# Dynamic Relationship Between Macroeconomic Variables and the Canadian Stock Market

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*In this study the relationship between the Toronto Stock Exchange (TSE) and a group of macroeconomic variables is examined. Using cointegration, we found that the Toronto Stock Exchange (TSE) is cointegrated with a group of four macroeconomic variables. The long-run coefficients are significant and have the expected signs. The Vector Autoregressive (VAR) Model and Error Correction Model (ECM) are used to forecast the TSE index. Comparing the out-of-sample forecasting performance of the VAR model and EMC model, we find that the error correction model outperforms the vector autoregressive model.*

## INTRODUCTION

There is significant empirical research supporting the hypothesis that the overall economic performance has a strong influence on the stock prices. Umstead (1977) and Fama (1981) show that a positive correlation exists between real economic growth and stock prices. Spiro (1990) and Cochrane (1991) find that economic fluctuations influence stock prices and that macroeconomic variables such as real output and interest rates can explain stock market movements in the long run. Chen, Roll and Ross (1986) examined the effect of a set of economic variables on returns of stocks listed on the New York Stock Exchange and concluded that macroeconomic variables, via their effect on future dividends and discount rates, exert systematic influence on stock returns. Mukherjee and Naka (1995) examine the long-term equilibrium relation between stock prices and macroeconomic variables in Japan. In their study, they selected six macro variables and examined their effect on required rate of return. They found that macroeconomic variables and stock prices cointegration and the signs of the long-term elasticity coefficients of macroeconomic variables are generally consistent with the hypothesized equilibrium relation.

The objective of this study is to examine the existence of a relationship between various macroeconomic variables and the Toronto Stock Exchange (TSE) index using the cointegration model. If the relationship is confirmed, then the Vector Autoregressive model and error correction model will be applied to forecast the stock prices. The forecasting performance of these models will be evaluated and compared using in-sample and out-of-sample forecasting.

This paper is organized as follows: Section II presents the model. Section III describes the data sources. In section IV the estimation methodology and empirical results are presented and section V presents summary and conclusion.

## THE MODEL

The single-index model has been used to show that stock prices move together only because of common movement with the market. This model is found to be restrictive since there are other factors beyond the market that cause stock prices to move together. Two different types of schemes have been put forth for handling additional influences: the general multi-index model and the industry index model. The multi-index model has performed when the parameters are estimated from historical data. The multi-index model has been used to forecast the future correlation structure between security returns and hold a great promise for the future, but the empirical results using this model in the past have been mixed.

Recently researchers showed interest in using the multi-index model. The testing has been to see how many indices best explain the historical data. Chen, Roll and Ross (1986) and others have produced a set of multi-index models based on a priori-hypothesised set of macroeconomics variable. These models are interesting and have application in finance. Chen, Roll and Ross (1986) demonstrate that macroeconomic variables, via their effect on the future dividends and discount rates, exert systematic influence on stock returns. They reach the conclusions that stocks are exposed to systematic economic news, and they are priced in accordance with their exposures.

According to the standard stock valuation model, the expected cash flows from the stock and the required rate of return commensurate with the cash flows' riskiness, are the determinants of stock prices. Accordingly any variable influencing these determinants also influence stock prices.

Following Chen, Roll and Ross (1986), we hypothesize the following relationship between the TSE index and six macroeconomic variables in Canada.

$$TSE = f\,(EX, CPI, IP, LGB, TB, M) \qquad (1)$$

Where TSE is the index of market value weighted average of closing prices for all shares listed on the Toronto Stock Exchange. EX is the end of month price of the U.S. dollar in terms of the Canadian dollar. CPI is the consumer price index. IP represents seasonally adjusted Industrial Production Index. The long-term government bond rate LGB is used as a proxy for the long-term interest rate. The three month Treasury bill rate TB is used for short-term interest rate. M is the narrowly defined money supply.

Canadian economy is heavily dependent on its exports of goods and services to other countries. Historically, depreciation of the Canadian dollar has resulted in increased volume of exports and therefore increased cash flows to Canadian companies. Therefore, we hypothesize a positive relationship between the exchange rate and stock prices.

Rising inflation increases the nominal risk-free rate resulting in higher discount rate in the valuation model. However, the effect of a higher discount rate on stock prices would be minimal if the cash flows also rise at the same rate as inflation. Empirically, cash flows do not rise at the same rate as inflation and this is usually attributed to nominal contracts that prevent adjustment of the firm's revenues and costs (DeFina, 1991). In practice, cash flows may decrease initially since input prices may adjust faster to rising inflation than output prices. Therefore, we hypothesize a negative relation between inflation and stock prices. Other empirical research, including Chen, Roll, and Ross (1986) and Fama (1977) have also documented a negative relationship between inflation and equity returns.

The level of economic activity affects expected future cash flows and thus influences stock prices. We hypothesize a positive relationship between stock prices and the level of real economic activity measured by the Industrial Production Index. Other empirical research, including Chen, Roll, and Ross (1986), Geske and Roll (1983) and Fama (1977) have also suggested a positive relationship between stock returns and real activity.

Changes in long-term and short-term interest rates are expected to influence the discount rate in the same direction. Therefore, we hypothesize a negative relationship between these rates and stock prices.

Finally, the effect of changes in the supply of money on stock prices is an empirical one. Changes in the supply of money and inflation are positively related. Therefore, in the long-term, rising money supply can lead to higher interest rates. This negative influence on stock prices can be neutralized by the positive effect of money growth on the level of real economic activity.

## THE DATA

The data used are monthly and cover the period of January 1974 to July 2002. TSE index, the consumer price index and the exchange rate series are obtained from the CANSIM database. For the industrial production index, two sequential series for two sequential periods are obtained from the Bank of Canada Review and the Canadian Economic Observation and they are simply spliced. The long-term government bond rate is used as a proxy for the long-term interest rate. We have used two short-term interest rate series: the three-month treasury bill rate and overnight money market rate. We note that the overnight rate is only available back to 1975. Therefore, we had to splice the overnight rate with the day loan rates series back to 1974. In their research, Armour et al. (1996) found that the spliced series provides a good measure of monetary policy. The money supply represented by Ml, long-term government bond rate and short term interest rate series are obtained from the Bank of Canada Review.

## ESTIMATION METHODOLOGY AND THE RESULTS

Before proceeding to test for the existence of a relationship between the Toronto Stock Exchange Index (TSE) stock prices and the macroeconomic variables shown in equation (1), it is useful to examine the univariate statistical properties of the individual series. For this, we used the augmented Dickey-Fuller (ADF) test. ADF test estimates the following equation:

$$\Delta Y_t = a + \beta Y_{t-l} + \delta T + \Sigma\delta_i \quad Y_{t-i} + \mu_t \qquad (2)$$

and test the null hypothesis that β is zero against the alternative hypothesis that it is less than zero. The null hypothesis of non-stationarity is rejected if B is negative and significantly different from zero. We used the Akaike final prediction error to determine the optimum lag order on the right-hand-side of (2). Results are shown in Table 1. All variables are in log-form.

ADF tests presented in Table 1 indicates that the null hypothesis of non-stationarity (unit root) for the macroeconomic variables used in this study can not be rejected. However, the presence of unit root in the first differenced series is strongly rejected for all variables.

**TABLE 1**
**TEST FOR THE PRESENCE OF UNIT ROOT JANUARY 1974 TO JULY 2002**

| | Constant and Trend | Constant and No Trend |
|---|---|---|
| LGTSE | -2.766 | 0.13767 |
| LGM | -2.1733 | -0.78097 |
| LGCPI | -0.8323 | -2.414 |
| LGER | -2.5157 | -1.4106 |
| LGIP | -2.8577 | -1.2121 |
| LGLGB | -2.0239 | -2.1685 |
| LGTB | -1.2896 | -1.4753 |
| LGOVER | -1.8404 | -1.9456 |
| ΔLGTSE | -5.2528 | -5.1928 |
| ΔLGM | -5.5019 | -5.469 |
| ΔLGCPI | -3.2263 | -1.8056 |
| ΔLGER | -3.2876 | -3.3155 |
| ΔLGIP | -4.6909 | -4.6810 |
| ΔLGLGB | -5.2235 | -5.1801 |
| ΔLGTB | -5.1312 | -4.9318 |
| ΔLGOVER | -3.6663 | -3.517 |
| | Critical value = -3.13 | Critical value = -2.57 |

Therefore, we can conclude that the macroeconomic variables used in this study are integrated of order one.

To test the presence of a relationship between the macroeconomic variables and stock price index, we examine whether they exhibit co-movements during the period covered in this study. To establish the existence of co-movements between these variables, we use the concept of co integration and the corresponding error correction mechanism.

Table 2 presents the estimate of the cointegration regression along with critical values for CRADF and CRDW. CRADF is the ADF test performed on the cointegration regression residuals. CRDW test proposed by Sargan and Bhargava (1983) is based on the Durbin Watson of the cointegration regression. Table 2 presents the estimated cointegration regression.

**TABLE 2**
**COINTEGRATION REGRESSIONS DEPENDENT VARIABLE: LGTSE**

Sample Size: 14-324

$$LGTSEt = \underset{(0.24)}{-0.18} + \underset{(6.52)}{0.91}\, LGIPt + \underset{(1.44)}{1.215}\, LGCPIt - \underset{(2.65)}{0.25}\, LGLGBt + \underset{(0.68)\,(0.68)}{0.07}\, LGOVERt - \underset{(4.25)}{0.46}\, LGMt + \underset{(2.32)}{0.34}\, LGERt + \varepsilon t \quad (3)$$

R2 = 0.93
F = 629.726
CRDW = 0.2332
Final Prediction error = 0.024

Residuals: CRADF = -3.6359
CRITICAL VALUE = -4.42

$$LGTSEt = \underset{(0.25)}{-0.23} + \underset{(6.64)}{0.85}\, LGIPt - \underset{(3.2)}{0.15}\, LGLGBt - \underset{(5.62)}{0.49}\, LGMt + \underset{(3.36)}{0.38}\, LGERt + \varepsilon t \quad (4)$$

R2 = 0.92
F = 631.934
CRDW = 0.49
Final prediction error = 0.013

Residuals: CRADF = -4.7584
CRITICAL VALUE = -4.42

The estimated equation (3) shows that all variables except for CPI and short-term interest rate have the expected signs. However, the CRDW and the CRADF statistics are well below their critical values. Thus, we cannot reject the hypothesis that these variables are not a cointegrated vector. Next we omit the variables which did not have the expected sign, i.e., CPI and the short-term rate. The cointegration regression improves significantly. The CRDW and ADF tests are now well above their critical values suggesting that variables in equation (4) represent a cointegrated vector.

Having achieved a suitable specification of the co integrating equation, we can now proceed to estimating the vector error correction model. Defining Z to be the derived residual from equation (4), we include these residuals in a standard error correction model (ECM). A simple search procedure produced the following equation:

Sample Size: 15-324

$$\Delta STOCK_t = -0.12 - 0.12\, Z_{t-1} + 0.16\Delta_6 STOCK_{t-6} - 0.41\Delta_1 TB_{t-1}$$
(1.87) (2.39) (2.9) (6.2)
$$1.03\Delta_2 CPI_{t-2} - 0.13\Delta_2 TB_{t-2} + 0.21\Delta_3 M1_{t-3} + 0.24\Delta_4 M1_{t-4} +$$
(1.83) (1.95) (2.23) (2.83)
$$0.51\Delta_7 ER_{t-7} - 0.24\Delta_{12} M1_{t-12} + U_t \quad (5)$$
(1.85) (3.01)

$R^2 = 0.26$
D.W.= 1.98

The transformed variables in equation (5) are defined in Table 3.

**TABLE 3**
**FIRST DIFFERENCE TRANSFORMATION AND DEFINITION OF LAGGED DIFFERENCES**

| First Difference Transformation |
|---|
| $\Delta$STOCKt = Log[$STOCK_T$ / $STOCK_{T-1}$] return on the TSE |
| $\Delta$IPt = Log[ $IP_1$ / IP $_{t-1)}$ ] Growth rate of industrial production |
| $\Delta$CPIt = Log[ $CPl_t$ / $CPI_{t-1}$] Realized inflation rate |
| $\Delta$Mlt = Log[$Ml_t$ / $Ml_{t-1}$] Growth rate of money supply (M1) |
| $\Delta$EXt= Log[ $EX_t$ / $EX_{t-1}$] Changes in Exchange rate |
| $\Delta$LGBt =Log[$LGB_t$ / $LGb_{t-1}$] Change in Long-term government bonds rate |
| $\Delta$OVERt = Log[ $OVER_t$ / $OVER_{t-1}$] Changes in overnight money market rate (Short-term) |
| $\Delta$TB = Log[ $TB_t$ / $TB_{t-1}$] Change in T-Bill rate (Short-term) |

Equation (5) shows that all variables have the expected signs and are significant. Even though CPI and the short-term interest rate were not cointegrated with TSE index, they are significantly influencing stock returns in the short-term. The coefficient of the error-correction term, Z, is highly significant and negative signifying the fact that if the stock prices are above their equilibrium value in one period, they would return to it during the next period.

Having estimated an error correction model, we now turn into the estimation of a vector autoregressive model (VAR). The VAR model is a dynamic model and has proven to be a successful method for forecasting in time series analysis. The only problem with the VAR model is that it ignores the long-term relationship between macroeconomic variables and the stock prices and concentrates on the short-term influences of these variables. Since all the variables used in the study are integrated of degree one, the VAR model is estimated using first difference series. Using Akaike final prediction error criterion, we estimated the following VAR model:

Sample size: 14-324

$$\Delta STOCK_t = -0.10 + 0.14\ \Delta_6 STOCK_{t-6} - 0.39\ \Delta_t\ TB_{t-1} + 1.10\Delta_2 CPI_{t-2} + 0.86\ \Delta IP_t$$
$$(0.66)\quad (2.6)\qquad\qquad (5.69)\qquad (1.87)\qquad (5.34)$$
$$-0.14\Delta_2 TB_{t-2} - 0.11\ \Delta GOVER_t + 0.198\ \Delta_3 Ml_{t-3} + 0.23\ \Delta 4Ml_{t-4} + 0.53\ \Delta 7ER_{t-7}$$
$$(1.99)\quad (2.34)\qquad\qquad (2.26)\qquad (2.56)\qquad (2.06)$$
$$-0.24\Delta_{12} Ml_{\ t-12} + \varepsilon_{1t}$$
$$(-2.96) \qquad\qquad (6)$$

$R^2 = 0.18$
D.W. = 1.8659

To compare the forecasting power of VAR model and error correction model, the root mean square error (RMSE) is used. The first 324 observations are utilized to estimate both models and saved the final 20 observations for forecasting comparison. The RMSE of the out-of sample forecast for vector error correction model was 0.025 compared to 0.036 for the VAR model. This represents a 44% reduction in the forecast errors when the error correction model is used. Therefore, it appears that the error correction model which takes into account the long-term relationship outperforms the vector auto regression model.

## CONCLUDING REMARKS

Before testing the relationship between stock prices and the macroeconomic variables, the univariate statistical properties of the individual time series data are examined. The presence of unit root was detected in the original time series data. However, the presence of unit root in the first difference series is strongly rejected for all variables. It is concluded that the macroeconomic variables used in this study are integrated of order one.

After omitting variables which did not have the expected sign, i.e., CPI and the short-term rate, the cointegration regression improves significantly. The cointegration approach was used to examine the existence of a long-term relationship between macroeconomic variables and Toronto Stock Exchange index. We found that major macroeconomic variables and stock price index are related in Canada.

Using the vector error correction model, the coefficients for short-term and long-term relationship between TSE and major macroeconomic variables in Canada are estimated. Equation (5) shows that all variables have the expected signs and are significant. Even though CPI and the short-term interest rate were not cointegrated with TSE index, they are significantly influencing stock returns in the short-term. The coefficient of the error-correction term, Z, is highly significant and negative signifying the fact that if the stock prices are above their equilibrium value in one period, they would return to it during the next period.

We also estimated a vector autoregressive model, which has been a popular means of estimating and forecasting stock returns. Comparing the root mean square error of out-of-sample forecasts of both models, we found that error correction model that takes the long-term equilibrium relationship into account outperforms the forecasting accuracy of VAR model by a factor of 44%.

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