

United States-Canadian Economic Relationships

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It is generally thought that the United States and Canada have a very close economic and financial interrelationship. It is also thought that, due to the relatively larger size of the United States, economic developments in the United States influence economic developments in Canada. Reflecting these views, George Freeman, Adviser of the Bank of Canada, recently asserted: "This [inter-relationship], it seems to me, is the principal reason why Canada's monetary policy and domestic rate of inflation have never been allowed to depart very long or very far from those of the United States." Milton Friedman—in commenting on the direction of influence between the two countries—has also said: "If you want to know what happens to Canadian income, you do better to know what happens to the U.S. money stock than to know what happens to the Canadian money stock."²

To support the view about the close interdependence between the United States and

Canada, reference is usually made to the similarity in the growth paths of economic variables in each country. For example, Chart 1 depicts the growth in the narrowly defined money stock, M1, in each country during the period 1953-73. While Chart 1 does not lend itself to determining the direction of influence between the money stocks, the existence of a strong common trend in the two countries' money supplies would appear to indicate that the two variables are indeed very closely related. The strong trend in these variables, however, may invalidate many conclusions drawn about the interdependence of the United States and Canada.¹

This article, therefore, examines with detrended data the two widely held hypotheses about U.S.-Canadian economic relationships: that there is close interdependence between the U.S. and Canadian economies and that the direction of influence runs from the U.S. economy to the Canadian economy. In gen-

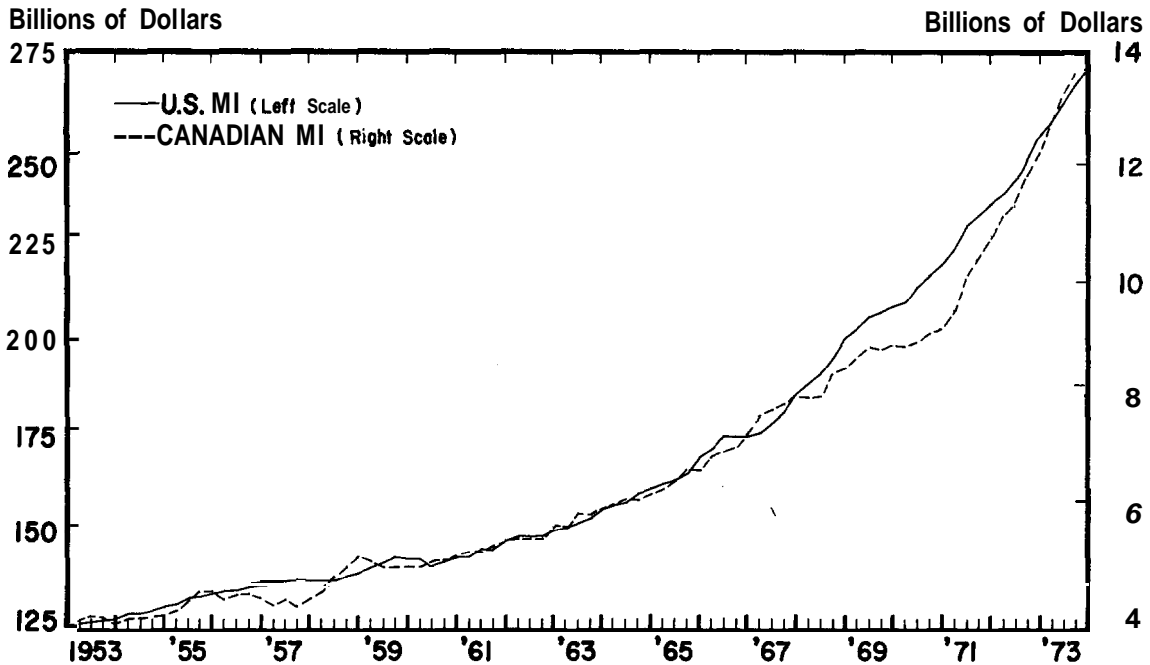
A theoretical version of this article was presented at the Allied Social Science Association meetings in San Francisco, December 29, 1974, where the authors benefited from Anna Schwartz's suggestions.

1/Federal Reserve Bank of Chicago, *International Inflation: Four Commemoratives* (Chicago: Federal Reserve Bank of Chicago, July 1974), p. 11.

2/Milton Friedman, *Money and Economic Development: The Horowitz Lectures of 1972* (New York: Praeger Publishers, 1973), p. 17.

3/Glenn P. Jenkins, in a technical paper "The Role of the United States Monetary Stock in a Model of the Canadian Economy" presented at the Money and Banking Workshop of the University of Chicago (April 20, 1971), concluded that changes in the stock of money in the United States would lead to corresponding actions by the Canadian monetary authorities to keep the interest rate differential between the two countries constant. To do this, the money supply of Canada would have to follow the direction of changes in the U.S. money supply very closely. Jenkins' statistical work, however, is marred by the presence of strong trend so that his conclusions are suspect.

Chart 1
U. S. M1 AND CANADIAN M1, 1953-73
Quarterly Data



eral, the results presented here appear to contradict these two widely held beliefs when detrended data are employed.

METHOD OF ANALYSIS

In analyzing the interdependence and direction of influence between the U.S. and Canadian economies, several conventional economic measures were employed. First, examination was made of the relationship between money, or nominal, gross national product (GNP) in the United States and money GNP in Canada. Next, the relationship between each country's GNP adjusted for prices, or real GNP, was examined. Also, the relationship of the price level and its determinants in each country were considered, as well as two different concepts of the money stock: the narrowly defined money supply,

M1, which includes currency and demand deposits at commercial banks, and the more broadly defined money supply, M2, which includes M1 plus time deposits other than large negotiable certificates of deposit. The period 1953-73 was tested using quarterly data for each of these variables.

One of the major problems in examining the relationship between economic variables over a period of time, such as 1953-73, is that the variables usually contain a strong upward trend, as is illustrated in Chart 1. The presence of trend biases the relationships estimated by ordinary statistical tools toward acceptance of the hypothesis that the variables are related when indeed they may not be. The presence of a trend may also invalidate statistical tests for measuring the direction of influence between two variables. Thus,

before relationships between the variables with a trend can be estimated properly, the effect of the trend must be removed from each variable.⁴

Several methods are used by economists to remove the trend from a time series. Most of these methods, however, do not adequately remove the trend. The method used in this article is a relatively new technique which appears to be far superior to other methods in removing trend. This technique, called the autoregressive technique, removes that part of a variable which is related to its own past history.⁵ Chart 2 illustrates the values of U.S. and Canadian M1 after the trend is removed by use of the autoregressive technique.

⁴The necessity for removing the trend, or more properly the autoregressive structure, when examining the relationship between two variables is emphasized by C. W. J. Granger and P. Newbold in "Spurious Regressions in Econometrics," *Journal of Econometrics*, Vol. 2 (July 1974), pp. 111-20. They indicate that the presence of trend biases the multiple correlation coefficient, R^2 , so that it appears both high and significant when in reality it is not. See, also, George S. Fishman, *Spectral Methods in Econometrics* (Cambridge, Mass.: Harvard University Press, 1969), p. 58; and Christopher A. Sims, "Money, Income, and Causality," *The American Economic Review*, Vol. 62 (September 1972), pp. 540-52.

⁵Two common methods for removing the trend are the use of first differences and compound rates of changes. These techniques, however, have been found by the authors to leave a substantial amount of trend in the variable. A third technique is to use quasi-second differences, but it too does not remove the trend adequately. The autoregressive technique was judged superior to these methods after testing them by spectral analysis. The previously mentioned techniques almost uniformly failed to remove the entire trend, while the autoregressive technique was generally successful.

The autoregressive technique used in this article is summarized as follows. First, each variable (after being converted into natural logarithms) is regressed on its past values. Then, only the past values significant at the 99 per cent level are retained and a second regression is run. This procedure is repeated until all the coefficients are significant at the 99 per cent level. Then the residuals, i.e., the current values less the weighted past values—where the weights are the regression coefficients—are tested through spectral analysis to determine if the trend has been adequately removed. When it is determined that it has been adequately removed, the residuals are the new variables used in place of the levels.

The autoregressive technique has been suggested, but not employed, by the following econometricians: George Fishman, *Spectral Methods in Econometrics* (Cambridge, Mass.: Harvard University Press, 1969); Phoebus Dhrymes, *Econometrics: Statistical Foundations and Applications* (New York: Harper and Row, 1970); and Granger and Newbold, "Spurious Regressions in Econometrics," pp. 111-20. The authors wish to thank Emanuel Parzen for his helpful comments on the autoregressive technique.

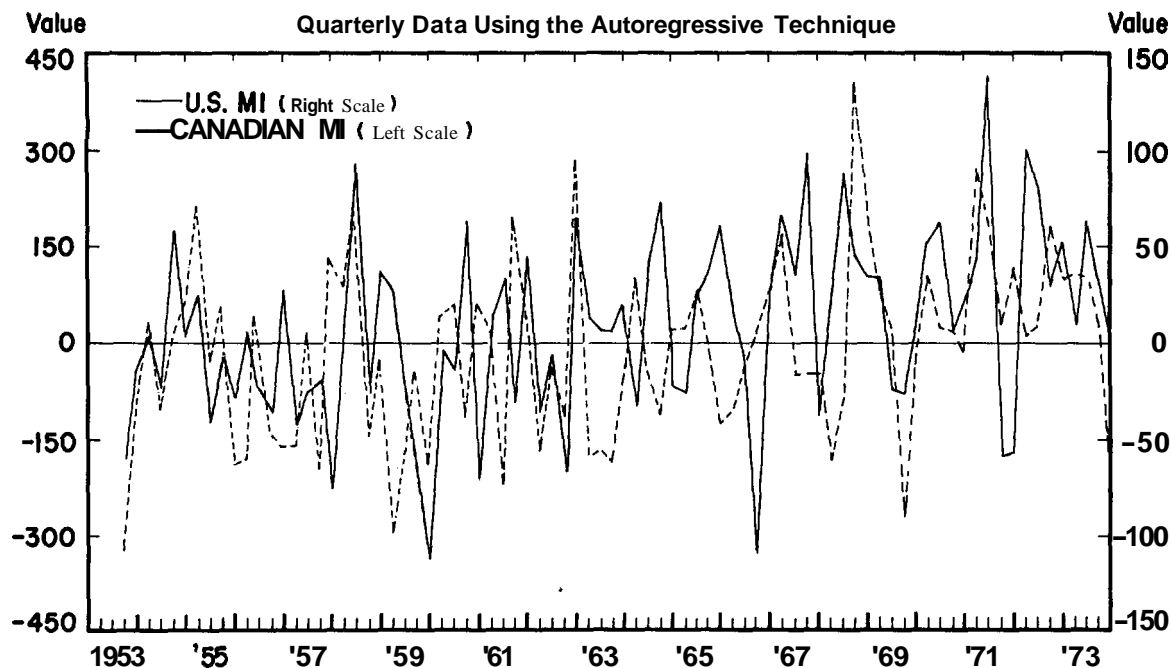
After the trend was removed from each of the variables examined, statistical tests were conducted to determine the degree to which selected U.S. and Canadian economic variables are correlated. For example, the degree of correlation between the Canadian money supply and the U.S. money supply over the period 1953-73 was examined.

Statistical tests were also conducted to determine the direction of influence, or *causality*, between pairs of economic or financial variables, such as Canadian M1 and U.S. M1, based on the following line of reasoning. Suppose there are theoretical reasons to believe movements in Canadian M1 are caused in part by movements in U.S. M1. If it is then found that movements in Canadian M1 occur after movements in U.S. M1, it may be concluded that movements in Canadian M1 are caused in part by movements in U.S. M1. Suppose it is simultaneously found that movements in Canadian M1 are also followed by movements in U.S. M1. In this case, it may be concluded that, while movements in U.S. M1 may cause movements in Canadian M1, movements in Canadian M1 may also cause movements in U.S. M1. In other words, the direction of causality runs in both directions so the two variables are said to exhibit two-way or *bidirectional causality*.

Alternatively, one-way or *unidirectional causality* is said to exist in the following cases. If movements in Canadian M1 follow movements in U.S. M1, but are not themselves followed by movements in U.S. M1, the two variables can be said to exhibit unidirectional causality. In this case, the causality can be said to run from U.S. M1 to Canadian M1. Similarly, if movements in Canadian M1 are followed only by movements in U.S. M1, then unidirectional causality can be said to run from Canadian M1 to U.S. M1.

Regression analysis was employed to test these possibilities concerning the direction of causality. In the analysis, current values of

Chart 2
DETRENDED VALUES OF U.S. M1 AND CANADIAN M1, 1953-73



each variable were regressed on current, past, and future values of the other variable. For example, current values of Canadian M1 were regressed on current, past, and future values of U.S. M1. The results of these re-

6/These concepts can be summarized by reference to the following simplified equation:

$$\text{Current MI (Can)} = f[\text{Current MI (US), Past MI (US), Future MI (US)}]$$

In this equation the current value of Canadian M1 is assumed to be a function of current, past, and future values of U.S. M1. If, upon statistical examination, Canadian M1 is found to be significantly related to only past values of U.S. M1, it can be said that unidirectional causality runs from U.S. M1 to Canadian M1. Similarly, if Canadian M1 is related to only future U.S. M1, the direction of influence would run one way from Canada to the United States. Finally, if both these influences are present, i.e., past U.S. M1 affects current Canadian M1 which in turn affects future U.S. M1, it can be said that current MI (Can) is related to both past and future MI (US), so that bidirectional causality exists between these variables.

The technique used here was first suggested by C. W. J. Granger, "Investigating Causal Relations by Econometric Models and Cross-Spectral Methods," *Econometrica*, Vol. 37, No. 3 (July 1969), pp. 424-38, and later modified by Sims, "Money, Income, and Causality," pp. 540-52.

gressions show if unidirectional or bidirectional causality exists.⁶

EMPIRICAL RESULTS

This section presents the empirical results of examining the degree of correlation and the direction of influence between selected economic variables in the United States and Canada over the 20-year period ending 1973. Table 1 summarizes these empirical results.⁷ The degree of correlation between selected variables is shown by the multiple correlation

7/In practice, four regressions were fitted for each pair of variables. First, one variable was regressed on 1 synchronous, 8 past, and 4 future values of the other variable. Then a second equation was fitted with the dependent and independent variables reversed. Two additional equations were fitted by attaching seasonal dummies and a time variable to the first two equations. Note that the equations in Table 1 were selected because they were considered most representative of the general findings. The entire table of regressions with R²'s will be furnished on request.

Table 1
SELECTED REGRESSION RESULTS
Detrended Quarterly Data, 1953-73

| Equation Number | Dependent Variable | Direction of Causation | Explanatory Variable | Adjusted R ² |
|-----------------|--------------------|------------------------|----------------------|-------------------------|
| 1 | USGNP | ↔ | CGNP | .50 |
| 2 | CGNP/P | ← | USGNP/P | .19 |
| 3 | USP | → | CP# | .24 |
| 4 | CM2/GNP/P | ← | USM2/GNP/P# | .41 |
| 5 | CM1 | | USM1 | .14* |
| 6 | USM2 | ↔ | CM2 | .31 |
| 7 | CGNP | ↔ | CM1 | .23 |
| 8 | CGNP | | USM1 | .06* |
| 9 | CGNP | | USM2 | .06* |

NOTE R², the multiple correlation coefficient adjusted for the degrees of freedom, is marked * where it is not significantly different from zero at a 95 per cent level of confidence. Arrows indicate significant direction of causality, and # means a significant coefficient has been found for the synchronous explanatory variable. Where the adjusted R² is not significant at the 95 per cent level, the direction of causation is also insignificant. The symbols use conventional notation: e.g., P is the price deflator and the U.S. money supply defined as M1 is USM1.

coefficient, or R², with the higher value of the R² denoting a higher degree of correlation. The arrows in the table indicate the direction of influence, or causality, between two variables, with a single arrow designating unidirectional causality and a double arrow meaning bidirectional causality.

A relatively strong relationship was found between money values of Canadian GNP and U.S. GNP. As shown by equation 1 in Table 1, the R² for these variables was .50. There was also evidence of bidirectional causality between the two money GNP's, as indicated by the double arrow in equation 1. This suggests that despite the fairly strong relationship between the two money GNP's, there was no consistent one-way cause and effect relationship from one economy to the other.

In contrast to the two countries' money GNP's being fairly well related, only a weak relationship was found between the countries' real GNP's, i.e., their GNP's divided by a price deflator. As shown in equation 2, the R² between the real values of the two GNP's was only .19. Although it was also found that there was unidirectional causation running

from real U.S. GNP to real Canadian GNP, as indicated by the single arrow, the entire relationship was so weak that little confidence can be put in this finding.⁸

The price levels in the United States and Canada also showed a weak relationship, although the relationship was somewhat stronger than for the real GNP's of the two countries. In equation 3, the R² between the GNP price deflators in the United States and Canada was only .24. Bidirectional causation was also found in this relationship, suggesting there was no consistent one-way cause and effect relationship between the price levels in the two countries.⁹

The finding that Canadian and U.S. price levels are not closely related contrasts with the results of tests run on money per unit of output, a variable which is one of the determinants of prices.¹⁰ Other things equal, if money per unit of output increases—that is, if money grows faster than output—the price level would tend to increase. Thus, the result

8/Vittorio Bonomo and Ernest J. Tanner in "Canadian Sensitivity to Economic Variables in the United States," The Review of Economics and Statistics, Vol. 54, No. 1 (February 1972), pp. 1-8, found through spectral analysis that neither country's industrial production index consistently led associated changes in the other country's industrial index. Moreover, equation 2 of Table 1 was the only equation with an adjusted R² significantly different from zero in the four equations fitted.

9/In Table 1, the adjusted R² for the relationship between the two price levels shown in equation 3 was .24 and the adjusted R² for the two real GNP's in equation 2 was .19. Adding these two R²'s yields a combined value of .42 which is .08 less than the R² of .50 found for the relationship between the two money GNP's. (Note: Numbers may not add to totals because of rounding.) This suggests some relationship between the real GNP in one country with the other country's price level and vice versa. Equations with these relationships were fitted and significant R²'s with evidence of bidirectional causation were obtained. For example, real CGNP on USP yielded an adjusted R² of .15 and evidence of bidirectional causality.

10/The determinants of the price level can be considered as money per unit of output (money divided by output) and velocity (GNP divided by money). In a technical sense, this can be seen from the equation of exchange: MV = Py, where M is the money stock, V is velocity, P is prices, and y is output. If M is divided by y, the result is the equation: (M/y) • V = P. If the variability of velocity (V) is small relative to the variation in money per unit of output (M/y), then M/y will be the dominant determinant of the price level (P). Changes in other variables, such as interest rates and secular income growth which affect V, may weaken the simple correlation between M/y and P.

which shows a relatively high correlation between Canadian and U.S. money per unit of output—as well as unidirectional causality from the U.S. to the Canadian variable—contrasts with the previous result showing a weak relationship between prices. This suggests that while prices may be influenced by money per unit of output, they are also significantly affected by other factors.

One of the more surprising results was that the two countries' money supplies displayed little or no relationship. In examining the correlation between M1 in the United States and Canada, little or no significant relationship was discovered (see equation 5).¹¹ In terms of the more broadly defined money stock, M2, a somewhat stronger relationship was found, although the R^2 was still only .31 (see equation 6). In addition, there was also evidence of bidirectional causality between U.S. M2 and Canadian M2.

The absence of a strong relationship between the two countries' money supplies, M1 or M2, and the presence of bidirectional causality for M2 suggest that the Canadian monetary authorities have not been closely tied by a simple relationship to changes in the U.S. monetary aggregates. That is, the evidence does not support the hypothesis that the monetary authorities of Canada have kept their money supply closely tied to the U.S. money supply.¹²

In addition to the tests of the relationships between the money supplies of the two countries, tests were conducted to determine the relationships between Canadian and U.S. money supplies with Canadian GNP. Contrary to Friedman's assertion, mentioned earlier, that Canadian GNP is better explained by the U.S. money supply than by the Cana-

dian money supply, the results indicate Canadian GNP was more strongly related to Canadian M1 than to either U.S. M1 or U.S. M2 (see equations 7, 8, and 9 in Table 1). In addition, where significant relationships were found, such as those between Canadian GNP and Canadian M1, there was evidence of bidirectional causality. It should be stressed that the presence of bidirectional causation makes it incorrect to try to explain Canadian GNP with a simple regression containing only past values of Canadian M1, or any other monetary aggregate for that matter.

CONCLUSION

The analysis presented here questions the general belief that certain financial variables in the United States and Canada are as closely related as commonly believed." After the strong upward trend in these variables was removed, no significant relation was found between the two countries' narrowly defined money supplies, and only weak relations were found between the countries' broadly defined money stocks, price levels, and real GNP's. Somewhat stronger relations were found, however, between the two countries' money GNP's and their money stocks adjusted for real output.

The results also appear to contradict the general view that, because the U.S. economy is much larger than the Canadian economy, changes in U.S. economic variables precede and cause changes in Canadian variables. In most of the cases examined, no consistent pattern was found of a one-way influence from the U.S. economy to the Canadian economy. The common belief about the direction of causation was further contradicted by tests showing the relationship of Canadian GNP to the money stock in the United States

11/Only one of the four equations fitted for CMI and USM1 was found to be significant, and it contained an R^2 of only .19. Separate spectral analysis using monthly data also failed to reveal any significant relationship between the variables except in the long-run trend.

12/See footnote 3.

13/These conclusions do not exclude the possibility that a larger, more fully specified model would reveal a closer relationship. Rather, they only apply to the simple reduced form equations used in testing the hypothesis about dependence and causality.

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and the money stock in Canada. These tests showed Canadian GNP was more closely related to the Canadian money supply than to the U.S. money supply.

These results have broader implications for many other statistical studies which have dealt with economic variables containing a

strong upward trend. It is very likely that, because of the trend problem, many of these studies are biased toward accepting the hypothesis that such variables are closely related. If the effects of the trend were to be properly removed, however, little or no relationship might be found.