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# **Volatility Reversal from Interest Rates to the Real Exchange Rate**

## **Financial Liberalization in Chile, 1975-82**

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and  
Klaus Schmidt-Hebbel

Data for Chile (1975-82) indicate that liberalizing the capital accounts does not eliminate variations in the domestic interest rate but shifts them to the real exchange rate.

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McNelis and Schmi. Hebbel analyze the dynamic adjustment of the real exchange rate, the domestic interest rate, and foreign borrowing under conditions of perfect and imperfect capital mobility during financial liberalization.

Making use of a two-sector model with current and capital accounts interacting, they show that the domestic interest rate is more volatile under imperfect mobility and the real exchange rate more volatile under perfect mobility.

So liberalizing the capital accounts does not eliminate variations in the domestic interest rate but shifts them to the real exchange rate.

Studying data for Chile during the period of financial liberalization from 1975 to 1982, they found that the domestic interest rate became less volatile and less responsive to domestic variables — and more dependent on the covered international interest rate.

And the real exchange rate became more responsive to domestic wealth.

Foreign reserve holdings and net exports followed a similar pattern: the covered international rate had stronger effects on reserve changes while real wealth became more important for determining net exports.

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Volatility Reversal from Interest Rates to the Real Exchange Rate:  
Financial Liberalization in Chile, 1975-82

by

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## I. INTRODUCTION

Significant fluctuations of foreign credit flows, domestic interest rates and real exchange rates affected most financially semi-open economies in recent years. Especially affected were those countries which liberalized their capital accounts, overborrowed, and then experienced a foreign credit squeeze.

Several issues appear in recent literature detailing these macroeconomic experiences. One is the relationship between the large capital inflows and the appreciation of the domestic currency, which occurred either during the process of liberalization (such as Chile and Argentina) or in countries with completely open capital markets (such as Venezuela). Edwards (1986) treats the capital inflows as exogenous. The foreign capital was simply bottled up by government controls, and when liberalization occurred, foreign capital flowed into the country in large amounts. These inflows led to real appreciation of the domestic currency and subsequent trade deficits. Corbo (1985), on the other hand, argues that the inflows were endogenous, and thus a response to domestic financial policies. The appreciation of the domestic currency (through preannouncing of nominal exchange rate devaluations at rates lower than domestic and foreign inflation differentials) made foreign borrowing attractive and relatively cheap. This policy also led to large trade deficits, through the government conversion of these inflows into domestic money, and the ensuing wealth effects of this increased currency on aggregate demand.

In Chile as well as Argentina, domestic interest rates did not converge rapidly to covered world interest rates following the liberalization of the capital markets. This slow convergence posed severe problems. With interest

rates remaining high during the liberalization process, and imports becoming relatively cheap, domestic producers faced a credit squeeze at the worst possible time.<sup>1</sup>

Several studies have analyzed interest rate adjustment in Chile. Corbo and Matte (1984) estimated a simple portfolio adjustment model. The offset coefficient for Chile was less than minus one, implying less than perfect capital mobility, despite the liberalization policies. Edwards (1985), on the other hand, defined a "semi-open" economy as one in which the interest rate depends on both domestic credit conditions as well as on covered foreign interest rates. With standard econometric techniques, he found Chile (as well as Colombia) to be financially semi-open, and not open (in which case only covered foreign interest rates matter).

Extending recent work, we develop a model which captures the interaction between foreign debt accumulation, the real exchange rate and domestic interest rate adjustment, when all three variables are endogenous, under imperfect asset substitutability and imperfect capital mobility. The latter feature reflects the financial semi-openness of the small economy, and is consistent with the recent studies of Corbo-Matte and Edwards. With regard to trade in goods and non-financial services, different degrees of openness are consistent with this general framework. We wish to explain the sharp fluctuations in domestic interest rates, real exchange rates, and capital inflows following financial liberalization. In particular, we wish to show that during the process of financial liberalization, the variability of the

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<sup>1</sup> See Dornbusch and Reynoso (1989) for a more general survey of financial issues, including the role of inflationary finance, in the development process. They argue that the expected benefits of financial liberalization are not supported by the evidence.

domestic interest rate diminishes over time, as it slowly converges to the covered world interest rate, while the real exchange rate becomes increasingly volatile.<sup>2</sup>

Our methodological starting point is Dornbusch and Fischer (1980). We modify their model of current and capital account interaction in a number of ways. Instead of focusing on a national/foreign goods dichotomy, we stress the real exchange rate as a pivotal relative price in a traded/non-traded goods model. We also introduce a third asset, domestic bonds, which enables us to model imperfect asset substitutability and imperfect capital mobility. We assume imperfect capital mobility in response to domestically imposed restrictions on flows or on holdings of foreign capital or foreign debt. Imperfect capital mobility thus allows for short-run deviations of domestic interest rates from their long-run equilibrium levels. Because of imperfect asset substitutability, stationary equilibrium interest rates also deviate from values under perfect arbitrage.

Kouri and Porter (1974) have used a portfolio model in which domestic and foreign assets are imperfect substitutes. But there are two differences between our portfolio model and theirs. We model explicitly the variables which are behind imperfect substitutability between domestic and foreign bonds and we distinguish between instantaneous and long-run asset market equilibria.

Another feature of our dependent-economy specification is that the

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<sup>2</sup> We thus compare dynamic adjustment of the nominal interest rate with the real exchange rate, rather than the real interest rate with the real exchange rate. We do so because the nominal interest rate is the variable which "clears" the money market, and the real exchange rate "clears" the non-traded goods market in the model we develop, and their dynamic behavior reflects the underlying disequilibria in these two markets.

current account is residually determined by the excess of income over absorption. We assume that the nominal exchange rate is controlled by the government and is subject to discrete or continuous changes or even to fixed exchange rate periods.

In the next section we present our model, for the benchmark case of perfect capital mobility. We lift this assumption in section 3, and study the dynamics of the real exchange rate, capital inflows and domestic interest rates under imperfect capital mobility. In section 4 we present the results of our model applied to the Chilean economy during the 1975-1982 bust-boom-bust period of financial liberalization and high foreign debt accumulation.

## II. GENERAL EQUILIBRIUM UNDER IMPERFECT ASSET SUBSTITUTABILITY AND PERFECT CAPITAL MOBILITY

We focus on current and capital account interaction by combining a real intertemporal specification for the current account with a portfolio asset model.

We start by defining asset and goods markets equilibrium conditions, and turn to capital mobility and foreign asset accumulation. We derive dynamic equilibrium conditions for foreign assets and the real exchange rate.

### A. Asset markets equilibrium and wealth

Total private domestic wealth ( $w$ ) is composed of financial wealth ( $w_f$ ) and real wealth ( $w_r$ ). Financial wealth is the sum of three "outside" assets: domestic money in private hands ( $M$ ), domestic government bonds in private hands ( $B$ ) and foreign assets ( $F$ ), each of them deflated by the domestic price

index (Q).

Continuous asset market clearing ensures that real asset demands L, BD and FD equate actual real asset holdings at equilibrium returns. The signs of the partial derivatives of each variable in the equations appear in parentheses below the corresponding functions. The three demand functions have the following form:

$$\begin{aligned}
 (1) \quad M / Q &= L ( i, i^* + \mu LR + \hat{E}^e + \Phi, y, wf ) \\
 &\quad (-) \quad \quad \quad (-) \quad \quad \quad (+) \quad (+) \\
 (2) \quad B / Q &= BD ( i, i^* + \mu LR + \hat{E}^e + \Phi, y, wf ) \\
 &\quad (+) \quad \quad \quad (-) \quad \quad \quad (?) \quad (+) \\
 (3) \quad E F / Q &= E FD ( i, i^* + \mu LR + \hat{E}^e + \Phi, y, wf ) \\
 &\quad (-) \quad \quad \quad (+) \quad \quad \quad (?) \quad (+)
 \end{aligned}$$

where  $i$  and  $i^*$  are the nominal domestic and foreign interest rates, respectively,  $LR$  is a variable measuring legal restrictions imposed on capital flows,  $\mu$  is the corresponding non-negative coefficient,  $E$  is the nominal exchange rate (units of domestic currency per unit of foreign currency),  $\hat{E}^e$  is the expected rate of devaluation,  $\Phi$  is a risk-premium parameter, and  $y$  is current real disposable income.

Legal restrictions can be established by domestic authorities on foreign asset or liability holdings, and/or on flows of foreign assets or liabilities. Restrictions on holdings of foreign assets or liabilities are those which determine the "LR" variable influencing asset demands in equations (1) - (3), even in the case of perfect capital mobility. But capital mobility is mainly impaired by restrictions on capital flows, which are introduced in the following section. For the purpose of our analysis the variable  $LR$  captures the extent of restrictions on both foreign capital holdings and flows.

Domestic and foreign assets also are imperfect substitutes because of a



second variable, the risk premium on domestic assets. In section 3 we define  $\Phi$  as a function of the foreign position, determined by foreign asset holdings. The domestic - foreign interest spread thus depends on foreign asset holdings.

Finally the domestic interest rate could differ in the short run from its long run (imperfect) arbitrage value represented by the second argument in the preceding equation, because of imperfect or slow capital mobility. This is the case modelled in section 3. Here we assume the benchmark case of perfect capital mobility with imperfect arbitrage.

Consistent with the above equations, total financial wealth must satisfy the following adding-up constraint:

$$(4) \quad wf = [ M + B + E F ] / Q$$

where  $Q$  is the price deflator defined as a weighted average of domestic traded ( $P_T$ ) and non-traded ( $P_N$ ) goods prices:

$$(5) \quad Q = P_T^{(1-\alpha)} P_N^\alpha$$

where  $\alpha$  is the share of non-traded goods in the price deflator.

Assuming PPP for domestic traded goods prices ( $P_T = E P_T^*$ , with international traded goods prices denoted by  $P_T^*$ ), and defining the real exchange rate  $p$  as the ratio of domestic traded and non-traded goods prices, the effective exchange rate,  $E/Q$ , is a function of the real exchange rate:

$$(6) \quad E/Q = p^\alpha / P_T^*$$

Total real wealth of the private sector is the valuation of current and future income streams adjusted by changes in the terms of trade. With the domestic price index  $Q$  as the numeraire, real wealth depends on the domestic (ex-ante) real rate of interest, permanent income ( $yp$ ) and the terms of trade ( $tt$ ):

$$(7) \quad w_r = w_r (i - \pi^e, y_p, \tau) \\ \quad \quad \quad (-) \quad (+) \quad (+)$$

where  $\pi^e$  is the expected rate of domestic inflation.

Combining equations (4) and (7) and using (6), we obtain the following function for total wealth:

$$(8) \quad w = M + B + E F / Q + w_r (i - \pi^e, y_p, \tau) \\ = w (M, B, p, f, i - \pi^e, y_p, \tau) \\ \quad \quad \quad (+) (+) (+) (+) \quad (-) \quad (+) \quad (+)$$

In this equation, real asset holdings  $M/Q$  and  $B/Q$  are replaced by a function of nominal holdings and the real exchange rate,<sup>3</sup> and  $f$  represents the value of foreign assets in real domestic currency. Hence,  $f = E F / Q$ .

#### B. Goods markets equilibrium in a dependent economy

In a two-sector dependent economy, the real exchange rate (and the absolute non-traded goods price) is determined by the following equilibrium condition for non-traded goods:

$$(9) \quad y_N (p, \dots) = c_N [ p, w (f, i - \pi^e, p, y_p, \tau), \\ \quad \quad \quad (-) \quad \quad \quad (+) (+) (+) \quad (-) \quad (+) \quad (+) \quad (+) \\ \quad \quad \quad i - \hat{P}_N^e, \dots ] + j_N (p, i - \hat{P}_N^e, \dots) + \quad \quad \quad g \\ \quad \quad \quad (?) \quad \quad \quad (+) \quad (-)$$

where the sub-index  $i$  ( $i = N$  for non-traded goods in equation (9),  $T$  for traded goods in equation (10) below) denotes the goods sector,  $y_i$  is sectoral

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<sup>3</sup> $Q$  is replaced by a function depending negatively on the real exchange rate. The positive influence of  $p$  on  $w$  stems from the fact that an increase in  $p$  reduces the general price deflator and therefore increases the value of real money and domestic bond holdings for given  $M$  and  $B$ .

output supply,  $c_i$  is sectoral consumption demand,  $j_i$  is sectoral investment demand,  $\hat{P}_i^e$  is non-traded expected inflation, and  $g$  is public consumption.

Sector supply and demand equilibrium equation (9) is consistent with intertemporal optimization, although we do not explicitly derive it from an optimization program.<sup>4</sup> Non-traded consumption depends positively on the real exchange rate and on private wealth, and ambiguously on its own rate of interest, while investment in non-traded goods depends positively on the real exchange rate and negatively on the own real interest.<sup>5 6</sup>

The trade surplus (or net exports) in quantity terms is determined by the excess supply of traded goods:

$$(10) \quad NX = y_T (p, \dots) - c_T (p, w (f, i-\pi^e, p, y_p, \\ \text{tt}), i-\hat{P}_T^e, \dots) - j_T (p, i-\hat{P}_T^e, \dots)$$

(+)
(-) (+) (+) (-) (+) (+)
(+)
(-) (-)

By adding equation (9) to the equilibrium condition for the value in domestic currency of traded goods production in equation (10), we can easily

<sup>4</sup>We cite the recent work by Butlin (1985), Brock (1985) and Schmidt-Hebbel (1987), among others, which extend previous work on intertemporal optimization, and derive behavioral functions in the context of a dependent or small open economy.

<sup>5</sup> Consumption demands in equations (9) and (10) depend ambiguously on own real interest rates because of the well-known opposite signs of the substitution and wealth effects. Investment demands depend unambiguously and negatively on their own real rates of interest in each sector. We simplify our dynamic analysis by dropping the effect of interest rates on consumption.

<sup>6</sup> In addition to the variables we include in (9), factor prices could determine output supplies while investment could depend either on factor prices or output levels. This opens the possibility of explicitly introducing unemployment and business cycles, through exogenous or sluggish factor prices and accelerator mechanisms.

obtain an aggregate income-expenditure equilibrium condition.

Since the real exchange rate comes from the non-traded market clearing condition, we solve equation (9) for the following real exchange rate equation:

$$(9') \quad p = p ( f , i-\pi^e , y_p , g , tt )$$

(-) (+) (-) (-) (-)

Collecting terms in equation (10), we derive the following function for quantum net exports or the trade balance:<sup>7</sup>

$$(10') \quad NX = NX ( p , w ( f , i-\pi^e , p , y_p , tt ) , i-\pi^e )$$

(+)(-)(+)(-) (+)(+)(+) (+)

### C. Foreign sector equilibrium

Foreign asset accumulation satisfies the following balance of payments identity defined in terms of foreign currency:

$$(11) \quad \dot{F} = P_T^* NX ( p , w(f , i-\pi^e , p , y_p , tt ) , i-\pi^e ) +$$

(+)(-)(+) (-) (+) (+) (+) (+)

$$+ i^* (F + R) - \dot{R}$$

where R measures international reserves in units of foreign currency.

Balance of payments surpluses or deficits are consistent with different pegged exchange rate systems. The nominal exchange rate can be subject to discrete or continuous as well as surprise or pre-announced changes, or to

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<sup>7</sup>We postulate that net exports depend unambiguously and positively on the real exchange rate. This assumes very realistically that the indirect price effect of a higher real exchange rate on consumption via a wealth rise is more than compensated by the sum of the direct effects of higher p on traded goods production, consumption and investment.

periods of fixed rates. This policy environment encompasses many developing economies and is consistent with varying devaluation expectations.

Multiplying equation (11) by  $E/Q$  we obtain the balance of payments restriction in real domestic currency units. By an appropriate substitution,<sup>8</sup> we transform equation (11) into an equation describing the accumulation of foreign assets defined in terms of real domestic currency units:

$$(11') \quad \dot{f} = p^\alpha NX(p, w(f, i-\pi^e, p, yp, tt), i-\pi^e) + \\ (+) (-)(+) (-) (+) (+) (+) (+) \\ + (i^* + \hat{E} - \pi)(f + r) - \dot{r}$$

where  $r$  measures the stock of international reserves in real domestic currency units:  $r = R E/Q$ .

The difference between equations (11) and (11') stems from the capital gain obtained from a domestic "real effective" devaluation. This increases

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<sup>8</sup>We substitute the changes in foreign assets and international reserves, both in terms of foreign currency, by the changes of these stocks in terms of real domestic currency. This involves valuation or capital gains effects, as follows:

$$(E/Q) \dot{F} = \dot{f} (\hat{E} - \pi), \text{ and } (E/Q) \dot{R} = \dot{r} + f(\hat{E} - \pi)$$

These equations are valid approximations only if the changes of the variables are small.

the total value of foreign assets and international reserves in real domestic currency units ( $f + r$ ) by the rate of the "real effective" devaluation ( $\hat{E} - \pi$ ).<sup>9</sup>

#### D. General equilibrium

Domestic financial markets (for money and government bonds) clear instantaneously. We assume perfect capital mobility, implying an infinite velocity of capital flows in response to foreign-domestic interest differentials. The interest arbitrage condition holds continuously for given levels of devaluation expectations, legal restrictions and country risk. We call this the imperfect arbitrage condition:

$$(12) \quad i = i^* + \hat{E}^e + \mu LR + \Phi$$

This condition implies that the values of foreign assets and of domestic assets, for given values of the right-hand variables in (12), are perfect substitutes and could be added together. But for any change in devaluation expectations, in the degree of domestic restrictions on capital flows or in country risk, the value of domestic bond holdings  $B$ , in terms of domestic currency, will be affected.

The dynamic paths of foreign assets and the real exchange rate appear in Figure 1. The phase diagram is based on equations (9') and (11'). The NN schedule represents in ( $f$ - $p$ ) space continuous non-traded goods market clearing equation (9'). Appendix 1 shows that the NN curve is unambiguously downward sloping, because higher foreign assets have a positive wealth effect

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<sup>9</sup>We can replace the rate of real effective devaluation,  $\hat{E} - \pi$ , with a function of the rate of change of the real exchange rate (or rate of "real" devaluation):  $\alpha p - P_T^*$ , which comes from equation (5). This expression could replace the capital gain term in equation (11').

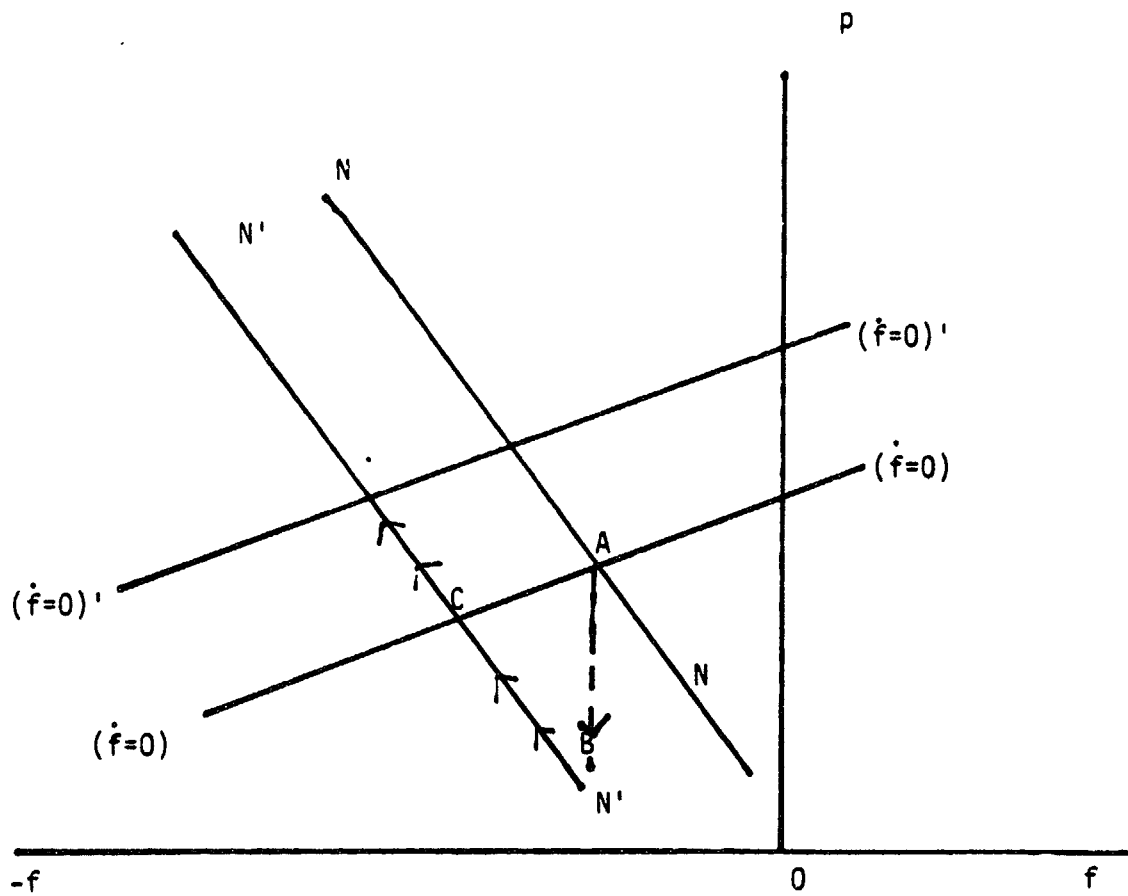


Figure 1  
 Real Exchange Rate and Foreign Asset Accumulation  
 under Capital Mobility

on consumption which lowers the equilibrium real exchange rate. Imposing the steady state equilibrium condition on equation (11'), we obtain the  $(f=0)$  schedule in Figure 1. Its slope is ambiguous and depends on the current account consequences of the wealth effect on consumption relative to the debt-servicing effects when foreign assets increase. Assuming the wealth effect dominates, the  $(f=0)$  schedule has a positive slope. We show this in Appendix 1.

Dynamic adjustment takes place along the NN schedule. Steady-state equilibrium is reached when the increase in foreign debt stops at point A.

An increase in (perceived) permanent income increases consumption of both traded and non-traded goods, and forces a leftward shift of both the NN and the  $(f=0)$  curves in Figure 1. The impact effect of higher spending is an appreciation of the real exchange rate. The effect depends only on the size of the increase in  $y_p$  and on the elasticity of the excess supply of non-traded goods with respect to real exchange rate. Dynamic adjustment along the  $N'N'$  schedule shows simultaneous real exchange rate depreciation and foreign debt accumulation. The final effect on  $p$  is ambiguous, depending on the value of final wealth resulting from higher levels of permanent income and of foreign debt, as compared to initial stationary wealth. If initial and final wealth levels coincide, the real exchange rate returns to its initial value.<sup>10</sup>

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<sup>10</sup> When the debt-servicing effect of a rise in  $f$  dominates the wealth effect, i.e. when the  $(f=0)$  curve is negatively sloped, there is an unambiguous rise in the stationary values of both the foreign debt and the real exchange rate.



### III. CAPITAL FLOWS AND DOMESTIC ADJUSTMENT UNDER IMPERFECT CAPITAL MOBILITY

With imperfect international capital mobility, domestic interest rates can transitorily deviate from their international imperfect arbitrage levels. Domestic interest rates adjust for continuous short-run money and domestic bond market equilibrium, although incentives for changing the portfolio composition remain as long as the imperfect arbitrage condition given by equation (12) is not met. This occurs because domestic asset holders can not quickly change their portfolio compositions by buying or selling foreign assets because of domestic legal restrictions imposed on foreign capital flows.

To derive the behavior of interest rates and international reserves under imperfect capital mobility, let's focus on the monetary flow equilibrium condition, which equates constant-price flow supply and demand:

$$(13) \quad \dot{(M/Q)} = \dot{L}$$

Money supply is increased through accumulation of domestic credit or international reserves. Asset holders adjust their monetary balances over time in response to the difference between their desired and actual holdings. They do this by exchanging international reserves for foreign assets at a speed  $\beta$  times the gap between desired and effective monetary holdings. Hence flow monetary equilibrium relates reserve accumulation and monetary flow demand as follows:

$$(13') \quad (\dot{ER/Q}) + (\dot{C/Q}) = \beta(L^D - (M/Q)) + (\dot{C/Q})$$

where  $L^D$  is desired or long-run real money holdings, under conditions of imperfect interest arbitrage,  $\beta$  is the speed of adjustment coefficient, and  $(C/Q)$  is the flow of real domestic credit of the central bank.

Excess demand of money causes domestic interest rates to increase instantly (and domestic bond prices to fall). Asset holders accumulate cash balances by turning to international credit markets, where they sell foreign assets or accumulate debt and change the proceeds at the domestic central bank for domestic currency. Through this sluggish monetary adjustment process, domestic interest rates come down and cash balances increase until stationary monetary equilibrium is reestablished.

The difference between the short-run interest rate and its long-run arbitrage level depends only on the partial derivative of the money demand with respect to the domestic interest rate.

The speed with which asset holders accumulate money balances depends on the legal restrictions which regulate the flows or acquisitions of foreign assets or liabilities. Hence  $\beta$  is a negative function of the legal restrictions variable LR:

$$(15) \quad \beta = \beta (LR) \\ (-)$$

The country-risk parameter  $\Phi$  depends negatively on the stock of foreign assets or liabilities. This is a frequently used "indicator" for a country's foreign position with a given GDP level:

$$(16) \quad \Phi = \Phi (f) \\ (-)$$

This function could be continuously differentiable or could have a kink at a critical value of the stock of foreign debt.

With substitution and use of desired and actual domestic money stocks  $L^D$

and  $L$ , we obtain the following equation for the change in international reserves:

$$(17) \dot{r} = \beta(LR) ( L^D (i=i^* + \mu LR + \hat{E}^e + \Phi(f), i^* + \mu LR + \hat{E}^e + \Phi(f), y, wf ) - L (i, i^* + \mu LR + \hat{E}^e + \Phi(f), y, wf ) )$$

We substitute the equilibrium real exchange rate from equation (9') into the trade balance equation, to obtain the following equation for foreign asset accumulation under imperfect capital mobility:

$$(18) \dot{f} = [ p( f, i-\pi^e, yp, g, tt ) ]^\alpha NX( f, i-\pi^e, yp, g, tt ) \\ \begin{matrix} (-) & (+) & (-) & (-) & (-) & & (-) & (+) & (-) & (-) & (-) \end{matrix} \\ + (i^* + \hat{E} - \pi) (f + r) - \\ - \beta(LR) ( L^D (i = i^* + \mu LR + \hat{E}^e + \Phi(f), i^* + \mu LR + \hat{E}^e + \Phi(f), \\ \begin{matrix} (-) & & (-) & (-) & & & (-) \end{matrix} \\ y, wf(f)) - L(i, i^* + \mu LR + \hat{E}^e + \Phi(f), y, wf(f)) \\ \begin{matrix} (+) & (+) & (+) & & (-) & & (-) & & (-) & (+) & (+) & (+) \end{matrix} \end{matrix}$$

In equation (18)  $\beta$  plays the role of the offset coefficient first presented by Kouri and Porter (1974), which measures the effect of an increase in domestic credit on foreign asset accumulation. But there are two important differences between our framework and the Kouri and Porter model. We specify the variables explaining imperfect substitution ( $LR$  and  $\Phi$ ), and we distinguish between instantaneous and long-run equilibria in asset markets. Our offset coefficient depends directly on the factor behind imperfect capital mobility ( $LR$ ), and not on the magnitude of the interest elasticities of asset demands, as in their model.

Substitution of  $\Phi$  from equation (9') into (18) reinforces the negative effect of  $f$  on foreign asset accumulation. We already assumed this when we postulated the dominance of the wealth effect over the interest effect when  $f$  increases.

On the other hand foreign asset accumulation in equation (18) depends ambiguously on the domestic interest rate. A rise in  $i$  increases net exports but also induces a higher foreign reserve accumulation as asset holders build up cash balances in response to their excess demand for money. If the latter effect dominates,  $f$  increases with the interest rate.<sup>11</sup> This is the case when we draw a negatively sloped ( $f=0$ ) schedule in Figure 2.

What about instantaneous or short-run equilibrium in the domestic money market? From equation (1) we obtain the following expression for  $i$  in terms of the determinants of stock supply and current (not desired) stock demand:

$$(19) \quad i = i \left[ (M/EP^*T), f, y_p, g, \pi, i^* + \mu LR + E^e + \Phi(f), y \right]$$

(-)      (+) (+) (+) (+)                      (-)      (-) (+)

The II curve in Figure 2 represents the unambiguously positive relation between  $i$  and  $f$  in equation (19). Adjustment takes place on this curve after a disturbance to the dynamic system given by equations (18) and (19).

Long-term or stationary equilibrium is reestablished when domestic interest rates reach the imperfect arbitrage levels in equation (12). This curve appears in Figure 2. It is consistent with a stationary value of domestic interest rates. To obtain an adjustment equation for domestic interest rates, we assume that the interest rate  $i$  is related to money by the

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<sup>11</sup>This dominance depends on value of the speed of adjustment  $\beta$ , and thus on the intensity of legal restrictions, as shown in equation (18).

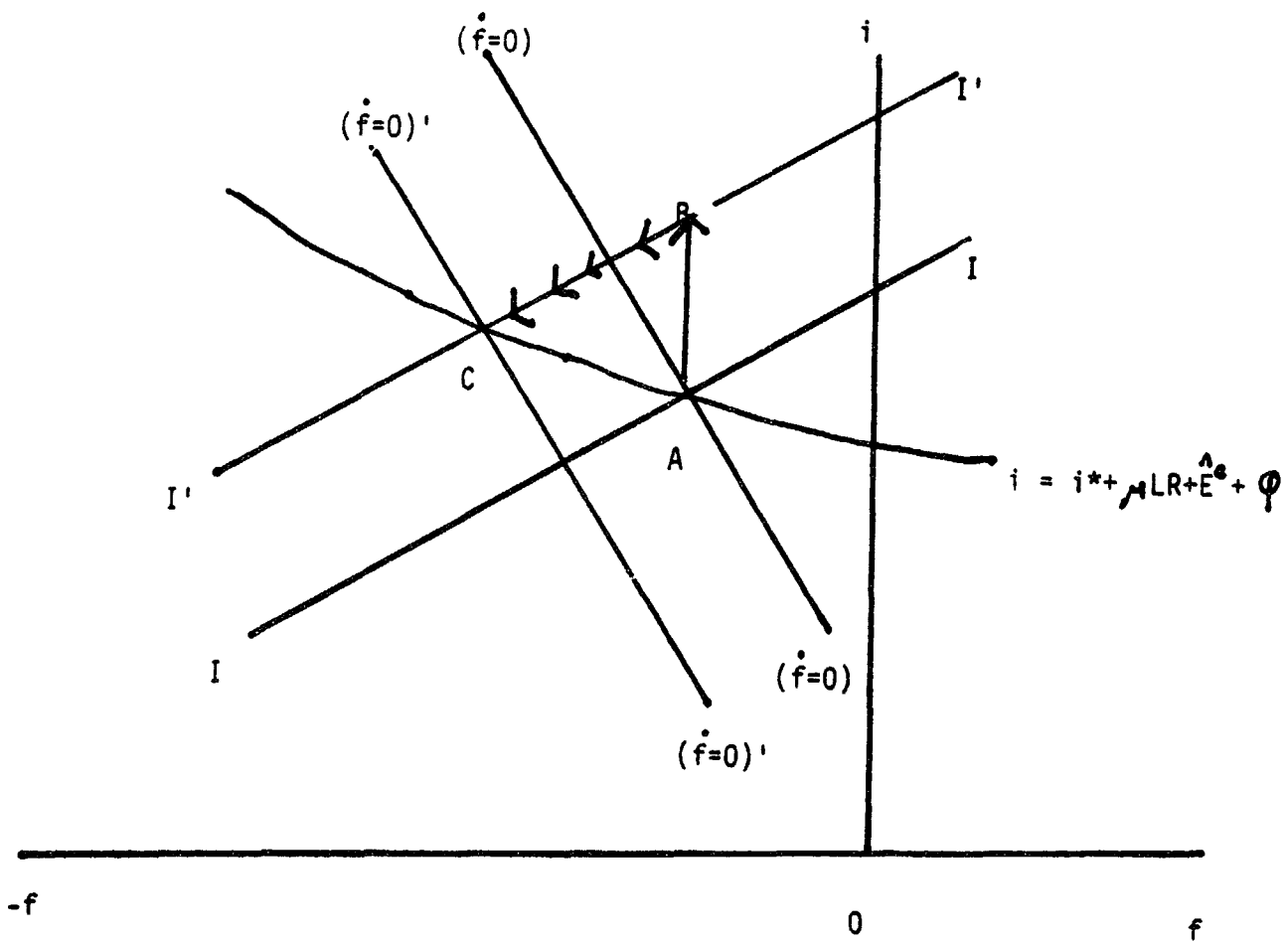


Figure 2  
 Interest Rate and Foreign Asset Accumulation  
 under Imperfect Capital Mobility

partial derivative of money demand with respect to the interest rate:

$$(20) \quad \dot{L} = \eta \dot{i} = \beta(LR) [L^D(\dots) - L(\dots)]$$

With further substitution, the adjustment of domestic interest rates is given by the following equation:

$$(21) \quad \dot{i} = [\beta(LR) / \eta] [L^D(i = i^* + \mu LR + \hat{E}^e + \Phi(f), i^* + \mu LR + \hat{E}^e + \Phi(f), y, wf(f)) - L(i, i^* + \mu LR + \hat{E}^e + \Phi(f), y, wf(f))]$$

(+)                      (-)                      (-)                      (-)                      (-)

y , wf(f)                      - L ( i , i^\* + \mu LR + \hat{E}^e + \Phi(f) , y , wf(f) )

(+)                      (+)                      (-)                      (-)                      (-)                      (+)                      (+)(+)

From equation (21) the steady-state condition  $\dot{i}=0$  is reached when domestic interest rates converge to their parity levels determined by equation (12), since  $\Phi$  depends negatively on  $f$ . The  $\dot{i}=0$  curve thus coincides with the imperfect arbitrage condition in Figure 2. This curve also represents the foreign credit supply schedule which relates higher foreign debt levels to higher credit costs.

An increase in permanent income generates leftward shifts of both the  $f=0$  and the II curves. The impact effect is a real exchange rate appreciation and an increase in the domestic interest rate, as shown in Figure 2. Then foreign debt is accumulated, the real exchange rate depreciates and the domestic interest rate falls as adjustment continues on the I'I' curve in Figure 2.

This adjustment process is quite different from the corresponding one under perfect capital mobility. Under perfect capital mobility the domestic interest rate is continuously maintained at its imperfect arbitrage level, while the real exchange rate shows greater variability. Under imperfect

capital mobility, the reverse is true. The increase in the domestic interest rate reflects a lower foreign debt accumulation and a lower domestic monetary accumulation than under perfect mobility, during the first phase of dynamic adjustment process. The instantaneous appreciation of the real exchange rate is smaller under imperfect capital mobility because of the partly offsetting effect of the higher interest rate on  $p$ .

Although the dynamic transition of  $f$ ,  $i$ , and  $p$  is different in the polar cases of perfect and imperfect mobility, the final stationary levels are the same.

#### IV. MODEL IMPLEMENTATION AND EMPIRICAL RESULTS: CHILE 1975 - 1982

In this section we first focus on deriving an estimable form of the model developed above, and then turn to the empirical results of the model implemented for Chile during 1975-1982.

##### A. Model implementation

In the following a slightly modified, discrete-time version of the theoretical structure of sections 2 and 3 is derived.

With regard to real and financial wealth, we will focus on their levels instead of their functional forms as in equations (7) and (8) above. In addition we consolidate private and public net asset holdings into net national holdings<sup>12</sup>, obtaining national financial wealth as the sum of foreign assets (or gross foreign debt) and international reserves:

$$(22) \quad w = wr + wf = wr + (f + r)$$

---

<sup>12</sup>This is a form of Ricardian equivalence, implying that public bonds and the domestic credit component of the money stock are cancelled out of net national financial wealth.

With regard to relative traded/nontraded goods prices, one often observes price sluggishness in many economies. Therefore one should consider market clearing condition (9) as a benchmark case, implementing a version of equation (9') which recognizes the role of past relative prices or real exchange rates. Hence we obtain the following equation for the real exchange rate:

$$(23) \quad p_t = p ( w r_t , w f_t , i r_t , g_t , p_{t-1} )$$

$$(-) \quad (-) \quad (+) \quad (-) \quad (-)$$

where  $i r_t$  is the real interest rate defined as  $i - \pi_t^e$ <sup>13</sup>.

For deriving the domestic nominal interest rate we specify the following discrete-time version of equation (13) for monetary flow equilibrium under partial stock adjustment:

$$(24) \quad L_t - L_{t-1} = m_t - m_{t-1} = \beta [L_t^D - z_t] + c_t - c_{t-1}$$

where  $z$ , the ex-ante stock supply of money, is defined by:

$$z_t = m_t + c_t - c_{t-1}$$

From (24) we derive the current or short-run money demand (equal to current money holdings) as a weighted average of the desired or long-run money demand and the current ex-ante supply of money, after substituting the

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<sup>13</sup>Expected inflation  $\pi_t^e$  (the expectation of inflation between periods  $t$  and  $t+1$ , as of period  $t$ ) and expected nominal devaluation (defined similarly) are obtained from autoregressive time-series specifications for actual rates of inflation and nominal devaluation.



functional forms for L and  $L^D$ <sup>14</sup> into (24):

$$\begin{aligned}
 (25) \quad & L_t [ i_t, i^*e_t + \mu LR_t + \Phi(f_t), f_t + r_t ] \quad ( = m_t ) = \\
 & \quad (-) \quad \quad (-) \quad \quad (-) \quad \quad (+) \\
 & - \beta (LR_t) L^D_t [ i - i^*e_t + \mu LR_t + \Phi(f_t), i^*e_t + \mu LR_t + \Phi(f_t), \\
 & \quad (-) \quad \quad (-) \quad \quad (-) \quad \quad (-) \quad \quad (-) \quad \quad (-) \\
 & \quad f_t + r_t ] + (1 - \beta (LR_t)) z_t \\
 & \quad (+) \quad \quad \quad (-)
 \end{aligned}$$

where  $i^*e_t$  is the perfect arbitrage interest rate defined by  $i^*_t + E^e_t$ .

Equation (25) is an implicit equation for the short-run domestic nominal interest rate. Inverting this equation, we obtain  $i_t$  as follows:

$$\begin{aligned}
 (26) \quad & i_t = i ( i^*e_t, LR_t, f_t, r_t, z_t ) \\
 & \quad (?) (+) \quad (?) (+) \quad (?) (+) \quad (+) \quad (-)
 \end{aligned}$$

The first three right-hand variables in general present an ambiguous sign. But for empirical reasons we might expect the dominance of the positive effects in each case, as discussed in appendix 2.

The discrete-time version for the domestic-currency balance of payments equation (11') is:

$$\begin{aligned}
 (27) \quad & f_t - f_{t-1} = (p_t)^\alpha NX_t + (i^* + E_t - \pi_t) (f_t + r_t) - \\
 & \quad - (r_t - r_{t-1}) + ov_t
 \end{aligned}$$

where  $ov_t$  is the sum of other balance of payments variables such as

---

<sup>14</sup>We have dropped current real disposable income from the functional forms for L and  $L^D$  because of empirical reasons.

unilateral transfers and direct foreign investment.

Instead of estimating directly equation (27) for foreign asset accumulation (such as equation (18) under continuous time), we specify two separate equations, for net exports and foreign reserve accumulation.

The net exports (quantum) function consistent with (10') is:

$$(28) \quad NX_t = NX ( p_t, wr_t, wf_t, ir_t )$$

(+ ) (- ) (- ) (+ )

Finally, for the stock of foreign reserves we specify the following form, which is consistent with foreign reserve accumulation as defined in equations (17) and (24):

$$(29) \quad r_t = r ( i^*e_t, LR_t, f_t, z_t, r_{t-1} )$$

(- ) (?) (- ) (+ ) (- ) (+ )

Although the effect of the legal restrictions on  $r_t$  is in general ambiguous, depending on the sign of the ex-ante excess demand for money ( $L_t^D - z_t > 0$ ), we may expect a negative sign of the effect due to a positive ex ante excess monetary demand during most of the sample period.

#### B. Empirical results: Chile, 1975-1982

The model was applied to the bust-boom-bust period which characterized the Chilean economy from 1975 to 1982. During this period the country underwent significant structural reforms. Domestic goods and factor market liberalization was soon followed by foreign trade opening (1974-1979) and capital inflow liberalization (1977-1981). A wild spending frenzy during 1979-1981 (financed by huge foreign credit inflows), in addition to a

deterioration of foreign conditions culminating in the foreign credit freeze in late 1982, were behind the deep recession and crisis of 1982-1983.

This period has been documented elsewhere<sup>15</sup>. Our goal is to apply to it the framework developed above, to illustrate the interaction of the pivotal variables under real and financial general equilibrium conditions. Hereby we stress the role of financial liberalization and of slow adjustment in the goods, foreign asset, and domestic money markets. We estimate the model with a time-varying parameter method, the Kalman filter, in order to allow the coefficients to reflect the underlying structural changes. Specifically, we wish to show that the underlying parameter changes make the domestic interest rate relatively more volatile before liberalization, and the real exchange rate more volatile after liberalization. Information on data sources is given in Appendix 3.

### B.1 Results with Constant Coefficients

In Table 1 we present the empirical results for the four dependent variables, obtained from three-stage least squares estimation methods. They correspond to linear forms in the levels of the variables<sup>16</sup>, as specified in equations (23), (26), (28) and (29), respectively. These results assume constant coefficients. While financial liberalization makes this assumption hard to defend, these results serve as a benchmark for assessing how much

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<sup>15</sup>In addition to the already cited papers by Corbo (1985), Corbo and Matte (1984), Edwards (1985, 1986), and Schmidt-Hebbel (1987), see particularly the books by Arellano (1982), Edwards and Edwards (1987), and Morande and Schmidt-Hebbel (1988).

<sup>16</sup>We estimated regressions for variables in levels (and not in logs) only, because of the identities, defined for variables in levels, introduced in the simultaneous equation alternative.

Table 1  
Three Stage Least Squares Estimates, Chile, 1975.3 - 1982.4

The Real Exchange Rate (p):

$$p = 1.11 - 0.0001 wr - 0.0003 wf - 1.32 ir - 0.023 g - 0.34 p_{t-1}$$

(2.67) (3.23) (0.6) (1.63) (1.43) (1.72)

D.W. = 1.54 Durbin's H = None RSQC = .84

**Diagnostics:** L.M. Stat (dgf) P-Value

Serial correlation 3.06 4 .46

Functional form 1.84 1 .17

Normality 17.95 2 .001

Heteroskedasticity 1.96 1 .16

Misspecification 4.41 3 .21

The Nominal Interest Rate (i):

$$i = -0.15 + 0.65 (i^*+E) + 0.25 LR + 0.0005 f + 0.0065 r - 0.0001 z$$

(1.3) (6.6) (3.8) (1.5) (2.3) (0.2)

D.W. = 1.47 RSQC = .87

**Diagnostics:** L.M. Stat (dgf) P-Value

Serial correlation 7.91 4 .09

Functional form 1.09 1 .29

Normality .42 2 .80

Heteroskedasticity 1.94 1 .16

Misspecification 9.92 3 .01

Net Exports (nx):

$$nx = -25.2 + 24.6 p - 0.0054 wr + 0.0105 wf + 53.3 ir$$

(1.8) (2.7) (3.0) (0.4) (1.2)

D.W. = 1.78 RSCQ = .84

**Diagnostics:** L.M. Stat (dgf) P-Value

Serial correlation 4.54 4 .33

Functional form 0.00 1 .99

Normality 1.18 2 .55

Heteroskedasticity 6.12 1 .01

Misspecification 7.35 4 .11

Foreign Reserves (r):

$$r = -16.0 - 7.38 (i^*+E) - 7.9 LR - 0.0024 f - 0.061 z + 0.71 r_{t-1}$$

(3.0) (1.5) (2.6) (0.16) (0.4) (6.3)

D.W. = 1.43 Durbin's H = 1.68 RSCQ = 0.97

**Diagnostics:** L.M. Stat (dgf) P-Value

Serial correlation .95 4 .91

Functional form .04 1 .82

Normality .94 2 .62

Heteroskedasticity .08 1 .77

Misspecification 6.26 3 .09

**Regressors:** E: nominal exchange rate; f: foreign assets; g: government spending; i\*: foreign interest; ir: real interest rate; LR: legal restrictions; wf: financial wealth; z: domestic credit

time-varying coefficient values depart from the constant parameter values which represent the average coefficient values for the entire period. For instrumental variables for the first stage of the estimation, we used current and lagged values of all exogenous and predetermined variables, as well as the lagged values of the endogenous variables which do not appear as predetermined variables.

Table 1 shows that the real exchange rate is significantly determined by real wealth ( $wr$ ) and its own lagged value. Financial wealth has no effect on the relative traded/nontraded goods price.<sup>17</sup> While government spending has a weak negative effect, as expected, on the real exchange rate, the real interest rate affects  $p$  positively. However, both coefficients are not significant at the ten percent level of significance.

Nominal interest rates are significantly sensitive to most variables expected a priori. Foreign arbitrage interest levels ( $i^*+E^e$ ) have a dominant influence on domestic nominal rates, during a period characterized by significantly changing conditions in the access to foreign credit markets. These changes are signalled by the high sample variance of the legal restrictions variable ( $LR$ ), which itself is significant in determining domestic interest rates. While foreign assets (the negative of the gross foreign debt) are not significant, the role of foreign reserves is significant.

Ex ante domestic money supply  $z$  presents the correct sign, negatively

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<sup>17</sup> For real (and for total) national wealth we specified two alternatives with regard to future variables: a random-walk version ( $rw$ ) and a limited perfect foresight alternative ( $lpf$ ). As in earlier results, the former alternative dominates significantly over the latter, showing that Chilean consumers overestimated their wealth levels during the 1979-1981 period.

associated to domestic nominal interest rates, although its significance level is low, possible due to its collinearity with the other regressors.

With regard to the determination of the excess supply of traded goods or the net exports quantum (NX), all the regressors have the expected signs but only two, the real exchange rate and real wealth, are significant.

Foreign reserve accumulation, the mechanism by which money holders hoard real balances, and thus a co-determinant of interest rates, is determined by similar variables (which show similar significance levels) as the nominal interest rate  $i$ . Hence the stock of foreign reserves is highly dependent on the foreign arbitrage interest level and on legal restrictions (as well as on its own lagged value), while the role of foreign assets (debt) is negligible. Domestic money appears to be of small significance, because of its high collinearity with other right-hand variables. Lagged foreign reserves are also significant.

Table 1 shows a set of diagnostic tests for each of the equations, for evaluating autocorrelation, function form, normality of the disturbance terms, heteroskedasticity, and misspecification, with chi-square statistics.

At the five percent level of significance, practically all of the tests are insignificant, and thus do not allow us to reject the hypothesis of white noise. The exceptions are for normality in the real exchange rate equation, misspecification in the interest rate equation, and heteroskedasticity in the net export equation.

The absence of serial correlation in the equations permits the use of Kalman filtering for evaluating the variability of the coefficients over time. The possibility of specification error in the linear model with constant coefficients, reflected in the chi-square LM (Lagrange multiplier)

statistics for non-normality, misspecification, and heteroskedasticity, indicates that the use of a time-varying coefficients may be a more appropriate specification for the model during the liberalization process.

## B.2 Time-varying parameter results

The Kalman filter estimates for the significant coefficients estimated in Table 1 appear in Figures 3 through 8.

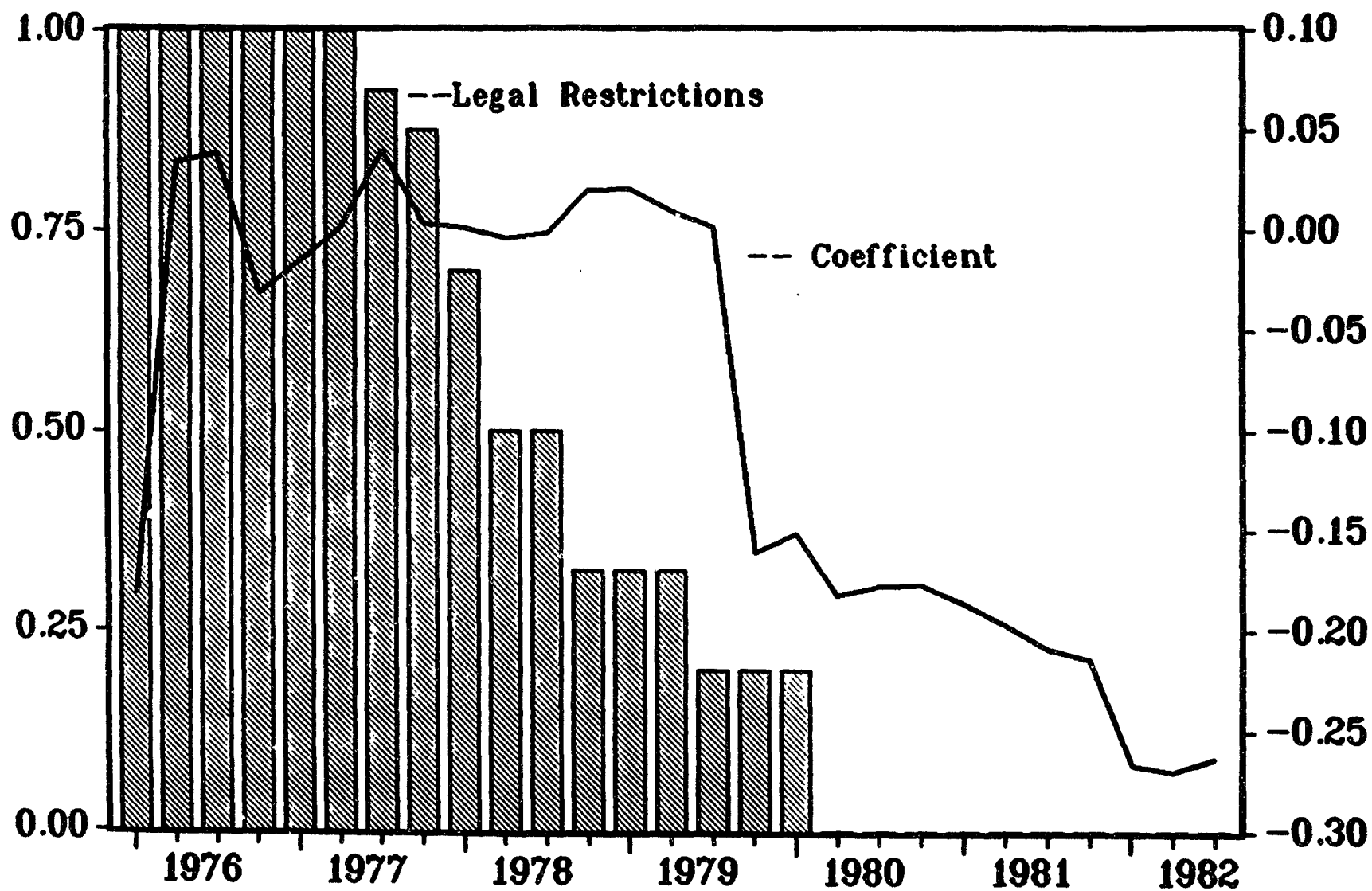
In each of the figures, we plot the evolution of two variables, one with a bar graph and the other with a line graph. The bar chart pictures the discrete downward movement of the legal restrictions variable, which we have normalized as a variable between zero and 1, with zero representing the financial openness present at the end of the liberalization process. The appropriate values for the bar chart appear on the left vertical axis. The line plot shows the movement of the time-varying coefficients. The values for the coefficient appear on the right vertical axis in each figure. We thus picture the evolution of the legal restrictions variable with the time-varying coefficient to show the influence of the increasing financial openness on the movements of each coefficient, both in the direction and the extent of its change.<sup>18</sup>

The Kalman filter follows a two-stage process for estimating the time-varying coefficients. At time  $t$ , an optimal predictor for the dependent

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<sup>18</sup> Of course, there were other macroeconomic regime changes taking place. During the period of liberalization, the exchange rate system moved from one of rough indexation to a fixed nominal rate. Thus our analysis of the co-movements of the index of openness with the coefficients is based on prior information on the timing of the liberalization. Since the exchange rate rules changed at virtually the same time, we cannot rule out effects coming exchange rate regime changes on the coefficients. We can only verify if the coefficient movements are consistent with expected adjustment following liberalization.

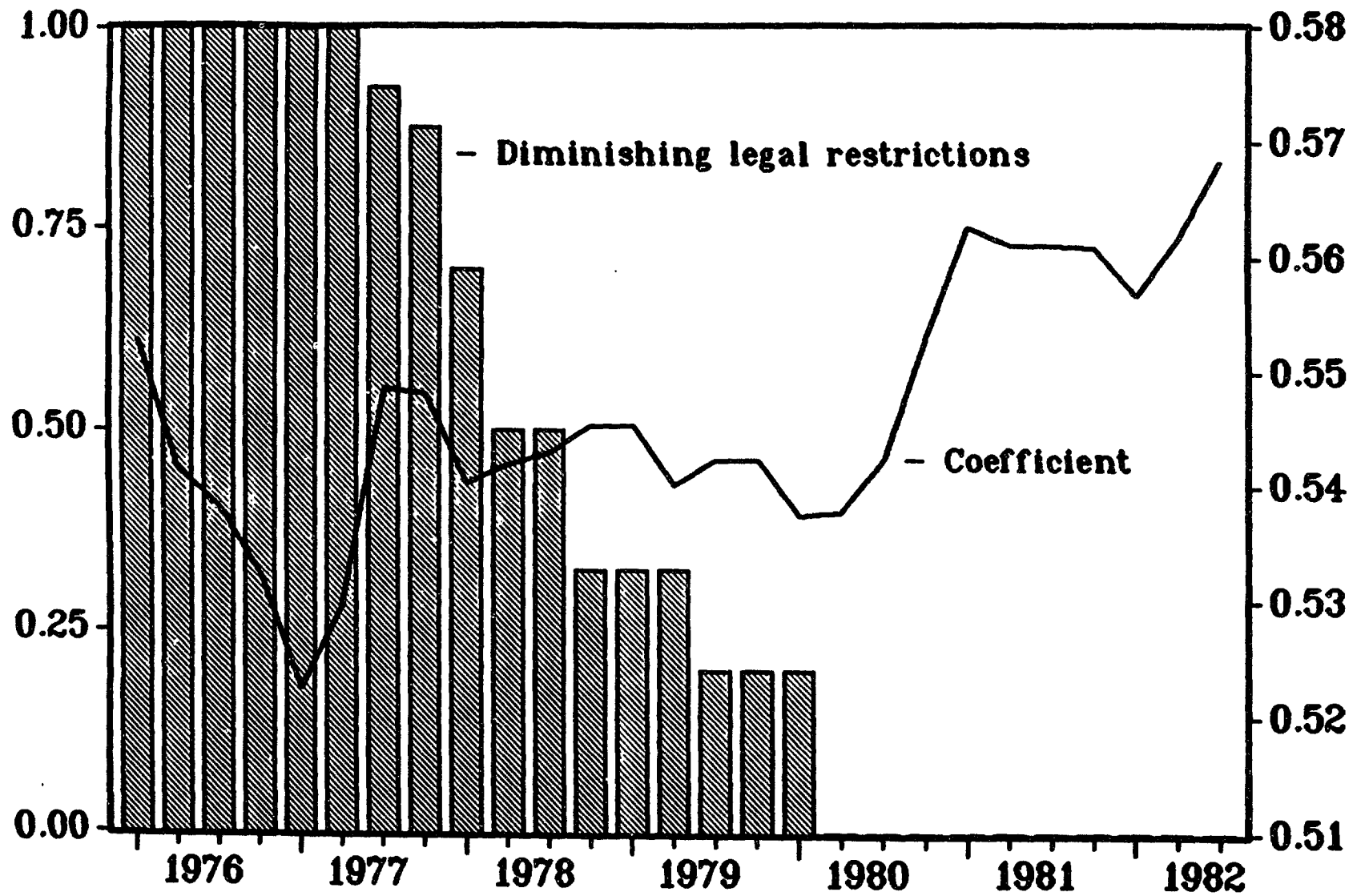
FIGURE 3



Time-Varying Coefficient of Real Interest Rate on the Real Exchange Rate

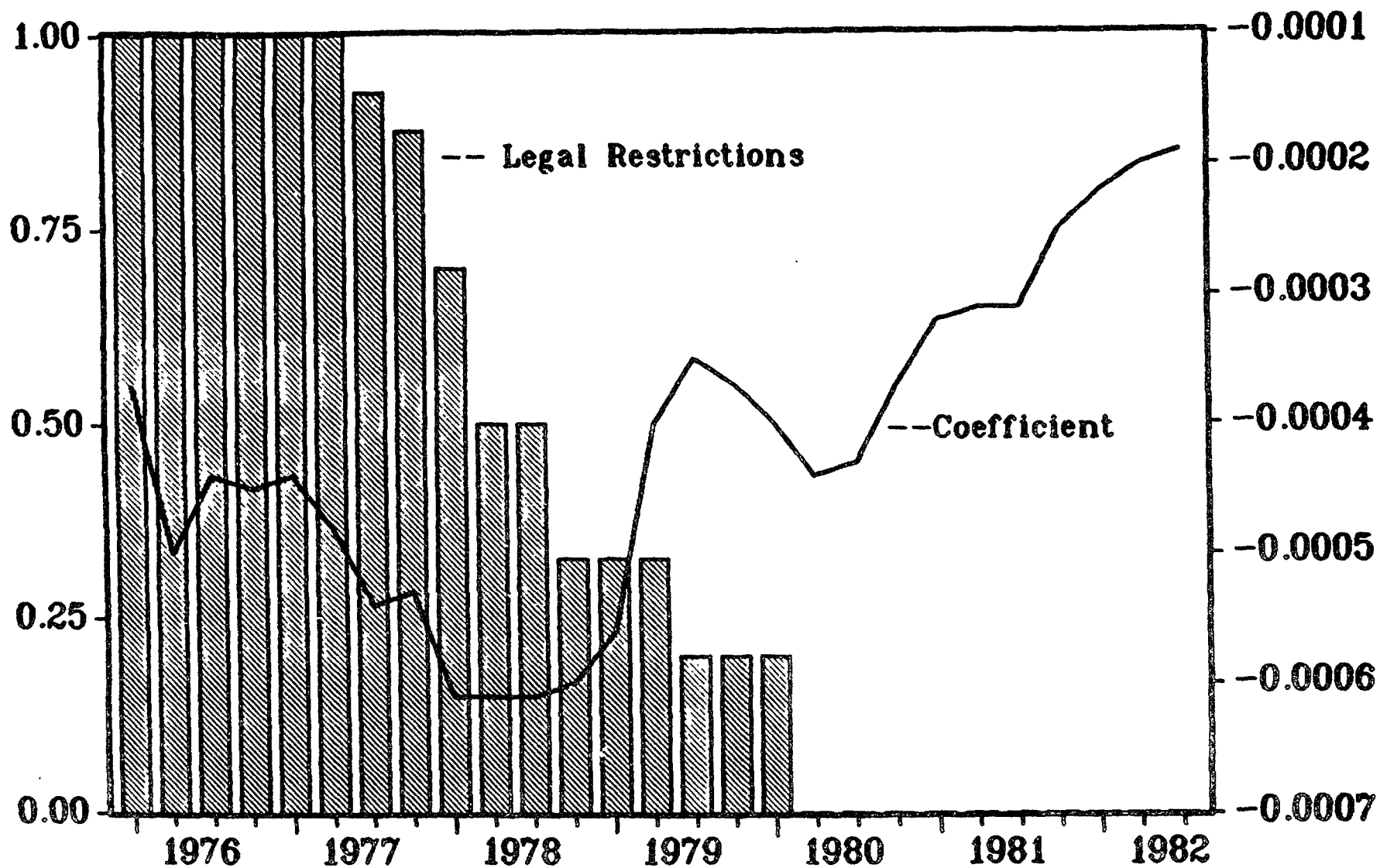


FIGURE 4



Time-Varying Coefficient of International Interest  
on the Domestic Interest Rate

FIGURE 5



Time-Varying Coefficient of Domestic Credit on Domestic Interest Rates

FIGURE 6

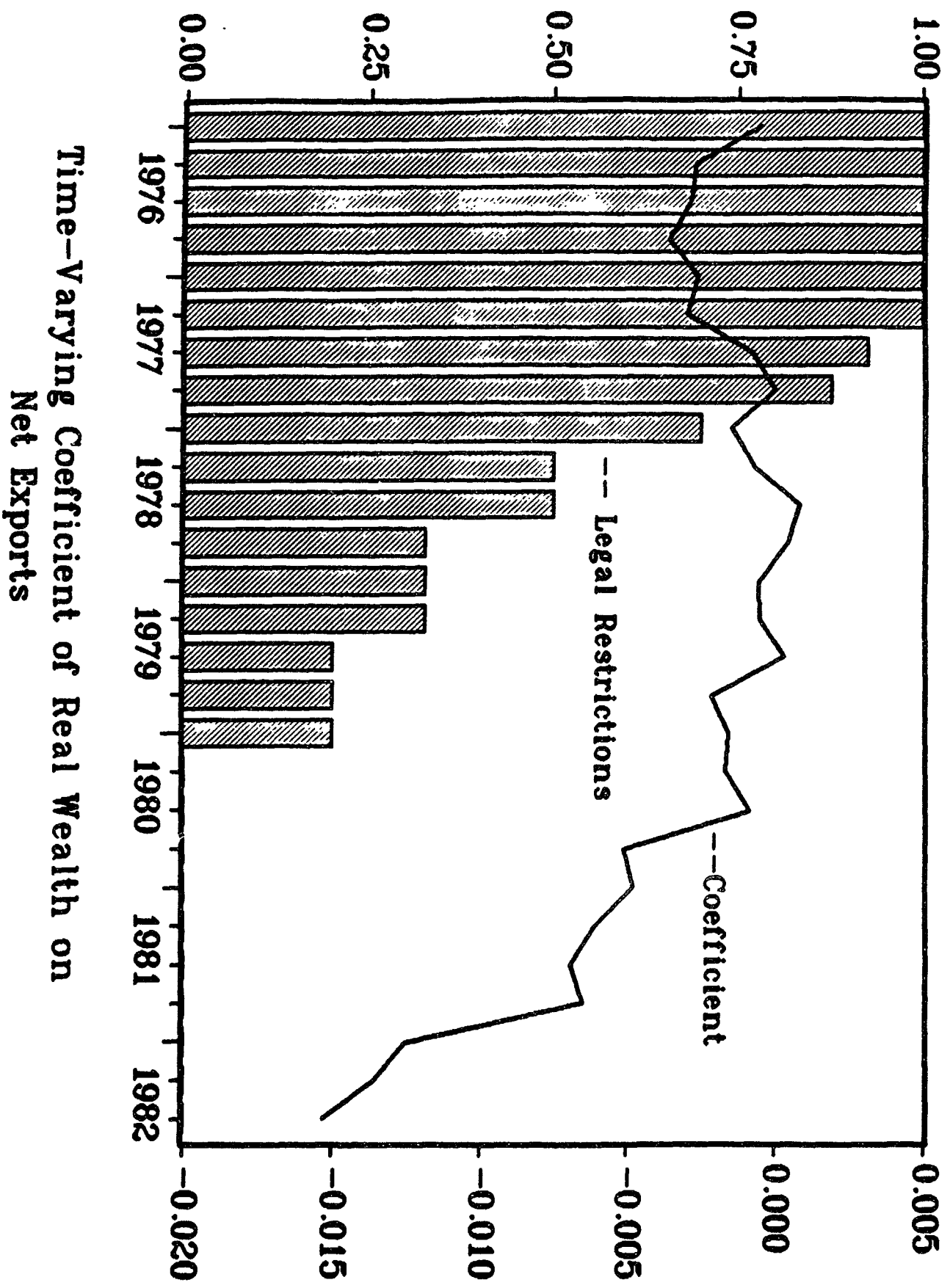
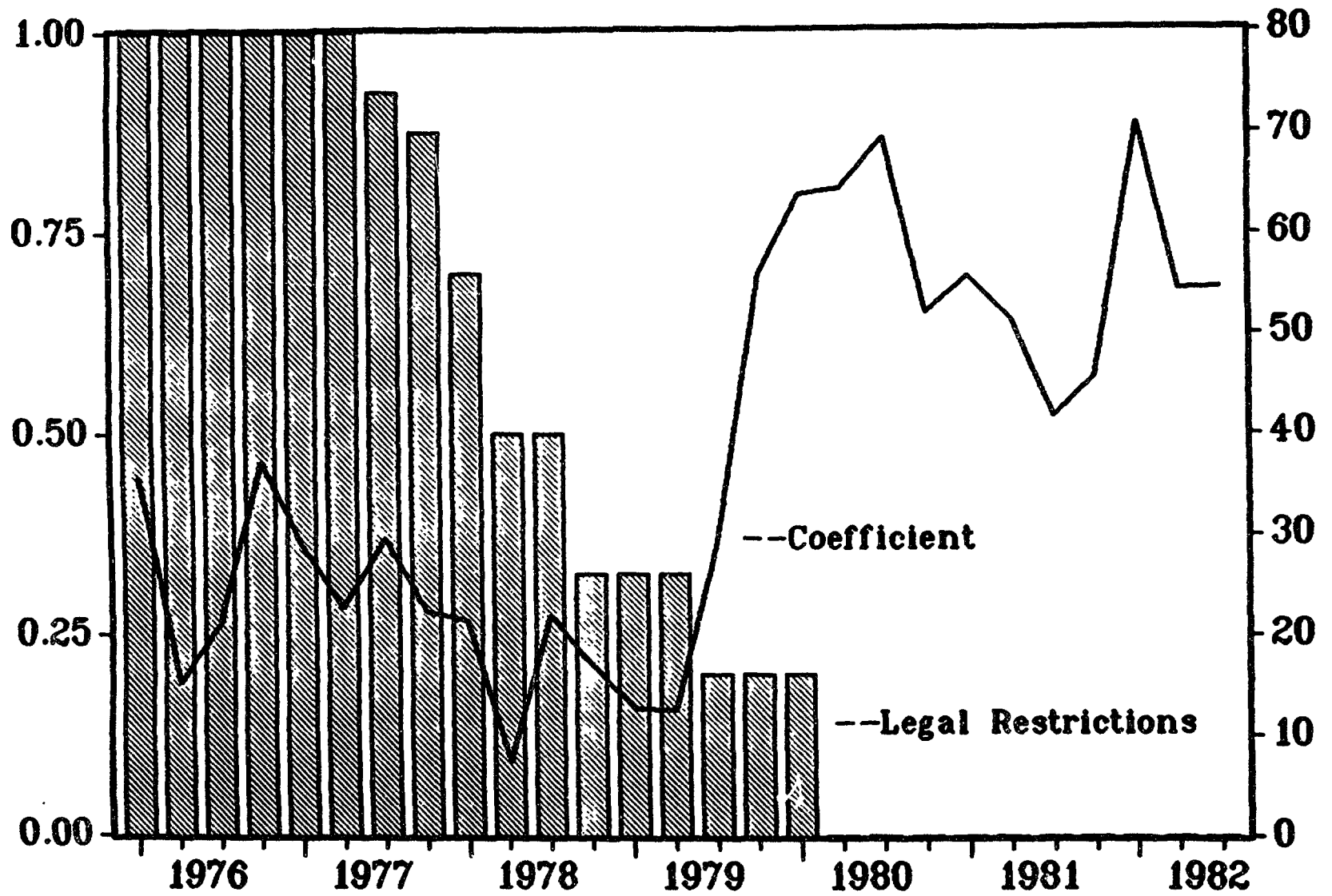
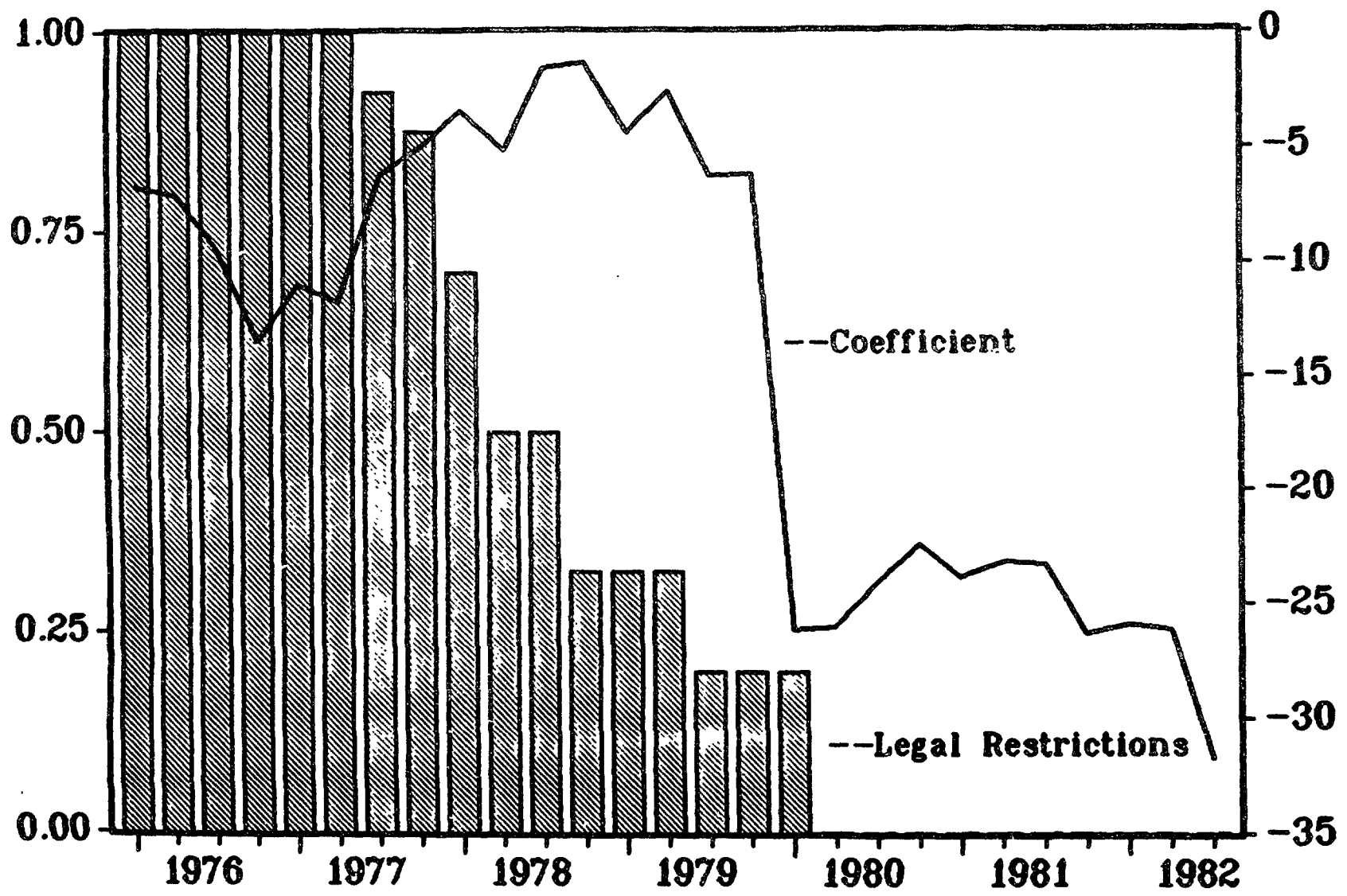


FIGURE 7



Time-Varying Coefficient of Real Interest Rate on Net Exports



**Time-Varying Coefficient of International Interest Rate on Reserves**

variable is formed, using all information available up to and including time  $t$ . In the second-stage, the forecast error is used to modify the coefficients, and new information is used to generate new predictions at time  $t+1$  for time  $t+2$ . Detailed descriptions of Kalman filtering appear in Anderson and Moore (1979), Pagan (1980), Harvey (1981) and Chow (1984). Intuitively, the Kalman filter may be described as an "optimal discounting" of past data to find the best one-period forward predictor.

Figure 3 pictures the coefficient of the real interest rate for determining the real exchange rate. We see that during the period of low capital mobility, following deregulation of domestic markets in 1975, the real interest rate had little or no effect on the real exchange rate, but as financial openness progressed, the real exchange rate became more responsive to the real interest rate.<sup>19</sup>

Figures 4 and 5 show that the domestic interest rate becomes progressively more dependent on the covered foreign interest rate and less dependent on domestic monetary conditions (represented by the time-varying coefficient of domestic credit) as the financial opening continued. The domestic interest rate became more and more an internationally-determined variable, more dependent on foreign interest rate conditions, and less on domestic conditions, while the real exchange rate was becoming more sensitive to the domestic real interest rate.

Figures 6 and 7 show that net exports became more sensitive to real wealth and the real interest rate as the liberalization process unfolded.

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<sup>19</sup> Similarly, the autoregressive component, represented by the coefficient of the lagged real exchange rate, became more pronounced during the liberalization process, thus increasing the sensitivity of the real exchange rate to current and past shocks.

Since the interest rate became relatively more stable during this period, the increasing effect of the real interest rate on net exports may be due to the greater certainty associated with this variable.

Figure 8 pictures the effect of the international interest rate on the level of international reserves. As the liberalization progressed, the effect of legal restrictions diminished, reserves became more volatile, and thus responded more quickly and more strongly to international interest rate movements.

## V. CONCLUDING REMARKS

We have derived a model for analyzing dynamic adjustment of the real exchange rate, the domestic interest rate, foreign assets (or foreign debt) in a small economy. In the first case we assumed perfect integration into world capital markets. Then we shifted to imperfect capital mobility, when domestic interest rates deviate from their perfect or imperfect international arbitrage values. Our analysis shows that the trajectory and the speed of adjustment of the real exchange rate and the foreign debt will be significantly influenced by the presence of capital flow restrictions because of their impact on domestic interest rates. During the early phases of liberalization, the domestic interest rate will be relatively more volatile, while the real exchange rate will become more volatile during the later stages. With financial liberalization, policy makers do not eliminate financial volatility -- they transfer it from the domestic interest rate to the real exchange rate.

Applying our model to the 1975-1982 bust-boom-bust period in Chile, when significant financial liberalization took place, we found that the lifting of

restrictions on the access to foreign credit had a profound impact on the dynamic paths of the real exchange rate, domestic interest rates, and foreign debt accumulation. The real exchange rate became more responsive to real interest rates, while the interest rate became more dependent on foreign interest rates and less responsive to domestic credit conditions.

Concomitantly, real wealth and real interest rates had progressively stronger effects on net exports, while reserves became increasingly volatile and responsive to international interest rates. The results indicate that as the domestic interest rate became less volatile and more dependent on foreign interest rate, the domestic interest rate became a more influential determinant of the real exchange rate and net exports, while reserves became more responsive to international financial conditions.



### References

- Anderson, B. and J. Moore, Optimal Filtering. Englewood Cliffs, 1979.
- Arellano, J.P.: Modelo económico chileno: trayectoria de una crítica, Aconcagua, 1982.
- Brock, P.L.: "Temporary and Permanent Economic Liberalization", Manuscript, Dept. of Economics, Duke University, 1985.
- Butlin, M.W.: "Imported Inputs in an Optimizing Model of a Small Open Economy", Journal of International Economics, 1985.
- Chow, G., "Random and Changing Coefficient Models" in Z. Griliches and M. Intrilligator, eds. Handbook of Econometrics 2: 1213-1245. North Holland, 1979.
- Corbo, V.: "Reforms and Macroeconomic Adjustment in Chile during 1974-1984", World Development, 13: 893-913, 1985.
- Corbo, V. and R. Matte, "Capital Flows and the Role of Monetary Policy: the Case of Chile", Working Paper, Catholic University of Chile, 1984.
- Dornbusch, R.: Open economy macroeconomics, Basic Books, New York, 1980.
- Dornbusch, R. and S. Fischer: "Exchange rates and the Current Account", American Economic Review, 70: 960-71, 1980.
- Dornbusch, R. and A. Reynoso, "Financial Factors in Economic Development". NBER Working Paper 2889, March 1989.
- Edwards, Sebastian, "Money, the Rate of Devaluation, and Interest Rates in a Semi-Open Economy", Journal of Money, Credit, and Banking, February, 1985.
- \_\_\_\_\_, "Monetarism in Chile, 1973-83: Some Economic Puzzles", Economic Development and Cultural Change, April 1986.
- Edwards, S. and A.C. Edwards: Monetarism and Liberalization: The Chilean Experiment, Ballinger, 1987.
- Harvey, A.C., Time Series Models. Philip Allen Publishers, 1981.
- Kouri, P. and M. Porter: "International Capital Flows and Portfolio Equilibrium", Journal of Political Economy, 86, 1974.
- Morandé, F. and K. Schmidt-Hebbel: Del auge a la crisis de 1982: ensayos sobre liberalización financiera y endeudamiento en Chile, IIMC - ILADES Georgetown University, 1988.
- Pagan, A., "Some Identification and Estimation Results for Regression Models with Stochastically Varying Coefficients". Journal of Econometrics, 1980.

Schmidt-Hebbel, K.: "A Short-run Macro Model for a Small Open Economy with An Application to Chile", in Foreign Shocks and Macroeconomic Adjustment in Small Open Economies", Ph.D. dissertation, M.I.T., 1987.

Schmidt-Hebbel, K.: Consumo e inversión en Chile: una interpretación "real " del boom", in Morandé and Schmidt- Hebbel, op.cit.

Appendix 1

To obtain the slopes of the non-traded market equilibrium condition and of the steady-state equilibrium condition implying a stationary level of foreign assets, as represented by schedules NN and  $f=0$  in figure 1, differentiate equations (9) and (11). The corresponding slopes are the following:

(A1)

$$dp/df = (\delta c_N/\delta w) / [\delta y_N/\delta p - \delta c_N/\delta p - \delta c_N/\delta w \delta w/\delta p - \delta j_N/\delta p] < 0$$

(+)            (-)            (+)            (+)            (+)            (+)

(A2)

$$dp/df = [p^\alpha \delta c_T/\delta w - (i^* + \hat{E}^e - \pi)] / [(\alpha p^{\alpha-1} NX) +$$

(+)

$$p^\alpha (\delta y_T/\delta p - \delta c_T/\delta p - \delta c_T/\delta w \delta w/\delta p - \delta j_T/\delta p)] \quad 0$$

(+)            (-)            (+)            (+)            (-)

While equation (A1) has an unambiguous negative sign, both the numerator and the denominator of equation (A2) can have either sign. However in footnote 4 we assume that net exports depend unambiguously and positively on the real exchange rate  $p$ , implying a positive denominator of (A2).

In the absence of additional information on parameter values one could expect that the magnitude of the slopes of the excess demand curves for traded and non-traded goods with respect to  $p$  are similar, so that the magnitude of the denominator of (A1) is higher than that of (A2).

The sign of the numerator of (A1) depends on the magnitude of the wealth effect on consumption relative to the interest effect stemming from higher foreign assets. In Figure 1 we assume that the wealth effect dominates, so that the numerator is positive.

## Appendix 2

### Sign-dependencies in equation (26)

We might expect a dominance of the positive effects of  $i^*e$ , LR, and  $f$  on  $i$  because of the following reasons.

The ambiguous effect of  $i^*e_t$  stems from the fact that an increase in the arbitrage interest level reduces desired (i.e. long-run) money demand  $L^D$ , therefore increasing  $i_t$ , but at the same time it reduces (shifts) the short-run or current money demand, reducing  $i_t$  (see figure A1). The higher  $\beta$  is, and the lower the magnitude of the cross partial derivative of the money demand ( $\delta L/\delta(i^*e+..)$ ), the higher is the probability that the first effect dominates, as we assume is the case.

The ambiguity of the sign of the effect of LR on  $i$  stems from two sources. The first is again the fact that LR affects negatively both  $L$  and  $LD$ , the net effect depending on the value of  $\beta$  as compared to the magnitude of  $\delta L/\delta(i^*e+..)$ . A second source of ambiguity is related to the fact that LR affects  $\beta$ , and an increase in  $\beta$  affects ambiguously the right-hand side of equation (25), depending on the sign of the ex-ante excess demand for money ( $LD - z = 0$ ).

Assuming again the dominance of  $\beta$  over  $\delta L/\delta(i^*e+..)$  (for the first source of ambiguity), and considering that during most of the sample period (Chile, 1975.3 - 1982.4) desired money holdings  $LD$  exceeded ex-ante monetary supply  $z$ , we have a net positive effect of LR on  $i$ .

Also the ambiguity of the effect of  $f$  on  $i$  stems from two sources. Assuming the dominance of  $\beta$  on  $\delta L/\delta(i^*e+..)$ , an increase in  $f$  reduces  $i$ . But on the other hand there is also a wealth effect of  $f$  via higher financial wealth, which rises  $i$ . Under dominance of the second source the net effect of  $f$  on  $i$  is positive.

### Appendix 3

#### Data

This appendix discusses sources and transformations of the data used in the empirical estimations. The 1974-82 data base for the Chilean economy is available on request. Published quarterly data were used whenever available. All real variables were obtained by deflating current-price variables by the domestic price index defined below.

The source of total foreign assets ( $f$ , the negative of total foreign debt), gross international reserves ( $r$ ), net exports ( $nx$ , the trade surplus), and net other balance of payments flows ( $ov$ , flows other than trade and net foreign asset flows) is the Monthly Bulletin of the Central Bank of Chile (Boletín Mensual del Banco Central), various issues.

The source of the money stock ( $m$ , private sector  $M1$ ) and domestic credit ( $c$ ) is J. Vial and B. Marín: "Series Monetarias: 1960-1985", Estudios de Economía, vol. 13, No. 2, Dec. 1986.

The source of the real exchange rate ( $p$ , the relative price of traded and non-traded goods), government consumption ( $g$ ), the nominal domestic interest rate ( $i$ ), and the nominal foreign interest rate ( $i^*$ ) is K. Schmidt-Hebbel, F. Castro and I. Leng: "Una Base de Datos Trimestrales para la Economía Chilena", Research Paper, No. 24, ILADES-Georgetown University, 1990.

Total wealth ( $w$ ) is the sum of financial wealth ( $wf$ ) and real wealth ( $wr$ ), the former being the sum of total foreign assets and gross international reserves. Real wealth is defined as the present value of current and expected future GNP flows, discounted at a constant 10% real discount rate. Two alternative specifications for expected future income streams were used: a partial perfect foresight case defined by the arithmetic average of actual future GNP flows 12 quarters into the future, and a static expectations alternative given by the current-period GNP. The source of the quarterly income flows is Schmidt-Hebbel et al., cited above.

The perfect or uncovered foreign arbitrage rate is defined as the sum of the foreign rate  $i^*$  and the expected rate of devaluation of the nominal exchange rate. The latter expected value is formed by estimating an AR process for the rate of change of the nominal exchange rate. The source of the latter is the Central Bank of Chile Boletín Mensual, cited above.

The real domestic interest rate is obtained by subtracting the expected rate of domestic price change from the nominal domestic interest rate. The domestic price level ( $q$ ) is defined as a geometric average of domestic traded and non-traded goods price indexes, with weights 0.47 and 0.53, correspondingly. The source of the latter price indexes is Schmidt-Hebbel (1987). The expected rate of change is formed by estimating an AR process of the actual rate of change.

The variable for legal restrictions to capital inflows (LR) was constructed in accordance to the stringency of both domestic legal restrictions (gradually relaxed during 1977-1980) and foreign resources constraints (imposed in 1982). Finally, the current-period ex-ante monetary supply ( $z$ ), is defined as:  $z_t = m_{t-1} + c_t - c_{t-1}$ .

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