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PRICE EXPECTATIONS, FOREIGN EXCHANGE AND INTEREST RATES, AND DEMAND FOR MONEY IN AN OPEN ECONOMY

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SUMMARY

Traditional studies on demand for money have often ignored influence of foreign monetary developments. The literature on international capital mobility, on the other hand, focuses on the impact of adjustments in international reserves on domestic money supply with the implicit assumption that aggregate demand for money is inelastic with respect to foreign monetary developments such as changes in exchange and foreign interest rates. These two views have often led to the conclusion that domestic monetary policy is fairly ineffective, and domestic financial markets are highly vulnerable to changes in foreign monetary developments.

In this paper, the formulation of a demand function for real cash balances generalizes the traditional demand functions for money which explicitly take into account changes in exchange rates, foreign interest rates, and inflationary expectations. The underlying theoretical model is a general portfolio model of asset holding which specifies the channels through which the influence of monetary developments abroad are transmitted to the supply and demand for money in a particular country. The demand function for real cash balances derived from this model is estimated using the time series data for the period 1960-75 for Canada, United States, United Kingdom, and Germany. The results indicate that foreign monetary developments affect demand for money significantly, and considerable mis-specification occurs when they are ignored. The results indicate that demand for real cash balances is not, as the traditional theory suggests, inelastic with respect to changes in foreign financial developments, and is fairly stable over the stressful period of 1970-75 when significant international monetary crises came in succession.

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INTRODUCTION

Traditional studies on demand for money have often ignored the influence of foreign monetary developments.[1] However, the question of monetary linkages among national economies is addressed in literature on international capital mobility. The focus of discussion in this literature is on the impact of adjustments in international reserves on a domestic money supply,[2] with the assumption that aggregate demand for money in a country is inelastic with respect to foreign monetary developments, such as changes in exchange and foreign interest rates. The emphasis on the supply side and the assumption about the demand often leads to the conclusion that domestic monetary policy is fairly ineffective and domestic financial markets are highly vulnerable to changes in foreign financial and monetary developments. However, when both sides of the market are systematically considered, the effects of changes in foreign financial conditions upon a national economy are found to be milder (or even neutralized) than the traditional portfolio studies describe.

The purpose of this paper is to modify the traditional demand functions for money to take account of foreign monetary developments, such as changes in exchange rates and foreign interest rates.[3] A simplified portfolio model of the financial market is developed to specify the channels through which the influence of monetary developments abroad are transmitted to the supply and demand for money in a particular country. The demand function for real cash balances deduced from this model is shown to depend upon domestic variables such as permanent income, domestic interest rates, and price expectations, as well as actual or anticipated foreign monetary developments. The model is estimated using quarterly time series data for the period 1960 to 1975 from four major industrialized countries: Canada, Germany, the United Kingdom, and the United States.

The major results of this study can be summarized briefly:

1. The demand function for real cash balances in these countries are fairly similar. Permanent income and domestic interest rates are important determinants of aggregate demand for money in each of the countries, thus confirming the results of previous studies.[4]

2. Price expectations seems to be a consistent explanatory variable in each country equation, though the magnitudes of its effect vary from one country to another.

3. Changes in foreign interest rates affect desired stock of real cash balances and excahnge rate expectations do play an important role in portfolio decisions concerning the degree of substitution between money and foreign assets. When these international factors

are omitted, the empirical results point to significant misspecification biases in the traditional demand functions for real cash balances.

4. There is evidence of rapid adjustment of real cash balances to their desired values, though the speed of adjustment varies among the countries. Further, the demand functions are stable during the sample period, especially during the early 1970's when extensive international monetary instability prevailed.

The paper is organized as follows: in Section I a simplified portfolio model is specified and its comparative static properties are examined. The demand for real cash balances is specified and tested empirically for each of the four countries in Section II. A comparision of these results is undertaken in Section III. The summary and conclusions of this paper are presented in Section IV.

SECTION I

A SIMPLE PORTFOLIO MODEL

Consider a small, open economy and assume that financial variables influence the real variables in this economy with a lag; income, price levels, and the current account balance are assumed to be exogenous;[5] the stock of wealth is given and capital gains or losses do not affect current portfolio choice.[6] Finally, assume that the monetary authority buys and sells whatever amount of foreign exchange is supplied or demanded by the private market so as to keep the exchange rate fixed but the rate level may be changed at will.

The model is composed of five basic elements: (i) demand functions for aggregate domestic demand for money (M^d),[7] domestic securities (S^d_d) and foreign securities (rS^f_d); (ii) foreign demand functions for domestic securities (S^d_f); (iii) the supply function for domestic securities (S^d), which consists of supplies of privately issued bonds (PB^d) held by commercial banks (PB^d_b) and foreigners (PB^d_f), domestic government bonds (GB^d_o), and domestic equity (E^d); (iv) the supply of money; and (v) an exogenous supply of foreign securities. The exogenous variables on the domestic side are: wealth (W^d), income (Y^d), price level (P^d), inflationary expectations ($\dot{P}'$), central bank discount rate (i^d_c), required reserve ratio (h), the fraction of money held in the form of deposits (g), central bank holdings of government bonds (GB^d_c), current account balance (CAB), exchange rate (r), and exchange rate expectations (r'). On the foreign side, they are: wealth (W^f), income (Y^f), price level (P^f), inflationary expectations ($\dot{P}'^f$), and interest rate (i^f).[8]

The underlying assumption is that all assets entering the portfolio of the decision-making units are gross substitutes, which implies that the relevant returns enter all demand functions.[9] Finally, because of the wealth constraint, two conditions must be fulfilled at each point in time: (1) for a given level of wealth the sum of the substitution effects must add up to zero, and (2) the sum of changes in asset holdings due to a change in wealth should equal the change in wealth itself.

A. Aggregate Demand Functions

Aggregate domestic demand function for the three assets--money, domestic securities, and foreign securities--and the foreign demand for domestic securities are specified below, along with the assumed signs of their partial derivatives.[10]

Demand for Money

$$M^d = P^d \phi(W^d, Y^d, i^d, i^f, r, r', \dot{P}'); \qquad (1.1)$$

$$\phi_{W^d}, \phi_{y^d}, \phi_r > 0; \phi_{i^d}, \phi_{i^f}, \phi_{r'}, \phi_{\dot{P}'} < 0$$

Demand for Domestic Securities

$$S_d^d = P^d \theta(W^d, Y^d, i^d, i^f, r, r', \dot{P}') + \phi(i^d, i_c^d, (1-h)gM^d); \qquad (1.2)$$

$$\theta_{W^d}, \theta_{i^d}, \theta_r, \phi_{M^d} > 0; \theta_{\dot{P}'} \gtrless 0; \theta_{Y^d}, \theta_{i^f}, \theta_{r'}, \phi_{i_c^d} < 0$$

Demand for Foreign Securities

$$rS_d^f = P^d \gamma(W^d, Y^d, i^d, i^f, r', \dot{P}'); \qquad (1.3)$$

$$\gamma_{W^d}, \gamma_{i^f}, \gamma_{r'} > 0; \gamma_{Y^d}, \gamma_{i^d}, \gamma_{\dot{P}'} < 0$$

Foreign Demand for Domestic Securities

$$S_f^d = fP^f \delta(W^f, Y^f, i^d, i^f, r', \dot{P}'^f); \qquad (1.4)$$

$$\delta_{W^f}, \delta_{i^d} > 0; \delta_{Y^f}, \delta_{Y^f}, \delta_{\dot{r}'}, \delta_{\dot{P}'^f} < 0$$

Some general features of the equation system (1.1) to (1.4) should be noted. Domestic and foreign residents are assumed to incorporate the same set of decision variables, as can be seen from a comparison of equations (1.3) and (1.4). In contrast to the conventional demand functions for money and securities, functions (1.1) and (1.2) explicitly include the levels of foreign interest and exchange rates as well as exchange rate expectations and price expectations about price changes as the determinants of asset holdings. Note also that the form of the equations differ. For example, the aggregate domestic demand for domestic assets (1.2) is composed of the non-bank public $\theta(\cdots)$ and commercial bank components $\theta(\cdots)$. The reason is that variables affecting banking portfolio decisions are not necessarily the same as those influencing the public's asset holdings for, among other things, the public is assumed not to hold foreign assets while the banks do not face the same constraint.

All demand functions of the public are homogeneous of the first degree in prices. However, this is not so for the banking sector because, as intermediaries, their concern is with nominal value. Equations (1.3) and (1.4) are also homogeneous of degree one in $1/r$ and r, respectively, since it is assumed that portfolio holders distribute their wealth in terms of their home country's currency. This, in turn, requires the inclusion of r in the remaining functions. For example, in the case of an exchange rate decrease, domestic residents would have to finance the increase in the foreign currency value of their holdings of foreign securities by drawing down holdings of other assets.

Real wealth enters as the relevant constraint in all demand functions and changes in assets are positively related to changes in real wealth, i.e., none of the assets are assumed to be inferior. On the other hand, in distributing their portfolio, banks are constrained by the deposits net of required reserves, which is expressed as $(1-h)gM^d$ in equation (1.2).

The direction of the effects of interest rates (i^d, i^f) in the public's demand functions follow from the assumption of gross substitutability between assets. The effects of changes in domestic and foreign interest rates are negative in the demand for money while for the remaining assets the own rate effect is positive and the cross effect is negative. For example, a rise in the foreign rate, (i^f), increases domestic holdings of foreign securities and decreases those of real cash balances, (M^d), domestic holdings of domestic securities, (S_d^d), and foreign holdings of domestic securities, (S_f^d).

The effects of changes in exchange rate expectations, (r'), are similar to those for the changes in the foreign interest rate, *i.e.*, they are negative in all cases except in domestic demand for foreign assets. This is due to the fact that, when individuals expect domestic currency to depreciate, they will increase their holdings of foreign securities at the expense of domestic securities and money. Increases in the expected rates of inflation, ($\dot{P}'$, $\dot{P}'^f$), lead to a shift away from money and foreign securities to other assets.

B. Aggregate Supply Functions

1. Aggregate Supply of Domestic Securities

The aggregate supply of domestic securities is composed of an endogenous component issued by the non-bank private sector and an exogenous part composed of domestic government bonds and domestic equity. The supply function for domestic securities can be written as:

$$S^d = P^d \psi(W^d, Y^d, i^d, i^f, r, r', \dot{P}') + GB_o^d + E^d; \qquad (1.5)$$

$$\psi_{W^d}, \psi_{Y^d}, \psi_{i^f}, \psi_{r'}, \psi_{\dot{P}'} > 0; \quad \psi_{i^d}, \psi_r < 0$$

$GB_o^d = GB^d - GB_c^d$ is the net supply of government bonds to the domestic private market, that is, total government debt outstanding minus central bank holdings. The partial derivatives with respect to i^f and r' are assumed to be positive, as increases in those two variables may induce the public to finance higher levels of desired holdings of foreign assets, partially through borrowing. The signs with respect to both i^d and r are negative. The first is self-explanatory, while the second is explained in terms of the redistribution toward domestic assets that takes place when the domestic currency value of foreign securities increases above its desired level as a result of an increase in r.

2. Supply of Money

The sources of the monetary base are defined as:

$$B = GB_c^d + BR + ICAB + (S_f^d - \dot{r}S_d^f) \qquad (1.6)$$

where the first two terms refer to central bank holdings of domestic government securities and borrowed reserves. The remaining terms are the foreign components or international reserves. ICAB $(= \sum_{i=0}^{t} CAB_i)$ is the cumulative balance on current accounts; the expression in brackets is the difference between the stock of domestic securities held by foreigners and the domestic currency equivalent of the stock of foreign securities held by domestic residents.[11] From the private sector's balance sheet, the uses of the base are:

$$B = RR + FR + BR + C \qquad (1.7)$$

RR, FR, and BR being required, free, and borrowed reserves, respectively, and C is currency outside banks. FR is specified as:[12]

$$FR = \zeta[i^d, i_c^d, (1-h)M^d]; \quad \zeta_{i^d} < 0; \quad \zeta_{i_c^d}, \zeta_{M^d} > 0 \qquad (1.8)$$

From equations (1.7) and (1.8), the money supply function becomes:

$$M^s = [GB^d_c + ICAB + (S^d_f - \dot{r}S^f_d) - FR]k \tag{1.9}$$

where k= k/[1-(1-h)g]. Given that the current account component is exogenous while the capital account component depends upon the behavioral assumptions already specified, the effects of changes in interest rates and exchange rate expectations upon the money supply may be easily traced using equation (1.9).

C. Comparative Static Properties of the Model

Given that the foreign interest rate and wealth are exogenous, the domestic interest rate equilibrates both money and domestic securities markets. Therefore, two alternative equilibrium conditions, (2.1) and (2.2), together with the wealth constraint, (2.3), may be considered:

$$M^d = M^s \tag{2.1}$$

$$S^d_d + S^d_f = S^d \tag{2.2}$$

$$W^d = \frac{1}{P^d}(NB + NS^d_d + rS^f_d - PB^d_f) \tag{2.3}$$

where NB refers to the net monetary base and NS^d_d represents net holdings of domestic securities of the domestic private sector. The two conditions implied by the wealth constraint that must hold throughout are expressed as:

$$\sum_i e_i(Z_i, W^d)\frac{Z_i}{W^d} = 1 \tag{2.4}$$

$$\sum_i e_i(Z_i, X)\, Z_i = 0 \tag{2.5}$$

where e_i are elasticities, Z_i's refer to the different assets, and

$X = i^d, i_c^d, r, r', Y^d$. Condition (2.4) states that the weighted sum of the elasticities with respect to wealth--the weights given by the proportions held in each asset--should equal one. Condition (2.5) indicates that, given wealth, the weighted elasticities with respect to any return, i.e., the substitution effects, should add up to zero.

We shall use the money market conditon, (2.1), to derive the comparative static properties of the model in terms of elasticities. A summary of the comparative static results of the model is presented in Table 1, indicating the effects of changes in the exogenous variables

TABLE 1

THE COMPARATIVE STATIC RESULTS OF CHANGES IN EXOGENOUS VARIABLES ON DOMESTIC INTEREST RATE (i^d)

	Exogenous Variable	Direction of Change in i^d		Exogenous Variable	Direction of Change in i^d
i^f	Foreign interest rate	+	GB_c^d	Open market operations	-
r'	Exchange rate expectations	+	i_c^d	Discount rate	+
r	Exchange rate	-	h	Required reserve ratio	+
W^f	Foreign wealth	-	Y^d	Domestic income	?
Y^f	Foreign income	+	CAB	Current account balance	-
P^f	Foreign prices	-	$\dot{P}'$	Domestic price expectations	?

upon the domestic interest rate.

Since the distinctive feature of the model is the explicit introduction of international factors into the money demand function, the discussion of comparative static properties will be limited to the effects of the foreign interest rate, exchange rate, and exchange rate expectations on domestic interest rate. The effect of changes in i^d on domestic income is discussed in more detail and the expressions for elasticities of the domestic interest rate with respect to other variables are given in Appendix A.

1. Changes in the Foreign Interest Rate

If there is an increase in the foreign interest rate, it induces both domestic and foreign residents to increase their holdings of foreign securities. Domestic residents finance those increase by drawing down money holdings, decreasing their holdings of domestic securities, and issuing private debt (increasing the supply of domestic securities), and foreigners decrease their holdings of domestic securities. These actions have an immediate negative impact on the monetary base. However, because of the fractional reserve system, the effect on the money supply is not of the same magnitude. As soon as banks find their reserves diminished by a proportion, g, of the initial capital outflow, they start decreasing their holdings of domestic securities and thus further reduce the money supply. Provided that the level of wealth remains constant during this adjustment period, the excess demand and supply so generated in the money and securities markets, respectively, push the domestic interest rate in an upward direction.[13]

The elasticity of the domestic interest rate with respect to the foreign rate is given by:[14]

$$\varepsilon(i^d, i^f) = \frac{-\overset{-}{e}(M^d, i^f)\,M^d + k[\overset{-}{e}(S_f^d, i^f)\,S_f^d - \overset{+}{e}(rS_d^f, i^f)\,rS_d^f - \overset{+}{e}(FR, m)\,\overset{-}{e}(M^d, i^f)\,FR]}{D} > 0 \quad (2.6)$$

where

$$D = \overset{-}{e}(M^d, i^d)M^d - k[\overset{+}{e}(S_f^d, i^d)S_f^d - \overset{-}{e}(rS_d^f, i^d)\,rS_d^f - \overset{-}{e}(FR, i^d)FR - \overset{+}{e}(FR, m)\,\overset{-}{e}(M^d, i^d)FR] < 0;$$

$m = (1-h)gM^d$; and $k = 1/[1-(1-h)g]$

The first term in the numerator and the denominator of expression (2.6) refer to money demand changes, and all succeeding terms refer to changes in the money supply. The denominator D is unambiguously negative since the first term in D is negative while the expression in the bracket is positive and <0 for the numerator of (2.6), though there are forces working in opposite directions, it can be shown that the overall sign has to be negative.[15] Thus, the net result of an increase in the foreign interest rate is to increase the domestic rate. The magnitude of the elasticity $(i^d. i^r)$, however, depends on the way in which changes in foreign asset holdings are financed out of, or absorbed by, the different domestic assets. The impact upon the domestic interest rate is smaller the larger the degree of substitution between foreign securities and money holdings, and it is larger the more domestic and foreign securities are substitutes for each other. Finally, two extreme cases: perfect substitutability between domestic and foreign securities, and changes in foreign security holdings being totally financed out of money holdings under conditions of no inside money, resulting in unitary and zero elasticities, respectively. Thus, if the monetary authority engages its open market purchases in order to prevent the domestic interest rate from rising and ignores the sensitivity of the demand for money to the foreign interest rate, the result could be a lower domestic rate than its optimum level.

2. Changes in Exchange Rate Expectations

The effect of exchange rate expectations upon the domestic interest rate is given by:

$$\varepsilon(i^d, r') = \frac{-\overset{-}{e(M^d, r')}M^d + k[\overset{-}{e(S_f^d, r')}S_f^d - \overset{+}{e(rS_d^f, r')}rS_d^f - \overset{+}{e(FR,m)}\overset{-}{e(M^d, r')}FR]}{D} > 0 \qquad (2.7)$$

The components of the numberator of (2.7) have identical signs to those of (2.6). An increase in the exchange rate expectation and foreign interest rate have similar effects on the domestic interest rate, though the magnitudes of these effect may vary.

3. Changes in the Exchange Rate

The effect of a change in the level of the exchange rate on domestic interest rates is given by:

$$\varepsilon(i^d, r) = \frac{-\overset{+}{e(M^d, r)}M^d + k[\overset{-}{e(S_f^d, r)}S_f^d - \overset{-}{e(S_d^f, r)}rS_d^f - \overset{+}{e(FR, m)}\overset{+}{e(M^d, r)}FR]}{D} < 0 \qquad (2.8)$$

An increase in the foreign exchange rate means that domestic residents find the value of their holdings of foreign securities increased while domestic holdings of foreigners, as valued in their own currency, decrease. Given the behavioral assumption that wealth-holders evaluate their portfolios in terms of home-currencies, this disequilibrating process manifests itself as an increase in the domestic monetary base, forcing the domestic interest rate downward. However, because a portion of the repatriated funds is allocated to money holdings, the domestic rate falls less than it would if the demand for money were independent of foreign factors.

4. Changes in Domestic Income

Unlike the case of a closed economy, the effect of domestic income on i^d is indeterminate in our model. The expression for the relevant elasticity is:

$$\varepsilon(i^d, Y^d) = \frac{-\overset{+}{e}(M^d, Y^d)M^d - k[\overset{-}{e}(rS_d^f, Y^d)rS_d^r + \overset{+}{e}(FR, m)\overset{+}{e}(M^d, Y^d)FR]}{D} \gtreqless 0 \qquad (2.9)$$

The magnitude of this elasticity depends on the means by which the higher desired level of money balance is financed. The magnitude of the multiplier, k, is crucial. The first and last terms in the numerator work in the same direction; the former depicts the effect of an increase in the demand for money and the latter the effect of an increase in disposable funds allocated to free reserves. The middle term refers to that portion of funds obtained from abroad to partially finance the increase in money holdings. If individuals resort heavily upon this type of financing, a negative effect on the domestic interest rate becomes likely. However, normally we expect that the final effect of an increase in Y^d on i^d will likely be positive, though perhaps slight.

SECTION II

THE DEMAND FOR REAL CASH BALANCES IN AN OPEN ECONOMY

Our model suggests that domestic interest rates, exchange rates, and real cash balances are endogenous. To estimate the structural relations specified in the previous section, it would be necessary to specify a complete econometric model and gather data for foreign and domestic variables which are difficult to obtain. We have chosen, instead, to concentrate on the demand for money function, (1.1), using the two-stage least squares estimation technique in order to take into account the endogeneity of i^d and r. We assume a log linear specification of the form:[16]

$$\ln M_t^* = a_0 + a_1 \ln YP_t + a_2 \ln i_t^d + a_3 \ln i_t^f + a_4 \ln r_t + a_5 \ln r_t' + a_6 \ln \dot{P}_t' + u_t \quad (3.1)$$

where M* = desired real money holdings (billions of domestic currency); YP = real permanent income (billions of domestic currency); i^d = short-term domestic interest rate (percent); i^f = short-term foreign interest rate (percent); r = exchange rate (domestic currency per unit of foreign currency); r' = exchange rate expectations; $\dot{P}'$ = inflationary expectations; u = stochastic disturbance; and the coefficients a_i(1,...6) are long-run elasticities of M* with respect to a given variable.

According to the behavioral assumptions, the expected signs are: a_1, $a_4 > 0$ and a_2, a_3, a_5, $a_6 < 0$. To incorporate dynamic characteristics into model (3.1), the following partial adjustment mechanism is adopted:

$$\ln M_t - \ln M_{t-1} = \lambda(\ln M_t^* - \ln M_{t-1}) \tag{3.2}$$

Relation (3.2) implies that the adjustment in actual real money holdings (M) that takes place at time t is a fraction, λ, of the gap between the desired level at that period and the actual holdings at t-1. Combining (3.1) with (3.2):

$$\ln M_t = \lambda a_0 + \lambda a_1 \ln YP_t + \lambda a_2 \ln i_t^d + \lambda a_3 \ln i_t^f + \lambda a_4 \ln r_t + \lambda a_5 \ln r_t' + \lambda a_6 \ln \dot{P}_t' + (1-\lambda)\ln M_{t-1} + \varepsilon_t \tag{3.3}$$

Model (3.3) specifies the short-run demand for money, where λaj's give short-run elasticities and a_i's long-run elasticities.[17] We shall assume that the error term, ε_t, in (3.3) is subject to a first order serial correlation, i.e.,

$$\varepsilon_t = \rho\varepsilon_{t-1} + e_t \tag{3.4}$$

where ρ is the serial correlation coefficient. The equation

$$\ln M_t = \psi_0 + \psi_1 \ln YP + \psi_2 \ln i_t^d + \psi_3 \ln i_t^f + \psi_5 \ln r_t + \psi_6 \ln r_t' + \psi_7 \ln \dot{P}_t' + \psi_8 \ln M_{t-1} + e_t \tag{3.5}$$

is used to estimate aggregate demand for real cash balances in four industrial economies. According to our model specification, i_t^d, r_t, and M_t are endogenous variables and the exogenous variables are YP, foreign interest rate, and inflationary expectations, as well as a lagged dependent variable. To deal with the simultaneity problem between M_t, i_t^d, and r_t

in equation (3.5) and at the same time insure consistency of the estimates, a two-stage procedure developed by Fair (1970) was employed. In addition to the exogenous variable included in the money demand equation, the following variables (included in the model but excluded from that equation) were used in the two-stage procedure: foreign permanant income, foreign price level, foreign inflationary expectations, the current account balance, and the discount rate.[18]

Construction of Variables and Sources of Data

(i) M is stock of nominal money (demand deposits plus currency), seasonally adjusted, end of period (billions of domestic currency). M is the real money stock; M' is deflated by the wholesale price index (billions of domestic currency).

(ii) i^d is domestic short-term interest rate measured by call money rate for Canada, Germany, and the U.K. and by call loan rate for the U.S.

(iii) i^f is a proxy for short-term international interest rate, constructed as the average of the short-term interest rates of Canada, Germany, France, the U.K., and the U.S. For each country, its own rate was excluded.

(iv) $\dot{P}$ is domestic rate of inflation. To obtain quarterly figures at equivalent annual rates, the following formula was applied:

$$\dot{P}' = [(\frac{P^d_t}{P^d_{t-1}})^4 - 1]\ 100$$

where P^d_t is the domestic wholesale price index (1970 = 100).

(v) P^f is the foreign wholesale price index constructed as the average of the wholesale price indices of Canada, Germany, France, Japan, the U.K., and the U.S. For each country, its own price index was excluded.

(vi) $\dot{P}'^{f}$ is the foreign rate of inflation generated using the same methodology as in point (iv) above, but based on P^f.

(vii) PR is the premium or discount in foreign exchange, obtained as:

$$PR = (\frac{r_f}{r_s}) - 1)\ 400$$

where r_f is the three month forward exchange rate in units of domestic currency per U.S. dollar, end of period, and r_s is spot exchange rate in units of domestic currency per U.S. dollar, end of period.

(viii) r_{US} is U.S. spot exchange rate, calculated as an average of the indices (with base 1970) of the exchange rates of Canada, France, Germany, and the U.K. (all defined as U.S. dollars per unit of each country's currency).

(ix) YP^d is domestic real permanent income. The permanent income series is based on the following adaptive expectations mechanism:[19]

$$YP_t = {}_{t-1}YP'_t + b(Y_t - {}_{t-1}YP'_t) \quad (B.1)$$

and

$$t\text{-}1YP'_t = (1 + c)YP_{t-1} \quad (B.2)$$

That is, permanent income in period t is composed by the expectation formed at period t-1(${}_{t-1}YP'_t$) adjusted by a proportion, b, of the difference between the expectation and the actual current income of the period. The expectation for period t is based on permanent income of the previous period adjusted by a trend growth rate of income, c. Combining (B.1) and (B.2), the formula used for estimation of the series is obtained:

$$YP_t = bY_t + (1+c)\ (1-b)YP_{t-1}$$

Y is real GNP and c was obtained by fitting a quadratic trend function,

$$\ln Y_t = c_0 + c_1 t + c_2 t^2 + u_t$$

so that $c = c_1 + c_2 t$. The initial value of YP was taken to be $YP_0 = e^{c_0}$ and the assumed b was 0.15.

(xi) YP^f is the foreign real permanent income. This variable was calculated as an aggregate of the permanent incomes of Canada, Germany, the U.K., and the U.S., all converted to the respective country's currency using the par exchange rates as of 1970-71. For each country, its own permanent income was excluded. France was not included because of data constraints.

(xii) CAB is the current account balances in millions of domestic currency.

Since the estimation was carried out in logarithms, some of the variables, like the rate of inflation and the foreign exchange premium, may have negative values. These were introduced as $1+x$, x being the variable.

The quarterly data for constructing the variables of the model came from diverse sources. The main sources of data were: Main Economic Indicators (an OECD publication), International Financial Statistics (of the IMF), the National Bureau of Economic Research data bank, and publications of the Federal Reserve Bank of St. Louis. The specific sources of data for each variable in the model are:

Data Sources*

Variable	Canada	Germany	U.K.	U.S.	Variable	Canada	Germany	U.K.	U.S.
CAB	MEI	MEI	MEI	MEI	Y	IFS	IFS	IFS	IFS
i^d	MEI	IFS	MEI	NBER	i_c^d	IFS	IFS	IFS	IFS
i'	IFS	IFS	IFS	IFS	M'	FRBSL	IFS	IFS	IFS
p^d	IFS	IFS	IFS	IFS	p^t	IFS	IFS	IFS	-
r	IFS	IFS	IFS	-	r_f	IFS	IFS	IFS	-

*Note: FRBLS Rates of Change in Economic Data for Ten Industrialized Countries, Federal Reserve Bank of St. Louis
IFS International Financial Statistics, IMF
MEI Main Economic Indicators, OECD
NBER National Bureau of Economic Research data bank

SECTION III

ESTIMATION OF THE MODEL

The results of estimation for the four countries are presented in TABLE 2. To compare the implications of alternative assumptions about channels through which foreign financial developments act upon the demand for money for each country, we performed the following experiments: (i) it was assumed that foreign influences were transmitted only through the foreign interest rate, and (ii) a conventional demand function for real balances was estimated by dropping the variables depicting international monetary developments in equation (3.3). The general results of these experiments were that the fit of equation (3.3) for each country deteriorated; when exchange rate variables were excluded, the coefficients of interest rates i^d and i^f became larger and the average adjustment lag between actual and desired real balances became longer. Substantial changes occurred, especially in the coefficient of the domestic interest rate, when all variables depicting international monetary developments were dropped.[20]

The estimates in TABLE 2 indicate that the overall goodness of fit of the model is excellent and that the individual variables in (3.3) contribute significantly to the explanation of behavior of real cash balances. As Charts 1 to 4 indicate, the model traces both turning points and levels of the dependent variable in each country, except in the U.K. where its performance is somewhat weak.

TABLE 2

Two-Stage Estimate of Demand for Real Cash Balances for Four Industrialized Countries, Canada, Germany, the U.K., and the U.S., for the Period 1960:I to 1975:IV*

Country	Constant	$\ln YP_t$	$\ln i^d_t$	$\ln i^f$	$\ln r_t$	$\ln r'_t$	$\sum_1 \omega_i \ln \dot{P}_{t-i}$	$\ln M_{t-1}$	R^2	DW	SEE	$\hat{\rho}$
Canada	-.417 (5.8)	.254 (5.4)	-.026 (2.1)	-.030 (2.5)	.061 (.9)	-.437 (1.7)	-.208 (6.1)	.734 (12.6)	.996	1.85	.0131	-.161
Germany	-.901 (3.9)	.457 (4.4)	-.027 (3.3)	-.035 (2.2)	.023 (.9)	-.369[a] (2.0)	-.236 (2.2)	.565 (5.6)	.996	2.06	.0165	-.143
United Kingdom	-.018 (0.1)	.152 (4.5)	-.028 (1.9)	-.020 (1.8)	.026 (0.5)	-.452[b] (2.0)	-.124 (2.5)	.799 (17.3)	.911	1.97	.0188	-.407
United States	-.118 (0.2)	.188 (7.5)	-.029[c] (4.2)	.020 (1.9)	-	-.162[d] (2.8)	-.228[e] (4.6)	.743 (16.6)	.990	1.94	.010	-.301

*The dependent variable is lnM, R^2 is the coefficient of determination, DW the Durbin-Watson statistics, SEE the standard error of estimate, and $\hat{\rho}$ the estimated coefficient of autocorrelation.

[a]Second order distributed lag over four quarters, with far end zero restriction.

[b]First order distributed lag over six quarters, with far end zero restriction.

[c]Second order distributed lag over three quarters with far end zero restriction.

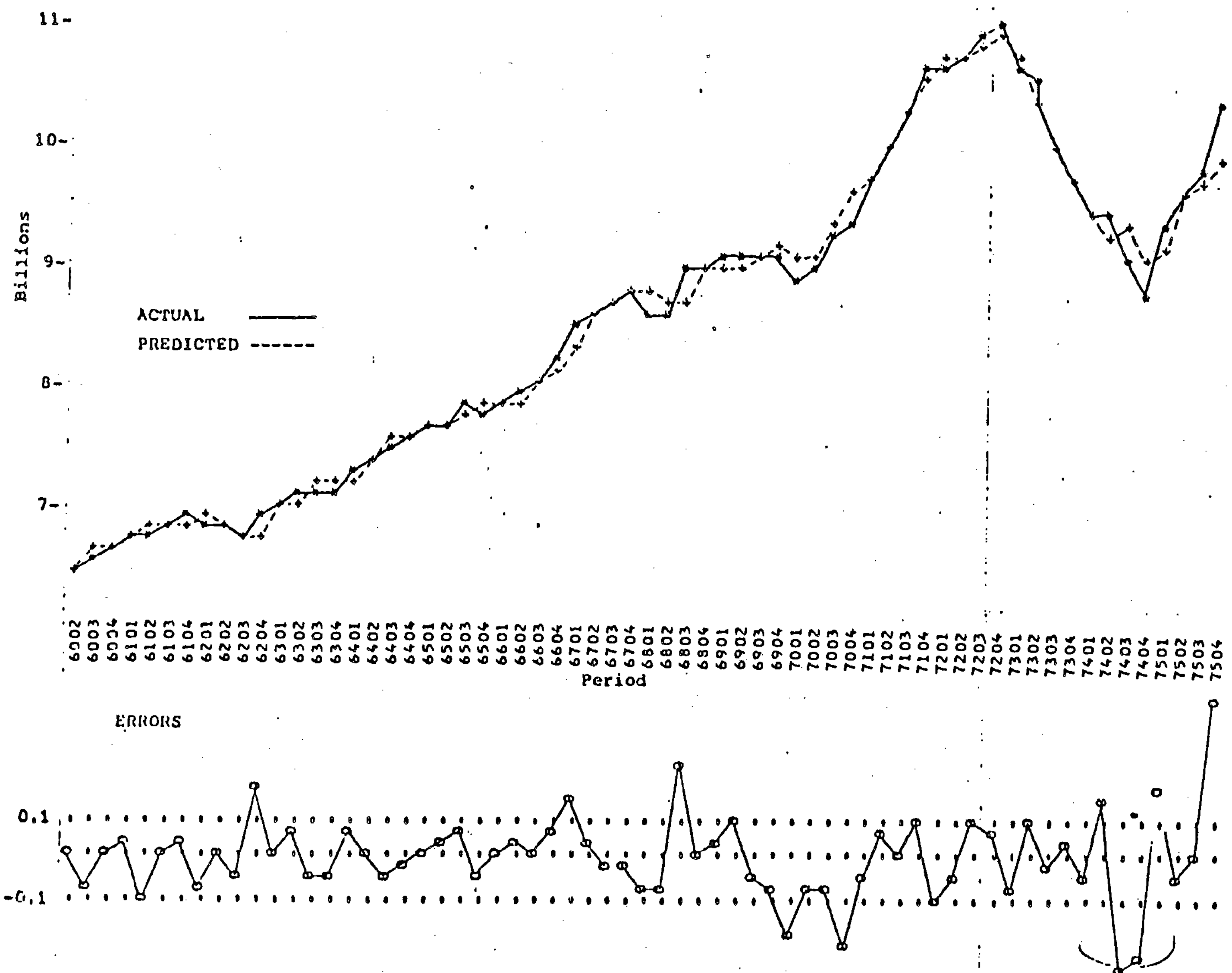
[d]Second order distributed lag over five quarters with far end zero restriction.

[e]First order distributed lag over four quarters, with far end zero restriction.

For all other countries, the distributed lag polynomial is specified over three quarters.

Chart 1

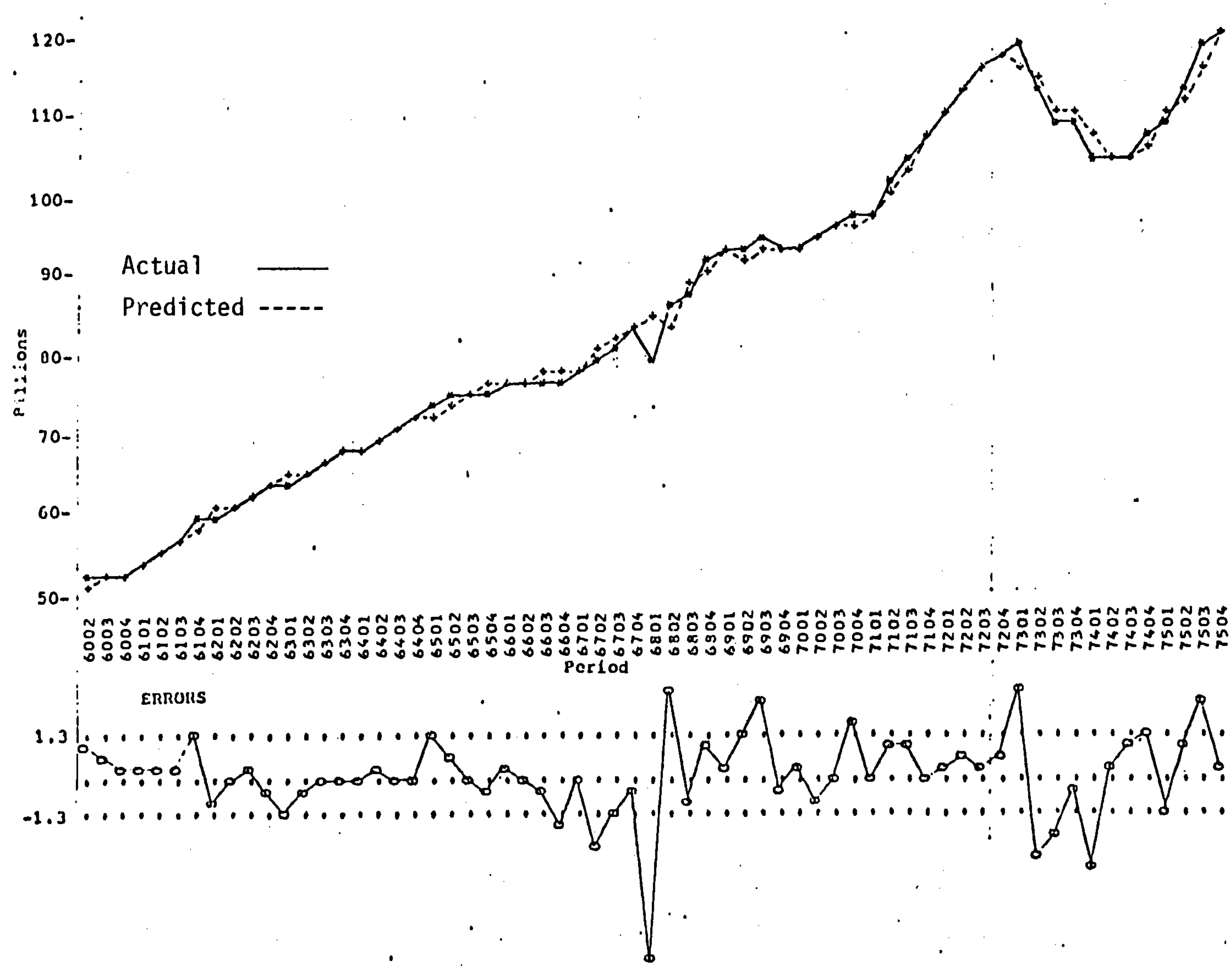
CANADA - ACTUAL AND PREDICTED VALUES OF THE REAL MONEY STOCK
1960:2 - 1975:4



Correlation coefficient	= 0.9957
Regression coefficient of actual on predicted	= 1.0010
Root-mean-squared error	= 0.1202
Mean absolute per cent error	= 0.97 %
Theil's inequality coeffic.	= 0.0070
Fraction of error due to:	
Bias	= 0.00006
Different variation	= 0.0036
Different co-variation	= 0.9955

Chart 2

GERMANY - ACTUAL AND PREDICTED VALUES OF THE REAL MONEY STOCK
1960:2 - 1975:4



Correlation coefficient = 0.997

Regression coefficient of actual on predicted = 1.004

Root-mean-squared error = 1.330

Mean absolute per cent error = 1.028

Theil's inequality coeffic. = 0.007

Fraction of error due to:

Bias = 0.000

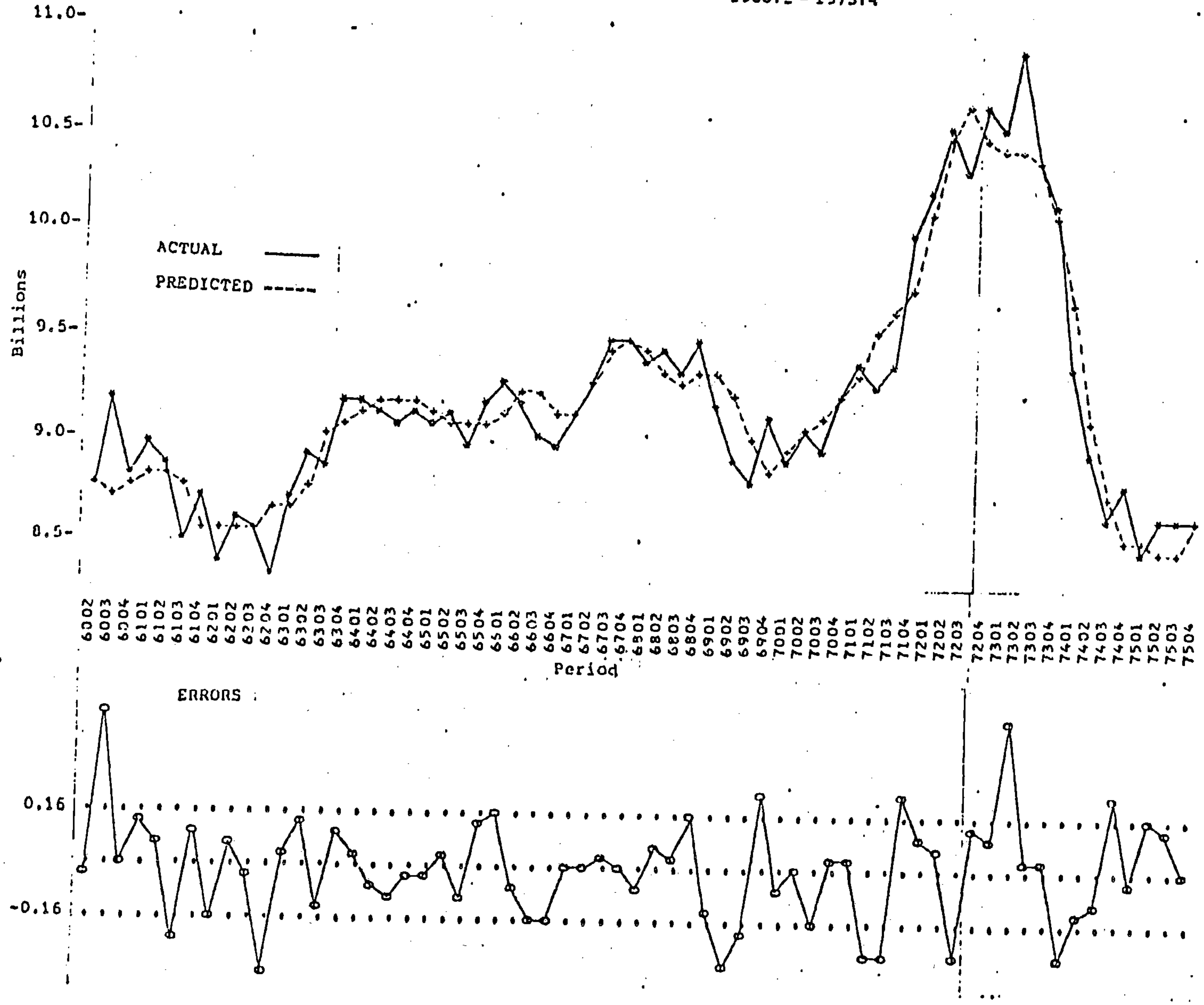
Different variation = 0.009

Different co-variation = 0.98

Chart 3

UNITED KINGDOM - ACTUAL AND PREDICTED VALUES OF THE REAL MONEY STOCK

1960:2 - 1975:4



Correlation coefficient = 0.9566

Regression coefficient of actual on predicted = 1.0080

Root-mean-squared error = 0.1625

Mean absolute per cent error = 1.32 %

Theil's inequality coeffic. = 0.0000

Fraction of error due to:

Bias = 0.0001

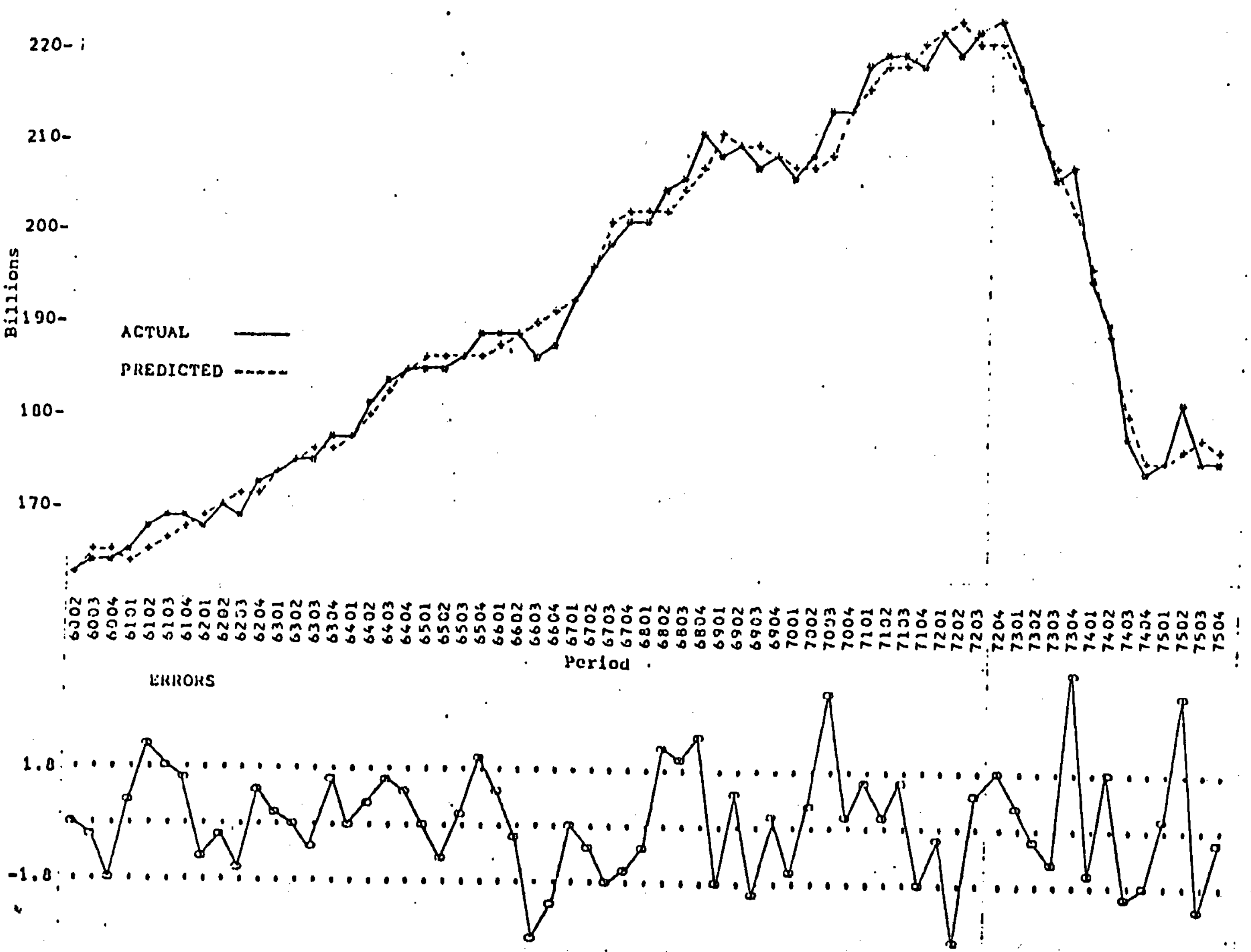
Different variation = 0.0310

Different co-variation = 0.9689

Chart 4

UNITED STATES – ACTUAL AND PREDICTED VALUES OF THE REAL MONEY STOCK

1960:2 – 1975:4



Correlation coefficient	= 0.9940
Regression coefficient of actual on predicted	= 1.0000
Root-mean-squared error	= 1.0470
Mean absolute per cent error	= 0.75 %
Theil's inequality coeffic.	= 0.0040
Fraction of error due to:	
Bias	= 0.00004
Different variation	= 0.0030
Different co-variation	= 0.9973

The signs of all explanatory variables are consistent with our *a priori* specifications. The coefficient of the lagged dependent variable implies that there is generally a short adjustment period for actual real cash balances to adjust to their desired values. TABLE 3 shows the short- and long-run elasticities, E_S and E_L, of real cash balances, M, with respect to the explanatory variables. They are calculated by dividing the relevant coefficients in TABLE 2 $(1-\lambda)$, where λ is the adjustment coefficient.

Several features of the results given in TABLES 2 and 3 should be noted. Permanent income is a significant variable in explaining holdings of real cash balances, expecially in Germany and Canada. The magnitudes of the coefficients in regression for the U.K. and U.S. are rather small, but highly significant statistically. The long-run elasticities of real cash balances with respect to YP is unity in the former two countries and close to unity (.75) for the latter two countries. The overall conclusion is that, in the long run, the elasticity of M with respect to YP is near unity for all four countries. Changes in the domestic short-term interest rate have the correct negative coefficient in all the regression equations. There is a substantial similarity in the magnitudes (about .027) of coefficients of i_t^d throughout the equations. However, the long-run elasticities of M with respect to i^d is much higher for the U.K. and the U.S. than for Canada and Germany. Note that in the case of the U.S. a distributed lag of the domestic interest rate had to be employed due to its high multicollinearity with the short-term foreign interest rate.

TABLE 3

The Short and Long-Run Elasticities, E_S and E_L, of Demand for Real Cash Balances With Respect to the Explanatory Variables, the Coefficient of Adjustment, λ, and Average Adjustment Period, AAP

Variables / Country	YP		i^d		i^f		r'		$\dot{p}'$			
	E_S	E_L	E_S	E_L	E_S	E_L	E_S	E_L	E_S	E_L	λ	AAP
Canada	.254	.955	-.026	-.098	-.030	-.113	-.437	-1.642	-.208	-.782	.266	2.8
Germany	.457	1.05	-.027	-.062	-.035	-.080	-.369	-.849	-.236	-.542	.435	1.3
United Kingdom	.152	.756	-.028	-.139	-.020	-.108	-.452	-2.248	-.124	-.617	.201	3.9
United States	.188	.732	-.029	-.113	-.020	-.078	-.162	-.630	-.228	-.887	.257	2.9

The results verify the hypothesis that foreign financial and monetary influences upon demand for real cash balances are transmitted by changes in foreign interest rates and exchange expectations. The magnitude of the short-term elasticity of real cash balances with respect to changes in foreign short-term interest rates differs among countries, being highest in Germany, followed by Canada, the U.K., and the U.S. However, the long-run elasticity seems to be highest for Canada and followed by the U.K., Germany, and the U.S. What is interesting is that the elasticity of real balances with respect to changes in foreign interest rates is similar in magnitude to its elasticity with respect to the domestic interest rate in each country.

The coefficients of the level of exchange rate, $\ln r_t$, as indicated in TABLE 2, have the correct positive sign, but are statistically insignificant in each regression. This suggests that the "rebalancing effect" brought about by changes in the exchange rate does not appear to be very important in any of the countries, but the sign of its coefficient implies that it is not altogether absent in the portfolio decision process. This may reflect the relative stability of the exchange markets in the major part of the period under consideration. On the other hand, rather than variation in the level of the exchange rate, changes in the premium, which depicts the acceleration of market pressures, do induce short-term changes in the money balance. The coefficients of $\ln r_t'$ seem to be fairly large--about 0.4--in all countries except the U.S. However, the long-run elasticity of real cash balances with respect to a change in exchange rate expectations is fairly large for the U.K. and Canada (greater than unity) and less than unity for Germany and the U.S. The long-run elasticity of real cash balances to changes in exchange rate expectations is lower in the U.S. than in the other countries and is distributed over a period of four quarters.[21]

Changes in domestic price expectations had a significant negative effect on real cash balances in each country. The magnitude of the coefficient of $\ln\dot{P}'$ seems to be about -0.21 except in the U.K. This effect is about four times the short-run effect of changes in the domestic and foreign interest rate combined. The relatively small magnitude of short-term elasticity of real cash balances in the U.K. with respect to changes in expected prices is rather surprising. However, the long-run elasticity of M with respect to changes in expected prices--as can be seen from TABLE 4--is fairly high in the U.S. and Canada but lower for the U.K. and Germany. When the effects of foreign financial markets, i.e., the coefficients of $\ln i_t^f$ and $\ln r_t'$, were set to zero, the elasticity of real cash balances with respect to changes in expected prices tended toward unity. But with foreign variables present, the magnitudes of the long-run elasticity of M with respect to $\dot{P}'$ is less than unity.

Finally, the results in TABLE 1 indicate that actual real cash balances adjust to their desired levels within a year. The average adjustment period, (AAP) [calculated as AAP = $\frac{1-\lambda}{\lambda}$, where λ is the adjustment coefficient], is very small for Germany--slightly over one quarter--and almost one year for the U.K.; the average adjustment period for Canada and the U.S. is about three quarters. These results are consistent with what has been reported in the literature.

Stability of the Demand Functions

To infer appropriate policy conclusions from the estimated results reported earlier, it is essential to examine whether the demand functions are stable over time. There are several ways to test for structural change. We have chosen periods during which some specific, important, and potentially destabilizing event occurred in the money markets rather than the conventional procedure of choosing arbitrary sub-samples. In keeping with our emphasis on international monetary and financial developments on demand for real cash balances, we considered three major destabilizing international financial events: the dollar crisis of 1971:3, the closing of the exchange markets in the first quarter of 1973, and the transition from fixed to floating exchange rates which was established at different periods in each of the countries.

To test for structural change, we calculated the F statistics

$$F_{(m,\ n-k)} = \frac{SSR - SSR_1/m}{SSR_1/n-k}$$

where SSR is the sum of squared residuals of the regression fitted to the entire period; SSR_1 is the sum of squared residuals for the regression estimated using the first n observations, m being the number of additional observations ($m < k$); and k is the number of estimated parameters.[22]

The results shown in TABLE 4 indicate that the demand function for real cash balances estimated for the four countries remain stable, especially up to the events of 1973:1. There was some deterioration in stability of these functions for the two North American countries while the demand functions for the U.K. and Germany remained highly stable throughout the financially stressful period of 1970-1975 when significant international monetary crises came in succession.

TABLE 4

Tests of Structural Change for Money Demand Function

Periods	Calculated F Values	Critical Values F.05	Critical Values F.01
A. Canada*			
1970:2	1.99	2.51	3.66
1971:3	.81	2.35	3.32
1973:1	4.41	1.99	2.64
B. Germany			
1971:3	.83	2.36	3.35
1973:1	1.50	1.99	2.64
C. U.K.**			
1971:3	2.00	2.86	4.36
1972:2	.86	2.84	4.31
1973:1	1.54	1.98	2.63
D. U.S.			
1971:3	1.11	2.36	3.33
1973:1	2.44	1.99	2.63

* In 1970:2 Canada abandoned the pegged exchange rate.

** U.K. abandoned the fixed exchange rate system in 1972:2.

SECTION IV

CONCLUDING REMARKS

A major implication of this study is that, in an increasingly interdependent world, monetary developments in one country affect both the supply and demand for money in other countries. This suggests that a monetary policy directed to counteract foreign monetary and financial developments requires not only knowledge of the sensitivity of the money supply to those events, but also knowledge of the response of demand for real cash balances to them.

We have shown in the theoretical part of our analysis that changes in domestic interest rates, induced by movements of foreign interest rates, are partially offset by adjustments in the demand for money. These adjustments take place through the sale or purchase of foreign assets financed out of (absorbed by) cash holdings. Similarly, the effects of changes in exchange rate expectations on the domestic money market is partly offset by changes in real cash balances within the domestic economy. The strength of those counteracting forces was shown to depend upon the elasticity of the demand for money with respect to the foreign interest rate, exchange rate expectations, and the level of the short-term domestic rate.

On purely statistical grounds, despite the data problem ecountered, we conclude that the estimates provide a good explanation of the determinants of real cash balances in an open economy. The traditional variables, such as permanent income and domestic interest rate variations, are important explanatory variables in the demand equation for real balances. The long-run elasticity of real cash balances with respect to permanent income is close to unity and much greater than its elasticity with respect to changes in the interest rate--a result confirming previous findings.[23] Also, the changes in price expectations have a strong negative effect on holdings of real cash balances, but the long-run effect of changes in price expectations is less than unity. In contrast to the traditional demand functions for money, it is clear that: (i) failure to take account of exchange rate expectations, as is commonly the case in studies of capital flows, results in specification biases, especially of the domestic and foreign interest rate coefficients; and (ii) the magnitude of the bias is further increased when variables that account for foreign monetary and financial developments are missing altogether in the demand function for real cash balances. In the last case--in addition to the effects upon interest rate coefficients--the adjustment coefficient is substantially affected. Thus, ignoring the effects of foreign interest rates and exchange rate expectations not only leads to misspecification of the demand for money, but also to the implicit conclusion that monetary authorities have very little room to offset changes in the inflow of capital induced by changes in domestic or foreign interest rates or exchange rate changes.

NOTES

[1]Hamburger (1974) and Willms (1971) are the only writers to our knowledge that have postulated functions for demand for money in an open economy.

[2]Hodjera (1971) and (1973); Branson (1968) and (1970); and Branson and Hill (1971).

[3]See S. Goldfeld (1973) for a summary of the traditional literature on demand for money in the U.S.

[4]Goldfeld.

[5]It appears that this assumption may not be proper in the case of the U.S. economy. It is adopted here for simplicity, though for empirical purposes this assumption will be relaxed.

[6]See Tobin (1969).

[7]Defined as currency plus demand deposits.

[8]In the remainder of this section, the discussion of explanatory variables will be mainly devoted to non-standard variables, such as the foreign interest rate and exchange rate expectations.

[9]If none of the portfolio components is constrained to zero cross-price effects (and there are no theoretical grounds to do so), they all would adjust to a price disturbance in any one of the components. On this point, see Brainard and Tobin (1968).

[10]For detailed specification of these functions see the APPENDIX and S. Arango, "A Portfolio Approach to the Demand for Money in an Open Economy."

[11]Since the monetary authority transacts foreign exchange at the rate of exchange prevailing at any given time, such stock is valued by a weighted average of past and current exchange rates, $\dot{r}$,

$$\dot{r}_t = \sum_{i=0}^{t} r_i \frac{\Delta S^f_{d_i}}{S^f_{d_i}}$$

[12]The funds that banks can allocate freely to their portfolio are DD=RR. Letting DD=gM^d and RR=hDD, then DD-RR = (1-h)hM^d. For simplicity, only demand deposits are considered.

[13]It should be noted that, if the level of wealth remains constant during the process, all that takes place is a redistributing of assets. Furthermore, the contractionary effect on the money supply is precisely due to the wealth constraint, since the aggregate private sector--in the process of acquiring foreign reserves partially with inside money--forces private borrowing to shrink by some multiple of the initial change. In the end, therefore, it is the monetary base that is substituted in favor of foreign assets.

[14]The signs of the individual elasticies are obtained from the behavioral assumptions and are indicated above each term.

[15]This statement holds even in an extreme case in which the entire change in foreign securities is accompanied by an opposite but equal change in money holdings. The former is amplified through a multiplier effect so that under a fractional reserve system the variation in the money supply becomes greater than that of the money demand.

[16]Portfolio theory suggests a functional form multiplicative in stock of wealth and non-linear in rates of return.

[17]The responses of M_t to changes in the right-hand variables are assumed to have identical lags. A more complicated structure, varying with different independent variables, can be easily introduced. But not much was gained when we experimented with different lag structures. Similar results were obtained by Goldfeld (1973).

[18]The money demand function is clearly identifiable at both the empirical and theoretical levels. Empirically, the condition $m \leq G_*$ (where m is the number of included endogenous variables and G_* excluded exogenous variables) is fulfilled. Theoretically, the money supply function (1.9) contains several variables not included in the money demand function (1.1).

[19]This method is adopted from Darby (1972).

[20]There are two opposing forces which influence the size of the coefficient in i^d. The interest rates, i^d and i^f, bear a positive relationship and their coefficients are of the same sign. Therefore, the exclusion of i^f raises in absolute value the coefficient of i^d. On the other hand, the exclusion of exchange rate expectations and exchange rates may have an opposite effect that could be due to an inverse causal relationship running from the domestic interest rate to exchange rate expectations. That is, decreases in the domestic interest rate cause outflows of capital that create pressure on the foreign exchange market, and this, in turn, could lead to the formation of expectations about depreciation of the domestic currency.

[21]The polynomial distributed lag of the second degree, with the far end constrained to zero, had the following weights:

$$v_0 = -.62;\ v_1 = .07;\ v_2 = .49;\ \text{and}\ v_4 = .45$$

[22]The general test for structural change between two sub-periods of a sample is the F statistics given

$$F_R,\ n + m\text{-}2k = \frac{(SSR - \sum_{i=1}^{2} SSR_i)/k}{\sum_{i=1}^{2} SSR_i/n + m\text{-}2k}\ ;\ i = 1, 2$$

where SSR is the sum of squared residuals of the pooled regression; SSR_1 is the sum of squared residuals corresponding to the first n observations; SSR_2 is the sum of squared residuals corresponding to m additional observations; and k to the number of estimated parameters. This test is feasible whenever $n,m > k$. Given that most of the sub-periods considered in our test for structural change is characterized by $m < k$, we have used the F statistics indicated in the text. (For derivation of these test statistics, see H. Johnston, Econometric Methods, 2nd ed. New York: McGraw-Hill, 1972). Since several structural changes within the sample period are considered, the test is applied consecutively, each additional test being made subject to the restriction that the null hypothesis in the preceding test had been accepted.

APPENDIX

Mathematical Derivation of the Comparative Static Properties

The money market equilibrium condition may be expressed as:

$$P^d f^1(W^d, Y^d, i^d, i^f, r, r', \dot{P}') - k(GB_c^d + ICAB + (S_f^d - \bar{r}S_d^f) - FR) = 0 \qquad (A.1)$$

Total differentiation of (A.1) gives:

$$di^d\left(\frac{\partial M^d}{\partial i^d} - k\frac{\partial S_f^d}{\partial i^d} + k\frac{\partial rS_d^f}{\partial i^d} + k\frac{\partial FR}{\partial i^d} + k\frac{\partial FR}{\partial m}(1-h)g\frac{\partial M^d}{\partial i^d}\right) =$$

$$- dW^d\left(\frac{\partial M^d}{\partial W^d} + k\frac{\partial rS_d^f}{\partial W^d} + k\frac{\partial FR}{\partial m}(1-h)g\frac{\partial M^d}{\partial W^d}\right)$$

$$- dY^d\left(\frac{\partial M^d}{\partial Y^d} + k\frac{\partial rS_d^f}{\partial Y^d} + k\frac{\partial FR}{\partial m}(1-h)g\frac{\partial M^d}{\partial Y^d}\right)$$

$$- di^f\left(\frac{\partial M^d}{\partial i^f} - k\frac{\partial S_f^d}{\partial i^f} + k\frac{\partial rS_d^f}{\partial i^f} + k\frac{\partial FR}{\partial m}(1-h)g\frac{\partial M^d}{\partial i^f}\right) \qquad (A.2)$$

$$- dr\left(\frac{\partial M^d}{\partial r} - k\frac{\partial S_f^d}{\partial r} - kS_d^f + k\frac{\partial FR}{\partial m}(1-h)g\frac{\partial M^d}{\partial r}\right)$$

$$- dr^e\left(\frac{\partial M^d}{\partial r'} - k\frac{\partial S_f^d}{\partial r'} + k\frac{\partial rS_d^f}{\partial r'} + k\frac{\partial FR}{\partial m}(1-h)g\frac{\partial M^d}{\partial r'}\right)$$

$$- d\dot{P}'\left(\frac{\partial M^d}{\partial \dot{P}'} + k\frac{\partial rS_d^f}{\partial \dot{P}'} + k\frac{\partial FR}{\partial m}(1-h)g\frac{\partial M^d}{\partial \dot{P}'}\right)$$

$$- dP^d\left(\frac{M^d}{P^d} + k\frac{rS_d^f}{P^d} + k\frac{\partial FR}{\partial m}(1-h)g\frac{M^d}{P^d}\right)$$

$$+ dGB_c^d k + dICAB k + dW^f (k\frac{\partial S_f^d}{\partial Y^f}) + dY^f (k\frac{\partial S_f^d}{\partial Y^f}) + d\dot{P}'^f (k\frac{\partial S_f^d}{\partial \dot{P}'^f})$$

$$+ dP^f (k\frac{S_f^d}{P^f}) + di_c^d (k\frac{\partial FR}{\partial i_c^d}) + dh((NB - FR)g\, k^2$$

where $m = (1 - h)g\,M$ and $NB = GB_c^d + ICAB + (S_f^d - rS_d^f)$.

To transform the derivatives into elasticities, multiply and divide the left-hand side of (A.2) by i^d and each individual term within the parentheses by the respective asset; the first expression appearing on the right-hand side is multiplied and divided by W^d and each individual term within the parentheses is multiplied and divided by the corresponding asset, etc.

Let

$$\frac{di^d}{dx}\frac{x}{i^d} = \varepsilon(i^d, x),$$

$$\frac{\partial x}{\partial Y}\frac{y}{x} = e(x, y),$$

and $D = e(M^d, i^d)M^d - k\{e(S_f^d, i^d)S_f^d - e(rS_d^f, i^d)rS_d^f - e(FR, i^d)FR$
$- e(FR, m)\ e\ (M^d, i^d)FR\} < 0.$

Thus, the comparative static elasticities become:

$$\varepsilon(i^d,W^d) = \frac{-e(M^d,W^d)M^d - k[e(rS_d^f,W^d)rS_d^f + e(FR,m)e(M^d,W^d)FR]}{D} > 0$$

$$\varepsilon(i^d,Y^d) = \frac{-e(M^d,Y^d)M^d - k[e(rS_d^f,Y^d)rS_d^f + e(FR,m)e(M^d,Y^d)FR]}{D} \gtrless 0$$

$$\varepsilon(i^d,i^f) = \frac{-e(M^d,i^f)M^d + k[e(S_f^d,i^f)S_f^d - e(rS_d^f,i^f)rS_d^f - e(FR,m)e(M^d,i^f)FR]}{D} > 0$$

$$\varepsilon(i^d,r) = \frac{-e(M^d,r)M^d + k[e(S_f^d,r)S_f^d - e(S_d^f,r)rS_d^f - e(FR,m)e(M^d,r)FR]}{D} < 0$$

$$\varepsilon(i^d,r') = \frac{-e(M^d,r')M^d + k[e(S_f^d,r')S_f^d - e(rS_d^f,r')rS_d^f - e(FR,m)e(M^d,r')FR]}{D} > 0$$

$$\varepsilon(i^d,\dot{P}') = \frac{-e(M^d,\dot{P}')M^d - k[e(rS_d^f,\dot{P}')rS_d^f + e(FR,m)e(M^d,\dot{P}')FR]}{D} < 0$$

$$\varepsilon(i^d,\dot{P}^d) = \frac{-e(M^d,\dot{P}^d)M^d - k[e(rS_d^f,\dot{P}^d)rS_d^f + e(FR,m)e(M^d,\dot{P}^d)FR]}{D} > 0$$

$$\varepsilon(i\ ,GB_c^d) = \frac{k\ GB_c^d}{D} < 0$$

$$\varepsilon(i^d,ICAB) = \frac{k\ ICAB}{D} < 0$$

$$\varepsilon(i^d,W^f) = \frac{k\ e(S_f^d,W^f)S_f^d}{D} < 0$$

$$\varepsilon(i^d,Y^f) = \frac{k\ e(S_f^d,Y^f)S_f^d}{D} > 0$$

$$\varepsilon(i^d,\dot{P}^{ef}) = \frac{k\ e(S_f^d,\dot{P}^{ef})S_f^d}{D} > 0$$

$$\varepsilon(i^d,P^f) = \frac{k\ e(S_f^d,P^f)S_f^d}{D} < 0$$

$$\varepsilon(i^d,i_c^d) = \frac{-k\ e(FR,i_c^d)FR}{D} > 0$$

$$\varepsilon(i^d,h) = \frac{(NB - FR)\ e\ (k,h)k}{D} > 0$$

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