opposite effects on the parallel market premium. Solving for the effects of the terms of trade shock on inflation gives

$$d\pi/d\rho = [-y_n' c_3 f_p + \theta y' c_1 c_3 f_p(1 - \pi^* L_2)]/[m(1 - \epsilon)f_p \theta c_3]. \tag{17}$$

The denominator of this expression is positive under our maintained assumption that $\epsilon < 1$. A sufficient condition for the numerator to be positive is that $\pi^* L_2 < 1$—that is, that the increase in real income net of inflation tax associated with the improvement in the terms of trade is positive, a condition that is likely to be satisfied in practice.[9] We conclude

[7] The fact that $y_n' < 0$ can be rigorously shown by substituting into the output supply function the equilibrium real wage as a function of the terms of trade. See Khan and Montiel (1987).

[8] Again, our comparative statics results do not depend on this assumption.

[9] Notice that this condition is equivalent to the requirement that the product of the share of seigniorage in real income and the income elasticity of money demand be less than unity, something that would be easily satisfied for any plausible values of the parameters.

that an improvement in the terms of trade raises the steady-state inflation rate under real exchange rate targeting and no capital mobility.[10] This is shown by the movement from point A to point B in Figure 1. The premium, b, will certainly decline for sufficiently inelastic money demand, but may increase otherwise.

II. Can a Money Supply Rule Stabilize Prices?

Suppose now that the authorities, anticipating the inflationary effects of a shock under real exchange rate targeting, attempt to stabilize the inflation rate (that is, set $\pi = \pi^*$) by pursuing a monetary target. Under this regime, the nominal money supply continues to grow at the world rate of inflation, π^*. This rule therefore implies

$$\dot{m} = (\pi^* - \pi)m. \tag{18}$$

Of course, holding the nominal money supply on this path requires abandoning the assumption that the real stock of credit, d_p, is constant, since credit policy must now be geared to sterilizing the effects of the balance of payments on the money supply. Returning to the system consisting of equations (5), (6), and (9), the new monetary policy regime implies replacing $\dot{m}$ by $(\pi^* - \pi)m$ in equation (6), with $\dot{d}_p$ now an endogenous variable. Thus, equation (7) is replaced by

$$\dot{d}_p = \pi^* m - \{y(\rho) - t - c[y(\rho) - t, \hat{b}, m + bf_p - d_p]\} + \hat{b}d_p. \tag{19}$$

The new system consists of equations (5), (19), (9), and (18). To solve this system, it is convenient to define a variable, $w = bf_p - d_p$, which represents households' nonmonetary financial wealth. Since $\dot{w} = \dot{b}f_p - \dot{d}_p$, we can now rewrite (19) as

$$\dot{w} = y(\rho) - t - c[y(\rho) - t, \hat{b}, m + w] + \hat{b}w - \pi^* m. \tag{20}$$

Next, the equilibrium condition for the nontraded goods market (equation (5)) can be solved for $\hat{b}$, yielding

$$\hat{b} = b(m + w, \rho), \quad b_1 = -c_3/c_2 > 0,$$
$$b_2 = (y_n' - \theta c_1 y')/(\theta c_2) > 0. \tag{21}$$

Substituting this expression into equations (9) and (20), and the resulting version of (9) into (18), produces a two-equation system in m and w given by

[10] By contrast, under a fixed exchange rate regime, this shock would lead to a real exchange rate appreciation in the model, with no change in the steady-state rate of inflation (see Khan and Montiel (1987)).

$$\dot{m} = \{\pi^* - \pi[b(m + w, \rho), m, \rho]\}m \tag{22}$$

$$\dot{w} = y(\rho) - t - c[y(\rho) - t, b(m + w, \rho), m + w] - \pi^* m + b(m + w, \rho)w. \tag{23}$$

It can be readily shown that the roots of this system are positive. Since m and w are both jumping variables, this implies that the unique perfect foresight path is given by the solution of (22) and (23), with $\dot{m} = \dot{w} = 0$.

The immediate implication of this result is that the money supply targeting rule considered in this section stabilizes the domestic inflation rate at the world rate, π^*, even in the face of a terms of trade shock. This follows from equation (22), with $\dot{m} = 0$, since $\pi = \pi^*$, regardless of the value of ρ. Thus, when capital controls are perfect, a money supply rule can indeed stabilize the domestic inflation rate under a real exchange rate target. Notice, however, that equations (22) and (23) also imply that in response to a change in ρ, m and w will, in general, undergo discrete changes. Since the *rate of growth* of the nominal money supply is fixed by the rule (19), a discrete change in m can come about either through a jump in the domestic price level or through a once-for-all change in the stock of credit, d_p, to accommodate the impact of the terms of trade shock on the real demand for money. Thus, a jump in the price level can also be avoided under this rule if credit policy is accommodative.

To determine which way the stock of credit will have to move in order to stabilize the domestic price level on impact, equations (22) and (23), with $\dot{m} = \dot{w} = 0$, can be solved for the effects of the terms of trade improvement on the equilibrium values of m and w. In our case, it proves convenient to solve for m and $m + w$ instead. The result is

$$dm/d\rho = -mc_3[y'(1 - wL_2/L_1) - y_n'/\theta]/(c_2\Delta) > 0 \tag{24a}$$

$$d(m + w)/d\rho = -m[y'(1 - L_2\pi^*) - y_n'/\theta + (w - L_1\pi^*)(y_n' - \theta c_1 y')/(\theta c_2)]/(\Delta L_1) < 0, \tag{24b}$$

where $\Delta = -mc_3(\pi^* - w/L_1)/c_2 > 0$ is the determinant of the system (equations (22) and (23)). Thus, the favorable terms of trade shock results in an *increase* in the real demand for money, the accommodation of which requires a once-for-all expansion of credit to prevent a discrete fall in the domestic price level. At the same time, the free exchange rate must undergo a discrete appreciation. This follows from the result in equation (24b) that real wealth falls. Since $m + w = m + bf_p - d_p$, and since credit-financed changes in m leave $m - d_p$ unchanged, the exogeneity of f_p under perfect capital controls implies that $m + w$ can fall only through a reduction in the premium, b.

In addition to the finding that monetary targeting can indeed stabilize the domestic inflation rate, the second key result of this section is that

this initial change in the premium is not the end of the story. In fact, the premium will continue to change over time, even while m and w remain at their stationary values. To see this, notice from equation (20) that the increase in p and decline in $m + w$ will tend to move the rate of increase in the premium—which effectively represents movements in the domestic real interest rate—in opposite directions. The favorable terms of trade shock tends to induce an excess demand for nontraded goods, requiring an increase in the domestic real interest rate (that is, in $\hat{b}$) to restore equilibrium in that market, while the reduction in household wealth, $m + w$, induces an excess supply of nontraded goods, requiring a fall in $\hat{b}$ to restore equilibrium. The net effect can be derived by using equation (24b) in equation (21), which yields

$$d\hat{b}/d\text{p} = [y'(1 - L_2\pi^*) - y_n'/\theta]/(L_1\pi^* - w) < 0. \tag{25}$$

Thus, the exchange rate (or equivalently, the premium) in the parallel market undergoes a discrete initial drop and then appreciates continuously at a constant rate. The permanent rate of appreciation represents a reduction in the domestic real interest rate required to maintain equilibrium in the market for nontraded goods in the face of the reduction in the demand for such goods caused by the decline in real household wealth.

Under real exchange rate targeting, then, the only way that a permanent wedge between the domestic and foreign real interest rates can emerge is with an ever-widening gap between the commercial and financial exchange rates (that is, $\hat{b} \neq 0$).[11] While this may be sustainable in the short run, it is unlikely to be so in the long run, when an ever-widening gap between the two exchange rates would create unbounded incentives to engage in cross transactions between official and unofficial markets. We now examine whether monetary targeting can effectively stabilize the price level when capital controls are less than perfect.

III. The Model with Leakages

The results of the previous section suggest that our model should explicitly incorporate the effects of incentives to engage in cross transactions that arise when a substantial gap begins to emerge between the

[11] In this case, $\hat{b}$ must be negative, implying an appreciation of the financial exchange rate relative to the (fixed) commercial exchange rate. Notice also that, since $w = bf_p - d_p$ is constant and f_p is exogenous, the fact that $\hat{b} < 0$ implies that $\dot{d}_p < 0$. This perpetual credit contraction, resulting from the need to sterilize permanently the current account surplus induced by the favorable terms of trade shock, is in effect what causes the continual pressure on the financial exchange rate to appreciate.

financial and commercial exchange rates. In this section, we incorporate such leakages between markets in the simplest way possible. We make the conventional assumption that when the financial exchange rate, v, is depreciated (appreciated) relative to the commercial rate, s—that is, $b > 1$ ($b < 1$)—arbitrage flows are created between these two markets.[12] Thus, inflows into the parallel market will be an increasing function, $k(\,.\,)$, of the premium, $b - 1$:

$$\dot{F}_p = k(b - 1) + i^* F_p, \quad k(0) = 0, \quad k'(0) > 0, \tag{26}$$

where the second term in (26) represents interest earnings on holdings of foreign securities (which we have already assumed to be exchanged through the parallel market). Using the definition of the real value of foreign securities, f_p, we can rewrite equation (26) as[13]

$$\dot{f}_p = k(b - 1). \tag{27}$$

Thus, given the properties of the $k(\,.\,)$ function, it is clear that when $b = 1$, so that there is no premium, inflows into the parallel market in the form of interest earnings are just sufficient to offset the erosion in the real value of foreign securities due to foreign inflation, as in the last section. When $b > 1$, however, households are able to direct foreign exchange into the free market, implying that $\dot{f}_p$ is positive. Increases in b further increase inflows into this market. Conversely, when $b < 1$, $\dot{f}_p$ is negative as individuals find it profitable to sell in the official market foreign exchange acquired in the unofficial market. Although inflows are negative in this case, they become less negative as b rises toward unity, so that $k(\,.\,)$ is still an increasing function as stated in equation (26).

Consider now the regime of Section I in which the authorities keep the real stock of credit, d_p, constant. The internal balance condition continues to be given by equation (5), which can be solved for $\hat{b}$ as a function of b, f_p, and m:

$$\hat{b} = \Phi(b, f_p, m), \quad \Phi_1 = -f_p c_3/c_2 > 0;$$

$$\Phi_2 = -c_3/c_2 > 0; \quad \Phi_3 = -c_3/c_2 > 0. \tag{28}$$

A rise in b, f_p, or m raises real private holdings of financial wealth and creates an excess demand for home goods, the elimination of which requires a rise in the domestic real interest rate and, hence, in $\hat{b}$.

Substituting equation (28) and the definition of $\hat{v}$ into the money market equilibrium condition (equation (2)) and solving for π gives

$$\pi = \omega(b, f_p, m), \quad \omega_1 = f_p c_3/c_2 < 0;$$

$$\omega_2 = c_3/c_2 < 0; \quad \omega_3 = c_3/c_2 + 1/L_1 < 0. \tag{29}$$

[12] See, for example, Guidotti (1988) and Bhandari and Végh (1990).
[13] Recall the assumption, $i^* = \pi^*$.

A rise in b or f_p raises the domestic interest rate, thereby lowering money demand and creating excess supply in the money market. Equally, a rise in m creates an excess supply of real balances. In all three cases, therefore, a fall in the inflation rate, π, is required to restore money market equilibrium. Substituting equations (26), (28), and (29) into the private sector's budget constraint and setting $\dot{d}_p = 0$ gives the following expression for $\dot{m}$:

$$\begin{aligned} \dot{m} &= y(\rho) - t - c[y(\rho) - t, \Phi(b, f_p, m), m + bf_p - d_p] \\ &\quad - \omega(b, f_p, m)m - \Phi(b, f_p, m)d_p - bk(b - 1) \\ &= \Psi(b, f_p, m), \quad \Psi_1 = -k' - Rf_p c_3/c_2; \\ \Psi_2 &= -Rc_3/c_2; \\ \Psi_3 &= -Rc_3/c_2 - (1 - \epsilon)m/L_1, \end{aligned} \tag{30}$$

where $R = (m - d_p)$ represents the central bank's holdings of foreign exchange reserves, which are assumed to be positive.[14] Under the assumption that ϵ (the absolute value of the interest elasticity of money demand) is less than unity, Ψ_1 is ambiguous in sign (since $k' > 0$), but Ψ_2 and Ψ_3 are both positive.[15] Equations (27), (28), and (30) form a three-equation dynamic system in b, f_p, and m. The trace of the matrix associated with this dynamic system is equal to $\Phi_1 + \Psi_3$, which is positive, implying that not all the roots of the system can be negative. The determinant of the matrix associated with the dynamic system is equal to $-m(1 - \epsilon)k'c_3/(c_2L_1)$, which is negative, implying that the number of negative roots must be odd. From these two facts, it follows that the matrix associated with the dynamic system possesses exactly one negative and two positive roots. Recalling that the system possesses a single predetermined variable, (f_p), it follows that the equilibrium defined by $\dot{f}_p = \hat{b} = \dot{m} = 0$ is a saddlepoint.

Rather than solve for the dynamics of the system, which are not of immediate interest, we proceed directly to analyze the effects of a terms of trade shock on the long-run equilibrium, focusing particularly as before on the effects on the steady-state rate of inflation.

Since in the steady state, the real stock of foreign securities must be constant (that is, $\dot{f}_p = 0$), it is clear from equation (27) that the premium must also reach a constant value—that is, $b = 1$. Having established that b is constant (that is, $\hat{b} = 0$), the internal balance condition (equation (5))

[14] If the central bank extends credit to the government, $m - d_p$ is reserves plus credit to the government; in either case, $m - d_p$ is positive.

[15] As mentioned previously, all results are evaluated around an initial steady state with $b = 1$.

now determines the level of private wealth, $m + bf_p - d_p$. With b and f_p reaching constant values (equation (27)), and with monetary policy holding d_p constant, it is clear that internal balance requires m to be constant. Therefore, the private sector budget constraint (equation (6)) may be written as in Section I above with $\dot{m} = \dot{b} = \dot{f}_p = \dot{d}_p = 0$. It follows that the steady state of the system is formally identical to the one analyzed in Section I (given specifically by equations (11) and (12) above). Because b and f_p enter the steady-state model only multiplicatively, the solutions for bf_p and π will be identical in this section with those in Section I. The only difference between the models is that, rather than determining π and b as in Section I, the system now determines the steady-state values of π and f_p. In particular, under the domestic credit rule, $\dot{d}_p = 0$, the steady-state response of the rate of inflation to a terms of trade shock is the same in the model with leakages as in the model without.

The analysis of this section thus indicates, first, that the incorporation of leakages into the basic model of capital controls implies that, rather than adjusting instantaneously to terms of trade or other shocks, the economy moves gradually toward a steady-state equilibrium, with its position at any instant being driven by the value of the system's only predetermined variable, f_p. In the steady state, the only differences between the models with and without leakages concern the values of b and f_p. In the model of Section I, f_p is exogenous while b is endogenous, and vice versa in the model with leakages. Since b and f_p only enter the system as a product, it is clear that the value of bf_p must be the same in both cases. Equally, it is clear that the values of all other endogenous variables, and specifically the inflation rate, to which the economy ultimately converges in the steady state, are the same in both models. Therefore, as in Section I, an improvement in the terms of trade is inflationary under real exchange rate targeting in the model with leakages, with the long-run effect on π being given by the expression in equation (17). With this result in hand, we now proceed to address the issue of whether a monetary policy rule can contain this inflationary impact once the possibility of leakages is taken into account.

IV. Effect of a Monetary Rule in the Model with Leakages

To analyze the consequences of monetary targeting in the presence of leakages, we again assume that the authorities adopt the money supply rule (18). To derive the required rate of credit expansion, substitute (18) in (6) as before, and solve for $\dot{d}_p$ without, however, setting $\dot{f}_p = 0$ in this case. The resulting credit policy is given by

$$\dot{d}_p = \pi^*m - \{y(\rho) - t - c[y(\rho) - t, \hat{b}, m + bf_p - d_p]\} + \hat{b}d_p + b\dot{f}_p, \tag{31}$$

which differs from equation (19) only by the inclusion of the term, $b\dot{f}_p$, representing the credit expansion required to offset the monetary consequences of leakages into the unofficial foreign exchange market.

The resulting model consists of the nontraded goods market clearing condition (5), the money market equilibrium equation (9), equation (18) describing the evolution of the real money supply, the leakage function (27), and the credit rule (31). Proceeding as in Section II by making use of the variable, $w = bf_p - d_p$, and noting that now $\dot{w} = \hat{b}bf_p + b\dot{f}_p - \dot{d}_p$, we can again substitute into the credit rule—in this case, equation (31). It is immediately clear, however, that the resulting version of (31) is identical to equation (23). Thus, the system that emerges in this section is identical to that of Section II, with the addition of the leakage function (27).

The introduction of leakages, however, turns out to have radical implications for the model of Section II. The interpretation of the system is exactly as before, except that corresponding to the new leakage function (27), the variable f_p now becomes predetermined, rather than exogenous. Since the system is forward looking, the solution implies working backward from a steady-state configuration. Consider, then, the steady-state version of the model. For the system to reach a steady state, the predetermined variable, f_p, must satisfy $\dot{f}_p = 0$. From (27), this requires that $b = 1$—that is, the premium must disappear in the steady state—and f_p becomes an endogenous variable. Recall, however, from Section II that in the steady state the model determines values for both w and $\hat{b}$. By examining equations (22) and (23), moreover, it is easy to verify that f_p does not appear in the model's steady-state equations. The condition, $\dot{f}_p = 0$, with f_p made endogenous, therefore in effect introduces an additional restriction on the model ($b = 1$, so $\hat{b} = 0$), without introducing an additional endogenous variable (since f_p does not appear in the model). It is not surprising, therefore, that this model does not possess a steady-state solution. There is no perfect foresight path consistent with monetary targeting in the model with leakages.

The economics underlying this result are straightforward. In brief, the presence of leakages implies that in the long run the economy effectively exhibits perfect capital mobility. Changes in the stock of credit will not, therefore, affect the real money supply. Instead, since the system determines an equilibrium value of the stock of real nonmonetary assets, w, changes in d_p will simply be offset by corresponding changes in f_p, just as in our previous model, and monetary policy will be powerless to alter

the economy's steady-state inflation rate. The only steady-state solution of the system, therefore, is that of the previous section, with $\pi > \pi^*$ in response to a permanent improvement in the terms of trade. Money supply targeting cannot provide an alternative nominal anchor in this case, simply because monetary policy cannot control the money supply in the long run in the presence of leakages.

Suppose, however, that, in full awareness of this result, the authorities nevertheless respond to a terms of trade shock by *temporarily* supplementing their real exchange rate target with capital controls and a money supply target, intending to abandon such controls at some future date. Could such a policy, while it is in place, succeed in stabilizing the domestic inflation rate at the world rate π^*?

This question is addressed in Figure 2. Setting $\dot{m} = 0$ in equation (22) and $\dot{w} = 0$ in (23) yields the dotted loci labeled with the corresponding conditions in Figure 2. Along the $\dot{m} = 0$ locus, the domestic rate of inflation, π, equals the world rate, π^*, so that with the target growth rate of the domestic money supply set equal to π^*, the real money supply is unchanged. Along the $\dot{w} = 0$ locus, real household nonmonetary financial wealth is unchanged.[16] The relative slopes of these loci follow from

$$dm/dw\Big|_{\dot{w}=0} = (-wc_3/c_2)/(\pi^* + wc_3/c_2)$$

$$< dm/dw\Big|_{\dot{m}=0} = (-c_3/c_2)/(c_3/c_2 + 1/L_1) < 0. \tag{32}$$

A favorable terms of trade shock in a context of real exchange rate and monetary targeting causes the $\dot{w} = 0$ locus to shift to the left.[17] The $\dot{m} = 0$ locus may shift in either direction, but in any case will intersect the new $\dot{w} = 0$ locus (labeled $\dot{w}' = 0$) to the northwest of point B, so that the intersection of the two loci corresponds to a lower value of w and higher value of m, say at point C. This follows from equations (24a) and (24b) in Section II, and corresponds to the perfect foresight equilibrium in the absence of leakages between markets.

In the presence of leakages, however, point C no longer represents an equilibrium. To study the economy's dynamics in this case, consider the family of loci in Figure 2 corresponding to constant values of real private

[16] We assume that the $\dot{w} = 0$ locus is negatively sloped, which will be the case if the world rate of inflation is small. Our results do not depend on this assumption, however.

[17] The magnitude of the shift is given by

$$dw/dp\Big|_{\dot{w}=0} = [y'(1 - wc_1/c_2) - y_n'/\theta(1 - w/c_2)]/(wc_3/c_2) < 0.$$

wealth, $m + w$, which for convenience we will call a (that is, $a = m + w$). Each member of this family has a slope of -1, and one such member, denoted DE, is indicated in Figure 2. Another such locus, corresponding to a higher value of a, passes through the initial equilibrium at A, while yet a third, with the lowest value of a, passes through C. The relationship between the value of a at C and its initial value at A is derived in equation (24b). It is also possible to show that, once capital controls are abandoned, the long-run equilibrium value of a, which we refer to as a^*, will settle somewhere between its value at C and at A—that is, the long-run free capital mobility equilibrium must be along a locus such as DE.[18]

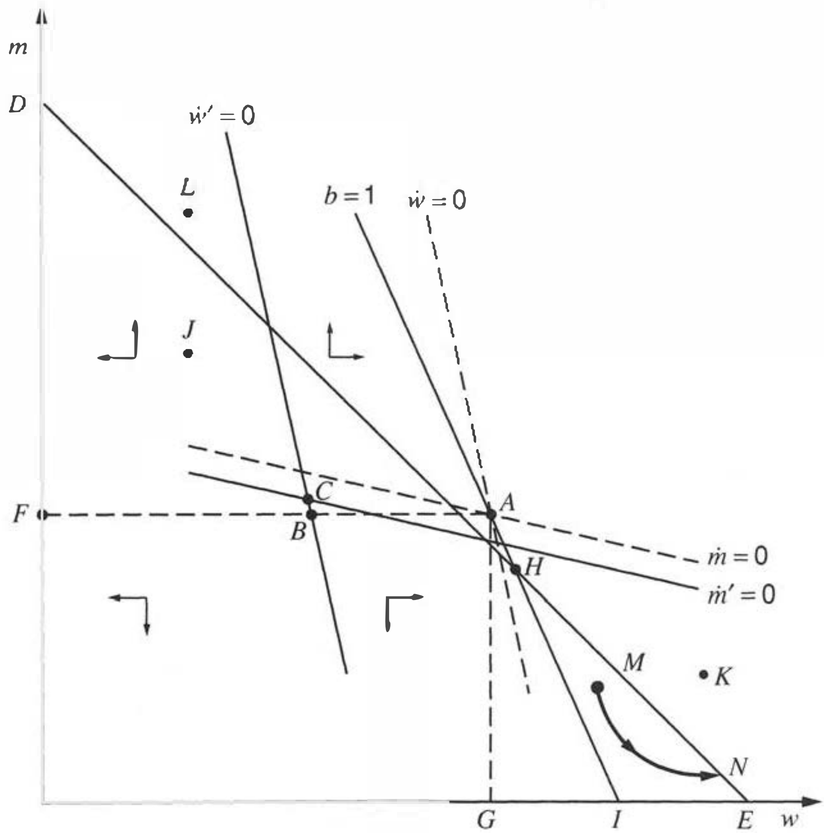
To see how the economy gets from A to its long-run position along DE in the presence of leakages, notice that, along a perfect foresight path, neither the premium, b, nor the aggregate price level can be expected to move discontinuously, since this would create arbitrage opportunities among assets or across time. The implication of this is that household wealth cannot jump at the instant that capital controls are abandoned—that is, the perfect foresight path must move the economy on to the locus DE at that instant.[19] On impact, then, the economy must move into a region in the m–w plane, from which it can reach DE at the appropriate instant. Notice that both m and w can jump to the perfect foresight path, as in Section II. Because the nominal values of the stocks of money, foreign assets, and credit are all predetermined, these jumps must come about through changes in the premium, b, and in the aggregate price level. From such an initial point, the dynamics of the system must obey the directional arrows indicated in Figure 2, which are derived with reference to the $\dot{m}' = 0$ and $\dot{w}' = 0$ loci, since these govern the system's dynamics until capital controls are abandoned.

To see where the economy moves on impact, consider, first, the locus of all points that can be reached from A by a jump in the price level, with b unchanged at its initial value of unity. This locus is labeled $b = 1$ in Figure 2. It has a negative slope (because an increase in the price level reduces both m and d_p, and the latter increases w), which is greater than unity in absolute value. To reach points to the left of this locus, b has to

[18]This can be shown as follows. Totally differentiating equation (5) under the assumption of perfect capital mobility, so that $b = 1$ (and therefore $\dot{b} = 0$), we have $d(m + w)/d\rho = (y_n' - \theta c_1 y')/\theta c_3 < 0$. Comparing this to the result in (24b) shows that the reduction in $m + w$ is smaller under perfect capital mobility than under perfect capital controls.

[19] Since $m + w$ cannot jump at the moment that controls are abandoned, equation (5) implies that b also cannot change discontinuously.

Figure 2. *Dynamics Under Temporary Capital Controls*



fall, while to reach points to the right, b has to rise. Points that are simultaneously below the $b = 1$ and DE loci, such as J, cannot be on a perfect foresight path, because such points are characterized by $b < 1$ and $m + w < a^*$. The latter implies, from equation (21), that $\hat{b} < 0$, so b is unable to reach its final value of unity when controls are abandoned without undergoing a discrete upward jump, an event that we have previously ruled out. Similarly, points simultaneously above both loci, such as K, have $b > 1$ and $m + w > a^*$, so $\hat{b} > 0$, and the same problem arises (except that a discrete drop is required in this case). Finally, it can be shown that the locus DE cannot be reached from points above DE and

$\dot{m}' = 0$, but below $b = 1$, such as L.[20] It follows that on impact the economy must jump to a position *below* $\dot{m}' = 0$, and between the loci $b = 1$ and DE, to a point such as M in Figure 2. From M, the economy must follow a path such as the one indicated in the figure, reaching a point such as N on the locus DE at the instant capital controls are abandoned.

The relevant observation about this path for our purposes is that along MN, the real money supply is continuously *falling*. Since, from equation (22), this implies that $\pi > \pi^*$ along MN, it follows that targeting the growth rate of the money supply at its preshock level succeeds neither in stabilizing the price level—which jumps on impact—nor the rate of inflation, which remains above the world rate even as the domestic money supply is targeted to grow at the world inflation rate, π^*, by continuous sterilization with capital controls. Moreover, it can also be shown (see Montiel and Ostry (1991)), that the steady-state domestic inflation rate remains above the world rate when capital controls are eventually abandoned. It follows, then, that in the presence of leakages, targeting the money supply fails to stabilize the rate of inflation over all time horizons.

The intuition behind these results is as follows: the favorable terms of trade shock creates an incipient excess demand in the market for nontraded goods, both because production shifts to the exportables sector (away from nontraded goods) and because the positive income effect of the favorable terms of trade shock increases the demand for nontraded goods. Since the real exchange rate rule prevents the relative price of domestic goods from rising (that is, through a real exchange rate appreciation), the burden of adjustment on impact is borne by an increase in the domestic price level that reduces the real value of private wealth, $m + w$.

The combination of increased real income due to the terms of trade improvement and reduced real spending on the part of households gives rise to a trade surplus on impact. This makes necessary the adoption of

[20] Above the $\dot{m}' = 0$ locus, the directional arrows in Figure 2 imply that m is increasing, which from equation (22) implies that $\pi < \pi^*$. As shown in Montiel and Ostry (1991), we know that when capital controls are ultimately abandoned, say at time T, the rate of inflation $\pi(T)$ will be above the world rate, π^*, which implies that above $\dot{m}' = 0$, $\pi < \pi(T)$. Summing equations (22) and (23) gives an expression for a, which is decreasing in π (under our maintained assumption that money demand is interest inelastic). Since real wealth is constant in the absence of capital controls, it follows that $\dot{a}(\pi) = 0$ for $\pi = \pi(T)$, and, since $\dot{a}(\pi)$ is a decreasing function, it follows that for values of $\pi < \pi(T)$ (such as at point L in Figure 2), $\dot{a} > 0$. To sum up the argument thus far, $\dot{a}$ must be positive for all points in the indicated region—that is, above $\dot{m}' = 0$ and DE, but below $b = 1$. However, in order to reach DE from a position in the indicated region, a has to be falling, so $\dot{a} < 0$. We conclude, therefore, that it is not possible to reach the locus DE, along which the equilibrium at time T must lie, from a position in the indicated region.

a contractionary credit policy in order to keep the growth of the money supply at its targeted level. Because domestic credit and foreign currency assets are taken to be close substitutes, continuous credit contraction will result in a continuous appreciation of the parallel exchange rate while capital controls remain in place.

However, since at the moment that capital controls are abandoned foreign currency assets must sell at par, holders of such assets would expect to reap a windfall. This causes arbitrageurs to bid up the price of foreign currency assets (that is, to increase b) at the instant that the shock hits, to the point where potential windfall gains are eliminated. Notice that the reduction in the real value of private wealth must be such that $m + w$ falls in spite of the fact that, due to the increase in b and the reduction in the real stock of credit, real private nonmonetary wealth, w, actually *rises*. The decrease in real wealth thus comes about through a reduction in the real money stock, m. The combination of lower real money stock, higher real income, and lower domestic real interest rate results in an incipient excess demand for money. Money market equilibrium thus requires that the domestic nominal interest rate *increase*. This can happen along the perfect foresight path only if the domestic rate of inflation rises on impact and remains higher than the world rate during the transition from M to N.

V. Conclusion

This paper has examined whether the money supply can serve as a nominal anchor for the price level under real exchange rate targeting when the nominal exchange rate cannot serve this purpose. It was argued that, when capital controls are perfect, so that the government can permanently segment official and unofficial markets for foreign exchange, the inflation rate can indeed be stabilized in the face of exogenous shocks when the authorities follow an appropriately chosen money supply rule. However, we also showed that the stabilization of the inflation rate carried with it the implication that in the long-run equilibrium, an ever-widening gap between the official and unofficial exchange rates would emerge. Since this growing gap between the two exchange rates would ultimately create unbounded incentives to engage in cross transactions between official and unofficial markets, we argued that the effectiveness of capital controls could not ultimately be sustained.

The paper then examined whether monetary targeting could effectively stabilize the inflation rate when these incentives for cross transactions create leakages between official and unofficial markets for foreign exchange. Our finding once again was that using money as a nominal

anchor for the price level is problematic. Although the model with cross transactions did not have the problem of a continuously growing gap between official and unofficial exchange rates in the steady state, and hence avoided some of the difficulties that were inherent in the model with perfect capital controls, our conclusion was nonetheless that a money supply rule could not prevent the emergence of inflation when the economy was subjected to a permanent terms of trade shock. The reason was simply that, in the presence of leakages, the long-run behavior of the economy must be identical to that of an economy without any capital controls—that is, with perfect capital mobility. Since, under perfect capital mobility, changes in the stock of credit cannot affect the real money supply, so too in the model with leakages, the money supply becomes endogenous and, hence, cannot be used as a nominal anchor for the domestic price level. In addition, however, the paper showed that if capital controls are used temporarily to target the rate of growth of the money supply, a monetary rule would still fail to stabilize the rate of inflation, even in the short run. To conclude, then, this paper finds little support for the view that a money supply rule can stabilize the inflation rate when the authorities target the real exchange rate.

REFERENCES

Adams, Charles, and Daniel Gros, "The Consequences of Real Exchange Rate Rules for Inflation: Some Illustrative Examples," *Staff Papers,* International Monetary Fund, Vol. 33 (September 1986), pp. 439–76.

Bhandari, Jagdeep S., and Carlos A. Végh, "Dual Exchange Markets Under Incomplete Separation," *Staff Papers*, International Monetary Fund, Vol. 37 (March 1990), pp. 146-67.

Dornbusch, Rudiger, "PPP Exchange Rate Rules and Macroeconomic Stability," *Journal of Political Economy*, Vol. 90 (February 1982), pp. 158–65.

Guidotti, Pablo E., "Insulation Properties Under Dual Exchange Rates," *Canadian Journal of Economics* 21 (November 1988), pp. 799–813.

Khan, Mohsin S., and Peter J. Montiel, "Real Exchange Rate Dynamics in a Small Primary-Exporting Country," *Staff Papers*, International Monetary Fund, Vol. 34 (December 1987), pp. 681–710.

Lizondo, J. Saúl, "Real Exchange Rate Targets, Nominal Exchange Rate Policies, and Inflation," *Revista de Analisis Economico* 6 (June 1991), pp. 5–22.

Montiel, Peter J., and Jonathan D. Ostry, "Macroeconomic Implications of Real Exchange Rate Targeting in Developing Countries," *Staff Papers*, International Monetary Fund, Vol. 38 (December 1991), pp. 872–900.

Woodford, Michael, "Monetary Policy and Price Level Indeterminacy in a Cash-in-Advance Economy" (unpublished; Chicago: University of Chicago, December 1988).

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Collapse of a Crawling Peg Regime in the Presence of a Government Budget Constraint

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The dynamics of the collapse of a crawling exchange rate in the presence of an explicit link between the fiscal deficit and domestic credit is investigated. Such an exchange rate regime is generally characterized by two potential steady-state equilibria, which introduce an ex ante indeterminacy in the timing and magnitude of a speculative attack on international reserves in the presence of a sustained inconsistency between the country's fiscal and exchange rate policies. The paper discusses the conditions that define the actual timing of the regime's breakdown. [JEL F31, F41]

Following the pioneering studies of Salant and Henderson (1978) and Krugman (1979), the recent literature on balance of payments crises has analyzed extensively the conditions under which a fixed or otherwise managed exchange rate regime will collapse.[1] According to

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[1] See, for example, the studies by Flood and Garber (1984), Connolly and Taylor (1984), Garber (1985), Obstfeld (1984, 1986b), Dornbusch (1987), Wyplosz (1986), Blackburn (1988), and Willman (1987). Additionally, almost all of the recent literature on portfolio models applied to developing countries analyzes the consequences of a collapse of the official exchange rate in the presence of a parallel currency market; see, for instance, Kiguel and Lizondo (1986) and Edwards (1988, 1989).

these models, expansive domestic credit policies that create a persistent deficit in the balance of payments will inevitably lead to a speculative attack on the central bank's stock of international reserves. The precise timing of the attack is determined by the speculators' rational anticipation of the regime's collapse, the policies they expect the central bank to follow after the run, and the requirement that no unplanned discrete jump in the exchange rate occur at the transition.[2] A common assumption of these studies is the exogeneity or invariance of the rate of growth of domestic credit. This feature allows them to nail down agents' expectations and to obtain a unique and well-defined stationary equilibrium in the post-attack exchange rate regime. Specifically, these models obtain the well-known sustainability condition for an open economy that follows an active domestic credit policy: in the steady state, the rate of depreciation of the exchange rate will be equal to the (unchanged) rate of creation of domestic credit.

However, by treating domestic credit expansion as the fundamental and invariant variable driving the speculative attacks, these models obscure the fiscal forces that are usually behind the breakdown of managed exchange rate regimes. In fact, if it is assumed, instead, that domestic credit policies are geared to the financing of the fiscal deficit, some of the features and predictions of the standard models of balance of payments crises are altered substantially. For instance, it will no longer be correct to assume that the rate of growth of domestic credit remains invariant after the speculative attack takes place. If the unsustainable credit policies are directly related to an increase in the fiscal deficit, the decline in the demand for domestic money balances that characterizes the transition to the post-attack equilibrium will prompt an upward adjustment in the growth rate of domestic credit (to the level determined by the higher expected rate of depreciation), in order to finance the larger borrowing requirements of the public sector.

Considering explicitly the linkage between credit and fiscal policies in these models also gives rise to the possibility of obtaining *two* potential stationary positions at which the fiscal deficit is financed by the inflation tax, and the balance of payments is in equilibrium. This steady-state feature, in turn dependent on the assumed existence of an inflation-revenue Laffer curve, is common to all the models that include a financing constraint for the government, and has been studied in detail for the case of a closed economy.[3] However, its extension to an open economy with

[2] By definition, market-determined exchange rate regimes are not subject to such "surprises" in official rate setting.

[3] Following the study by Cagan (1956), Sargent and Wallace (1981, 1987), Evans and Yarrow (1981), Liviatan (1983), Dornbusch and Fischer (1986), Bruno and

a managed exchange rate is not trivial, because the possibility of temporarily eliminating a given monetary disequilibrium through losses of international reserves changes the dynamic adjustment of the system.

In particular, in this case the re-attainment of a stationary equilibrium will coincide with a speculative attack on the central bank's foreign exchange holdings, the timing of which will depend on the public's expectations regarding monetary and exchange rate policies. Whether the economy will end up at an equilibrium with high or low inflation will, thus, depend heavily on the government's ability to commit credibly to certain policies during the transition period.

Potentially, this framework can be extended further to analyze the interaction of fiscal and monetary policies with tax and tariff reforms in stabilization programs under managed exchange rates. For instance, the framework can be used to illustrate how a sustained disinflation would reverse the erosion of conventional tax yields and, thus, reduce the distortions stemming from an intensive use of the inflation tax; or how anti-inflation policies can be reinforced by opening up the economy to imports and to sustainable foreign financing. The model derived in this paper, however, does not incorporate all of these factors, since it assumes that the economy is already fully open, tax proceeds are exogenous, and external financing is unavailable.

The model and its steady-state properties are presented in Section I. Section II illustrates the effects of an inconsistency between the stance of fiscal and exchange rate policies and derives expressions for the exact timing and magnitude of the two potential speculative attacks. It also discusses some ways in which the ex ante indeterminacy of the stationary equilibrium reached after the attack can be resolved. Finally, Section III summarizes the policy implications of the model and relates them to the recent literature on the sustainability of alternative exchange rate regimes.

I. A Portfolio Model of a Crawling Peg Regime

This section will discuss the effects of introducing a financing constraint for the government in a continuous-time portfolio model of a small open economy with a crawling exchange rate. Let the nominal exchange rate be denoted by E, and the rate of crawl, by π (that is, $\pi = \dot{E}/E$, where

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Fischer (1987), and others have discussed the stability properties of the two stationary equilibria for the inflation rate in a closed economy. Kharas and Pinto (1986) extended this line of analysis to an open economy with a dual and implicitly floating exchange rate regime.

a dot over a variable represents its derivative with respect to time). In the tradition of portfolio models, it will be assumed that domestic residents allocate their wealth between two non-interest-bearing assets: domestic money, M—held only by the nationals of the country—and foreign money, f.[4] The nominal stock of private wealth of the economy will then be

$$A = M + Ef. \tag{1}$$

The fraction of wealth held as domestic money, λ, is assumed to be a decreasing function of the expected rate of depreciation. Provided that the public has rational expectations—equivalent to perfect foresight in this deterministic framework—this equals the actual rate of depreciation, π. Thus, the demand for domestic money balances can be expressed as

$$m = \lambda(\pi)a; \quad \lambda'(\pi) < 0; \quad 0 < \lambda(\pi) < 1, \tag{2}$$

where $m = M/E$ and $a = A/E$ are the desired stock of domestic money and the stock of private wealth expressed in terms of foreign currency. Dividing equation (1) by the exchange rate, E, and substituting in equation (2), the portfolio equilibrium condition may also be written as

$$f = \delta(\pi)m; \quad \delta'(\pi) > 0. \tag{3}$$

On the supply side, ignoring the existence of a banking system, the nominal money stock at any point in time will be determined from the balance sheet of the central bank as the sum of the outstanding stock of domestic credit, D, and the domestic currency value of international reserves, ER:

$$M = D + ER. \tag{4}$$

The evolution over time of this aggregate will, in turn, depend on the behavior of each of its components. In particular, if it is assumed—as is customary in open economy models—that the central bank does not monetize the changes in the domestic currency value of international reserves that arise from the continuous depreciation of the exchange rate in a crawling peg regime, the flow money supply will be given by[5]

[4] This is a simplifying assumption of all the currency-substitution portfolio models that use the framework developed by Calvo and Rodriguez (1977). See, for example, Connolly and Taylor (1984), Kiguel and Lizondo (1986), Kharas and Pinto (1986), Khan and Lizondo (1987), and Edwards (1988, 1989).

[5] The assumption that the central bank sterilizes the capital gains stemming from its exchange rate policy implies that the nominal money stock at any point in time will be given by

$$M_t = D_t + E_t R_t - \int_{-\infty}^{t} R_s \dot{E}_s d_s$$

$$\dot{M} = \dot{D} + E\dot{R}. \tag{5}$$

In this context, the inclusion of a financing constraint for the government imposes some restrictions on the evolution of domestic credit. Specifically, in the absence of alternative financing sources, the particular level of the fiscal deficit, $\bar{d}$, will determine the rate of domestic credit expansion; that is

$$\bar{d} = (g - t) = \dot{D}/E, \tag{6}$$

where g and t are, respectively, the levels of government expenditures and tax revenues expressed in terms of foreign currency.[6]

The behavior of the second component of the money supply will be dictated by the overall result of the balance of payments, and can be expressed as

$$\dot{R} = CA - \dot{f}, \tag{7}$$

where CA stands for the current account balance in foreign currency, and $\dot{f}$ represents the capital account.[7] Notice that the second term of equation (7) will be positive only if there is an expected change in the rate of depreciation; in that case, the public's accumulation of foreign money balances will contribute to the drainage of international reserves and accelerate the timing of the speculative attack.

From equations (1), (3), (5), and (7), one can obtain an expression for the evolution over time of the real stock of private domestic wealth:

$$\dot{a} = CA + \dot{D}/E - m\pi, \tag{8}$$

where $m\pi$ can be interpreted as the authorities' proceeds from the inflation (depreciation) tax. However, according to these models, for a given set of domestic policies the public will carry out the necessary adjustments so that it always maintains its portfolio of assets in equi-

Equation (5) is then obtained by taking the time differential to this expression. For an alternative assumption, see Cumby and van Wijnbergen (1989).

[6]Most of the studies on "passive" monetary policy have modeled the linkage between the fiscal deficit and the rate of money creation by means of the closed economy counterpart of equation (6); see Auernheimer (1983), Evans and Yarrow (1981), and Bruno and Fischer (1987). However, the use of this type of constraint for the case of an open economy requires two qualifications: first, monetary policy is restricted to domestic credit policy; and second, as noted in the text, it must be assumed that foreign and domestic borrowing are not available for the country in question. For an analysis of speculative attacks when the government is able to borrow, see Obstfeld (1986a) and Buiter (1987).

[7]Adding more structure to the real sector of the model by specifying, for instance, the consumption and production functions for tradable and nontradable goods and the behavior of the real exchange rate can be done easily. However, leaving the model at this level of aggregation will suffice to highlight the problem under analysis.

librium. Once this position is achieved, the stock of private wealth will remain constant (that is, $\dot{a} = 0$), and equation (8) will become

$$-CA = \dot{D}/E - m\pi = \bar{d} - m\pi. \tag{9}$$

Notice that assuming that agents hold their desired portfolios does not imply that the economy has reached a stationary position. In fact, a situation of flow equilibrium in the assets market is, in principle, consistent with the presence of a current account deficit (if the government deficit is larger than the proceeds from the inflation tax) or a current account surplus (in the opposite case). Since neither of these situations is sustainable in the long run, an additional condition has to be fulfilled for this system to reach a steady state, namely (from equation (9)), that the current account be in equilibrium ($CA = 0$). This, in turn, requires that the fiscal deficit be fully financed by the revenues from the inflation tax.

The precise implications of the condition derived above can be made more clear once one considers the particular way in which the inflation tax is collected in this model. The assumption that the central bank does not monetize capital gains arising from the continuous revaluation of its international reserves restricts the government to collecting inflationary revenue only from the fraction of the money supply that is backed by domestic credit. Calling this fraction γ ($\gamma = D/M$), and rewriting equation (9) yields[8]

$$-CA = (\theta - \pi)\gamma m, \tag{10}$$

where $\theta = \dot{D}/D$ is the rate of growth of domestic credit.

From equation (10) it is now evident that a stationary equilibrium will require that the growth rate of domestic credit equal the rate of depreciation of the currency ($\theta = \pi$). In principle, this condition is equivalent to the one obtained in those models where the central bank sets an invariant rule for the creation of domestic credit independently of the stance of fiscal policies (see, for instance, Connolly and Taylor (1984) and Dornbusch (1987)). However, the requirement in this case that the fiscal deficit be permanently financed (equation (6)) significantly alters the nature of the adjustment process toward the steady-state solution.

[8] Although this assumption has been adopted consistently by almost all portfolio models since the early developments of the monetary approach (Johnson (1972)), the empirical studies on seigniorage collection have not distinguished the different implications of alternative rules regarding the sterilization of capital gains (see, for instance, the estimates presented in Fischer (1982)). Indeed, although the same equilibrium condition would be obtained if it were assumed that the central bank monetizes the changes in valuation of international reserves, the empirical computation of the inflation tax would be different under the two rules.

Because of this financing requirement, in general, there will be *two* different growth rates of domestic credit that will satisfy the condition for stationary equilibrium. In effect, the properties of the inflation-tax Laffer curve implicit in the most common specifications of the demand for money balances will allow for the possibility of collecting the same level of revenue from two different rates of inflation (depreciation).[9]

Moreover, once the government financing constraint is included, some features of the temporary equilibrium of the model will be modified. In order to be in this position, the economy will now have to satisfy simultaneously equation (10)—flow equilibrium in the assets market—and equation (6). In particular, if it is assumed, as is common in the literature, that the demand for domestic money balances is of the semilogarithmic (Cagan) form—$\lambda(\pi) = \bar{\lambda}e^{-\alpha\pi}$—equation (6) can be rewritten as[10]

$$\bar{d} = \theta\gamma\bar{\lambda}\exp(-\alpha\pi)a, \tag{11}$$

and, from equation (9), the expression for the temporary equilibrium of the system will be given by

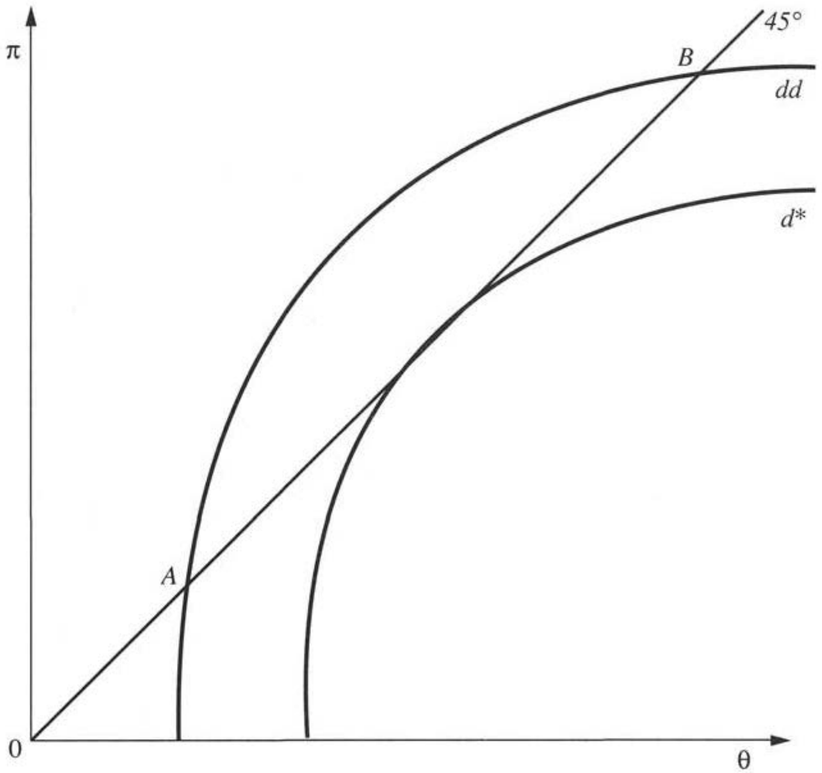
$$-CA = \bar{d} - \pi\gamma\bar{\lambda}\exp(-\alpha\pi). \tag{12}$$

The situation just described is illustrated in Figure 1. The sustainability condition implicit in equation (10), $\theta^* = \pi^*$, is shown as the 45-degree line, and the budget financing constraint (equation (11)), where the economy should always be located, is represented by the schedule dd. The size of the fiscal deficit, $\bar{d}$, the level of private wealth, a, and the initial share of domestic credit in the money supply, γ_0, will determine the intercept of the dd curve on the horizontal axis. If agents hold their desired portfolios, at every point on dd and below the 45-degree line (that is, at every point where $\theta > \pi$), the economy will be in a temporary equilibrium, experiencing a continuous loss of reserves due to a deficit in the current account; at every point above that line, the economy will be running a persistent external surplus. In the long run, however, the stationary equilibrium condition requires that both the growth rate of domestic credit, θ, and the rate of depreciation, π, adjust to one of the

[9]This result was first obtained by Cagan (1956) and has been analyzed in detail for the closed economy case in the literature (see footnote 3). Notice, however, that an inflation-tax Laffer curve cannot be obtained from some functional forms of the demand for money, such as the hyperbolic function, $\lambda(\pi) = \alpha/(\alpha + \pi)$.

[10]The necessary condition for the qualitative results that follow is that the unit inflation-tax Laffer curve $\psi(\pi) = \pi\lambda(\pi)$ is concave in π and has a global maximum where the inflation elasticity of the demand for money equals unity. The Cagan specification is one possible functional form that satisfies this condition and has been assumed because of its tractability.

Figure 1. *Potential Equilibria with a Government Budget Constraint*



two points of intersection of the budget constraint with the sustainability line.

The figure also shows clearly that there is a limit to the size of the budget deficit that can be financed with inflationary revenue. This limit is given by d^*, the financing of which requires maximizing the inflationary tax by setting the rate of depreciation equal to the inverse of the inflation semi-elasticity of the domestic money demand ($1/\alpha$).[11] If the actual deficit is larger than d^*, no steady-state equilibrium will exist. For any other level of the budget deficit, however, there will be two possible steady-state positions, one at a low rate of depreciation (point A) and the other at a high rate of depreciation (point B).

[11] This is the well-known condition for maximizing inflationary revenue in a nongrowing economy derived by Cagan (1956) and Friedman (1971).

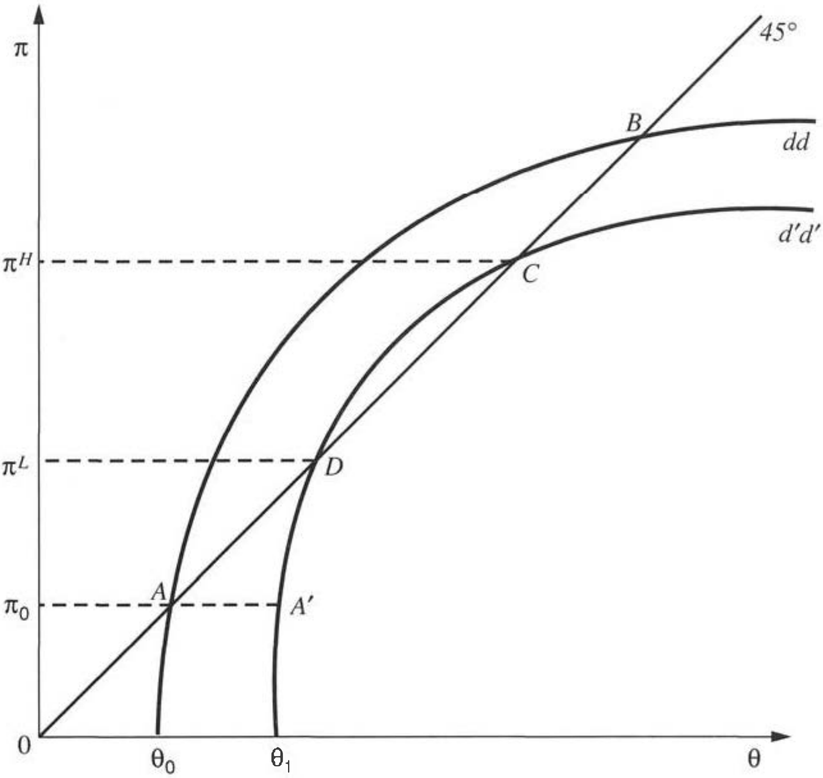
It is important to emphasize that in a managed exchange rate regime like this, the economy may remain for some time at any point on the *dd* schedule that is different from the two stationary equilibria. In fact, if the temporary equilibrium condition (equation (10)) is satisfied, the divergence between the government's financing requirements and its collection of inflationary revenue will be reflected in the current account, without any need for a continuous change in the rate of depreciation. This implies that the dynamic adjustment of this system differs significantly from that presented in the literature on dual inflationary equilibria in closed economies (see footnote 3). In particular, in this case the economy's transition toward one of its steady-state positions will not be gradual and will not depend on the local stability properties of the two potential equilibria. Instead, the movement toward steady-state equilibrium will be abrupt and will coincide with the collapse of the managed exchange rate regime. As will be seen in the following section, the factors determining whether this collapse will take the economy to the stationary equilibrium corresponding to the high or to the low rate of depreciation will depend crucially on the public's expectations about the future actions of the country's authorities.[12]

II. Inconsistent Fiscal Policies

As mentioned before, the inclusion of a financing constraint for the government in a portfolio model of an open economy highlights the role that fiscal policies commonly play in the breakdown of a managed exchange rate regime. In contrast to the usual assumptions in the literature on balance of payments crises, the model derived in Section I permits one to relate the presence of an unsustainable domestic credit policy directly to an inconsistency between the size of the fiscal deficit and the chosen exchange rate policy; moreover, the need to restore the consistency between these policies is precisely what explains the collapse of the exchange rate regime. However, as this section will show, the existence of two different rates of depreciation at which such consistency can be restored introduces a potential indeterminacy with respect to the timing and magnitude of the speculative attack.

[12] Notice that the dynamic adjustment of the economy to exogenous disturbances in the post-collapse floating exchange rate regime will be driven by the same stability conditions as those obtained in the aforementioned closed economy models; that is, under the assumption of rational expectations, the high-depreciation equilibrium will be stable, and the low-depreciation equilibrium, unstable.

Figure 2. *Fiscal Expansion in a Crawling Peg Regime*



In order to illustrate this feature of the model, let us assume an economy with a crawling exchange rate whose initial position is one of steady-state equilibrium with a relatively low rate of depreciation. Thus, the economy will be located at a point such as A in Figure 2, with a rate of growth of domestic credit, θ_0, and a rate of depreciation, π_0. Now suppose that the government decides to increase its real expenditures, g, without implementing a corresponding increase in taxes, while the central bank maintains unchanged the rate of depreciation of the currency.[13] From equation (11), this increase in the fiscal deficit (from $\bar{d}$ to, say, $\tilde{d}$) will require an immediate upward adjustment in the rate of expansion of

[13]This behavior of the central bank implies either that it maintains its previously announced rate of crawl or that it follows some sort of backward-looking adjustment rule in setting this rate.

domestic credit in order to satisfy the larger financing needs of the public sector.

In terms of Figure 2, this particular fiscal shock will imply a rightward shift of the budget financing schedule from dd to $d'd'$, an increase in the growth rate of domestic credit from θ_0 to θ_1, and the repositioning of the economy at a point such as A'. At this new position the flow equilibrium in the economy's asset (money) market will be sustained, according to equation (10), by a persistent deficit in the current account. This situation, however, can only be temporary. Even in the absence of a speculative attack, the maintenance of a divergence between θ and π will ultimately lead to the depletion of the central bank's international reserves, a discrete jump of the exchange rate, and the adoption of a floating exchange rate regime.[14]

The inevitability of the discrete adjustment in the exchange rate when the system is left on its own (that is, when the collapse is not anticipated) can be shown by using equations (2) and (4) to rewrite the portfolio equilibrium condition (equation (10)) at point A' as

$$M_t = [E_0 \exp(\pi_0 t)]\bar{\lambda} \exp(-\alpha\pi_0)a = D_0 \exp(\theta_1 t) + E_0 R_t, \tag{13}$$

where the subscript "0" indicates the initial steady-state value of the corresponding variable. According to equation (13), the evolution of international reserves (given by the current account deficit) will be dictated by

$$E_0 R_t = [M_0 - D_0 \exp(\theta_1 - \pi_0)t] \exp(\pi_0 t). \tag{14}$$

If no speculative attack occurs, the central bank will run out of foreign exchange at some point, t^*, where

$$t^* = \frac{\log\left(\dfrac{M_0}{D_0}\right)}{(\theta_1 - \pi_0)} = \frac{-\log \gamma_0}{(\theta_1 - \pi_0)}, \tag{15}$$

and at that instant two adjustments will have to take place: (1) both θ and π will have to adjust to a point on the sustainability line consistent with the financing constraint of the government; and (2) portfolio equilibrium (equation (13)) will need to be maintained through a discrete devaluation of the currency.

However, the above scenario is inconsistent with the assumption that agents possess perfect foresight. As the literature on balance of payments

[14] Of course, the expansionary fiscal policy would be sustained for a longer period if other sources of deficit financing were available; see Obstfeld (1986a) and Buiter (1987).

crises has emphasized, in a situation like the one just described the private sector would anticipate the eventual breakdown of the managed exchange rate regime and would be able to make enormous capital gains by selling its domestic money holdings to the central bank just an instant before t^*. The realization of these potential profits by all speculators will cause the collapse of the regime to occur earlier than t^* (that is, before the international reserves have been depleted), and the equilibrium in the agents' desired portfolios will be maintained by a decline in their nominal money holdings rather than by a discontinuous jump in the exchange rate.

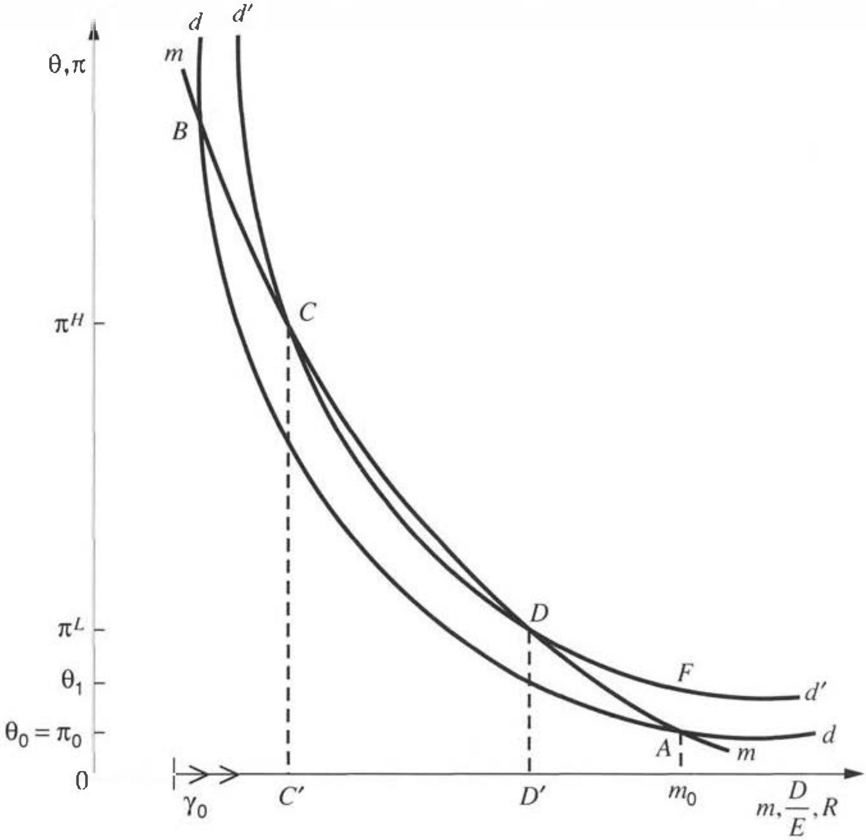
A necessary condition for this smooth transition to take place, however, is that the public be able to anticipate exactly the stationary position at which the system will stay in the post-attack regime. In this sense, the assumption that the central bank follows an active domestic credit policy has been crucial for obtaining a unique solution in the existing models of speculative attack. In fact, in those models the invariance of the growth rate of domestic credit actually nails down agents' expectations and permits them to cause the collapse of the managed exchange rate regime at a well-defined date.

However, in the presence of an inflation-tax Laffer curve and a financing constraint for the government, the system's steady state is no longer unique. In that case there will exist two potential rates of depreciation (the ones corresponding to points C and D in Figure 2), at which the consistency between the fiscal and exchange rate policies can be restored in the post-attack regime. Moreover, since the required decline in the demand for domestic money will be different for each of these two sustainable depreciation rates, there will be an ex ante indeterminacy with regard to the timing and magnitude of the speculative attack needed to achieve the transition to a float without violating the continuity condition for the exchange rate. As will be discussed below, the particular way in which this indeterminacy will be solved will be extremely sensitive to the public's perception of the policies the authorities will follow during the period of transitory equilibrium.

The different magnitude and timing of the speculative attack associated with each of the two stationary equilibria can be illustrated by Figure 3.[15] The curve dd, a hyperbola asymptotic to the axes, shows the combinations of steady-state rates of depreciation and domestic money holdings that are consistent with the initial fiscal deficit, $\bar{d}$. The curve mm, in turn, represents the Cagan-type demand for real domestic money balances; in order to satisfy the portfolio equilibrium condition (equation

[15]This figure has been adapted from the studies of Liviatan (1983) and Dornbusch (1987).

Figure 3. *Magnitude of Speculative Attack for Two Potential Steady States*



(10)), the economy will always have to be located at some point on this schedule. The potential steady states of the system are indicated by the points of intersection of these two curves. It is assumed that the initial position of the economy is given by point A; as in Figure 2 this point corresponds to a rate of depreciation, π_0, that is equal to the growth rate of domestic credit, θ_0. The real stock of domestic money balances that sustains this equilibrium is represented by the distance Om_0, and it is further assumed that this stock of money is backed by an amount proportional to $O\gamma_0$ of domestic credit and by $\gamma_0 m_0$ of international reserves (see equation (4)).

An increase in the fiscal deficit, such as the one discussed before (that is, from $\bar{d}$ to $\tilde{d}$), will shift the dd schedule to a position such as $d'd'$ and will change the possible stationary equilibria to points C and D. Assuming that the central bank maintains the rate of crawl at π_0, the economy

will stay temporarily at A. However, the jump in the growth rate of domestic credit (from θ_0 to θ_1) implied by the larger fiscal requirements will originate a continuous increase in the stock of domestic credit that will be exactly offset by losses of international reserves reflecting the current account deficit. In terms of Figure 3, this process will imply a rightward expansion of the domestic credit share of the money stock along the horizontal axis. If the authorities commit all their foreign exchange to the defense of the managed exchange rate regime, and the public, for some reason, anticipates that the consistency between the fiscal and exchange rate policies will be restored at the high rate of depreciation, π^H, the collapse of the regime will have to occur as soon as the stock of domestic credit reaches the level OC'. At that instant a speculative attack of a magnitude $C'm_0$ will have to take place. However, if the private agents believe that the more expansive fiscal policy will be sustained by the low rate of depreciation, π^L, they will wait until domestic credit reaches the level OD' before acquiring the remaining stock of international reserves, $D'm_0$. Notice that, even though in both cases the central bank's initial stock of international reserves, $\gamma_0 m_0$, will be depleted, the collapse will have to take place earlier if the agents share the expectation that the exchange rate will depreciate at π^H in the post-attack regime.

In fact, exact expressions can be derived for the magnitude and timing of the two potential speculative attacks represented in Figure 3. Ruling out the possibility of capital gains, the regime's collapse should occur as soon as the stock of domestic credit (growing at the unsustainable rate, θ_1) equals the nominal value of the demand for domestic money corresponding to the new steady state. Using equations (2) and (4), as was done in equation (13), this terminal condition will be

$$D_t = D_0 \exp(\theta_1 t) = [E_0 \exp(\pi_0 t)]\bar{\lambda} \exp(-\alpha\pi^H)a, \tag{16}$$

for the high-depreciation equilibrium (point C), and

$$D_t = D_0 \exp(\theta_1 t) = [E_0 \exp(\pi_0 t)]\bar{\lambda} \exp(-\alpha\pi^L)a, \tag{17}$$

for the low-depreciation one (point D). Substituting each of these equations back in equation (4) yields the precise expression for a run of magnitude, $C'm_0$, in Figure 3:

$$R^H = m_0\{1 - \exp[-\alpha(\pi^H - \pi_0)]\} \exp(\pi_0 t), \tag{18}$$

and the expression for the amount of reserves lost in the transition to point D (the distance $D'm_0$):

$$R^L = m_0\{1 - \exp[-\alpha(\pi^L - \pi_0)]\} \exp(\pi_0 t). \tag{19}$$

Thus, as the figure shows, the difference in the size of the run associated with each of the stationary equilibria is proportional to the difference between the two sustainable rates of depreciation, π^H and π^L. By manipulating equations (16) and (17) one can also determine the exact timing of the attacks indicated by (18) and (19). Given an inconsistency between the fiscal and exchange rate policies, the collapse of the managed exchange rate regime will occur either at

$$t^H = \frac{-\log \gamma_0 - \alpha(\pi^H - \pi_0)}{(\theta_1 - \pi_0)} \tag{20}$$

or at

$$t^L = \frac{-\log \gamma_0 - \alpha(\pi^L - \pi_0)}{(\theta_1 - \pi_0)}, \tag{21}$$

from which it can be seen that $t^H < t^L$; that is, the collapse will take place earlier if agents anticipate the high rate of depreciation, π^H. Moreover, since $t^L < t^*$ (from equation (15)), the public will necessarily carry out the speculative attack before the accumulated deficit in the current account exhausts the initial stock of international reserves. It should also be noticed that the difference between the two potential timings of the attack (and between the two sustainable rates of depreciation) will be smaller the larger the fiscal deficit, as long as the latter stays below the critical level, d^*.

Although the above computations have been made for the case where the inconsistency between fiscal and exchange rate policies arises from an exogenous increase of the fiscal deficit, the framework can also illustrate the probable effects of other measures that create similar macroeconomic inconsistencies. In particular, this analysis can be applied, with minor modifications, to the case where the authorities implement an exchange rate-based stabilization program.[16]

Suppose that in this alternative scenario the economy's initial position is given by point D in Figure 3, where a rate of devaluation, π^L (equal to a growth rate of domestic credit, θ^L) sustains the fiscal deficit represented by curve $d'd'$. Suppose now that the authorities decide to preannounce a lower rate of devaluation, π_0, presumably as part of a comprehensive stabilization program. Even if there is no immediate change in the underlying fundamentals of the fiscal deficit, the public can inter-

[16]This type of program has been covered extensively, at the theoretical and empirical levels, in the literature on the Southern Cone liberalization reforms of the 1970s. See, for instance, Calvo (1986a, 1986b), Edwards and Cox-Edwards (1987), Kiguel and Liviatan (1988), and Rodriguez (1982).

pret the reduction of the rate of crawl as a signal that the central bank is willing to use part of its international reserves (assumed proportional to the distance, $\gamma_0 D'$) to support the stabilization attempt. Consequently, in order to maintain portfolio equilibrium, agents' initial response will be to convert the equivalent to the distance $D'm_0$ of their foreign currency assets into domestic currency and to move along the money demand schedule to a position such as A.

The one-time increase of the central bank's international reserves and the reduction in the rate of inflation provoked by the lower rate of crawl are, however, misleading indicators of the program's success. If the fiscal deficit is not reduced *rapidly* to a level consistent with that of curve dd in Figure 3, the exchange rate-based disinflation scheme will break down. Specifically, if the fiscal deficit stays at $d'd'$ and is financed by domestic credit growing at the rate θ_1, the collapse of the preannouncement regime will have exactly the same features as the previous example of an expansionary fiscal policy. The temporary reduction in inflation and increase in reserves will be a false sign of the agents' confidence in the program and, depending on their expectations regarding future government actions, the economy might end up with a rate of inflation higher than the one that prevailed at the outset of the stabilization attempt.

A crucial issue, then, is to identify the factors that will determine which of the two possible steady states is going to characterize the post-attack regime of this economy in the presence of an inconsistency between the fiscal and exchange rate policies. Given the self-fulfilling nature of private agents' anticipations, this turns out to be equivalent to analyzing the variables, policies, and interactions that will be considered by the public in forming its expectations. In particular, the public will have to evaluate, first, the preferences and incentives of the authorities regarding the two feasible stationary equilibria; and second, the potential (private) costs of each possible course of action.

For the first group of factors it is clear that, since both steady-state positions will yield the same permanent flow of inflationary revenue, the government should be indifferent on this account only as to which rate of depreciation (π^H or π^L) finally sustains its budget deficit, d. Nevertheless, even though the model's structure does not incorporate explicitly the preferences of the authorities, it may be reasonable to assume that most governments would prefer the low-depreciation equilibrium. In the first example of an expansive fiscal policy, they would do so because it implies that the regime with a relatively low rate of depreciation, π_0, will last longer; and in the second, because the apparent success of the disinflation program will be maintained for a longer period. In this sense, the government might have some incentives to influence the post-attack outcome

by revealing its preference for the low-depreciation equilibrium and by trying to precommit itself not to take any action that would interfere with the continuous loss of reserves that will take place during the pre-collapse period.

If the authorities lack the means to ensure that they will not deviate from their preferred outcome, however, an announcement of this type will not be credible. Private agents will realize that the government will very likely be tempted to try to catch them by surprise in order to postpone even further the collapse of the managed regime, either by the *unanticipated* imposition of capital controls or by undertaking an *unanticipated* devaluation. In this case, the private sector will hedge its portfolio against the risk of a capital loss by provoking the collapse of the regime as soon as domestic credit reaches the threshold corresponding to the high-depreciation equilibrium (distance OC' in Figure 3).[17]

In a way, the lack of credibility of government announcements (or, more precisely, the lack of means to enhance such credibility) provides a possible solution to the ex ante indeterminacy of the post-attack steady state of this economy. Since in this model speculation is privately costless, the existence of the slightest probability that the authorities will attempt to delay the transition to a float by a once-and-for-all devaluation will give agents a "one-way-option"; that is, to attack the central bank's international reserves at the time t^H (see equation (20)).

Of course, the outcome will be different if the government finds a credible method for "tying its own bands" during the precollapse period. If this is a feasible alternative, the inconsistency between the fiscal and exchange rate policies will last longer and the attack will take place at t^L (equation (21)). Although nothing in the structure of the model prevents the authorities from making agents' expectations converge to the low-depreciation equilibrium, it may be argued that in the first case considered the fiscal origin of the disequilibrium will erode the government's credibility. In the case of an exchange rate-based stabilization, by contrast, the authorities can blame their delay in reducing the fiscal deficit on the existence of structural rigidities and/or political opposition to the

[17]Notice that the authorities will also be tempted to carry out these surprises in the one-equilibrium models used in the literature on speculative attacks. In spite of the assumption that agents foresee perfectly the law of motion of domestic credit and international reserves consistent with a given rate of devaluation, the private sector in these models does not have enough information to anticipate the imposition of capital controls or a discrete devaluation different from the one required when the peg is abandoned. Thus, when these events take place *before* the collapse date, agents are unable to take advantage of the potential capital gains created by the authorities' measure. On this, see Obstfeld (1984), Wyplosz (1986), and Dornbusch (1987).

needed measures. In both cases, however, the intervention of an outside party might be required to coordinate the self-fulfilling beliefs of the public and avoid attainment of the high-depreciation equilibrium. In this regard, some recent studies indicate that an outside party (such as a foreign central bank) that promises to lend foreign exchange in the event of a confidence crisis can help to postpone the speculative attack.[18] In particular, that party might increase the commitment capacity of the government and persuade private agents that the authorities are not going to surprise them by imposing capital controls or devaluing the currency in the period of transitory equilibrium.

In summary, the solution to the ex ante indeterminacy of the timing and magnitude of the collapse of a crawling peg depends on the credibility of the authorities' resolve not to interfere with the persistent current account deficit caused by the inconsistency between their fiscal and exchange rate policies. This result highlights the severity of the problems that can be generated by an inconsistent fiscal policy in a managed exchange rate regime. If the authorities do not take into account the self-fulfilling nature of the private sector's expectations when implementing unsustainable policies, the economy may very rapidly end up "trapped" in an undesirable high-depreciation equilibrium.

III. Conclusions

This paper has extended the research on collapsing exchange rate regimes by including a financing constraint for the government in a continuous-time, portfolio model of a small open economy with a crawling exchange rate. By considering explicitly the linkage between credit and fiscal policies this analysis has dispensed with the common assumption in the literature on balance of payments crises about the invariance of the growth rate of domestic credit and the associated uniqueness of the post-attack equilibrium. At the same time, it has been argued that the extension of the analysis of dual inflationary equilibria to the case of an open economy with a managed exchange rate is not trivial. Specifically, it has been shown that the possibility of temporarily financing a monetary disequilibrium through losses of international reserves alters the adjustment dynamics that have been obtained for the closed economy case.

It was found that the speculative attack on the central bank's international reserves required to eliminate an inconsistency between fiscal and

[18] See the discussion on this issue in Dellas and Stockman (1988) and Giavazzi and Pagano (1988).

exchange rate policies can occur at two different points in time. Due to the self-fulfilling nature of private agents' expectations, an open economy with a managed exchange rate will restore its steady-state equilibrium after an imbalance created by a fiscal expansion or by a reduction in the rate of crawl by switching to a floating exchange rate regime that can be sustained by either a high or a low rate of depreciation. However, this switch will not be gradual and will not depend on the local stability properties of the two potential equilibria; instead, it will be abrupt and will coincide with the collapse of the managed exchange rate.

The paper also showed that the solution to the ex ante indeterminacy of the post-attack depreciation rate will depend on the government's capacity to make credible announcements regarding policies to be followed in the disequilibrium period preceding the collapse. In particular, if the authorities cannot make a credible precommitment to refrain from delaying the attack through the unanticipated imposition of capital controls or by undertaking an unplanned discrete devaluation, rational private speculators will trap the economy at the high-depreciation equilibrium.

This result affects some of the policy recommendations implicit in the recent literature on portfolio models that has analyzed the main features of alternative exchange rate regimes in developing countries.[19] Specifically, although they discuss explicitly the effects of unsustainable fiscal policies, these studies have disregarded the possibility that the collapse of a fixed or managed exchange rate regime may place the economy on the "wrong" side of the inflation-tax Laffer curve. Indeed, most of this literature has simply assumed that, given a fiscal shock, the stationary equilibrium will always lie on the upward-sloping portion of that schedule. Thus, without the necessary qualifications, these studies inexactly conclude that the negative effects of successive increases in the fiscal deficit (or in the black market premium) can always be avoided by an upward adjustment in the rate of devaluation.

The model presented in this paper also captures some of the stylized facts observed in recent exchange rate-based stabilization episodes. It shows that these programs can work even before the ex post consistency between fiscal and exchange rate policies is attained, but that the success of the disinflation attempt will be short lived if it is not rapidly backed by a reduction of the fiscal deficit to a level that can be sustained by the lower proceeds from the inflation tax. Furthermore, the model suggests that if the measures aimed at restoring the consistency of macroeconomic policies are sufficiently rapid and decisive, an exchange rate-based stabi-

[19] See, for instance, the studies by Dornbusch (1986), Kiguel and Lizondo (1986), and Lizondo (1987a, 1987b).

lization program can prompt a "virtuous cycle" of lower inflation, increased tax yields, and larger international reserves. The model, however, also illustrates that these programs may provoke an inflationary outburst if the authorities delay the necessary adjustment and are unable to make credible commitments during the transitory disequilibrium period. Whether the crisis episodes that ultimately determined the failure of this type of program in the early 1980s were actually characterized by a movement toward an equilibrium inflation rate placed on the wrong side of the inflation-tax Laffer curve, as this model contemplates, can only be properly assessed with a thorough empirical investigation; subsequent research should take this direction.

REFERENCES

Auernheimer, Leonardo, "Deficit, Gasto Publico y el Impuesto Inflacionario: Dos Modelos de Dinero Pasivo," *Cuadernos de Economia*, Vol. 20 (April 1983), pp. 75–84.

Blackburn, Keith, "Collapsing Exchange Rate Regimes and Exchange Rate Dynamics: Some Further Examples," *Journal of International Money and Finance*, Vol. 7 (December 1988), pp. 373–85.

Bruno, Michael, and Stanley Fischer, "Seigniorage, Operating Rules and the High Inflation Trap," NBER Working Paper No. 2413 (Cambridge, Massachusetts: National Bureau of Economic Research, August 1987).

Buiter, Willem H., "Borrowing to Defend the Exchange Rate and the Timing and Magnitude of Speculative Attacks," *Journal of International Economics*, Vol. 23 (November 1987), pp. 221–39.

Cagan, Phillip, "The Monetary Dynamics of Hyperinflation," in *Studies in the Quantity Theory of Money*, ed. by Milton Friedman (Chicago: Chicago University Press, 1956).

Calvo, Guillermo A. (1986a), "Fractured Liberalism: Argentina Under Martinez de Hoz," *Economic Development and Cultural Change*, Vol. 34 (April), pp. 511–33.

——— (1986b), "Temporary Stabilization: Predetermined Exchange Rates," *Journal of Political Economy*, Vol. 94 (December), pp. 1319–29.

———, and Carlos A. Rodriguez, "A Model of Exchange Rate Determination Under Currency Substitution and Rational Expectations," *Journal of Political Economy*, Vol. 85 (June 1977), pp. 617–25.

Connolly, Michael, and Dean Taylor, "The Exact Timing of Collapse of an Exchange Rate Regime and Its Impact on the Relative Price of Traded Goods," *Journal of Money, Credit and Banking*, Vol. 16 (May 1984), pp. 194–207.

Cumby, Robert E., and Sweder van Wijnbergen, "Financial Policy and Speculative Runs with a Crawling Peg: Argentina 1979–1981," *Journal of International Economics*, Vol. 27 (August 1989), pp. 111–27.

Dellas, Harris, and Alan Stockman, "Self-Fulfilling Expectations, Speculative Attacks, and Capital Controls," NBER Working Paper No. 2625 (Cambridge, Massachusetts: National Bureau of Economic Research, June 1988).

Dornbusch, Rudiger, "Special Exchange Rates for Capital Account Transactions," *World Bank Economic Review*, Vol. 1 (September 1986), pp. 3-33.

———, "Collapsing Exchange Rate Regimes," *Journal of Development Economics*, Vol. 27 (October 1987), pp. 71–83.

———, and Stanley Fischer, "Stopping Hyperinflations: Past and Present," *Weltwirtschaftliches Archiv*, Band 122 (March 1986), pp. 1-47.

Edwards, Sebastian, "Real and Monetary Determinants of Real Exchange Rate Behavior: Theory and Evidence from Developing Countries," *Journal of Development Economics*, Vol. 29 (November 1988), pp. 311–41.

———, *Real Exchange Rates, Devaluation and Adjustment: Exchange Rate Policy in Developing Countries* (Cambridge, Massachusetts: MIT Press, 1989).

———, and Alejandra Cox-Edwards, *Monetarism and Liberalization: The Chilean Experience* (Cambridge, Massachusetts: Ballinger Publishing Co., 1987).

Evans, Jean, and George K. Yarrow, "Some Implications of Alternative Expectations Hypothesis in the Monetary Analysis of Hyperinflation," *Oxford Economic Papers*, Vol. 33 (March 1981), pp. 61–80.

Fischer, Stanley, "Seigniorage and the Case for a National Money," *Journal of Political Economy*, Vol. 90 (April 1982), pp. 295–313.

Flood, Robert P., and Peter M. Garber, "Collapsing Exchange Rate Regimes: Some Linear Examples," *Journal of International Economics*, Vol. 1 (August 1984), pp. 1–16.

Friedman, Milton, "Government Revenue from Inflation," *Journal of Political Economy*, Vol. 79 (July/August 1971), pp. 846-56.

Garber, Peter M., "The Collapse of Asset Price-Fixing Regimes," in *The Economics of the Caribbean Basin*, ed. by Michael Connolly and John McDermott (New York: Praeger, 1985).

Giavazzi, Francesco, and Marco Pagano, "Confidence Crises and Public Debt Management" (unpublished; London: Centre for Economic Policy Research, August 1988).

Johnson, Harry G., "The Monetary Approach to the Balance of Payments Theory," in *Further Essays in Monetary Theory*, ed. by Harry G. Johnson (London: Allen & Unwin, 1972).

Khan, Mohsin, and J. Saúl Lizondo, "Devaluation, Fiscal Deficits and the Real Exchange Rate," *World Bank Economic Review*, Vol. 1 (January 1987), pp. 357–74.

Kharas, Homi, and Brian Pinto, "Exchange Rate Rules, Black Market Premia and Fiscal Deficits: The Bolivian Hyperinflation," CRD Discussion Paper No. 1986-35 (Washington: World Bank, 1986).

Kiguel, Miguel A., and Nissan Liviatan, "Inflationary Rigidities and Orthodox Stabilization Policies: Lessons from Latin America," *World Bank Economic Review*, Vol. 2 (September 1988), pp. 273–98.

———, and J. Saúl Lizondo, "Theoretical and Policy Aspects of Dual Exchange Rate Systems," Discussion Paper No. DRD201 (Washington: World Bank, 1986).

Krugman, Paul, "A Model of Balance-of-Payments Crisis," *Journal of Money, Credit and Banking*, Vol. 11 (August 1979), pp. 311–25.

Liviatan, Nissan, "Inflation and the Composition of Deficit Finance," in *Global Econometrics: Essays in Honor of Lawrence R. Klein*, ed. by F. Gerard Adams and Bert G. Hickman (Cambridge, Massachusetts: MIT Press, 1983).

Lizondo, J. Saúl (1987a), "Unification of Dual Exchange Markets," *Journal of International Economics*, Vol. 22 (February), pp. 57–77.

——— (1987b), "Exchange Rate Differential and the Balance of Payments Under Dual Exchange Markets," *Journal of Development Economics*, Vol. 26 (June), pp. 37–53.

Obstfeld, Maurice, "Balance-of-Payments Crises and Devaluation," *Journal of Money, Credit and Banking*, Vol. 16 (May 1984), pp. 208-17.

——— (1986a), "Speculative Attacks and the External Constraint in a Maximizing Model of the Balance of Payments," *Canadian Journal of Economics*, Vol. 19 (February), pp. 1–22.

——— (1986b), "Rational and Self-Fulfilling Balance of Payments Crisis," *American Economic Review*, Vol. 76 (March), pp. 72–81.

Rodriguez, Carlos A., "The Argentine Stabilization Plan of December 20th," *World Development*, Vol. 10 (September 1982), pp. 801–11.

Salant, Stephen, and Dale W. Henderson, "Market Anticipations of Government Policy and the Price of Gold," *Journal of Political Economy*, Vol. 86 (August 1978), pp. 627–48.

Sargent, Thomas J., and Neil Wallace, "Some Unpleasant Monetarist Arithmetic," *Quarterly Review*, Federal Reserve Bank of Minneapolis, Vol. 5 (Fall 1981), pp. 1–17. This article is reprinted as Chap. 5 in *Rational Expectations and Inflation*, ed. by Thomas J. Sargent (New York: Harper and Row, 1986).

———, "Inflation and the Government Budget Constraint," in *Economic Policy in Theory and Practice*, ed. by Assaf Razin and Efraim Sadka (London: McMillan, 1987).

van Wijnbergen, Sweder, "Inflation, Balance of Payments Crises and Public Sector Deficits," in *Economic Effects of the Government Budget*, ed. by Elhanan Helpman, Assaf Razin, and Efraim Sadka (Cambridge, Massachusetts: MIT Press, 1988).

Willman, Alpo, "Speculative Attacks on the Currency with Uncertain Monetary Policy Reactions," *Economic Letters*, Vol. 25 (October 1987), pp. 75–78.

Wyplosz, Charles, "Capital Controls and Balance of Payments Crises," *Journal of International Money and Finance*, Vol. 5 (June 1986), pp. 167–79.

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Portfolio Preference Uncertainty and Gains from Policy Coordination

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International policy coordination is generally considered to be made less likely—and less profitable—by uncertainty about how the economy works. This paper offers a counter example, in which investors' increased uncertainty about portfolio preference makes coordination more *beneficial. Without such coordination, monetary authorities may respond to financial market uncertainty by not fully accommodating demands for increased liquidity, for fear of inducing exchange rate depreciation. Coordinated monetary expansion would minimize this danger. This result is formalized in a model incorporating an equity market; then, the stock market crash of October 1987 and its implications for monetary policy coordination are discussed.* [JEL C73, E44, E52, F31]

A LARGE LITERATURE already exists that considers the conditions under which the international coordination of economic policies could be expected to be beneficial. Several factors have been shown to influence the gains, including the "reputation" of governments—that is, their ability to precommit to fully optimal, but possibly time-inconsistent, policies (Currie, Levine, and Vidalis (1988)), the size and nature of international spillovers (Cooper (1985), Oudiz and Sachs (1984)), the nature of governments' objective functions (Martinez Oliva and Sinn (1988)), and so forth. The likelihood of policy coordination being achieved has also been debated, and many observers have expressed

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skepticism about the possibility of agreement being reached on coordinated policies when there is disagreement on how the economy functions, and, in particular, on the effects of policies (Feldstein (1988), Frankel and Rockett (1988)).

It is important to distinguish between two types of uncertainty: *additive* uncertainty, which does not affect optimal policies in a linear model with a quadratic objective function;[1] and *multiplicative* uncertainty, which does affect them, because the incremental effects of policy changes are uncertain (Brainard (1967)). It is therefore natural to treat disagreement among policymakers about the appropriate model of the world economy in a framework of multiplicative, or model, uncertainty. This was done in Ghosh and Masson (1988), where disagreement about models was linked to uncertainty about key parameters of a general model that nests the various alternative views.[2] The empirical results in that paper confirmed the theoretical analysis of Ghosh and Ghosh (1991), who showed that uncertainty about parameter values can *increase* expected gains from coordination, especially when such uncertainty concerns the transmission effects of policies from one country to another, rather than their domestic effects.

This paper attempts to extend the intuition about the effects of uncertainty on expected gains from coordination[3] by considering a particular case of multiplicative uncertainty, one in which policymakers must take account of uncertainty concerning the preferences of investors across portfolio shares. These portfolio shares play the same role as model parameters, and they are assumed to be stochastic in the model used here.

This view of investment decisions—that they contain a random component—is consistent with observed behavior in financial markets. Fluctuations in asset prices are not explainable solely by news concerning fundamentals, but are plausibly also the result of shifts in asset preferences. This is one interpretation that can be given to the evidence of variance-bounds tests, which suggests that the volatility of asset prices exceeds that of fundamentals.[4] A recent example of sudden portfolio

[1] "Certainty equivalence" is said to apply in this case; see Simon (1956).

[2] However, disagreement over the correct model can exist even when each policymaker is certain that he or she is right. Conversely, uncertainty about parameter values does not imply that policymakers have different assessments of the distributions describing those parameters.

[3] Ex post, welfare may, of course, be lower when policies are coordinated than when they are not; however, policies are assumed to be chosen in order to maximize expected welfare, and, on average, ex post welfare is assumed to equal expected welfare.

[4] For such evidence, see Shiller (1981). Whether variance-bounds tests actually demonstrate the existence of excess volatility has been questioned, however; see, for instance, Flavin (1983) and Flood and Hodrick (1986).

shifts is associated with the generalized crash of all major stock markets in October 1987, during which many investors dumped their shares on the market in an attempt to shift out of stocks into other assets at virtually any price.

Moreover, shifts in portfolio preferences that lead to sudden declines in stock prices are often associated with increased uncertainty, as evidenced by increased volatility of stock prices. This was the experience in the days following October 19, 1987, and also in the August 1990 sell-off. From a macroeconomic policy perspective, the central concern in such an environment is that the real economy will be affected, owing to declines in real wealth and increases in the cost of capital to firms. However, the effects of monetary and fiscal policies on ultimate target variables are also increasingly uncertain, since these policies operate through financial markets. The effects of uncertainty in domestic financial markets are compounded by uncertainty in foreign exchange markets: a sharp depreciation will have unfavorable effects on inflation, for instance, and may exacerbate loss of confidence.

Greater uncertainty in financial markets may increase the need for policy coordination because of a dilemma facing a central bank when responding to shocks. For instance, if the central bank responded to a stock market crash by loosening monetary policy, it might bring about a collapse in the value of the currency. Fear of such a possibility might well lead to an inappropriately timid monetary policy, in which monetary expansion was kept too low. In contrast, a coordinated reduction in interest rates by central banks would diminish the risk of sharp exchange rate movements, while neutralizing the unfavorable effects of a generalized shift out of equities. Consistent with this, the October 1987 crash led to coordination among central banks, or at least some consultation among them about the need to increase liquidity, and interest rates were lowered simultaneously in all major industrial countries.

More generally, variation over time in the amount of financial market uncertainty may explain why coordination tends to be episodic, rather than institutionalized.[5] In times of crisis, the outlook is uncertain, as are the effects of policies; coordination of policies may decrease the danger of very bad outcomes. The incentives to pull together may be strengthened in such circumstances. It may be that in normal times gains from macroeconomic policy coordination are relatively small, consistent with estimates calculated using macroeconomic models (see, for instance, Oudiz and Sachs (1984)). However, great uncertainty about the effects of policies may make the gains from coordination larger, for instance when financial markets are turbulent and there is a danger that portfolio

[5] The terminology was used by Artis and Ostry (1986).

shifts may lead to large movements in asset prices and spillovers onto the real economy. Macroeconomic policy coordination may thus take on the character of "regime-preserving coordination" (Kenen (1988)), rather than a continuous attempt to maximize joint welfare, however defined.

This paper illustrates the effect of portfolio uncertainty on coordination with a simple model. Section I presents a two-country, two-good model in which the portfolio preferences of investors between domestic money and an international equity are random variables,[6] goods prices are sticky, and the value of financial wealth affects real output. It is shown in Section II that expected gains from policy coordination depend crucially on the perceived variances and covariances of the portfolio shifts. Policy at the time of the October 1987 crash is analyzed in the light of these results in Section III. Section IV presents conclusions.

I. The Model

In order to highlight the interaction between portfolio preferences, asset prices, and real activity, a simple, short-run model of two countries is specified. Portfolio preferences are stochastic, and can differ in the two countries. Longer-run questions such as wage adjustment and capital accumulation are ignored. Moreover, in this stylized model, there are only three assets: domestic money, foreign money, and a single equity, which is a claim to a composite consumption good (that is, the equity pays a real return, which is assumed exogenous).[7] A feature of this model is thus that there is a single world equity price; this assumption reflects in extreme form the reality that comovements of equity prices across countries have been very high in recent years—and especially so at the time of the October 1987 crash.

Each of the two countries is specialized in the production of a single good but consumes both. Utility is assumed to be Cobb-Douglas, so that consumption shares are constant; in the home country, expenditure falls in proportion, α, on home goods and $(1 - \alpha)$ on foreign goods. Consumption is assumed to be proportional to the real value of financial wealth (W, to be defined later), so that

[6] A number of articles have included equity markets in macroeconomic models; for instance, Diamond (1967) and Helpman and Razin (1978). This paper makes no attempt to model capital accumulation or to relate the riskiness of equities to technological uncertainty. What is at issue here is the risk related to shifts in portfolio preferences.

[7] Thus, the "fundamentals" are not the cause of asset price volatility. A more complicated model could make both production technology and portfolio preferences stochastic.

$$C = \rho W/P. \tag{1}$$

The consumption deflator, P, is a geometric average of the two goods prices, where p is the price of the home good, p^* is the price of the foreign good, and s is the price of foreign currency:

$$P = p^{\alpha}(sp^*)^{1-\alpha}. \tag{2}$$

Consistent with Cobb-Douglas utility, consumption is divided between the home good, C_1, and the foreign good, C_2, on the basis of fixed spending shares:

$$C_1 = \alpha(P/p)C \tag{3}$$

$$C_2 = (1 - \alpha)(P/sp^*)C. \tag{4}$$

In what follows it is assumed that for both the home and foreign countries, spending falls equally on the two goods, so that $\alpha = ½$. Therefore, equations (2) and (3) can be written as follows:

$$P = (psp^*)^{1/2} \tag{5}$$

$$C_1 = 0.5(P/p)C \tag{6}$$

$$C_2 = 0.5(P/sp^*)C. \tag{7}$$

Wealth is held in the form of money, M, which is nontraded, and in international equities, E, which are a promise to pay a given amount of the composite consumption good (which is the same in the two countries since $\alpha = \alpha^* = ½$), and for which there is a single world market. Money and equities are held in proportions, m and $1 - m$; these proportions are random variables. The price of a real equity claim is q:

$$M = mW \tag{8}$$

$$qPE = (1 - m)W. \tag{9}$$

Uncertainty in portfolio preferences is reflected in the variance of m. Shifts in domestic portfolio preferences may or may not be correlated with shifts in the preferences of foreign investors; the degree of correlation is shown below to be crucial to gains from coordination.

A symmetric foreign country has a similar structure, indicated by starred variables. Parameters are assumed identical, except the random portfolio share parameter, m^*, which may not be equal to m (in the next section the *distributions* describing m and m^* are, however, assumed to be the same). There is a single world equity price (that is, $q^* = q$), since both home and foreign equities pay returns in the same consumption basket. The counterparts of equations (1) and (5)–(9) are

$$C^* = \rho W^*/P^* \tag{1'}$$

$$P^* = [(p/s)p^*]^{1/2} \tag{5'}$$

$$C_1^* = 0.5(sP^*/p)C^* \tag{6'}$$

$$C_2^* = 0.5(P^*/p^*)C^* \tag{7'}$$

$$M^* = m^*W^* \tag{8'}$$

$$qP^*E^* = (1 - m^*)W^*. \tag{9'}$$

It is assumed that output prices are sticky, and that p and p^* are fixed in the short run; output is determined by demand:

$$y = C_1 + C_1^* \tag{10}$$

and

$$y^* = C_2 + C_2^*. \tag{10'}$$

However, consumer prices can vary since the exchange rate, s, is flexible. Similarly, the price of equities, q, moves to equate the demand for equities and the outstanding stock of equity shares, $K + K^*$, where K and K^* are the initial endowments of equities at home and abroad:

$$K + K^* = E + E^*. \tag{11}$$

The exchange rate is determined by an equilibrium condition that the current account surplus equal the capital account outflow, which is equivalent to the condition that the distribution of equities between the two countries satisfy portfolio preferences. The net capital outflow, CAP, from the home country (that is, net purchases of equities) is equal to

$$CAP = qP(E - K), \tag{12}$$

(which is, of course, equal, from equation (11), to $-qP(E^* - K^*)$, the inflow to the foreign country, which corresponds to net sales of equities). The current account surplus, CUR, is the excess of domestic output over domestic absorption (that is, saving), or exports minus imports:

$$CUR = (y - C_1)p - s(y^* - C_2^*)p^*, \tag{13}$$

and the balance of payments condition is

$$CAP = CUR. \tag{14}$$

II. Optimal Government Policy

In the context of this model, monetary policy has a role in cushioning portfolio preference shifts, which have real effects because prices are sticky and consumption depends on wealth. Under consideration will be

the optimal monetary policy of a government, or central bank, that desires to minimize deviations from target output $\bar{y}$—presumably its full employment level—and from price stability, which implies that the price level equals its initial equilibrium value, $\bar{P}$. A quadratic objective function of deviations from bliss levels is postulated for tractability. Such a formulation implies a symmetric treatment of positive and negative deviations, which is probably not realistic; however, this analysis will only consider a portfolio shift out of equities into money that tends to depress output. In particular, the optimal response of the money supply to a shock to the mean value of investors' portfolio preferences is considered in the face of uncertainty about these preferences. Thus, the situation is one in which an initial portfolio shift is observed (such as the shift leading to the fall in equity prices on October 19, 1987), but there is uncertainty about *subsequent* shifts.

Suppose that the home government's objective function is

$$L = E\{(y/\bar{y} - 1)^2 + \phi(P/\bar{P} - 1)^2\} \tag{15}$$

and similarly, for the foreign government

$$L^* = E\{(y^*/\bar{y}^* - 1)^2 + \phi(P^*/\bar{P}^* - 1)^2\}. \tag{15'}$$

It is assumed that in initial equilibrium, money supplies and asset proportions are equal, so that $M = M^* = \overline{M}$ and $1/m = 1/m^* = \bar{n}$, and so $\bar{s} = 1$, and $p = p^* = 1$. Consider a shift out of equities at home and abroad, so that now

$$E(1/m) \equiv E(n) = E(n^*) = \theta\bar{n}, \tag{16}$$

with $\theta < 1$. How does the optimal setting for monetary policy in the two countries, if each takes the other's policy as given, compare to the case of joint maximization of an equally weighted global objective function, G, where $G = 0.5(L + L^*)$?

In the absence of uncertainty, it can be shown that the optimal response to such a shock will be—not surprisingly—to accommodate fully the increase in liquidity preference. In this case, the Appendix shows that cooperative and noncooperative policy settings are the same; they both involve an increase in money supply by the increase in money demand, so $M = M^* = \overline{M}/\theta$. If there is no uncertainty, then in this model monetary policy can completely neutralize the negative output effects of the portfolio preference shock, and the noncooperative and cooperative policies are the same. This is true because each government has as many targets as instruments; in this case, despite possible spillovers through the exchange rate, gains from policy coordination are zero.

However, if there exists uncertainty about portfolio preferences, then only in the case where the portfolio shifts in the two countries are

expected to be perfectly correlated will the two policies be the same. It can be shown (see Appendix) that, in general—unless the weight on inflation in the objective function is zero—the optimal noncooperative policy will be too contractionary, relative to the optimal, cooperative solution. The reason for this bias is the externality associated with the exchange rate (Sachs (1985)): appreciation helps in moderating domestic prices but exports inflation to the foreign country, and the latter effects are ignored in the absence of cooperation. The difference between the noncooperative and cooperative policies and, hence, the gains from policy coordination depend both on the common variance, σ^2, of portfolio preferences and on the correlation, κ, between the two countries' portfolio preference shifts—directly in the first case, and inversely in the second.

The difference between the two policies increases monotonically as the correlation declines, and is maximized when their correlation is minus unity; that is, they are perfectly negatively correlated. In this case, governments set policy with the risk that a monetary expansion may lead to a large exchange rate depreciation because portfolio preferences of domestic and foreign residents for money and equities are expected to shift in ways that reinforce their effects on the exchange rate. The depreciation is undesirable because of its price level effects.

This example provides an additional reason why policy coordination may be beneficial, compared to the traditional literature in which the effects of policies are assumed to be known. In Sachs (1985), for instance, noncooperative monetary policies are too contractionary in response to an inflation shock because exchange rate appreciation improves the output/inflation trade-off, and there are two targets and only one instrument. In the present example, the effects of policies are uncertain because of possible shifts in portfolio preference, so that even if each government has as many instruments as targets it still has an incentive to coordinate. The fact that portfolio preferences are uncertain and that they contribute to the variance of the exchange rate makes uncoordinated policies overcontractionary in the face of an increase in liquidity preference.

III. The Stock Market Crash of October 1987

On October 19–20, 1987, the world's stock markets declined in a sudden sell-off of shares by investors. In local currency terms, stock market indices declined during the period from September 30 to October 31 by 21.5 percent in the United States, 26.1 percent in the United

Kingdom, 22.9 percent in Germany, and 12.6 percent in Japan (see Figure 1 for a visual impression of the comovements of major market indices). Other declines were even more dramatic: 58.3 percent in Australia, and 56.3 percent in Hong Kong (Federal Reserve Bank of New York (1988, p. 18)). To a large extent, therefore, at least during this period world equity markets seemed globally integrated—as is assumed in the model described above, in which there is only one equity market—although the reasons for the common movement of prices are subject to dispute. To some extent, this comovement may have been the result of the gradual increase in interlisting of shares on different exchanges; however, correlations between the main trading zones increased by a factor of three from their levels in the previous nine months (Bertero and Mayer (1989)). Common movements in October 1987 did not seem to result from significant international investment flows, since cross-border selling was relatively small (Federal Reserve Bank of New York (1988, p. 34)). More fundamentally, then, increased economic integration and the globalization of information led to a common reassessment of equity prices in all major stock markets at the time of the stock market crash.

As is argued above, the question of whether equity prices move together (because they are good substitutes—for instance, because they are claims to similar income streams) is logically separate from whether portfolio preferences for equities shift in the same way in different countries. Confirming a generalized shift out of equities, as opposed to a shift in investor sentiment in some countries but not in others, the sharp decline in equity values was associated with relatively small exchange rate movements (Figure 2). In the October 1987 crash, exchange rate movements do not seem to have been a consideration in the setting of monetary policies.[8]

What does seem to have been a major concern influencing policy was that the 1987 stock crash might be a replay of the 1929 one, which was followed by the Great Depression (Schwartz (1988)). In this regard, a high degree of uncertainty was attached to the linkage between the stock market and the real economy—that is, the spending propensities of consumers, whose wealth had declined, and businesses, whose investment plans might be scaled back reflecting increased caution. Also subject to increased uncertainty was the stability of the financial system: whether the inability of individuals to cover margin calls, or of financial institutions to transact in financial markets, would lead to bankruptcies,

[8]They are not mentioned, for instance, in Alan Greenspan's testimony at hearings on "Black Monday," held by the U.S. Senate Committee on Banking, Housing, and Urban Affairs, February 2–5, 1988. See U.S. Congress (1988).

Figure 1. *Stock Market Prices, January 1985 to September 1990*
(Indices: 1985 = 100)

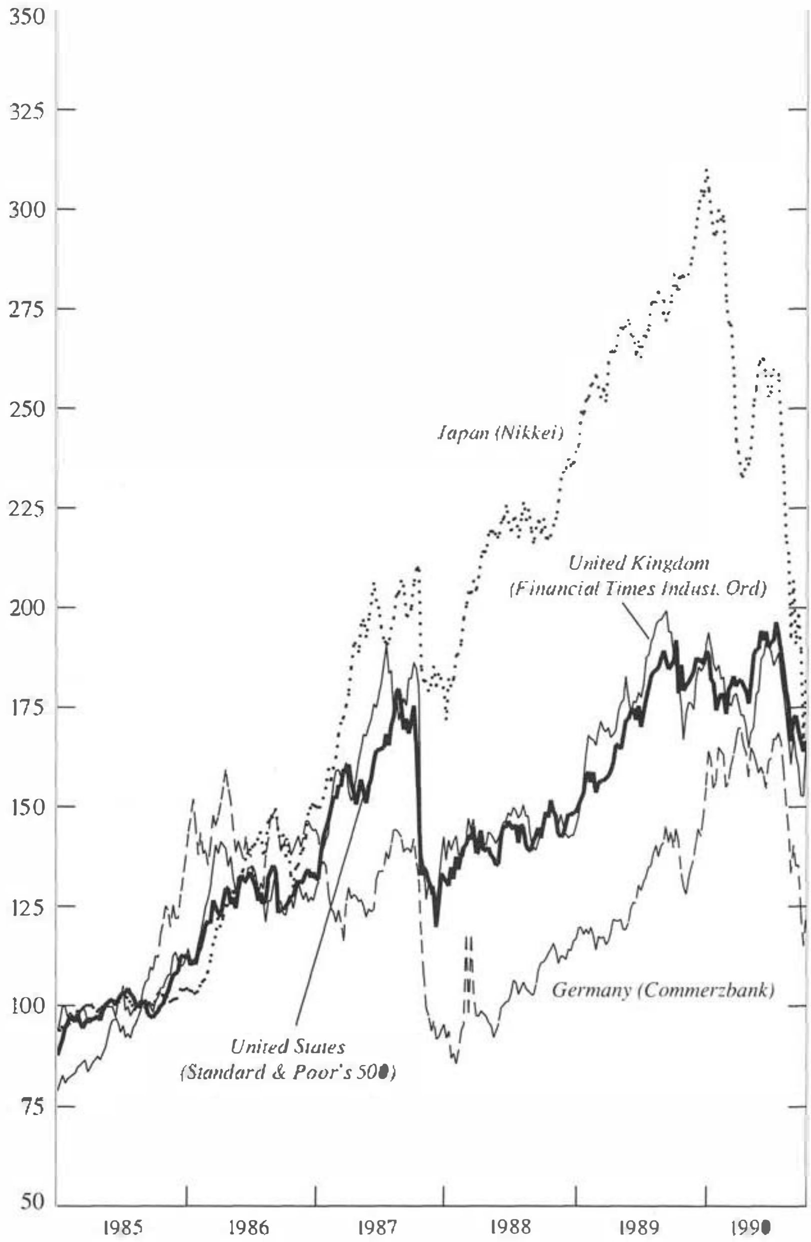
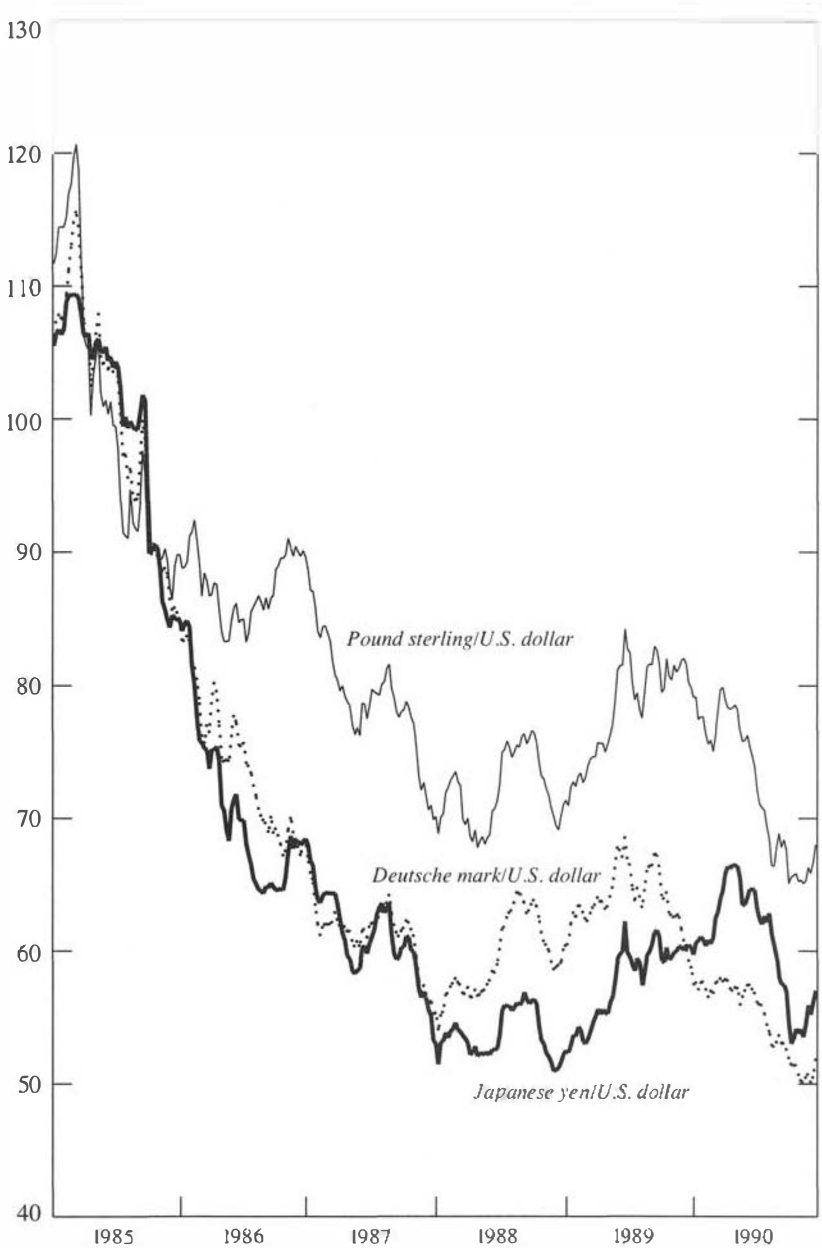


Figure 2. *U.S. Dollar Exchange Rates, January 1985 to December 1990*
(Indices: 1985 = 100)



and whether anticipation of such problems would cause the clearing and settlements system to collapse (Bernanke (1990)). It is hard to quantify the increase in uncertainty; however, one measure, the expected volatility implied by a comparison of equity and options prices, showed a dramatic increase in the United States in October 1987 (Figure 3).

Fear of financial collapse led governments and central banks to intervene by providing liquidity; moreover, they did so through closely coordinated actions. Of course, given the importance of the United States in world financial markets, the actions of the U.S. authorities were of paramount importance. The Federal Reserve reversed its tight monetary stance, flooding the system with liquidity; persuaded the banks to lend freely to securities firms; and closely monitored the situation, taking direct action where necessary (Bernanke (1990)). However, it did not act in isolation, according to Fed Chairman Alan Greenspan: "... we closely monitored the international ramifications of the stock market crash.... We communicated with officials of foreign central banks...." (U.S. Congress (1988, p. 92)). In describing the role of policy coordination among the major industrial countries in this period, Dobson (1991) says:

> The risk in 1987 was that, in the absence of close G-7 cooperation, the financial crisis could have turned into an economic crisis. Had the authorities turned their backs and refused to cooperate among themselves, it is very likely that the crisis would have deepened (p. 128).

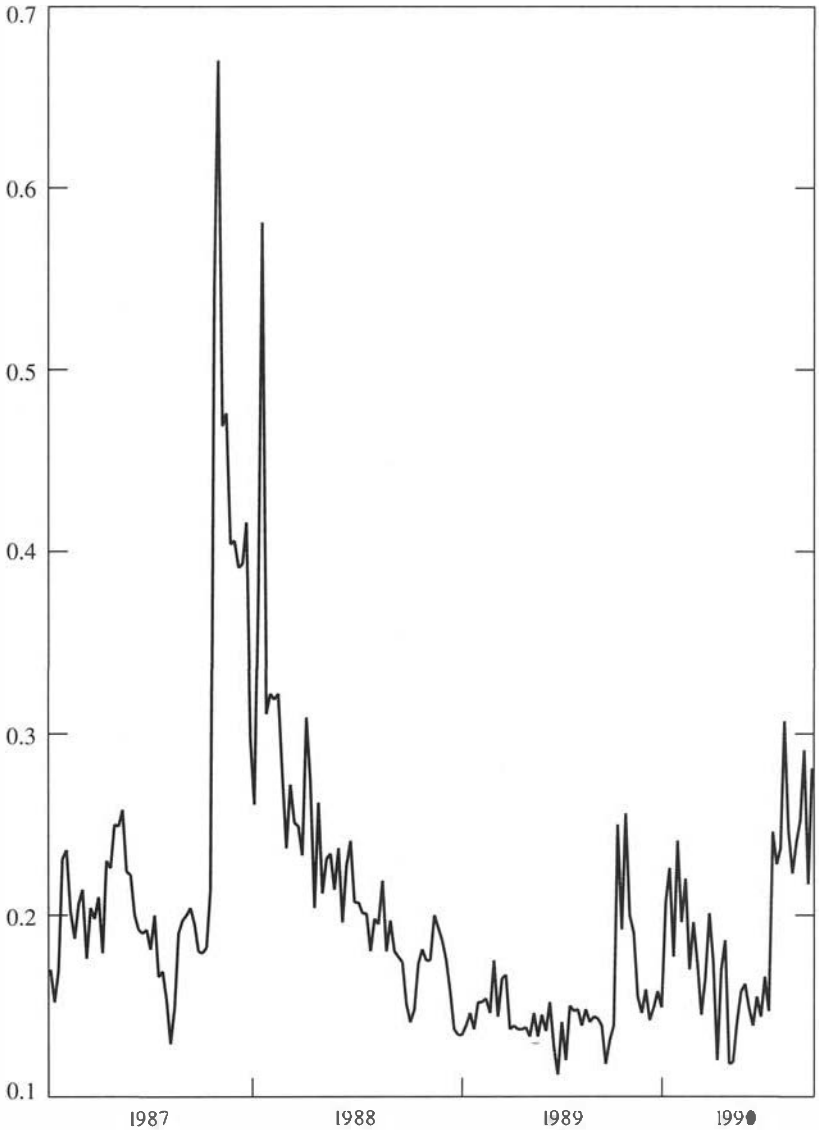
What occurred was a generalized decline in short-term interest rates as all central banks expanded liquidity (Figure 4). To some extent, a decline in interest rates on government paper (though not on private claims) might be expected from a "flight to quality," but central banks clearly favored a fall in rates, as indicated by Fed Chairman Alan Greenspan (U.S. Congress (1988)):

> By helping to reduce irrational liquidity demands, and accommodating the remainder, the Federal Reserve avoided a tightening in overall pressures on reserve positions and an increase in short-term interest rates. In fact, we went even further and eased policy moderately following the stock market collapse in light of the greater risk to continued economic expansion (p. 90).

In sum, therefore, the October 1987 stock market crash is an example of what appears to be a direct link between increased uncertainty and increased policy coordination. In describing the risks to the clearing and settlement system posed by the October 1987 crash and other events, the Governor of the Bank of Canada stated (Crow (1990)):

> These disturbances, and others since, were effectively contained through co-operation among major market participants ... [T]he temporary injection of liquidity by central banks ... helped to prevent the October 1987

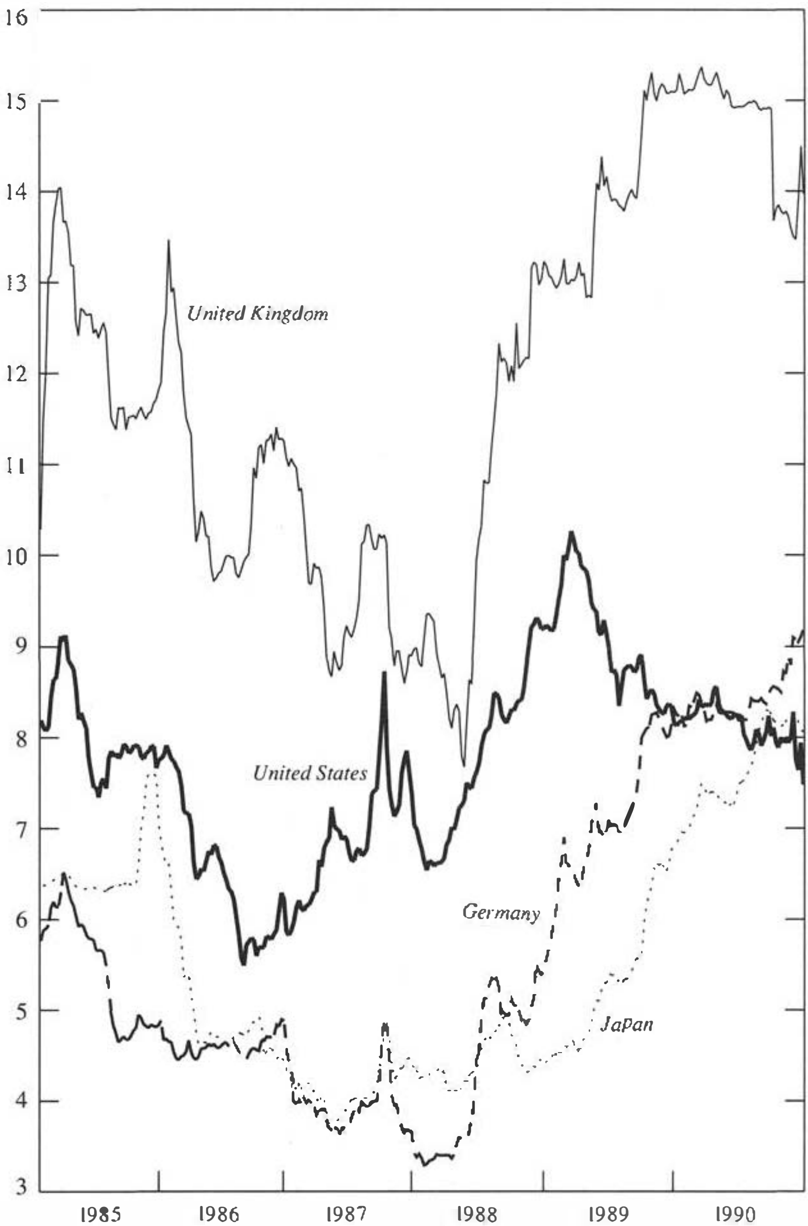
Figure 3. *Implied Volatility of Standard and Poor's 500, January 1, 1987 to October 12, 1990*



Source: Salomon Brothers.

Note: Calculated using the Black-Scholes option price formula, adjusted for dividend payments and using the price of a put option on the Standard and Poor's 500 Stock Index and the interest rate on U.S. Treasury Bills.

Figure 4. *Short-Term Interest Rates, January 1985 to December 1990*
(In percent per year)



> financial problems from degenerating into solvency problems. In retrospect, it is clear that the global community has come altogether too close to situations where market difficulties could have been severe enough to inflict lasting damage on financial markets and even on national economies (p. 2).

The model developed above has suggested that the need for policy coordination might have been even greater if the portfolio shifts had been less symmetric, for instance, if the fall in equity prices had been associated with severe weakness of the U.S. dollar. In this case, the Federal Reserve might have been much less willing to expand liquidity, for fear of adding to a run on the dollar. In cases such as these, a coordinated decline in interest rates in all countries would diminish the risk of disruptive exchange rate movements while minimizing the dangers of financial collapse.

IV. Conclusions

The paper has illustrated in a simple model the link between uncertain portfolio preferences of private investors and the difference between coordinated and uncoordinated policies. Greater uncertainty makes coordination more desirable in this example where portfolio shifts generate variations in output and exchange rates. The analysis suggests that if the perceived degree of uncertainty varies over time—perhaps as described in recent articles, for instance, by Flood, Bhandari, and Horne (1989)—then the incentives to coordinate policies will also vary. In particular, in situations of great uncertainty, where the prevailing international monetary system is threatened, policies are more likely to be influenced by shared goals.

In the particular source of uncertainty that is considered in the paper—uncertainty on the part of policymakers about the portfolio preferences of private investors—the degree of correlation across countries of portfolio shifts between equities and money is crucial in determining the gains from policy coordination. That conclusion is likely to remain in more general models with a wider menu of traded assets, in which portfolio shifts may also occur between different countries' equities and bonds. Paradoxically, if portfolio shifts are expected to be correlated across countries—as was the case with the shift out of equities at the time of the October 1987 crash—they may not require policy coordination to the extent that less symmetric portfolio preference shifts would. Of course, what is important is policymakers' anticipations of the degree of correlation of portfolio shifts; these anticipations are unlikely to involve perfect correlation. Thus, uncertainty about investors' preferences is at times likely to provide a powerful incentive to coordinate policies internationally.

APPENDIX

Solution of the Model

The solution for the variables that are of interest—it is assumed that policymakers have targets for domestic output and consumer prices—can be obtained as follows. Domestic output prices (but not consumer prices) are fixed in the current period. From equations (5) and (5′) in the text

$$P^* = P/s. \tag{17}$$

As a result, from equations (1), (8), and (17)

$$C = \rho(M/m)/P \tag{18}$$

$$C^* = s\rho(M^*/m^*)/P. \tag{18′}$$

From the conditions for goods market equilibrium, equations (10) and (10′)

$$y = 0.5\,[\rho M/m + s\rho M^*/m^*]/p \tag{19}$$

$$y^* = 0.5\,[\rho(M/m)/s + \rho M^*/m^*]/p^*. \tag{19′}$$

Turning to equilibrium in financial markets, substituting equations (9) and (9′) into (11) yields

$$qP = [(1 - m)M/m + (1 - m^*)sM^*/m^*]/(K + K^*). \tag{20}$$

Now the balance of payments equilibrium can also be expressed in terms of s and q; from equations (12)–(14)

$$qP(E - K) = 0.5\rho(sm^*/m^* - M/m). \tag{21}$$

Substitution of equations (9) and (20) into (21) yields an expression for s in terms of money supplies, portfolio preferences, and initial endowments of equities:

$$s = \{(1 - m)[K^*/(K + K^*)]M/m + 0.5\rho M/m\}/\{(1 - m^*) \cdot [K/(K + K^*)]M^*/m^* + 0.5\rho M^*/m^*\}. \tag{22}$$

In keeping with our assumption of symmetry, we further posit that initial endowments of the international equity are equal, so that $K/(K + K^*) = 0.5$. Therefore, the exchange rate can be written as

$$s = [(M/m)(1 - m + \rho)]/[(M^*/m^*)(1 - m^* + \rho)]. \tag{23}$$

Thus, for given portfolio preferences, the exchange rate is determined by relative money supplies; a shift out of equities into money (an increase in m) will tend to appreciate the currency (lower s).

Using the expression for s, reduced-form expressions can be derived for domestic and foreign outputs. From equation (19)

$$y = \rho(M/m)\{[1 - 0.5(m + m^*) + \rho]/(1 - m^* + \rho)\}/p \tag{24}$$

and from equation (19′)

$$y^* = \rho(M^*/m^*)\{[1 - 0.5(m + m^*) + \rho]/(1 - m + \rho)\}/p^*. \tag{24′}$$

It will be assumed that it is not possible to go short in equities, so that $1 - m > 0$ and $1 - m^* > 0$. Therefore, the terms in braces in (24) and (24′) are positive,

implying that an increase in the money supply in the home country increases output:

$$\partial y/\partial M > 0 \qquad \text{and} \qquad \partial y^*/\partial M^* > 0,$$

while an increase in the desire to hold domestic money decreases it:

$$\partial y/\partial m < 0 \qquad \text{and} \qquad \partial y^*/\partial m^* < 0.$$

In contrast, portfolio shifts abroad have the opposite effect (that is, they are negatively transmitted); it can be shown that

$$\partial y/\partial m^* > 0 \qquad \text{and} \qquad \partial y^*/\partial m > 0.$$

The first-order condition for optimal policy setting in the home country can be derived in the following way. Let $n = 1/m$, $n^* = 1/m^*$, and $F(n,n^*) = [(\rho + 1)n - 1]/[(\rho + 1)n^* - 1]$, and note that both the numerator and denominator of F are positive, from the assumption made above that portfolio shares must be positive. From equations (23) and (24) above

$$\begin{aligned}\partial L/\partial M = E\{&0.5M[n + n^*F(n,n^*)]^2/\overline{M}^2\overline{n}^2 \\ &-[n + n^*F(n,n^*)]/\overline{M}\overline{n} + \phi[F(n,n^*)/M^*] \\ &-\phi[F(n,n^*)/M^*M]^{1/2}\} = 0. \end{aligned} \tag{25}$$

Given the assumptions of symmetry, implying that $F(n^*,n) = 1/F(n,n^*)$, the foreign country's first-order condition is similar, and is not presented here.

Consider an equal change in the two countries in portfolio preferences, such that the desired wealth proportion held in the form of money rises equally—that is, n and n^* fall by the same amount. It is clear that, starting from the same position, the optimal policy response to the same portfolio shock will be the same in the two countries, so that $M = M^*$. Replacing M^* and M by M'', the common noncooperative policy setting, the following is obtained from (25):

$$\begin{aligned}M'' = 2[\overline{M}\overline{n}]&E[n + n^*F(n,n^*)]/E[n + n^*F(n,n^*)]^2 \\ &-[2\phi/M'']\{EF(n,n^*) - E[F(n,n^*)]^{1/2}\} \\ &\cdot \overline{M}^2\overline{n}^2/E[n + n^*F(n,n^*)]^2. \end{aligned} \tag{26}$$

If, instead, the two governments coordinate and minimize a joint objective function, G, that gives equal weights to L and L^*, then the first-order condition for the use of the home country's money supply instrument is

$$\begin{aligned}\partial G/\partial M = E\{&0.5M[n + n^*F(n,n^*)]^2/\overline{M}^2\overline{n}^2 \\ &-[n + n^*F(n,n^*)]/\overline{M}\overline{n} + \phi[F(n,n^*)/M^*] \\ &-\phi[F(n,n^*)/M^*M]^{1/2} - \phi F(n^*,n)(M^*/M^2) \\ &+\phi(MM^*)^{1/2}[F(n^*,n)]^{1/2}/M\} = 0. \end{aligned} \tag{27}$$

Not surprisingly, the first-order condition for M^* is symmetrical, and therefore it will not be presented. Solving (27) for the common coordinated money supply setting M^c

$$\begin{aligned}M^c = [2\overline{M}\overline{n}]&E[n + n^*F(n,n^*)]/E[n + n^*F(n,n^*)]^2 \\ &-[\overline{M}^2\overline{n}^2\phi/M^c]\{E[F(n,n^*)] - E[F(n,n^*)]^{1/2} \\ &-E[F(n^*,n)] + E[F(n^*,n)]^{1/2}\}. \end{aligned} \tag{28}$$

Equation (28) simplifies further in the case (assumed here) where the distributions describing portfolio preference parameters are the same in the two countries, although not necessarily their realizations. In this case, $EF(n,n^*) = EF(n^*,n)$ and $EF(n,n^*)^2 = EF(n^*,n)^2$. Therefore, the term in equation (28) between braces is zero, and the cooperative monetary policy is given by

$$M^c = [2\overline{M}\bar{n}]E[n + n^*F(n,n^*)]/E[n + n^*F(n,n^*)]^2. \tag{29}$$

In this case, although each country's objective includes inflation and, hence indirectly, the exchange rate (and both countries' inflation targets are included symmetrically in G), the exchange rate plays no role in the cooperative monetary policy: the latter, given by equation (29), is independent of the value of ϕ.

What is the effect of increased liquidity preference in the two countries under each policy regime? First, assume *absence of uncertainty*. In this case, since $n = n^* = \theta\bar{n} < \bar{n}$

$$EF(n,n^*) = EF(n^*,n) = E[F(n,n^*)]^{1/2} = E[F(n^*,n)]^{1/2} = 1$$

and

$$E[n + n^*F(n,n^*)] = 2\theta n.$$

It can be verified from equations (26) and (29) that

$$M^n = M^c = \overline{M}/\theta, \tag{30}$$

so that both policy regimes fully accommodate the shift in liquidity preference. In the absence of uncertainty, no negative exchange rate repercussions are to be feared from a symmetric portfolio shift.

Next, consider the effect of an increase in uncertainty in the two policy regimes, starting from the initial position with a common monetary policy stance, $M = M^* = \overline{M}$, and letting $E(n) = E(n^*) = \bar{n}$. The only element of uncertainty will relate to the common variance of n; that is

$$E(n - \bar{n})^2 = E(n^* - \bar{n})^2 = \sigma^2.$$

In order to evaluate expressions on the right-hand sides of equations (26) and (29), first, take a second-order Taylor series expansion of $F(n,n^*)$ and $F(n,n^*)^{1/2}$ around $E(n) = \bar{n}$, and $E(n^*) = \bar{n}$, and take expectations (letting $\text{var}(n) = \text{var}(n^*) = \sigma^2$, $\text{cov}(n,n^*) = \kappa\sigma^2$, and $\beta = [(\rho + 1)\bar{n} - 1]^{-2}$):

$$EF(n,n^*) \doteq 1 + (\rho + 1)^2\beta(1 - \kappa)\sigma^2 \tag{31}$$

$$EF(n,n^*)^{1/2} \doteq 1 + (\rho + 1)^2\beta(1 - \kappa)\sigma^2/4. \tag{32}$$

From approximations (31) and (32) it can be shown that

$$EF(n,n^*) - EF(n,n^*)^{1/2} \doteq 3(\rho + 1)^2\beta\sigma^2(1 - \kappa)/4 \geq 0 \tag{33}$$

$$E[n + n^*F(n,n^*)] \doteq 2\bar{n} + (\rho + 1)\beta\sigma^2(1 - \mu) \tag{34}$$

$$E[n + n^*F(n,n^*)]^2 \doteq 4\bar{n}^2 + 4\sigma^2 + 2[4(\rho + 1)\bar{n} - 1]\beta\sigma^2(1 - \kappa). \tag{35}$$

From equations (26), (29), and (31)–(35), it can be shown that increased uncertainty (a larger σ^2) makes both noncooperative and cooperative policies more contractionary, but it increases the gap between them (unless $\kappa = 1$); evaluated at $\sigma^2 = 0$

$$\frac{dM^c}{d\sigma^2} - \frac{dM^n}{d\sigma^2} = \frac{(\phi/2)\overline{M}}{1 + \phi/2}[(3/4)(\rho + 1) + 1/2\bar{n}](\rho + 1)\beta(1 - \kappa) > 0.$$

Thus, a moderate amount of uncertainty will imply gains from coordination. The general case is ambiguous, however; starting from a position where $\sigma^2 > 0$, the effect of additional uncertainty cannot be signed.

REFERENCES

Artis, Michael, and Sylvia Ostry, *International Economic Policy Coordination*, Chatham House Papers No. 30 (London: Royal Institute of International Affairs, 1986).

Bernanke, Ben S., "Clearing and Settlement During the Crash," *Review of Financial Studies*, Vol. 3, No. 1 (1990), pp. 133–51.

Bertero, Elisabetta, and Colin Mayer, "Structure and Performance: Global Interdependence of Stock Markets Around the Crash of October 1987," CEPR Discussion Paper No. 307 (London: Centre for Economic Policy Research, March 1989).

Brainard, William C., "Uncertainty and the Effectiveness of Policy," *American Economic Review*, Vol. 57 (May 1967), pp. 411–25.

Cooper, Richard N., "Economic Interdependence and Coordination of Economic Policies," in *Handbook of International Economics*, ed. by Ronald W. Jones and Peter B. Kenen, Vol. 2 (Amsterdam; New York: North-Holland, 1985).

Crow, John W., "Notes for Remarks by the Governor of the Bank of Canada at the Treasury Management Association of Canada's Eighth Annual Cash and Treasury Management Conference in Toronto on 7/11/90," *BIS Review*, No. 231 (November 26, 1990), pp. 1–6.

Currie, David, Paul Levine, and Nic Vidalis, "International Cooperation and Reputation in an Empirical Two-Bloc Model," in *Global Macroeconomics: Policy Conflict and Cooperation*, ed. by Ralph C. Bryant and Richard Portes (New York: St. Martin's Press, 1988).

Diamond, Peter A., "The Role of a Stock Market in a General Equilibrium Model with Technological Uncertainty," *American Economic Review*, Vol. 57 (September 1967), pp. 759–76.

Dobson, Wendy, *Economic Policy Coordination: Requiem or Prologue?*, Policy Analyses in International Economics No. 30 (Washington: Institute for International Economics, 1991).

Federal Reserve Bank of New York, *Quarterly Review*, Vol. 13 (Summer 1988).

Feldstein, Martin, "Distinguished Lecture on Economics in Government: Thinking about International Economic Coordination," *Journal of Economic Perspectives*, Vol. 2 (Spring 1988), pp. 3-13.

Flavin, Marjorie, "Excess Volatility in the Financial Markets: A Reassessment of the Empirical Evidence," *Journal of Political Economy*, Vol. 91 (December 1983), pp. 929–56.

Flood, Robert P., Jagdeep S. Bhandari, and Jocelyn P. Horne, "Evolution of Exchange Rate Regimes," *Staff Papers*, International Monetary Fund, Vol. 36 (December 1989), pp. 810–35.

Flood, Robert P., and Robert J. Hodrick, "Asset Price Volatility, Bubbles, and Process Switching," *Journal of Finance*, Vol. 41 (September 1986), pp. 831–42.

Frankel, Jeffrey, and Katharine Rockett, "International Macroeconomic Policy Coordination when Policymakers Do Not Agree on the True Model," *American Economic Review*, Vol. 78 (June 1988), pp. 318–40.

Ghosh, Atish R., and Swati R. Ghosh, "Does Model Uncertainty Really Preclude International Policy Coordination?" *Journal of International Economics*, Vol. 31 (November 1991), pp. 325–40.

Ghosh, Atish R., and Paul R. Masson, "International Policy Coordination in a World with Model Uncertainty," *Staff Papers*, International Monetary Fund, Vol. 35 (June 1988), pp. 230-58.

Helpman, Elhanan, and Assaf Razin, "Uncertainty and International Trade in the Presence of Stock Markets," *Review of Economic Studies*, Vol. 45 (June 1978), pp. 239–50.

Kenen, Peter B., "Exchange Rates and Policy Coordination in an Asymmetric Model," CEPR Discussion Paper No. 240 (London: Centre for Economic Policy Research, May 1988).

Martinez Oliva, Juan Carlos, and Stefan Sinn, "The Game-Theoretic Approach to International Policy Coordination: Assessing the Role of Targets," *Weltwirtschaftliches Archiv*, Band 124, Heft 2 (1988), pp. 252–68.

Oudiz, Giles, and Jeffrey Sachs, "Macroeconomic Policy Coordination Among the Industrial Economies," *Brookings Papers on Economic Activity: 1* (Washington: The Brookings Institution, 1984).

Sachs, Jeffrey, "The Dollar and the Policy Mix: 1985," *Brookings Papers on Economic Activity: 1* (Washington: The Brookings Institution, 1985).

Schwartz, Anna J., "The 1987 U.S. Stock Market Crash," *Economic Affairs*, Vol. 8 (February/March 1988), pp. 7–10.

Shiller, Robert J., "Do Stock Prices Move Too Much To Be Justified by Subsequent Changes in Dividends?" *American Economic Review*, Vol. 71 (June 1981), pp. 421–36.

Simon, Herbert A., "Dynamic Programming Under Uncertainty with a Quadratic Criterion Function," *Econometrica*, Vol. 24 (January 1956), pp. 74–81.

U.S. Congress, Committee on Banking, Housing, and Urban Affairs, "'Black Monday,' the Stock Market Crash of October 19, 1987: Hearings Before the Committee on Banking, Housing, and Urban Affairs, February 2, 3, 4, and 5, 1988" (Washington: Government Printing Office, 1988).

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Fisherian Transmission and Efficient Arbitrage Under Partial Financial Indexation

The Case of Chile

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Partial financial indexation in Chile has produced a system in which most bank deposits are 30-day nonindexed deposits or 90-day indexed deposits. This paper uses data on the interest rates of these financial assets to test the joint hypothesis of rational expectations, efficient arbitrage, and a time-invariant liquidity premium. The data are also used to test whether the indexed/nonindexed interest spread is an accurate predictor of future changes in inflation, as the Fisher effect dictates. The significant implications of this empirical analysis for monetary policy are discussed. [JEL E44, E43, E52]

> All variations in the value of the circulating medium are mischievous: they disturb existing contracts and expectations, and the liability to such changes renders every pecuniary engagement of long date entirely precarious.
>
> —John Stuart Mill (1848, p. 544)

THIS PAPER studies the mechanism of partial financial indexation currently operating in Chile. The analysis focuses on the behavior of interest rates on indexed and nonindexed bank deposits, to determine whether there is arbitrage in financial markets and whether interest rate

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differentials contain significant information for forecasting inflation. A variation of traditional market efficiency tests, as reviewed in Begg (1982), is used to explore the empirical relevance of the joint hypothesis that there is efficient arbitrage in financial markets, that expectations of inflation are formed rationally, and that indexed deposits bear a premium attributed to liquidity considerations or imperfect indexation. Simple econometric methods are also used to explore whether expectations of inflation are fully transmitted to nominal interest rates, as the Fisher effect indicates. Specifically, empirical tests are performed to show whether the interest spread between indexed and nonindexed deposits is an accurate predictor of future increases in inflation, following the work of Fama (1990) and Mishkin (1990).

The empirical analysis undertaken in this paper has significant implications for key operational issues related to the desirability of indexing the financial system and the conduct of monetary policy. In particular, the results of the econometric work give some support to the view that financial indexation diminishes the risks associated with inflation and does not necessarily induce an unjustified increase in interest rates. Moreover, the results suggest that the quoted real rate of return on indexed assets cannot be treated as a proxy for the relevant real interest rate of the economy, and that the interest rate spread between indexed and nonindexed assets is a better indicator of the public's perception of the stance of monetary policy.

The analysis of the Chilean experience is also useful as an empirical complement to the protracted debate on the effects of financial indexation, which is closely related to the recurrent controversy involving the costs of inflation.[1] Advocates of financial indexation argue that indexed financial assets, by neutralizing the effects of unanticipated inflation, eliminate income-redistribution effects induced by inflation and the inflation-risk component of nominal interest rates. Thus, indexation reduces the degree of uncertainty affecting credit transactions and facilitates the operation of financial markets under inflationary conditions. In

[1] The adverse effects of inflation on the distribution of income between creditors and debtors and on the degree of uncertainty affecting credit markets have long been a cause of concern (see Mill (1848, chap. XIII)). Two classic papers on indexation and the costs of inflation are Friedman (1974) and Gray (1976). For a textbook discussion of financial indexation, see Gordon (1978), and for wage indexation, see Parkin and Bade (1988). The advantages of financial indexation are explored from the perspective of the more recent intertemporal equilibrium approach by Calvo and Guidotti (1989). The risk of indeterminacy of the price level due to excessive inertia and other issues regarding the public's aversion to indexed contracts and the determination of the relevant price index are reviewed by Leijonhufvud (1981).

contrast, critics of financial indexation argue that indexing the financial system fuels the inflationary process by speeding up price changes.[2] Moreover, when coexisting with nonindexed labor and goods markets, financial indexation causes income-redistribution effects that affect those firms and households facing indexed debts with nonindexed revenue and income streams.[3]

Many of the arguments for and against financial indexation can be simply stated in terms of the Fisher effect, according to which the nominal interest rate, i, is equivalent to the ex ante real interest rate, r, plus expected inflation, p^e: $i = r + p^e$. For a given ex ante real rate of interest, the Fisher effect dictates that a higher nominal interest rate applies to financial transactions if prices are expected to rise. The case in favor of financial indexation can be presented by considering an environment in which errors in inflationary expectations are not made systematically and markets operate efficiently. Under these conditions, the Fisher effect implies that the evolution of interest rates in an indexed system cannot deviate *systematically* from the evolution of interest rates in a nonindexed system. The main advantage of indexation is that it flattens the term structure of interest rates, because risk premia associated with the variance of errors in forecasting inflation are eliminated, thereby easing the operation of financial markets under conditions of high and variable inflation.

The case against financial indexation is often based on the hypothesis that full Fisherian transmission never takes place, because expectations underestimate inflation systematically, or that there is no efficient arbitrage in financial markets to eliminate the inflation-risk component of interest rates. Thus, indexation forces nominal interest rates to be higher than under normal market conditions and induces persistent disturbances to the cost of credit and the demand for real money balances. The demand for money fluctuates because of the rise in interest rates and also because indexation sends destabilizing signals that fuel inflationary expectations even if fundamentals remain unaltered.

[2] A stronger version of this critique, as explained by Leijonhufvud (1981), argues that because indexation is equivalent to forcing price expectations to exhibit unitary elasticity, any small price change could cause an exploding inflationary spiral. However, advocates of financial indexation have shown that although changes in inflation are likely to be larger in indexed economies, the price level and inflation are well defined and stable as long as the supply of money is not fully indexed (see Parkin and Bade (1986)).

[3] Critics of indexation would argue that the social costs of the redistributive effects that occur when interest rates are not indexed are less important than those that occur under a partial indexation system. Issues related to income redistribution and its social cost are not addressed in this paper.

As these arguments show, the conflicting views about financial indexation are founded on different notions regarding the efficiency of credit markets and the manner in which individuals formulate expectations about future inflation. In economies where financial markets are well organized and competitive, and where market participants formulate expectations rationally, indexation eliminates the inflation-risk component of interest rates and cannot result in systematically higher interest rates than a system without indexation. The empirical tests undertaken in this paper attempt to establish to what extent Chilean financial markets fit this framework, by providing evidence on the degree to which there is efficient arbitrage, and by testing the forecasting power of interest rate differentials regarding future increases in inflation implicit in the Fisher effect.

The paper is organized as follows. The next section describes the operation of Chile's financial indexation mechanism, with a brief description of its role in the banking crash of 1983, and illustrates its impact on the structure of the deposit base of the banking system. Section II studies arbitrage conditions in the financial system, taking advantage of the existing regulations that force short-term nonindexed assets to coexist with medium- and long-term indexed assets. Section III analyzes the information contained in the interest rate spread between indexed and nonindexed time deposits regarding future changes in the inflation rate, and also provides some evidence on the real interest rate that is relevant for financial decisions. The last section presents conclusions.

I. Chile: Indexation and Financial Markets

The first part of this section describes how financial indexation operates in Chile, focusing on some of the imperfections of the mechanism being used. The second part offers a brief review of the characteristics of the Chilean financial system that help illustrate the effects of the indexation regime.

Financial Indexation in Chile

Financial indexation in Chile is based on the use of a unit of account known as the "Unidad de Fomento" (UF), or development unit. The UF operates as an exchange rate between Chilean pesos and development units that is linked to the inflation rate with a delay of approximately one month and serves to denominate all indexed financial transactions. A typical indexed time deposit operates as follows. The deposit is entered

by converting the amount in Chilean pesos into development units at the current UF exchange rate. Interest is paid on the balance denominated in UF on the basis of an annual rate compounded monthly. This interest rate will be referred to as the "premium over UF" throughout the rest of the paper. Upon maturity, principal and interest are converted back into Chilean pesos at the corresponding UF exchange rate. The deposit is indexed because the value of the UF grows each month at about the same rate as last month's inflation, and for this reason the premium over UF is viewed as a real interest rate.

The timing and methodology by which the value of the UF are adjusted have important implications. The UF begins to be adjusted on the tenth day of month t, by a proportional amount each day, to ensure that by the ninth day of month $t + 1$ it has increased by as much as the price level did in month $t - 1$. Figure 1 depicts the ex post nominal yield that was actually paid on 90-day indexed time deposits, as a 3-month percentage rate that considers both the interest rate and the observed change in the UF, and the ex post 90-day inflation rate. The figure illustrates the degree of imperfection affecting the adjustment of the yield on indexed deposits to inflation because of the 1-month lag imbedded in the indexation mechanism.

Figure 1. *Ex Post Indexed Interest and Inflation, August 1986 to April 1989*
(90-day to 1-year deposits)

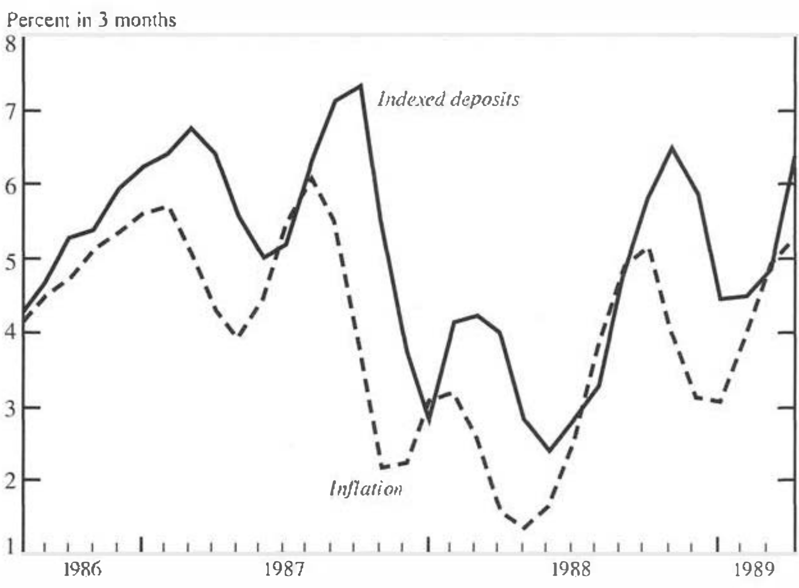
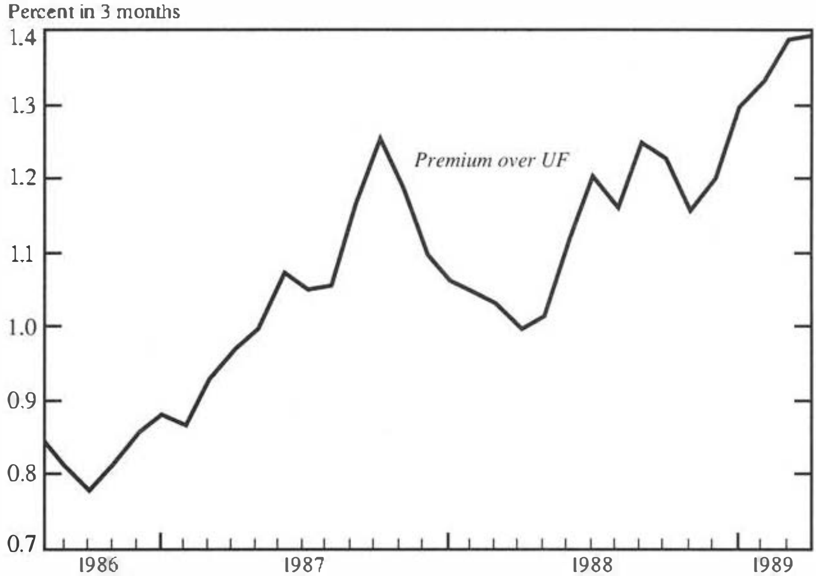


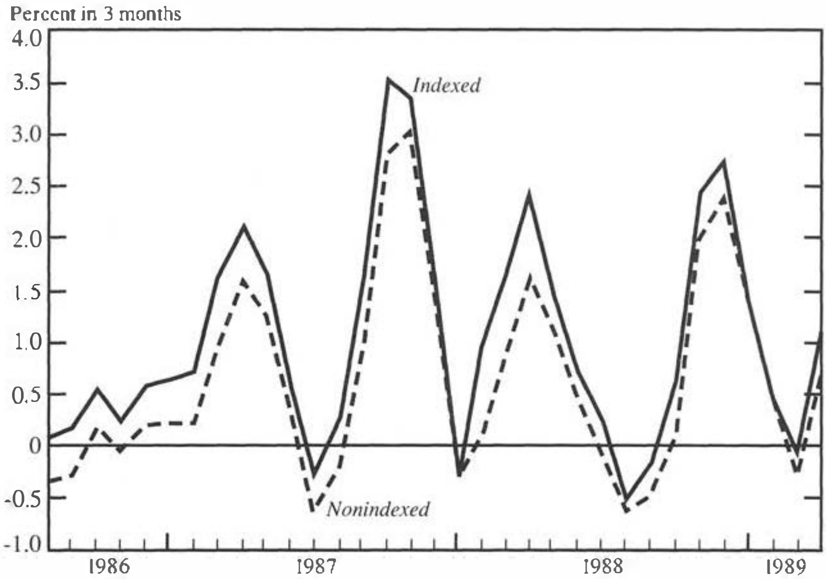
Figure 2. *Effective Premium on Indexed Deposits, August 1986 to April 1989*
(90-day to 1-year deposits)



The imperfection of the indexation mechanism is also reflected in the fact that, as shown in Figures 2 and 3, the premium over UF and the ex post real interest rate on indexed assets are not equivalent, as they should be under a perfect indexation system.[4] Figure 2 presents the premium over UF quoted on 90-day indexed time deposits as a percentage rate over 3 months. Figure 3 depicts the ex post real interest rates actually paid on 30-day nonindexed and 90-day indexed deposits as a percentage rate over 3 months (for 90-day indexed deposits, this ex post real interest rate corresponds to the difference between the two curves in Figure 1). As Figures 2 and 3 show, there is a significant discrepancy between the premium over UF and the ex post real interest rate paid on 90-day indexed deposits. For instance, in March 1989 a 90-day indexed time deposit offered a premium over UF of about 1.4 percent (5.7 percent on

[4] The ex post real interest rate on a 90-day indexed time deposit entered at date t is computed as the difference between the effective yield, which is the sum of the premium over UF quoted at t, plus the change in the value of the UF in the 90 days following t, and the inflation observed 90 days after t. The premium over UF is quoted in annual terms and compounds monthly. The rates in Figures 1–3 are returns over a period of 3 months.

Figure 3. *Ex Post Real Interest Rates, August 1986 to April 1989*
(30-day to 89-day and 90-day to 1-year deposits)



an annual basis), but the real return of this investment was in fact slightly negative. However, because the relevant real interest rates for economic decisions are the ex ante rates, which incorporate expectations of inflation rather than actual inflation, it is necessary to explore whether the premium over UF differs from the ex ante real interest rate on indexed deposits. This issue will be taken up later.

The Chilean indexation mecbanism was complemented with a set of regulations that govern the coexistence of indexed and nonindexed deposits. These regulations prevent full indexation of the money supply, as well as complete displacement of the Cbilean peso from the financial system by risk-averse agents seeking insurance against inflation.[5] Indexed time deposits are allowed only for maturities of 90 days or longer, whereas nonindexed interest-bearing deposits are legal for maturities of 30 days. The treatment is slightly different with respect to loans; indexed

[5]These regulations are consistent with some of the recent literature on monetary legal restrictions—for example, Smith (1988)—in which restrictions prevent the private sector from issuing close substitutes for money, so as to avoid large price fluctuations and adjustments in financial markets.

loans are allowed for terms as short as 30 days, but nonindexed lending operations are legal for maturities of less than 30 days.

Indexation and the Chilean Financial System

In general, Chile's financial markets are viewed as well organized and free from the distortions that result from excessive direct government intervention in many developing countries. Financial transactions are subject to strict supervision by the *Superintendencia de Bancos e Instituciones Financieras* (Superintendency of Banks and Financial Institutions), which strengthened its regulatory role after the major financial crisis that occurred in 1983.

The 1983 crash resulted from the accumulation of a large stock of nonperforming assets in the banking system, apparently as a result of high real interest rates, high debt-to-equity ratios of business firms, poor risk management of the bank's assets, and a significant decline in economic activity during 1981–82. The subsequent sharp depreciation of the peso in 1982–83 caused further damage by generating widespread defaults on loans contracted in foreign currency, and by causing significant operational losses to banks financing loans denominated in domestic currency with resources borrowed in foreign currencies. After 1983 the financial system started to recover slowly from the crisis, following the gradual improvement in economic conditions and the adoption of policies aimed at increasing liquidity and restoring solvency.[6]

The role that the indexation system may have played in generating the 1983 crash must be evaluated with caution, and a thorough discussion of the issue is beyond the scope of this paper. Financial indexation had been in place without causing any major disturbance long before the crisis started; it was maintained throughout and continued after the crisis ended.[7] For firms and banks involved in industries with declining relative prices, indexed loans and deposits were an important factor contributing to liquidity problems and inability to repay debts. In this way, the indexation system helped to speed up the rate at which the crisis spread. However, the prices of goods sold by the average firm increased at least

[6] These policies included the intervention and closing of banks, provision of massive liquidity support by the Central Bank, temporary public guarantee of bank deposits, establishment of credit lines in support of private debtors, and a recapitalization program based on voluntary sale of a fraction of bad loans to the Central Bank.

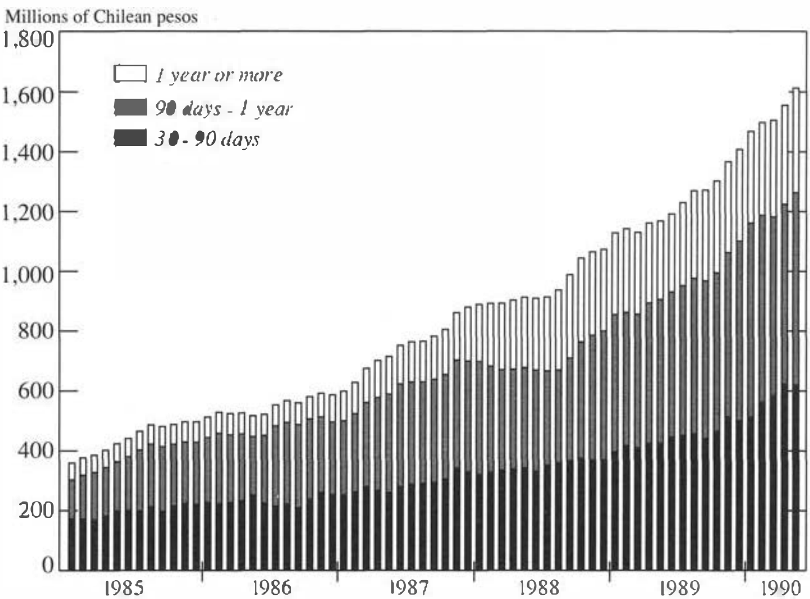
[7] Daily adjustments in the UF on the basis of the inflation from the previous month have been undertaken since 1977. The UF was first introduced in January of 1967 under a system of quarterly adjustments.

as fast as indexed debt commitments, and possibly faster because of the 1-month lag in the indexation system. Thus, it is likely that the widespread inability to service debts had more to do with the recession and poor banking practices than with indexation itself.[8] Moreover, by partially eliminating the risk of unanticipated inflation, financial indexation gave credibility to some of the policies used to attack the crisis, particularly the guarantee on bank deposits and the recapitalization programs.

There is evidence suggesting that financial indexation has induced important permanent changes in the structure of the Chilean financial system. In principle, partial financial indexation differentiates a subset of financial assets on the basis of the increased degree of protection against inflation that they provide. Consequently, risk-averse individuals are likely to reveal a preference for indexed assets in the allocation of their portfolio.

A review of the term structure of time deposits supports this hypothesis. Figure 4 illustrates the term structure of deposits in the financial

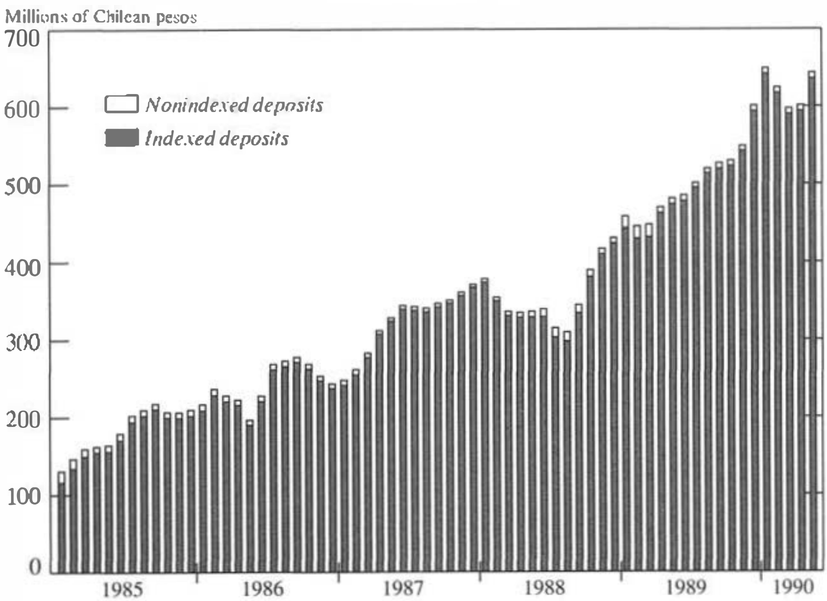
Figure 4. *Term Structure of Time Deposits, January 1985 to May 1990*
(Monthly averages)



[8]Unless it could be shown that a nonindexed system would have underestimated future inflation substantially in setting interest rates, resulting in lower interest rates than under indexation, it is likely that the chain of business failures would have followed in a similar manner even without indexation.

system using data on monthly average stocks of bank deposits for the period January 1986–May 1990. It shows that approximately 80 percent of all time deposits are concentrated in terms between 30 days and 1 year.[9] On average, 30- to 90-day deposits account for 38 percent of total time deposits, while 90-day to 1-year deposits account for 41 percent.[10] Figure 5 details the distribution of 90-day to 1-year deposits in terms of indexed and nonindexed deposits, and shows that the vast majority of them are indexed (about 98 percent on average).[11] Thus, the existing regime of partial financial indexation, operating in an environment of moderately high and variable inflation rates, has resulted in a market in which

Figure 5. *Structure of 90-Day Deposits, January 1985 to May 1990*
(Monthly averages)



[9]The secular growth in deposits with more than 1-year maturity reflects the growth of deposits from the pension funds, which should not be viewed as pertaining to the private sector but to nonbank financial intermediaries.

[10]Deposits in U.S. dollars are allowed for maturities of 30 days or longer, with adjustments in the exchange rate of the Chilean peso vis à vis the U.S. dollar that fluctuate around the difference between the movement of the UF and an estimate of foreign inflation. During the period January 1986–May 1990, these deposits were equivalent to less than one third of the total of deposits denominated in Chilean currency.

[11]A similar result is obtained from the data on total daily banking operations of time deposits.

depositors seek the best possible protection against inflation, which is found either in short-term, nonindexed deposits that are highly liquid, or in the most liquid indexed deposit available.

The fact that individuals hold substantial amounts of 30-day nonindexed deposits suggests that, in addition to liquidity considerations, they seem to regard them as relatively safe from the eroding effects of inflation. This may partly reflect the policy of setting an indicative nominal interest rate for 30-day deposits according to past and expected inflation plus a premium, which apparently was followed until June of 1987. However, as documented in the next section, efficient arbitrage with 90-day indexed deposits has also played a major role in ensuring that 30-day nonindexed deposits provide a good safeguard against inflation.

II. Efficient Arbitrage in Chilean Financial Markets

This section presents the results of some econometric tests that attempt to measure the degree of arbitrage present in Chilean financial markets. These tests focus on the effective rates of return paid on 30-day nonindexed and 90-day indexed time deposits. The rationale for dealing only with these two maturities is that, as noted above, the majority of time deposits in the Chilean financial system fall into these two categories.

Consider a perfectly competitive financial market in which there is no uncertainty. The public is endowed with perfect foresight regarding future values of short-term interest rates and the evolution of the UF, and arbitrage equalizes the ex post effective returns of 3-month investments on 30-day nonindexed deposits and a 90-day indexed deposit:

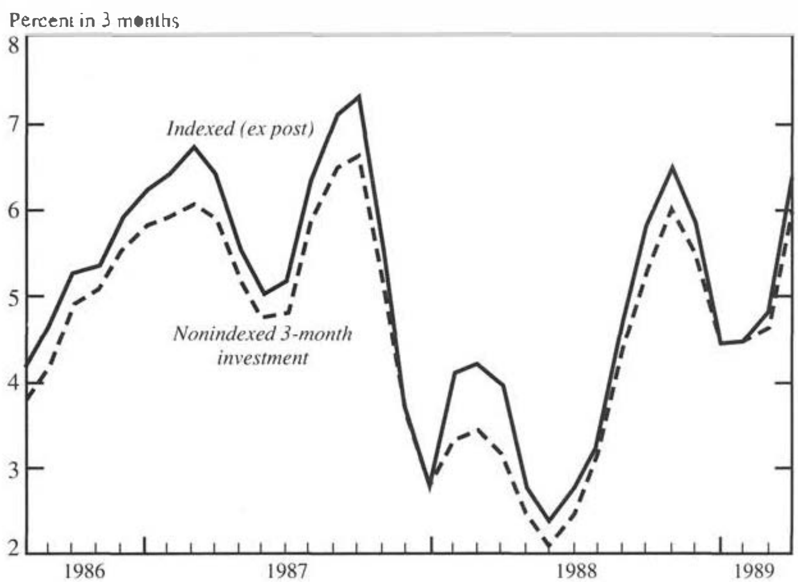
$$(1 + i_t)(1 + i_{t+1})(1 + i_{t+2}) = (1 + {}_tUF_{t+3})(1 + r_t). \tag{1}$$

The notation here is as follows: i_t is the monthly nominal interest rate on a 30-day nonindexed time deposit entered at date t, with i_{t+1} and i_{t+2} denoting the same rate as quoted 30 and 60 days after t; ${}_tUF_{t+3}$ is the percentage change actually observed in the UF in the 90 days following t; and r_t is the 90-day premium over UF quoted at date t on an indexed time deposit.[12] Thus, the left-hand side of equation (1) measures the actual effective yield of a 3-month investment in deposits with a maturity of 30 days, referred to here as *ex post nominal interest rate*, whereas the right-hand side measures the actual effective yield in Chilean pesos of a 3-month investment in a 90-day indexed deposit, referred to as *ex post indexed interest rate*.

[12]These rates are published in annual terms, but in evaluating equation (1), one must be aware that they are compounded monthly.

Figure 6 depicts the monthly evolution of the ex post nominal and indexed interest rates, as measured by the left- and right-hand sides of equation (1), respectively. The figure shows that both rates follow similar trends, although indexed deposits seem to be offered at a premium—the effective yield on indexed deposits is systematically higher than that on nonindexed deposits. Indexed deposits may need to be offered at a premium because the two financial assets are not perfect substitutes in terms of liquidity. For simplicity, this liquidity premium is assumed here to be a time-invariant constant. Moreover, indexed deposits may also offer a premium because the 1-month lag of indexation introduces an element of risk by making the real return on these deposits vary with the difference in the inflation rates between the month before the deposit is acquired and the month before it matures. When inflation rates are very volatile, or during turning points from increasing to decreasing inflation, this difference can be substantial and difficult to estimate. Thus, indexed deposits may pay a premium that follows a stochastic process determined by the agents' perception of the risk involved in the variance of monthly inflation due to imperfect indexation.

Figure 6. *Ex Post Nominal and Indexed Interest, August 1986 to April 1989*
(30-day to 89-day and 90-day to 1-year terms)



Even when the existence of a time-invariant liquidity premium is taken into account, the match of the two rates of return in equation (1) is not exact in actual data because the public and the banks do not know the future values of interest rates and the UF with certainty, and thus in practice expectations must replace the values of future variables in equation (1). Incorporating these arguments, taking logs of both sides of (1), and assuming that all rates involved are relatively small, the arbitrage condition can be rewritten as

$$i_t + E_t i_{t+1} + E_t i_{t+2} = E_t UF_{t+3} + r_t - LP. \tag{2}$$

Here, future short-term interest rates and the 3-month growth of the UF are expectations formed with the information available at date t,[13] and LP is a time-invariant liquidity premium on 90-day deposits.[14]

In order to perform formal econometric tests of arbitrage in Chilean financial markets using equation (2), it is necessary to introduce an assumption regarding the formation of expectations. The tests will analyze jointly efficient arbitrage, a time-invariant liquidity premium, and a particular hypothesis of how expectations are formed. The high degree of organization and development of Chilean financial markets suggests that both the banks and the public are potentially capable of forming an educated guess about future inflation by making extensive use of the information publicly available. Thus, the case of Chile provides a good basis for supporting the hypothesis that expectations of participants in financial markets are formed rationally.

If expectations are rational, forecasting errors are random variables that follow a stochastic process determined by how far in the future individuals must form expectations on the basis of the information available today. In the case that at period t expectations need to be formed for variables at $t + 1$, the errors follow a white-noise process, whereas in cases that require expectations for variables dated $t + 2$ or later, as in this paper, the errors follow a moving average representation.[15] Adding and

[13]This paper focuses on efficient arbitrage when expectations are formed on the basis of publicly available information, which in the finance literature is viewed as semistrong market efficiency since it ignores the role of "inside" information.

[14]Most of the econometric work discussed later in the paper only tests for the existence of this time-invariant liquidity premium, jointly with market efficiency and rational expectations, and cannot distinguish any form of stochastic premium associated with liquidity or the variance of inflation. Econometric results are viewed simply as evidence that the data can or cannot reject *this* joint hypothesis, despite the fact that other hypotheses may be observationally equivalent.

[15]The author thanks Charles Adams for clarifying this point.

subtracting the actual values of expected variables to equation (2) results in the following expression:

$$i_t + i_{t+1} + i_{t+2} = {}_tUF_{t+3} + r_t - LP + u_t, \tag{3}$$

where u_t is a random variable that includes forecasting errors with regard to future 30-day nonindexed interest rates (e^i_{t+1} and e^i_{t+2}) and the error in predicting the 90-day growth of the UF (e^{uf}_{t+3}), $u_t = e^i_{t+1} + e^i_{t+2} - e^{uf}_{t+3}$. Given the 1-month lag affecting the adjustments in the UF, it can be shown that u_t should follow a first-order moving average process in order to be consistent with rational expectations.[16] The moving average error reflects the fact that innovations in monthly interest rates or the UF that occur between date t and date $t + 3$ constitute information not available at t that is relevant for explaining the relative returns of the two investments.

The first test of the joint hypothesis of efficient arbitrage, rational expectations, and a time-invariant liquidity premium is conducted as follows. Expression (3) is rewritten to define the dependent variable as the ex post differential of the effective yields of the two investments in time deposits being considered, which is referred to as $DR9030F$. If the data support the hypothesis, $DR9030F$ should follow a stochastic process characterized as a first-order moving average with a constant term:

$$DR9030F \equiv (i_t + i_{t+1} + i_{t+2}) - ({}_tUF_{t+3} + r_t) = -LP + u_t, \tag{4}$$

with $u_t = v_t + \theta v_{t-1}$, and v_t is i.i.d. The test consists of identifying the time-series process that characterizes $DR9030F$ in the Chilean data to see if it satisfies the properties consistent with efficient arbitrage, rational expectations, and a time-invariant liquidity premium on indexed deposits. This test will only support or reject the three hypotheses jointly.

The time-series process corresponding to $DR9030F$ is identified following the Box-Jenkins method. The plots of the autocorrelation and partial autocorrelations show that the process is not white noise, with a Q-statistic = 47.7 for 25 lags, but do not provide a clear indication of the nature of the process. The results of estimating a first-order moving average (MA(1)) process with a constant using monthly Chilean data for the period August 1986 to April 1989 are the following:[17]

[16] Since $e^{uf}_{t+3} \equiv e^{\pi}_{t+1} + e^{\pi}_{t+2}$, where e^{π} is the forecasting error with regard to inflation, it follows that, assuming that i and π are white noise, $\text{cov}(U_t U_{t+1}) = \sigma^2_i + \sigma^2_{\pi}$, where σ^2_i and σ^2_{π} are the variances of the forecasting errors related to interest rates and inflation; and $\text{cov}(U_t U_{t+k}) = 0$ for all $k > 1$.

[17] The numbers in brackets in all regression results are t-statistics; those marked with an asterisk (*) are significant at the 5 percent level. The hypothesis of zero autocorrelation of regression residuals for up to ten lags was tested using the method of Box and Jenkins.

$$DR9030F = \underset{(-11.05)^*}{-0.353} + \underset{(2.762)^*}{0.496v_{t-1}} + v_t$$

$$\text{Adj. } R^2 = 0.234 \qquad \text{DW} = 1.793 \qquad \text{SE} = 0.183 \qquad F = 10.77.$$

(In this and succeeding regression results, adj. R^2 is the adjusted coefficient of determination, DW is the Durbin-Watson statistic, and SE is the standard error.)

These results show that the data give some support to the joint hypothesis stated above, but formally the hypothesis is rejected because the residuals, v_t, are not white noise. Estimation of an MA(1) process with a constant produces a time-invariant liquidity premium that is very close to the average of $DR9030F$ in the data, -0.35. Both coefficient estimates in the regression are statistically significant, and the estimate of θ is consistent with the sample autocorrelation for the first lag estimated at the identification stage ($\hat{\theta} = 0.5$ implies $\hat{\rho}_1 = 0.41$, which compares with $\hat{\rho}_1 = 0.48$ from the identification procedure). Despite these favorable results, the residuals, v_t, seem to follow a complicated stochastic process in which v_{t-3} is significant for explaining v_t (the partial autocorrelation coefficient for v_{t-3} is -0.51, with a standard error of 0.17). This pattern of autocorrelation could be indicative of the presence of quarterly seasonality in the data, or may suggest the existence of a stochastic premium associated with the riskiness of imperfectly indexed deposits, given wide changes in monthly inflation. Moreover, reflecting the ambiguity of the results of the identification procedure, estimating a second-order autoregressive process (AR(2)) produces a similar estimate of $-LP$ and statistically significant autoregressive terms.[18] Thus, in this case the data cannot distinguish clearly between an MA(1) and an AR(2) process.

An alternative test of the hypothesis under discussion is performed by estimating equation (3) directly:

$$(i_t + i_{t+1} + i_{t+2}) = \alpha_0 + \alpha_1({}_tUF_{t+3} + r_t) + u_t, \tag{5}$$

where $u_t = \theta v_{t-1} + v_t$, and v_t is white noise. To be consistent with the hypothesis mentioned, the coefficient estimates should be $\hat{\alpha}_0 < 0$, since $\alpha_0 = -LP$ is the time-invariant liquidity premium, and $\hat{\alpha}_1 = 1$, if there is efficient arbitrage under rational expectations. The error term, v_t, must be a serially uncorrelated random variable. Moreover, any variables added to equation (5) that are judged to be publicly available information

[18] However, by estimating an autoregressive moving average process (ARMA(2, 1)), it can be shown that the restriction that the two autoregressive terms are zero cannot be rejected by the data at the level of 5 percent significance (the corresponding F-statistic is $F(2, 27) = 3.363$).

dated t or earlier must exhibit coefficients that statistically are not significantly different from zero, since presumably these variables are part of the information set used to formulate the expectations. Variables such as current and past values of the inflation rate, the exchange rate, the UF, and the ex ante yields of indexed and nonindexed deposits were introduced to the equation to confirm that they do not convey significant additional information.

Estimation of equation (5) for the same sample period as the previous test produces the following results:

$$i_t + i_{t+1} + i_{t+2} = \underset{(-0.45)}{-0.05} + \underset{(41.64)^*}{0.94}({}_tUF_{t+3} + r_t) + \underset{(2.72)^*}{0.49}v_{t-1} + v_t$$

$$\text{Adj. } R^2 = 0.98 \qquad \text{DW} = 1.66 \qquad \text{SE} = 0.169 \qquad F = 879.3.$$

These results support the hypothesis that there is efficient arbitrage in Chilean financial markets in the sense that $\hat{\alpha}_1 \approx 1$. This implies that, everything else unchanged, changes in the effective return of indexed deposits are reflected in almost equally proportional changes in the effective return of nonindexed deposits. The regression as a whole has a very high explanatory power and a low standard error, and it produces residuals that follow a stochastic process according to which the autocorrelation between v_t and v_{t-3} is much weaker than in the previous case (the partial autocorrelation coefficient is −0.35, with a standard error of 0.18, and is not significantly different from zero at the 7 percent level). However, the regression fails to detect a significant time-invariant liquidity premium, and thus the joint hypothesis being tested is once again rejected by the data.

If equation (5) is re-estimated imposing the restriction that the liquidity premium is fixed at −0.35 (the average of *DR*9030*F*), the results show that the data cannot reject the restriction, and that changes in the ex post indexed interest rate are still reflected in close to one-to-one changes in the ex post nominal interest rate.[19] However, the joint hypothesis of efficient arbitrage, rational expectations, and a time-invariant liquidity

[19]The t-statistics for α_1 in the unrestricted and restricted estimates of equation (5) are unusually high. Augmented Dickey-Fuller statistics were computed for the variables in the regression, and the presence of a unit root that could account for large t-statistics was not detected. The regressions do not involve an identity, as Figure 6 shows, but the fact that movements in the ex post nominal interest rate mimic so precisely movements in the ex post indexed interest rate casts some doubts on whether these interest rates are fully determined by market forces in the sample; as noted in the text, in June 1987 the Central Bank ended a policy of setting indicative interest rates for nonindexed deposits according to a rule based on the UF premium.

premium is rejected once again because the residuals are not white noise. In this case the regression output is summarized as follows:

$$i_t + i_{t+1} + i_{t+2} = -0.35 + \underset{(162.63)^*}{0.99}({}_tUF_{t+3} + r_t) + \underset{(2.80)^*}{0.50}v_{t-1} + v_t$$

$$\text{Adj. } R^2 = 0.98 \qquad \text{DW} = 1.80 \qquad \text{SE} = 0.182 \qquad F = 1513.9.$$

The F-test for the restriction that $\alpha_0 = -0.35$ is $F_{(1,30)} = 5.889$, and this implies that the restriction cannot be rejected by the data at the level of 1 percent significance. The residuals, v_t, display a pattern of autocorrelation between v_t and v_{t-3} similar to that found in the first test (the partial autocorrelation coefficient for v_{t-3} is -0.49, with a standard error of 0.176).

Given that the first test and the restricted version of the second test detect third-order serial autocorrelation of the residuals, a third test of the joint hypothesis under study is performed by imposing a pattern of quarterly seasonality in the form of a multiplicative seasonal MA term at lag 3, $\text{SMA}(3)_t$. An empirical justification for this, as Figure 6 illustrates, is that the differential between ex post indexed and nominal interest rates tends to be lower in the second and fourth quarters, and higher in the first and third quarters. One theoretical interpretation of this seasonality pattern is that it could reflect the existence of a stochastic premium on indexed assets. As noted before, the return on indexed deposits is affected by the difference in the inflation rate between the month before the deposit is entered and the month before it matures. When monthly inflation rates fluctuate sharply, as has been the case in Chile according to Figure 1, this embodies a significant risk. Another interpretation of seasonality in the interest differential is that it represents changes in monetary policy that are not part of the information used by individuals to formulate their expectations. This hypothesis is not tested here, but it is interesting to note that Chile relies heavily on open market operations in indexed assets to manage monetary policy.

The estimated time-series process for $DR9030F$ with the seasonality component is

$$DR9030F_t = \underset{(-13.64)^*}{-0.37} + \underset{(4.84)^*}{0.68}v_{t-1} - \underset{(-4.98)^*}{0.88}\text{SMA}(3)_t + v_t$$

$$\text{Adj.} R^2 = 0.475 \qquad \text{DW} = 2.034 \qquad \text{SE} = 0.152 \qquad F = 15.46.$$

In contrast to the previous results, the introduction of quarterly seasonality eliminates completely the pattern of correlation in the error terms.[20]

[20]The restriction that the seasonal adjustment parameter is zero is clearly rejected by the data at the 1 percent and 5 percent significance levels ($F_{(1,30)} = 15.21$).

Thus, if the additional assumption of quarterly seasonality is taken into account, the data cannot reject the joint hypothesis of efficient arbitrage, rational expectations, and a premium on 90-day indexed time deposits consistent with time-invariant and stochastic components. This is a very weak hypothesis, however, since the stochastic element embodied in the seasonal moving average has many interpretations, and could be viewed simply as a rejection of rational expectations and market efficiency.

To summarize, the results of the tests performed here provide some evidence suggesting that efficient arbitrage takes place in Chilean financial markets, in the sense that changes in the ex post indexed interest rate are associated with changes in the ex post nominal interest rate of almost identical magnitude. There is also some evidence that market participants tend not to make systematic errors in forecasting short-term interest rates or the UF. However, the joint hypothesis of efficient arbitrage, rational expectations, and a time-invariant liquidity premium is not supported by the data—the relevant residuals display negative autocorrelation at the third lag, or, when the residuals are white noise, the time-invariant premium is not statistically significant. Although this joint hypothesis fails, the results lend some support to the view that financial indexation minimizes the risks associated with inflation, since no inflation-risk premium is detected in the effective yield paid on nonindexed deposits. The only premia detected in the tests are paid on indexed deposits, and are viewed as stemming from liquidity preference and imperfect indexation. The negative constant in the stochastic process of $DR9030F$ suggests that indexed deposits pay a time-invariant premium of approximately 1.5 percent a year. The coefficient of quarterly seasonality estimated in the last regression is also negative, suggesting—as one possible interpretation—the presence of a stochastic premium on indexed deposits.

Thus, the evidence from Chilean data suggests that indexation, at work in an environment where there is evidence of efficient arbitrage, facilitates financial operations by eliminating the inflation-risk component of nonindexed interest rates. Given rational expectations, efficient arbitrage, and a full Fisher effect, the elimination of financial indexation would only alter interest rates to the extent that inflation-risk premia are re-introduced. It is therefore important to search for further evidence on Fisherian transmission and rational expectations.

III. The Interest Spread and Increases in Inflation

It has been argued here that indexation does not induce systematic, unjustified increases in interest rates in response to inflation when expectations are rational and there is efficient arbitrage, because the Fisher

effect in a nonindexed system would produce similar increases. The tests conducted in the previous section suggest that Chilean financial markets conform well to some elements of the hypothesis of efficient arbitrage and rational expectations, but do not produce evidence on the validity of the Fisher effect, nor do they give a clear description of the relationship between the returns paid on indexed and nonindexed deposits and expectations of future inflation. In this section, a series of tests are undertaken to explore the empirical relevance of the Fisher effect and one of its key implications under the assumption of rational expectations—namely, that the differential between the premium over UF of an indexed deposit and the nominal interest rate of a nonindexed deposit should be a precise indicator of future changes in inflation. These tests also have the operational value of helping to establish whether the UF premium can be treated as equivalent to the relevant real interest rate, and thus whether it is proper to use it as an instrument or indicator in the design of monetary policy.

The informational content of the spread between indexed and nonindexed interest rates can be extracted by estimating a functional relationship that follows from the Fisher effect. This approach is a variation of the methodology applied recently to study inflation forecasts based on the term structure of nominal interest rates by Fama (1990) and Mishkin (1990).

The Fisher equations for 30-day nonindexed and 90-day indexed time deposits can be expressed as follows:

$$E_t P_{t,30} = i_{t,30} - R_{t,30} \tag{6}$$

$$E_t P_{t,90} = (r_{t,90} + E_t UF_{t,90}) - R_{t,90}, \tag{7}$$

where E_t denotes a rational expectation conditional on publicly available information available at date t; $P_{t,30}$ and $P_{t,90}$ are the inflation rates for the 30 and 90 days that follow t; $R_{t,30}$ and $R_{t,90}$ are the ex ante real interest rates of each type of deposit; $i_{t,30}$ is the monthly nominal interest rate quoted at date t on a 30-day nonindexed deposit; $r_{t,90}$ is the quarterly premium over UF quoted at date t on a 90-day indexed deposit; and $UF_{t,90}$ is the growth of the UF during the 90 days following t.

Following Mishkin (1990), equations (6) and (7) are combined in an expression that provides a framework useful for extracting the information about expectations of future inflation contained in the interest spread. This is done by imposing the conditions that expectations are formed rationally and that ex ante real interest rates fluctuate around constant averages over time. Subtracting (6) from (7) and imposing these two conditions yields the following result:

$$P_{t,90} - UF_{t,90} - P_{t,30} = \alpha_0 + \alpha_1(r_{t,90} - i_{t,30}) + \nu_t, \tag{8}$$

where

$$v_t = e^{\pi}_{t,90} - e^{uf}_{t,90} - e^{\pi}_{t,30} - e^{r}_{t,90} + e^{r}_{t,30}.$$

This expression must be treated with caution because the dependent variable on the left-hand side has a special interpretation. The dependent variable is the *uncovered* increase in inflation (*UNCINFCH*) during the period from 30 to 90 days after t. It is considered uncovered because it represents the residual change in inflation after taking into account the protection that indexation gives to 90-day deposits (that is, *UNCINFCH* is equal to the difference between the inflation rates minus the correction in the UF).

Expression (8) indicates that, if expectations are rational, the ex ante real interest rates vary around constant means, and the Fisher equations (6) and (7) hold, then *UNCINFCH* must be equal to the sum of the average differential in ex ante real interest rates, $\alpha_0 \equiv \bar{R}_{90} - \bar{R}_{30}$; the spread in the quoted returns of indexed and nonindexed deposits, $\alpha_1 \equiv 1$; and a random error, v_t. The error term is a combination of expectational errors pertaining to the 30- and 90-day inflation rates ($e^{\pi}_{t,30}$ and $e^{\pi}_{t,90}$), the change in the UF ($e^{uf}_{t,90}$), and the discrepancy between the period-by-period and mean values of the ex ante real interest rates ($e^{r}_{t,30}$ and $e^{r}_{t,90}$). To be consistent with rational expectations, this disturbance must have zero mean and constant variance, and may follow a second-order moving average process, because the data correspond to monthly observations and expectations need to be formed for variables up to three months ahead—in this case, an expectation for inflation in the third month after t is needed, whereas in the tests of efficient arbitrage only inflation expectations up to the second month ahead were required.

The economic interpretation of the movements implicit in equation (8) is the following. For a given value of α_0, a widening of 1 percentage point in the differential between the 90-day premium over UF and the 30-day nominal interest rate indicates that individuals expect inflation in 90 days to increase by 1 percentage point in addition to the expected growth in the UF (about 4 percentage points on an annual basis). Therefore, if the estimate of equation (8) produces an error term with an MA(2) representation and shows that the hypothesis $\hat{\alpha}_1 \neq 0$ is rejected and the hypothesis $\hat{\alpha}_1 = 1$ cannot be rejected, then the data would indicate (1) the spread of interest rates is a precise indicator of future increases in uncovered inflation as a joint test of the Fisher effect and rational expectations; and (2) the average of ex ante real interest rates is constant over time. This second result would suggest that the UF premium is not a good proxy for the relevant real interest rate because, as Figure 2 illustrates, the UF

premium exhibits an increasing trend and does not fluctuate around a time-invariant mean.[21]

Equation (8) was estimated by ordinary least squares using data from August 1986 to January 1990, July 1987 to January 1990, and August 1986 to December 1987. The last sample is dominated by observations from the period during which the Central Bank provided indicative interest rates for 30-day nonindexed time deposits, and consequently, the policy regime may have intervened with the Fisherian transmission of market-determined, rational expectations of inflation to interest rates. To allow for quarterly seasonality, the equation for the period August 1986–January 1990 was also estimated with a multiplicative seasonal moving average term at the third lag. To test the null hypothesis that $\hat{\alpha}_1 = 1$, two procedures were followed: a standard "t"-test, and an F-test that combined the sum of squared residuals of unrestricted and restricted versions of the model. The results of all estimates are summarized in Table 1.

With one exception, the results show that the hypothesis that the coefficient $\hat{\alpha}_1$ is significantly different from zero but insignificantly different from unity cannot be rejected by the data, and that the residuals follow an MA(2) process. Surprisingly, the exception is not the period of indicative interest rates but the period from July 1987 to January 1990. For the sample August 1986 to January 1990, the unrestricted estimate for $\hat{\alpha}_1$ is 1.38, with a standard error of 0.26. This implies that the hypothesis $\hat{\alpha}_1 = 0$ is rejected with less than 1 percent significance, and the hypothesis $\hat{\alpha}_1 = 1$ cannot be rejected with less than 1 percent significance. Moreover, estimating the model for all the sample periods with the restriction that $\alpha_1 = 1$ produces F-statistics according to which the data cannot reject the restriction at 1 percent significance. In general, these results suggest that the joint hypothesis of Fisherian transmission and rational expectations cannot be rejected by the data.

Figure 7 depicts the actual and predicted values of *UNCINFCH* produced by the unrestricted model for the sample August 1986 to January 1990. This figure illustrates clearly the predictive power of the regressions based on the spread between indexed and nonindexed interest rates to forecast the evolution of the uncovered increase in inflation. One of the interesting operational implications of this result is that the market-determined interest spread between indexed and nonindexed deposits is an accurate indicator of the public's perception of future changes in

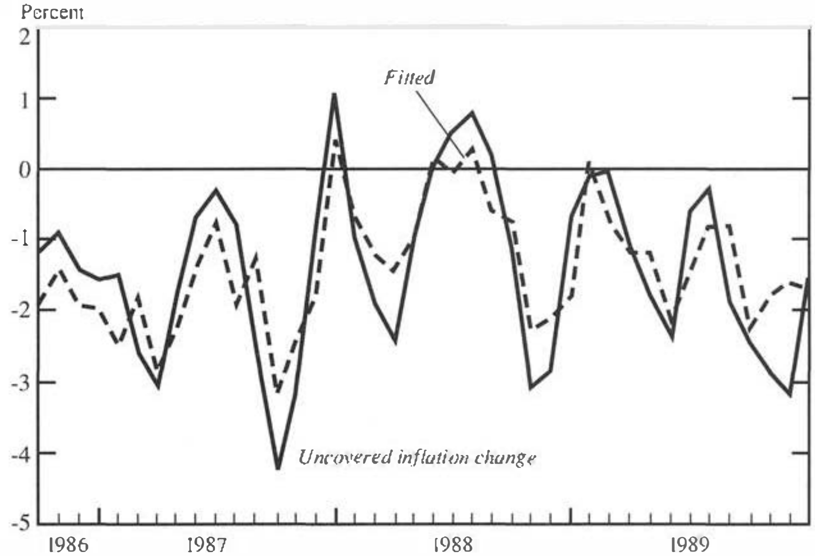
[21] This conclusion would not follow if the UF moved exactly with inflation month by month. In this case, the dependent variable in equation (8) collapses to $-P_{t,30}$, and the UF premium becomes identical to the ex ante real interest rate.

Table 1. *Estimates of Uncovered Inflation Change Equations*

Sample	$\hat{\alpha}_0$	$\hat{\alpha}_1$	SE	Adj. R^2	DW	t-test $\hat{\alpha}_1 = 1$	F-test $\hat{\alpha}_1 = 1$
				Unrestricted			
August 1986–January 1990	−0.75 (−4.45)*	1.38 (5.31)*	0.79	0.59	1.61	1.47	—
August 1986–December 1987	−0.40 (−0.72)	1.55 (2.31)**	0.79	0.51	1.35	0.82	—
July 1987–January 1990	−0.74 (−4.25)*	1.89 (6.05)*	0.79	0.66	1.77	2.86*	—
Seasonally adjusted August 1986–January 1990	−0.77 (−4.02)*	1.29 (3.69)**	0.78	0.59	1.67	0.84	—
				Restricted			
August 1986–January 1990	−0.92 (−7.23)*	1.00	0.82	0.31	1.63	—	3.89***
August 1986–December 1987	−0.83 (−4.55)*	1.00	0.75	0.43	1.26	—	2.89***
July 1987–January 1990	−1.02 (−6.53)*	1.00	0.87	0.34	1.62	—	6.62***
Seasonally adjusted August 1986–January 1990	−0.91 (−7.53)*	1.00	0.78	0.38	1.71	—	0.41***

Note: Numbers in brackets are t-statistics for the null hypothesis that the corresponding coefficient is not significantly different from zero. One asterisk denotes significance at the 1 percent level, two asterisks denote significance at the 5 percent level, and three asterisks denote that the restriction in question cannot be rejected at a level of 1 percent significance. All regressions also include first- and second-order moving average components. The residuals have been identified to be white-noise processes using the method of Box and Jenkins, except for the period August 1986 to December 1987, when the residuals exhibit second-order serial autocorrelation.

Figure 7. *Uncovered Inflation Change*
(Actual and predicted values)



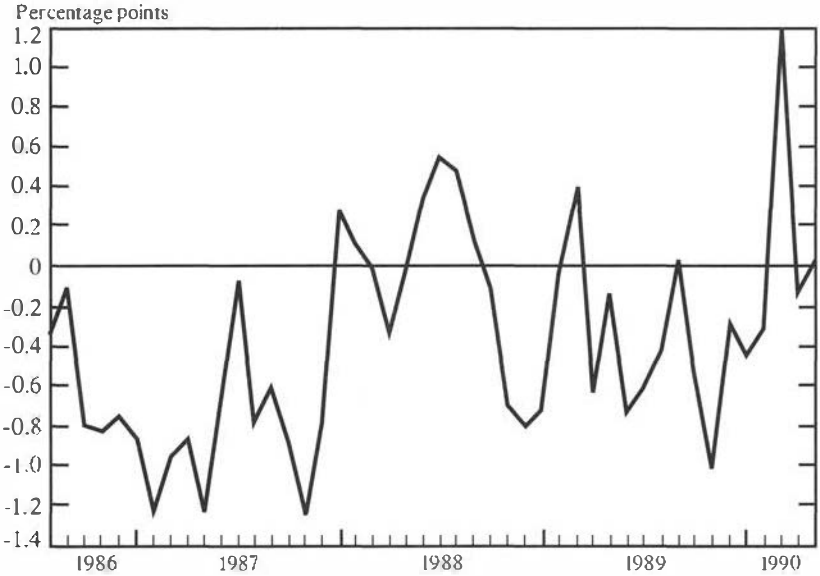
inflation. Policymakers have ready access to this interest spread and can use it as an indicator to assess the stance of monetary policy.[22]

Consider the interest spread between the quarterly UF premium and the monthly nominal interest rate depicted in Figure 8. According to the model, a declining spread is an indicator that monetary policy is recognized as tight, or that uncovered inflation is expected to fall, whereas an increasing spread indicates the opposite.[23] During the first and third quarters of 1989 the interest spread widened, and these two periods were also the two peaks of the uncovered acceleration of inflation during that year (see Figure 7). In the first quarter of 1990, the interest spread declined at first, as the Central Bank announced the introduction of an

[22]Note that the spread of interest rates is a useful indicator of the stance of monetary policy, but is not an instrument nor a target. The size of the spread per se does not indicate the extent of the adjustments that are necessary in instruments and targets, it only informs the authorities of the market's perception regarding monetary policy stance.

[23]The issue here is not how tight the Central Bank designs monetary policy, but how individuals in financial markets perceive it. Thus, it does not suffice that the authorities design a theoretically sound anti-inflationary policy; the reputation and credibility they command in financial markets also play a rucial role.

Figure 8. *Interest Rate Spread on Time Deposits, August 1986 to May 1990*
(90-day indexed minus 30-day nonindexed deposits)



adjustment program, but then it widened to reach 1.2 percent in March (4.9 percent annually). According to the model, the increase in the spread indicated that individuals viewed the adjustment policies either as transitory or insufficient to halt the increasing trend of inflation, possibly reflecting expectations of a fiscal expansion or large inflows of foreign capital attracted by a large favorable differential between domestic and foreign interest rates.

The data also support the hypothesis that ex ante real interest rates fluctuate around time-invariant means. With the exception of the estimate for the period August 1986 to December 1987, in which the estimate of the constant term is not statistically different from zero, the regressions show that the average 90-day ex ante real rate is more than ¾ of 1 percentage point higher than the average of the similar 30-day rate. As discussed previously, this evidence casts serious doubts on the use of the UF premium as an indicator of the relevant real interest rate because it clearly does not fluctuate around a time-invariant mean.

Equations (6)–(8) also provide an alternative test that can be used to substantiate further the claim that the UF premium is not equivalent to the ex ante real interest rate. These equations imply that, for both

rates to be statistically equivalent, the imperfection of the indexation mechanism should not be statistically significant. Thus, estimating equation (8) with a dependent variable that is just the negative of the 30-day-ahead inflation rate should produce similar results as those listed in Table 1. Estimation of this modified equation shows that this hypothesis is rejected. The coefficient $\hat{\alpha}_1$ is significant, but at a value of -0.42, the constant term rises to -1.6, and the first-order autocorrelation coefficient is higher than unity, which questions the stationarity of the residuals.

The UF premium is not the relevant ex ante real interest rate because, as explained earlier, in calculating the latter agents consider the discrepancy between the inflation of the month before they enter into a credit contract and their expectations of inflation in the last month before it expires. When the inflation rate is stable, this discrepancy is minimal and the UF premium reflects the relevant ex ante real rate, but when inflation fluctuates, this is no longer a correct approximation. The fluctuations affecting monthly inflation are due in part to seasonal or random factors, but they also reflect the underlying trend of the inflation rate. What the tests show is that, for Chile, the 1-month lag in financial indexation and the volatility of the month-to-month inflation rate cause discrepancies between the UF premium and the ex ante real interest rate that cannot be accepted as accidental. Thus, the results support the view that the spread between indexed and nonindexed interest rates is a better indicator of the stance of monetary policy than the UF premium itself.

IV. Concluding Remarks

This paper analyzes the Chilean mechanism of financial indexation and explores some aspects of its influence on the operation of the financial system. The results of a number of empirical tests support the view that indexation facilitates financial intermediation under inflationary conditions and does not automatically produce higher interest rates than a system free of indexation. In particular, the econometric evidence suggests that there is efficient arbitrage in Chilean financial markets and that market participants tend not to make systematic mistakes in forecasting future interest rates or future inflation. The evidence also supports the existence of the Fisher effect. The spread between indexed and nonindexed interest rates is found to convey significant information regarding future changes in inflation, and the average levels of ex ante real interest rates are estimated to be approximately constant over time.

The findings of this paper have four operational implications:

• *Efficient arbitrage is present in Chilean financial markets*. An increase in the effective rate of return on a 90-day indexed deposit is reflected in almost a one-to-one increase in the effective return on 3-month investments in 30-day nonindexed deposits.

• *Inflation changes are consistent with Fisherian transmission and rational expectations*. The difference between the 90-day UF premium and the 30-day nominal interest rate is a precise indicator of the expectations of economic agents regarding future changes in inflation (adjusted to account for the protection that imperfect indexation gives to 90-day deposits).

• *Indexation is imperfect*. The 1-month lag under which indexation is currently undertaken implies that the 90-day UF premium should not be regarded as the real interest rate relevant for economic decisions or for the purposes of designing monetary policy. The spread between indexed and nonindexed interest rates is a better indicator of monetary conditions.

• *Indexation eliminates the inflation risk from nonindexed financial contracts*. Because the data suggest that Fisherian transmission takes place in an environment where expectations are not systematically erroneous and efficient arbitrage exists, financial indexation minimizes the inflation risk (which is not detected in 30-day nonindexed deposits) and does not systematically force a full adjustment of nominal interest rates to inflation that would not have occurred otherwise.

REFERENCES

Begg, David K.H., *The Rational Expectations Revolution in Macroeconomics: Theories and Evidence* (Baltimore, Maryland: Johns Hopkins University Press, 1982).

Calvo, Guillermo A., and Pablo Guidotti, "Indexation and Maturity of Government Bonds: A Simple Model," IMF Working Paper 89/46 (Washington: International Monetary Fund, 1989).

Fama, Eugene F., "Term-Structure Forecasts of Interest Rates, Inflation, and Real Returns," *Journal of Monetary Economics*, Vol. 25 (January 1990), pp. 59–76.

Friedman, Milton, "Monetary Correction," in *Essays on Inflation and Indexation* by Herbert Giersch and others (Washington: American Enterprise Institute for Policy Research, 1974).

Gordon, Robert J., *Modern Macroeconomics* (Boston: Little Brown, 2nd ed., 1978).

Gray, Jo Anna, "Wage Indexation: A Macroeconomic Approach," *Journal of Monetary Economics*, Vol. 2 (August 1976), pp. 221–35.

Informacion Financiera, Superintendencia de Bancos e Instituciones Financieras, Santiago (various monthly issues).

Leijonhufvud, Axel, "Costs and Consequences of Inflation," in *Information and Coordination* (New York: Oxford University Press, 1981).

Mill, John S., *Principles of Political Economy* (London: John W. Parker, West Strand, 1848); reprinted (Fairfield, New Jersey: Augustus M. Kelley, Publishers, 1987).

Mishkin, Frederick S., "What Does the Term Structure Tell Us About Future Inflation?" *Journal of Monetary Economics*, Vol. 25 (January 1990), pp. 77–95.

Parkin, Michael P., and Robin Bade, *Modern Macroeconomics* (Deddington, Oxford: Philip Allan, 2nd ed., 1988).

Sintesis Monetaria y Financiera, Direccion de Estudios Economicos, Banco Central de Chile (various monthly issues).

Smith, Bruce D., "Legal Restrictions, 'Sunspots,' and Peel's Bank Act: The Real Bills Doctrine versus the Quantity Reconsidered," *Journal of Political Economy*, Vol. 96 (February 1988), pp. 3–19.

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The Cost of Export Subsidies

Evidence from Costa Rica

ALEXANDER HOFFMAISTER*

A model is developed to estimate the effects of export subsidies on the supply of exports. With data for Costa Rica over the 1980s, it is shown that although the export subsidy scheme in operation led to an increase in exports, the direct fiscal costs of the scheme were substantial. Furthermore, the subsidy scheme led to a significant increase in imports. These results suggest that elimination of export subsidies would not have a particularly harmful effect on the trade balance, and would, in addition, increase the fiscal position and generate economic efficiency. [JEL C22, F13, F17]

IN THE 1970S, the appeal of export promotion as a development strategy began to overshadow import substitution, particularly in Latin American countries hit by the debt crisis. The export-fueled growth of several Asian countries further sparked interest in export promotion schemes.

Policymakers have been creative in designing export incentives. Most export promotion programs involve a combination of fiscal and direct incentives. A drawback scheme, or some variation of it, allowing exporters to "draw back" taxes paid on imported inputs used in the production of exported goods, is a standard incentive. Many programs offer additional tax incentives such as exemptions from domestic taxes. Other programs allow for preferential rates on public utilities, subsidized interest rates, generous wastage allowances for imported inputs, and accelerated depreciation of capital goods.

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As widespread as export promotion programs are, empirical evidence on their effectiveness in increasing exports and on their costs is scarce. These costs include fiscal expenditures on export subsidies, forgone tax revenues, indirect subsidies related to public utility rates, and the costs associated with subsidized interest rates. Full measurement of the costs would ideally also account for distortions introduced by export promotion and the costs of administering the programs.

This paper measures the impact of export subsidies on export supply and evaluates their cost. A simple model is presented in Section I. The model is estimated with data from Costa Rica, where an export subsidy scheme was introduced in 1972 and enhanced by an export contract in 1984. The direct subsidy functions as a tax credit (CATS) worth 15 percent (f.o.b.) of nontraditional exports.[1] Other export incentives are available under the export contract, such as a drawback scheme; however, data on these incentives are not available. The time-series properties of the data are evaluated, and the estimation is accomplished using a Stock and Watson (1991) estimator that allows for valid hypothesis testing on the cointegrating vector. Section II presents the estimates.

The model is used to gauge the impact of the export subsidy. It is shown in Section III that, first, exports increased by roughly 10 percent; second, each dollar spent on the program increased exports by $1.35; and finally, imports of intermediates used in the production of exports increased significantly.

In general, the export subsidy has been a very costly way to promote exports, averaging 1.2 percent of gross domestic product (GDP) between 1988 and 1989, and prompting policymakers to consider alternatives to the subsidization scheme. The model indicates that the 15 percent subsidy could be offset by an average quarterly depreciation of 7 percent. It should be noted that this rate of depreciation would replicate the behavior of total exports, and thus implicitly assumes that the rate of growth of exports obtained under the subsidy is desirable. The socially optimum level of exports, however, is not addressed in the paper. The main findings are summarized in the concluding section.

I. The Basic Model

The key assumption underlying the standard empirical trade model is that exports are not perfect substitutes for the domestic good of the ex-

[1] The subsidy rate varies with the destination of exports. Nontraditional products shipped to Europe receive 20 percent, but the majority of nontraditional exports receive 15 percent.

porting country. Goldstein and Khan (1985) argued, that support for this assumption is based on the existence of two-way trade (precluded in a perfect substitute model) and evidence of significant and persistent deviation from the law of one price.

The basic model here begins with a firm that is able to allocate production between the domestic and the export market. Thus, the firm will simultaneously determine its supply of exports together with the domestic supply. Recent theoretical work seeking to account for intraindustry trade has modeled this simultaneity.[2]

Here, a simplified version of a model formulated by Behrman and Levy (1988) is used.[3] The representative domestic firm maximizes the profit function:

$$\Pi = P(Px, Pd)Q(L, K) - (WL + RK), \tag{1}$$

where Π denotes profits; P is an exact price index of the composite output, Q;[4] Px is the export price inclusive of export subsidies, S, multiplied by the exchange rate, E;[5] Pd is the price for the firm's product in the domestic market;[6] and L and K are the labor and capital quantities used in the production process. Throughout the text, uppercase symbols will denote levels, while lowercase symbols are reserved for logs. Equation (1) is maximized subject to

$$Q = [\beta Qx^{1+\Omega/\Omega} + (1-\beta)Qd^{1+\Omega/\Omega}]^{\Omega/1+\Omega}. \tag{2}$$

Equation (2) describes a constant elasticity of substitution (CES) relationship between domestic and export output.

Profit maximization will require the firm to choose Qx, Qd, L, and K, subject to equation (2). The first two first-order conditions from the lagrangian ($\partial l/\partial Qx$ and $\partial l/\partial Qd$) imply

$$\frac{Qx}{Qd} = \left(\frac{1-\beta}{\beta}\right)^{\Omega} \cdot \left(\frac{Px}{Pd}\right)^{\Omega}. \tag{3}$$

Figure 1 depicts the firm's maximization problem. At point A, the

[2] There are two major explanations for intraindustry trade: first, the reciprocal dumping of homogeneous products (Brander and Krugman (1983)); and second, a combination of product differentiation and increasing returns to scale (Helpman and Krugman (1985)). These models were developed using general functional forms and do not lend themselves to an estimable form.

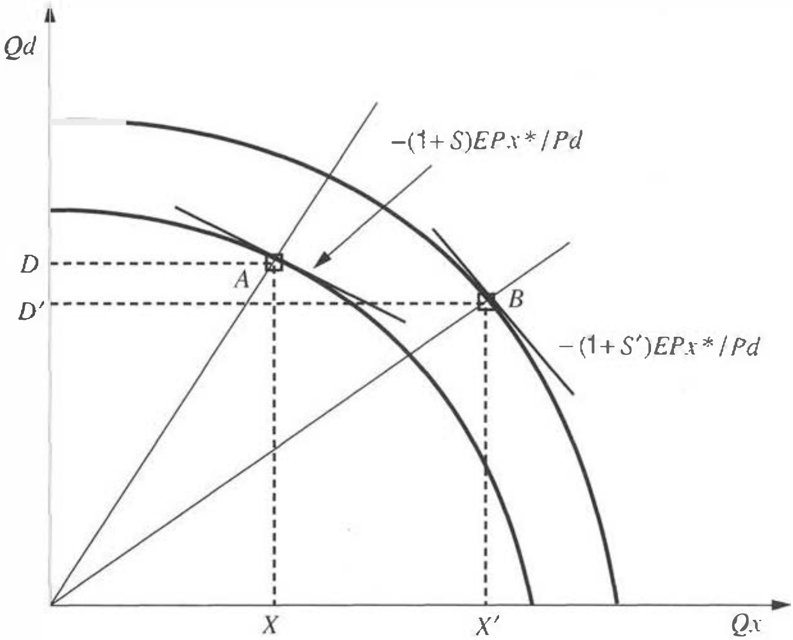
[3] These authors modeled the firm's labor and intermediate input decision. However, the present analysis is not concerned with either of these issues.

[4] This index is such that $P(Px, Pd) \cdot Q = PxQx + PdQd$.

[5] $Px = (1 + S)EPx^*$.

[6] It should be noted that Pd is potentially endogenous to the model; this issue will be discussed in Section II.

Figure 1. *Supply Decision*



firm is maximizing its profits. The firm first determines the level of composite output, Q, and allocates it according to the relative price, $(1 + S)EPx^*/Pd$. An increase in the export subsidy will have two effects. The price of the composite output increases, triggering an increase in the composite level of output, denoted by the outward shift of the output allocation curve.[7] The new subsidy increases the attractiveness of exports relative to domestic output, so that the ratio of exports to domestic output increases.[8]

To obtain the export supply curve requires combining equation (3) with the remaining three first-order conditions (requiring the value of the

[7] If initially the firm is at an equilibrium, the new composite output will require an increase in the capital stock.

[8] Figure 1 presents the case where there are increasing costs of shifting output from one market to the other. By reducing the elasticity of substitution, the transformation curve would become a right angle and the production technology would be that of joint production. The effect of a subsidy would then be exclusively an increase in the composite output. If the elasticity is very large the transformation curve turns into a straight line, so that the firm allocates all its output to one market. In that case, the supply of exports would be discontinuous.

marginal product of labor and capital to equal their corresponding prices, and the constraint (2)). In log form the export supply curve will be[9]

$$qx = b_0 + b_1(\tilde{p}x - pd) + b_2q(W,R). \tag{4}$$

Notice that this is very similar to the original Goldstein and Khan (1978) supply equation. The difference is the scale variable, which is the composite output of the firm, whereas Goldstein and Khan used capacity, or trend, income. Here, real GDP will be used as a proxy for Q.[10]

II. Empirical Results

This section presents estimates of the model using data from Costa Rica. The series are all integrated of order one. The model is estimated accordingly, following the two-step procedure suggested by Engle and Granger (1987).[11] If regressors are endogenous or residuals are serially correlated, standard hypotheses tests on ordinary-least-squares (OLS) estimates of the cointegration vector are not valid.[12]

Four single-equation estimation methods for cointegrating vectors, which account for serial correlation and endogeneity of regressors, are available.[13] All four methods are asymptotically optimal. Phillips and Hansen (1990) proposed a fully nonparametric estimator to correct for both serial correlation and endogeneity. Saikkonen (1991), Stock and Watson (1991), and Phillips and Loretan (1989) shared the same parametric correction for endogeneity. However, Stock and Watson used a nonparametric correction to deal with serial correlation, and Phillips and Loretan suggested a parametric procedure to deal with this problem.[14]

Although all four methods are asymptotically equivalent, they do not have the same small sample properties. Both Stock and Watson and Phillips and Loretan presented Monte Carlo simulation results showing that the Phillips-Hansen estimator has greater bias and mean squared

[9] Where, $b_0 \equiv -\Omega \cdot \ln(\beta)$, $b_1 \equiv \Omega$, $b_2 \equiv 1$.

[10] The demand for exports will not be modeled explicitly, but the endogeneity of regressors will be tested in Section II.

[11] The series and their unit root tests are described in the Appendix.

[12] OLS estimates of the cointegrating vector depend upon nuisance parameters for two reasons: serial correlation in the errors, and endogeneity of regressors. See Park and Phillips (1988, 1989).

[13] Phillips and Hansen (1990) showed that instrumental variable methods, although they reduce the simultaneity bias for cointegration vectors, do not eliminate the bias asymptotically. Saikkonen (1991) developed an asymptotically efficient instrumental variable estimator. He argued that the use of instruments was advisable only when the instruments and the regressors were cointegrated.

[14] The Appendix contains a brief description of these single-equation methods.

error than simple OLS. There are no Monte Carlo simulations that compare Stock and Watson with Phillips and Loretan or relate to Saikkonen's estimator. Thus, there is no a priori reason to favor either method. Nonetheless, preliminary estimation of the cointegration equation has favored the Stock-Watson approach.[15]

The Cointegration Equation

The relative price that exporters face can be expressed as $(1 + S)EPx^*/Pd$. This relative price is the combination of three elements: (1) the export subsidy, $(1 + S)$; (2) the nominal exchange rate defined as the price of foreign currency, E; and (3) the relative world price of exports in terms of the domestic price, Px^*/Pd.

If exporters are indifferent about the origin of their export revenues, one would expect that each component of this relative price would have the same effect on export supply. However, if subsidies are perceived as temporary, one would expect a relatively large short-run response to changes in the subsidy, relative to their long-run effect. This reasoning is analogous to Calvo's (1987) temporary trade liberalization argument. A temporary subsidy could induce exporters to increase supply today to take advantage of the subsidy that will not be there tomorrow. A long-run effect could occur to the extent that investment plans were shifted forward in an effort by exporters to further increase exports during the life of the subsidy. It seems plausible that a short-lived subsidy would not change investment plans and thus would not have long-run effects.

The perception that the subsidy is temporary might come from a law that states the subsidy's life span, such as Costa Rica's 1984 export contract, but this is not necessary. This perception can also be prompted by the expectation of medium-term changes in trade policies, such as joining the General Agreement on Tariffs and Trade (GATT). If the fiscal deficit is an issue, then the subsidy might come under attack because of its fiscal impact. Note that as the f.o.b. value of exports increases so will the expense of the program, increasing the likelihood that the program could be cut as exports grow. Regardless of the origin of the perception of temporariness, it will impinge on the effectiveness of the effort to promote exports.[16]

[15] Specifically, estimates of the price coefficients using Phillips and Loretan were less precise than either the Stock-Watson estimates or OLS estimates; see Hoffmaister (1991).

[16] It is also possible that the exporters might discount the nominal exchange rate, if they perceive that the authorities are not committed to keeping the exchange rate at market clearing levels.

The cointegration equation may be expressed as follows:

$$qx = \bar{\beta}_0 + \bar{\beta}_1 \log(1 + S) + \bar{\beta}_2 e + \bar{\beta}_3(px^* - pd) + \bar{\beta}_4 q + w_t. \quad (5)$$

The analysis of Costa Rica's export supply response to export subsidies will require testing several hypotheses regarding the price coefficients: $\bar{\beta}_1$, $\bar{\beta}_2$, and $\bar{\beta}_3$. The model, presented in Section I, suggests that all $\bar{\beta}_i$ will be equal. It is also conceivable that $\bar{\beta}_1$ will differ when exporters discount the export subsidy relative to EPx^*/Pd.[17]

If all three β's were found to be equal, this would imply that exports respond equally to all three price components. This response would suggest that the export subsidy was not viewed as temporary, which would have implied a weak long-run response by exports. Since the Costa Rican subsidies are indeed temporary (their life span is ten years), a possible interpretation of that result would be that exporters expect the subsidies to be extended indefinitely, thereby suggesting that the temporary subsidy scheme is time inconsistent.

The cointegration equation (5) was estimated using Stock and Watson and 80 quarterly observations covering 1970 through 1989. The coefficients of $(1 + S)$, E, and Px^*/Pd have been allowed to differ.[18] The results of the estimation of the static model are presented in Table 1; column (1) contains the unconstrained estimation, and columns (2) and (3) present two different constrained estimations described below.[19]

Two cointegration tests were performed—the augmented Dickey-Fuller (ADF) and the augmented Phillips and Perron (APP).[20,21] Notice

[17]The hypothesis $\beta_2 = \beta_3$ is also tested. This hypothesis suggests that exporters base their output decision on the relative price, EPx^*/Pd. Rejection of this hypothesis could be accounted for by data measurement problems. It is not unlikely that exporters know Px^*, since most exports are contractual. However, it is likely that exporters face larger uncertainty surrounding Pd and E when the output decision is made. Since the data consist of actual Pd and E, it is conceivable that these series imperfectly reflect expectations regarding these variables.

[18]The coefficients of px^* and pd were found to be equal and of opposite signs. The data did not reject this hypothesis.

[19]These estimates are subject to two qualifications. First, the estimates suffer from aggregation bias, because the measure of nontraditional exports includes maquila exports that do not qualify for the subsidy. However, this bias is probably small since these products have been growing at a steady rate, reaching about 9.5 percent of nontraditional exports in 1989. For a discussion of the aggregation bias, see Goldstein and Khan (1985). Second, since the subsidy is redeemed after a period of time, the relevant measure of the subsidy is its discounted value. Unfortunately, it has not been possible to discount the subsidy, because the maturity has changed on several occasions, so that each individual export contract has a different maturity period.

[20]Campbell and Perron's (1991) suggested method determined that four lags were needed in these tests.

[21]The critical values are taken from Engle and Yoo (1987).

Table 1. *Export Supply Static Estimation*

Dependent Variable	qx (1)	qx (2)	qx (3)
Observations	80	80	80
R^2	0.940	0.932	0.940
$\bar{R}^2$	0.937	0.930	0.937
Sum of squared residuals	1.112	1.262	1.117
Standard error of estimate	0.122	0.128	0.121
Durbin-Watson statistic	1.164	0.970	1.144
Q-statistic	72.393	83.370	73.602
Augmented Dickey-Fuller	−3.14	−2.72	−3.09
Augmented Phillips-Perron	−5.39***	−4.82**	−5.33***
Constant	−21.92	−20.39	−22.14
	(−14.81)	(20.19)	(15.93)
$\log(1 + S)$	0.18	0.08	0.15
	(1.38)	(1.60)	(2.50)
e	0.13	0.08	0.15
	(1.85)	(1.60)	(2.50)
$px^* - pd$	0.23	0.08	0.24
	(2.09)	(1.60)	(2.40)
q	2.31	2.17	2.33
	(12.53)	(16.69)	(15.53)
H_0, χ^2_2-statistic	3.504	—	—
H_1, χ^2_1-statistic	0.116	—	—

Note: Two asterisks denote significance at the 5 percent level; three asterisks denote significance at the 1 percent level; t-statistics in parentheses.

that the ADF tests failed to reject the presence of a unit root at the 10 percent significance level; that is, according to this test, the equations do not cointegrate. However, the APP rejected a unit root at the 1 percent significance level, implying that the equations do cointegrate. The failure of ADF to reject noncointegration is likely due to the fact that this test was developed for the case where disturbances are independent and identically distributed (i.i.d.).[22]

The unconstrained estimation, shown in column (1), suggests an upward-sloping supply curve of nontraditional exports, although it is relatively price inelastic. Casual observation of the results suggests that exports respond less to nominal exchange rates or subsidies than they do to changes in relative prices. This observation provides the motivation for the null hypotheses: H_0—all price coefficients are equal; and H_1—the

[22] Campbell and Perron (1991) discuss this issue.

subsidy and the exchange rate are equal. The results of these two tests are reported at the bottom of Table 1. Both hypotheses are supported by the data.

Columns (2) and (3) present the constrained regression results under H_0 and H_1, respectively.[23] It is clear from column (2) that price elasticity falls dramatically and cointegration is obtained at 5 percent, not 1 percent significance. Furthermore, the results suggest that supply is perfectly price inelastic. This result, although statistically valid, is not persuasive. Strictly speaking, it means that regardless of the subsidy or exchange rate policy, the quantity supplied of exports remains unchanged. Furthermore, the relative profitability of exports over the domestic market, measured by the relative price, does not play a role in the long-run export supply. Thus, an increase in domestic prices vis-à-vis export prices, such as when tariffbarriers are increased, does not change the firm's allocation of its output between markets, implying that tariffs do not create an anti-export bias.

Column (3) shows the estimation results when the subsidy and the exchange rate are constrained to be equal. Notice that the price elasticities are comparable to those obtained in the unconstrained regressions. It is also interesting to note that, once again, cointegration is attained at 1 percent significance.

This leaves the analyst with a dilemma. While the hypothesis tests suggest that price coefficients are equal, imposing this equality on the data renders exports perfectly price inelastic. However, when equality is imposed between the subsidy and the exchange rate, the estimates make more sense—that is, one obtains a small significant price elasticity and stronger evidence of cointegration. Also notice that the standard errors of the estimates (SEE) of the regressions in column (3) are smaller than those from both column (2) and those obtained from the unconstrained regression reported in column (1). This suggests the efficiency of imposing the second hypothesis over the unconstrained regressions.

One possible explanation for these contradictory results is that these Wald tests are asymptotically χ^2, and therefore might not perform adequately in finite samples. Monte Carlo experiments reported by Phillips and Hansen (1990) suggest that the probability distribution function is adequately approximated for sample sizes as small as 50 observations. Nonetheless, as Campbell and Perron (1991) note, these results have

[23]The Breusch (1978) and Godfrey (1978) test for serial correlation rejected the null of no serial correlation of up to fourth order; thus, OLS estimates are not efficient and standard hypothesis tests are not valid. Nonetheless, the standard F-tests were performed on OLS estimates of the cointegrating equation. These tests rejected H_0, but maintained H_1.

been obtained for small-scale models with only two or three variables in the cointegrating vector. It is not known whether these simulation results hold when the model is larger. In the rest of the paper, the estimates obtained in column (3) of Table 1 will be referred to, since they seem reasonable and are not rejected by the data.

The above results suggest that, in the Costa Rican experience, exporters have discounted the joint variations of subsidies and the nominal exchange rate relative to Px^*/pd. This evidence is consistent with the temporariness of the export subsidy as established by the export contract during 1984. Although it makes sense for a temporary change in policy to have a smaller long-run impact than permanent changes, it is hard to generalize this result, because estimates of the impact of export subsidies are scarce.

Balassa and others (1986) studied the export incentives implemented by Greece and the Republic of Korea. Their estimates for Korea—which is an important case, since it is part of the so-called Asian miracle—are comparable to those reported here for Costa Rica. Estimating the standard Goldstein-Khan export supply curve, using annual data from 1965 to 1979, they found that the elasticity of exports to $(1 + S)E$ differed from and exceeded that of Px^*/Pd—which is precisely the opposite of the result obtained here.[24,25] According to Balassa and others, exporters perceived the upward movement of $(1 + S)E$ as permanent (nonreversible), while the fluctuations of Px^*/Pd were less so. Indeed, $(1 + S)E$ increased continuously throughout their sample, whereas export incentives increased only up until 1971, reaching close to 32 percent (from about 13 percent in 1965), falling thereafter to about half this amount in 1979. Thus, it would seem that exporters perceived the depreciation of the exchange rate as permanent, which could explain the large elasticity with respect to $(1 + S)E$.

Exporters appear to perceive the origin of their export revenue differently. Tyler (1976) and Faini (1988) found, respectively, that Brazilian and Turkish exporters responded more to subsidies than to the relative price, but Moroccan exporters did not (Faini (1988)). It would therefore seem important that policymakers keep the perceptions of exporters in mind when evaluating the effects of reducing export subsidies. Specifically, the elasticity with respect to $(1 + S)E$ was found here to be less than

[24] It should be noted that the subsidies in Balassa and others (1986) are not direct export subsidies, as in these estimates. Rather, Balassa and others constructed an implicit indirect subsidization consisting of tax exemptions and other indirect subsidies.

[25] This result was confirmed independently by Jung and Lee (1986), although no hypothesis test was performed.

that of Px^*/Pd. This is important for policy decisions: using the elasticity of Px^*/Pd to evaluate the effect on exports of a reduction of export subsidies would tend to overstate, in the case of Costa Rica (or understate for the Republic of Korea), the negative impact on export revenues.

Another important empirical issue for the model is whether prices are endogenous. This will be important in Section III, since the model will be used to simulate the effect of the subsidy on export revenues. If prices were endogenous, a demand curve would be needed to measure correctly the impact of the subsidy on export revenues.

The data, however suggest that the regressors in the cointegrating equation (5) are exogenous.[26] This result is not trivial, since it implies that both Px^* and Pd are exogenous. It is also partly expected, at least for Px^*, given the size of Costa Rica's exports relative to the size of the major export market, the United States. Although Pd was more likely to be endogenous, its exogeneity is explained by the fact that the market for domestic goods is formed by a large number of suppliers, including some exporters. The data support the idea that Pd is determined by the actions of the exclusively domestic producers, while exporters take Pd as given. These results are important, since they allow one to concentrate exclusively on export supply, disregarding demand.[27]

Before examining the short-run dynamics, let us refer to the export elasticity of nontraditional exports with respect to the composite output, Q. The estimation results suggest that it is greater than 2. This value means that in the long run, for every percentage increase of the composite output, exports increase more than proportionally. This, of course, is not possible forever. Eventually, all or most output will be exported, and an increase in composite output should translate approximately into a one-to-one increase in exports. However, the typical Costa Rican exporting firm exports less than 30 percent of its output, so that for the long-run horizon it is possible that exports will increase more than proportionally. However, this long-run elasticity is not expected to fall closer to unity, as predicted by equation (4), when firms export a larger portion of their output.

[26]The evidence stems from the fact that the leds of the regressors are insignificant, either for the Stock-Watson procedure presented in the text or for the Phillips-Loretan. Additional evidence supporting the exogeneity of regressors comes from the standard Hausman specification test performed on the Phillips-Hansen estimates, which is also unable to reject the exogeneity of the regressors.

[27] This does not mean that Pd will always remain exogenous; Pd will eventually become endogenous as more and more firms allocate part of their output to exports, thereby reducing Qd. The data suggest that this has not yet occurred.

Estimation of an Error-Correction Model

The Granger representation theorem tells us that the short-run dynamics of the cointegrated process can be expressed by an error-correction mechanism of the following form:

$$\Delta y_t = \rho[y_{t-1} - \beta' x_{t-1}] + h(L)\epsilon_t, \tag{6}$$

where y_t is the endogenous variable; x_t corresponds to a vector containing exogenous regressors; $[1, -\beta]$ is the cointegrating vector; and $h(L)$ is a lag polynomial.

Table 2 presents the estimation results for both the unconstrained and constrained error-correction models—using the cointegrating vector from column (3) in Table 1—in columns (2) and (3), respectively.[28] Note that the constrained model results suggest a relatively fast pace for the adjustment of nontraditional exports to disturbances. The estimate for ρ is approximately one half, implying that 95 percent of the adjustment is made within the first year (four quarters).[29] Notice that imposing the error-correction restriction reduces, slightly, the standard error of the estimate. This suggests the efficiency gain obtained by imposing the restriction on the data.[30]

This final model was subjected to a series of diagnostic tests. Godfrey's (1978) and Breusch's (1978) generalization of Durbin's h-test was used to test for serial correlation of up to order one and up to order four. Neither serial correlation nor autoregressive conditional heteroscedasticity effects were found, and the residuals from the regression did not exhibit significant skewness or kurtosis.

III. Effect of the Export Subsidy

The export contract is the cornerstone of Costa Rica's export promotion policy. The contract, which was established during 1984:2, governs all export incentives, including the direct export subsidy, CATS. The

[28]The specification for the error-correction model presented was arrived at after testing four lags of the difference of each variable in the cointegrating vector. Using standard F-tests, none of the lags were significant and have thus been excluded from the estimates.

[29]It should be noted that the constrained error-correction model imposes the same speed of adjustment for all variables, whereas the unconstrained version allows for speed of adjustment to vary.

[30]Also note that the estimates for the unconstrained error-correction model have appropriate signs and sizes, but are not significant. They imply that the long-run elasticity of $\log[(1 + S)E]$ is about half that of Px^*/Pd, about 0.07; the elasticity with respect to composite output is about 2.27.

Table 2. *Error-Correction Model*

Dependent Variable	Δqx (1)	Δqx (2)
Observations	79	79
R^2	0.251	0.244
$\bar{R}^2$	0.211	0.234
Sum of squared residuals	0.792	0.800
Standard error of estimate	0.104	0.102
Durbin-Watson statistic	1.972	1.920
Q-statistic	39.569	38.779
Constant	−10.38 (−4.38)	−21.92 (−14.81)
ρ	— —	−0.49 (−4.90)
qx_{t-1}	−0.49 (−4.90)	— —
$\log[(1 + S)E]_{t-1}$	0.03 (0.43)	— —
$(px^* - pd)_{t-1}$	0.06 (0.60)	— —
q_{t-1}	1.11 (4.40)	— —

Note: t-statistics in parentheses.

contract has a life span of ten years during which firms are granted incentives to export.

This section measures the impact of the export subsidy on export revenues. The results suggest that exports have increased about 10 percent. The impact on export revenues is compared with the budgetary cost, which constitutes a lower bound for the cost of the subsidy. One important policy implication of the program emerges from the analysis: roughly half of the total expenditure on the subsidy has been used to increase imports of intermediate inputs.

A frequently mentioned alternative to export subsidies is exchange rate policy. The model is used to determine the impact and trade-off of reducing the export subsidy and compensating with a higher rate of depreciation.

Forecasting Performance

Before the model is used to simulate the effect of the export subsidy, its forecasting performance is gauged. To establish the model's ability to track the data during this period, it has been used to generate static

forecasts of dollar exports. Roughly two thirds of the one-period forecast errors, from 1984:2 through 1989:4 (23 quarters), were less than 10 percent of the dollar value of exports. Of the remaining eight errors, five were less than 15 percent. The models' ability to forecast exports can be measured through dynamic forecasts. Accordingly, it is simulated dynamically starting from 1984:2 through 1989:4. This simulation uses the export revenue forecast for one period in the forecast for the next. Thus, the simulation forecasts just under six years into the future. Under these circumstances, roughly half of the forecast errors are under 10 percent; the other half are distributed equally between 10–15 percent, 15–20 percent, and 20 percent and above. Figure 2 shows the static forecasts in panel A and the dynamic forecasts in panel B.

To further evaluate the model's ability to forecast exports, a series of statistics that summarize in-sample forecasts during the export contract have been compiled. The model is re-estimated each quarter and used to forecast up to 12 quarters. These in-sample forecasts were used to calculate the mean error (ME), the mean absolute value error (MAE), the root mean square error (RMSE), and Theil's U-statistic. Table 3 presents the results.

The results do not indicate a problem of consistently over- or underpredicting the data, since the ME and the MAE have very different magnitudes. Notice that the model's one-step forecast erred by an average of \$4.0 million, while the absolute forecast erred by \$9.5 million. Considering that quarterly export revenue averaged \$117 million during this period, these errors are quite small. Notice, however, that the model tends to underpredict actual exports; the Theil U-statistics for forecasts for three quarters and less are poor. However, as the forecasting horizon increases, the model consistently outperforms the naive forecast. These simulations suggest that the model can track and forecast Costa Rica's dollar exports with reasonable accuracy during the period of interest.

Simulations

Once the model's ability to forecast has been evaluated, the role of the subsidy in stimulating exports can be explored. First, the model will be used to simulate baseline exports, which are compared to a simulated counterfactual where the export subsidy is set to zero during the export contract.[31] The additional export revenues will be compared with the bud-

[31] At this point it is worthwhile to refer to the Lucas critique of policy evaluation. There is growing recognition that policy evaluation is not useless. Both Cooley, Leroy, and Raymond (1984) and Sims (1987) have argued that the usual interpretation of the critique is logically flawed. Sims (1987) argues that the Lucas

Figure 2. *Model Predictive Capacity*
(1984:2–1989:4)

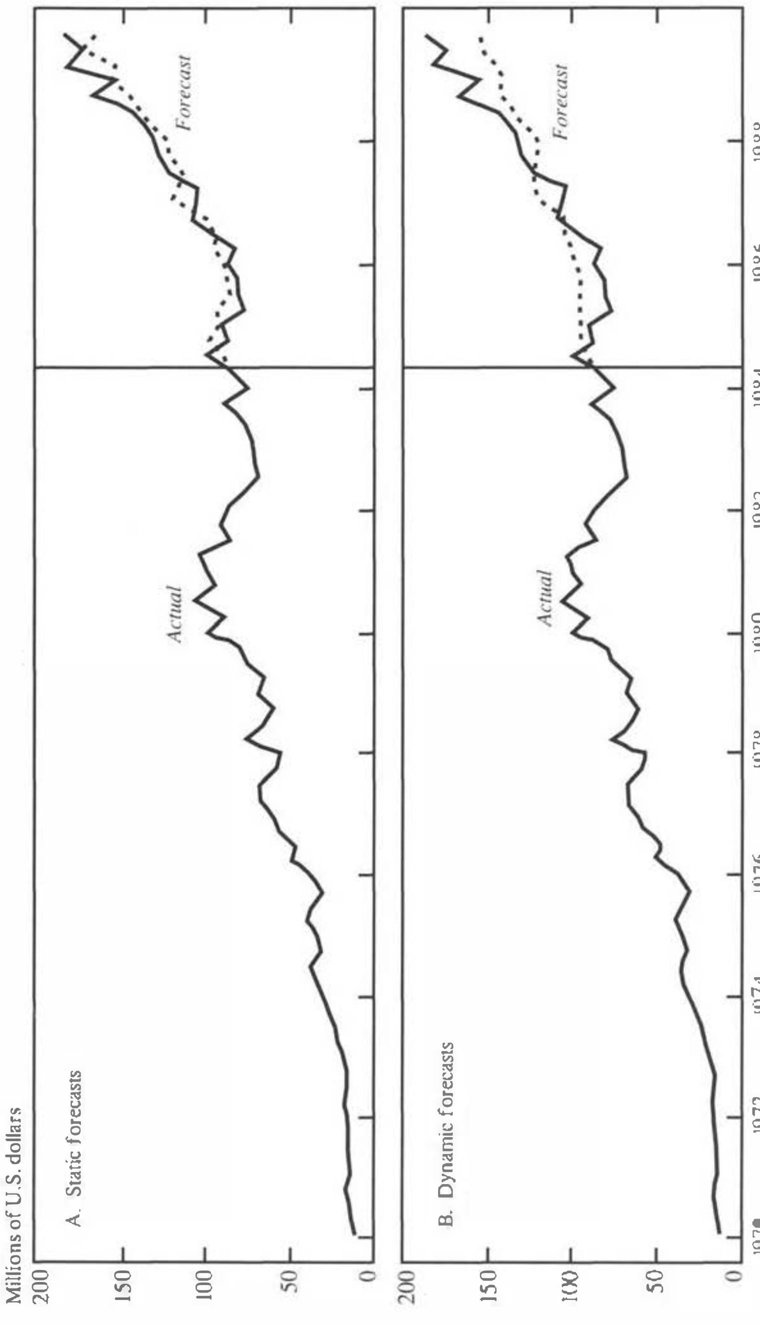


Table 3. *Forecasting Statistics*
(1984:2–1989:4)

Steps	Mean Error (In millions of U.S. dollars)	Mean Absolute Value Error (In millions of U.S. dollars)	Root Mean Square Error (In millions of U.S. dollars)	Theil U-Statistic	Observations
1	4.0	9.5	12.0	1.0	23
2	7.2	16.8	19.2	1.3	22
3	7.7	16.8	21.7	1.1	21
4	8.2	18.1	22.1	0.9	20
6	10.1	20.0	25.1	0.7	18
8	13.3	21.7	26.8	0.6	16
10	15.3	21.5	26.4	0.5	14
12	16.6	21.6	27.1	0.4	12

getary cost of the subsidy. Second, the model is used to simulate a common policy prescription to foster exports: exchange rate depreciation. The trade-off between export subsidy and exchange rate depreciation is assessed.

The Cost of the Subsidy

The model is used to evaluate the impact of export subsidies during the export contract period, 1984:2–1989:4. The baseline is obtained by dynamically simulating the model starting from 1984:1; in the following quarters, the subsidy was set to zero. The model was subsequently simulated to generate the counterfactual. Figure 3 shows the evolution of exports in both cases.

The model estimates that the impact on dollar exports was approximately \$275 million over these 23 quarters. Given that total nontraditional exports totaled about \$2.7 billion during this period, this represents roughly a 10 percent increase. This dollar amount should be compared with the cost of the subsidies. Table 4 presents the relevant data. The direct cost of the subsidization program is estimated at about \$205 million,[32] corresponding to an average of 0.8 percent of GDP over the six years. Nonetheless, the cost has been increasing, averaging 1.2 percent of GDP during 1988 and 1989.

Comparing this cost with the additional exports generated suggests that each dollar spent on export subsidies has yielded a gain of about 34 percent in export revenues over the 23 quarters. However, this yield is subject to two qualifications. First, note that the cost of the export subsidies consists exclusively of the direct cost and, as such, represents a lower bound for costs. Important administrative costs are associated with the program. Each firm's application is reviewed by a joint commission—composed of representatives of the Ministry of Finance, the Ministry of Economics, and the Commission to Promote Exports (CEMPRO). The most important requirement is that the product contain at least 35 percent domestic value added. When the application is approved, the conditions—markets and subsidy rate—are published in the *Official Gazette*. For every shipment, the central bank provides the exporter with the

critique does not raise a problem when the model is "... one in which policy is already optimal and persists in being so. Thus the process of policy choice does not change the expectations formation behavior implicit in the model's structure" (p. 305). It is in this context that policy simulations are conducted later in this section.

[32] The export subsidy, CATS, has been converted into dollars using the average exchange rate.

Figure 3. *Export Subsidies*
(Simulation: 1984:2–1989:4)

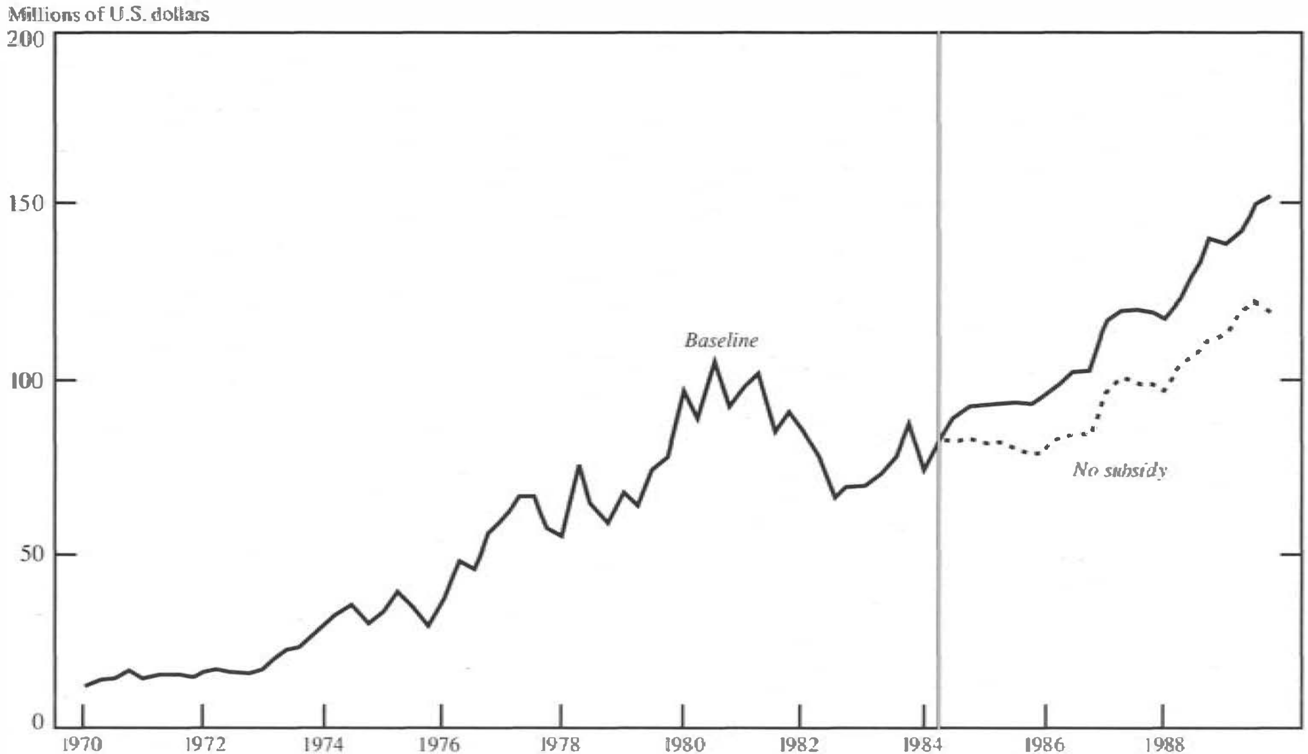


Table 4. *Simulation of the Export Subsidy*

Year	Exchange Rate (colón/U.S. dollar)	CATS colones	CATS U.S. dollars	Export Response (In millions of U.S. dollars)
1984	44.98	480.30	10.68	9.25
1985	51.31	973.50	18.97	30.98
1986	56.71	1,553.80	27.40	44.60
1987	64.15	2,030.50	31.65	54.34
1988	76.84	3,880.20	50.50	62.64
1989	82.09	5,394.90	65.72	74.73
Total		14,473.30	204.92	276.55

appropriate tax credit papers. These costs are difficult to measure, and have not been accounted for in the 34 percent yield.

The second qualification concerns the measurement of additional export revenues. Strictly speaking, the $275 million increase corresponds to gross exports, but these exports have a significant import component. On average, nontraditional exports contain about 40 percent of domestic value added.[33] This means that only $110 million has been generated, net of imports, over the 23 quarters. If the lower-bound estimate for cost is used to determine the yield of the subsidy program, the result is a net of 54 cents generated for each dollar spent. This implies that out of each dollar transferred from taxpayers to exporters via the export subsidy, 46 cents ended up subsidizing the import of intermediate inputs.[34]

Exchange Rate Depreciation

Exchange rate depreciation is frequently suggested as a way to compensate for a reduction in export subsidies. As already discussed, exports have the same elasticity with respect to the nominal exchange rate as they do with respect to the subsidy. This suggests that a reduction of the subsidy $(1 + S)$ could be offset by an equal percent change of the exchange rate.

The exact trade-off between the exchange rate and the subsidy is simple to calculate. The estimates were obtained using an index, S, for the export subsidy: S_t'/S_0'. Notice that the percentage change of $(1 + S)$

[33] Domestic value added is obtained by summing up the domestic value added of each input used to produce the final export good. Thus, the domestic value added in the final stage of production is typically less than 40 percent. Data for 1988 and 1989 provided by the Ministry of Finance were used to calculate an average for value added.

[34] It should be noted that imported intermediates used to produce exports are duty free; thus, the subsidy is not offset by tariff revenues.

can be expressed in terms of the export subsidy, S', as $S_t'/(S_t' + S_0') \cdot \hat{S}'$. This implies that $\hat{E} < -\hat{S}'$, as long as the base used to calculate the subsidy index is positive. Thus in the long run, the reduction of the export subsidy can be compensated by a smaller percentage depreciation.

To determine the average depreciation required to compensate for the elimination of the export subsidy, a counterfactual was generated by setting the rate of depreciation constant throughout the simulated period. The rate of depreciation was set so that total dollar exports during these six years was the same as the baseline, about $2.7 billion. Full compensation requires an increase in the quarterly depreciation by 7 percent.[35] Figure 4 depicts the trajectory of exports compensated with an increase of 7 percent over the baseline.[36]

The results imply that a 25 percent reduction of the export subsidy, via the proposed tax on CATS, will reduce nontraditional exports by approximately 2.5 percent in the long run, which could be compensated by an increase of about 1.75 percent in the quarterly rate of depreciation.

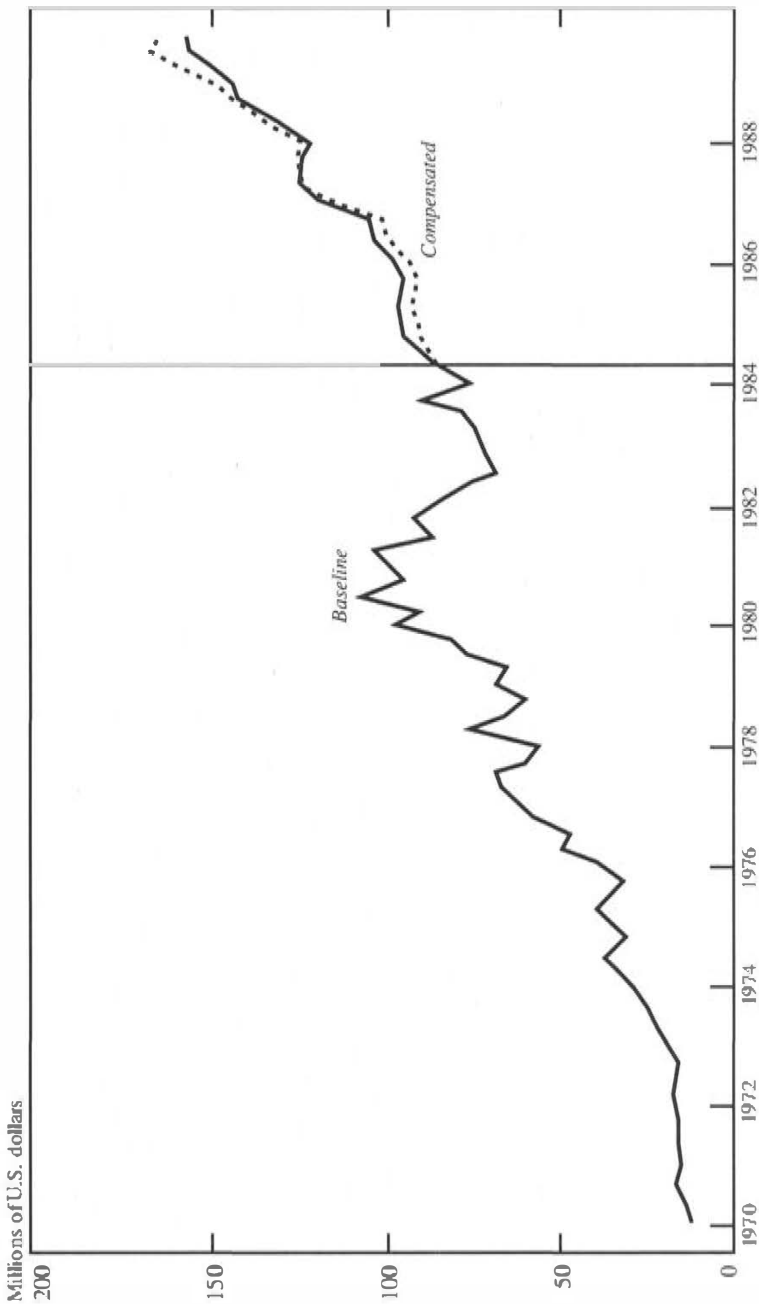
A final comment should be made about the compensating depreciation. It is possible that the depreciation will affect the domestic price of exportables, reducing its impact on exports. A higher rate of depreciation will tend to increase the domestic cost of imported goods, and can thus contribute to higher prices, which will tend to reduce the effectiveness of nominal depreciation. However, eliminating the export subsidy reduces public expenditure and thus contracts aggregate demand. This will tend to reduce inflationary pressures. In addition, the depreciation will improve the position of the Central Administration by increasing tax revenues, primarily import taxes, while expenditures in the rest of the public sector will tend to increase. The net impact on domestic prices is an empirical issue that can only be measured by a complete macro model of the Costa Rican economy. The present calculations of the compensating depreciation assume that the effects on inflation offset each other, thus replicating a concept analogous to real depreciation.[37]

[35] The rate of depreciation required was 10 percent. However, since the baseline included a 3 percent depreciation, compensation is attained with the reported rate.

[36] Notice that during the first two years the level of exports of the counterfactual is less than the baseline, while during the last two years it is larger. This implies that the 7 percent compensation does not necessarily result in the same discounted flow of export revenues as the baseline. However, the differences are relatively small.

[37] The caveat on real depreciation is due to the asymmetry between the effect of *pd* and the subsidy. The estimates here suggest that export supply is more sensitive to domestic prices than to the nominal exchange rate. The calculated effect on exports would require measuring the impact of the depreciation on the general price level and, in turn, the response by the price that exporters face in the domestic market. Given that the elasticities are different, this is not exactly the rate of depreciation accounting for inflation.

Figure 4. *Compensating Depreciation*
(Simulation: 1984:2–1989:4)



IV. Conclusions

In recent years, many countries have switched their development strategies from import substitution to export promotion. Empirical evidence regarding the effectiveness and costs of these export promotion policies, and particularly direct and indirect incentives to exports, is limited. In this paper, a direct export subsidy was introduced into a model that featured a firm facing two markets (domestic and world). The subsidy was found to increase output and switch sales to the world market.

The model analyzed the long-run supply of exports, and the short-run dynamics were generated by the data. However, explicitly modeling the short-run dynamics could prove worthwhile. A generalization of this model, where firms maximize a discounted stream of future profits, would shed light on the dynamics of export subsidies. It is likely that subsidies could trigger both intertemporal and intratemporal responses through their effect upon investment decisions. This model would be analogous to models that have analyzed the effect of terms of trade shocks on the trade balance (see, for example, Ostry (1988)). Indeed, it is likely that export subsidies would have very different effects when they are viewed as being temporary as opposed to being permanent, and modeling the short-run dynamics could be a fruitful avenue for future research.

The estimates of the long-run relationship between export supply and relative prices for Costa Rica showed strong evidence of cointegration, making it possible to estimate a constrained error-correction model, to capture the short-run dynamics of export supply. The estimates suggested that exports are price inelastic, and firms adjust within the year to shocks to the system. The forecasting performance of the estimated model was adequate.

The estimated model was used to measure the impact of the export subsidy. Exports increased by about $275 million during the six-year period, roughly a 10 percent increase in response to the 15 percent export subsidy. However, the impact on net exports was much smaller, estimated to be only about $110 million. The direct cost of the subsidy, not accounting for administrative costs, totaled about $205 million. This suggests that on average, a dollar spent on the program increased net exports by only 54 cents.

The cost of the subsidy averaged 1.2 percent of GDP during 1988 and 1989, prompting policymakers to consider modifying the scheme. The model indicates that about half of the amount spent on the program subsidized imports. Thus, it would seem that a more efficient way to spend tax dollars would be to subsidize the domestic value added of exports, which would reduce the cost of the incentive by avoiding the

subsidization of imports. Alternatively, a lump-sum transfer could also avoid the subsidization of imports. Such a transfer could be set up to cover initial investment costs or the initial costs of penetrating foreign markets.

Compensating depreciation is often prescribed as a substitute for export subsidies. The simulations suggest that compensating for the 15 percent export subsidy would require an increase of 7 percent of the quarterly rate of depreciation, or about 31 percent on an annual basis. This calculation implicitly assumes that the growth of exports attained by the export subsidy is socially desired—an issue not addressed in this paper.

A subsidy is not a first-best policy; it introduces distortions that offset its benefits. Many countries have introduced export incentives to reduce the anti-export bias caused by import barriers. Given the cost of introducing export subsidies—direct on the fiscal budget and indirect through their effect on production and consumption decisions—the economically preferable policy is to eliminate the source of the anti-export bias. Thus, the first-best policy is trade liberalization.

APPENDIX

Description of Data, Test Results, and Methodology

This Appendix provides a description of the data, as well as the results of the unit-root tests and the methods for solving single equations.

Data

The following quarterly series were taken from *International Financial Statistics*, (International Monetary Fund, various years): the exchange rate; domestic price; and Px^*. The latter series was used to distribute the export price of nontraditional exports using Chow and Lin (1971).

The following annual series came from Banco Central de Costa Rica (BCCR): (1) U.S. dollar exports of nontraditional exports, which was distributed using Litterman (1984); and (2) prices of nontraditional exports, which was distributed using Chow and Lin (1971). Dollar exports were deflated using the price of nontraditional exports to obtain the quantity of exports.

The Ministry of Finance of Costa Rica provided the CATS subsidy series. An annual series for "CATS Entregados" was distributed using Chow and Lin (1971) with the quarterly series "CATS Efectivos." The "Entregados" version is analogous to a commitment series of subsidy, while "Efectivos" corresponds to cash payments. The Ministry also provided information on the domestic value added of nontraditional exports.

Quarterly GDP figures are from Hoffmaister (1992). All relevant series have been indexed to 1985.

Unit-Root Test Results

Two standard unit-root tests were applied: (1) augmented Dickey-Fuller (ADF); and (2) augmented Phillips-Perron (APP). The number of lags included in each of these tests was determined following Campbell and Perron (1991). Hall (1990) shows that this procedure will come up with the correct number of lags with probability one asymptotically, provided that the procedure starts with a sufficiently high number of lags. The test results are included in Table 5.

The test results suggest the existence of one, but not two, unit roots. This is also true when a trend and/or drift is added to the null hypothesis. Notice that the augmented Dickey-Fuller test could not reject the existence of two unit roots in most cases. The lack of power of the augmented Dickey-Fuller test is discussed by Campbell and Perron (1991).

Single-Equation Methods

To discuss the four methods mentioned above, let us introduce the following equations:

$$y_t = \beta' x_{1t} + \mu_t^{(1)} \tag{7}$$

$$\Delta x_{1t} = \mu_t^{(2)} \tag{8}$$

$$\Delta x_{2t} = \mu_t^{(3)}. \tag{9}$$

Equation (7) is the cointegrating equation, (8) is a vector of k_1 regressors included in (7), and (9) is a vector of k_2 instruments that do not appear in equation (7) and are cointegrated with the regressors in equation (8). Let $\mu = [\mu^{(1)}, \mu^{(2)}]'$ be the $(k_1 + 1)$ vector of residuals in the system (7)-(8) and let its covariance matrix be

$$\Sigma = E[\mu \cdot \mu'] = \begin{bmatrix} \sigma_{11} & \sigma'_{21} & \sigma'_{31} \\ \sigma_{21} & \Sigma_{22} & \sigma'_{32} \\ \sigma_{31} & \sigma_{32} & \Sigma_{33} \end{bmatrix}, \tag{10}$$

partitioned to conform with equations (7)–(9).

Phillips and Hansen (1990) note that for time series

$$\sigma_{21} = \sum_{s=0}^{\infty} E[\mu_{t}^{(2)} \mu_s^{(1)}]. \tag{11}$$

Table 5. *Unit-Root Tests*

Test	Series			
	qx	$px - pd$	$\log(1 + S)e$	q
Augmented Dickey-Fuller				
Level	−1.440	−1.827	−0.259	−1.487
$(1 - L)$	−34.298**	−2.108	−2.050	−1.833
Augmented Phillips-Perron				
Level	−2.522	−1.609	−2.095	−2.200
$(1 - L)$	−74.770**	−31.450**	−23.788**	−600.153**

Note: Two asterisks indicate significance at the 1 percent level.

Their nonparametric correction for serial correlation adjusts OLS estimates obtained from equation (7) by adding to it: $-[x_1' x_1]^{-1} T\hat{\sigma}_{21}$, where $\hat{\sigma}_{21}$ is a consistent estimator of σ_{21}. This adjustment purges the OLS estimates of the nuisance parameters due to serial correlation.

Their "fully modified" estimator requires two corrections that are accomplished as follows. First, the left-hand-side variable in equation (7) is purged of endogeneity by the following transformation: $y_t^+ = y_t - \hat{\sigma}_{21}' \hat{\Sigma}_{22}^{-1} \Delta x_{1t}$. OLS is performed with this transformed variable, and in turn corrected for serial correlation by adding to it $-[x_1' x_1]^{-1} T\hat{\delta}^+$, where $\hat{\delta} = \hat{\Phi} \cdot [1, -\hat{\Sigma}_{22}^{-1} \hat{\sigma}_{21}]'$ and $\hat{\Phi}$ is a consistent estimate of $\Phi = \Sigma_{s=0}^{\infty} E[\mu_0^{(2)} \mu_s']$.

Stock and Watson (1991) suggest the following parametric method to deal with endogeneity of regressors. The basic idea is to make $\mu_t^{(1)}$ independent of $\mu_t^{(2)}$; to this effect they note that since $\mu_t^{(1)}$ is assumed Gaussian and stationary, then

$$E[\mu_t^{(1)} / \{\Delta x_{1t}\}] = E[\mu_t^{(1)} / \{\mu_t^{(2)}\}] = d_1(L)\Delta x_{1t},$$

where $d_1(L)$ is a two-sided lag polynomial. It should be noted that $d_1(L) = \Sigma_{i=-\infty}^{\infty} d_{1,i} \cdot L^i$ in practice is truncated. By adding and subtracting this term to (7)

$$y_t = \beta' x_{1t} + d_1(L)\Delta x_{1t} + c_{22}(L)\tilde{\mu}_t^{(2)}, \tag{12}$$

where $\tilde{\mu}^{(2)} = \mu^{(2)} - E[\mu^{(2)} / \{\mu_t^{(2)}\}]$ is independent of innovations from the left-hand-side variable by construction. Stock and Watson suggest using OLS on the dynamic equation (12). They call this estimator dynamic OLS.

This parametric correction for endogeneity is shared by Saikkonen (1991) and by Phillips and Loretan (1989), and is based on the work of Sims (1972) on causality tests. Recall that when a variable y_t causes (in Granger terms) x_{1t}, then y_t can be expressed as a linear combination of past, future, and present values of x_{1t}. Thus, future values of x_{1t} will provide information that helps in the prediction of y_t. These future values of x_{1t} are in essence Sims's causality test. Significant values for future x_{1t} provide evidence that x_{1t} is not weakly exogenous.

Equation (11) still contains serial correlation. Stock and Watson dealt with the serial correlation by correcting the covariance matrix used in the estimation of (11). The covariance matrix should be estimated using nonparametric methods, such as using a Bartlett window. They have also suggested estimating the covariance matrix using an autoregressive spectral estimator. Alternatively, they also model the errors as autoregressive processes, suggesting dynamic generalized least squares. Saikkonen (1991) suggested a different nonparametric correction that basically adds to equation (12), $d_2(L)x_{3t}$, where $d_2(L)$ is a two-sided lag polynomial. Phillips and Hansen (1990) suggested a parametric correction to deal with serial correlation. They proposed adding to equation (12) the term $d_3(L)(y_t - \beta' x_t)$, where $d_3(L)$ is a one-sided lag polynomial defined as $\Sigma_{i=1}^{\infty} d_{3,i} \cdot L^i$. Their estimator implies that the cointegrating vector enters nonlinearly; thus, it is estimated using nonlinear least squares.

REFERENCES

Balassa, Bela, Evangelos Voloudakis, Panagiotis Eylaktos, and Suk Tai Suh, "Export Incentives and Export Growth in Developing Countries: An Econometric Investigation," Discussion Paper, Report No. DRD159 (Washington: World Bank, February 1986).

Behrman, Jere, and Santiago Levy, "The Drawbacks of Export Drawbacks," CLADS Discussion Paper Series, 80 (Boston: Boston University, October 1988).

Brander, James, and Paul Krugman, "A 'Reciprocal Dumping' Model of International Trade," *Journal of International Economics*, Vol. 15 (November 1983), pp. 313–21.

Breusch, T.S., "Testing for Autocorrelation in Dynamic Linear Models," *Australian Economic Papers*, Vol. 17 (December 1978), pp. 334–55.

Breusch, T.S., and L.G. Godfrey, "A Review of Recent Work for Autocorrelation in Dynamic Simultaneous Models," in *Macroeconomic Analysis: Essays in Macroeconomics and Econometrics*, ed. by D. Currie, R. Nobay, and D. Peel (London: Croom Helm, 1981).

Calvo, Guillermo A., "On the Costs of Temporary Policy," *Journal of Development Economics*, Vol. 27 (October 1987), pp. 245–61.

Campbell, John Y., and Pierre Perron, "Pitfalls and Opportunities: What Macroeconomists Should Know about Unit Roots," Econometric Research Program, Research Memorandum No. 360 (Princeton, New Jersey: Princeton University, April 1991).

Chow, Gregory C., and An-loh Lin, "Best Linear Unbiased Interpolation, Distribution, and Extrapolation of Time Series by Related Series," *Review of Economics and Statistics*, Vol. 53 (November 1971), pp. 372–75.

Cooley, Thomas F., Stephen F. LeRoy, and N. Raymond, "Modeling Policy Interventions," Discussion Paper (Santa Barbara and Columbia, Missouri: University of California at Santa Barbara and University of Missouri, 1984).

Engle, Robert F., and C.W.J. Granger, "Co-Integration and Error Correction: Representation, Estimation, and Testing," *Econometrica*, Vol. 55 (March 1987), pp. 251–76.

Engle, Robert F., and Byuing Sam Yoo, "Forecasting and Testing in Cointegrated Systems," *Journal of Econometrics*, Vol. 35 (1987), pp. 143–59.

Faini, Ricardo, "Export Supply, Capacity, and Relative Prices," Economics Department Research Paper, WPS 123 (Washington: World Bank, 1988).

Godfrey, L.G., "Testing Against General Autoregressive and Moving Average Error Models When the Regressors Include Lagged Dependent Variables," *Econometrica*, Vol. 46 (1978), pp. 1293–302.

Goldstein, Morris, and Mohsin S. Khan, "The Supply and Demand for Exports: A Simultaneous Approach," *The Review of Economics and Statistics*, Vol. 60 (May 1978), pp. 275–86.

———, "Income and Price Effects in Foreign Trade," in *Handbook of International Economics*, Vol. 2, ed. by Ronald W. Jones and Peter B. Kenen (Amsterdam; New York: North-Holland, 1985).

Granger, C.W.J., "Co-Integrated Variables and Error Correction Models," USCD Discussion Paper 83-13 (San Diego: University of California, San Diego, 1983).

Hall, A., "Testing for a Unit Root in Time Series with Pretest Data Based Model Selection," (unpublished; Raleigh, North Carolina: North Carolina State University, 1990).

Helpman, Elhanon, and Paul R. Krugman, *Market Structure and Foreign Trade: Increasing Returns, Imperfect Competition, and the International Economy* (Cambridge, Massachusetts: MIT Press, 1985).

Hoffmaister, Alexander, "The Cost of Export Subsidies: Evidence from Costa Rica," IMF Working Paper 91/94 (Washington: International Monetary Fund, October 1991).

———, "Costa Rica: Trimestralizacion del PIB Real, y el Ajuste Dinamico ante Shocks Monetarios y de Tipo de Cambio," *Ciencias Economicas* (forthcoming, 1992).

Jung, Woo S., and Gyu Lee, "The Effectiveness of Export Promotion Policies: The Case of Korea," *Weltwirtschaftliches Archiv*, Vol. 122, No. 2 (1986), pp. 340–57.

Litterman, Robert B., "A Random Walk, Markov Model for the Distribution of Time Series," Federal Reserve Bank of Minneapolis, Research Department Staff Report 84 (Minneapolis: Federal Reserve Bank of Minneapolis, 1983).

Ostry, Jonathan, "The Balance of Trade, Terms of Trade, and Real Exchange Rate: An Intertemporal Optimizing Framework," *Staff Papers*, International Monetary Fund, Vol. 35 (December 1988), pp. 541–73.

Park, J., and P. Phillips, "Statistical Inference in Regressions with Integrated Processes: Part 1," *Econometric Theory*, Vol. 4 (1988), pp. 468–97.

———, "Statistical Inference in Regressions with Integrated Processes: Part 2," *Econometric Theory*, Vol. 5 (1989), pp. 95–131.

Phillips, Peter C.B., and Bruce E. Hansen, "Statistical Inference in Instrumental Variables Regressions with I(1) Processes," *Review of Economic Studies*, Vol. 57 (January 1990), pp. 99–125.

Phillips, Peter C. B., and Mico Loretan, "Estimating Long Run Economic Equilibria," Cowles Foundation for Research in Economics, Discussion Paper No. 928 (New Haven, Connecticut: Yale University, 1989).

Phillips, Peter C.B., and P. Perron, "Testing for a Unit Root in Time Series Regression," *Biometrika*, Vol. 75 (1988), pp. 335–46.

Saikkonen, Pentti, "Asymptotically Efficient Estimation of Cointegration Regressions," *Econometric Theory*. Vol. 7 (March 1991), pp. 1–21.

Sims, Christopher A., "Money, Income, and Causality," *American Economic Review*, Vol. 62 (September 1972), pp. 540–52.

———, "A Rational Expectations Framework for Short-Run Policy Analysis," in *New Approaches to Monetary Economics: Proceedings of the Second International Symposium in Economic Theory and Econometrics*, ed. by William A. Barnett and Kenneth A. Singleton (Cambridge; New York: Cambridge University Press, 1987).

Stock, James H., and Mark W. Watson, "A Simple Estimator of Cointegrating Vectors in Higher Order Integrated Systems," Federal Reserve Bank of Chicago Working Paper No. 91-3 (Chicago: Federal Reserve Bank of Chicago, February 1991).

Tyler, William G., *Manufactured Export Expansion and Industrialization in Brazil* (Tubingen: J.C.B. Mohr, 1976).

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Restoration of Access to Voluntary Capital Market Financing

The Recent Latin American Experience

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After a prolonged and almost total reliance on debt restructurings and concerted money facilities, several Latin American countries have mobilized voluntary financing from international capital markets. Although the phenomenon is still limited in terms of volume and number of borrowers, it has attracted considerable attention. This paper reviews the nature, magnitude, and terms of the market re-entry process and analyzes the factors that have facilitated it. A discussion follows, based on this review, of the key elements affecting the short-term prospects for Latin American private and public sector voluntary debt and equity financing from international capital markets. [JEL F34, G15, 054]

OVER THE LAST two years, several Latin American borrowers have regained limited access to voluntary financing from international capital markets. This restoration followed a period of over six years during which these countries' private external borrowing was limited essentially to concerted bank financing, primarily in the form of principal reschedulings and new money packages. Although the process of market

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re-entry is still at an early stage—in terms of both volume and number of borrowers—it has nevertheless attracted considerable attention and has affected a wide range of external financing instruments, including bonds, equity flows, derivative products, foreign direct investment, and capital repatriation.

This paper draws on recent country experiences to provide an overview of the process of market re-entry, to assess the factors that have facilitated it, and to discuss some of the elements affecting the prospects for the period ahead. Section I provides quantitative indicators of the magnitude and terms of recent voluntary financing for the main Latin American countries re-entering the capital markets. Section II analyzes the four basic elements that have allowed for the restoration of access: sustained implementation of comprehensive adjustment policies, appropriate restructuring of existing indebtedness, a reduction in transactions costs for accessing capital markets, and greater effectiveness in customizing financing instruments to market conditions. Based on this analysis, Section III assesses the prospects for both the main re-entrant countries and other developing countries that are still seeking to normalize their external financial relations.

I. Restoration of Access—Some Quantitative Indicators

The restoration of access to voluntary private financing is directly evident in several segments of the international capital markets—most notably bonds and equities. It is also reflected in the substantial turnaround in foreign direct investment and capital repatriation. By contrast, there has been only a limited response in the case of voluntary commercial bank loans.

Loan and Bond Financing

International capital markets were a major source of external financing for developing countries in the 1970s and early 1980s. Medium- and long-term publicized international bank credit commitments totaled some $225 billion in 1976–82. In 1982 alone, such commitments amounted to $42 billion, with Latin American countries accounting for $23 billion. For bond financing, publicized developing country issues amounted to $27 billion in 1976–82. Of this amount, $4 billion was issued in 1982, with Latin American borrowers accounting for $2 billion.

These estimates are in stark contrast to those for the following six years. The outbreak of severe debt-servicing problems in several Latin

American countries in 1982 was associated with a virtual drying up of all sources of voluntary financing, with the exception of short-term trade facilities. As a result, the total amount of voluntary loan and bond financing flows to Latin American countries during the 1983-88 period was considerably smaller than that for 1982 alone. Specifically, financial flows to Latin America in the form of voluntary medium- and long-term bank credits and bonds totaled only $7 billion in 1983–88. Concerted financing became the main source of private international financial support. Restructured medium- and long-term bank debt amounted to some $310 billion during this period,[1] with the associated cash flow relief being supplemented by new money facilities.

Several developments indicate that the quantitative international credit rationing facing some Latin American countries in the 1980s has been gradually relaxed in the last two years. Although still limited, the process of market re-entry is gaining momentum and is affecting a growing number of countries. Two groups of Latin American countries may be distinguished. The countries in the first group—which includes Chile, Mexico, and Venezuela—have established relatively solid footholds in the markets. The countries in the second group—comprising Argentina and Brazil—are at an earlier stage, having just recently been able to place selected voluntary issues at terms (interest rates and maturities) that are considerably less favorable than those obtained by the first group of countries. Although it has implications for the prospects of this latter group of countries, the present analysis is concerned primarily with the experience of the first group.[2]

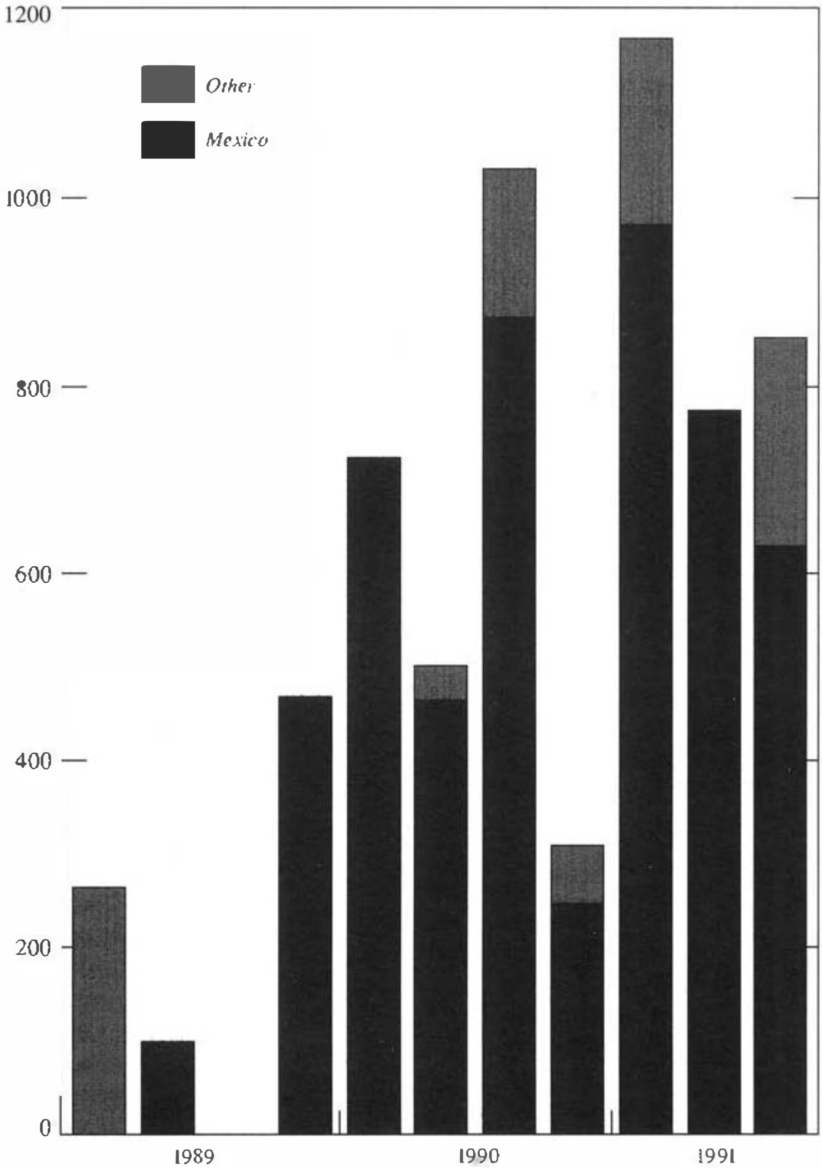
An important source of voluntary financing (in value terms) has been *international bond markets*. Mexico and, to a lesser extent, Venezuela and Chile, are reported to have issued some $3.4 billion of bonds in the two-year period ended December 1990 (Figure 1).[3] The majority of these were placed on markets in the United States and Germany, and mobilized investor funding from specialized institutions and residents' capital held abroad. On the borrowers' side, they tended to involve corporations with established international reputations and sound export history and prospects. The process intensified in the course of 1991, and these countries are estimated to have issued a total of $2.8 billion in the first nine months of the year. The increased volume was accompanied by a widen-

[1] This includes the rescheduling, under multiyear restructuring agreements, of obligations that would have fallen due beyond this period.

[2] See International Monetary Fund (1992) for information on bond issuance by Argentina and Brazil.

[3] An overview of the process of market re-entry may be found in International Monetary Fund (1991a, 1991b). A more detailed analysis of Mexico's restored access to voluntary capital market financing is contained in El-Erian (1991).

Figure 1. *Bond Issues by Chile, Mexico, and Venezuela*
(In millions of U.S. dollars)



Sources: *International Financing Review* and the *Financial Times*.

ing in the investment base to include a broader range of institutional and retail investors in a larger group of industrial countries.

The renewed access to international bond markets has been accompanied by some—albeit relatively limited—relaxation in the constraints on *voluntary commercial bank borrowing*. These borrowings have taken the form of trade and project financing, with Chile using such financing as its main source of voluntary external funding.[4] Overall, however—and in sharp contrast to developments in other segments of international capital markets—banks have remained reluctant to extend new voluntary medium-term credits to developing countries with recent debt-servicing problems.

The difference in risk attitudes between bank and bond lending reflects several factors, including banks' more difficult overall balance sheet situations, as well as past debt-servicing policies of countries that gave seniority to the relatively small stock of outstanding bonds compared to bank loans.[5] The impact of these factors has, in some cases, been compounded by regulatory considerations, including new capital-adequacy standards and required provisions for loan loss. Thus, under the agreement on risk-weighted, capital-asset ratios, banks, in adhering to regulatory jurisdictions and seeking to maintain the same level of risk-weighted capital, will be required to increase their capital by a minimum of $8 for every $100 increase in exposure to developing countries.[6] This requirement could act as a disincentive on bank lending to developing countries, especially if the lender is unable to raise the incremental capital on terms that are more favorable than those on the prospective loan. The cost of making loans to developing country borrowers is increased further to the extent that banks are also required to set up new loan-loss reserves against the increase in exposure. A distortionary impact may result if the regulatory requirements, which in some cases tend to lag developments in borrowers' creditworthiness, inadequately reflect the transfer and credit risks implicit in the lending activity.[7]

[4] Including the $20 million loan to Chile in September 1990, reported to be the first fully voluntary, unsecured general bank loan to a Latin American country since 1982.

[5] See International Monetary Fund (1992) for additional discussion of these issues.

[6] The capital-adequacy framework, formulated by the Basle Committee on Banking Supervision, is already reflected in the national practices of virtually all countries with large international banks. Some of these countries require minimum levels of risk-based capital above those specified under the framework (that is, 8 percent as of January 1, 1993, with a transitional requirement of 7.25 percent until then). Additional information is contained in Basle Committee on Banking Supervision (1990).

[7] Information on regulatory provisioning requirements of industrial countries

The relaxation in credit rationing has been accompanied by an improvement in market terms. This is most apparent in the sharp drop in yields on Mexican bonds—both on new issues and in the secondary market. The first unsecured voluntary bond issue by a Mexican public enterprise since 1982 (Bancomext in June 1989) carried an initial yield that implied a spread (or risk premium) of about 820 basis points over U.S. Government bonds. By the third quarter of 1990, the weighted average spread for new Mexican bond issues had declined to an estimated 320 basis points.[8] The spread increased somewhat in the final quarter due to a tightening in general market conditions, particularly investors' "flight to quality" reflecting uncertainties associated with the Middle East crisis,[9] but it was reversed in 1991. Thus, by the third quarter of the year, the yield spread at time of issue had declined to some 225 basis points—half the average level for 1990 as a whole.

These measures of improved creditworthiness are subject to bias, however, on account of the changing composition of borrowers and structures of bonds (particularly, the degree of credit enhancements). This bias may be overcome by tracking the secondary market yields on an individual bond issue—albeit at the cost of limiting the coverage of the analysis. As illustrated in Figure 2, the yield on the PEMEX long-dated issue reportedly fell from 14 percent in mid-1989 to about 9 percent by end-November 1991, implying a reduction in the risk premium indicator from over 500 basis points to about 200 basis points during this period. Over the same period, the yield on the Bancomext June 1989 issue fell to under 10 percent. As demonstrated in the figure, similar developments occurred with sovereign Venezuelan bond issues.

The improvement in interest rate terms was accompanied by a lengthening of maturities. This is most clearly illustrated in the case of Mexico where successive issues by PEMEX and NAFINSA in September–October 1991 involved maturity terms of seven and ten years, respectively. These were the longest dated voluntary debt instruments since the early 1980s issued by a developing country that had experienced debt-servicing problems.

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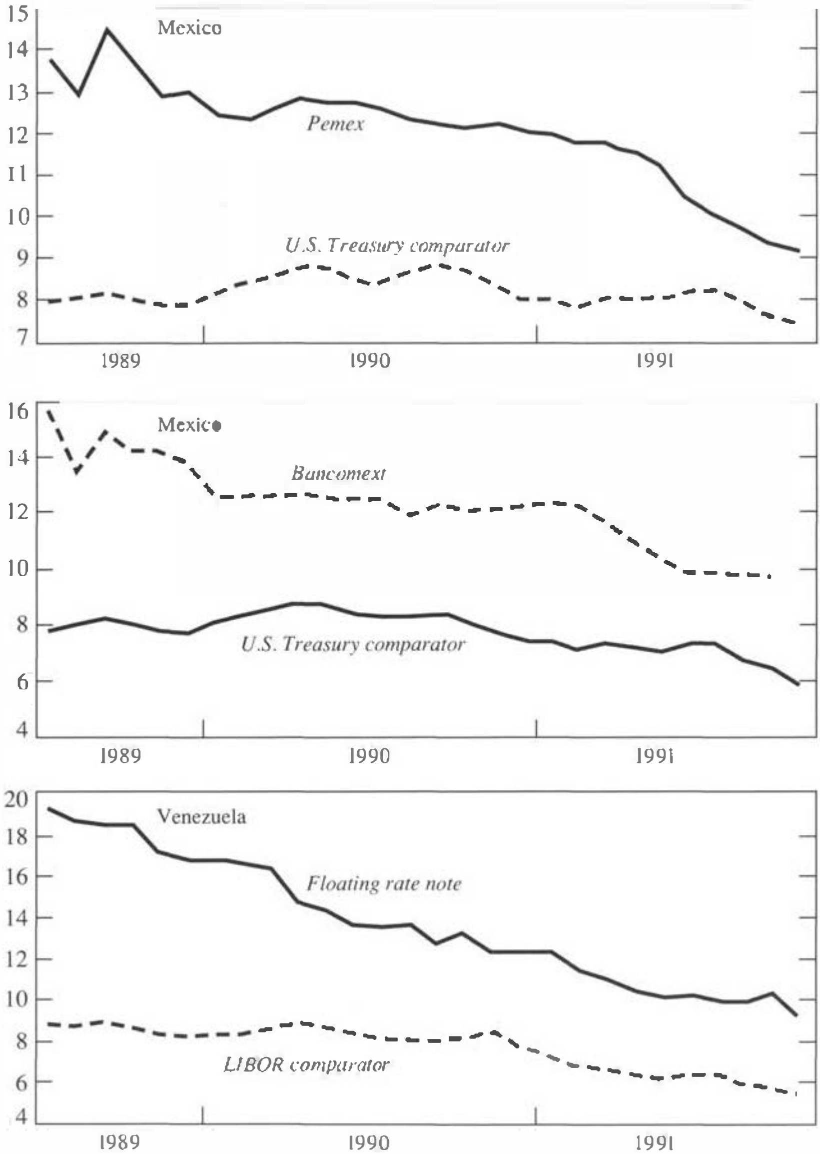
can be found in Owen Stanley Financial (1991). It should also be noted that, in some countries, the regulatory requirements are lower than those induced by market pressures.

[8]Yield spreads are measured relative to industrial country government paper of the same currency and maturity.

[9]International Monetary Fund (1991a) discusses developments in overall capital market conditions during this period.

Figure 2. *Developments in Secondary Market Yields*
(In percent)



Sources: *International Financing Review*, *Latin Finance*, and *International Financial Statistics*.

In contrast to bond financing, the terms on bank lending to developing countries worsened. This deterioration occurred in the context of an overall tightening of bank lending terms, including for borrowers from industrial countries. For developing countries as a whole (no consolidated data are readily available for the Latin American re-entrants), the average spread on voluntary loans increased by some 14 basis points in the first eight months of 1991, compared to the same period in 1990, while average maturity terms lengthened by two years and two months (Organization for Economic Cooperation and Development (1991)).

Equity Financing

A number of Latin American corporations—including, but not limited to, Mexico's TELMEX (public telephone company), Cemex (private cement company), and Vitro (glass manufacturer), and Chile's Compania de Telefonos—have also completed equity offerings in industrial country markets; these offerings have complemented the impact of a growing number of country funds channeling resources to emerging capital markets in the region.[10] The equity placements were the first significant Latin American foreign stock offerings since the 1960s; in the 1970s borrowers found it easier to resort to debt financing in the form of bank loans, and in the 1980s equity markets were effectively closed to Latin American borrowers partly as a result of the heightened perceptions of country transfer risk.

The TELMEX privatization, completed on May 20, 1991, involved the issuance of some $2.3 billion of equities on several capital markets including in Canada, France, Germany, Japan, Switzerland, the United Kingdom, and the United States, including the over-allotment provision of 15 percent (from the residual government share) to meet larger-than-anticipated investor demand. This equity offering is reported to be the sixth largest placement of shares in the world (nominal values) and the largest for any Latin American country. Cemex mobilized $140 million in May 1991, while Vitro raised a total of $73 million in April 1991 through the sale of 4 million shares. The latter issue was oversubscribed despite having been increased from an initial offering of $50 million. The earlier (July 1990) offering of the Chilean telephone company of 6.5 million shares raised some $90 million.

[10] Recent developments in equity financing for developing countries are discussed in International Finance Corporation (1991a, 1991b).

Other Capital Inflows

The above developments have been reinforced by substantial capital inflows in the form of foreign direct investment and capital repatriation. In Mexico, for example, registered foreign direct investment inflows in 1989–90 were twice the level recorded in 1987–88, with the pipeline of new investment registration growing to over $5 billion. Similar developments were recorded in Chile.

The magnitude of capital repatriation is more difficult to specify with confidence. Most available indicators point to a significant turnaround in the last two years in the capital flight that has plagued several countries in the region. These indicators include a recent study by Chartered WestLB, which estimates net total inflows of $14.1 billion for Chile, Mexico, and Venezuela in 1989–90; this compares to an estimated outflow of $4.5 billion in 1987–88, implying a turnaround of almost $20 billion (Chartered WestLB (1991)).

II. Factors Contributing to Market Re-Entry

The restoration of access to voluntary capital market financing has clear benefits. A direct benefit is that it provides a wider and more flexible range of financing instruments to fund productive activities, compared to concerted sources of financing. This is particularly important in the context of narrow, although expanding, domestic capital markets and increasingly protracted negotiations on debt restructurings and concerted new money loans. Capital market re-entry also has several indirect benefits, the most significant of which is the signal provided to agents in other international and domestic markets about reduced credit and transfer risks.

The growing availability of, and improving terms on, voluntary external financing for several Latin American countries—the manifestation of the pronounced improvement in private sector perceptions of creditworthiness—reflect four basic elements: successful implementation of economic adjustment policies, appropriate restructuring of existing indebtedness, a reduction in transactions costs for accessing capital markets, and greater effectiveness in customizing financing instruments to market conditions.

Economic Policy Implementation

Just as inappropriate economic policies, together with adverse exogenous developments, were major contributors to the emergence of debt

problems, the sustained implementation of adjustment policies has been the critical factor in the restoration of voluntary access. In effect, appropriate macroeconomic and structural reform policies have reduced perceptions of country transfer risk.

Although the economic and financial programs have varied in the countries under consideration, including entailing different policy trade-offs, it is possible to identify several key elements. First, domestic financial imbalances have been reduced due to improved budgetary performance and prudent monetary policies. These policies have involved reinforcing the fiscal revenue effort, rationalizing expenditures, and allowing domestic interest rates to reflect fully the cost of compensating savers for the considerable initial risk premia. Second, the supply responsiveness of the economy has been enhanced through appropriate pricing policy, including promoting the competitiveness of the tradables sector. Third, economic efficiency has been improved through fundamental structural reforms. These reforms have included liberalization of the trade regime, reform of the taxation system, divestiture of public sector enterprises, financial liberalization, rationalization of legal and other procedures governing foreign investment, and deregulation of domestic activities.

The implementation of these programs must be sustained if they are to be translated into a lasting reduction in country transfer risk. Indeed, the experience of several other developing countries suggests that policy slippages can quickly negate the economic and financial benefits of these programs. This is particularly important, given that many Latin American economies remain vulnerable to sudden and large reversals of private capital flows in response to such slippages. Indeed, for some of these countries whose economies have become much more integrated into the international financial system, the potential for more rapid transmission of shocks from the financial to the goods markets is greatly enhanced. The effectiveness of the economic policy package will also depend on the availability of appropriate financial support. This involves the provision of financial inflows that not only meet the immediate cash flow requirements of the adjustment program, but also contribute to a debt stock consistent with medium-term viability—an issue addressed in the next section.

Restructuring of Existing Indebtedness

Although sustained implementation of appropriate economic and financial policies is a necessary condition for market re-entry, it may not be sufficient in all cases. The experience of some Latin American coun-

tries in the 1980s suggests that, in some cases, the implementation of sound policies may be undermined by continued high risk aversion on the part of the private sector because of the country's outstanding contractual debt obligations—the so-called debt overhang effects.

Growth in indebtedness increases concerns among economic agents about the country's ability to service its debt fully in a sustained manner.[11] Specifically, investor sentiment deteriorates as questions arise about the authorities' ability to meet contractual payments without further increases in effective taxation. The latter lowers the expected return on domestic investment activities, thereby discouraging inflows of foreign direct investment and stimulating capital flight and the diversion of resources to consumption. Agents' concerns mount further if the process of securing sufficient concerted financing is subject to protracted negotiations, with uncertainties about the timing and nature of the outcome. This increases the risk of confrontation between creditor and debtor, with adverse implications for other forms of capital inflows.

Debt overhang effects require that the debt problems in some countries be addressed through contractual debt and debt-service reduction operations, rather than through the refinancing and rescheduling of obligations falling due. By lowering perceptions of country risk, the reduction in contractual obligations would trigger an investment response in excess of the one that would result solely from the larger domestic availability of resources associated with lower debt-servicing payments. Debt and debt-service reduction operations may also improve the willingness and ability of the authorities to implement adjustment policies; this willingness is linked to perceptions that foreign creditors will not secure an "undue" share of the benefits of adjustment.

After the outbreak of debt-servicing problems and until 1987–88, most Latin American countries were involved in a process of repeated and often protracted debt renegotiations. Centered on the provision of liquidity support through principal rescheduling and concerted new money, the process resulted in an increase in contractual debt obligations. Specifically, despite some improvements in the performance of the non-interest current account, the region's external debt rose from $331 billion (271 percent of exports of goods and services) in 1982 to $421 billion (over 340 percent of exports of goods and services) in 1987 (International Monetary Fund (1991c)).

It is in this context that Chile, Mexico, and Venezuela took steps to reduce the burden of bank contractual indebtedness through market-

[11] A fuller exposition of the debt overhang concept may be found in Dooley and others (1990).

based debt and debt-service reduction operations. The Chilean authorities reduced the country's total debt to banks by more than half in four years, from \$14.5 billion at end-1985 to \$6.7 billion in 1990 (the stock of restructurable bank debt declined to about \$4 billion) through a series of voluntary market-based debt conversions. Mechanisms for these conversions were introduced in mid-1985 and supplemented by direct cash buybacks in 1988–89. These buybacks extinguished some \$440 million of bank debt at a cost of \$250 million, involving an average discount of 43.5 percent.

In contrast to Chile, Mexico and Venezuela reduced their indebtedness through comprehensive bank restructuring packages. The 1990 Mexican package covered some \$48 billion of bank claims,[12] resulting in an effective reduction of gross bank debt of about \$15 billion through conversions into partially collateralized discount bonds (65 percent of face value) and reduced interest (6¼ percent, fixed) par bonds. An additional \$3 billion of claims will be extinguished if the conversion rights awarded under the new debt-equity program are fully exercised.

Venezuela's 1990 bank agreement involved an effective reduction of gross bank debt of \$4.6 billion. This was achieved through a menu of five options, including an "indirect buyback" (discount of 55 percent) and conversions of claims into partially collateralized discount bonds (70 percent of face value), reduced interest (6¾ percent) par bonds, and front-loaded bonds with provisions for temporary interest reduction (5 percent for the first two years, 6 percent for the third and fourth years, 7 percent for the fifth year, and LIBOR plus ⅞ percent thereafter).

Preliminary indicators suggest that, together with appropriate economic policies, the debt and debt-service reduction operations have reduced debt overhang concerns. This is most evident in the case of Mexico where the announcement of the bank financing package was followed by a sharp improvement in country risk indicators. Real ex post domestic interest rates fell by 20 percentage points to about 10 percent a year following the announcement—a decline that was sustained thereafter. The yield on Mexican external traded bonds also fell sharply (by 75 to 230 basis points). Finally, the secondary market price for bank claims on Mexico generally improved, with its ratio to other Baker 15 countries rising from 1.20 before the package to 1.34 by end-1990.

The secondary market prices for bank claims on Chile and Venezuela also recovered strongly.[13] By end-November 1991, the prices for bank

[12] Additional information on the Mexican package is contained in Aspe Armella (1990), El-Erian (1990), and van Wijnbergen (1991).

[13] The derivation of the Mexican and Venezuelan prices includes adjusting (or

claims on all three countries were at their highest relative levels since comprehensive reporting of such data was initiated in the mid-1980s (see Figure 3). Moreover, in the case of Chile, the secondary market discount fell to only 10 percent, consistent with the discounts for several developing countries that had retained voluntary market access throughout the 1980s.

Reduced Transaction Costs

The improvement in country fundamentals (that is, lower transfer risk) has been accompanied by a reduction in the transactions costs for accessing international capital markets. This has resulted, among other things, from regulatory changes in industrial country capital markets and increased market-credible information regarding borrowers' creditworthiness.

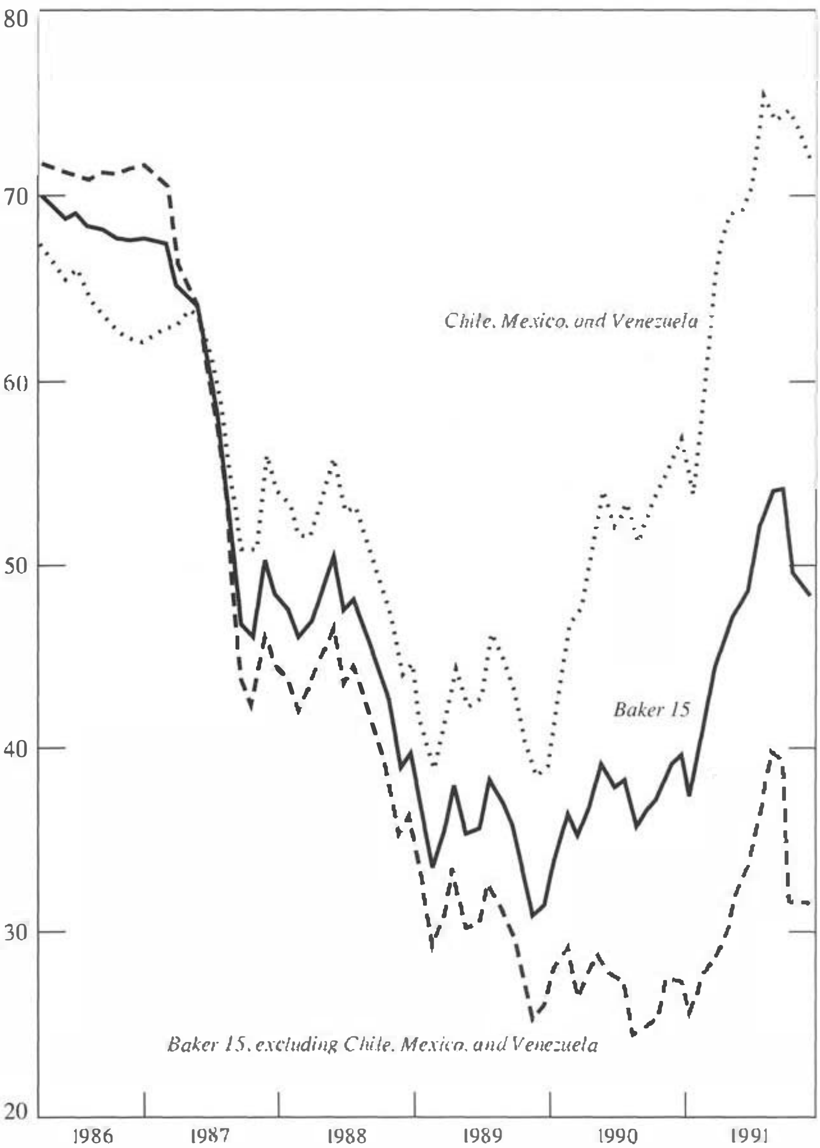
The most important regulatory changes have occurred in the U.S. markets. Specifically, the 1990 approval of "Regulation S" and "Rule 144A" reduced the transactions costs and liquidity problems facing developing countries in tapping U.S. capital markets.

Before April 1990, the average costs of meeting bond registration and disclosure requirements for first-time developing country issuers were estimated at about $500,000–$700,000. Avoidance of some of these costs through private placements was possible but involved reducing the liquidity of the instruments. Thus, the prevailing Securities Act required buyers of securities not offered publicly to hold them for at least two years after the initial offering. At the same time, the Act imposed heavy penalties on issuers that adopted the public offering route but were not able to meet fully all the registration requirements. Indeed, under the Act, a purchaser of a security could choose at any time to rescind a transaction that has not been properly registered.

By clarifying the definition of what constitutes a sale and offer of a security in the United States, Regulation S facilitated the sale of Euro-issues to U.S. citizens. It exempts securities from registration requirements, provided the buyer is outside the United States; if the buyer is within the United States, the exemption conditions relate to the marketing of the securities. Concurrent with the reduction in transactions costs,

"stripping") the reported prices for the debt and debt-service reduction bonds for the value of the associated principal and interest collaterals, as well as the notional value of the value recovery feature in the bank package. This provides for a closer approximation of the market valuation of country risks.

Figure 3. *Secondary Market Prices for Developing Country Loans*
(In percent of face value)



Source: Salomon Brothers.

the adoption of Rule 144A reduced the loss of liquidity associated with private placements. The changes relaxed the requirement of a two-year holding period, provided the sale of the financial instrument was to "qualified institutional buyers." Such buyers are defined as entities managing and owning at least $100 million in securities and, in the case of banks, having a net worth of at least $25 million.[14] On this basis, it is estimated that there are about 5,000 qualified institutional buyers in the United States—mainly insurance companies, commercial banks, and money managers.

The changes cited above have reinforced the possibilities offered by the American Depository Receipts (ADR) program, under which developing countries may access equity markets without meeting the full costs of offerings and listings on these markets. Under this program, each American Depository Share (ADS) traded in the United States represents a batch of shares in the local market. This route was used by a number of Latin American corporate re-entrants, including Chile's telephone company in mid-1990 for an offering of 6.5 million shares. These ADSs correspond to more than 110 million shares of Series A Common Stock on the Santiago exchange, or 13.5 percent of the company's equity. In the case of the TELMEX privatization, the 65 million ADSs correspond to 1.3 billion shares.

There have been several other recent regulatory changes in industrial countries that have the potential of facilitating developing country access. In Japan, for example, in June 1991 the authorities lowered the minimum credit rating standards for public bond issues on the Samurai market (from single A to triple B). In Switzerland the regulatory authorities took steps in January 1991 to abolish the minimum credit rating requirements (previously set at triple B) for foreign bond issues. Consideration is also being given to removing other quantitative barriers to entry, such as the requirements relating to the minimum size of the issues and capitalization of debtor firms.

Increased interest among international investors in bond issues by re-entering Latin American entities has led to, and been reinforced by, the establishment of market-credible credit ratings, thereby reducing some of the costs investors face in compiling purchase information. In December 1990 Mexico received its first credit rating by Moody's Investors Service. The ceiling rating for Mexican debt was set at Ba2 (equivalent to double B plus)—just below investment grade—with Brady bonds receiving a Ba3 rating as a result of the perception of greater

[14] Registered dealer-brokers are exempt, provided they own and manage a total of $10 million in securities.

restructuring risk based on historical experience. In July 1991 Venezuela was upgraded to Ba1 from Ba3.

The specification of credit ratings allows for developing country issues to be targeted explicitly to meet specific portfolio allocation segments along the risk-return spectrum of the prospective investors. Moreover, the potential existence of investment grade paper would, other things being equal, open new segments of the international capital markets to Latin American re-entrants; these segments include areas where regulatory credit rating requirements apply and cases where certain investors (for example, pension funds and other institutional investors) are subject to internal quantitative risk level cut-offs.

Customizing Financial Instruments

In an environment of still significant—if declining—perceptions of credit and transfer risks, borrowers must be prepared to customize their borrowing instruments to the requirements of the market. This requirement becomes more important when there is a general tightening of market conditions, as was the case during 1990.

In several of the initial bond issues by Latin American re-entrants, borrowers have attempted to differentiate the instruments by providing explicit credit enhancements. Most of these have been in the form of collateralization (on the basis of existing assets or an expected stream of receivables), but various put options have also been offered, including preferential treatment for privatization and early redemption possibilities.

The credibility of collateralization, and therefore the extent to which it improves market terms, has depended on the form of the collateral, its location, and the costs involved in taking possession and disposing of it, should the need arise. Several borrowers have provided collaterals in the form of assets/receivables generated outside the country, thereby allowing them to address investors' concerns about both transfer and credit risks. TELMEX, for example, provided investors protection in the form of a claim on payments due from AT&T on account of international communications. Accordingly, investors' exposure to TELMEX credit and Mexican transfer risks was effectively transformed into an exposure to AT&T credit and U.S. transfer risks. The resulting reduction in perceptions of risk was reflected in the spreads paid by TELMEX. Specifically, the risk premia on the collateralized October 1989 and March 1990 bond issues averaged some 200 basis points, compared to a premium of 450 basis points for the noncollateralized July 1990 issue.

Other forms of collateralization used by Latin American re-entrants have included bank deposits and electricity accounts, suppliers, and credit card receivables.

III. Short-Term Prospects

The above overview has important implications for Latin American countries, as well as for other developing countries, that are still seeking to normalize financial relations and regain access to voluntary capital market financing. It may also be used to shed light on the short-term prospects for countries that have succeeded in regaining market access.

Given the small magnitudes involved relative to the size of the markets (gross international bond financing totaled an estimated $256 billion in 1989, and international bank lending amounted to some $820 billion), these borrowers may be viewed as facing "small country conditions" on international capital markets. Consequently, the re-entry of Latin American borrowers is unlikely to result in any significant tightening of market conditions. Increased effective demand (as opposed to notional demand) from Eastern Europe and the Middle East may have some impact on market terms but is not expected to crowd out Latin American re-entrants, provided they succeed in sustaining the improvement in credit and transfer risks. Moreover, the potentially adverse impact on terms may be minimized by the actions of borrowers themselves.

The key to continued and increased access will remain the sustained implementation of sound economic and financial policies and an avoidance of another round of excessive borrowing. Supporting efforts at the country level will be needed to reduce exposure to adverse developments in exogenous prices. Such efforts could include greater use of interest rate hedges (as has been done in Chile); commodity hedges (such as the recent sale in Mexico of future oil contracts consistent with the price assumed in the specification and implementation of the government budget),[15] which could reinforce the beneficial impact of export diversification (in Mexico, for example, the share of petroleum receipts in total exports declined from over 70 percent in 1980–82 to an estimated 30 percent in 1988–90); the establishment of commodity stabilization funds (for example, Chile's oil and copper stabilization funds); and a reduction in bank debt subject to commercial variable interest rates (an important component of the Mexican and Venezuelan debt packages). Corporate

[15] El-Erian (1991) provides further information on the Mexican approach to risk management and use of credit enhancements.

borrowers should also make greater use of financial risk management techniques, thereby avoiding the excessive open positions associated with pre-1982 borrowings. Indeed, the improvement in country transfer risk has rendered less costly the increased use of such techniques for both public and private sector entities.

Although collateralization and other credit enhancements are useful in allowing re-entrants to overcome extreme market risk aversion (compounded by "adverse-selection" effects and other information-related market influences[16]), they should be used only by entities that have already strengthened their underlying financial position. Moreover, as recognized by several country authorities, their use should be subject to prudent aggregate limits based on considerations of intertemporal maximization that balance the immediate gains of lower borrowing costs against potential longer-term adverse effects on liquidity management and access to unsecured voluntary credits. In effect, by pledging existing assets or future receipts, borrowers may lose future financial flexibility as well as lower the seniority of creditors with unsecured debt. Other re-entrants may be subject to precedent or contagion effects, which could increase their borrowing costs and raise public policy issues.

Although the greatest impact will come from the actions borrowers themselves take, industrial countries may also have a role to play in reducing barriers to developing countries' return to voluntary financing. Indeed, as discussed above, steps have been taken in recent years to relax quantitative barriers to entry to certain segments of the international capital markets. Consideration could also be given to introducing greater flexibility in regulatory provisioning requirements in industrial countries. Such requirements affect the willingness of bank creditors to hold loan and bond instruments issued by countries with recent debt-servicing problems. In several industrial countries, regulatory provisioning requirements are determined by backward-looking factors (particularly reschedulings and/or arrears) and, as noted earlier, tend to respond with a lag to a recovery in debtors' prospects (typically involving a five-year rule). There is thus a need, in some cases, to allow for flexibility in "graduating" a country from regulatory provisioning requirements in response to evidence of a fundamental improvement in its economic and financial outlook.[17]

[16]These factors are relevant to lenders when pricing the risk implicit in the loans, particularly since the price itself may affect the subsequent behavior of the borrower or contribute to the selection of more risky borrowers. These issues are discussed in Stiglitz and Weiss (1981).

[17]An example of increased flexibility is provided by the Canadian system where the Superintendent of Financial Institutions may, at his or her discretion, remove a country from the provisioning list two years (rather than the standard five years)

IV. Conclusions

The progress achieved so far by Latin American countries in restoring market access, while still limited in magnitude and country distribution, is to be welcomed and encouraged. The turnaround in market sentiment has been substantial in a number of countries, allowing for a return to voluntary bond and equity placements at sharply improving terms. It has also encouraged foreign direct investment inflows and the repatriation of flight capital.

However, the progress made in restoring market access has to be consolidated in order to reduce the further risk of a "re-exit." The sustained implementation of sound macroeconomic and structural reform policies is therefore essential in reducing country transfer risk. With such policies, and given prudent debt management practices, public and private borrowers can complement their access to domestic financing sources by taking advantage of the broader opportunities offered on international capital markets.

The beneficial effects of restored market access should nevertheless not obscure the fact that international capital markets are not for everyone, and access should not be re-established or retained at any cost. It is important that borrowers have solid balance sheets, sound financial prospects, and financing requirement for high-yielding investments. Consideration should be given to the use of financial risk management tools to reduce exposure to adverse external developments. At the same time, in deciding when to issue and how to structure market instruments—particularly, the degree of credit enhancements—policymakers must take care to maintain an appropriate balance between the immediate gains and the potentially adverse longer-term implications for liquidity management and the ability to raise funds on an unsecured basis.

REFERENCES

Aspe Armella, P., "The Renegotiation of Mexico's External Debt," *IDS Bulletin*, Vol. 21 (April 1990), pp. 22–26.

Basle Committee on Banking Supervision, *Report on International Developments in Bank Supervision* (Basle: Committee on Banking Supervision, September 1990).

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after the most recent rescheduling if the country has shown ability to raise funds of over one-year maturity on international capital markets. Another example is the U.K. system, which bases provisioning decisions on a matrix that incorporates leading indicators of countries' creditworthiness.

Chartered WestLB, *Developing Country Investment Review* (London: Chartered WestLB, April 1991).

Dooley, Michael P., and others, *Debt Reduction and Economic Activity*, IMF Occasional Paper No. 68 (Washington: International Monetary Fund, 1990).

El-Erian, Mohamed A., "Mexico Commercial Bank Financing Package," *Finance and Development*, Vol. 27 (September 1990), pp. 26–27.

———, "Mexico's External Debt and the Return to Voluntary Capital Market Financing," IMF Working Paper 91/83 (Washington: International Monetary Fund, August 1991).

International Finance Corporation (1991a), *Emerging Stock Market Factbook* (Washington: International Finance Corporation).

——— (1991b), *Quarterly Review of Emerging Stock Markets* (Washington: International Finance Corporation, November).

International Monetary Fund, *International Capital Markets: Developments and Prospects*, World Economic and Financial Surveys (Washington: International Monetary Fund, 1990).

——— (1991a), *International Capital Markets: Developments and Prospects*, World Economic and Financial Surveys (Washington: International Monetary Fund).

——— (1991b), *Private Market Financing for Developing Countries* (Washington: International Monetary Fund).

——— (1991c), *World Economic Outlook*, World Economic and Financial Surveys (Washington: International Monetary Fund, October).

——— (1992), *International Capital Markets: Developments and Prospects*, World Economic and Financial Surveys (Washington: International Monetary Fund, forthcoming).

Organization for Economic Cooperation and Development, *Financial Market Trends* (Paris: OECD, October 1991).

Owen Stanley Financial, *The Constraints and Motivation of International Banks with the Market-Based Menu Approach to LDC Debt Restructuring: A Review of Tax, Accounting and Regulatory Regimes* (Paris: Owen Stanley Financial, June 1991).

Stiglitz, Joseph E., and Andrew Weiss, "Credit Rationing in Markets with Imperfect Information," *American Economic Review*, Vol. 71 (June 1981), pp. 393–410.

van Wijnbergen, Sweder (1991), "Mexico and the Brady Plan," *Economic Policy: A European Forum*, Vol. 6 (April 1991), pp. 13–56.

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Comments

The Derivation of the Liquidity Ratio in the EMS

Comment on Kremers and Lane

IVO J.M. ARNOLD*

KREMERS AND LANE (1990) analyze the money demand in the European Monetary System (EMS) over the period 1978–87. They conclude that aggregate demand for M1 in countries participating in the Exchange Rate Mechanism (ERM) is a stable function of income, inflation, interest rates, and the ECU-U.S. dollar exchange rate. Therefore, a European central bank might be able to implement monetary policy more effectively than the individual central banks.

In this comment, I claim that Kremers and Lane made two errors in the derivation of their aggregate data. The first concerns the use of purchasing power parity (PPP) exchange rates. The second has to do with the procedure that has to be followed in aggregating and deflating data. I then assess the sensitivity of Kremers and Lane's cointegration results to the questions I raise.

I. Converting National Data Using PPP Exchange Rates

When estimating an ERM-wide money demand function, one has to find ways to convert national data in one currency. Kremers and Lane consider three methods. The first method uses current exchange rates.

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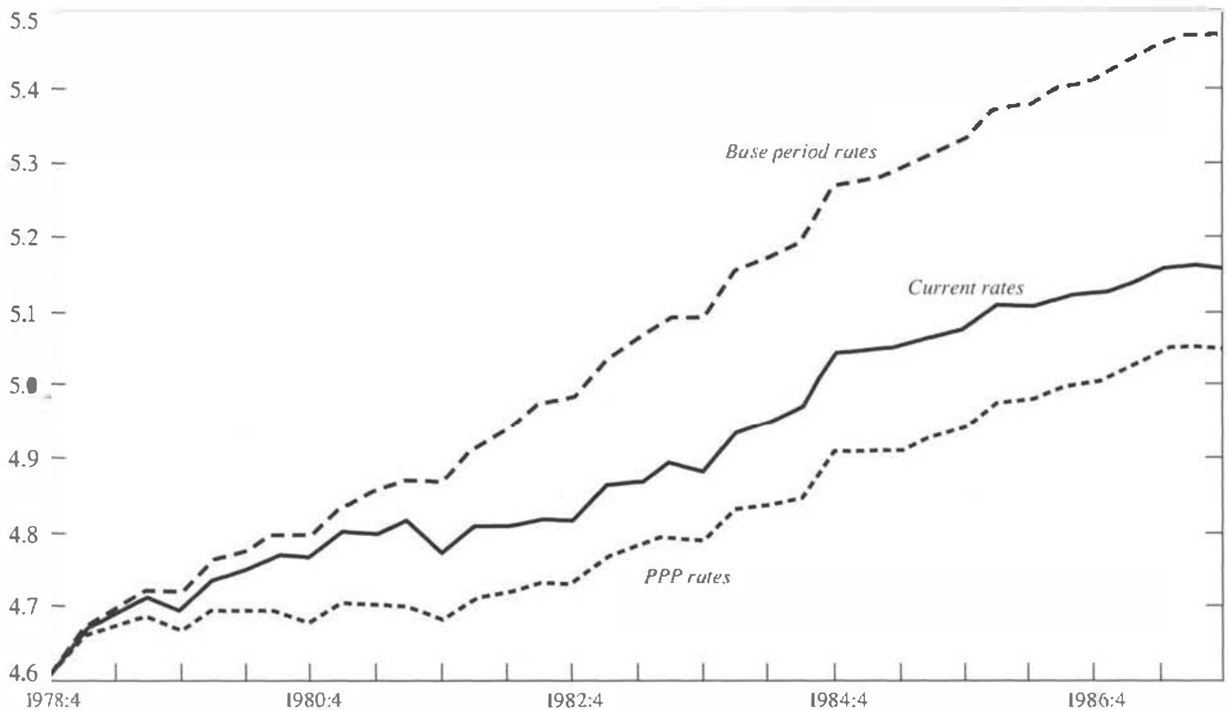
The author wishes to thank Jeroen J.M. Kremers for providing the aggregate series used in this paper, and Eduard Bomhoff and Dave Smant for useful comments.

Figure 1. *Nominal Money in the ERM*
(Log of Series Indexed to 1978:4 = 100)



In a system of fully floating exchange rates with large swings in the exchange rate, this method would cause equally large and undesirable swings in constructed aggregates. In a system like the EMS, this has not been much of a problem. In the second approach, which uses fixed base-period exchange rates, the measurement of aggregates is not influenced by nominal exchange rate fluctuations. This is a disadvantage when inflation differentials are large. The third method uses PPP exchange rates, which implies that national data are converted in proportion to the purchasing power of the national currency. The weight of each country in the aggregate thus reflects the size of the real economy. Because of this attractive property, Kremers and Lane prefer the PPP approach.

A comparison of PPP rates and current rates during the period investigated by Kremers and Lane shows both series to be very similar (see Organization for Economic Cooperation and Development (OECD) (1991)). Both the PPP rates and the current rates show a (nominal) depreciation of all ERM currencies vis-à-vis the deutsche mark. According to these observations, aggregates obtained using PPP rates should resemble aggregates obtained using current rates and should be quite different from aggregates obtained using fixed base-period rates. Inspection of Figure 2 in Kremers and Lane (1990, p. 787) shows the opposite to be the case.

In Figure 1, I present the results of my own calculations, which show that for nominal money the PPP aggregate lies far below the base-period aggregate and somewhat below the aggregate derived with current rates.[1] This is in line with what one expects in an exchange rate system where realignments (partly) compensate inflation differentials. The PPP aggregates in the paper by Kremers and Lane must be incorrectly calculated.

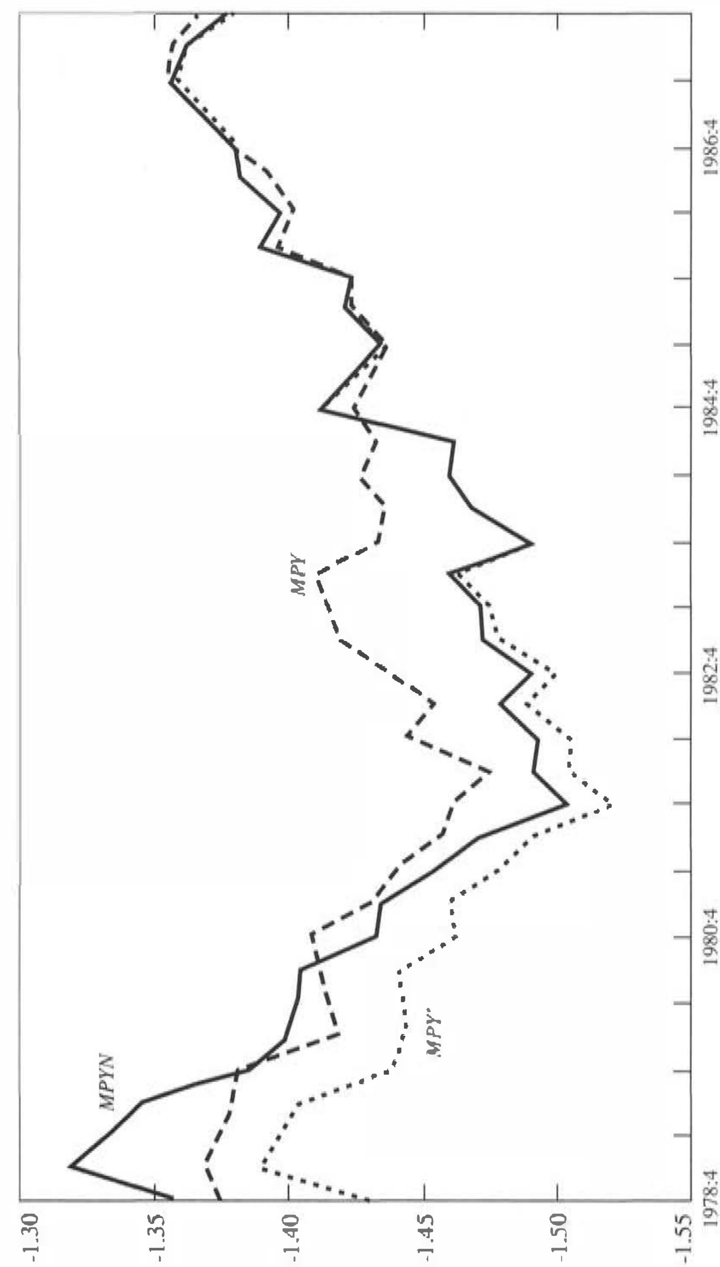
II. Aggregating Real Data

My second comment concerns the procedure that has to be followed in aggregating and deflating national data. The discussion will be restricted to aggregation using PPP rates.

As long as the right exchange rates and deflators are used, it doesn't matter whether one first equalizes purchasing power across countries or through time. The conversion into deutsche mark of nominal national

[1] I use the nominal money series as an example. The money series are taken from the *International Financial Statistics* (*IFS*) datatape (line 34b). I obtained quarterly PPP exchange rates by linear interpolation of the yearly OECD (1991) data. All other data are as in Kremers and Lane.

Figure 2. *Alternative Measures of the Liquidity Ratio*
(Log)



series using contemporaneous PPP rates and subsequent deflation using a *German* deflator yields the same result as the conversion into deutsche mark of real national series using a *fixed* PPP exchange rate of the base-year of the price indices (see the Appendix for a more formal discussion).

The procedure of Kremers and Lane is to convert into deutsche mark using contemporaneous PPP rates, the national *real* income series, and the national *nominal* money series (see Kremers and Lane (1990, p. 785)). The aggregate nominal money series is subsequently deflated using a weighted average of the national deflators (see Figure 3 in Kremers and Lane (1990, p. 788)). Finally, the liquidity ratio is derived as the ratio of real money and real income. The procedure of Kremers and Lane contains two deviations from the correct procedure. First, the aggregate nominal money series is deflated using an ERM-wide deflator instead of a German deflator. Second, the real income series are aggregated using contemporaneous PPP rates instead of a fixed base-year PPP rate.[2]

Figure 2 shows a comparison of the following three measures of the log of the ERM-wide liquidity ratio during the period 1978–87: (1) MPY: the original series used by Kremers and Lane; (2) MPY': my reconstruction of (1). First, national series for nominal money and real income are aggregated using PPP rates. The aggregate nominal money series is subsequently deflated, yielding an aggregate real money series. The deflator is computed as a weighted average of national consumer price indices (CPIs), the weights being GNP/GDP shares based on PPP rates (see OECD (1991)). Finally MPY' is calculated as the log of the quotient of the aggregated real income and real money series.[3]

(3) $MPYN$, the third measure, was obtained by first aggregating national series for nominal income and nominal money using PPP rates and then taking the log of the quotient of these two series. This is the correct procedure.

Differences between series (2) and (3) reflect the deviations discussed above. Differences between series (1) and (2) reflect the incorrect use by Kremers and Lane of PPP rates, as discussed in Section I.

[2] This error should be distinguished from the other error in the use of PPP rates, discussed in Section I.

[3] In footnote 18 in Kremers and Lane (1990, p. 794), the aggregate price level is defined as a four-quarter moving geometric average of ERM-wide CPI. I assume, in conformity with their Figure 3 (p. 788), that this definition applies only to the inflation variable in their equation (1) and not to the price level appearing in (1) as a deflator of nominal money.

Table 1. *Equation (1) Re-Estimated*
(1978:4–1987:4)

Endogenous Variable	Exogenous Variables: *C*	*RS*	*INFL*	*ECU*	SEE (In percent)
MPY	−1.31	−0.67	−1.4	0.079	1.0
	(−167.0)	(−4.12)	(−2.49)	(10.47)	
MPY'	−1.33	−0.10	−5.59	0.064	1.6
	(−104.0)	(−0.38)	(−6.14)	(5.30)	
MPYN	−1.29	−0.68	−3.09	0.138	2.2
	(−72.0)	(−1.85)	(−2.44)	(8.14)	

Note: See Note to Table 2.

III. The Error-Correction Model Re-Estimated

New estimates of equations (1) and (2) from Kremers and Lane's paper are presented in Tables 1 and 2, respectively, along with the original estimates.[4] Table 1 shows estimates for the level regression using the three different measures for the liquidity ratio discussed above. Table 2 presents the corresponding error-correction regressions.[5] It can be seen that coefficients and *t*-values vary considerably across equations, the coefficients for *RS*, *DY*, and *DRS*3 being insignificant at a 5 percent level in the new equations. Furthermore, the standard errors of the new equations are much larger than for the original equations.

IV. Conclusion

The claim, made by Kremers and Lane, that European money demand is stable, is based on questionable treatment of the data. Re-estimating the original specifications using a better series for the liquidity ratio results in a large decrease in almost all *t*-values and a significant increase in standard errors of the equation. This new evidence provides no support for Kremers and Lane's claim to have identified a stable European money demand.

[4]The regressions with *MPY* and *DMP* as endogenous variables are Kremers and Lane's original estimates. The preferred regressions are those with *MPYN* and *DMPN* as endogenous variables.
[5]I followed Kremers and Lane in taking the growth rate of real money as an endogenous variable, although the growth rate of the liquidity ratio would be a more logical choice.

Table 2. *Equation (2) Re-Estimated*
(1979:1–1987:4)

Endogenous Variable	Exogenous Variables					SEE
	C	DY	DRL	$DRS3$	EC	(In percent)
DMP	0.002	0.67	−0.86	−0.46	−0.95	0.8
	(1.03)	(2.85)	(−3.18)	(−2.67)	(−5.87)	
DMP'	−0.007	0.65	−1.03	−0.22	−0.73	1.7
	(−1.95)	(1.43)	(−1.86)	(−0.62)	(−3.83)	
$DMPN$	0.002	0.71	−1.20	−0.08	−0.38	1.7
	(0.45)	(1.50)	(−2.20)	(−0.22)	(−2.73)	

Note: For MPY, MPY', and $MPYN$, see text; C is the constant term; RS is the short-term interest rate; $INFL$ is the lagged inflation rate; ECU is the U.S. dollar/ECU exchange rate; DMP is the change in the log of real money, as derived by Kremers and Lane; DMP' is the reproduction of DMP following the procedure of Kremers and Lane; $DMPN$ is equal to DMP', except for the use of a German deflator instead of an ERM-wide deflator; DY is the change in the log of real income; DRL is the change in long-term interest rate; $DRS3$ is the change in short-term interest rate (three-quarters lagged); EC is the error-correction term (residuals from equation (1)); SEE is the standard error of the equation; t-values are given in parentheses.

APPENDIX

Deriving an Aggregate Deflated Series

Specializing to a two-country case, consider two ways to derive an aggregate deflated series of some nominal variable, X:

$$\frac{X_{1t} + (X_{2t}/e_{pppt})}{P_{1t}} \tag{i}$$

$$X_{1t}/P_{1t} + X_{2t}/(P_{2t}*e_{ppp85}), \tag{ii}$$

where

X = a nominal variable

P = price deflator

e_{ppp} = PPP exchange rate (currency country 2/currency country 1)

e_{ppp85} = the PPP rate in 1985, the base-year of the price deflators

t = time subscript

1, 2 = country subscripts.

It can easily be seen that both methods are equivalent if the definition of PPP rates is substituted in (ii):

$$e_{pppt} = e_{ppp85}*(P_{2t}/P_{1t}).$$

REFERENCES

Kremers, Jeroen J.M., and Timothy D. Lane, "Economic and Monetary Integration and the Aggregate Demand for Money in the EMS," *Staff Papers*, International Monetary Fund, Vol. 37 (December 1990), pp. 777–805.

Organization for Economic Cooperation and Development, *National Accounts, Main Aggregates*, Vol. 1, 1960-89 (Paris: OECD, 1991).

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The Derivation of the Liquidity Ratio in the EMS

Reply to Arnold

JEROEN J.M. KREMERS and TIMOTHY D. LANE*

IN HIS COMMENT, Ivo Arnold makes some forceful statements about alleged departures from the "correct" procedure in our use of purchasing power parity (PPP) exchange rates to construct aggregate monetary data for the countries participating in the exchange rate mechanism (ERM) of the European Monetary System (EMS). The comment's clarity unfortunately does not match its forcefulness: most of the comment is in the form of claims that the author does not state precisely and makes little attempt to justify.

The waters are further muddied by an important misstatement by Arnold (1992) about the procedures that we follow in our paper: he states that we "convert into deutsche mark using the contemporaneous PPP rates, the national *real* income series, and the national *nominal* money series" (p. 199). This is not factual. Actually, we used base-period (1985) PPP rates to aggregate both real income and nominal money. Given Arnold's misapprehension about the procedures we followed, his claim that deviations between this reconstruction and our series are the result of errors on our part is obviously unfounded, and his empirical results based on these incorrectly reconstructed data have no bearing on our work.

In order to restore some clarity to the discussion, let us explain and justify the approach we used in aggregating using PPP exchange rates.

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I. Aggregation Using PPP Rates

A PPP exchange rate converts amounts expressed in different currencies to a common unit of measurement by weighting by these currencies' relative purchasing powers—that is, the reciprocal of the countries' price levels. The PPP rates that we use in our paper are derived from an Organization for Economic Cooperation and Development (OECD) survey for 1985, and are based on the price deflators for gross domestic product (GDP); our common unit of measurement is the deutsche mark. Consider PPP rates for country i with respect to Germany (defined as, for example, Dutch guilders per deutsche mark). Once PPP rates PPP^i_{85} have been determined for one year (1985), contemporaneous rates for year t can be constructed as

$$PPP^i_t = PPP^i_{85} * P^i_t / P^G_t, \tag{1}$$

where P^i_t and P^G_t are, respectively, the GDP deflator for country i and for Germany, also with base period 1985 (where, by definition, $PPP^G_t = 1$).

In aggregating *real* GDP across the ERM countries, it is appropriate to use *base-period* PPP rates, not the constructed contemporaneous rates.[1] This can be seen by noting that converting real magnitudes at contemporaneous rates would involve "double deflation," as is clear from equation (1), since the GDP deflator would then be used twice, once in deflating the countries' nominal GDPs and once in calculating contemporaneous PPP rates. Accordingly, aggregate real GDP for the ERM is

$$Y^{ERM}_t = \sum_i Y^i_t / PPP^i_{85}, \tag{2}$$

where Y^i_t is real GDP for country i, with base period 1985.

Another way of thinking about this aggregation can be seen by using equation (1) to write (2) in the equivalent form

$$Y^{ERM}_t = \left[\sum_i YN^i_t / PPP^i_t\right] / P^G_t, \tag{3}$$

where YN^i_t denotes country i's nominal GDP. Thus, the method we use to derive real GDP for the ERM is equivalent to aggregating nominal GDPs using contemporaneous PPP rates, and then deflating using the GDP deflator for Germany.[2]

[1] 1985 PPP rates are also used by the OECD to aggregate real variables; see OECD (1991, Part Two, "Main Aggregates: Zones").

[2] This is the equivalence that Arnold correctly describes in Section II of his comment; where he is incorrect is in failing to recognize that we also use this method to aggregate real GDP.

Now we turn to the aggregation of nominal magnitudes. Here, we use the same PPP rates:

$$YN_t^{ERM} = \sum_i YN_t^i/PPP_{85}^i. \tag{4}$$

This method, using the same rates for aggregating real and nominal variables, has the following important property. Equations (3) and (4) yield the following implicit GDP deflator for the ERM, as the ratio of aggregate nominal and real GDP:

$$P_t^{ERM} = YN_t^{ERM}/Y_t^{ERM} = \sum_i [(Y_t^i/PPP_{85}^i)/Y_t^{ERM}]P_t^i. \tag{5}$$

That is, the resulting aggregate GDP deflator has the desirable property that it is a weighted average of the national GDP deflators, where the weights (given by the expression in square brackets) are the shares of each country's real GDP in the ERM aggregate.[3]

Finally, as we state in our paper (Kremers and Lane (1990, p. 784)), "in order to maintain the national relativities between money and income in the ERM aggregate, the money stocks are added up at the same exchange rates as are the income variables." Thus, our procedure involves using base-period PPP rates to aggregate both nominal and real magnitudes, and using each country's share in aggregate GDP to construct ERM price indices.

An alternative would be to aggregate nominal GDP at current PPP rates, as suggested by Arnold in his Section II. This yields

$$\tilde{YN}_t^{ERM} = \sum_i YN_t^i/PPP_t^i,$$

giving rise to an implicit deflator of

$$\tilde{P}_t^{ERM} = \tilde{YN}_t^{ERM}/Y_t^{ERM} = \sum_i [(Y_t^i/PPP_{85}^i)/Y_t^{ERM}]P_t^G = P_t^G. \tag{6}$$

Thus, using contemporaneous PPP rates to aggregate nominal GDPs would imply that ERM inflation is the same as German inflation. This is an undesirable property in constructing an ERM-wide money demand function, especially when the object of the exercise is to illustrate the possibility of specifying a money demand equation that might be useful for monetary policy by a European central bank: a European central bank would clearly be concerned with the price level throughout the

[3] Price indices for country zones are calculated by the OECD on the same basis: see OECD (1991, Part Four, "Growth Triangles: Zones").

currency area, not just in Germany. Arnold makes much of the fact that although PPP rates behave much the same as current rates, the behavior of PPP aggregates depicted in the figures in our paper is rather similar to that of aggregates using base-period nominal exchange rates—a fact that we also note in our paper (Kremers and Lane (1990, p. 785)). He regards this as proof that "the PPP aggregates in the paper by Kremers and Lane must be incorrectly calculated" (Arnold (1992, p. 197)). In the light of the foregoing discussion, the similarity of base-period and PPP aggregates can be readily understood as resulting from a procedure that we have shown to be defensible.

II. Empirical Results

In Section III of his comment, Arnold seeks to compare empirical results derived with our data with those derived using his reconstruction of our series, and then with the series constructed using his own method. As mentioned in our opening paragraphs, his reconstruction—and therefore any empirical work based on this reconstruction—is of no direct interest, as it is based on a misapprehension as to the aggregation method we followed.

Two further points could be made in comparing Arnold's first and third specifications. First, it is not surprising that estimating *our* empirical specification with *Arnold's* data produces different results; there is simply no reason for two different data sets to produce identical regression results. Second, the fact that our aggregation procedure—contrary to Arnold's—yields an apparently well-specified money demand relationship would, if anything, provide *support* for our approach, in addition to the theoretical considerations advanced above.

III. Conclusion

In this reply, we have sought to clarify some issues involved in aggregating across countries, and to show that the procedure we used was an appropriate one. On the basis of our discussion, we argue that Arnold's comment misinterprets what we do in our paper and fails to justify the alternative he suggests. Thus, our evidence for the possibility of a stable ERM-wide money demand function stands. The past year's remarkable progress toward monetary union in Europe makes further scrutiny and investigation of the relationships among ERM-wide aggregates all the more worthwhile.[4]

[4] In a paper now in preparation, we consider the theoretical implications of aggregating across countries and analyze an extended data set.

REFERENCES

Arnold, Ivo J.M., "The Derivation of the Liquidity Ratio in the EMS: Comment on Kremers and Lane," *Staff Papers*, Vol. 39 (March 1992), pp. 195–202.

Kremers, Jeroen J.M., and Timothy D. Lane, "Economic and Monetary Integration and the Aggregate Demand for Money in the EMS," *Staff Papers*, Vol. 37 (December 1990), pp. 777–805.

Organization for Economic Cooperation and Development, *National Accounts, Main Aggregates*, Vol. 1, 1960–89 (Paris: OECD, 1991).

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