The Efficiency of Canadian Foreign Exchange Markets

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Introduction

In recent years, the significant movements in foreign exchange rates have led researchers to question the efficiency (in the weak-form sense) of foreign exchange markets. Previous tests of market efficiency may be characterised by two different research methodologies. In the first approach, various statistical tests of randomness are applied to the exchange rate data. Research representative of this approach is that of Poole (14), Cornell (5), Cornell and Dietrich (6), Burt, Booth and Kaen (4), Rogalski and Vinso (17), Logue, Sweeney and Willett (12), and Giddy and Dufey (8). In the second approach the performance of individuals and/or organizations providing exchange rate forecasting services is compared with such naive market participation strategies as buy-and-hold.[1] Examples of this approach are provided by Goodman (9) and Goodman (10) which test primarily the semi-strong-form version of the efficient markets hypothesis.

This paper adopts the first approach in testing whether Canadian Foreign Exchange Markets are weak-form efficient. Before empirical results are discussed, however, some general issues with reference to the testing of weak-form market efficiency are considered.

Efficiency-Provable or Not?

Tests of the existence of weak-form efficiency in foreign exchange markets
apply similar techniques to those used in testing stock market efficiency.[2]
Basically if weak-form efficiency exists then past rate movements provide no
significant information about future rate movements. Thus an appropriate model
for rate movements over time should be a Random Walk process (or Martingale) of
the form:[3]

$$A_t = A_{t-1} + e$$

A_t = Exchange Rate at time t

A_{t-1} = Exchange Rate at time t-1

e = Randomly distributed error term with mean 0.

In order to test the appropriateness of the model, the first difference
of the rate series is tested for randomness. In testing for randomness one
must confront a problem first elucidated by Popper (15). It cannot be proved
that a market is weak-form efficient because weak-form efficiency implies that
there is no pattern to past prices which could be used to predict future
prices. However, it is always logically possible that there is a pattern
which has not been identified. Thus, it can only be stated that one has
failed to find sufficient evidence of specific patterns. The hypothesis that
a given market is weak-form efficient is only disprovable not provable. A
similar point is made by Smidt (18), and more indirectly by Goodman (9).

The Canadian Markets-Data and Analysis[4]

Foreign exchange rates for the U.S. Dollar, Deutsche Mark, and British
Pound were obtained from the Globe and Mail for the period January 1976 to
November 1979. Each currency series was divided into two equal sub-series of
493 data points each and analysed with the following techniques:

i) Lagged autocorrelations

ii) Runs Test on Raw Series

iii) Filter Methods

i) <u>Autocorrelations</u>

Autocorrelations up to lag 54 were calculated for the first difference of each series along with the Box-Pierce Q Statistic (3). Two tests were applied to determine the significance of autocorrelations. In the first place Bartlett's Test (2) was used to test the significance of individual autocorrelations. Secondly the Box-Pierce Statistic was used to test the significance of a number of autocorrelations taken together. The results of the application of Bartlett's Test at a 5% significance level are presented in Table 1. If the differenced series were "white noise" one would expect 2 to 3 significant autocorrelation spikes. It will be noted that most of the series fail this test of randomness. When one considers the Box-Pierce test for all series, with the exception of the second half of the Pound series and the second half of the U.S. Dollar series, the Q statistic indicates significant deviations from randomness at the 1% level of significance (see Table 2).

In previous research on U.S. data Cornell (5) found significant autocorrelations for the Pound, Yen, and Canadian Dollar.[5] Burt, Booth and Kaen (4)[6] found significant autocorrelations for Pound and Deutsche Mark. In contrast Cornell and Dietrich (6)[7] did not find any individually significant autocorrelations but found significant deviations from randomness, when measured with the Q statistic, for the Deutsche Mark, Franc and Guilder. Rogalski and Vinso (17)[8] failed to find any significant single autocorrelations or Q statistics for any of the five currencies studied (Pound, Guilder, Swiss Franc, or Deutsche Mark, Canadian Dollar). Logue, Sweeney and Willett (12)[9] argue that the Q statistics are inappropriate due to their reliance on normality assumptions and hence they

use the Kolmogorov Power-test. On the application of this test to seven currency series (Deutsche Mark, French Franc, Pound, Yen, Guilder, Swiss Franc and British Pound) they found no significant deviations from randomness.

The above results imply the rejection of the hypothesis that Canadian Foreign Exchange Markets are efficient for the respective time periods.[10] It will be noted, however, that the Q Statistic for the second half of each series is lower than that for the first half. One interpretation of this reduction is that the markets are moving toward weak-form efficiency.

ii) Runs Test

Runs tests were carried out on all the raw sub-series and the results tabulated in Table 2. All the series had significantly more runs at the 5% level than would be expected from a randomly generated process.

In similar tests on U.S. data Cornell (5) and Dietrich (6) and Burt, Booth and Kaen (4) did not find significant deviations from randomness (except in the case of the Canadian Dollar in (4)) and indeed the deviations that occurred were toward low rather than high values.

The interpretation of the above results is difficult. They could indicate a destabilisation caused in part by flexible exchange rates or deliberate action on the part of authorities to reverse trends. Whatever interpretation is choosen the results do not unanimously support the hypothesis even though they deviate in an unexpected direction.

iii) Filter Rules

Following the approach of Alexander (1) Poole (14), and Cornell and Dietrich (6) filter rules of the following type were applied to each raw sub-series:

> If the rate rises x% above a previous minimum, buy and hold until it
> falls y% from a subsequent maximum. Then sell short and buy in when
> the rate rises x% above a subsequent minimum, and so on...

The results of the application of filter rules with x and y set equal appear in Tables 4(A) and 4(B). Table 4(A) covers the results obtained ignoring transaction costs and Table 4(B) considers simple transaction costs in the form of a 1% buy/sell spread.

With the exception of the Pound series the results obtained are in general agreement with the results of Cornell and Dietrich (6). Burt, Booth and Kaen (4) applied filter rules successfully to the Canadian Dollar[11] and Cornell (5) found that filter rules generated significant gains for the Deutsche Mark, Guilder and Franc.

Conclusions

There is strong evidence that the Canadian foreign exchange markets are still inefficient. However there are indications, particularly in the auto-correlations of the differenced series, that the markets are moving toward efficiency.

Future research could be directed valuably toward tests for randomness derived from spectral analysis.[12] Alternatively Giddy and Dufey's work (8) on U.S. Data could be extended. This basically involves the fitting of a Random Walk and a number of different ARIMA models to the series and comparing "fits." Finally it has been argued that tests involving more sophisticated "technical rules" should be applied in addition to tests using simple filter rules (9).

Table 1

Bartlett's Test Results for each Series

Series	Number of Significant Spikes at 5% Level
DM1	6
DM2	5
PD1	4
PD2	0
US$1	5
US$2	3

Table 2

Box–Pierce Q Statistics for each Series

Series	Box – Pierce Q		
	K=12	K=24	K=36
DM1	63.6	84.6	92.3
DM2	33.0	57.6	81.6
PD1	50.8	68.6	79.6
PD2	6.5	11.9	20.9
US$1	30.7	53.6	60.5
US$2	14.1	26.9	35.5
Q significance level 0.05	21.0	36.4	47.2
0.01	26.2	43.0	38.6

K = Number of successive lagged autocorrelations.

Table 3

Runs Test for Each Series

Series	Observed Runs	Expected Runs	Z-Value
DM1	260	131	2.016
DM2	267	134	2.015
PD1	235	118	2.017
PD2	220	111	2.019
US$1	232	117	2.018
US$2	242	122	2.000

Table 4(A)

Results of Filter Rule Applications -- Without Transaction Costs

Series	Buy & Hold Gain/Loss	Max. Gain with Filter (No T.C.) %	T	Filter %
DM1	31.00	14.97	4	4.0
DM2	31.93	43.75	20	2.0
PD1	-2.49	36.22	5	3.5
PD2	29.33	36.03	184	0.1
US$1	8.47	12.63	21	0.6
US$2	7.37	15.75	86	0.2

Table 4(B)

Results of Filter Rule Applications -- with Transaction Costs

Series	Buy & Hold Gain/Loss	Max. Gain with Filter (T.C.) %	T	Filter %
DM1	31.00	11.54	4	4.0
DM2	31.93	21.35	20	2.0
PD1	-2.49	32.81	5	3.5
PD2	29.33	15.00	7	4.5
US$1	8.47	6.67	3	3.5
US$2	7.37	0	-	--- (1)

TC = Transaction costs calculated on a 1% spread buy/sell
 T = Total number of transactions
(1)= All filters yielded negative results

FOOTNOTES

1. Strictly speaking this approach could be used to test the weak, semi-strong or strong versions of the efficient markets hypothesis. In order for this approach to test the weak-form the information set used for preparing forecasts would have to be shown to include only past exchange rate data.

2. For a guide to the empirical tests of market efficiency that have been applied see Fama (7).

3. If the series has a trend component a sub-Martingale would be appropriate. A sub-Martingale is simply a Martingale with a constant term added to model trend.

4. Since comparable research into Canadian Markets was not available results in this section are compared to studies of U.S. data.

5. Data from April 1973 to January 1977.

6. Data from April 1973 to April 1975.

7. Data from March 1973 to September 1975.

8. Data from 1973 to 1975 (excepting the Canadian Dollar which was for the period 1960 to 1975).

9. Data from April 1975 to January 1976.

10. It has been assumed that the residuals of the differenced series are normally distributed and therefore the Q statistic will be distributed according to a X^2 (chi-squared) distribution. Burt, Booth and Kaen (4), Westerfield (10), Rogalski and Vinso (17) et al. have indicated that residuals may not be normally distributed. However, since the test is fairly robust and given the specific values obtained in this study conclusions on significance will still be valid.

11. Contrary to Poole's (13) results of filter rule application to earlier rates for the Canadian Dollar (1950-1962).

12. For specific tests see Poole (14), Praetz (16) and for an application of spectral analysis to forward foreign exchange series see Upson (19).

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