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THE ROLE OF U.S. INTEREST RATES IN CANADIAN INTEREST-RATE EQUATIONS: AN EXPLORATORY ANALYSIS

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RÉSUMÉ

Dans cette étude, les auteurs analysent en détail l'importance relative des taux d'intérêt américains et canadiens dans la détermination de trois taux canadiens à court terme, soit le taux des dépôts à terme, le taux du papier des sociétés de financement et le taux de base des prêts bancaires. La principale technique employée consiste en une analyse de régression portant sur les statistiques hebdomadaires des taux d'intérêt de la période comprise entre 1963 et 1975. Aux fins de comparaison, les auteurs ajoutent à cette étude des équations mensuelles et trimestrielles. Utilisant une seconde approche, les auteurs effectuent une analyse des composantes principales pour isoler les variations autonomes des taux canadiens non expliquées par des variations des taux américains. Tout au cours de cette étude, les auteurs suivent de près les variations structurelles qui ont influencé le comportement des taux d'intérêt canadiens durant la période en question et analysent également la façon dont se détermine le report sur le dollar canadien. Ils en arrivent à la conclusion générale que les taux américains jouent un plus grand rôle dans la détermination du taux du papier des sociétés de financement canadiennes que dans celle du taux des dépôts à terme canadiens; cette conclusion est compatible avec le fait que les étrangers détiennent une part beaucoup plus importante du papier des sociétés de financement canadiennes que des dépôts à terme canadiens.

ABSTRACT

In this study the authors examine in detail the relative importance of U.S. and Canadian interest rates in the determination of three Canadian short-term interest rates: the term-deposit rate, the rate on finance company paper and the prime loan rate. The main technique used is regression analysis on weekly interest-rate data for the period 1963-75. Monthly and quarterly equations are also presented for comparison. A second approach employs principal-components analysis to isolate the independent variation of Canadian interest rates that is not explained by movements of U.S. rates. Throughout the study, careful attention is paid to structural changes over the period that have affected the behaviour of Canadian interest rates. In the course of the analysis the authors also examine the determination of the forward premium of the Canadian dollar. The general conclusion is that U.S. interest rates are more important in the determination of the interest rate on Canadian finance company paper than in the determination of the Canadian term-deposit rate, a result that is consistent with the fact that foreigners hold a substantially larger share of Canadian finance paper than of Canadian term deposits.

1 INTRODUCTION

The authors of several recent studies have attempted to explain the behaviour of particular interest rates in terms of other, presumably more basic, interest rates.[1] In at least two studies of the Canadian financial system, [9] and [21], U.S. interest rates have played an important role in the explanation of Canadian interest rates. Here we examine in more detail than previously the role of U.S. interest rates in the interest-rate equations for three Canadian short-term rates: the rate on 90-day, non-personal term and notice deposits at Canadian chartered banks (the term-deposit rate), the rate on 90-day finance company paper, and the rate on prime business loans at Canadian chartered banks. The period considered in this report is July 17, 1963, to December 31, 1975.

There are at least three interpretations for the role of U.S. interest rates in explaining Canadian interest rates. The first interpretation involves the reaction of the Bank of Canada to changes in U.S. interest rates. This reaction-function approach has been used to explain the one- to three-year Government of Canada bond rate [14, 21], and the 90-day finance-paper rate [14].[2] Although several other variables help to determine Canadian interest rates, the role of U.S. interest rates is very significant in the reaction-function approach.

The second interpretation focusses on the role of international capital flows. Thus changes in U.S. interest rates lead to changes in the demand for and supply of Canadian-dollar financial instruments. These latter changes, in turn, affect Canadian interest rates.[3] This formulation has been applied to long-term Canadian interest rates as part of a small model explaining long-term interest rates, portfolio capital flows, and net new issues of securities retained in Canada [7]. It has also been used to explain the setting of the swapped deposit rate by Canadian banks [16]. A similar approach is employed by Clinton and Masson [9] to explain the determination by banks of the interest rates they pay on their notice deposits.[4]

The third interpretation of the introduction of U.S. interest rates into Canadian interest-rate equations is based on expectations and is used in the determination of Canadian long-term interest rates. The U.S. long rate is employed "as a measure of prevailing opinion concerning the level of North American interest rates that is viable in the long run" [7, pp. 116-117]. Similar roles for U.S. interest rates are reported in [9] and [21].

In this study weekly data on a number of Canadian and U.S. interest rates are used to determine the relative importance of U.S. rates compared with Canadian rates in the determination of three short-term Canadian interest rates: the term-deposit rate, the finance-paper rate, and the prime rate.[5] We focus on the second interpretation of the presence of U.S. interest rates in the equations, namely the substitutability between Canadian and U.S. instruments when relative interest rates change. In the course of examining the determination of Canadian interest rates, we comment on the interdependence of the term-deposit rate and the finance-paper rate, the determination of the forward premium on the Canadian dollar, and the effect on interest-rate determination of changes in economic structure (e.g., the Bank Act revision and the Winnipeg Agreement, Section 3.B). We also deal with the question of how the use of average monthly data, end-of-month data and average quarterly data affects the empirical results. In some of our regressions we use the principal components of various interest rates as explanatory variables instead of the individual interest rates themselves. Finally, we compare the size of the coefficients on U.S. interest-rate variables in Canadian interest-rate equations with the magnitudes of foreign holdings of Canadian financial instruments.

Generally speaking, the results indicate that changes in U.S. interest rates have a greater effect on the finance-paper rate than on the term-deposit rate. This is consistent with the fact that the share of Canadian finance paper held by foreigners is substantially greater than the share of Canadian term deposits held by foreigners. However, the sensitivity of the interest-rate equations to the method of estimation and the lack of robustness of the equations over the various periods (due in part to structural changes) imply that further research is necessary to obtain completely satisfactory results.

The study is arranged as follows: In Section 2 we examine the models of interest-rate determination needed for the specification of the regression equations. In Section 3 we discuss the data used, the various structural breaks over the period July 17, 1963, to December 31, 1975, and the econometric techniques employed. The weekly interest-rate equations are presented in Section 4 and the monthly and quarterly equations in Section 5. In Section 6, we present some of the results produced by principal components analysis. The results of the interest-rate equations are compared in Section 7 with data on the magnitudes of particular instruments held abroad.

2 MODELS OF INTEREST-RATE DETERMINATION

2.A Market-Determined Rates of Interest

Assume a market for a financial instrument, such as finance paper, in which interest rates are determined by the equilibration of demand and supply.

$$D(i,\ I,\ W,\ \Delta W) = S(i,\ J,\ T,\ \Delta T)$$

$$\frac{\partial D}{\partial i} > 0,\ \frac{\partial D}{\partial I} < 0,\ \frac{\partial D}{\partial W} > 0,\ \frac{\partial D}{\partial \Delta W} \gtrless 0$$

$$\frac{\partial S}{\partial i} < 0,\ \frac{\partial S}{\partial J} > 0,\ \frac{\partial S}{\partial T} > 0,\ \frac{\partial S}{\partial \Delta T} \gtrless 0.$$

Here D, the stock demand for the financial instrument, is a function of the interest rate on the financial instrument (i), the rates on competing instruments (I), a scale variable such as wealth (W), and, possibly, the change in W. The supply of the instrument in question (S) is a function of the interest rate on the instrument (i), the interest rates on other liabilities of the issuer[6] (J), a scale variable such as the total debt of the issuer (T), and the change in T. Solving for i results in the regression equation

$$i = f(I,\ J,\ W,\ \Delta W,\ T,\ \Delta T)$$

$$\frac{\partial i}{\partial I} > 0,\ \frac{\partial i}{\partial J} > 0,\ \frac{\partial i}{\partial W} < 0,\ \frac{\partial i}{\partial \Delta W} \gtrless 0,\ \frac{\partial i}{\partial T} > 0,\ \frac{\partial i}{\partial \Delta T} \gtrless 0.$$

Because we were using weekly data it was impossible to introduce scale variables into the actual regression. However, in the context of an equation using monthly data we did enter a relative supply variable of the form s/w*, where s is total Canadian dollar short-term paper outstanding and w* is currency and privately held deposits at chartered banks, a proxy for w.[7] To test the notion that the market has difficulty 'digesting' a large increase in the supply of a financial instrument in a short time, we also entered the percentage increase in the amount of the financial instrument outstanding, $\Delta \ln S$, as an explanatory variable in the determination of i.[8] To test whether tightness in the banking system affects the rate on finance paper directly, and not simply through its effect on the term-deposit rate, we also entered a variant of the chartered bank free liquid asset ratio (FMA) as an explanatory variable in the equations for the rate on finance paper. In addition, to allow for the possibility that U.S. rates compete on a covered basis with Canadian rates, we entered the interest-rate equivalent of the forward spread (RFS) into the equation. Thus the basic regression equation used was

$$i = b_0 + \Sigma c_k I_k + \Sigma d_m J_m + b_1 RFS + b_2 \frac{S}{W^*} + b_3 \Delta \ln S + b_4 FMA$$

We expect that the sum of all the interest-rate coefficients in the equation will be about one and that the size of the coefficients on the interest-rate variables will be directly related to the importance of the competitive instrument as a substitute in either the demand or supply function for the instrument under study. For example, the size of the coefficient c_1 will be related to the magnitude of $\frac{\partial D}{\partial I_1}$ and the size of d_1 will be related to the magnitude of $\frac{\partial S}{\partial J_1}$. Also, by entering uncovered U.S. dollar interest rates and RFS separately into the above equation (rather than covered interest rates), we get an indication of the relative importance of uncovered and covered capital flows responding to changes in U.S. interest rates.[9]

2.B Administered Rates[10]

Assume that the demand for term deposits issued by a bank can be written as

$$D(i, I) \qquad \frac{\partial D}{\partial i} > 0, \frac{\partial D}{\partial I} < 0$$

where

i is the rate of interest paid on the term deposit, and

I is the rate paid on competing instruments.[11]

If the average interest rate on assets in which the banks invest is r, then (ignoring reserves held by the banks) bank profits, P, are P = (r-i)D. Assume for the moment that r is not under the control of the banks; then differentiating P with respect to i gives

$$\frac{\partial P}{\partial i} = (r-i)\frac{\partial D}{\partial i} - D = 0$$

The implicit-function theorem can be used to show that i is a function of r, I, and other variables entering the demand function for deposits. Thus the regression equation becomes

$$i = \Sigma c_k I_k + \Sigma d_m r_m + u$$

where

I represents the various competing rates,

r represents the rates on the various investment assets, and

u captures any other variable entering the demand function and any other factor affecting bank behaviour.

By entering a variant of the free liquid asset ratio as an explanatory variable, we tested the hypothesis that tightness in the banking system will affect the interest rate offered on term deposits. The introduction of RFS into the equation allowed for the possibility that it is covered U.S. dollar instruments that compete with term deposits.

In this equation we expect that the sum of the coefficients on all the interest rates, I and r, is equal to about one.[12] The size of the coefficient c_1 is related to the magnitude $\frac{\partial D}{\partial I_1}$. That is, the more strongly instrument 1 competes with term deposits, the more the banks will respond to changes in the interest rate on instrument 1. Also, the size of the coefficient on RFS compared with the size of the coefficients on U.S. interest rates will indicate the relative importance of uncovered capital flows when interest rates change.

When the analysis is broadened to include the possibility that the banks set the prime rate on loans and that the quantity of loans is determined by borrowers as a function of the prime rate and of interest rates on other forms of corporate borrowing two cases result.[13] If the banks invest in an asset on which the interest rate is set by market forces and free of bank influence,[14] then the term-deposit rate will be a function of the rates on instruments competing for the funds of depositors and of the rates on investment assets determined by the market. The term-deposit rate will not, however, be a function of the prime rate or of rates on other forms of corporate borrowing. The prime rate will be a function of interest rates on competing forms of borrowing and of rates on investment assets determined by the market. The prime rate will not, however, be a function of the term-deposit rate or of rates on instruments competing for the funds of depositors.

If, on the other hand, term deposits are used entirely for making business loans and if the banks do not invest in any asset with a market-determined rate of interest, then the prime rate and the term-deposit rate will each be a function of rates on instruments competing for the funds of depositors and of rates on forms of corporate borrowing competing with bank loans. It can be shown that the rates on instruments competing for the funds of depositors will play a relatively more important role than the rates on other forms of corporate borrowing in the equation for the interest rate on term deposits. It can also be shown that rates on competitive forms of borrowing will play a relatively more important role than the rates on instruments competing for the funds of depositors in the equation for the prime rate. Unfortunately, since finance paper plays a dual role in that it is both an alternative instrument for depositors and an alternative form of borrowing for corporations, it may not be possible to infer from the econometric results which of the two cases mirrors the Canadian situation better.[15]

2.C The Interest-Rate Equivalent of the Forward Spread (RFS)

An equation for RFS is needed to deal with simultaneity problems. Also, it would be interesting to know which Canadian and which U.S. dollar interest rates have been most important in the determination of RFS. In the case of U.S. dollar rates, we wish to know the relative importance of Euro-dollar rates vis-à-vis interest rates in the United States.

The regression equation used is

$$RFS = \Sigma c_k RCAN_k - \Sigma d_k RUS_k + b_1 \frac{\Delta PFX}{PFX_{-1}} + b_2 \frac{\Delta PFX_{-1}}{PFX_{-2}}$$

where

RCAN represents Canadian interest rates,

RUS represents U.S. dollar interest rates, and

$\Delta PFX/PFX_{-1}$ is the percentage change in the spot exchange rate. The latter variable and its lagged value are introduced as a simple form of speculative influence on RFS. We expect Σc_k to equal Σd_k and the sums to be equal to the arbitrage element in the determination of RFS.[16]

3 THE EMPIRICAL APPROACH

3.A Data

The interest-rate series used in this paper have been collected from a variety of sources by the Bank of Canada. The rates are generally those prevailing on Wednesday of each week.[17] When rates have been collected on a different basis, we have attempted to adjust them to make them comparable.[18] The following mnemonics denoting interest rates are used throughout:

RCBANK Bank Rate set by the Bank of Canada

RCCD Interest rate on 90-day deposit receipts or term deposits, at Canadian chartered banks

RCDAY Interest rate on day loans at Canadian chartered banks

RCFP Interest rate on 90-day Canadian finance company paper

RCPRI Interest rate on prime business loans at Canadian chartered banks

RCTB Interest rate on three-month Government of Canada treasury bills

RED Interest rate on three-month Euro-dollar deposits in

London

RFS	Ninety-day forward spread between the U.S. dollar and the Canadian dollar expressed as an annual interest rate
RUSCD	Interest rate on three-month U.S. certificates of deposit
RUSCOM	Interest rate on 90-day U.S. commercial paper[19]
RUSFP	Interest rate on 90-day U.S. finance company paper
RUSPRI	Interest rate on prime business loans at U.S. banks
RUSTB	Interest rate on three-month United States treasury bills

In addition to the interest rates there are two other non-dummy explanatory variables:

FMAi	The ratio of 'free' Canadian liquid assets to total Canadian dollar major assets of Canadian chartered banks minus a moving average of this ratio taken over i periods
PFX	Spot exchange rate (Canadian cents per U.S. dollar), average noon rate

3.B Structural Breaks

During the period considered in this report - July 17, 1963, to December 31, 1975 - there were a number of major institutional changes and other types of structural breaks in the economy that affected the interest-rate equations. We have taken these changes into account by including dummy variables or by testing for structural change in coefficients at the time these changes occurred. For convenience we list here all the structural changes examined.

The failure of Atlantic Acceptance Corporation Limited in the summer of 1965 raised the risk premium associated with 90-day finance paper. Having defaulted on some of its short-term obligations and having been placed in receivership in mid-June, Atlantic Acceptance had its shares suspended from trading on the Toronto Stock Exchange on July 13. By the following week there was a distinct upward jump in the interest rate on 90-day finance company paper. This was followed by another jump during the week of August 18. These events are picked up by the dummy variables QATL1 (equals one from July 21 to August 11) and QATL2 (equals one from August 18 until the 1967 Bank Act revision). In the monthly and quarterly equations in Section 5, QATL takes on the value one for the period July 1965 - June 1967.

Most of the other institutional changes directly affected the term-deposit market in Canada. The first of these was the revision of the Bank Act in 1967, which eliminated the interest-rate ceiling on chartered bank loans and prohibited collusion among banks on interest rates.[20] Between June 14 and June 21, 1967, the term-deposit rate rose 90 basis points, while all other interest rates moved very slowly. We thus date our post-Bank Act revision period from June 21, 1967, and therefore the dummy variable QDBA, which we use to represent the effects of the Bank Act revision, has the value one from that date on.

In 1969 the Bank of Canada's goal of reducing the availability of credit provided by the chartered banks was effected in part "by the Bank's request to the larger chartered banks that they compete less aggressively for large blocks of Canadian dollar short-term deposits ... In response to the requests of the Bank of Canada, the larger banks ... limited the rates paid on their short-term Canadian dollar certificates of deposit" [2, p. 12]. The maximum rate on term deposits stayed at 7.5 percent from July 30, 1969, to May 27, 1970. We refer to this period as the 1969-70 control period.

Again in 1972, interest-rate ceilings on 90-day term deposits came into play. Under the Winnipeg Agreement, which became effective June 12, 1972, "the banks requested and received the concurrence of the Minister of Finance, in accordance with Section 138 of the Bank Act, to an agreement that rates of interest offered on deposits of $100,000 or more for terms up to 364 days would be limited to a maximum of 5.5 percent" [3, p. 16]. The agreement permitted the chartered banks to adjust this ceiling as the general level of interest rates in Canada changed. The Winnipeg Agreement was terminated in early January 1975.

During the first ten weeks of 1968 Canada had a balance-of-payments crisis arising from the announcement of a new U.S. balance-of-payments program at the beginning of 1968. The crisis ended in March when it was announced that Canada was to be exempted from the U.S. controls. The variable QCRISIS, which has the value one for these ten weeks, is used to represent the effect of the crisis in the RFS equations.

One would think that expectations in the foreign exchange market might by formed differently under fixed and flexible exchange-rate regimes. We therefore tested for a change in the structure of the RFS equation as of June 1, 1970, when Canada changed from a fixed to a floating rate.

3.C Econometric Techniques

Since the theory described above gives no precise indication of which interest rates belong as explanatory variables in the equations for RCCD, RCFP, RCPRI, and RFS, the strategy used in this study was to run initial ordinary least squares (OLS) regressions containing all the interest rates described in Section 3.A as explanatory variables. In addition chartered bank liquidity variables were constructed, by subtracting the moving average of the lagged free liquid asset ratio from its current value, and used in the RCCD, RCFP, and RCPRI equations. Terms to capture expected exchange rate movements were also constructed from PFX and its lagged values and then used in the RFS equation. Supply variables were also entered into the monthly RCFP equation.

Insignificant explanatory variables or variables with the wrong sign in the initial regression were dropped and the regression was allowed to choose the appropriate interest rates. Given the many interest rates, the explanatory variables were dropped only one or two at a time. Then checks were made to determine whether the order of dropping the variables affected the list of interest rates that belonged.

Once the best OLS regression was decided upon, the equation was subjected to a number of statistical tests to determine the appropriate lag structure and stochastic specification. The tests used follow Hendry [23]. We started with our best OLS regression and its Hildreth-Lu [28] counterpart and performed a X^2 test to determine whether there was significant first-order autocorrelation. If autocorrelation was found to be significant, we tested to see if it derived from true autocorrelation of the error terms or from dynamic misspecification (i.e., the omission of lagged dependent and independent variables). This was done by running a regression with all the appropriate lagged variables and by testing, with the X^2-statistic, the nonlinear restrictions that would hold if the true model were the first-order autocorrelation of the error terms. If autocorrelation was significant and we could not reject the null hypothesis of autocorrelation in the test versus dynamic misspecification, we dropped any insignificant variables and repeated the procedure. Otherwise we reformulated the equation by including the lagged variables found to be significant in the general regression that included lagged variables and by dropping the impact variables found to be insignificant. We then repeated the procedure while ensuring that explanatory variables were not repeated. Checks were made to ensure that, by throwing out a number of insignificant variables at once, we had not mistakenly thrown out a variable that by itself would be significant.

To deal with problems of simultaneous equation bias we used an instrumental-variable technique (two-stage least squares). From the final OLS equations for RCFP, RCCD, RCPRI, and RFS, we drew up a list of all the predetermined variables in the system including the lagged endogenous variables. Fitted values for each endogenous variable were constructed from a regression of each variable on all the predetermined variables. The four equations were then re-estimated by an instrumental-variable technique involving the use of fitted values as instruments for the endogenous variables and the use of predetermined variables as their own instruments.[21]

4 WEEKLY INTEREST-RATE EQUATIONS

4.A The Interest Rate on Canadian Finance Paper (RCFP)

As discussed in Section 3.C we began by regressing RCFP on all the available Canadian and U.S. interest rates and on RFS for the entire period 1963-75. Systematically dropping insignificant variables and those having the wrong sign we arrived at the first equation presented in Table 1. The t-statistics are shown in parentheses below the coefficients. The sum of the coefficients on the three Canadian variables is only slightly greater than the coefficient on the U.S. certificate of deposit rate.[22] The rate on Canadian term deposits is by far the most important Canadian rate. A decrease in the tightness of the banking system - an increase in FMA12 - leads to a decline in RCFP. Presumably, reduced tightness in the banking system leads to increased demand by banks for short-term liquid assets, which helps to drive down RCFP.[23]

Because FMA12 is the difference between the current free liquid asset ratio and a 12-week moving average of past values of this ratio, a permanent increase of 1 percent in the free liquid asset ratio of the banks would lead to a decrease of 7.7 basis points in RCFP in the first week, followed by increases of 0.64 basis points in each of the next twelve weeks, which would result in a return to the original value of RCFP, and have no effect thereafter. The behaviour of the Atlantic Acceptance dummy variables shows the substantial increase in finance paper interest rates caused by the failure of Atlantic

Acceptance.[24]

The second equation in Table 1 differs only in that QDBA, the dummy variable for the Bank Act revision, is introduced. Although a slightly different set of variables proved to be significant and the sum of the coefficients of U.S. rates is now slightly greater than the sum of the coefficients of Canadian rates, this equation gives the same general impression as the first equation.[25,26]

The next step was to do a Hildreth-Lu transformation on the basic equations. The correction for first-order serial correlation in the error term for equation 1 led to equation 3 in Table 1. Although all the coefficients remained significant there were substantial changes in the relative importance of the various interest rates, especially of RUSCD and RFS, the coefficients on which declined substantially. The null hypothesis that there was no serial correlation was strongly rejected. The X^2 on this test was 593.46 compared with a critical X^2 of 3.84.

Following the Hendry procedure, we tested whether this autocorrelation derived from true autocorrelation of the error terms or from the dynamic adjustment of the dependent variable to changes in the independent variables. The X^2 on the hypothesis that it was autocorrelation of the error term rather than true dynamics that underlay the RCFP equation was 36.20 compared with a critical X^2 of 15.51. Therefore we concluded that RCFP responds with a lag to changes in the explanatory variables.

The best dynamic equation we were able to find, after various intermediate statistical tests on first-order and second-order lags, is presented as equation 4 in Table 1. In the first row of this regression we give the coefficients of the current explanatory variables and of $RCFP_{-1}$, in the second row the coefficients of the explanatory variables lagged once and of $RCFP_{-2}$, and in the third row the coefficients of the explanatory variables lagged twice and of $RCFP_{-3}$. The equilibrium effect of changes in the various explanatory variables of RCFP is given in the final row. Further testing showed no autocorrelation of the errors when the Hildreth-Lu technique was applied to equation 4. The X^2 on this test was 0.57 compared with a critical X^2 of 3.84.

The equilibrium effects in equation 4 are similar to those in equation 1 for the OLS equation without lags. The sum of the equilibrium effects of a change in Canadian rates is .605, slightly larger than the equilibrium effect of a change in the U.S. rate. The sum of all the equilibrium effects is 1.177. The equilibrium effect of a change in RFS is 78 percent of the equilibrium effect of a change in RUSCD. This indicates that 78 percent or more of the capital movements in response to changes in relative interest rates is covered. It also indicates that we are capturing the substitution effect of changes in interest rates rather than the reaction function of the Canadian authorities.[27]

The hypothesis of a structural break at the time of the Bank Act revision was subjected to a Chow test on the preferred equation - equation 4. The F-statistic was 1.15, substantially smaller than the critical F of 1.79 at the 5 percent level of significance. Nonetheless, it is interesting to examine the preferred equations that

Table 1

WEEKLY EQUATIONS FOR RCFP (WHOLE PERIOD)

Lag structure	C	RCCD	RCT8	RCPRI	RUSCD	RUSFP	RUSPRI	RFS	FMA12	QATL1	QATL2	QD8A	$RCFP_{-1}$	U_{-1}	SEE	R^2	DW
(1)	-.518 (8.75)	.353 (12.25)	.107 (7.45)	.135 (6.98)	.544 (28.57)			.423 (20.44)	-.077 (4.12)	.296 (2.23)	.577 (19.97)				.228	.982	.523
(2)	-.394 (8.03)	.438 (14.35)	.095 (6.75)		.413 (14.41)	.097 (2.19)	.127 (5.28)	.417 (18.43)	-.079 (4.30)		.369 (10.41)	-.302 (8.91)			.219	.983	.537
(3)	-.603 (2.11)	.547 (13.41)	.049 (3.44)	.247 (5.40)	.283 (8.86)			.106 (4.26)	-.044 (2.08)	.227 (2.10)	.525 (5.26)			.926	.173	.990	1.788
(4) Current	-.149 (4.20)	.396 (9.28)	.022 (2.41)	.145 (2.78)	.208 (6.53)			.086 (5.67)	-.023 (2.14)	.176 (1.67)	.375 (3.47)		1.003 (22.45)		.123	.995	1.892
Lag 1		-.338 (7.63)		-.109 (2.15)	-.016 (0.35)					-.125 (1.08)	-.261 (2.40)		-.131 (2.15)				
Lag 2					-.082 (2.46)								-.065 (1.77)				
Equilib.		.303	.115	.187	.571			.446	-.120	.264	.593						

Table 2

WEEKLY EQUATIONS FOR RCFP

Period	Lag structure	C	RCCD	RCT8	RCPRI	RUSCD	RUSCOM	RUSPRI	RED	RFS	FMA12	QATL1	QATL2	$RCFP_{-1}$	SEE	R^2	DW
(1) Prior to Bank Act revision	Current	-.030 (0.06)	.224 (2.76)	.191 (2.29)	.314 (1.69)				.079 (4.36)	.060 (2.71)	-.020 (1.95)	.218 (3.53)	.483 (5.04)	1.078 (16.23)	.060	.996	2.23
	Lag 1		-.208 (2.67)	-.137 (1.64)	-.303 (1.68)							-.211 (2.88)	-.419 (4.33)	-.228 (3.44)			
	Equilib.		.109	.360	.068				.524	.399	-.135	.042	.433				
(2) Post Bank Act revision	Current	-.219 (4.70)	.423 (8.26)			.065 (1.89)	.314 (5.77)	.051 (2.33)		.121 (5.56)	-.027 (1.78)			1.007 (19.34)	.142	.993	1.94
	Lag 1		-.319 (5.83)				-.263 (6.02)							-.238 (5.36)			
	Equilib.		.450			.283	.222	.220		.524	-.116						

resulted from the use of the same procedures for the two sub-periods. These are presented in Table 2.[28] Not surprisingly, the rate on term deposits is much more important than the treasury-bill rate in the period succeeding the Bank Act revision; the treasury-bill rate is much more important than the term-deposit rate in the earlier period. Since the term-deposit rate became much less sluggish in the later period one may reasonably suppose that it should play a more important role in this period than previously. The reason for the importance of the Euro-dollar rate in the earlier period is not apparent, although this result is consistent with the findings on the determination of the swapped deposit rate reported in Freedman [16, p. 54].[29] In the later period RUSCOM and RUSPRI are about equally important and RUSCD somewhat more important than the others in terms of equilibrium effect. The significance of the U.S. prime rate may reflect the potential of Canadian finance companies as borrowers from American banks either directly or through their parent companies. Alternatively, it may reflect an increase in the cost of funds to the U.S. investor in Canada [15]. In the first sub-period, U.S. dollar interest rates and Canadian rates are about equally important. In the second sub-period, the U.S. rates are rather more important than Canadian rates. In both sub-periods, as in the entire period, the equilibrium coefficient of RFS is about 75 percent of the sum of the equilibrium coefficients of U.S. dollar interest rates. As explained above, this indicates that at least 75 percent of the capital movement in response to changes in interest rates is covered.

4.B The Interest Rate on Canadian Term Deposits (RCCD)

Because of the many sub-periods considered, we do not present the various intermediate regressions for RCCD in this section but only the final preferred regressions for the various periods and sub-periods. Consequently, the discussion will be less detailed than that for RCFP.

We began by examining the question of a structural break when the Bank Act was revised.[30] The hypothesis that the same equation can be used to explain RCCD before and after the Bank Act revision was rejected strongly. The F-statistic was 9.81 compared with a critical F of 3.08 at the 1 percent level of significance.[31] This result is not surprising in that one effect of the Bank Act revision was a change in the nature of the term-deposit market, leading to greater competition among banks and much more frequent rate changes.[32]

The best equation for the period prior to the Bank Act revision is equation 1 in Table 3. Because of the importance of RCFP in this equation, we tested the hypothesis that the period before and after the failure of Atlantic Acceptance can be explained by the same regression. This hypothesis was rejected with an F-statistic of 4.75 compared with a critical F of 3.41 at the 1 percent level of significance. The final equations for the two sub-periods, based on the Hendry procedure, are equations 2 and 3 in Table 3. In the period prior to the failure of Atlantic Acceptance the Canadian treasury-bill rate and the Canadian Bank Rate appear to have been the dominant Canadian influence on RCCD along with relatively small effects from changes in RCFP. The uncovered U.S. treasury-bill rate also appears

Table 3

WEEKLY EQUATIONS FOR RCCD

Period	Lag structure	C	RCFP	RCTB	RCBANK	RUSTB	$RCCD_{-1}$	SEE	R^2	DW
(1) Prior to Bank Act revision	Current	2.20 (4.44)	.069 (4.67)		.035 (1.42)		.838 (28.86)	.053	.989	2.00
	Equilib.		.426		.215					
(2) Prior to failure of Atlantic Acceptance	Current	-.573 (3.48)	.176 (2.59)	.181 (3.33)	.296 (3.09)	.125 (1.87)	.726 (11.96)	.044	.962	2.14
	Lag 1		-.148 (2.10)		-.193 (2.14)					
	Equilib.		.103	.663	.376	.456				
(3) Post failure of Atlantic Acceptance	Current	.617 (3.85)	-		-		.694 (9.69)	.051	.958	1.82
	Lag 1		-.136 (1.72)		.249 (3.90)					
	Lag 2		.237 (2.75)		-.189 (3.05)					
	Equilib.		.328		.198					

to have had a major effect. The sum of the equilibrium effects of interest rate changes is 1.60 - substantially higher than the value of unity expected a priori.

Equation 3 in Table 3 for the period between the collapse of Atlantic Acceptance and the Bank Act revision has a number of peculiarities. First, there are no immediate effects; all changes require one period to have any effect.[33] Second, the initial effect, although not the equilibrium effect, of an increase in RCFP is negative, a result that we find to be, a priori, unacceptable. Third, the sum of the equilibrium effects falls to a very low .53.[34]

We present the regressions for the period after the 1967 Bank Act revision in Table 4, where equation 1 is the best equation for the entire period, including the 1969-70 sub-period in which RCCD remained at 7.5 percent. The hypothesis that the equation had the same parameters for all five sub-periods - the period immediately following the Bank Act revision, the 1969-70 period of the 7.5 percent rate, the uncontrolled period 1970-71, the Winnipeg Agreement period, and the post-Winnipeg Agreement period - was rejected with an F-statistic of 2.42 compared with a critical F of 1.78 at a 1 percent level of significance.[35] The preferred equations for the four sub-periods for which regressions can be run (i.e., excluding the 1969-70 period in which RCCD remained at 7.5 percent) are presented in rows 2 to 5 in Table 4. Although the specific explanatory variables change in the various sub-periods, a number of regularities do stand out. First, in none of the periods were any of the U.S. rates of great significance in explaining RCCD. Second, the Canadian treasury-bill rate played a

Table 4

WEEKLY EQUATIONS FOR RCCD

Period	Lag structure	C	RCFP	RCTB	$RCPRI_{-2}$	RUSFP	RUSCOM	RFS	FMA4	$RCCD_{-1}$	SEE	R^2	DW
(1) Post Bank Act revision	Current	.127	.688			.056		.038		.696	.196	.982	1.96
		(1.89)	(10.08)			(1.61)		(1.63)		(13.09)			
	Lag 1		-.589							.128			
			(8.04)							(2.58)			
	Equilib.		.565			.319		.217					
(2) Immediate post Bank Act revision	Current	.402	.264	.127						.817	.120	.963	1.97
		(2.90)	(2.02)	(4.26)						(18.95)			
	Lag 1		-.264										
			(2.02)										
	Equilib.		0	.692									
(3) Between controls		.579	.930								.195	.932	1.45
		(4.24)	(33.54)										
(4) Winnipeg Agreement	Current	.137		.419	.279		.178	.240	-.159	.185	.261	.986	2.04
		(0.76)		(3.96)	(3.55)		(4.16)	(4.78)	(1.47)	(2.05)			
	Equilib.			.514	.343		.218	.295	-.195				
(5) 1975		-1.89	.553	.515		.250		.041			.127	.986	2.42
		(5.52)	(5.69)	(6.88)		(2.59)		(0.57)					

major role in the determination of RCCD in three of the four sub-periods. The Canadian finance-paper rate was also important in three of the four sub-periods.[36] Third, the relationship between the coefficient on RFS and the coefficient on the U.S. interest rates is rather peculiar. The former coefficient is greater than the latter in the third sub-period, although theoretically this should not be the case, and the former is substantially less than the latter in the last sub-period.[37] The sum of the coefficients ranged from .69 in the first sub-period to 1.318 in the last sub-period.[38]

Equations for the periods in which RCCD is a posted rate have relatively slow speeds of adjustment - about 20 percent to 30 percent per week - whereas equations for the periods in which RCCD is the actual rate paid on term deposits have very fast speeds of adjustment. An adjustment to the new equilibrium of between 80 percent and 100 percent per week is portrayed by the latter equations.

We can summarize the results of this section and the previous section as follows: First, in general, U.S. dollar interest rates including the Euro-dollar rate play a substantially more important role in the determination of RCFP than in the determination of RCCD.[39] Second, although there is interaction between RCFP and RCCD, most of the time, especially in the later period, RCFP drives RCCD more than RCCD drives RCFP. Third, tightness in the banking system affects RCFP but not RCCD, except possibly during the period of the Winnipeg Agreement. Fourth, supply variables do not seem to affect RCFP. Fifth, in different periods, defined by institutional changes and verified by Chow tests, there are different patterns of results.

4.C The Interest Rate on Canadian Prime Loans (RCPRI)

The best equation for RCPRI during the 1963-75 period, without lags or adjustment for autocorrelation, is equation 1 in Table 5. The Canadian Bank Rate, and the U.S. prime rate are about equally significant in explaining the Canadian prime rate. When the usual battery of tests was applied equation 2 in Table 5 was obtained. The two key variables in the determination of RCPRI are RCBANK with large impact effects but small multiplier effects and RCFP with small impact effects but large multiplier effects. Note that the addition of lagged variables to equation 1 resulted in the coefficient on RUSPRI becoming insignificant. For the period as a whole, and for both sub-periods, the variable for the tightness of the banking system was never significant.

The Chow test on the hypothesis that no change in structure occurred at the time of Bank Act revision yielded an F-statistic of 2.44 compared with a critical F of 1.90 at the 5 percent level of significance and 2.45 at the 1 percent level of significance. Since the test rejects the null hypothesis at the 5 percent level and is marginal at the 1 percent level, we present the preferred equations for the two sub-periods in equations 3 and 4 in Table 5.

For the period preceding revision of the Bank Act the Canadian prime rate is driven by RCBANK,[40] RUSTB, and RUSPRI. The sum of the equilibrium effects is only .176 and the constant explains most of RCPRI. The equilibrium value of the constant is 5.07 compared with a mean value of RCPRI over the period of 5.83. This is not surprising

Table 5

WEEKLY EQUATIONS FOR RCPRI

Period	Lag structure	C	RCFP	RCCD	RCBANK	RUSTB	RUSPRI	$RCPRI_{-1}$	SEE	R^2	DW
(1) Whole		1.458 (21.27)		.073 (1.97)	.416 (14.07)		.421 (14.86)		.418	.930	.06
(2) Whole	Current	.031 (1.57)	.047 (1.78)		.360 (11.01)			.907 (21.24)	.093	.996	2.03
	Lag 1		.058 (1.31)		-.294 (6.25)			.067 (1.60)			
	Lag 2		-.086 (3.06)		-.062 (1.69)						
	Equilib.		.768		.184						
(3) Prior to Bank Act revision	Current	.573 (3.65)			.044 (2.14)	.063 (2.95)	.105 (3.26)	.887 (28.31)	.022	.968	2.13
	Lag 1				-.044 (2.14)	-.046 (2.11)	-.049 (1.18)				
	Lag 2						-.053 (2.14)				
	Equilib.				0	.145	.031				
(4) Post Bank Act revision	Current	.052 (1.64)	.050 (1.48)		.386 (8.91)			.962 (86.15)	.115	.995	2.17
	Lag 1		.059 (1.04)		-.378 (8.63)						
	Lag 2		-.082 (2.30)								
	Equilib.		.709		.228						

given that RCPRI was changed only twice over the entire sub-period.

Equation 4 for the period following the Bank Act revision shows RCPRI responding only to Canadian rates. An initial sharp increase of 39 basis points in RCPRI in response to a 1 percent increase in the Bank Rate slowly declines to an equilibrium increase of only 23 basis points. However, the initial small response to the finance-paper rate eventually builds up to an equilibrium effect of .71. The sum of the equilibrium effects is a reasonable .94. The speed of adjustment for this equation is only 3.8 percent per week - by far the slowest adjustment rate of any variable in this study.

4.D The Forward Spread (RFS)

In most studies of the forward spread and of the forward rate a single U.S. interest rate and a single Canadian interest rate have been used as explanatory variables. We allow all the interest rates available to enter into the determination of RFS, in line with our general approach to interest-rate determination.[41]

For the period 1963-75, after systematically dropping wrong-signed and insignificant variables, we arrived at regression 1 in Table 6. When the usual tests are made for autocorrelation and lagged dependent variables, the preferred equation for the whole period is equation 2 in Table 6. Thus RFS is a function of three Canadian rates, three U.S. dollar rates, and current and lagged changes in the spot rate. In some versions of the equation RUSPRI also enters significantly. These results are consistent with the approach of those dealing in foreign exchange markets who sometimes

Table 6

WEEKLY EQUATIONS FOR RFS

Period	Lag structure	C	RCFP	RCCD	RCTB	RUSCD	RUSCOM	RED	$\Delta PFX/PFX_{-1}$	$\Delta PFX_{-1}/PFX_{-2}$	QCR1S1S	RFS_{-1}	U_{-1}	SEE	R^2	DW
(1) Whole		.216	.565	.185	.102	-.203	-.390	-.278	-34.86	-30.02	.585			.354	.852	0.38
		(3.93)	(12.50)	(4.88)	(3.48)	(3.04)	(5.28)	(8.77)	(3.73)	(3.20)	(4.97)					
(2) Whole		.186	.360	.117	.246	-.122	-.279	-.304	-13.15	-7.31	.610		.859	.197	.954	2.32
		(0.94)	(5.77)	(1.91)	(3.64)	(2.10)	(4.44)	(8.51)	(2.76)	(1.57)	(4.26)					
(3) Fixed	Current	-.160	.132	.067				-.156	-51.03		.627	.769		.183	.918	2.20
		(2.73)	(4.14)	(2.14)				(5.83)	(3.76)		(4.54)	(23.71)				
	Lag 1										-.411					
											(2.97)					
	Equilib.		.573	.291				-.674			.937					
(4) Floating		.501	.486	.267		-.248	-.234	-.353	-11.67	-6.87			.766	.200	.968	2.28
		(2.47)	(7.45)	(3.89)		(3.63)	(3.16)	(8.28)	(2.37)	(1.49)						
(5) Floating	Current	.089	.466	.276		-.237	-.192	-.322	-16.37			.805	-.231	.195	.980	1.94
		(1.64)	(7.46)	(3.99)		(3.23)	(2.43)	(7.88)	(3.51)			(22.08)				
	Lag 1		-.305	-.276		.144	.142	.281								
			(4.60)	(3.99)		(1.84)	(1.86)	(6.65)								
	Equilib.		.827	0		-.474	-.255	-.211								

focus on the covered differential between one pair of rates and sometimes on a totally different pair of rates. That is, as the structure of interest rates of a given term changes in the United States vis-à-vis Canada, the importance of different pairs of interest rates will also change.[42] The regression results give the average effect on RFS of various interest rates over the period being examined. Thus our results indicate that, on average, RCFP played the most important role on the Canadian side in the determination of RFS, with RCCD and RCTB having somewhat smaller effects. Of the U.S. dollar rates, RED was the single most important rate although the sum of the effects of the U.S. rates RUSCD and RUSCOM was greater than the effect of RED. The percentage change in the spot-rate variable is intended to capture the effect of speculation on the Canadian dollar. If the Canadian dollar depreciates, i.e., if PFX increases, then RFS will fall. This implies regressive expectations in that past depreciations of the spot Canadian dollar lead to an appreciation in the forward Canadian dollar relative to the spot Canadian dollar. Thus a 1 percent depreciation leads to a decrease of 0.13 percent in RFS in the first week, an offsetting increase of 0.06 percent in the second week, and an offsetting 0.07 percent increase in the third week following the change. In this equation, therefore, the effects of speculation die out quickly.

The sum of the coefficients on Canadian dollar rates is .72 and that of the coefficients on U.S. dollar rates is .71. This implies that about 72 percent of movements in the forward spread can be explained by arbitrage and the remaining 28 percent can be explained by speculation. These findings on the relative importance of arbitrage are similar to those of Haas [20].

The hypothesis of no structural break on June 1, 1970, when the Canadian dollar was floated, was rejected with an F-statistic of 2.59 compared with a critical F of 1.90 at the 5 percent significance level and 2.45 at the 1 percent significance level. The preferred equations for the two sub-periods are equations 3, 4, and 5 in Table 6.

For the fixed-exchange-rate period the χ^2 -statistic strongly rejected autocorrelation in favour of dynamics.[43] The final equation is equation 3 in Table 6.[44] Here the two Canadian rates entering significantly are RCFP and RCCD, the former being twice as important as the latter. The only foreign rate in the equation is the Euro-dollar rate. Note that the importance of the Euro-dollar rate is consistent with previous findings [16] on the role of the Euro-dollar asset as the main destination of foreign currency investments by Canadian chartered banks in the period preceding the 1968 guidelines. The dummy variable QCRISIS takes on the value of one in the first ten weeks of 1968 when a Canadian balance-of-payments crisis followed the announcements of a new U.S. balance-of-payments program. This crisis ended in March following the announcement that Canada was to be exempted from the U.S. program. According to the regressions the crisis added about 94 basis points to the forward spread on the Canadian dollar.

For the period of the floating exchange rate the test on whether autocorrelation or dynamics is more appropriate rejected autocorrelation at the 5 percent level of significance but not at the

1 percent level. The X^2 on this test was 12.68 compared with a critical X^2 of 12.59 at the 5 percent level of significance. Hence we present both final versions in equations 4 and 5 in Table 6.[45] In both equations RCFP and RCCD are the Canadian interest rates influencing RFS, and the U.S. dollar interest rates determining RFS are RUSCD, RUSCOM, and RED. In both equations RCFP is the more important Canadian rate but the relative importance of the RCFP variable is clearly greater, at least in equilibrium, in equation 5 than in equation 4.[46] Similarly, the equilibrium effects of U.S. rates relative to that of the Euro-dollar rate are larger in equation 5 than in equation 4. The sum of the equilibrium effects of the Canadian rates in both equations is slightly smaller than the sum of the equilibrium effects of the U.S. dollar rates; these sums imply that over 80 percent of movement in RFS is arbitrage determined.

Our procedure, as noted, leads to the conclusion that a number of interest rates influence RFS. An alternative procedure is to find the pair of rates that best explain RFS. To examine the results of this procedure more closely, we ran six sets of regressions using in pairs one of the two Canadian rates RCFP and RCCD and one of the three U.S. dollar rates RUSCD, RUSCOM, and RED that were significant in equation 5 of Table 6. Each equation covered the floating period, with some gaps because of missing data, and each included the contemporaneous and lagged value of the interest-rate variables, the percentage change in the spot rate, and the lagged dependent variable. There was no Hildreth-Lu transformation for autocorrelation of the error terms. The results are presented in Table 7.

Table 7

A COMPARISON OF SEVERAL RFS EQUATIONS

Canadian rate	U.S. rate	SEE	Equilibrium effect of Canadian rates	Equilibrium effect of U.S. rates
RCFP	RUSCD	.231	.848	-.932
RCFP	RUSCOM	.223	.867	-.956
RCFP	RED	.218	.649	-.725
RCCD	RUSCD	.243	.849	-.761
RCCD	RUSCOM	.242	.878	-.792
RCCD	RED	.221	.717	-.666
RCFP RCCD	RUSCD RUSCOM RED	.199	.813	-.935

For each equation, and for the equation with all five interest rates run over the same period without a Hildreth-Lu transformation, we present the standard error of estimate and the equilibrium effects of changes in the Canadian and U.S. dollar rates on RFS. Of the equations with two rates, the equation containing RCFP and RED performs best. This is not surprising since these are the two variables with the highest t-statistics in the equation with all five interest rates. The equation with all five interest rates has a standard error of estimate (SEE) 19 basis points or 9 percent lower than the SEE of the equation including only RCFP and RED. We conclude that substantial benefit can be gained by including a variety of rates in the RFS equation.

4.E Instrumental-Variable Estimates

Thus far we have used OLS regressions despite the existence of simultaneity in the determination of the four rates we are looking at. In this section we examine the effect on the regressions of using instrumental-variable (IV) procedures. More precisely, we treated as predetermined all those variables that, in the context of our system of equations, were either exogenous or lagged endogenous variables[47] and we ran first-stage regressions of the current endogenous variables on all the predetermined variables.[48] The fitted values from these first-stage regressions were then used as instruments in our regression.[49] The results of these regressions are presented in Tables 8 and 9.

Before discussing these results, it should be noted that they are not exactly comparable to the OLS regressions presented earlier. This is due to the omission of some observations in this series of regressions that were included in the earlier OLS regressions.[50] The change in data period leaves most of the OLS equations relatively unaffected. The change in gaps does, however, tend to increase the coefficients on RCTB and RUSFP and reduce the coefficient on RCFP in the RCCD equation for 1975.

The main differences between the IV regressions and the OLS regressions are the following. In the RCFP equation, the effect of RCCD more than doubles, RCTB disappears, and the effect of RCPRI falls substantially. The equilibrium effects of RUSCD and RFS fall by about one-third. Also FMA12 becomes completely insignificant. A number of

Table 8

INSTRUMENTAL VARIABLE EQUATIONS FOR RCFP, RCPRI, AND RFS

Period	Dependent Variable Y	Lag structure	C	RCFP	RCCD	RCTB	RCPRI	RCBANK	RUSCD	RUSCOM
(1) Whole	RCFP	Current	-.098 (1.95)		1.053 (4.28)	-.004 (0.26)	.155 (1.03)		.127 (2.63)	
		Lag 1			-.939 (4.02)		-.141 (0.99)		-.042 (0.70)	
		Lag 2							-.034 (0.70)	
		Equilib.			.740	-.027	.095		.333	
(2) Post Bank Act revision	RCPRI	Current	.049 (1.59)	-.014 (0.24)				.391 (8.70)		
		Lag 1		.152 (1.76)				-.381 (8.44)		
		Lag 2		-.112 (2.82)						
		Equilib.		.688				.262		
(3) Fixed	RFS	Current	-.157 (2.73)	.126 (3.89)	.077 (2.43)					
		Lag 1								
		Equilib.		.557	.339					
(4) Floating	RFS	Current	.132 (1.13)	.742 (1.61)	.071 (0.11)				-.217 (2.28)	-.284 (2.48)
		Lag 1		-.535 (1.41)	-.113 (0.20)				.141 (1.37)	.209 (1.62)
		Equilib.		.941	-.191				-.346	-.339

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(1) Whole	RCFP	Current	-.098		1.053	-.004	.155		.127	
			(1.95)		(4.28)	(0.26)	(1.03)		(2.63)	
		Lag 1			-.939		-.141		-.042	
					(4.02)		(0.99)		(0.70)	
		Lag 2							-.034	
									(0.70)	
		Equilib.			.740	-.027	.095		.333	
(2) Post Bank Act revision	RCPRI	Current	.049	-.014				.391		
			(1.59)	(0.24)				(8.70)		
		Lag 1		.152				-.381		
				(1.76)				(8.44)		
		Lag 2		-.112						
				(2.82)						
		Equilib.		.688				.262		
(3) Fixed	RFS	Current	-.157	.126	.077					
			(2.73)	(3.89)	(2.43)					
		Lag 1								
		Equilib.		.557	.339					
(4) Floating	RFS	Current	.132	.742	.071				-.217	-.284
			(1.13)	(1.61)	(0.11)				(2.28)	(2.48)
		Lag 1		-.535	-.113				.141	.209
				(1.41)	(0.20)				(1.37)	(1.62)
		Equilib.		.941	-.191				-.346	-.339

RED	RFS	FMA12	QATL1	QATL2	$\Delta PFX/PFX_{-1}$	QCRISIS	Y_{-1}	U_{-1}	SEE	R^2	DW
	.045 (2.03)	.002 (0.13)	.347 (2.32)	.775 (3.83)			.923 (14.81)		.160	.993	1.83
			.353 (2.05)	-.662 (3.24)			-.061 (0.77)				
							-.017 (0.34)				
	.293	.013	-.041	.733							
							.961 (86.22)		.116	.995	2.15
-.160 (5.90)					-58.34 (4.32)	.645 (4.78)	.773 (24.01)		.178	.917	2.13
						-.431 (3.20)					
-.705						.943					
-.298 (1.88)					-12.09 (1.88)		.795 (14.23)	-.081	.226	.965	1.98
.255 (4.36)											
-.195											

Table 9

INSTRUMENTAL-VARIABLE EQUATIONS FOR RCCD

Period	Lag structure	C	RCFP	RCTB	$RCPR1_{-2}$	RCBANK	RUSFP	RUSTB	RUSCOM	RFS	FMA4	$RCCD_{-1}$	SEE	R^2	DW
(1) Prior to failure of Atlantic Acceptance	Current	-.640	.165	.187		.318		.115				.724	.446	.957	2.14
		(2.91)	(0.60)	(2.76)		(2.91)		(1.19)				(11.01)			
	Lag 1		-.141			-.189									
			(0.57)			(1.82)									
	Equilib.		.088	.679		.470		.415							
(2) Immediate post Bank Act revision	Current	.159	.529	.097								.834	.124	.960	1.94
		(0.27)	(0.76)	(0.89)								(10.27)			
	Lag 1		-.482												
			(0.80)												
	Equilib.		.281	.585											
(3) Between controls		.697	.899										.235	.886	1.49
		(3.46)	(20.55)												
(4) Winnipeg Agreement	Current	.081		.393	.283				.159	.214	-.079	.228	.254	.986	1.97
		(0.47)		(3.64)	(3.66)				(3.43)	(3.83)	(0.74)	(2.25)			
	Equilib.			.509	.367				.206	.277	-.102				
(5) 1975		-1.500	.677	.359			.211			.049			.183	.970	1.81
		(2.65)	(4.39)	(2.56)			(1.61)			(0.52)					

lagged variables that were significant in the OLS regression become insignificant in the instrumental-variable regression.

In the RCCD equation for the period before the collapse of Atlantic Acceptance the RCFP variables become insignificant as does the RUSTB variable. There is no instrumental-variable regression for the period following the collapse of Atlantic Acceptance because only predetermined variables appear on the right-hand side of the equation. In the equation for the period immediately following revision of the Bank Act all the explanatory variables except the lagged dependent variable become insignificant. Equations for the sub-period between controls and for the Winnipeg Agreement sub-period are largely unchanged except that the tightness variable in the latter sub-period falls in significance. This is due to the change in the time over which the regression is run and not to the use of instruments. In the RCCD equation for 1975 the RCFP coefficient increases substantially and the coefficients on RCTB and RUSFP decline markedly compared to the OLS coefficients for the same period.

The equation for RCPRI in the period preceding Bank Act revision requires no instrumental-variable regression because it contains only predetermined variables on the right-hand side. The equation for RCPRI in the period following Bank Act revision shows contemporaneous RCFP becoming insignificant but very little change in equilibrium effects or in the time path of RCBANK effects.

The major changes in the equations for RFS are that RCCD becomes totally insignificant in the floating period and that the autocorrelation coefficient declines substantially in the instrumental-variable regression.

The most important differences between the OLS estimates and the IV estimates are increased RCCD coefficients in the RCFP equation for the whole period and an increased RCFP coefficient in the RCCD equation for 1975. These are rather surprising because theory leads us to expect that consistent techniques will lead to a decline in these coefficients.[51] One possible explanation for the increase in coefficients is the existence of a large, negative correlation of the error terms in the RCFP and RCCD equations.[52] For the five sub-periods in Table 9, the correlation coefficients for the errors in the RCFP and RCCD instrumental-variable equations are -.61, -.93, -.16, -.01, and -.27. Since omitted variables that affect both equations in the same way would lead to positive correlation of the error terms, negative correlations indicate that there are shifts between term deposits and finance paper that cause the interest rates to move in opposite directions but which are not captured by the variables in the equations.

The results of this section point to further research in two directions. First and more important, it appears that initial experimentation in the Hendry framework should be done in the context of instrumental-variable procedures and not OLS. Although Hendry's own GIVE program [24] allows for this, we were unable to use it because it does not allow for gaps in the data. Second, the existence of large negative correlations between the errors in the RCFP equation and those in the RCCD equation suggests the use of three-stage least squares (3SLS) to obtain more efficient estimates, and it is to some exploratory 3SLS estimates that we now turn our attention.

We applied 3SLS estimation to the data for two sub-periods: the period of the Winnipeg Agreement and 1975. Because of the nature of the 3SLS program it was necessary to run separate equations for each dependent variable for each sub-period. Thus, despite the fact that in OLS estimation only RCCD showed structural change between the two sub-periods, all four dependent variables had separate 3SLS equations for each sub-period.

The results can be briefly summarized as follows. For the Winnipeg Agreement sub-period, there was very little difference in the size of equilibrium effects among the OLS, IV and 3SLS equations for RCCD. The speed of adjustment, however, was substantially less in the 3SLS equation than in the other two.

For the 1975 sub-period we ran separate OLS and 2SLS regressions for all four dependent variables in addition to the 3SLS regressions. In general, whenever an equilibrium effect increased in size in 2SLS estimation compared with OLS estimation, it increased further in 3SLS estimation. The speed of adjustment increased in the RCFP and RCPRI equations as one moved from OLS to 2SLS to 3SLS but decreased slightly in the RFS equation. The U.S. interest rates disappeared almost entirely as explanatory variables in the 3SLS equations for RCFP, RCPRI and RCCD in 1975.

5 MONTHLY AND QUARTERLY EQUATIONS

The question of aggregation over time and the use of different types of data-averaging has interested econometricians in the last few years.[53] The question may be put in terms of the usefulness of monthly or quarterly equations when the period during which decisions are being made or actions taken is shorter than the data period.

To throw some light on this question, we reworked the equations for RCFP using the Hendry methodology for (i) average monthly data, (ii) end-of-month data, and (iii) average quarterly data. The regression results are presented in Table 10 and are directly comparable to the weekly results presented in equation 4 in Table 1. The first point to note is that there is some change in the variables in the different equations. Thus, RCPRI appears only in the weekly equation whereas RCCD and RCTB appear in all four equations: weekly, average monthly, end-of-month, and quarterly. In the weekly equation, RUSCD is the only U.S. interest rate. The variable RUSCD continues to appear in the equation for the other three data periods, but RUSPRI enters the monthly average and quarterly equations and RED enters the monthly average and end-of-month equations. The variable QDBA is significant in all the equations except the weekly equation.

Although the variables entering the equations differ, the sum of the equilibrium effects on Canadian rates and the corresponding sum on U.S. rates do not change much from equation to equation. The former sum is about .60 for all but the quarterly equation in which it is .46; the latter sum is about .57 for all except the quarterly equation in which it is .68. The sum of the equilibrium effects for a change in all interest rates ranges from 1.15 to 1.18, i.e., it is virtually the same for all the equations. The standard error of estimate of the equations is lowest for the weekly equation (.123), somewhat higher

Table 10

MONTHLY AND QUARTERLY EQUATIONS FOR RCFP (WHOLE PERIOD)

Kind of data	Lag structure	C	RCCD	RCT8	RUSCD	RUSPR1	RED	RFS	FMA3	QATL	QDBA	$RCFP_{-1}$	U_{-1}	SEE	R^2	DW
(1) Monthly average	Current	-.186	.495	.267	.363	.236	.102	.358		.117	-.234	.559		.149	.995	1.94
		(2.87)	(7.47)	(3.73)	(6.76)	(2.56)	(3.17)	(7.38)		(2.06)	(4.17)	(7.93)				
	Lag 1		-.418	-.265	-.230	-.222		-.035								
			(4.07)	(3.62)	(3.93)	(2.62)		(0.54)								
	Lag 2		.184					-.110								
			(2.96)					(2.53)								
	Equilib.		.592	.005	.302	.030	.231	.482		.265	-.530					
(2) Month end with autocorrelation correction	Current	-.235	.281	.432	.450		.114	.413		.152	-.252	.521	-.302	.199	.993	1.97
		(3.70)	(5.83)	(5.80)	(7.27)		(3.07)	(8.61)		(2.64)	(4.17)	(7.99)				
	Lag 1			-.424	-.292			-.182								
				(5.32)	(3.74)			(3.35)								
	Equilib.		.587	.018	.330		.238	.482		.317	-.526					
(3) Month end without autocorrelation correction	Current	-.276	.357	.416	.387		.121	.407		.212	-.286	.347		.205	.988	2.27
		(3.42)	(6.36)	(4.85)	(5.79)		(2.83)	(7.74)		(2.94)	(3.79)	(4.75)				
	Lag 1			-.384	-.136			-.105								
				(4.17)	(1.65)			(1.82)								
	Equilib.		.546	.050	.384		.185	.462		.325	-.437					
(4) Quarterly average	Current	-.390	.386	.219	.410	.271		.445	-.019	.405	-.253			.156	.995	1.94
		(3.85)	(4.53)	(3.73)	(8.15)	(3.08)		(7.25)	(0.77)	(4.56)	(2.98)					
	Lag 1			-.141												
				(3.02)												

for the monthly average equation (.149) and the quarterly equation (.156), and highest for the end-of-month equation (.199).

We can now compare the dynamics of the effects of variable changes for the different equations. In Table 11 we present the number of time periods (weeks for the weekly equation, months for the monthly equation) for the cumulated effects to be within 5 percent of the equilibrium effects. For the non-starred items this means the time needed to achieve 95 percent of the equilibrium value; for the starred items, which denote those variables that overshoot equilibrium, this means the time needed to reach 105 percent of the

Table 11

DYNAMICS OF RCFP EQUATIONS: TIME REQUIRED TO REACH WITHIN 5% OF EQUILIBRIUM

	Weekly equation (in weeks)	Monthly average equation (in months)(1)+	Month-end equation with transformation (in months)(2)+	Month-end equation without transformation (in months)(3)+
RCCD	11*	6	5	3
RCTB	9	14*	11*	6*
RCPRI	6*			
RUSCD	5	4*	5*	1*
RUSPRI		10*		
RED		6	5	3
RFS	9	3*	3	2
QATL1	3			
QATL2	4			
QATL		6	5	3
QDBA		6	5	3

+ See Table 10

equilibrium values. It is obvious from Table 11 that the lags are substantially longer in the monthly average equation and end-of-month equation, with adjustment for autocorrelation, than in the weekly equation. The month-end equation without the Hildreth-Lu transformation has substantially shorter lags.[54] Thus we conclude that the monthly equations have a tendency to extend the lag time compared with the weekly equation.

6 SOME EXPERIMENTS WITH PRINCIPAL-COMPONENTS ANALYSIS

Our approach thus far has been to use individual interest rates in regressions and to assess the importance of U.S. interest rates by the coefficients on the individual U.S. rates. An alternative approach, pursued in this section, is to use principal-components analysis. It is possible that the use of principal-components analysis will reduce the multicollinearity created by using a large number of variables on the right-hand side of equations. The advantages of this procedure have been discussed by Cheng and Iglarsh [8]. Also, the approach can be used to discover the extent to which interest-rate movements in Canada and the United States have a common pattern.

Principal-components analysis is a technique for finding mutually uncorrelated variables that explain the observed variation.[55] The first principal component explains the largest part of the variance, the second explains the second largest part, and so on. In making the computations the finding of principal components reduces to the calculation of characteristic roots and vectors, with the first principal component being the characteristic vector, normalized to unit length, of the largest characteristic root multiplied by the original data matrix. Principal-components analysis is closely related to factor analysis, which seeks to relate observed variables to unobserved factors which 'cause' them. In this framework one can associate the principal-components with unobserved factors and examine the 'factor loadings'. Since the interest rates have been standardized to unit variance,[56] the factor loading f_{ij} can be taken as the simple correlation coefficient on interest rate i with factor j.

The Canadian interest rates used in the analysis are RCFP, RCCD, RCTB,[57] RCPRI, RCDAY, and RCBANK. The foreign interest rates used are RED, RUSTB, RUSCOM, RUSFP, RUSCD, and RUSPRI. Our first task was to compute a set of principal components for the six foreign rates and a second set of principal components for the six Canadian rates to discover the degree of common movement in foreign interest rates and the degree of common movement in Canadian interest rates. We then obtained a set of principal components for all 12 rates to discover the extent to which Canadian and foreign rates move together. Finally, we used the first principal component for the six foreign interest rates, RFS, and the first principal component for five Canadian rates as explanatory variables for the sixth Canadian rate. This procedure was carried out in turn for RCFP, RCCD, and RCPRI. In the case of

RCCD it turned out that the second principal component of the other five Canadian rates was also significant. We also ran regressions of RFS on the first principal component of the Canadian rates and the first principal component of the foreign rates. The data used were the weekly series for the period from November 1970 to December 1975.[58]

In Tables 12 and 13 we show the results of applying principal-components analysis to the set of six foreign rates. These results show that there is very little independent variation among the short-term foreign interest rates examined. The first principal component accounts for over 95 percent of the variance of the six interest rates. Furthermore, each of the rates is highly and positively correlated with the first component, whereas correlations with the second component are low and alternate in sign; the other components have even smaller factor loadings showing no discernible pattern. The lowest correlation with the first principal component is .955 and is for the prime rate. In fact it is surprising that the correlation is so high, since during much of this period the prime rate moved at discrete and infrequent intervals. We conclude that the first principal component should serve as a good proxy for foreign, short-term, interest-rate movements.[59]

In Tables 14 and 15 we apply principal-components analysis to the set of six Canadian rates. The results show that these rates also moved together very closely over the period, which includes both controls and non-controls sub-periods. Once again the first principal component captures over 95 percent of the variance. The second principal component captures over 3 percent of the variance and is

Table 12

THE CHARACTERISTIC ROOTS AND THE PROPORTION OF VARIANCE EXPLAINED BY THE PRINCIPAL COMPONENTS FOR SIX FOREIGN RATES, NOV. 1970 TO DEC. 1975

Principal component	Root	Variance explained(%)
1	5.732	95.53
2	.118	1.97
3	.100	1.67
4	.024	.40
5	.020	.34
6	.005	.08

Table 13

FACTOR LOADINGS FOR THE FIRST TWO PRINCIPAL COMPONENTS SHOWN IN TABLE 12

	Correlation of interest rate with	
Interest rate	first component	second component
Euro-dollar	.970	-.030
U.S. treasury bill	.963	.225
U.S. commercial paper	.994	-.001
U.S. finance paper	.989	.023
U.S. certificate of deposit	.992	.035
U.S. prime	.955	-.255

Table 14

THE CHARACTERISTIC ROOTS AND THE PROPORTION OF VARIANCE EXPLAINED BY THE PRINCIPAL COMPONENTS FOR SIX CANADIAN RATES, NOV. 1970 TO DEC. 1975

Principal component	Root	Variance explained(%)
1	5.705	95.08
2	.189	3.15
3	.066	1.10
4	.019	.32
5	.015	.26
6	.006	.10

Table 15

FACTOR LOADINGS FOR THE PRINCIPAL COMPONENTS SHOWN IN TABLE 14

Canadian interest rate	Correlation of interest rate with first component	Correlation of interest rate with second component
Prime	.980	-.065
Finance paper	.962	.259
Day loan	.982	-.104
Term deposit	.971	.214
Treasury bill	.988	-.060
Bank rate	.967	-.239

useful in further analysis.

Since Canadian rates and U.S. dollar interest rates are so highly intercorrelated, it is of interest to see if one can identify much independent variation between the two sets of rates, or whether a Canadian rate behaves essentially like a U.S. dollar rate with some random noise. Principal-components analysis of the two sets of rates pooled together can help answer this question. The results are presented in Tables 16 and 17.

Table 16

THE CHARACTERISTIC ROOTS AND THE PROPORTION OF VARIANCE EXPLAINED BY THE PRINCIPAL COMPONENTS FOR SIX CANADIAN AND SIX FOREIGN RATES, NOV. 1970 TO DEC. 1975

Principal component	Root	Variance explained(%)
1	10.503	87.52
2	1.087	9.06
3	.132	1.10
4	.121	1.01
5	.069	.58
6	.028	.23
7	.020	.17
8	.017	.14
9	.009	.08
10	.007	.06
11	.004	.03
12	.004	.03

The variation here is much less closely explained by the first principal component. Although the rates all have high correlations with it, these are in general substantially smaller than those with

Table 17

FACTOR LOADINGS FOR THE PRINCIPAL COMPONENTS OF TABLE 16

Interest rate	Correlation of interest rate with first component	second component	third component
Euro-dollar	.900	-.373	-.006
U.S. treasury bill	.912	-.306	-.189
U.S. commercial paper	.940	-.328	.027
U.S. finance paper	.952	-.266	-.043
U.S. certificate of deposit	.931	-.355	.032
U.S. prime	.981	-.046	.056
Canadian prime	.942	.283	-.001
Canadian finance paper	.973	.089	.162
Canadian day loan	.917	.363	-.065
Canadian term deposit	.954	.193	.196
Canadian treasury bill	.937	.314	-.066
Bank rate	.882	.439	-.128

the principal component for the subset of rates shown in Tables 13 and 15. Furthermore, a pattern emerges for the second component: Canadian rates are all positively correlated with it whereas U.S. rates are all negatively correlated with it. These results suggest a conclusion one would expect to arrive at for a period during which Canada was on a floating exchange rate: the movement of Canadian rates during this period reflects some variation that is independent of the movement of U.S. rates.

In Tables 18 and 19 we present the results of regressions of RCFP, RCCD, and RCPRI on the first principal component of U.S. dollar interest rates (PCUS), the first principal component of the other five Canadian rates (PCCAN) (i.e., excluding the dependent variable), the second principal component of these rates (PCCAN2) in certain cases, and RFS. We also present the regression of RFS on PCUS and the first principal component of all six Canadian rates. For the RCFP, RCPRI, and RFS regressions in this section of the paper we present three forms: an equation with contemporaneous variables on the right-hand side and with no Hildreth-Lu adjustment , an equation with contemporaneous variables on the right-hand side and with a Hildreth-Lu adjustment for first-order autocorrelation, and an equation with both independent and dependent variables lagged once.[60] Forms of the RCCD equations which gave virtually the same results as those presented in Table 19 were omitted.

The coefficients on the principal components cannot be interpreted directly. However, since each principal component is a linear combination of the interest rates (the weights being the factor loadings divided by the relevant eigenvalue), the coefficients on the interest rates can be derived from those on the principal components. The sum of the derived interest-rate coefficients for Canada and that for the United States are presented in Tables 18 and 19, where the

Table 18

EQUATIONS FOR RCFP AND RCPRI USING PRINCIPAL COMPONENTS (1970-75)

Dependent variable Y	Lag structure	C	PCCAN	PCUS	RFS	Y_{-1}	U_{-1}	SEE	R^2	DW	Implicit sum of weights on interest rates: Canadian	U.S.
(1) RCFP		7.269	.214	.873	.749			.314	.983	0.45	.256	1.031
		(332.72)	(8.16)	(34.03)	(23.77)							
(2) RCFP		7.117	.641	.497	.290		.927	.170	-	2.04	.768	.587
		(51.66)	(10.43)	(9.08)	(6.54)							
(3) RCFP	Current	1.237	.682	.553	.316	.830		.166	.995	2.01	.817	.653
		(5.08)	(9.02)	(9.10)	(7.19)	(24.84)						
	Lag 1		-.647	-.405	-.177						-.775	-.478
			(8.50)	(6.36)	(3.72)							
	Equilib.		.208	.873	.818						.247	1.028
(4) RCPRI		7.947	.893	-.048	-.120			.444	.946	0.14	1.025	-.057
		(251.41)	(21.40)	(1.17)	(2.44)							
(5) RCPRI		8.068	.361	-.010	.012		.993	.140	-	2.17	.414	-.012
		(9.75)	(5.85)	(0.20)	(0.32)							
(6) RCPRI	Current	.832	.277	-.042	-.007	.897		.132	.995	2.20	.318	-.050
		(5.42)	(4.62)	(0.84)	(0.19)	(46.54)						
	Lag 1		-.214	.070	.018						-.246	.083
			(3.32)	(1.41)	(0.50)							
	Equilib.		.615	.279	.106						.702	.321

Table 19

EQUATIONS FOR RCCD AND RFS USING PRINCIPAL COMPONENTS

Dependent variable Y	Period	Lag structure	C	PCCAN	PCCAN2	PCUS	RFS	Y_{-1}	U_{-1}	SEE	R^2	DW	Implicit sum of weights on interest rates: Canadian	U.S.
(1) RCCD	Between controls		6.994 (97.88)	.862 (7.75)	1.887 (10.50)	.032 (0.33)	.066 (0.67)			.170	.950	1.86	.806	.038
(2) RCCD	Winnipeg Agreement		7.216 (162.28)	1.092 (16.69)	.416 (2.19)	-.146 (2.16)	.000 (.00)			.255	.986	1.60	1.257	-.172
(3) RCCD	1975		6.599 (23.90)	.699 (2.57)	.582 (1.15)	.405 (1.73)	.450 (2.16)			.190	.965	1.29	.767	.478
(4) RCCD	1975		6.611 (18.61)	.604 (2.03)	.356 (0.65)	.496 (1.97)	.529 (2.36)		.356	.179	-	2.17	.680	.586
(5) RFS	1970-75		-.325 (9.21)	.650 (24.30)		-.715 (26.81)				.573	.737	0.17	.821	-.844
(6) RFS	1970-75		-.310 (1.88)	.590 (8.49)		-.683 (10.90)			.916	.234	-	2.12	.745	-.807
(7) RFS	1970-75	Current	-.026 (1.52)	.530 (5.28)		-.684 (9.14)		.915 (35.96)		.235	.956	2.09	.669	-.808
		Lag 1		-.477 (4.77)		.625 (7.96)							-.602	.738
		Equilib.		.632		-.689							.793	-.822

effect of standardizing the variables in calculating the principal components has also been corrected.

We can compare the results of these regressions with the earlier results as follows:[61] The RCFP, RCPRI, and RFS equations bear a reasonably close resemblance to the equations in Section 4. The RCFP equation does attribute rather more influence to U.S. rates than was the case in the earlier regressions, but the difference is not as great when the comparison is made with the RCFP equation for the post-1967 period (Table 2, equation 2). When RCCD was regressed on PCUS, PCCAN, and RFS the equations gave substantially different results from those of the earlier equations for the sub-period between controls and the 1975 sub-period. In both cases the U.S. rate was given substantially more weight in these equations than in the earlier ones. However, when PCCAN2 was added as an explanatory variable, the results were much closer to the earlier regressions. The reason for this difference in the results is that RCFP is more closely related to the second principal component - with a correlation coefficient of .31 - and less closely related to the first principal component than any of the other Canadian rates. Hence, if RCFP is the most important element in determining RCCD it is not surprising to find that it required the introduction of PCCAN2 to get results similar to those in Section 4.

Results of the experiments with principal-components analysis indicate that U.S. rates are a more important influence on RCFP than on RCCD or RCPRI. Thus our earlier conclusions regarding the relative importance of U.S. interest rates in the different equations are still generally valid. In the next section we look more closely at the reasons for this situation.

7 COEFFICIENTS ON INTEREST RATES AND HOLDINGS OF CANADIAN FINANCIAL INSTRUMENTS BY FOREIGNERS

The theory outlined in Section 2 of this paper suggests that the coefficients of U.S. interest rates in the equations for RCFP are functions of the responses of the holders of Canadian finance paper - residents of the United States, other foreigners, or Canadians - to changes in competing U.S. interest rates. Similarly, in setting RCCD and RCPRI, the banks respond to movements of various competing interest rates. The magnitude of the response is related to the importance of the rate in attracting funds away from Canadian dollar term deposits or attracting borrowers away from Canadian dollar loans at the banks. One would also expect the coefficients on various rates in the RFS equation to reflect the importance of the market for the instrument in covered international capital flows. There is, however, a distinction to be made between the coefficients in the interest rate equations and the coefficients in the RFS system. The coefficients in the RCFP equation, for example, reflect the relative importance of competing rates in the market for Canadian finance paper. Similarly, the coefficients in the RCCD equation reflect the relative importance of competing rates in the demand for Canadian term deposits. In the RFS equation, the comparison of relative importance is being made in the market for forward swaps - a combination of transactions in forward and spot currencies. Thus, for example, U.S. investment might be much more important in the market for finance paper than in the market for term deposits (resulting in higher coefficients on U.S. interest rates in the RCFP equation than in the RCCD equation), but the absolute response in the latter market might be bigger than in the former market (resulting in higher coefficients on RCCD than on RCFP in the RFS equation). Also, only covered investments enter the RFS equation whereas uncovered movements will lead to higher coefficients on the U.S. interest rate, although not on the RFS variable, in the RCCD and RCFP equations.

As indicated above, partial derivatives of the demand for various assets with respect to changes in interest rates are important in the determination of the various coefficients. Unfortunately, no data exist on what financial instruments Canadians sell when they invest outside Canada. Data do exist, however, on the Canadian instruments in which foreigners invest.[62] Although these data are on amounts outstanding and not partial derivatives they give an indication of the importance of the foreign response in the demand for various Canadian instruments. More formally, assume that elasticities of demand by foreigners for Canadian instruments with respect to competing interest rates are the same for all Canadian instruments and that the same statement can be made regarding the Canadian demand for Canadian instruments. If foreigners are more responsive to changes in U.S. rates than to changes in competing Canadian rates, and if Canadians are more responsive to changes in competing Canadian rates than to changes in U.S. rates, then the size of the coefficients on U.S. rates in interest-rate equations will be directly related to the quantity of foreign holdings of the instruments.[63,64] That is, under these assumptions the coefficients on U.S. interest rates should be larger the more important foreign

In Table 20 we present data on holdings by foreigners as a proportion of the total term deposits and finance paper outstanding.

Table 20

FOREIGN HOLDINGS OF CANADIAN INSTRUMENTS AS PERCENTAGE OF TOTAL OUTSTANDING

Date	1. Interest-bearing deposits of non-residents	2. Finance company paper	3. Finance company paper plus other finance company obligations	4. Total paper	5. Total paper plus other finance company obligations
4Q65	12	35	45	30	41
4Q70	7	34	54	21	35
4Q75	6	23	31	15	21

In column 1 we present the interest-bearing Canadian dollar deposits of non-residents (other than banks) in Canada as a percentage of total non-personal term and notice deposits at Canadian chartered banks. This figure is an overestimate of the theoretically correct number in that it includes some personal savings deposits other than term deposits. It is an underestimate to the extent that the credit balances of foreign banks in Canadian banks include some interest-bearing term deposits. Columns 2 to 5 refer to various measures of foreign holdings of finance paper and other obligations of finance companies, commercial paper, etc. A number of series are presented since it is not clear which is the most appropriate. In column 2, we restrict our attention to sales finance and consumer loan company paper. In column 3 we show sales finance and consumer loan company paper plus "other finance company obligations". The latter includes obligations by finance companies to foreign parent companies and foreign banks. In column 4 we show the total of finance paper, commercial paper, banker's acceptances and short-term paper of junior levels of government. In column 5 we include all the items in column 4 and "other finance company obligations". Columns 2 to 5 include U.S.-dollar-denominated paper held by foreigners. Restriction of the data to Canadian-dollar-denominated paper would reduce the size of the ratios but leave the general impression unchanged.

The figures in Table 20 are broadly consistent with the results in Section 4. The substantially larger proportionate holdings by foreigners of finance paper than of term deposits under all definitions explain the larger coefficients on U.S. interest rates generally found in the RCFP equation compared with the RCCD equation. However, attempts to relate changes in the coefficients on the U.S. rates in different sub-periods to changes in the foreign holdings of the Canadian instruments were not particularly successful.

The interpretation of the coefficients in the RFS equation in terms of absolute holdings of the various instruments is also moderately successful. Throughout the period the holdings of paper exceeded the holdings of term deposits in absolute value. Hence we expect that, in the RFS equation, the coefficient of RCFP will be greater than the coefficient of RCCD, which indeed turns out to be the case.

FOOTNOTES

1. For Canada see Helliwell et al. [21], Freedman [16], Clinton and Masson [9], and Pesando [33]. For the United States see any discussion of the MPS model such as [11] or [31], Slovin [34], and Slovin and Sushka [35]. For a detailed discussion of the rationale for interest-rate-setting equations see Ando and Modigliani [1]. For the Euro-dollar market see Hendershott [22], Marston [30], and Herring and Marston [25] and [27].

2. A third approach to the reaction function is that of Herring and Marston [26] who treat unborrowed reserves supplied by the Bank of Canada as a function of a number of variables including the U.S. treasury-bill rate. In conjunction with an international capital flow equation and deposit demand and supply equations, the reaction function determines the Canadian treasury-bill rate.

3. The monetarist approach to the balance of payments implies that foreign rates would be virtually the only explanatory variables used in determining the level of Canadian interest rates in a fixed-exchange-rate system [19]. Under a flexible-exchange-rate system the expected change in the exchange rate for the Canadian dollar would also enter into the determination of Canadian interest rates.

4. Although both Freedman [16] and Clinton and Masson [9] base their analyses on a micro model of profit maximization by the banks, similar results can be derived from the simple hypothesis that interest-rate setters in Canada emulate their U.S. counterparts. However, unless the demand for deposits in Canada is in fact a function of U.S. interest rates, such emulation would be irrational.

5. An obvious extension of this approach would be to use the same techniques on medium-term and long-term Canadian rates.

6. These might include bank loans, long-term liabilities, and loans from parent companies in the case of Canadian subsidiaries of foreign companies.

7. For a detailed discussion of the role of the relative supply variable see Ando and Modigliani [1].

8. See Pesando [33] for an example of the use of such variables in term structure equations.

9. If the coefficient on the interest rate equivalent of the forward spread (RFS) is approximately equal to the sum of the coefficients on U.S. rates, two conclusions can be drawn. First, capital flows in response to interest-rate changes are covered. Second, what we are capturing is not a reaction function, since Canadian interest rates are a function of

uncovered U.S. interest rates and not on RFS in the case of a reaction function. If the coefficient on RFS is less than that on U.S. interest rates, we are either capturing a reaction function or there are substantial uncovered capital flows in response to interest-rate changes or both. It is not clear how one can untangle the two factors from such a result.

10. For a more detailed discussion including proofs on the theory of interest-rate determination for a financial intermediary see Freedman [16].

11. If there is more than one competing instrument, I is the vector of interest rates on these instruments.

12. For the proof of the assertions in this paragraph see Freedman [16].

13. Details of the analysis are available from the authors on request.

14. It is sufficient that the banks do not take into account their effect on this interest rate in making their decisions in setting interest rates.

15. Simply looking at chartered bank balance sheets is not sufficient, because the amounts of investment assets other than loans (e.g., bonds) are small relative to the quantity of bank loans.

16. See Kesselman [29] and Haas [20] for estimates ranging from .5 to .8 for this arbitrage element.

17. Where observations were missing, we simply gapped those observations out of the regressions.

18. The difficulties arise from the change in the nature of the term-deposit rate data. Prior to November 1970 these are averages of typical posted rates on large deposits on Wednesdays. Since November 1970 the rates are averages of actual rates on transactions with maturity of 90 to 179 days for the week ending on the Wednesday. For the later period our data were adjusted as follows: For regressions with the term-deposit rate as the dependent variable, we took a simple two-term average of all explanatory variables to make their timing comparable to that of the term-deposit rate. For regressions using the term-deposit rate as an explanatory variable, we took a simple two-term average of the term-deposit rate and centered it so that it was equivalent to the Wednesday data of the other rates.

19. This series is available from 1967 on. In the empirical work done for the entire period the interest rate on 90-day U.S. finance paper was used as a proxy for this series

from 1963 until 1966. In the RCCD and RCFP regressions this proxy was spliced directly onto RUSCOM and a dummy variable was allowed to pick up any change in the levels. In the RFS equation the proxy was augmented by 12 basis points to bring its level at the start of 1967 up to the level of RUSCOM.

20. See [10] for a detailed discussion of the effects of the 1967 Bank Act revision.

21. The use of lagged endogenous variables as part of the set of predetermined variables is correct only if there is no autocorrelation of errors. Although the final RFS equation for the floating exchange rate period shows some autocorrelation, the degree of such autocorrelation is so small that we hope it will not unduly bias our results.

22. It is interesting to note that RUSCD dominated RUSFP when both were entered into the equation. This result is consistent with that presented in Freedman [15] in which foreign holdings of Canadian dollar finance and commercial paper depended on RUSCD rather than RUSFP.

23. One might expect that any such effect would be captured through the dependence of RCFP on other short-term Canadian rates but this does not seem to be the case.

24. The dummy variable QATL2 ends on June 14, 1967, at the time of the Bank Act revision. This was done mainly because of the impossibility of distinguishing between the effects of the revision and the enduring effects of the failure unless one made the strong assumption that the effects of the latter continued unchanged until the end of the whole period. Some experiments with simplistic formulations in which the effect of the collapse decays over time were unsuccessful.

25. Although equation 2 is slightly superior to equation 1 in terms of standard error of estimate, we limit discussion to the further experiments based on equation 1 because QDBA became insignificant when lagged dependent variables were added to the equation.

26. Because of the difficulty of getting the supply variable in weekly terms, we first tested the supply of finance paper in the monthly equations. Neither the percentage rate of increase in the supply of finance paper nor the ratio of the supply of finance paper to a proxy variable for wealth entered significantly with the correct sign. Therefore we did not attempt to get weekly data for the supply variables.

27. There is some discussion of the time paths of the effects on RCFP of changes in the explanatory variable at the end of Section 5.

28. We encountered a number of difficulties in deriving the final equation for the earlier period. In particular, the

equilibrium effects on RCPRI tended to be large and negative when we allowed $RCPRI_{-2}$ to enter the equation. In our final version the latter variable was dropped from consideration because of this result.

29. For much of the later period, there were controls on banks and non-banks limiting capital flows to Europe in response to changes in the Euro-dollar rate. This might account for the absence of the Euro-dollar rate in the later period.

30. Because the shift in the data on RCCD from posted rates to actual rates in November 1970 might itself lead to rejection of the hypothesis of no structural shift, we tested the equation over the period of posted rates only, i.e., 1963-70, for the effect of the 1967 shift.

31. This Chow test included the 1969-70 period in which RCCD was held at 7.5 percent. If this period is omitted, the F-statistic on the null hypothesis of no structural change is 9.20 - still very significant.

32. For a different view of the effects of the revision, see Clinton and Masson [10 p. 7] and the statement by MacIntosh cited therein.

33. Current RCFP and current RCBANK are completely insignificant when added to the regression.

34. One possible cause of the problems in the regressions for the period preceding the Bank Act revision is the nature of the data in this period. The RCCD rate was a step function with only periodic changes. It may be that different techniques are required to explain movements of a series that moves in discrete jumps.

35. When the test was made for the four sub-periods for which regressions could be run (i.e., excluding the 1969-70 period during which RCCD was 7.5 percent), the F-statistic took on the value of 3.71 compared with a critical value of 1.82. Our conclusion regarding structural breaks thus remains unchanged.

36. For the period immediately following the 1967 Bank Act revision the coefficients on RCFP and lagged RCFP were constrained to be equal since otherwise the equilibrium effect of a change in RCFP was negative, although small. The statistical test showed that the hypothesis that the two coefficients were equal could not be rejected (F-statistic of .29 compared to a critical F of 3.94 at the 5 percent level of significance).

37. One possible explanation for the larger coefficient on RFS during the sub-period of the Winnipeg Agreement was that RFS was proxying for the rate on swapped deposits. However, when the rate on swapped deposits was added to the regression it was insignificant.

38. Two further points should be made about the equations for the period after 1967. First, the period between controls had a Durbin-Watson statistic of 1.45, and the Hildreth-Lu transformation yielded an autocorrelation coefficient of .25. There were practically no changes in the coefficients on the explanatory variables. The χ^2-test on the null hypothesis that there was no autocorrelation could not be rejected at the 1 percent significance level although it was rejected at the 5 percent significance level. Second, it appears at first glance that for the first two sub-periods we have a problem of identification in the RCFP equation since all variables in the RCCD equation also appear in the RCFP equation. However, since the RCFP equation covers the entire period 1963-75 and since variables appear in some of the sub-period RCCD equations that are excluded from the RCFP equation, the RCFP equation remains identified.

39. This is consistent with the relative importance of the involvement of foreigners in the two markets as discussed in Section 7.

40. The coefficient on RCBANK was constrained to equal that on lagged RCBANK to prevent the equilibrium effect from being negative. The F-statistic on the hypothesis that the constraint was valid was equal to 0.13 compared to a critical F of 3.89.

41. For an earlier example of such an approach using monthly data see [16] p. 204.

42. This assumes that the sources of these changes in interest-rate structure are not simply changes in perceived risk.

43. The χ^2-statistic was 51.64 compared with a critical χ^2 of 15.08 at the 1 percent significance level.

44. The test on whether equation 3 had autocorrelated errors yielded a χ^2 of 4.76, which exceeds the critical χ^2 at the 5 percent level of significance but not at the 1 percent level. When the Hildreth-Lu procedure is applied to equation 3 it results in an autocorrelation coefficient of -.142 and little change in the coefficients.

45. Equation 5 is presented with a Hildreth-Lu transformation despite the presence of lagged dependent variables. The test on the hypothesis of no autocorrelation yielded a χ^2-statistic of 9.214, significant at the 1 percent level.

46. In a freely estimated version of equation 5 the equilibrium effect of RCCD was negative, although small. The test of the constraint that the coefficients on RCCD and lagged RCCD are equal yielded an F-statistic of 0.51 compared with a critical F of 3.88.

47. This means that we ignored the remaining autocorrelation in the RFS equation for the floating period. Since the autocorrelation coefficient on this equation is small we hope that our results will not be unduly biased.

48. In the first-stage regressions for RCFP, RFS, and RCPRI we used the ordinary data. In the first-stage regression for RCCD we used the moving average of RCCD on the left side of the equation for the post-1970 data.

49. In equations with correction for autocorrelation we used the OLS regression routine and not the instrumental-variables routine, since the latter has no option for Hildreth-Lu transformation. Hence the standard errors and t-statistics in these regressions are not correct although the coefficients are correct.

50. There are two reasons for the change in the gaps. The use of all the predetermined variables as instruments means that a missing observation in any variable causes a gap in all the regressions. More important, our program allows for only nine gaps and so requires the merging of a number of small gaps.

51. See Bronfenbrenner [4] for expressions for the least-squares bias in a two-equation model.

52. See Bronfenbrenner [4] who shows how the covariance of the error terms enters into the expression for the bias.

53. See, for example, Mundlak [32], Zellner and Montmarquette [39], Cargill and Meyer [6], Gibson [18], Teigen [36], and Gibson [17].

54. However, the test on the hypothesis that autocorrelation was absent rejected the hypothesis at the 5 percent significance level and was marginal at the 1 percent significance level.

55. See Dhrymes [12], pp. 53-64 and pp. 77-82 for details of the explanation that follows.

56. That is, the characteristic roots were calculated for the correlation matrix, rather than the covariance matrix of the data, because of the convenience in interpreting the factor loadings. The qualitative conclusions in the text hold true for the components calculated with non-standardized data. These results are not reported.

57. Because of missing observations in the Wednesday RCTB data, we use the Thursday tender data in this section.

58. The choice of starting date was related to the change in the RCCD series from Wednesday posted rates to actual average rates for the week ending on Wednesday.

59. The first principal component calculated from the covariance

matrix, that is, from non-standardized variables, is associated with an even higher proportion of the variance.

60. No experimentation was done with higher order lag structures. Nor was the battery of statistical tests used in Sections 4 and 5 applied to the regressions presented in this section.

61. The reason the constant is so large in all these regressions is that the principal components are computed from variables normalized to have a zero mean and unit variance.

62. The data used in this section have been gathered by the authors from a variety of sources, the main ones being: the balance-of-payments statistics compiled by Statistics Canada [5], and banking numbers compiled at the Bank of Canada.

63. A formal proof of this assertion is available from the authors on request.

64. In fact, unpublished work by Charles Freedman suggests that the interest rate elasticity of the demand for Canadian finance paper by foreigners is larger than the interest-rate elasticity of the demand for Canadian term deposits by foreigners. See Freedman [15] for equations explaining the holdings of Canadian finance paper by foreigners.

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