CANADIAN FOREIGN EXCHANGE RATE DETERMINATION: A MONETARY APPROACH

by

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~~Canadian Foreign Exchange Rate Determination:~~

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ABSTRACT

In recent years various models of foreign exchange rate determination have been formulated, one of which is the flexible-price monetarist exchange rate model. The model, which is founded on the purchasing-power parity doctrine (PPP), sees the exchange rate as being determined mainly by relative changes in the money supply, interest rates and real income. Several econometric studies have been done by some scholars to test the validity of the model: most of the results indicate that it is unsatisfactory in explaining exchange rate fluctuations.

The purpose of this work is to explain briefly the theory behind the model, and to assess its adequacy and reliability in explaining movements of the Canadian exchange rate. In the course of doing so, the PPP doctrine is reviewed, and the essential features of some competing models of exchange rate determination highlighted. The model's validity is tested by using it to estimate the Canadian dollar/US dollar, the Canadian dollar/pound sterling and the Canadian dollar/Japanese yen exchange rates.

The results of the estimates confirm the conclusions of previous studies: the flexible-price monetarist exchange rate model seems to be unsatisfactory. It is therefore necessary that future econometric studies of exchange rate determination focus on models that incorporate more explanatory variables and on those which consider other functional forms of the relationship between the exchange rate and its relevant explanatory variables.

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1. INTRODUCTION

The objective of this study is to estimate the Canadian dollar/US dollar, the Canadian dollar/pound sterling, and the Canadian dollar/Japanese yen exchange rates, using the flexible-price monetarist exchange rate model and to examine the model's adequacy in explaining fluctuations in the foreign exchange rate. Until fairly recently, the literature on foreign exchange rate determination emphasized a monetarist approach with most of its versions assuming strict purchasing-power parity (PPP).

Exchange rates are relative prices of national currencies, and are considered to be determined mainly by the interplay of the forces of supply and demand in foreign exchange markets operating under a floating exchange rate regime. The importance of the study of foreign exchange rate fluctuations could be attributed to several reasons including the following. Firstly, the exchange rate has a direct influence on prices and on the profitability of tradeable goods and services in a global economy that is becoming increasingly integrated. Secondly, as it is a relative price, it determines greatly the allocation of resources in an economy over the medium term. The main transmission mechanism is the impact of sustained movements of the exchange rate on the competitive position of domestic industries as against that of foreign industries. The performance of industries most exposed to foreign competition is affected in both relative and absolute terms, and this in turn has some impact on resource allocation. An undervalued exchange rate may engender a transitory period of high profitability in the tradeable goods sector, which may cause some enterprises to expand

their operations when underlying structural considerations suggest that they should contract, and an overvalued exchange rate may have the opposite effects. Since expectations about the future are influenced by current profitability, investment decisions may also be affected.

In the short-run exchange rate volatility may also give rise to serious structural considerations. But this is due more to the uncertainty about the future development of the exchange rate than to its actual behaviour. It is usually argued that short-run fluctuations in the exchange rate are a problem for firms engaged in international business, either because of exchange risk or because of the expense of forward cover. If this were the case, it could lead to a lower level of trade, and to a commensurately inferior allocation of resources.

Thirdly, changes in the price level may also be induced by short-run movements in the exchange rate. There is, indeed, the possibility that short-run exchange rate fluctuations may escalate inflation if depreciations are translated quickly into higher prices and wages, but currency appreciations may not have a symmetric effect. For example, wage earners may react strongly to protect real earnings following depreciations, but they may refuse to accept smaller wage increases following appreciations.

The demand for, and the supply of, currencies which determine the exchange rate depend on conditions which exist in other real and financial markets, and there is interdependence between the exchange rate and these real and financial market conditions. And because of this interdependence, the exchange rate can be considered as a function of the complex interaction of several variables in an international setting.

But an attempt to incorporate all these variables in a model of exchange rate determination could be very cumbersome, so what is usually done in practice is to make simplifying assumptions which allow the incorporation of the most important variables. The flexible-price monetarist model with which we are concerned in this study is just one of the several most popular models that have been used recently in foreign exchange rate determination.

The main contention of this model is that relative changes in the money supply, interest rates and real income affect the exchange rate, which is defined as the amount of the domestic currency needed to purchase one unit of the foreign currency. The validity of the model is tested using quarterly time series data for the years 1957-1961 and 1971-1987. Data for the period 1962-1970 are excluded because throughout those years Canada was not on a flexible exchange rate regime. In the sections that follow there will be a brief review of various models of exchange rate determination followed by a discussion of the results obtained from regressions based on the monetarist model, and the conclusion to the study.

2. MODELS OF EXCHANGE RATE DETERMINATION

Over the years, several econometric models of exchange rate determination have been specified, but these can be classified under two main groups: Balance of Payments (BOP) flows models of exchange rates and asset-market models of exchange rates.

(i) BOP Flows Models of Exchange Rates:

These models are of the view that the exchange rate is determined by BOP flows. The main mechanism that brings this about is the responsiveness of the current account to variations in international competitiveness. It is predicted that internal monetary expansion will precipitate a depreciation of the domestic currency in order to maintain, through the current account, external balance with whatever mix of lower interest rates, and that higher output will be required to restore internal equilibrium.

(ii) Asset-market Models of Exchange Rates:

This view identifies five components of, or contributors to, exchange rate movements. It indicates that the value of a currency will tend to rise in any period if:

(a) foreign prices are currently rising faster than domestic prices;

(b) expectations of domestic interest rates are being revised upwards in relation to expectations of foreign interest rates;

(c) expectations of domestic inflation are being revised downwards in relation to expectations of foreign inflation;

(d) expectations of the future real exchange rate are being revised upwards;

(e) there is an increase in the risk premium of foreign currency.

This approach retains what may be regarded as the central insight of the asset-market approach: that exchange rates, like the prices of all durable (or financial) assets which are purchased and held with a view to resale, are crucially dependent on expectations, so that changes in them may be very largely a reflection of revisions to expectations resulting from "news" or "surprises".

Within the asset-market framework, three models based on different special assumptions may be distinguished:

(i) The flexible-price monetarist (monetary) model;

(ii) The sticky-price monetary (or "Dornbusch") model;

(iii) The portfolio-balance model with static or stable exchange rate expectations.

The first two are referred to as "monetarist" because money is the only asset whose supply and demand play any role. Other assets denominated in different currencies are assumed to be perfect substitutes in demand: it is assumed that there are no risk premia or portfolio preferences and that expected returns are always equalized irrespective of asset supplies.

2.1 THE FLEXIBLE-PRICE MONETARIST MODEL:

The flexible-price monetarist model assumes that purchasing power parity rules: the real exchange rate is constant and is expected to remain so. This, together with the assumption of no risk premium,

carries the further implication that the differential between domestic and foreign interest rates is given by the difference between expected rates of inflation. The monetarist model thus eliminates influences (b) - (e) of the above framework and concentrates on the influence of relative price levels via PPP. It assumes finally that prices are sufficiently flexible to hold the supply and demand for money in equilibrium. The relationship between the supplies of domestic and foreign money relative to the demands for them, therefore, determines the exchange rate.

The hallmarks of the model are the assumptions of no risk premium and of flexible prices. According to this model, if, starting from equilibrium, there is an increase in the domestic money supply, assuming that the price-elasticity of demand for money is unity, the price level must rise and the exchange rate must depreciate in the same proportion. If there is an increase in the domestic interest rate, the domestic currency must again depreciate, because higher interest rates imply a lower demand for, and an excess supply of, money. For equilibrium to be restored, prices must rise and this requires the exchange rate to fall. This unequivocal implication that the value of the domestic currency will be negatively related to the interest rate differential in its favour is a distinctive feature of the flexible-price monetarist model. Its sense is clear when it is recalled that changes in interest rates in this model do not represent changes in relative yields: by the assumption of no risk premia, yields are always equalized, and changes in the interest rate differential occur in order to offset changes in inflation and exchange rate expectations which would otherwise give

rise to disparities in expected yields. Interest rates then affect exchange rates only indirectly via the demand for money. Finally, an increase in domestic real income (perhaps owing to a resource discovery or to a more favourable current account balance) should cause the exchange rate to appreciate through an increase in the demand for money. The implications for the exchange rate of changes in the corresponding foreign variables follow in the same way from the assumed maintenance of equilibrium in the foreign money market by the foreign price level.

On the whole, exchange rates in the flexible-price monetary model are determined by domestic and foreign monetary conditions; factors which do not affect the supply or demand for money at home or abroad do not affect the external value of the domestic currency. As stated earlier, the monetarist model is based on the principle of purchasing power parity (PPP). It is necessary at this juncture to review PPP since such a review may help us to understand the model better.

2.2 THE PURCHASING POWER PARITY PRINCIPLE:

The principle, popularized by Gustav Cassel in the 1920s, asserts that there is a long-run connection between inflation and exchange rates, and that this connection is underlined by the Law of One Price. In its simplest terms, it states that if two goods are identical, they must sell for the same price. In an international setting, therefore, the exchange rate reflects the ratio of prices. (For a detailed discussion of the development of PPP see Cassel, 1916).

The PPP principle can be stated in both absolute and relative forms. In its absolute form, it states that the general level of prices,

when converted to a common currency, will be the same in every country. Symbolically, it can be represented as:

$$Pus = S(\$/£) \cdot Puk$$

where the subscripted p's are the price levels of the respective countries and S($/£) is the US dollar/pound sterling exchange rate. The above can be re-arranged to give the spot exchange rate in terms of the relative costs of baskets of commodities in the two countries to obtain:

$$S(\$/£) = P_{us}/P_{uk}$$

In the relative form, PPP states that one country's inflation rate can only be higher (lower) than another's to the extent that its exchange rate depreciates (appreciates). It can be represented as follows:

$$\dot{S}(\$/£) = \dot{P}us - \dot{P}uk$$

Over the years, the PPP doctrine has aroused much criticism and there seems to be little (if any) empirical support for it. Most of the empirical results reveal that there have been departures from PPP. These departures are due partly to the presence of factors which are not in consonance with the assumptions of PPP, such as restrictions on movement of goods and the presence of non-traded outputs, and partly to statistical problems associated with price indices and with the evaluation of the basic PPP econometric equation:

$$S(\$/£) = ß_0 + ß_1(\dot{P}us - \dot{P}uk) + U$$

There are also measurement errors of the inflation differential, P - P* (where P and P* are the domestic and foreign price levels respectively), and problems associated with the simultaneous determination of the variables S($/£) and P- P*.

PPP has also been criticized on both statistical and theoretical grounds. Statistically, we must assume that the price index used to construct the PPP test accurately reflects the level of the prices at which transactions occur, and this raises several questions:

(i) What commodities/services are taken into consideration when we are building this price index?

(ii) What weights can be attached?

(iii) Can we compare the price index of country A to that of country B?

(iv) Can we accept the assumption that price control and/or commodity rationing are not important?

(v) Does the Law of One Price really hold?

Theoretically, several criticisms have been levelled against PPP among which are the Samuelson and the Balassa critiques.

THE SAMUELSON CRITIQUE:

He states that:

" Unless very sophisticated indeed, PPP is a misleadingly pretentious doctrine, promising us what is rare in economics, detailed numerical predictions....." (See Samuelson, 1964, p. 153).

He justifies this strong criticism on the basis of the strong features of our modern economy which PPP does not take into account:

(a) the presence of non-traded goods;

(b) the role of tariffs, quotas, and transport costs;

(c) the difference in weights used in the construction of price indices.

He goes further to ask why we should expect the exchange rate between two countries to be related to their CPI's, if within one country (that is, with the same currency) we observe differences in prices. In other words, if spatial arbitrage does not work within the same country why should we expect it to work between countries?

"From BLS data, I find that by this reasoning the San Francisco dollar has been overvalued relative to the Houston dollar by (106.0 - 83.3)/83.3 or by 27 per cent". (Ibid; p.147).

THE BALASSA CRITIQUE:

"He [Houthakker] argues that, while the US dollar appears to be overvalued as compared to the German mark, the mark itself is overvalued, and the Austrian shilling, the Spanish crown, and especially the Dutch guilder, undervalued..... If we were to apply this principle to [the] less developed countries, these currencies would generally appear to be undervalued. Now given that Houthakker proposes to correct that alleged overvaluation of the US dollar by devaluation, the corresponding adjustment would entail a substantial appreciation of the currencies of the developing countries. Since this recommendation can hardly be taken seriously, the question arises as [to] what meaning can be attached to an international comparison of exchange rates and purchasing-power parities." (See Balassa, 1964, p.585).

Balassa goes on to explain with a five step demonstration, how the inclusion of non-traded goods and services in the price indices and how productivity differentials between countries will produce a "systematic gap between PPP and the equilibrium exchange rate". The five steps are as follows:

(a) Without transportation/insurance costs and trade restrictions, the exchange rate will equate the prices of traded goods.

(b) Intercountry wage differentials in the traded goods sector will equal to productivity differentials; moreover, for each country, the wage rate for similar labour will be equal in both the traded and non-traded good sectors.

(c) With international differences in productivity being smaller in the service sector than in the production of goods, services will be relatively more expensive in countries with higher levels of productivity.

(d) Since services do not directly affect the exchange rate, but are a part of the CPI, "the PPP between the currencies of any two countries, expressed in terms of the currency of the country with higher productivity levels, will be lower than the equilibrium rate of exchange".

(e) The conclusion is that the greater the productivity differential in the production of traded goods, the greater will be the gap between the exchange rate predicted by PPP and the equilibrium exchange rate.

The Balassa critique is very important for at least two reasons. First, it points out the importance of the productivity differential and the role of non-traded goods. Second, it provides a justification for the

rejection of the simple PPP criterion to determine whether a currency is under- or overvalued.

The statistical problems and the seminal articles of Samuelson and Balassa should cause us to be suspicious when we try to generate and interpret empirical results of the PPP theory. According to Frenkel (1978) the PPP doctrine provides "a guide to the general trend of exchange rates rather than to the day-to-day fluctuations".

Much empirical research has been done on PPP and there seem to be some major results on which there is broad consensus. From post-war data in industrialized countries, the following features emerge:

(i) Short-run deviations from PPP are frequent and substantial, and certainly too great to be satisfactorily explained by international differences in the methods used to collect statistics.

(ii) There is lack of sufficient evidence to support that PPP holds even in the long-run. Available data in the 1970s and 1980s reveal that long periods of exchange rate overvaluation relative to PPP have been followed by equally long periods of undervaluation. Consequently, the only few times in which PPP have been confirmed look like chance encounters on the way from one extreme disequilibrium to an opposite one of more or less equal scale.

(iii) All available evidence indicates that exchange rates have varied far more than prices.

(For a more detailed discussion of these points see Copeland, 1989).

3. ECONOMETRIC ESTIMATES OF THE CANADIAN EXCHANGE RATE

In its simplest form, the flexible-price monetarist model states that exchange rates move promptly in order to maintain the international linkage of prices. Using e as the logarithm of the home currency price of foreign exchange, and p and p^* as the logarithm of home and foreign prices, respectively, the model implies the following (Bhandari and Putman, 1983):

$$e = p - p^* \qquad \text{....(1)}$$

It takes prices as determined by domestic nominal money supply and real money demand. Since money demand is a function of real income and the nominal interest rate, the expression becomes:

$$\left.\begin{aligned} p &= m - ky + hi \\ p^* &= m^* - ky^* + hi^* \end{aligned}\right\} \qquad \text{.....(2)}$$

where,

m = logarithm of nominal money supply (M1)

k = income elasticity of real money demand

y = logarithm of real income

h = semilogarithmic interest response of real balances

i = nominal interest rate (three-month treasury bill rate)

Combining equations (1) and (2) yields the exchange rate equation of the flexible-price monetarist model:

$$e = a + b(m - m^*) + h(i - i^*) - k(y - y^*) \quad ...(3)$$

where coefficients are assumed to be equal for both countries. Equation (3) is the standard form in which the model has been stated by several scholars including Dornbusch (1976, 1983), Frenkel (1976) and Frankel (1979). The model uses the nominal rather than the real interest rate because of the prominent role it gives to nominal prices.

As mentioned earlier, the contention of this approach is that relative changes in the money supply, interest rates and real income are the main influences on the exchange rate. A rise in e in the above equation implies a depreciation, while a fall implies an appreciation of the domestic currency. An increase in the money supply at home leads to an equiproportionate depreciation. Since an increase in domestic real income raises the demand for real balances and thus leads to a fall in domestic prices, it induces an offsetting exchange rate appreciation. Relatively higher domestic interest rates, by contrast, reduce the demand for real balances, raise prices and bring about an exchange rate depreciation. It is therefore expected that the coefficients of $m - m^*$ and $i - i^*$ will be positive, which implies that when these variables increase, there is a depreciation of the Canadian dollar. The coefficient of $y - y^*$ is expected to be negative, which means that an in increase in the real GNP differential leads to an appreciation of the Canadian dollar.

In this study, an attempt is made to use this model to estimate the Canadian dollar/US dollar, the Canadian dollar/pound sterling and the Canadian dollar/Japanese yen exchange rates. These exchange rates have been chosen because the United States, the United Kingdom and Japan are Canada's principal trading partners.

The data are quarterly time series data for the years 1957 - 1961 and 1971 to 1987 and are taken from the International Financial Statistics (except for the data on the exchange rates which are from Statistics Canada) published by the International Monetary Fund (IMF). The data are stored in the IMF and CANSIM tapes in the University data storage system. The reason for the exclusion of the data for the years 1962 - 1970 is that throughout those years Canada was not on a flexible exchange rate regime. All the regressions on the Canadian dollar/pound sterling exchange rate involve only 1971-1987 data, because pre-1963 data on the exchange rate are not available.

3.1 METHODOLOGY:

The estimation of the regression equation of the model is done using ordinary least squares (OLS) with the aid of the SHAZAM Version 6.2 program. As the regression equation is linear in logarithms, the data are first converted into logarithms before the regression is run. The exchange rate data have been converted from monthly to quarterly data. Separate regressions are run for the three exchange rates. After noting the basic results of the regressions, the model is examined for adequacy in terms of the characteristics of a good model and for the existence of any econometric errors: autocorrelation, multicollinearity,

heteroscedasticity and specification errors. Attempts are made to correct any of these errors that exist and to improve on the basic regression results.

3.2 STATISTICAL RESULTS:

The basic statistical results obtained are as follows:

CANADIAN DOLLAR/US DOLLAR

R-SQUARE = 0.6095 R-SQUARE ADJUSTED = 0.5954

DURBIN WATSON = 0.2001 VON NEUMANN = 0.2024

CHI-SQUARE = 10.8881 WITH 4 DEGREES OF FREEDOM

	SS	DF	MS	F
REGRESSION	0.61606	3	0.20535	43.188
ERROR	0.39466	83	0.47549E-02	
TOTAL	1.0107	86	0.11753E-01	

ANALYSIS OF VARIANCE FROM MEAN

VARIABLE NAME	ESTIMATED COEFFICIENTS	STANDARD ERROR	T-RATIO
83 DF			
GNP	0.65777E-01	0.24972E-01	2.6341
UCANM1	0.34627	0.31251E-01	11.080
RATE	-0.21259E-01	0.51330E-01	-0.41416
CONSTANT	1.3077	0.13252	9.8677

GNP = y - y*

UCANM1 = m - m*

RATE = i - i*

CANADIAN DOLLAR/POUND STERLING

R-SQUARE = 0.8828 R-SQUARE ADJUSTED = O.8774

DURBIN-WATSON = 0.5741 VON NEUMANN = O.5827

CHI-SQUARE = 3.2014 WITH 4 DEGREES OF FREEDOM

ANALYSIS OF VARIANCE FROM MEAN

	SS	DF	MS	F
REGRESSION	1.2811	3	0.42703	160.757
ERROR	0.17001	64	0.26564E-02	
TOTAL	1.4511	67	0.21658E-01	

VARIABLE NAME	ESTIMATED COEFFICIENTS	STANDARD ERROR	T-RATIO 64 DF
GNP	-0.67421	0.51041E-01	-13.209
UCANM1	-0.24086	0.26916E-01	-8.9487
RATE	-0.28604E-01	0.23150E-01	-1.2356
CONSTANT	-0.45925	0.23407	-1.9621

CANADIAN DOLLAR/JAPANESE YEN

R-SQUARE = 0.8071 R-SQUARE ADJUSTED = 0.8001

DURBIN-WATSON = 0.3215 VON NEUMANN = 0.3253

CHI-SQUARE = 6.9301 WITH 4 DEGREES OF FREEDOM

ANALYSIS OF VARIANCE FROM MEAN

	SS	DF	MS	F
REGRESSION	8.8620	3	2.9540	115.752
ERROR	2.1182	83	0.25520E-01	
TOTAL	10.980	86	0.12768	

VARIABLE NAME	ESTIMATED COEFFICIENT	STANDARD ERROR	T-RATIO 83 DF
GNP	-0.20451	0.54738E-01	-3.7361
UCANM1	0.16363	0.37753E-01	4.3341
RATE	0.41498	0.46724E-01	8.8815
CONSTANT	-5.5461	0.55411E-01	-100.09

3.3 ANALYSIS OF STATISTICAL RESULTS:

As shown in the above tables, the unadjusted R^2 statistics are 0.6095, 0.8828 and 0.8071, respectively, for the regressions on the Canadian dollar/US dollar, the Canadian dollar/pound sterling and the Canadian dollar/Japanese yen exchange rates. All three regressions have significant F statistics and impressive R^2 figures.

The coefficients of GNP and interest rate of the Canadian dollar/US dollar regression have the wrong signs; only the coefficient of the money supply is significant with the predicted sign. Contrary to the prediction of the model, the above results show that the coefficient of GNP (k, which is the income elasticity of real money demand) is positive, which means that an increase in domestic real income ultimately leads to a depreciation of the exchange rate. The implication of the negative coefficient of the interest rate (h, the semi-logarithmic interest response of real balances) is that when the domestic interest rate increases, the Canadian dollar appreciates. The insignificant t-ratios of the coefficients and a Durbin-Watson (DW) statistic of 0.2001, and a Von Neumann ratio of 0.2024 indicate the presence of serious econometric problems with this model and make one suspect of the adequacy and reliability of the model in explaining exchange rate fluctuations satisfactorily.

As for the regression on the Canadian dollar/pound sterling, the coefficient of GNP has the predicted sign, -0.67421 and a significant t-ratio. But the coefficients of the money supply and the interest rate have the wrong signs: -0.24086 and -0.028604, respectively. The DW statistic, 0.5741, and the Von Neumann ratio, 0.5827 indicate the presence of autocorrelation.

The results of the regression on the Canadian dollar/Japanese yen are, however, impressive when compared with the other two. All the coefficients have the predicted signs: GNP -0.20451, money supply 0.16363 and interest rate 0.41498 and the t-ratios are significant at the 95% confidence level. It seems interest rate plays a significant role in the variability of the Canadian dollar/Japanese yen exchange rate. But the

data on the DW statistic and the Von Neumann ratio are similar to those of the other two regressions: DW = 0.3215 and Von Neumann ratio = 0.3253.

On the whole, the results are far from satisfactory, and the information points to the existence of some econometric problems with this model. This makes it questionable on the grounds of proper specification and adequacy of the number of explanatory variables used. In the sections that follow, the above results are further examined for the presence of any econometric errors. Wherever possible, corrections are made and the results checked for any improvements on the basic results.

3.4 AUTOCORRELATION:

All the relevant statistics for the three regressions indicate that autocorrelation, which is defined as the correlation of successive error terms, is a problem. The DW statistics and the Von Neumann ratios indicate the presence of high autocorrelation. It should be noted that the break in the data between 1961 and 1971 in two of the data sets has an influence on the evidence of autocorrelation given here and on the results of the subsequent corrections made; care must be taken in interpreting the statistics. Plots of the residuals against their lagged values indicate a linear relationship between successive error terms. The existence of autocorrelation means that the OLS estimators are no longer efficient in the sense of having minimum variances, although they are still unbiased and consistent. To detect the order of autocorrelation, the OLS residuals are run through the identification stage of an ARIMA process. The plots of the

autocorrelation functions (ACF) and the partial autocorrelation functions (PACF) indicate that the Canadian dollar/US dollar residuals have first order autocorrelation, the Canadian dollar/Japanese yen residuals have second order autocorrelation and the Canadian dollar/pound sterling residuals have 4th order autocorrelation. To correct for this problem the three regressions are re-run with the AUTO command in the SHAZAM program. The results obtained are shown below:

CANADIAN DOLLAR/US DOLLAR

R-SQUARE = 0.9851 R-SQUARE ADJUSTED = 0.9846 RHO = 0.99320

VARIABLE NAME	ESTIMATED COEFFICIENT	STANDARD ERROR	T-RATIO 83 DF
GNP	-0.14520E-01	0.11856E-01	-1.2247
UCANM1	-0.93430E-01	0.26913E-01	-3.4716
RATE	-0.14487E-02	0.10682E-01	-0.13563
CONSTANT	-0.20293	0.12961	-1.5657

CANADIAN DOLLAR/POUND STERLING

R-SQUARE = 0.9595 R-SQUARE ADJUSTED = 0.9577

RHO1 = 0.63188 RHO4 = 0.36811

VARIABLE NAME	ESTIMATED COEFFICIENT	STANDARD ERROR	T-RATIO 64 DF
GNP	-0.68471	0.60257E-01	-11.363
UCANM1	-0.10585	0.34812E-01	-3.0404
RATE	0.11430E-01	0.18349E-01	0.62289
CONSTANT	0.70304	0.32327	2.1748

CANADIAN DOLLAR/JAPANESE YEN

R-SQUARE = 0.9862 R-SQUARE ADJUSTED = 0.9857

RHO1 = 1.47491 RHO2 = -0.48541

VARIABLE NAME	ESTIMATED COEFFICIENT	STANDARD ERROR	T-RATIO 83 DF
GNP	-0.55152E-01	0.32568E-01	-1.6935
UCANM1	0.112563E-03	0.28211E-01	0.44531E-02
RATE	-0.60879E-02	0.24949E-01	- 0.24401
CONSTANT	-5.4709	0.30406	-187.993

For the Canadian dollar/US dollar exchange rate, there is a significant improvement in the R^2 statistic from 0.6095 in the original regression to 0.9851 in the AUTO command regression. However, there is a reversal of the signs of the coefficients of the regressor variables. The GNP and money supply variables now have negative signs and the absolute t-ratios of the coefficients of the GNP and the interest rate variables would be insignificant at the 0.05 significance level. The ACF and PACF of the residuals resulting from the AUTO command regression show that the autocorrelation problem has been solved.. But the combination of a high R^2 and insignificant t-ratios make us suspect the presence of multicollinearity, which will be examined later.

The AUTO command regression results for the Canadian dollar/pound sterling exchange rate also show an improvement in the raw R^2 from 0.9153 to 0.9595. But the signs of the coefficients remain

the same with that of the money supply having the wrong sign. However, the t-ratio for the interest rate is now insignificant, 0.62289 as compared to 4.7873 in the original results. The ACF and PACF of the residuals show that the problem is still not solved. The high R^2, the insignificant t-ratio of the interest rate and the wrong sign of the coefficient of the money supply point to the existence of other problems with the model (or the theory).

The data on the Canadian dollar/Japanese yen exchange rate show a marked increase in the value of R^2 from 0.8071 in the basic results to 0.9862 in the AUTO command results. As for the coefficients, those of the GNP and the money supply retain the original and predicted signs, but that of the interest rate now has the wrong sign. The most notable change is that all the t-ratios are now insignificant. The ACF and PACF of the residuals indicate that the autocorrelation problem has not been solved.

In the final analysis, it does seem that the problem is much more fundamental than that of autocorrelation; there is reason to suspect the existence of a specification error along with multicollinearity. Autocorrelated residuals can arise from functional form- or dynamic mis-specification. A high R^2 in conjunction with a low DW statistic suggests that the model may be mis-specified in some way.

3.5 MULTICOLLINEARITY:

This is a problem associated with the correlation of the explanatory variables in a model, and its existence puts doubt on the reliability of the estimators although they are still best linear unbiased estimators (BLUE). The model is tested for the presence of multicollinearity using a number of tests on the three data sets.

As mentioned earlier, the three regression results have high R^2 coupled with insignificant t-ratios and/or wrong signs of coefficients. This is an indication that multicollinearity may exist in two of the data sets. The correlation coefficients of variables also show the presence of multicollinearity.. For the data sets on the Canadian dollar/US dollar and the Canadian dollar/pound sterling there is no indication of multicollinearity. The Canadian dollar/Japanese yen data indicate a correlation of 0.85175 between the GNP and money supply variables, a correlation of -0.84083 between the GNP and interest rate variables, and a correlation of -0.72303 between the money supply and interest rate variables. The correlation matrices of variables for each of the three regressions are presented below:

CANADIAN DOLLAR/US DOLLAR

CORRELATION MATRIX OF VARIABLES

GNP	1.0000		
UCANM1	-0.36674	1.0000	
RATE	0.68741E-02	0.19859	1.0000
	GNP	UCANM1	RATE

CANADIAN DOLLAR/POUND STERLING

CORRELATION MATRIX OF VARIABLES

GNP	1.0000		
UCANM1	0.11028	1.0000	
RATE	-0.42058	0.57997	1.0000
	GNP	UCANM1	RATE

CANADIAN DOLLAR/JAPANESE YEN

CORRELATION MATRIX OF VARIABLES

GNP	1.0000		
UCANM1	0.85175	1.0000	
RATE	-0.84083	-0.72303	1.0000
	GNP	UCANM1	RATE

Condition indexes and Farrar-Glauber tests can also be used to test for the presence of multicollinearity. The condition indexes for all three regressions do not indicate the existence of multicollinearity. On the bases of the SCALE and COR options in the SHAZAM program, all the condition indexes are below 15. In order to be sure whether multicollinearity is a serious problem, there is a need to go into a more sophisticated test such as the Farrar-Glauber test. The Farrar-Glauber (F-G) test involves testing the null hypothesis that the explanatory variables are orthogonal against the alternative that they are not. A statistic is calculated:

$$\chi 2 = -[n - 1 - 1/6(2k + 5)] \cdot \log_e |R|$$

where R = the value of the standardized determinant.

n = size of the sample

k = no. of explanatory variables

$\chi 2$ has a chi-square distribution with v = 1/2k(k-1) degrees of freedom. If the chi-square calculated is greater than the critical value from the chi-square distribution tables, we reject the assumption of orthogonality. The higher the observed chi-square the more severe is the multicollinearity. On the other hand, if the observed chi-square is less than the critical value, we accept the assumption of orthogonality; that is we accept that there is no significant multicollinearity in the function. The results obtained in this study are as follows: Canadian dollar/US dollar 16.2, Canadian dollar/pound sterling 56.4, and Canadian dollar/Japanese yen 212.2. At the 95% confidence level these indicate that there is non-orthogonality in all three regressions. It should be noted that proof of the existence of multicollinearity must not be based only on the F-G test since this test has an inherent high probability of rejecting the null hypothesis of orthogonality. In order to locate which of the variables are responsible for the multicollinearity, each of the independent variables is regressed on the other two and the t-ratios of the partial correlation coefficients tested at 0.05 significance level. For the Canadian dollar/US dollar data, it is found that the GNP variable is collinear with the money supply variable, which is also collinear with the interest rate variable. All the three variables are collinear with one another in the Canadian dollar/pound sterling data. The data on the Canadian dollar/Japanese yen regression show that the GNP variable is

collinear with the money supply and interest rate variables,, but these two are not collinear.

It should be noted in passing, however, that in spite of multicollinearity, the OLS estimates are still BLUE. The main implication of its existence is that it makes the estimates sensitive to the samples used. It is said that if the estimated equation is to be used for prediction purposes only and that if the multicollinearity is expected to prevail in the situations to be predicted, then one should not bother about it.

3.6 HETEROSCEDASTICITY:

As the data are time series data, there is no a priori reason to suspect the presence of heteroscedasticity, which is mostly a problem associated with cross-sectional data. Nevertheless, graphical plots of the squares of the error terms against the predicted values of the dependent variables and against each of the independent variables are made and examined for the existence of heteroscedasticity. None of them exhibits any pattern indicating the presence of heteroscedasticity, and therefore it is not necessary to go into further tests such as the Park, Glejser, Goldfeldt-Quandt and the Breusch-Pagan tests.

3.7 SPECIFICATION ERROR:

A specification error is likely to be the problem because of the poor estimates even after correcting for autocorrelation in two of the regressions. Two formal tests, the Hausman test and Ramsey's Regression Specification Error Test (RESET) are used to investigate the existence of a specification error.

One specification of the Hausman test requires an OLS regression on the differenced data and a comparison of the results with those obtained from the level data. The fact that there is a break in the data between 1961 and 1971 has made it necessary to drop the 21st observations in the differenced data for the Canadian dollar/US dollar and the Canadian dollar/Japanese yen exchange rates. The test supports the existence of specification errors, because the values of the coefficients are very different in the two sets of regressions. The results of the regressions on differenced data are as follows:

CANADIAN DOLLAR/US DOLLAR

R-SQUARE = 0.1996 R-SQUARE ADJUSTED = 0.1699

DURBIN-WATSON = 1.7981 VON NEUMANN = 1.8195

ANALYSIS OF VARIANCE FROM MEAN

	SS	DF	MS	F
REGRESSION	0.33780E-02	3	0.11260E-02	6.731
ERROR	0.13550E-01	81	0.16728E-03	
TOTAL	0.16928E-01	84	0.20152E-03	

VARIABLE NAME	ESTIMATED COEFFICIENT	STANDARD ERROR	T-RATIO 81 DF
DGNP	-0.14511E-01	0.11363E-01	-1.2770
DUCANM1	-0.11166	0.26476E-01	-4.2174
DRATE	-0.31941E-02	0.10261E-01	-0.31127
CONSTANT	0.38097E-02	0.14317E-02	2.6610

CANADIAN DOLLAR/POUND STERLING

R-SQUARE = 0.6312 R-SQUARE ADJUSTED = 0.6137

DURBIN-WATSON = 2.0168 VON NEUMANN = 2.0474

ANALYSIS OF VARIANCE FROM MEAN

	SS	DF	MS	F
REGRESSION	0.10869	3	0.36230E-01	35.949
ERROR	0.63493E-01	63	0.10078E-02	
TOTAL	0.17218	66	0.26088E-02	

VARIABLE NAME	ESTIMATED COEFFICIENT	STANDARD ERROR	T-RATIO 83 DF
DGNP	-0.50296	0.67203E-01	-7.4841
DUCANM1	-0.11610	0.45568E-01	-2.5479
DRATE	0.59552E-01	0.23639E-01	2.5192
CONSTANT	-0.27629E-02	0.39052E-02	-0.70749

CANADIAN DOLLAR/JAPANESE YEN

R-SQUARE = 0.3807 R-SQUARE ADJUSTED = 0.3577

DURBIN-WATSON = 1.5971 VON NEUMANN = 1.6161

ANALYSIS OF VARIANCE FROM MEAN

	SS	DF	MS	F
REGRESSION	0.71865E-01	3	0.23955E-01	16.594
ERROR	0.11693	81	0.14436E-02	
TOTAL	0.18879	84	0.22475E-02	

VARIABLE NAME	ESTIMATED COEFFICIENT	STANDARD ERROR	T-RATIO 83 DF
DGNP	-0.17084	0.33908E-01	-5.0385
DUCANM1	-0.25333	0.49827E-01	-5.0841
DRATE	0.23671E-01	0.22611E-01	1.0468
CONSTANT	0.99993E-02	0.41766E-02	2.3941

From the above tables, it can be seen that the values of the coefficients derived from differenced data are very different from those of level data. In some cases there were reversals of coefficient signs with some of the t-ratios becoming insignificant. The F statistic on the Canadian dollar/US dollar equation indicates that the explanatory variables do not explain adequately the variability of the dependent variable. The DW statistics and the Von Neumann ratios of two of the regression results show that the residuals are autocorrelated.

Ramsey's RESET test involves finding out if the correct specification of the model involves a nonlinear function of all or some of the

independent variables. It involves plotting $\hat{e}_i$ obtained from the regression against $\hat{Y}_i$. If the plot of the residuals shows a pattern, it suggests that if we introduce $\hat{Y}_i$ in some form as a regressor it should increase the R^2. And if the increase in R^2 is statistically significant (on the basis of the F test), it would suggest that the original model was mis-specified. In the SHAZAM program, the RESET test is automatically carried out with the use of the DIAGNOS/RESET command. The results of the tests for two of the regressions, the Canadian dollar/US dollar and the Canadian dollar/Japanese yen, indicate that the monetarist model is mis-specified. But that of the Canadian dollar/pound sterling fails to support a mis-specification as the F statistic is insignificant.

RAMSEY'S RESET SPECIFICATION TESTS USING POWERS OF YHAT

CANADIAN DOLLAR/US DOLLAR

RESET(2) =	16.996	-F WITH DF1 =	1 AND DF2 = 82
RESET(3) =	14.904	-F WITH FD1 =	2 AND DF2 = 81
RESET(4) =	9.9698	-F WITH DF1 =	3 AND DF2 = 80

CANADIAN DOLLAR/POUND STERLING

RESET(2) =	4.2372	-F WITH DF1 =	1 AND DF2 = 63
RESET(3) =	3.4675	-F WITH DF1 =	2 AND DF2 = 62
RESET(4) =	2.4944	-F WITH DF1 =	3 AND DF2 = 61

CANADIAN DOLLAR/JAPANESE YEN

RESET(2) =	19.547	-F WITH DF1 =	1 AND DF2 = 82
RESET(3) =	12.540	-F WITH DF1 =	2 AND DF2 = 81

Attempts have been made in this study to specify the model in some other way by incorporating lags of the dependent and independent variables as additional regressors. The results are not impressive except for the fact that the coefficients of the lags of the dependent variables in the three regressions are significant. To test whether it is necessary to add the lagged dependent variable as an explanatory variable a COMFAC test is done. The test involves a comparison of the product of the coefficients of the lagged endogenous variable and a particular exogenous variable with the coefficient of the lag of the exogenous variable. If they are equal in magnitude and opposite in sign, then there is a common factor between the endogenous variable and the particular exogenous variable. And in this case the problem is autocorrelation. Of the nine such comparisons made in this study seven of them indicate the existence of common factors. The implication of this finding is that it is not necessary to incorporate the lag of the endogenous variable in this model. The results are shown below.

COMFAC ANALYSIS

CANADIAN DOLLAR/US DOLLAR

R-SQUARE = 0.9868 R-SQUARE ADJUSTED = 0.9858

VARIABLE NAME	ESTIMATED COEFFICIENT	STANDARD ERROR	T-RATIO 78 DF
LFOREX3	0.99063	0.14232E-01	69.605
GNP	-0.16586E-01	0.11526E-01	-1.4391
LGNP	0.14612E-01	0.11694E-01	1.2495
UCANM1	-0.11134	0.26976E-01	-4.1273
LUCANM1	0.11039	0.26505E-01	4.1650
RATE	-0.10386E-01	0.11614E-01	-0.89431
LRATE	-0.55149E-02	0.11586E-01	-0.47599

CANADIAN DOLLAR/POUND STERLING

R-SQUARE = 0.9613 R-SQUARE ADJUSTED = 0.9574

VARIABLE NAME	ESTIMATED COEFFICIENT	STANDARD ERROR	T-RATIO 60 DF
LCANUK3	0.7813	0.78472E-01	9.9530
GNP	-0.52530	0.69953E-01	-7.5093
LGNP	0.37660	0.78815E-01	4.7782
UCANM1	-0.15684	0.48309E-01	-3.2467
LUCANM1	0.11755	0.48568E-01	2.4202
RATE	0.57289E-01	0.23255E-01	2.4635
LRATE	-0.75372E-01	0.23779E-01	-3.1697

CANADIAN DOLLAR/ JAPANESE YEN

R-SQUARE = 0.9901 R-SQUARE ADJUSTED = 0.9893

VARIABLE NAME	ESTIMATED COEFFICIENT	STANDARD ERROR	T-RATIO 78 DF
LCANJAP3	1.0009	0.23746E-02	421.50
GNP	-0.18227	0.33161E-01	-5.4965
LGNP	0.15167	0.34896E-01	4.3464
UCANM1	-0.24237	0.49943E-01	-4.8528
LUCANM1	0.25407	0.48765E-01	5.2101
RATE	0.12276E-01	0.22953E-01	0.53485
LRATE	-0.21210E-01	0.22817-01	-0.92960

Two other regressions using only data for the period 1971 to 1987 are also run in order to verify whether the break in the data for the Canadian dollar/US dollar and the Canadian dollar/Japanese yen regressions have had serious impacts on the results of the study. The results obtained, which are reported below, still do not support the claim of the flexible-price monetarist exchange rate model.

CANADIAN DOLLAR/US DOLLAR

R-SQUARE = 0.4311 R-SQUARE-ADJUSTED = 0.4041

DURBIN-WATSON = 0.1750 VON NEUMANN RATIO = 0.1777

VARIABLE NAME	ESTIMATED COEFFICIENT	STANDARD ERROR	T-RATIO 63 DF
GNP	0.73102E-01	0.24717E-01	2.9576
UCANM1	0.25442	0.42321E-01	6.0118
RATE	0.44572E-01	0.64302E-01	0.69317
CONSTANT	1.0687	0.15521	6.8856

CANADIAN DOLLAR/JAPANESE YEN

R-SQUARE = 0.7479 R-SQUARE ADJUSTED = 0.7359

DURBIN-WATSON = 0.2701 VON NEUMANN RATIO = 0.2742

VARIABLE NAME	ESTIMATED COEFFICIENT	STANDARD ERROR	T-RATIO 63 DF
GNP	-0.14571	0.60082E-01	-2.4252
UCANM1	0.76344E-01	0.96805E-01	0.78863
RATE	0.53913	0.58543E-01	9.2093
CONSTANT	-5.7270	0.26570	-21.554

4. CONCLUSION

As mentioned in the introduction, the purpose of this study is to examine the adequacy of the flexible-price monetarist model in explaining exchange rate fluctuations. The main focus has been on the Canadian dollar exchange rate, and data on the Canadian dollar/Us dollar, the Canadian dollar/pound sterling and the Canadian dollar/Japanese yen have been used for the analysis. From the results obtained it is obvious that the model is unsatisfactory in explaining the variability of the Canadian dollar exchange rate. The results indicate that some important variables may have been left out of this model. Earlier work by Rudiger Dornbusch supports the results reported here. Using time series data on the US dollar/Deutsch mark exchange rate to test the adequacy of the model, he comes to the following conclusion (Bhandari and Putnam, 1983):

"The evidence on PPP and the econometric evidence reported here leave little doubt that the monetary approach in the form of equation (3) is an unsatisfactory theory of exchange rate determination. The key link between exchange rate and PPP fails to hold, and any reasonable model must include a theory of real exchange rate determination."

The results obtained by Dornbusch show that some of the coefficients have signs which are contrary to what the model leads us to expect, and some of the t-ratios are insignificant. For some periods, the R^2 is high while it is low for others.

Further econometric evidence on the inadequacy of the flexible-price model has been reported in a publication by the OECD (See OECD,

1985). According to the report, some relatively successful results were obtained for the model by Frenkel for the 1920s and by Bilson for the period 1970-1977. However, these positive results on the explanatory power of the model have been offset by the observation (by Frankel, Haache and Townend among others) of data which contradict the model's prediction about the relationship between exchange rates and interest rates. The OECD report also states that "there may be an inherent mis-specification in the usual assumption that the money supply (particularly its external counterpart) and interest rate are exogenous to the exchange rate".

The empirical validity of the model has been questioned on the basis of more recent work on PPP. This has led to increasing doubts about the reliability of PPP even in the long-run, and to a general acceptance of its failure in econometric investigations to explain some of the most important exchange rate developments in recent years. For example, Dornbusch (1978) found that the model could not explain the depreciation of the US dollar in 1977-78 which occurred in spite of the relatively slow monetary growth in the United States. Haache and Townend (1981) obtained similar results when they attempted to explain the movements in sterling between 1972 to 1980 in terms of a number of variants of the flexible-price model. Beenstock, Budd and Warburton (1981), using this same model, also failed to quantify the influences which had resulted in the pound sterling's appreciation between 1976 and 1980. Finally, Frankel (1981) described the failure of the model to fit 1974-81 data for most of the major currencies.

Available evidence thus points out the inadequacy of the model to explain in a satisfactory manner the variability of the exchange rate. It is therefore necessary that future econometric studies of exchange rate determination will need to focus on models that incorporate more explanatory variables and on those which consider other functional forms of the relationship between the exchange rate and its relevant explanatory variables.

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