DEMAND FOR MONEY IN OPEN ECONOMIES

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The demand for real cash balances deduced from an underlying portfolio model of the financial market is shown to depend upon domestic variables and foreign monetary developments. The model is estimated using quarterly postwar data for Canada, Germany, U.K. and U.S. There is clear evidence that demand for money is affected not only by changes in domestic variables such as permanent income, domestic interest rate and price expectations but also by fluctuations in exchange rate expectations and foreign interest rates. The conclusion, that domestic monetary policy is fairly ineffective and domestic financial markets are highly vulnerable to changes in foreign financial and monetary developments need to be modified in light of the results presented in this paper.

1. 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 the 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 lead 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 can be shown to be milder (or even neutralized) than the traditional portfolio studies describe.

1Hamburger (1974) and Willms (1971) are the only writers who, to our knowledge, have postulated functions for demand for money in an open economy. For a summary of traditional literature on demand for money in the U.S., see Goldfeld (1973). For the U.K., see Fisher (1968) and Laidler and Parkin (1971).
The purpose of this paper is to generalize the traditional demand functions for money to take account of foreign monetary developments, such as changes in exchange rates and foreign interest rates. Our model is derived from a simplified portfolio model of the financial market which specifies the channels through which the influence of monetary elements 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. 3

(2) Price expectations do affect demand for real cash balances in each country, 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 exchange rate expectations 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 of real cash balances 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: the demand for real cash balances is specified and the nature of the data and construction of the variables are described in section 2. A comparison of the empirical results and their interpretations as well as a test of the stability of the demand functions are presented in section 3. The summary and conclusions are presented in section 4.

3See Goldfeld (1973) for a summary of the traditional literature on demand for money in the U.S.
2. Specification of demand for real cash balance in an open economy

A general portfolio model can be constructed to integrate five basic behavioral relations: (i) demand functions for aggregate domestic real cash balances, domestic securities, and foreign securities, (ii) foreign demand functions for domestic securities, (iii) the supply function for domestic securities, domestic government bonds, and domestic equity, (iv) the domestic supply of money, and (v) an exogenous supply of foreign securities.\(^4\)

The underlying assumptions of this model are that financial variables influence the real variables with a lag, income and price levels, and the current account balance are exogenous, the stock of wealth is given and capital gains or losses do not affect current portfolio choice,\(^5\) and monetary authorities buy and sell whatever amount of foreign exchange is supplied or demanded by the private market so as to keep the exchange rate fixed, though the rate level may be changed at will.\(^6\)

The underlying portfolio model suggests that domestic interest rates, \((i^d)\), exchange rates, \((r)\), and real cash balances, \((M_t)\) are endogenous. Estimation of the structural relations of the model requires specification of a complete econometric model and gathering of data from diverse sources. Our interest, however, is to concentrate on the demand for money function. Therefore, a two-stage, least squares estimating technique is used to take account of endogeneity of \(i^d\) and \(r\). The desired demand for real cash balances is specified as

\[
\ln M_t^* = a_0 + a_1 \ln YP_t + a_2 \ln i_t^d + a_3 \ln i_t^f + a_4 \ln r_t \\
+ a_5 \ln r_t' + a_6 \ln \hat{p}_t + u_t,
\]

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, \(\hat{p}\) = inflationary price expectations, \(u\) = stochastic disturbance, and the coefficients \(a_i\) \((i = 1, \ldots, 6)\), are long-run elasticities of \(M_t^*\) with respect to a given variable.

According to the behavioral assumptions, the expected signs are

\[
a_1, a_4 > 0 \quad \text{and} \quad a_2, a_3, a_5, a_6 < 0.
\]

\(^4\)The theoretical framework of the model is described in Arango and Nadiri (1979).

\(^5\)See Tobin (1969) for further discussion of the portfolio model of asset demand.

\(^6\)It is further assumed that all assets entering the portfolio of the decision-making units are gross substitutes, i.e., the relevant rates of returns enter all demand functions [Brainard and Tobin (1968)]. The wealth constraint is fulfilled at each point in time which implies that (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.
The direction of effects of income, domestic interest rate, and price expectation on real cash balances is well known and therefore needs no further discussion. However, it would be useful to comment briefly on the direction of effects of changes in foreign interest rate \( (i') \), exchange rate \( (r) \), and exchange rate expectations \( (r') \) on desired stock of real cash balance \( (M^*_p) \).

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 these increases 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 effects on the money supply is not of the same magnitude. As soon as the 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 market, respectively, push the domestic interest rate in an upward direction and the demand for real cash balances in a downward direction.\(^7\)

It can be shown that expectations of increase in exchange rate and foreign interest rate have similar effects on the domestic interest rate. The magnitudes of the effects of changes in exchange rate expectations and foreign interest rate may differ, however, depending on the magnitude of the elasticities of foreign interest rate and exchange rate expectation with domestic interest rate.

An increase in the foreign exchange rate \( (r) \), 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, decreased. Given the 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

\(^7\)The magnitude of the elasticity between domestic and foreign interest rates \( (i^* - i') \), 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. In the two extreme cases of perfect substitutability between domestic and foreign securities, changes in foreign security holdings, being totally financed out of money holdings under the conditions of no inside money, result 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.
holdings, the domestic rate falls less than it would if the demand for money were independent of foreign factors.

To take account of the lag between actual and desired stock of real balances, the following partial adjustment mechanism is adopted:

$$\ln M_t - \ln M_{t-1} = \lambda (\ln M_t^* - \ln M_{t-1}).$$  \hspace{1cm} (2)

Relation (2) implies that the adjustment in actual real money holdings \(M\) that takes place at time \(t\) is a fraction, \(\lambda\), of the gap between the desired level at that period and the actual holdings at \(t-1\). Combining (1) with (2) we get eq. (3),

$$\ln M_t = \lambda a_0 + \lambda a_1 \ln YP_t + \lambda a_2 \ln i_t^d + \lambda a_3 \ln \hat{i}_t^f + \lambda a_4 \ln r_t$$

$$+ \lambda a_5 \ln r_t' + \lambda a_6 \ln \hat{P}_t' + (1 - \lambda)T \ln M_{t-1} + e_t.$$  \hspace{1cm} (3)

This equation specifies the short-run demand for money where \(\lambda a_i\)'s \((i = 0 \ldots 6)\) give the short-run elasticities, and \(a_i\)'s are the long-run elasticities of real cash balances with respect to the independent variables. From the coefficient of the lagged dependent variable, \((\ln M_{t-1})\), the speed of adjustment of actual real cash balances to their desired values can be calculated.\(^8\)

We shall assume that the error term, \(e_t\), in (3) is subject to a first-order serial correlation, i.e.,

$$e_t = \rho e_{t-1} + \epsilon_t,$$  \hspace{1cm} (4)

where \(\rho\) is the first-order serial correlation coefficient. The equation

$$\ln M_t = \psi_0 + \psi_1 \ln YP_t + \psi_2 \ln i_t^d + \psi_3 \ln \hat{i}_t^f + \psi_4 \ln r_t$$

$$+ \psi_5 \ln r_t' + \psi_6 \ln \hat{P}_t' + \psi_7 \ln M_{t-1} + \epsilon_t,$$  \hspace{1cm} (5)

is used to estimate aggregate demand for real cash balances in four industrial economies: U.S., Canada, United Kingdom, and Germany for the period 1960 to 1975. As we noted, according to our model specification, \(i_t^d\), \(r_t\), and \(M_t\) are endogenous, while permanent income, \(YP_t\), foreign interest rate, \(\hat{i}_t^f\), inflationary expectations \(\hat{P}_t\), and the lagged dependent variable, \(M_{t-1}\), are exogenous variables. To deal with the simultaneity problem between \(M_t\), \(i_t^d\), and \(r_t\) in eq. (5), and at the same time insure consistency of the estimates, a

\(^8\)The responses of \(M_t\) to changes in the right-hand side 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).
two-stage procedure estimation developed by Fair (1970) is employed. In addition to the exogenous variable included in the money demand equation, variables such as foreign permanent income ($YP_f$), foreign price level ($P^f$), foreign inflationary price expectations ($P^f_{ij}$), the current account balance ($CAB$), and the discount rate are as instruments used in the two-stage estimation of the model.\(^9\)

**Construction of variables and sources of data**

(i) $M'$ is stock of nominal cash balances (demand deposits plus currency), seasonally adjusted, end of period (billions of domestic currency). $M$ is the real money stock. $M'$ is deflated by each country's wholesale price index ($1970 = 100$).

(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, 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:

$$\dot{P}' = ((P^d_t/P^d_{t-1})^4 - 1) \times 100,$$

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

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

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

(vii) $r$ is the premium or discount in foreign market exchange, obtained as

$$r = (r_f/r_s) - 1 \times 400,$$

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) $r_{es}$ is the U.S. spot exchange rate, calculated as an average of the indices (based—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).

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\(^9\)The money demand function is identified; the condition $m \leq G_s$ (where $m$ is the number of included endogenous variables and $G_s$ excluded exogenous variables) is fulfilled. The money supply function, in specification of the underlying theoretical model, contains several variables not included in the money demand function (1). For further discussion, see Arango and Nadiri (1979).
(ix) \( YP \) is domestic real permanent income. The permanent income series is based on the following adaptive expectations mechanism:\(^{10}\)

\[
YP_t = YP'_{t} + b(Y_t - YP'_{t}),
\]

and

\[
YP'_{t} = (1 + c)YP_{t - 1}.
\]

That is, permanent income in period \( t \) consists of expectations about future income formed at the beginning of period \( t \) \( (YP'_{t}) \) adjusted by a proportion, \( b \), of the difference between the expected and the actual current income. Expected income, in turn, is based on permanent income of the previous period adjusted by a trend growth rate of income, \( c \). Combining these two relations, 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 \( YP_0 = \epsilon^{c_0} \) and the assumed \( b \) was 0.15.\(^{11}\)

(x) \( YP' \) 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 1970–1971. For each country, its own permanent income was excluded.

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

The quarterly data for constructing the variables of the model came from diverse sources. The main sources of data were: Main Economic Indicators [OECD (1976)], International Financial Statistics [IMF (1978)], the National Bureau of Economic Research data bank [NBER (1979)], and Rates of Change in Economic Data for Ten Industrialized Countries [Federal Reserve Bank of St. Louis (1976)].

\(^{10}\)This method is adopted from Darby (1972).

\(^{11}\)The polynomial distributed lag of the second degree, with the far end constrained to zero, had the following weights:

\[
v_0 = 0.62, \quad v_1 = 0.07, \quad v_2 = 0.49 \quad \text{and} \quad v_4 = 0.45.
\]
3. Estimation of the model

The estimated regression equations for real cash balances, shown in table 1, indicate that the overall goodness of fit of the model is excellent and that the individual variables contribute significantly to the explanation of behavior of real cash balances. Plots of actual and estimated real cash balances, not shown here, indicate that the model traces well both the turning points and levels of the dependent variable in each country, except in the U.K. where its performance was somewhat weak.

The signs of all explanatory variables are consistent with 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. In table 2, the short- and long-run elasticities, $E_S$ and $E_L$, of real cash balances with respect to the explanatory variables are shown. They are calculated by dividing the relevant coefficients in table 1 by $(1 - \lambda)$, where $\lambda$ is the adjustment coefficient.

Several features of the results given in tables 1 and 2 should be noted. Permanent income is a significant variable in explaining holdings of real cash balances, especially 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 $YP$, the measure of permanent income, is unity in the former two countries and close to unity (0.75) 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 magnitude (about 0.027) of coefficient of $i^d$ in each of the estimated 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.

The results verify the hypothesis that foreign financial aid and monetary influences upon demand for real cash balances are transmitted by changes in foreign interest rates and exchange rate 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 balance, 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 1,
Table 1
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 1960:1 to 1975:IV.\textsuperscript{a}

<table>
<thead>
<tr>
<th>Country</th>
<th>Constant</th>
<th>ln $YP_i$</th>
<th>ln $r_i^d$</th>
<th>ln $i_f$</th>
<th>ln $r_i$</th>
<th>ln $r_i^*$</th>
<th>$\sum_1 \omega_i \ln \hat{P}_{i-1}$</th>
<th>ln $M_{i-1}$</th>
<th>$R^2$</th>
<th>$D-W$</th>
<th>SEE</th>
<th>$\hat{\rho}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canada</td>
<td>-0.417</td>
<td>0.254</td>
<td>-0.026</td>
<td>-0.030</td>
<td>0.061</td>
<td>-0.437</td>
<td>-0.028</td>
<td>0.734</td>
<td>0.996</td>
<td>1.85</td>
<td>0.0131</td>
<td>-0.161</td>
</tr>
<tr>
<td>(5.8)</td>
<td>(5.4)</td>
<td>(2.1)</td>
<td>(2.5)</td>
<td>(0.9)</td>
<td>(1.7)</td>
<td>(6.1)</td>
<td>(12.6)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Germany</td>
<td>-0.901</td>
<td>0.457</td>
<td>-0.027</td>
<td>-0.035</td>
<td>0.023</td>
<td>-0.369\textsuperscript{b}</td>
<td>-0.236</td>
<td>0.565</td>
<td>0.996</td>
<td>2.06</td>
<td>0.0165</td>
<td>-0.143</td>
</tr>
<tr>
<td>(3.9)</td>
<td>(4.4)</td>
<td>(3.3)</td>
<td>(2.2)</td>
<td>(0.9)</td>
<td>(2.0)</td>
<td>(2.2)</td>
<td>(5.6)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>United Kingdom</td>
<td>-0.018</td>
<td>0.152</td>
<td>-0.028</td>
<td>-0.020</td>
<td>0.026</td>
<td>-0.452\textsuperscript{c}</td>
<td>-0.124</td>
<td>0.799</td>
<td>0.911</td>
<td>1.97</td>
<td>0.0188</td>
<td>-0.407</td>
</tr>
<tr>
<td>(0.1)</td>
<td>(4.5)</td>
<td>(1.9)</td>
<td>(1.8)</td>
<td>(0.5)</td>
<td>(2.0)</td>
<td>(2.5)</td>
<td>(17.3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>United States</td>
<td>-0.118</td>
<td>0.188</td>
<td>-0.029\textsuperscript{d}</td>
<td>0.020</td>
<td>-0.162\textsuperscript{e}</td>
<td>-0.228\textsuperscript{f}</td>
<td>0.743</td>
<td>0.990</td>
<td>1.94</td>
<td>0.010</td>
<td>-0.301</td>
<td></td>
</tr>
<tr>
<td>(0.2)</td>
<td>(7.5)</td>
<td>(4.2)</td>
<td>(1.9)</td>
<td></td>
<td>(2.8)</td>
<td>(4.6)</td>
<td>(16.6)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\textsuperscript{a}The dependent variable is ln $M$, $R^2$ is the coefficient of determination, $D-W$ is the Durbin-Watson statistics, SEE is the standard error of estimate, and $\hat{\rho}$ is the estimated coefficient of autocorrelation.

\textsuperscript{b}Second-order distributed lag over four quarters, with far-end zero restriction.

\textsuperscript{c}First-order distributed lag over six quarters, with far-end zero restriction.

\textsuperscript{d}Second-order distributed lag over three quarters with far-end zero restriction.

\textsuperscript{e}Second-order distributed lag over five quarters with far-end zero restriction.

\textsuperscript{f}First-order distributed lag over four quarters, with far end zero restriction. For all other countries this distributed lag is over three quarters.
Table 2

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, $\lambda$, and average adjustment period, AAP.

<table>
<thead>
<tr>
<th>Country</th>
<th>$YP$ $E_S$ $E_L$</th>
<th>$\pi^*$ $E_S$ $E_L$</th>
<th>$\pi^f$ $E_S$ $E_L$</th>
<th>$r^*$ $E_S$ $E_L$</th>
<th>$p^*$ $E_S$ $E_L$</th>
<th>$\lambda$</th>
<th>AAP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canada</td>
<td>0.254</td>
<td>0.955</td>
<td>-0.026</td>
<td>-0.098</td>
<td>-0.030</td>
<td>-0.113</td>
<td>-0.437</td>
</tr>
<tr>
<td>Germany</td>
<td>0.457</td>
<td>1.05</td>
<td>-0.027</td>
<td>-0.062</td>
<td>-0.035</td>
<td>-0.080</td>
<td>-0.369</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>0.152</td>
<td>0.756</td>
<td>-0.028</td>
<td>-0.139</td>
<td>-0.020</td>
<td>-0.108</td>
<td>-0.452</td>
</tr>
<tr>
<td>United States</td>
<td>0.188</td>
<td>0.732</td>
<td>-0.029</td>
<td>-0.113</td>
<td>-0.020</td>
<td>-0.078</td>
<td>-0.162</td>
</tr>
</tbody>
</table>
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 affecting demand for real cash balances in any of the countries. However, the sign of the coefficient of ln \( r \) 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 real cash balances. The coefficients of ln \( r \) depicting short-term effect of changes in exchange rate expectations on real cash balances are fairly large — about 0.4 — in each of the regression equations in table 1 except that of the U.S. The long-run elasticity of real cash balances with respect to a change in exchange rate expectations, however, 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.

Changes in domestic price expectations had a significant negative effect on real cash balances in each country. The magnitude of the coefficient of ln \( P' \) seems to be about —0.21 except in the U.K. This effect is about four times that of the short-run effects 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 2 — 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 \( i_f \) and ln \( r \), 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 \( P' \) 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 = \((1 - \lambda) / \hat{\lambda} \), where \( \hat{\lambda} \) 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.

To compare the implications of alternative assumptions about channels through which foreign financial developments act upon the demand for real cash balances in 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 eq. (5). The general results of these experiments were that the fit of eq. (5) 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.\textsuperscript{12}

**Stability of the demand functions**

To infer appropriate policy conclusions from the estimated results reported earlier, it is essential to examine whether the estimated money 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 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

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

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.\textsuperscript{13}

The results shown in table 3 indicate that the demand function for real cash balances estimated for the four countries remain stable especially up to

\textsuperscript{12}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.

\textsuperscript{13}The general tests for structural change between two sub-periods of a sample is the $F$
Table 3
Tests of structural change for money demand functions.

<table>
<thead>
<tr>
<th>Periods</th>
<th>Calculated F values</th>
<th>Critical values</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>F0.05</td>
</tr>
<tr>
<td>(A)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Canada*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1970:2</td>
<td>1.99</td>
<td>2.51</td>
</tr>
<tr>
<td>1971:3</td>
<td>0.81</td>
<td>2.35</td>
</tr>
<tr>
<td>1973:1</td>
<td>4.41</td>
<td>1.99</td>
</tr>
<tr>
<td>(B)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Germany</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1971:3</td>
<td>0.83</td>
<td>2.36</td>
</tr>
<tr>
<td>1973:1</td>
<td>1.50</td>
<td>1.99</td>
</tr>
<tr>
<td>(C)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>U.K.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1971:3</td>
<td>2.00</td>
<td>2.86</td>
</tr>
<tr>
<td>1972:2</td>
<td>0.86</td>
<td>2.84</td>
</tr>
<tr>
<td>1973:1</td>
<td>1.54</td>
<td>1.98</td>
</tr>
<tr>
<td>(D)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>U.S.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1971:3</td>
<td>1.11</td>
<td>2.36</td>
</tr>
<tr>
<td>1973:1</td>
<td>2.44</td>
<td>1.99</td>
</tr>
</tbody>
</table>

*aIn 1970:2 Canada abandoned the pegged exchange rate.
*bU.K. abandoned the fixed exchange rate system in 1972:2.

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.

4. Concluding remarks

A major implication for this study is that, in an increasingly interdependent world, monetary developments in one country affect both the

statistics given

\[
F_{R,n+m-2k} \approx \frac{(SSR - \sum_{i=1}^{2} SSR_i)/k}{\sum_{i=1}^{2} SSR_i/n + m - 2k}, \quad i = 1, 2,
\]

where \(SSR\) is the sum of squared residuals of the pooled regression; \(SSR_i\) is the sum of squared residuals corresponding to the first \(n\) observations; \(SSR_{i}\) 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 Johnston (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.
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.

It can be shown 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 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.

The estimated demand equations, despite the data problems encountered, provide a good explanation of the determinants of real cash balances in open economies. 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. Also, the changes in expected prices 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: (1) 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 rates.

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