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Does Government Debt Affect the Exchange Rate? An Empirical Analysis of the U.S.-Canadian Exchange Rate

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This paper examines the effects of the market value of privately held U.S. and Canadian government debt on the real Canadian dollar/U.S. dollar exchange rate within a small vector autoregressive model that includes, in addition to debt and the exchange rate, output, price level, nominal money, interest rate, and government purchases variables for both the U.S. and Canada. Variance decompositions based on this model indicate significant effects of debt on the exchange rate while impulse response functions indicate that debt shocks lead to a short-lived depreciation of the U.S. dollar rather than to an appreciation as conventional theory would suggest. Similarly we find that debt shocks have a temporary negative effect on the interest rate. These effects on the exchange rate and the interest rate can be explained within the Ricardian Equivalence framework, although there may be other explanations.

I. Introduction

The simultaneous appreciation in the value of the dollar relative to other currencies and the rise in the U.S. federal budget deficit in the early to middle 1980s stimulated debate on the relation between government debt and the value of the dollar. The conventional view is that the debt issued to finance the rising deficit made a substantial contribution to the appreciation of the dollar. The view is supported by the empirical findings of Feldstein (1986). However, this conventional view has recently been challenged by Evans (1986), who argued that Ricardian equivalence could explain his findings that government deficits led to a depreciation of the dollar relative to many other currencies.[1]

The aim of this paper is to investigate empirically the relationship between government debt and the exchange rate. The studies cited above are single-equation studies, and this study differs from those by examining the effects of government debt on the

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[1]It should be noted that while Feldstein fits his model to levels data, Evans uses first-differenced data. Macro data of the type used in these studies is often nonstationary in levels. Granger and Newbold (1974) found that spurious regression relations may arise when an integrated series is regressed on other integrated series. For a general discussion of the conditions under which ordinary least squares provides an acceptable framework for analysis with integrated variables, see Stock and Watson (1988).

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exchange rate within a small macroeconomic model. Specifically, the impact of the market value of privately held U.S. and Canadian government debt on the real Canadian dollar/U.S. dollar exchange rate is analyzed within a small vector autoregressive (VAR) model that also includes output, price level, nominal money, long-term interest rate, and government purchases of goods and services data for both the United States and Canada.[2] These are variables typically included in a structural model, and, as noted by Backus (1986), these variables include most of the variables used in empirical analyses of the exchange rate. Because it might be argued that it is short-term, rather than long-term, rates that affect the exchange rate, the system was also estimated with short-term rates replacing the long-term rates. The results were quite similar and only the results for the model with long-term rates are reported in the text.[3] The market value of government debt is used, as it is the market value of debt, rather than the par value, that is relevant for the operation of any wealth effects of debt.

The VAR methodology is by now a common approach for investigating macroeconomic issues. It is particularly useful for characterizing the dynamic relationships among economic variables without imposing certain types of theoretical restrictions. The VAR framework avoids the imposition of potentially spurious a priori constraints (such as, for example, econometric exogeneity of debt in an exchange rate equation), and it is quite useful in examining the channels through which a variable operates, because few restrictions are imposed on the way the system's variables interact. Of course, inasmuch as the VAR is a reduced form, it is difficult to distinguish sharply among structural hypotheses.[4] The VAR framework has recently been employed by Backus (1986) to examine the relationship between the Canadian–U.S. dollar exchange rate and macroeconomic variables. However, Backus's model does not contain government debt and hence does not provide any evidence of the effect of government debt on the exchange rate. The effects of debt on the exchange rate are evaluated by computing variance decompositions and impulse response functions (IRFs). A Monte Carlo simulation technique similar to that described in Doan and Litterman (1988) is used to compute standard errors for the variance decompositions and impulse response functions. This allows a judgment as to the significance of debt shocks on the exchange rate.

As noted earlier, the model includes monetary and fiscal variables for both the United States and Canada. Evans's (1986) review of conventional theory indicates that

[2]A bilateral framework is chosen because series for the market value of both U.S. and Canadian government debt are available.

[3]Specifically, U.S. and Canadian government three-month Treasury bill rates were substituted for the AAA rates used in the results reported in Table 1. Variance decompositions (VDC), discussed in the text in Section II, for the four horizons and four orderings in Table 1 were computed. In all cases, the VDC results for the Treasury bill model were within one standard deviation of those for the long-term rate model. Thus there appears to be no significant difference between the results for the short-term rate model and the long-term rate model. The response of the exchange rate to a debt shock in the short-rate model follows patterns similar to those in Figures 1 and 2.

[4]We stress that our model is a reduced-form model and not a structural model that allows only actual debt to affect the exchange rate. It may be the case that expectations of future debt influence the exchange rate today, and we note that expectations of future debt formed at a particular time are based upon information available at that time. The information set that conditions the expectations of debt includes lagged values of variables relevant to forecasting debt. Most specifications of the information set relevant to formation of debt expectation would include the macro variables in our model. For an elaboration of this, see Evans (1987). While we do not attempt to measure expectations directly, the model is a reduced form and can be thought of as implicitly incorporating expectations in the sense that the explanatory variables of the model are variables typically thought to condition expectations about the debt. In fact, the model is consistent with the reduced form of a linear rational expectations model. We cannot, however, distinguish between the effects due to actual and to expected deficits.

an increase in U.S. government debt will lead to an appreciation of the real Canadian dollar/U.S. dollar exchange rate, because U.S. real interest rates are raised relative to those abroad. Because an increase in U.S. government purchases will have similar effects on relative interest rates and because government debt and purchases are correlated, it is crucial to include government purchases in the model. If government purchases were omitted, effects due to variations in government purchases might be incorrectly attributed to government debt.[5] Conventional theory also suggests that an increase in the U.S. money supply leads to a depreciation of the real exchange rate, because U.S. real interest rates are (temporarily) reduced relative to those abroad. Changes in Canadian policy variables will have the opposite effect.

In section II of the paper, the data and empirical evidence are described and analyzed. The final section presents a summary and conclusions.

II. Data and Empirical Evidence

Quarterly data for the period 1961:1–1984:4 are used. Data from the period 1961:1–1963:1 are used as presample data, and the estimation of the system is carried out over 1963:2–1984:4. The beginning of the sample reflects the initial availability of data on Canadian government purchases. The end of the sample reflects the availability of data on the market value of debt, because the data on market value of debt constructed by Cox (1985) for the United States and by Cox and Haslag (1986) for Canada end in 1984:4. We note that the sample spans the fixed- and the floating-rate periods. The exchange rate variable employed is the real exchange rate, which is constructed as the product of the Canadian dollar/U.S. dollar nominal exchange rate and the ratio of the U.S. price level to the Canadian price level. It is evident that the real exchange rate can fluctuate even though the nominal rate is fixed.

We chose to combine data from the fixed- and the floating-rate periods for the following reasons. One is based upon Stockman's (1986) argument that there is no necessary reason to restrict the sample to flexible exchange rates because, if changes in (for example) government debt affect real exchange rates, variations in government debt will alter real exchange rates regardless of the exchange rate regime. The second is that use of quarterly data and restriction of the sample to just the flexible-rate period substantially reduces the degrees of freedom for estimation. Monthly data were not used, because government purchases data are not available monthly. As noted earlier, if government purchases were omitted, effects due to variations in government purchases might incorrectly be attributed to government debt, because purchases and debt are correlated.

The stability of the model across the fixed- and the floating-rate periods was tested by a straightforward multivariate extension of the procedure suggested by Dufour (1980, 1982). In the single-equation variant of Dufour's test, a 0–1 dummy is added for *each* observation in the period in which instability is suspected. The dummy takes on a value of 1 for one particular observation and 0 for all other observations. In the current case, we desire to see if the fixed-rate period (1963:2–1970:2) differs from the floating-rate period. Because the 1963:2–1970:2 period spans 29 observations, the test would require adding 29 dummies to the equation to be tested. The coefficients on a particular

[5]Ideally, marginal tax rates would also be included, but this was not done owing to the unavailability of reliable marginal tax rate measures for both the United States and Canada.

dummy variable measure the prediction error for that observation. The equation is estimated over the full sample, and the joint significance of the coefficients on the dummies is tested. Rejection of the null hypothesis that the coefficients on the dummies are jointly equal to zero is indicative of instability.

In the multivariate extension of this test, the system was first estimated with 6 lags on each variable over 1963:2–1984:4. Dummy variables for each observation in 1963:2–1970:2 were then added to *each* equation in the system, and this system was estimated over 1963:2–1984:4. The joint significance of the coefficients on all the dummy variables was tested by a likelihood ratio test. The test statistic

$$(T - C) \cdot (\log |DR| - \log |DUR|)$$

was formed, where $|DR|$ = determinant of the variance–covariance matrix of the restricted system, $|DUR|$ = determinant of the variance–covariance matrix of the unrestricted system (system with the dummy variables), T = number of observations in the sample period 1963:2–1984:4, and C = number of parameters in each unrestricted equation (72). This statistic is distributed as χ^2, with degrees of freedom equal to the number of restrictions (i.e., the number of coefficients on the dummy variables, which equals 203 in this case). Subtracting C from T is suggested by Sims (1980) as a means of correcting for a presumed small sample bias for rejecting the null hypothesis that the coefficients on the dummy variables are jointly equal to zero. The calculated χ^2 statistic was 119.5. The marginal significance level of this statistic is .99. Thus, the hypothesis that the coefficients on the dummy variables are jointly equal to zero cannot be rejected, and no instability is indicated. Finally, as an informal test of the stability of the results, the long-term rate model was estimated over the flexible-rate period. The results were similar to those reported in Table 1 for the full sample period.[6] On the basis of these results (which are available on request) and the stability test, the longer sample period was employed.

The symmetry of expected effects of the U.S. and Canadian variables on the real exchange rate led us to work with the ratios of the U.S. variables to the Canadian variables.[7] Backus (1986) employed a similar formulation in his VAR model. For example, in the conventional view, an increase in U.S. debt relative to Canadian debt

[6]Specifically, the model was estimated over the 1970:3–1984:4 period. The variance decomposition results for ordering 1 were somewhat greater than those in Table 1 but were within two standard deviations of those in Table 1 at horizons of 8, 12, and 20 quarters. The results were slightly above two standard deviations (SD) of those in Table 1 at a horizon of 4 quarters. There appears to be no significant difference in the results for the full period and the flexible-rate period.

[7]More precisely, we computed the natural logs of the ratios of U.S. and Canadian output, price, money supply, government purchases, and debt. The ratio of the level of the U.S. interest rate to the Canadian rate was formed.

The definitions of the variables and the data sources are the following: output = real GNP; price level = GNP deflator; interest rate = nominal AAA corporate bond rate (last month of the quarter); money supply = nominal M1 (last month of the quarter); government purchases = real federal government purchases; and government debt = nominal market value of privately held government debt (last month of the quarter). The Canadian variables (except for debt) were provided by the Bank of Canada, and the U.S. variables (except for debt) were taken from Citibase. The Canadian debt series is from Cox and Haslag (1986) and the U.S. debt series is from Cox (1985). The nominal exchange rate (Canadian dollars per U.S. dollar, last month of the quarter) was taken from the November, 1986 *International Financial Statistics* tape.

All data except for the interest rates and the real exchange rate are seasonally adjusted, and all seasonally adjusted data except for the debt series are seasonally adjusted at the source. The debt series were adjusted with the X-11 routine of SAS. Ideally one might want to use non-seasonally-adjusted data. However, this was not done, owing to the unavailability of non-seasonally-adjusted data for real GNP, the GNP deflator, and government purchases.

leads to a rise in the U.S. interest rate relative to the Canadian rate and hence to an appreciation in the exchange rate. Tests for first-order unit roots of the type described by Nelson and Plosser (1982) indicated that for each variable the hypothesis of a first-order unit root could not be rejected. Furthermore, tests of cointegration of the type recommended by Engle and Yoo (1987) revealed no evidence of cointegration. Thus, first differences of these variables were employed in the estimation. The details of these tests are available on request.

Although theory focuses upon relative real interest rates, nominal rates were employed. This was done because of the difficulty of accurately measuring expected inflation rates and because many of the variables that influence the expected inflation rate (like nominal money) are included in the model and hence are controlled for in the estimation.[8]

The seven-variable VAR model employed is a standard Sims-type model in which each variable enters each equation with the same lag length. The lag length employed was 6 and was determined from a sequence of likelihood-ratio tests (with the correction suggested by Sims (1980)). The maximum lag considered was 8. In order to conserve space, the results of the likelihood-ratio tests and the estimated equations are not presented, but they are available on request. In all cases, the Q statistics indicated white noise residuals.

The effects of government debt are evaluated by examining variance decompositions (VDCs) and impulse response functions (IRFs) that are based upon the moving-average representation of the VAR model. VDCs show the proportion of forecast error variance for each variable that is attributable to its own innovations and to shocks to the other system variables. Forecast errors for a particular variable (for example, the exchange rate) at a particular time horizon will be due to errors in forecasting the exchange rate in previous periods as well as to errors in forecasting the other variables in the system. The VDC for the exchange rate will thus indicate the percentage of the forecast error variance of the exchange rate accounted for by shocks to itself, debt, and the other variables. Sims (1982) suggests that the strength of Granger-causal relations can be measured by VDCs. If government debt explains only a small fraction of the forecast error variance of the real exchange rate, this could be interpreted as a weak Granger-causal relation. IRFs show the response of each variable in the system to a 1-SD shock to one of the system's variables and can be thought of as a type of dynamic multiplier. IRFs thus indicate the direction and magnitude of effect of one variable on another. Details of the derivation of the moving-average representation and the computation of the VDCs and IRFs are provided in Judge et al. (1988).

Runkle (1987) stressed the importance of providing estimates of the precision with which the VDCs and IRFs are computed. He pointed out that reporting VDCs and IRFs without estimates of the associated standard errors is analogous to reporting regression coefficients without t statistics. Consequently, we employ a Monte Carlo integration technique similar to that described in Doan and Litterman (1988) to generate estimates of the standard errors for the VDCs and IRFs. Five hundred draws were employed in the Monte Carlo procedures.

Because no contemporaneous terms enter the VAR, any contemporaneous relationships among the variables are reflected in the correlation of residuals across equations.

[8]The model was also estimated by using the ratio of the ex post real interest rates in place of the ratio of the nominal interest rates. For every ordering, the VDC results for the model using the ratio of the ex post real rates are within one standard deviation of those in Table 1.

In calculating the VDCs and IRFs, the variables are ordered in a particular fashion, and the variance-covariance matrix for the VAR is orthogonalized by Choleski decomposition. The orderings considered are determined by theoretical considerations. Ordering 1 is government purchases, government debt, money, output, price level, interest rate, and the real exchange rate. The efficient-markets hypothesis leads us to place the interest rate and exchange rate last; this allows shocks to all the other variables to contemporaneously alter these variables. We place the policy variables first; this suggests that the information sets that condition the settings of the policy variables contain only lagged values of the nonpolicy variables. This is a common assumption in the macro literature. Since the fiscal variables precede the monetary variable, monetary policy is allowed to respond contemporaneously to the fiscal variables. Ordering 2 reverses the positions of the monetary and fiscal variables. Ordering 3 is similar to ordering 1 except that the interest rate and exchange rate are placed before the goods market variables, output, and the price level. Finally, ordering 4 is similar to ordering 3 except that the positions of the monetary and fiscal variables are reversed.

The VDC results for the four orderings are presented in Table 1. Only the proportion of the variation in the real exchange rate explained by shocks to the debt variable are presented, in order to conserve space. Point estimates of the VDCs at horizons of 4, 8, 12, and 20 quarters are presented in order to convey a sense of the dynamics of the system. The estimated standard errors are presented in parentheses beside the VDC results. The estimates of the proportion of forecast error variance explained by each variable are judged to be "significant" if the estimate is at least twice the estimated standard error. The results indicate economically important effects of debt on the real exchange rate. The effects are larger than those of any other variable, and are of a magnitude comparable to the effects of shocks to the real exchange rate itself.[9]

Figure 1 presents the IRF results. It shows the response of the real exchange rate to a shock to the debt variable. The dotted line indicates the point estimate of the IRF, and the upper and lower lines represent a 2-SD band around the mean. We note that the initial effect is positive, but because the 2-SD band includes zero, it is judged to be insignificant. In periods 2 and 3, we observe negative effects that are significant in the sense just defined. A marginally significant, positive effect is observed in period 7. None of the effects in the other periods are significant.

Because the model is fitted to differenced data, a better understanding of how the level of the real exchange rate responds to a debt shock can be obtained by computing cumulative IRFs, which add prior-period shocks to obtain the current-period shock. Figure 2 plots the cumulative IRF results. Again the dotted line represents the point

[9] In all four orderings reported in Table 1, the exchange rate appears last. We also examined the robustness of the results when the exchange rate is placed before the other variables in the system. The relative variation in the exchange rate explained by innovations in the debt variable were 22.9%, 24%, 22.8%, and 21.4% at horizons of 4, 8, 12, and 20 quarters, respectively. Therefore, a change in the ordering by placing the exchange rate before the other variable does not change our inferences about the effect of debt on the exchange rate. Furthermore, we also considered an ordering in which the exchange rate was placed first and debt was placed last. The results were all within 1 SD of those in Table 1.

At the suggestion of a referee, we examined the effects of the exchange rate on debt. When we examined the determinants of the variation in debt (not reported in Table 1), we found no evidence of important effects of the exchange rate on debt. For example, for ordering 1, we found that the exchange rate explains 1.7% of the variation in debt, with an associated standard error of 2.7 at a horizon of 4. For horizons 8, 12, and 20, the percentages of the variation in debt explained by the exchange rate are 3.2% (2.9), 3.1% (2.8), and 3.9% (3.0), respectively (standard errors in parentheses). In no case are these effects significant.

Table 1. Variance Decomposition Results

Relative variation in	Horizon (quarters)	Explained by innovations in the debt variable[a, b] 1	2	3	4
Real exchange rate	4	21.0 (7.0)	21.6 (7.0)	21.0 (6.8)	21.6 (6.4)
	8	22.2 (6.5)	23.2 (6.6)	22.2 (6.5)	23.2 (6.2)
	12	21.0 (6.2)	21.8 (6.3)	21.0 (6.3)	21.8 (5.9)
	20	19.7 (6.1)	20.5 (6.3)	19.9 (6.2)	20.5 (5.8)

[a]All VDC values are at least 2 SD larger than the estimated standard errors, which are in parentheses.
[b]Columns 1–4 present the results, respectively, for ordering 1: government purchases, debt, money, output, price level, long-term interest rate, real exchange rate; ordering 2: money, government purchases, debt, output, price level, long-term interest rate, real exchange rate; ordering 3: government purchases, debt, money, long-term term interest rate, real exchange rate, output, price level; ordering 4: money, government purchases, debt, long-term interest rate, real exchange rate, output, price level. Because debt appears second in orderings 1 and 3, the point estimates of the VDCs are the same. Because debt appears third in orderings 2 and 4, the point estimates of the VDCs for these two orderings are the same. A different Monte Carlo simulation was performed to generate standard errors for each ordering; hence, the estimated standard errors are different for each ordering.

estimate of the cumulative IRF, and the solid lines represent a 2-SD band around the mean. As expected, the temporary effects on the rate of change of the exchange rate found in Figure 1 are reflected in a temporary effect on the level of the exchange rate. The response of the level of the exchange rate is significantly negative in period 3, but is not significantly different from zero in other periods. Thus, debt shocks have no lasting effect on either the level or rate of change in the exchange rate.

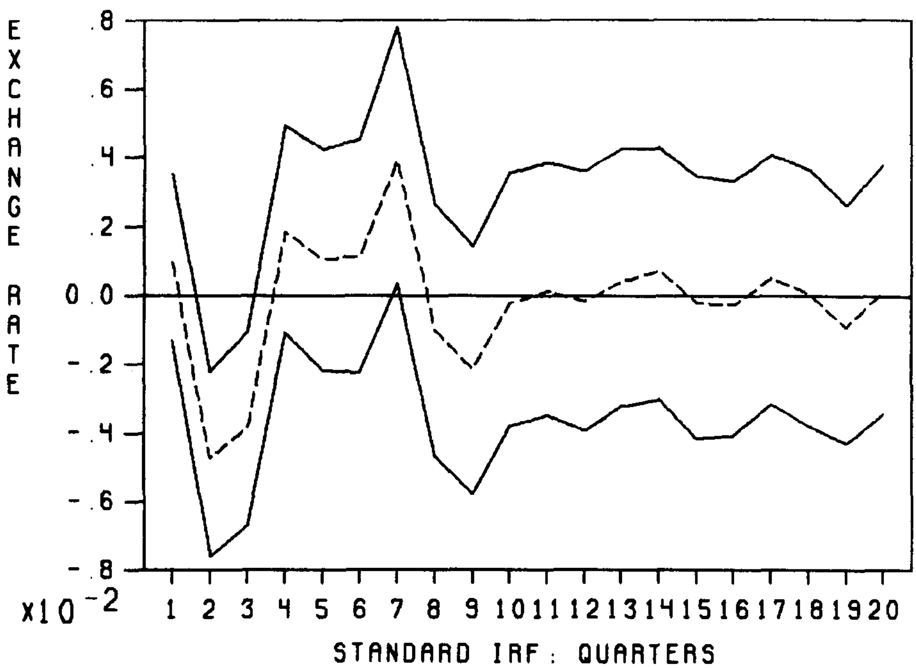

Figure 1. Impulse response function.

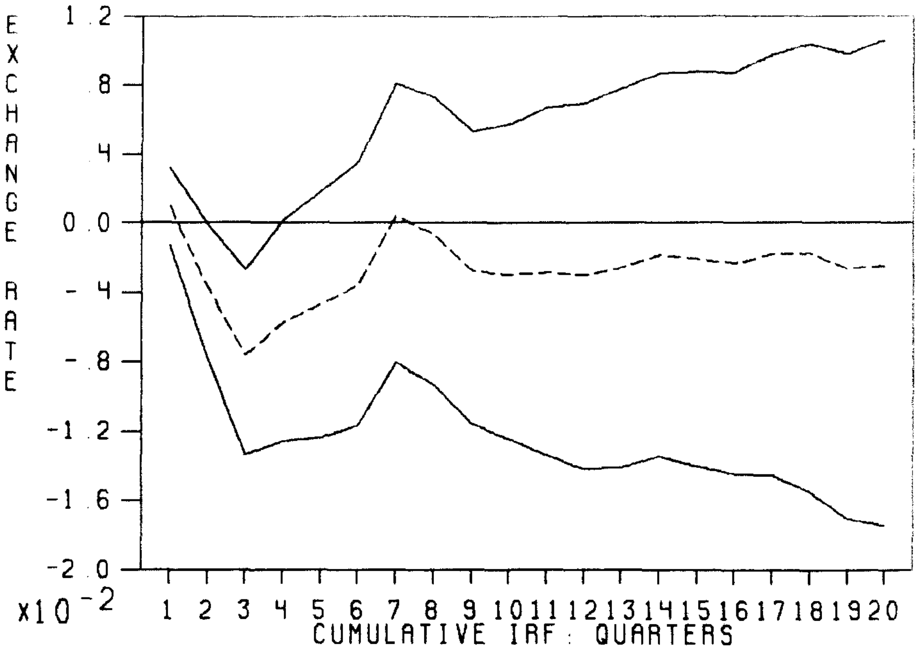

Figure 2. Cumulative impulse response function.

The IRF results are difficult to explain within the conventional view of the effects of debt on the exchange rate. The first-period result is in the direction predicted by the conventional view, but it does not appear to be significant. The next two effects are significant but are in the direction opposite to that of the prediction of conventional theory. It is interesting to note a similar pattern for the interest rate variable. The first-period effect of a debt shock on the interest rate variable is positive but not significant, while the effects in the next three periods are negative. However, only the third-period effect is significant. Similar results are found for the short-term rate model. The cumulative IRFs indicate that the response of the interest rate to a debt shock is significantly negative in period 3 but is not significantly different from zero in other periods.

The exchange rate results for the first period appear roughly consistent with those of Evans (1986), who finds that unanticipated increases in the U.S. deficit have a positive, but not significant, effect on the U.S.-Canada exchange rate. His analysis is not dynamic, however, and provides no evidence of effects in subsequent periods. For other countries, he finds that frequently the unanticipated deficit significantly leads to a depreciation in the relevant bilateral exchange rate. The negative effects on the interest rate ratio are consistent with those of Evans (1985).

The negative effects on the real exchange rate and the interest rate can be explained within the Ricardian equivalence framework. For example, Kormendi (1985) suggests that because of uncertainty about their share of future taxes and the timing of these taxes, individuals may save more than the present value of the income streams associated with bonds issued to finance a government deficit. In this case, one would expect declines in interest rates and depreciation of the exchange rate.

III. Conclusions

This paper has examined the impact of government debt on the exchange rate. The effects of the market value of privately held U.S. and Canadian government debt on the real Canadian dollar/U.S. dollar exchange rate are examined within a small vector autoregressive model that includes—in addition to debt and the exchange rate—output, price level, nominal money, interest rate, and government purchases variables for both the United States and Canada. The effects of debt on the exchange rate are examined by computing variance decompositions and impulse response functions. A Monte Carlo simulation technique is used to estimate the standard errors of the variance decompositions and impulse response functions.

The variance decomposition results indicate significant effects of debt on the exchange rate. However, the impulse response functions indicate that debt shocks lead to a short-lived depreciation of the U.S. dollar rather than to an appreciation, as conventional theory would suggest. Similarly we find that debt shocks have a temporary negative effect on the interest rate. These effects on the exchange rate and the interest rate can be explained within the Ricardian equivalence framework, although there may be other explanations. As Kormendi (1985) notes, uncertainty about their share of future taxes and the timing of these taxes may lead individuals to save more than the present value of the income streams associated with bonds issued to finance a government deficit. In this case, a fall in the interest rate and a depreciation of the exchange rate are expected.

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