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A TEST OF THE INTERNATIONAL TERM STRUCTURE OF  
INTEREST RATES: THE UNITED STATES-CANADIAN  
EXPERIENCE, 1973-80

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A TEST OF THE INTERNATIONAL TERM STRUCTURE OF INTEREST RATES: THE UNITED STATES-CANADIAN EXPERIENCE, 1973-80

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Abstract. A new theory of the term structure of interest rates for small open economies has been developed in which a small country with internationally integrated capital markets will have its domestic financial markets dominated by international influences. The international theory of the term structure of interest rates demonstrates how a foreign financial disturbance will directly affect domestic real and nominal interest rates and exchange rates which then affect the price and output channels. We employ univariate and multivariate time series analysis to Canada and the United States to test the imported term structure of interest rates hypothesis. We do not find evidence to support the assumption of proportionality between the countries' term structures.

Keywords. Time series, foreign exchange.

INTRODUCTION

A new theory of the term structure of interest rates for small open economies was recently presented by Michael Beenstock and J. Andrew Longbottom (1981). Although the neoclassical theory of interest rates has long been recognized, no theory had explicitly attempted to incorporate the international effects on the domestic interest rate term structure. When international financial markets are integrated, foreign financial influences are transmitted to domestic financial markets. The foreign financial markets impact on domestic markets depends on the extent of financial market integration, the relative size of the domestic financial markets, the degree assets denominated in different currencies are substitutes, and the relation between interest rates and exchange rates. Our study closely follows the Beenstock and Longbottom format; however, critical differences do exist. Beenstock and Longbottom employed a composite world term structure of interest rates to determine the domestic term structure of a small open economy; we consider the international term structure theory more relevant for a small country that is dominated by a larger (trading partner) country.

In section 2, we will examine the theory of the international term structure of interest rates for a small country dominated by a large country. In section 3, we will follow

closely the Beenstock and Longbottom procedures for modeling the theory and develop an estimating equation almost identical to their estimating equation. In section 4, we will present the results of empirical tests of the theory. We employ univariate and multivariate time series analysis to test the theory. We consider this mode of testing superior to the methods used by Beenstock and Longbottom particularly because causality testing in the Ashley, Granger, and Schmalensee (1980) and Ashley (1981) manner can be employed.

THE THEORY OF THE INTERNATIONAL TERM STRUCTURE OF INTEREST RATES

Agents hold portfolio of assets with different currency denominations in a world of integrated capital markets. If international financial markets are efficient, then financial capital flows until risk adjusted rates of return on assets are equal. Fisher open or uncovered interest rate parity will hold if assets denominated in different currencies are considered perfect substitutes. Fisher open has the difference between nominal interest rates equal to the expected rate of change in the exchange rate:

$$i - i^* = \frac{S^e - S}{S}, \quad (1)$$

where  $i$  is the domestic nominal interest rate,  $i^*$  is the foreign nominal interest rate,  $S$  is the exchange rate (the number of domestic currency units required to buy one unit of foreign currency); and  $S^e$  is the expected future spot rate for the date of maturity of the asset.

Covered interest rate parity has domestic interest rates adjusted by the appropriate forward premium (or discount) equal to foreign interest rates:

$$i - \frac{F - S}{S} = i^*, \quad (2)$$

where  $F$  is the forward exchange rate for the date when the assets mature. Uncovered interest rate parity will equal covered interest rate parity if the forward exchange rate equals the expected spot exchange rate:

$$F = S^e. \quad (3)$$

This equality exists if foreign exchange markets are efficient and if the forward exchange rate does not contain a risk premium, an indication of risk neutrality. Financial economists normally view the risk premium in the style of Grauer, Litzenberger, and Stehle (1976), who held that deviations between the forward and expected future spot rates depend upon the systematic risk associated with the foreign exchange position. Cornell (1976) found little support for the existence of a liquidity premium. The systematic risk of open exchange positions are insignificant (Cornell and Dietrich (1978)).

If financial markets are dominated by the foreign financial markets, then the uncovered

interest rate parity relation restricts the ability of the domestic country to determine interest rates. Domestic economic factors cannot affect interest rates unless they simultaneously affect exchange rate expectations or affect the systematic risk of the foreign exchange position. Without changes in foreign interest rates, domestic interest rates can increase (decrease) only if there is an expected depreciation (appreciation) of the domestic currency. Exchange rates and exchange rate expectations have important implications for determining interest rates in small economies.

Foreign real interest rates exogenously determine domestic real interest rates if exchange rates are determined according to the purchasing power parity theory.<sup>1</sup>

By adding the small country assumption, domestic real interest rates are not only equal to foreign real interest rates but they are also exogenously determined by foreign real interest rates. Any real interest rate differential between domestic and foreign real rates will cause shifts in asset holdings until the real interest rates are equal. Changes in domestic money supply and demand or bond supply and demand only affect nominal interest rates, not real interest rates.

The international term structure of interest rates theory follows directly from the foreign financial effects on domestic financial markets. Short term domestic interest rates adjusted for short term exchange rate expectations will equal short term foreign interest rates; likewise long term domestic interest rates adjusted for long term exchange rate expectations will equal long term foreign interest rates.

<sup>1</sup>When purchasing power parity is used to predict exchange rate changes, the difference between the expected rate of change in the domestic price level and the foreign price level will equal the expected rate of change in the exchange rate:

$$\pi - \pi^* = \frac{S^e - S}{S},$$

where  $\pi$  and  $\pi^*$  are the expected percentage changes in the domestic and foreign price levels. If nominal interest rates are determined according to the Fisher closed theory, then nominal interest rates are equal to real interest rates plus the expected percentage change in the price level:

$$i = r + \pi$$

$$i^* = r^* + \pi^*,$$

where  $r$  and  $r^*$  are the domestic and foreign real interest rates. The assumptions of perfect asset substitution, risk neutrality, uncovered interest rate parity, Fisher closed and relative purchasing power parity result in having domestic real interest rates equal to foreign real interest rates:

$$r = r^*.$$

The term structure of interest rates can be represented by the difference between long term and short term interest rates. The domestic term structure of interest rates adjusted for the term structure of exchange rate expectations will equal the foreign term structure of interest rates:

$$i_L - i_s + \left( \frac{S_L^e - S_s^e}{S} \right) = i_L^* - i_s^* \quad (4)$$

where subscript  $s$  indicates short term interest rate and exchange rate expectations and subscript  $L$  indicates long term interest rate and exchange rate expectations. Equation (4) presents the international theory of the term structure of interest rates for a small country.

Restricting the form of exchange rate expectations allows a stronger form of the international theory. If we assume relative purchasing power parity, then the equality of real interest rates produces a domestic term structure of real interest rates exogenously determined by the foreign term structure of real interest rates. Since expected rates of inflation have compensating effects on expected exchange rate changes and nominal interest rate differentials, the domestic term structure of real interest rates will equal the foreign term structure of real interest rates.

If expected rates of inflation are equal in both countries, then the nominal and real interest rate term structures will also be equal. Restricting exchange rate expectations by assuming purchasing power parity results in the strong form of the international theory. The strong form has the domestic term structure of real interest rates equal to and determined by the foreign term structure of real interest rates. Differences in the nominal interest rate term structures are due to differences in expected rates of inflation. If purchasing power parity is not assumed, then exchange rate expectations drive a wedge between the domestic and foreign term structures of real interest rates as well as between the term structures of nominal interest rates. The domestic term structure of interest rates, however, is still determined by international considerations. Any change in the foreign term structure of interest rates will result in a change in the domestic term structure of interest rates, a change in the term structure of exchange rate expectations, or a change in  $\alpha$ . Substituting the estimates of the expected short term and long term rates of change of exchange rates into equation (4), our estimable equation is:

$$(i_L - i_s)_t = \alpha + (i_L^* - i_s^*)_t - \ln\left(\frac{M^*}{MS}\right)_t - \ln\left(\frac{Y^*}{Y}\right)_t - \ln\left(\frac{S_t + j}{S}\right)_t + V_t,$$

where  $\alpha$  is a constant and  $V_t$  is a disturbance term.

Equation (5) will be estimated with Canada as the small domestic country and the United States as the large foreign country. In the next section we will present our empirical results.

#### AN EMPIRICAL ESTIMATION OF THE INTERNATIONAL TERM STRUCTURE OF INTEREST RATES

Equation (5) is estimated using monthly data for the United States and Canadian economies from July 1973 to October 1980, a period of floating exchange rates. The Canadian economy is quite small in comparison with the United States economy and the integration of the countries financial markets should make a reasonable test of the Beenstock and Longbottom proportionality hypothesis and of the term structures. The data employed in this study were obtained from Data Resources, Inc. and the International Monetary Fund International Financial Statistics. The differential in the Canadian term structure of interest rates, RDC, the dependent variable in this study, is represented as the difference between the ten year government bond rate and the three month government bill rate. The United States interest rate differential, RDUS, is the corresponding ten year and three month Treasury bond and bill differential. The expected rate of currency depreciation, EXX, is estimated using the McCallum (1977) method using the relevant future rate to approximate the long run equilibrium rate. The Canadian money supply, MSC, movements (relative to United States money supply) is standardized by the spot rate on the Canadian dollar. Productivity growth is assumed to be measured by the Canadian industrial production level relative to United States industrial production, INDP.

$$RDC_t = .632 + .557RDUS_t + .158EXX_t - .048INDP_t - .236MSC_t$$

(t-value) (.26) (6.92) (2.03) (-.05) (-.24)

$$R^2 = .88, F = 143.4,$$

$$D-W = 1.94, RHO = .89.$$

Empirical evidence is not produced to support the Beenstock and Longbottom proportionality position on the domestic and dominant countries term structures. We find a short term elasticity between the Canadian and United States term structures of .56; an elasticity not inconsistent with some of the alternative specifications of the Beenstock and Longbottom formulations. A Goldfeld-Quandt test was performed to test for heteroscedasticity; non-normal error terms could exist because of the presence of the currency depreciation variable which generally is non-normal (Upson 1972). Exchange rates normally follow a stable Paretian distribution (Cornell 1977). The regression period was equally divided into two parts and the resulting F-value of 2.056 does not allow the null hypothesis of equal subset variances.

The rejection of proportionality seems to imply real changes in output may result from the

Influence United States interest rates might have on Canadian interest rates and output. The variables hypothesized to influence the Canadian term structure, given in equation (5), are employed in time series analysis to possibly build a multivariate time series model that can forecast better than a univariate Canadian term structure model and thus test for causal relationships between the independent and dependent variables of equation(s). Causality can be tested using the Ashley tests in which the multivariate model forecasts are paired with the univariate time series model forecasts; if the multivariate time series model forecasts are statistically more accurate, then the independent variables are causally related to the Canadian term structure.

The univariate time series models are estimated using monthly data from July 1973 to February 1980; the post-sample period from March 1980 to October 1980 is reserved to test the forecasting abilities of the model and test for causality when paired with the multivariate models. The Canadian term structure is modeled as an ARIMA (0,1,1) process, a randomwalk with drift process.

$$RDC = .001 + (1-.637B)A_t$$

(s.e.) (.028) (.090)

$$X^2_{22} = 9.80, \text{variance estimate} = .459.$$

TABLE 1: ARIMA Models

Series	Process	Model
RDUS	0,1,2	RDUS=.017+(1-.431B <sup>2</sup> )A <sub>t</sub> (.048) (.010)
EXX	0,0,3	EXX=-.007+(1-.999B <sup>3</sup> )A <sub>t</sub> (.003) (.025)
MSC	1,1,0	(1+.501B)MSC=.002 (.096) (.043)
INDP	1,1,0	(1-.495B)INDP=.001 (.096) (.043)
Series	X <sup>2</sup> <sub>22</sub>	Variance
RDUS	29.22	.583
EXX	.45	.223
MSC	12.09	.337
INDP	11.70	.344

The fact that the spot rate on the Canadian dollar may not follow a random walk is supported by Levich (1979). Univariate time series models are built for the independent variables of equation (5) and are used as pre-whitened input in calculating cross-correlograms with the pre-whitened Canadian term structure series to examine the possibility of using the series in a multivariate model. The ARIMA models for the independent variables of equation (5) are shown in Table 1. The pre-whitened Canadian term structure is cross-correlated with these pre-whitened inputs and only the pre-whitened United States term structure series is statistically significantly correlated with the Canadian term structure such that it

can be employed in building a multivariate (bivariate) time series model. The cross-correlograms are shown in Table 2. The standard error for the series are  $1/\sqrt{N}$ .

TABLE 2: Cross-Correlogram Estimates

Series	0	1	2	3
$\bar{VRDC}_t, \bar{VRDUS}_{t-k}$	.072	.200	-.352	.281
$\bar{VRDC}_t, \bar{VEXX}_{t-k}$	.053	-.093	.050	.047
$\bar{VRDC}_t, \bar{VMSC}_{t-k}$	-.029	.102	.004	-.017
$\bar{VRDC}_t, \bar{VINDP}_{t-k}$	-.033	.103	.006	-.020
Series	4	5	6	7
$\bar{VRDC}_t, \bar{VRDUS}_{t-k}$	-.087	-.099	.094	-.026
$\bar{VRDC}_t, \bar{VEXX}_{t-k}$	-.138	.984	.046	-.115
$\bar{VRDC}_t, \bar{VMSC}_{t-k}$	-.041	.051	.010	-.082
$\bar{VRDC}_t, \bar{VINDP}_{t-k}$	-.039	.056	.009	-.081
Series	8	9	10	11
$\bar{VRDC}_t, \bar{VRDUS}_{t-k}$	-.065	.096	-.102	.051
$\bar{VRDC}_t, \bar{VEXX}_{t-k}$	.059	.065	.086	.020
$\bar{VRDC}_t, \bar{VMSC}_{t-k}$	.049	.022	-.058	-.003
$\bar{VRDC}_t, \bar{VINDP}_{t-k}$	.057	.023	-.064	-.005
Series	12			
$\bar{VRDC}_t, \bar{VRDUS}_{t-k}$	-.014			
$\bar{VRDC}_t, \bar{VEXX}_{t-k}$	.083			
$\bar{VRDC}_t, \bar{VMSC}_{t-k}$	.020			
$\bar{VRDC}_t, \bar{VINDP}_{t-k}$	.019			

The bivariate time series model built using the significantly correlated RDUS series input in the RDC model is estimated as:

$$\bar{VRDC}_t = .004 + (1 - 1.108B)A_t + \frac{.397}{(1 - .825B - .336B^2)} \bar{VRDUS}_t$$

(s.e.) (.006) (.974) (.140) (.039)

$$X_{22}^2 = 15.47, \text{ Variance estimate} = .166.$$

The variance of the bivariate model is substantially less than the univariate model variance (.459) during the sample period; however, there is no statistically significant difference in the MSFE errors of the models and hence no causality. The Ashley et al. test is employed in testing causality using one-step ahead forecasts.

The bivariate model one-step ahead mean square forecasting error (MSFE) is 1.693, some 51.0 percent less than the univariate model MSFE of 2.555; however, due to the large variances of the model errors, this MSFE reduction is not statistically significant. The Ashley test of causality is built upon the following regression:

$$DIF_t = \beta_1 + \beta_2 (SUM_t - E(SUM)) + \sigma_t$$

where

$$DIF_t = e_t^{\text{univariate}} - e_t^{\text{bivariate}}$$

$$SUM_t = e_t^{\text{univariate}} + e_t^{\text{bivariate}}$$

The regression tests the null hypothesis that  $\beta_1$  and  $\beta_2$  are equal to zero and there is no causality. The regression employing the univariate and bivariate model errors supports the absence of causality.

$$DIF_t = .285 + .110 (SUM_t - E(SUM)), R^2 = .144. (t)^t (.91) (1.00)$$

We find little evidence of proportionality between the Canadian and United States term structures and no support for the hypothesis that the United States "exports" its term structure of interest rates to the Canadian economy.

### CONCLUSIONS

We cannot find evidence to support the proportionality of the term structure of interest rates between the Canadian and United States economies. The lack of proportionality appears to imply that movement in the United States term structure could influence the Canadian term structure and output; however, we find no evidence to support causality between the United States and Canadian term structures.

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