Money Supply, Interest Rate, Liquidity and Share Prices: A Test of Their Linkage

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Abstract

This paper reports new evidence of a liquidity effect on share prices from money supply changes. Money supply impacts on interest rate *and* liquidity were first proposed in 1969 and there is evidence that money supply increase leads to interest rate decline. Yet the proposition that money supply increase should lead to liquidity surge – thus to credit expansion – has yet received unanimous empirical support. Using quarterly data over 1968-2011, our results from a two-stage simultaneous solution of a system of equations indicate that money supply changes lead to a *positive liquidity effect*, as per the theory prediction. By extending the liquidity equation to asset prices, we also show that liquidity change has a significant *positive* effect on share prices, after controlling the effect of earnings. These findings, obtained after solutions to serious econometric issues of existing studies, appear to provide a clear verification of theory on the money supply effect on liquidity *and* on asset price.

JEL Classification: E41 and E44

Key words: Liquidity, Money supply, System of equations, Causality test, Share prices, Interest rate, Two-stage least squares, Structural break

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1. Introduction

Friedman's (1969) suggestion of a *negative* money supply effect on interest rate has been verified in a number of studies while his suggestion of a *positive* money supply effect on liquidity has yet been supported unanimously.[1] While Hamilton (1997) attempted to show a liquidity effect by using daily observations, others (Pagan and Robertson, 1995; Goodfriend, 1997, and Lepper and Gordon, 1992; Edmond and Weill, 2005; and Thornton, 2007) have not been successful in verifying this proposition in their empirical reports. This paper is therefore an attempt to approach the money-to-liquidity proposition by first carefully specifying the model after a number of refinements to remove statistical and econometric problems and then applying a system of equations to test if the money-to-liquidity effect is evident. We use quarterly data series of Canadian economy over 1968 and 2011 by specifying controls for regime changes and the global financial crisis so that structural breaks in the variables are controlled in all tests. An innovation of this study is the extension of the money supply theory on liquidity to include share prices. As a robustness test of our hypotheses, we provide causality tests linking money supply to liquidity as well as share prices and earnings.

This paper is organised as follows. The readers will find in section 2 a very brief discussion of the money supply theory, also its variations, while focusing the discussion on (i) liquidity and (ii) share price effect. The next section 3 is devoted to explaining the data preparation steps (to correct for stationarity, multicollinearity, serial correlations and heteroscedasticity), the test models for causality tests, the system of equations and the regression models. The

[1] The empirical literature on the liquidity effect dates back at least to Cagan and Gandolfi (1969), Gibson (1970a,b), Leeper and Gordon (1992), Goodfriend (1997), Pagan and Robertson (1995), Christiano, Eichenbaum and Evans (1996), Hamilton (1997), Thornton (2001) Carpenter and Demiralp (2006) and Thornton (2007).

findings are presented and discussed in section 4 before the paper ends with relevant comments in section 5. In our opinion, this paper's contribution is the verification of the old proposition by Friedman *op cit* of a money supply impact on liquidity after controlling the interest rate effect. Two further contributions of this paper are: money supply is directly related to liquidity, and by extension, liquidity changes lead to share price changes.

2. Monetary Supply, Interest Rate, Liquidity and Share Price

A brief review of literature is provided in this section. First, we describe the liquidity effect proposition which remains unconfirmed to-date. The link between liquidity and asset (stock) prices is then explored before considering the endogenous money supply equation.

2.1 Liquidity Effect

The phrase liquidity effect was introduced by Friedman (1969) to describe the first of three effects on interest rates caused by an unexpected exogenous change in the money supply (the other two being income and inflation expectations effects). While there is controversy (Bryant *et al*., 1988) as to whether money supply changes do lead to negative interest rate changes as some authors conclude (Laidler, 1985). The linkage between money supply and interest rates has been recognized among policy makers on the basis of evidence of its interest rate effect. The money stock is itself an asset in the portfolio of wealth-holders. Increases in the stock of money will cause decreases in the benefits of holders from the last dollar of money held. Changes in the supply of money are, therefore, a proxy for changes in the return on money.

The risk-free interest rate has been assumed to be a function of the long-term bond rate. Alternately, it is proposed that the demand for money is a function of, among other interest rates, the yield on equities. Any increase in the supply of money will tend to cause all interest rates across the board in the demand of money to fall. The speed with which yield on other assets respond depends on the rate at which excess holdings of money balances are reduced: this provides a clue on how the central bank uses reserves to influence this to happen. The reaction rate of prices of different assets in turn depends upon the responsiveness of their potential purchasers to changes in the excess holdings of money. If those potential purchasers such as institutions, dealers, and wealthy individuals with the bulk of the floating supply of corporate stock are responsive to changes in their money balances, then the returns on corporate stock will be affected. Thus, stock prices will be responsive to movements in money supply with a negative coefficient through this channel.

Despite its prominent role in conventional theories of the monetary policy transmission mechanism, there has been very little evidence of a statistically significant or economically meaningful liquidity effect being confirmed in studies. Since previous attempts to identify the liquidity effect have been unsuccessful because the use of low frequency data necessarily mixes together the effects of policy on economic variables with the effects of economic variables on policy, Hamilton (1997) sought to develop a more convincing measure of the liquidity effect by estimating the response of the federal funds rate to exogenous reserve supply shocks using daily data, i.e., by estimating the daily liquidity effect.

Among other things, the failure to find evidence of the liquidity effect using low frequency monetary and reserve aggregates has been attributed to the response of nominal income or inflation expectations to money supply shocks or to the inability of researchers to isolate exogenous monetary shocks. Researchers have attempted to overcome these problems using, among other things, structural vector autoregressions (SVARs). SVAR models have been estimated using a variety of monetary and reserve aggregates. Pagan and Robertson (1995) show that it is difficult to find convincing evidence of a liquidity effect with these models.

Generally, most economists believe that liquidity effects appear in the data for US economy, though the size of the effects is a subject of controversy, due largely to identification problems in statistical work.

Lepper and Gordon (1992) for example felt that in the absence of strong identifying assumptions, there is no consistent evidence of liquidity effects in the US data. Others suggest that liquidity effects reflect part of the economy's coordination on a particular equilibrium when multiple solutions are possible. Goodfriend (1997) suggests a model in which imperfectly competitive firms face kinked demand curves and so price sluggishness emerges endogenously creating real effects of monetary policy in which liquidity effects play a role.

2.2 Stock Prices

The portfolio model of Cooper (1970) assumes that individuals could hold wealth in two forms, money and common stock. The marginal returns of stock assets determine the quantities of assets individuals will hold. A portfolio is said to be balanced when the marginal returns to holding these two assets are equal.

$$MNPS_t^M - \overline{P} = MNPS_t^S + \bar{r}_t^s \qquad (1)$$

Where, using the term of the author, the left side is the return to money asset and the right side is the return to stock asset; $\bar{P}_t$ is anticipated percentage change in general price level ; $\overline{r}_t^*$is the anticipated real pecuniary return of stocks (dividend plus change in stock prices); $MNPS_t^s$ is marginal pecuniary return to the j-th asset (the risk of j-th assets is incorporated into its pecuniary returns. $MNPS_t^M$ is implicitly a function of demand for money except for returns on alternative assets. An underlying assumption is that the positive income effect on $MNPS_t^{M,S}$ cancel each other. Thus, the difference between $MNPS_t^M$ and $MNPS_t^{M,S}$

is primarily a function of money. In this model, money changes induce portfolio adjustments through $MNPS_t$ schedules and prices. The result is that money supply leads to stock returns.

By re-arranging this equation, it could be shown that the stock return is:

$$\bar{r}_t^S = MNPS_t^S - (MNPS_t^M - \bar{P}) \qquad \sim \qquad (2)$$

Thus, Cooper's model is equivalent to the asset pricing model in finance. It would be interesting to examine the link between the liquidity effect from money supply affecting the stock prices, as proposed in this study. Friedman's proposition could be extended as money supply having an influence on asset prices namely share prices in this study.

The model of equity pricing used with this kind of effect is

$$P_0 = \sum_{t=1}^{N} \frac{D_o\ (1+g_t)^t}{(1+i_t+r_t)^t} \qquad \sim \qquad (3)$$

where P_o is the current price of a share; D_o is the dividend at time 0; g is the constant growth rate of dividends; i_t is the risk-free rate at time t; and r_t is the equity risk premium at time t.[2] By noting the equation "D = EPS(payout)", a relationship could be shown that stock prices are correlated with EPS or some proxy such as industrial output as representing corporate earnings, since payout ratio tends to be constant in most economies.

The relationship of stock prices to money has been a subject of academic research for several decades from other approaches as well while there is renewed interest given the recent discovery of endogenous money theory. In the light of current perennial financial crisis in the world, liquidity impact of money supply on stock prices has become a hot topic in policy circles to understand what ails financial systems. Most of these studies use Monetary Portfolio (MP) model developed by Brunner (1961), Friedman and Schwartz (1963) and

[2] By substituting EPS (payout ratio), the numerator may be replaced as $EPS_O(POR)\ (1+g)^t$. Thus, a proxy to represent EPS could be used to test if P_O is significantly affected by earnings proxy.

Cagan (1972) as their starting premise. An investor is assumed as reaching an equilibrium position in which, in general, she holds a number of assets including money in portfolio of assets. A monetary disturbance such as an unexpected increase (or decrease) in the growth rate of the money supply causes disequilibrium in asset portfolios. Investors attempt to rebalance their desired money positions, which are transmitted as monetary changes to the financial markets at large.

From a different perspective, using a pooled cross-section and time-series analysis – we prefer a system of equations approach as more effective to model complex structures involved - Brennan, Chordia, and Subrahmanyam (1998) report significant positive relation between expected share returns and illiquidity.

Hence the relationship between the money supply and the stock prices discovered by Sprinkel (1964) plays an important role in money supply leading to asset prices such as common stock prices. However, studies by Cooper (1970), Pesando (1974), Kraft and Kraft (1977), and Rozeff (1974)) have questioned this linkage between stock prices and money supply. Over time, studying this issue has lapsed until the emergence of the Global Financial Crisis, which has been diagnosed as having been caused by *liquidity surges* that created imbalance in the financial sector and real sector: Ariff *et al*., (2012).

2.3 Money supply Effect

The main channel of influence of the money supply on dividends is through the firm's current and expected earnings especially the expectation effect of the money supply on dividends. Although the current prices of common stock will be affected by changing current dividends, the main effect of money supply is on the expected growth rate of dividends arising from *permanent* change in earnings of firms from positive NPV projects being chosen at lower cost of capital when interest rates fall after money supply increases. This also suggests that a proxy for earnings is a better variable than dividends. Thus, the money supply and stock prices are positively related through this channel.

The theoretical framework presented by monetarists for the relationship between the money supply and stock prices is from the quantity model or the more sophisticated portfolio theory. The quantity theory of money (Brunner, 1961; Friedman, 1961; and Friedman and Schwartz, 1963) states that an increase in the money supply results in a change in the equilibrium position of money with respect to non-money other assets, for example shares, in the portfolio balance of asset holders. This alters the demand for other assets that compete with money balances.

Quantity Theory of Money states

$$\mathrm{M.V} = \mathrm{P.Q} \qquad (4)$$

Where, M is the total amount of money in circulation in an economy during the period, say a year; *P* the corresponding price level; P.Q is the nominal money value of output; *V* is the velocity of money in final expenditures; and *Q* is an index of the real value of final expenditures. An increase in money supply is expected to increase excess supply of money balance, which in turn leads to excess demand for shares. Share prices are expected to rise as a result. This channel of interaction has been described as a direct channel for the first time in Sprinkel (1964). He explicitly tested a model incorporating SQT in a model of asset pricing. As the supply of money expands, the portfolio of desired versus actual cash holding is thrown out of balance. Since the stock of money must be held by the agents, the prices of other assets and goods and services for consumption are bid up to a new equilibrium level. This theory is still in vogue although the question of how the money supply influences the asset prices has newer interpretations, as for example, in Effa *et al*., (2011). Therefore, the relationship between the money supply and stock prices is said to be positive in nature through this adjustment mechanism.

In summary, the most plausible explanation of the relationship between money supply changes and stock returns conditional on liquidity effect seems to be a combination of the quantity theory of money and asset pricing model in portfolio setting. Monetary theory is enhanced by the introduction of liquidity as the missing link between money and aggregate demand. Increasing liquidity can be observed during business upturns strengthening investment and expanding the volume of money in account, thus enhancing financial activities. Research studies by post-Keynesian economists have provided new insights on money being endogenously rather than exogenously determined. In theoretical as well as in empirical finance, the role of liquidity has been highlighted in recent policy debates so it is an area of applied research with potential usefulness.

3. Data Sources, Variables and Methodology

3.1 Hypotheses and Methodology

A system of equations comprising 2 simultaneous equations of stock returns (P) and liquidity (LQ), is developed to be solved endogenously as follows:[3]

$$P_{it} = f\,[LQ^{-}, MS^{+}, IPI^{+}] \quad (5)$$

$$LQ_{it} = f\,[MS^{+}, Y^{+}, LR^{-}] \quad (6)$$

$$MS_{it} = f\,[LQ^{+}, Y^{+}, TBR^{-}, P^{+}, CPI^{+}, CPI(1)^{+}] \quad (7)$$

[3] The basis of the model in this section stems from Effa *et al.* (2011). Not all the variables used in that paper are used in this study because the focus of this study is on liquidity and stock returns.

where P_{it} is aggregate share price index, LQ_{it} is liquidity as proxied by reserve money, MS_{it} is money supply, IPI is industrial production index, Y is real GDP, LR is lending rate, TRB is Treasury bill rate and CPI is inflation. All variables are in in log change ratios.

It is hypothesized that money supply (MS) is endogenously determined by economic activity as mediated via the deposit-taking institutions. The literature on post-Keynesian theory on endogenous money is extensive.[4] Economic activity is proxied by real gross domestic product (Y), liquidity (LQ) is endogenously determined by money supply (MS) and asset prices (P) from liquidity (LQ). Money supply (MS) is also determined by stock returns (P), inflation (CPI), real GDP (Y) and Treasury bill rate (TBR). Liquidity is determined by real GDP (Y), money supply (MS) and Lending rate (LR).

Using the simultaneous equation model above, test models shown below will be used to test hypotheses 1 to 7:

H_1: MS causes GDP (suggesting money is exogenous)

H_2: GDP causes MS or there is bidirectional causality between MS and GDP.

H_3: There is bidirectional causality between money supply and real GDP (implying money is endogenous). This needs to be established first before analysis.

H_4: MS causes Liquidity: this follows from Friedman's proposition still not verified.

H_5: Liquidity causes MS. This is to test the bi-directional causality.

H_6: Share Prices causes Liquidity. Credit expansion from liquidity caused earnings to rise and that in turn causes share prices to rise.

H_7: Liquidity causes Share Prices. This is to test the bi-directional causality.

It is hypothesised under hypotheses 1 to 3 that there may be unidirectional or bidirectional causality from real GDP to money supply.

3.2 Test Models

[4] Influenced greatly by Kaldor and Moore in 1988 developed the post-Keynesian view on money, which is today the cornerstone of the PK theory of endogenous money (Rochon, 2006). The core of this theory is that causality runs from bank lending to bank deposits, instead of the traditional notion that deposits create loans.

3.2.1 Causality Testing

A number of test models are developed to carefully examine the hypothesized relationship between liquidity and share prices as well as money supply. The first of these is the causality test. If cointegration can be identified between dependent and independent variables as presented in the results discussed in the last section, then it can be understood that there is at least a single aspect of causality (Granger, 1969). Causality refers to the ability of one variable to predict and thus cause the other. The Granger (1969) causality test for two variables x_t (see equations 5-6) and y_t (see equations 5-6) involves the following Vector AutoRegressive (VAR) model to be estimated:

$$y_t = a_1 + \sum_{i=1}^{n} \beta_j X_{t-i} + \sum_{j=1}^{m} \gamma_j y_{t-j} + e_{1t} \quad (8)$$

$$x_t = a_2 + \sum_{i=1}^{n} \theta x_{t-i} + \sum_{j=1}^{m} \delta_j y_{t-j} + e_{2t} \quad (9)$$

where it is assumed that both e_{1t} and e_{2t} are uncorrelated white-noise error terms.

Thus, x_t does not Granger cause y_t if $\beta_1 = \beta_2 = \ldots\ldots = \beta_i = 0$, where this hypothesis is tested using the F test.

If no cointegration is found between variables, then the standard causality test (Granger, 1969) can be applied. If there is cointegration, then causality can be examined using the vector error-correction model (VECM) (Granger, 1988) as below:

$$\Delta y_t = \alpha_0 + \sum_{i=1}^{n} \alpha_{1i} \Delta y_{t-1} + \sum_{i=1}^{n} \alpha_{2i} \Delta x_{t-1} + \sum_{i=1}^{n} \alpha_3 \Delta EC_{t-n} + \varepsilon_t \quad (10)$$

The short-term causality of the VECM can be tested using the Wald test (χ^2 test), and the long-term causality is tested by examining whether the error-correction coefficient α_3 in the model is significantly different from zero.

3.2.2 System of Equation Structural Model

$P_{it} = f[LQ^{-}, MS^{+}]$ (5a)

$LQ_{it} = f[MS^{+}, P^{+}]$ (6a)

$MS_{it} = f[GDP^{+}]$ (7a)

where P_{it} is aggregate share price index, LQ_{it} is liquidity as proxied by reserve money and MS_{it} is money supply. All variables are in log change ratios. The use of the testable equations will be further elaborated later in this section.

If 2 variables are cointegrated as discussed above, a vector error-correction model (VECM) and Granger causality test may also be used to test for causality between Share Price and Liquidity: equations (5a and 5b) will be employed since both these variables are simultaneously determined. Equation (5c) will also be used to test Hypothesis 3 on whether there is bidirectional causality between real GDP and money supply.

Under hypotheses 4 to 7, share price is expected to cause liquidity and liquidity is expected to cause share price. By employing a VECM and Granger causality tests, equations (5a and 5b) may be useful in determining whether these hypotheses hold.

Hypothesis 5, which suggests that there is either unidirectional or bidirectional causality between share price and liquidity, may be tested using a VECM and Granger causality test by applying equations (5a) and (5b).

Hypothesis 7, which suggests that there is a simultaneous relationship (or effect) between share price and liquidity and between liquidity and share price, may be tested by using equations (5a) and (5b). These empirical structural relationship will be tested using a system of equations. A simultaneous equations approach lends structure to the nature of the joint measurement errors, and has several desirable features. First, security price and liquidity variables are viewed as endogenous. The structural relationship is carefully derived to a reduced form equation: see Appendix 3.

Under this perspective, security price and liquidity are viewed as being jointly determined by a larger set of publicly available information, which is not explicitly captured in equations, (5) and (6). However, not all items of information are relevant to each variable, which is reflected in the residuals in each equation. In other words, liquidity could change for reasons not leading to price changes, and vice versa. Second, if either equations (5) or (6) were estimated in isolation, the coefficient estimates would be potentially subject to simultaneous equations bias. An empirical assessment of how much the coefficients from a single-equation approach differ from those provided by a simultaneous equations approach will be provided.

Our view is that the estimated earnings response coefficient and the return response coefficient from a system of equations will be greater than under single-equation OLS estimation, because the bias will be reduced. By including all the variables discussed above, the structural equations for the system of equations is:

$$\ln P_{it} = a_0 + a_1 \ln LQ_{it} + a_2 \ln MS_{it} + a_3 \ln IPI_{it} + e_{it} \qquad (11)$$

$$\ln LQ_{it} = b_0 + b_1 \ln MSit + b_2 \ln Y_{it} + b_3 LR_{it} + v_{it} \qquad (12)$$

$$MS_{it} = c_0 + c_1 \ln INF_{it} + c_2 \ln Y_{it} + c_3 TBR_{it} + c_4 \ln P_{it} + c_5 \ln LQ_{it} + z_{it} \qquad (13)$$

3.3 Data and Variables

Data needed for all variables are from the Datastream database while the macroeconomic variables are verified against the International Financial Statistics (IFS) database of the International Monetary Fund (IMF) for consistency to ensure that there are no errors. The data are quarterly series for the period 1960:1 – 2011:2, where the number after colon refers to the quarter. It is important to note that income is included as an explanatory variable in some equations specified above. Real gross domestic product is used as a proxy for income and since only quarterly data are available for income, the highest frequency is quarter.

To specify a proxy for earnings, we searched the literature. The industrial production index (IPI) is highly correlated with income, which in turn is known to determine the earnings of firms in a modern economy. Hence, we use the log change of IPI as a proxy for earnings in the equation for asset pricing: if IPI goes up, the earnings of the firms go up. Liquidity is another difficult variable to specify. There are three alternative proxies: bid-ask spread used in market studies (Amihud and Mendelson, 1986); volume of transactions (Amihud, 2002; Chordia, Subrahmanyam and Anshuman 2001); reserve money (Gordon and Leeper, 2002). Using reserve money appears to be a right choice because, if the banking system has more money in the central bank, liquidity declines, and if it keeps less reserves, liquidity goes up. Hence, liquidity is inversely related to reserves.

Data for money supply, M2, values are used. The Treasury bill rate and the bank lending rate are the domestic 3-month Treasury-bill rate and lending rate respectively. The MSCI stock index values reported in Datastream is widely used for stock returns, P, computed as log change. The consumer price index is used as a proxy for inflation, INF. The bank lending rate, LR, deposit rates, TBR, and real gross domestic product, RGDP, are also obtained. All variables are seasonally adjusted where available and transformed to logarithmic form, with the exception of interest rates, which are the local 3-month Treasury bill rate, TBR.

The asset pricing theory as discussed in section 2 suggests a relationship between share prices and corporate dividend streams growing at g-rate of growth. The g and dividends depend in the long run on earnings of the corporations, which directly depends on IPI. Although we are testing the relationship between liquidity and share prices, there is a need to control the effect of earnings changes in the system of equations. For this, we use the IPI after some initial tests using cointegration. Once the series are tested for stationarity, we ran a cointegration test with income RGDP and IPI: see Appendix 2. As is evident from the test statistics, IPI is a good proxy for earnings. So, we specify this as a control in our liquidity equation for share prices.

3.4 Econometric Problems

3.4.1 Unit root tests

Unit root tests are performed on the variables so as to prepare the data set for cointegration and causality tests. Cointegration analysis is valid if the unit root test establishes the order of integration of the variables of interest is *I(1)*. Thus, we validate the stationarity properties of the variables prior to conducting the cointegration tests. For this, the Johansen cointegration equation is applied.

$$\Delta \mathrm{X_t} = a_0 + a_1 \mathrm{X_{t-1}} + a_2 \mathrm{t} + \sum_{i=2}^{p} b_i \, \Delta \, \mathrm{X}_{t-i+1} + \; u_t \qquad (14)$$

where p is the number of lagged changes in X_t necessary to make u_t serially uncorrelated. Testing the null against the alternative hypothesis H_a: $a_1 < 0$, the null hypothesis of the unit root is rejected if the observed t-statistic is sufficiently negative in the MacKinnon (1996) lower tail critical value. Two other tests needed are for the series to be characterised as an *I(1)* process with a drift or time trend:

$$\Delta \mathrm{X_t} = a_0 + a_1 \mathrm{X_{t-1}} + \sum_{i=2}^{p} b_i \, \Delta \, \mathrm{X}_{t-i+1} + \; u_t \qquad \sim \qquad (15)$$

$$\Delta \mathrm{X_t} = a_1 \mathrm{X_{t-1}} + \sum_{i=2}^{p} b_i \, \Delta \, \mathrm{X}_{t-i+1} + \; u_t \qquad \sim \qquad (16)$$

In all three cases, the hypotheses tested are: H_0: the series contain a unit root, against H_1: the series is stationary. The test statistic (Equation 11) is then tested against the critical values at the accepted level of significance:

Test statistic = $\frac{\widehat{a_1}}{\widehat{SE}(\widehat{a_1})}$ (17)

3.4.2 Johansen cointegration tests

Cointegration results based on Johansen's (1988) procedure are sensitive to the choice of lag length in VAR (Cheung and Lai, 1993). Thus, the optimum lag lengths of the VAR are is determined by minimising the Schwarz (1978) Bayesian Information Criteria (SBC). This criterion is designed to select the model with maximum information available. The general concept of cointegration between variables suggests that there exists an equilibrium or a long-run relationship between two time series provided the series are integrated of the same order. This will be confirmed using the Phillips-Perron test.

The rank of the coefficient matrix Γ represents the number of cointegrating vectors. The likelihood ratio test for the null hypothesis that there are at most r cointegration vectors is used as the Trace Test statistic:

$$TraceTest = -T\sum_{i=r+1}^{p}\ln(1-\widehat{\lambda_\iota}) \quad \sim \qquad (18)$$

where *T* is the sample size and $\widehat{\lambda_\iota}$, K, $\widehat{\lambda_p}$ are the *p-r* smallest squared canonical correlations. The MacKinnon, Haug and Michelis (1999) critical values are used to determine whether the null hypothesis that there are at most r cointegration vectors is rejected or not. The critical values differ depending on whether a linear trend is included or not and are summarised in Appendix 2B-2D. Another restricted maximum likelihood ratio test is referred to as the Maximal Eigenvalue Test statistic:

$$Maximal\ Eigenvalue\ Test = T\ \sum_{i=1}^{r}\ln(1-\hat{\lambda}_i^*)/(1-\hat{\lambda}_i) \qquad (19)$$

where $\hat{\lambda}_i^*$, K, $\hat{\lambda}_r^*$ are the r largest squared canonical correlations. Similar to the Trace Test, the Maximal Eigenvalue Test statistics will be compared against the MacKinnon, Haug and Michelis (1999) critical values as given in their paper.

There are instances when there is a discrepancy between the results of the Trace Test and the Maximal Eigenvalue Test, where one test will indicate the presence of cointegration and the other will not. In such cases, Johansen and Juselius (1990) suggest that the Trace Test may lack power relative to the Maximal Eigenvalue Test. Thus any discrepancies will be resolved through acceptance of the Maximal Eigenvalue Test.

The three tests – namely, the unit root test, Johansen cointegration and the causality test discussed in this section and the former two sections – will be used to determine the validity of hypotheses 1 to 6 and 7.

4. Findings

The results of these carefully run tests are presented in this section. After discussing the descriptive statistics, the data transformation test results are summarised and discussed. The causality test results are presented next before presenting the results of single equation and then the system of equations results.

4.1 Descriptive statistics

The Table 1 provides summary descriptive statistics of the variables used in the regression (single and system of equations). The variables are first differenced and computed by ratio relative to prior observation. The Jarque-Bera (JB) test indicates that all variables are not normal except for one variable, ln liquidity (LRLQ). Most of these variables are skewed (> 0, for normality should be close to 0). The use of panel regression addresses this issue satisfactorily. A quick read of the values of these variables suggest that these are as one would expect in Canadian economy. For example, the Treasury rate over the test period of 44 years is 6.97 and the lending rate is 8.61. These first moment values are as reported for this economy. Another expected value within known ball park is inflation with a mean of 4 per cent.

Table 1: Descriptive statistics of the variables used in tests

	LCPI	LRGDP	LRIPI	LRLQ	LRM2	LSPRICE	RLQ	TBR	LR
Mean	4.00	4.11	0.14	-1.06	8.28	3.42	0.35	6.97	8.61
Median	4.21	4.17	-0.01	-1.08	8.39	3.50	0.34	6.40	7.88
Maximum	4.68	4.67	0.76	-0.64	9.07	4.95	0.53	20.15	21.67
Minimum	2.85	3.41	-0.24	-1.54	7.31	2.11	0.21	0.23	2.25
Std. Dev.	0.58	0.35	0.31	0.18	0.44	0.85	0.06	3.70	3.54
Skewness	-0.71	-0.15	0.86	-0.15	-0.46	0.03	0.35	0.81	0.93
Kurtosis	2.09	2.00	2.24	2.97	2.24	1.78	2.86	3.50	3.84
Jarque-Bera	19.73	7.49	24.64	0.65	9.80	10.33	3.53	19.94	28.90
Probability	0.00	0.02	0.00	0.72	0.01	0.01	0.17	0.00	0.00
Sum	664.40	682.41	22.83	-176.73	1374.53	568.47	58.19	1156.92	1428.58
Sum Sq. Dev.	55.09	20.57	15.77	5.51	31.88	119.30	0.67	2257.38	2067.10
Observations	166.00	166.00	166.00	166.00	166.00	166.00	166.00	166.00	166.00

Note: S.D. is standard deviation. LSPRICE, LRM2, LRIPI, LRGDP, LCPI, TBR, LR and LRLQ are Stock price index, Money supply, Industrial production index, Income, Inflation, Treasury bill rate, Lending rate and Reserve money respectively. All variables are in logarithmic form except for TBR and LR.

4.2 Causality test results

The Table 2 is a summary of bidirectional causality tests using all the variables, money supply, MS, income, GDP, and Liquidity, LRLQ. It is evident that all variables have bidirectional impact on one another except for the variable asset price (share price) to real GDP and real GDP to asset price (share price). As is summarized in the table in Panel A, the bi-directional relationship is indicated by ⟺ while ⇨ shows a unidirectional relationship. There is no prior on whether share price relationship should be bi-directional.

Hence w2e accept these empirical results as the way the relationship hold in our data set. For all other variables, finding bidirectional causality needs to be interpreted carefully.

Finding bidirectional causality between money and income is as predicted by the endogenous money supply theory as reported in several studies since the famous paper by Moore (1989). Significant for the Friedman's proposition of money effect on liquidity is confirmed in our tests: note that the money and liquidity effect is bidirectional. This is a new finding confirming the proposition holds in the long run in this tested economy. The theoretical relationship is shown in Figure 1.

Figure 1: Theoretical Relations Identified in our Models

Monetarist	Accommodationist	Structuralist
$MS \Rightarrow Y$	$Y \Leftrightarrow MS$	$Y \Leftrightarrow MS$
$MS \Rightarrow LQ$	$MS \Leftrightarrow SP$	$MS \Leftrightarrow SP$
$LQ \Rightarrow SP$	$LQ \Leftrightarrow SP$	$LQ \Leftrightarrow SP$

Table 2: Summary of Causality Test Results

Pairwise Granger Causality Tests
Date: 12/03/11 Time: 21:02
Sample: 1960Q1 2010Q4
Lags: 1

Null Hypothesis:	Obs	F-Statistic	Prob.
LRGDP does not Granger Cause LRM2	171	7.75497	0.0060
LRM2 does not Granger Cause LRGDP		5.44788	0.0208
LSPRICE does not Granger Cause LRM2	171	2.91760	0.0895
LRM2 does not Granger Cause LSPRICE		3.32416	0.0700
LRLQ does not Granger Cause LRM2	165	5.41030	0.0213
LRM2 does not Granger Cause LRLQ		5.85895	0.0166
LSPRICE does not Granger Cause LRGDP	203	5.30702	0.0223
LRGDP does not Granger Cause LSPRICE		2.28904	0.1319
LRLQ does not Granger Cause LRGDP	197	0.08448	0.7716
LRGDP does not Granger Cause LRLQ		12.0413	0.0006
LRLQ does not Granger Cause LSPRICE	197	1.29574	0.2564
LSPRICE does not Granger Cause LRLQ		5.87808	0.0162

All variables have bidirectional impact on one another except for P to GDP and GDP to P.

Although Canada adopted monetary targeting, the Central Bank abandoned monetary targeting in 1982 by changing its monetary policy to price stability by targeting inflation. The change could be prompted by practical reasons because the Central Bank of Canada failed to hit its monetary targets due to the endogeneity of money supply. The evidence in statistics presented in Table 2 Panel B is a summary of tests results of pairs of variables for Granger causality tests. These statistics indicate bidirectional causality for all the variables, MS, GDP and Liquidity. All variables have bidirectional impact on one another except for P to GDP and Liquidity to GDP and P.

4.3 Single Equation Results

We discuss the results of single equation regressions first before presenting the system of equation. The statistics presented in Table 3 indicate that the dependent variable - share price - in the first equation is determined by reserve money (that is liquidity LQ), money supply MS and proxy for earnings IPI. All the variables are significant in terms of the t-statistics. Money supply in the second equation is determined by income RGDP, reserve money LQ, share price P, Treasury bill rate TBR and inflation CPI. The significant relation between LQ and money is as per Friedman's proposition highlighted in Granger causality test. Except for inflation, all the variables are significant given t-statistics at the 0.01, 0.05 and 0.10 levels of acceptance. The income elasticity of money is less than one, 0.2 per cent given we use M2: in endogenous money supply studies the use of M3 quasi money elicits a large effect because M2 does not reflect the transaction demand for money.

The liquidity impact on money supply is quite significant reflecting reserve increases will lead to an increase in money supply. In the third equation, liquidity is determined by money supply, income meaning real GDP and lending rate LR. All the variables are significant given their t-statistics at the same acceptance levels of 0.01, 0.05 and 0.10.

Table 3: Results of Estimation Using Single Equation

Panel A: Results of First equation for share price

	Variables	Coefficients	t-statistic
Equation 1	α	-21.42	[-13.2]***
	LQ	-1.15	[-4.91]***
	MS	2.83	[16.93]***
	IPI	1.05	[6.33]***

R-squared	0.917820	Mean dependent var	3.424501
Adjusted R-squared	0.916298	S.D. dependent var	0.850324
S.E. of regression	0.246010	Sum squared resid	9.804381
Prob(F-statistic)	0.169753		

Panel B- Results of second equation for money supply

Equation 2	α	4.74	[12.1]***
	LRGDP	0.48	[3.7]***
	LRLQ	0.10	[3.1]***
	LSPRICE	-0.04	[-1.6]
	TBR	-0.004	[-1.9]*
	LCPI	-0.48	[-0.6]
	LCPI (1)	0.96	[1.3]

R-squared	0.9860	Mean dependent var	8.280
Adjusted R-squared	0.9854	S.D. dependent var	0.439
S.E. of regression	0.053	Sum squared resid	0.446
Prob(F-statistic)	0.000		

Panel C: Results of third equation for liquidity

Equation 3	α	-2.05	[-5.86]***
	LRM2	-0.26	[-2.31]**
	LRGDP	0.75	[5.26]***
	LR	0.003	[1.17]

R-squared	0.6751	Mean dependent var	-1.065
Adjusted R-squared	0.6691	S.D. dependent var	0.183
S.E. of regression	0.105	Sum squared resid	1.791
Prob(F-statistic)	0.363		

Note: Numbers in square brackets are t-statistics and in parentheses are p-values. ***, **, * denote significance at the 1, 5 and 10 percent levels respectively. α is a constant for each equation. P is stock price index, LQ is liquidity as proxy by reserve money, MS is M2 as proxy for money supply, IPI is industrial production index as proxy for earnings, Y is real GDP as proxy for income, TBR is treasury bill rate, CPI is inflation and LR is lending rate.

4.4 Results from System of Equations

Table 4 is a summary of results from running a system of equations tests. The statistics indicate that the dependent variable share price, P, in the first equation, is determined by reserve money LQ, money supply MS and earnings of firms IPI. All the variables are significant in terms of the t-statistics at the same levels normally used.

In the second equation, money supply is determined by RGDP (proxy for income), reserve money (proxy for liquidity) LQ, share price P, Treasury bill rate TBR and inflation CPI. Except for inflation, all the variables are significant given their t-statistics at the 0.01, 0.05 and 0.10 acceptance levels. In the third equation, liquidity is determined by money supply, MS and real GDP (proxy for income), and lending rate LR. All the variables are significant also at the same acceptance levels given their respective t-statistics of -5.15, 6.97 and 3.03. These test statistics are robust given the panel regressions eliminates some of the econometric problems highlighted as likely to affect single equations and OLS regressions in the majority of studies.

Table 4: Results of Estimation Using System of Equation for Equations 1 and 3

Panel A - Results of first equation for share price

	Variables	Coefficients	t-statistic
Equation 1	α	-43.49	[-10.75]***
	LQ	-4.37	[-7.23]***
	MS	5.06	[12.38]***
	IPI	2.90	[8.03]***

R-squared	0.7322	Mean dependent var	43.101
Adjusted R-squared	0.7289	S.D. dependent var	34.965
S.E. of regression	18.204	Sum squared resid	54018.400
Prob(F-statistic)	0.124		

Panel B - Results of second equation for money supply (stand alone for comparison)

Equation 2	α	4.74	[12.1]***
	LRGDP	0.48	[3.7]***
	LRLQ	0.19	[3.1]***
	LSPRICE	-0.04	[-1.6]
	TBR	-0.004	[-1.9]*
	LCPI	-0.48	[-0.6]
	LCPI (1)	0.96	[1.3]

R-squared	0.9860	Mean dependent var	8.280
Adjusted R-squared	0.9854	S.D. dependent var	0.439
S.E. of regression	0.053	Sum squared resid	0.446
Prob(F-statistic)	0.000		

Panel C: Results of third equation for Liquidity

Equation 3	α	0.84	[1.17]
	LRM2	-0.92	[-5.15]***
	LRGDP	1.59	[6.97]***
	LR	0.01	[3.03]***

R-squared	0.6751	Mean dependent var	-1.065
Adjusted R-squared	0.6691	S.D. dependent var	0.183
S.E. of regression	0.105	Sum squared resid	1.791
Prob(F-statistic)	0.363		

Note: Numbers in square brackets are t-statistics and in parentheses are p-values. ***, **, * denote significance at the 1, 5 and 10 percent levels respectively. α is a constant for each equation. P is stock price index, LQ is liquidity as proxy by reserve money, MS is M2 as proxy for money supply, IPI is industrial production index as proxy for earnings, Y is real GDP as proxy for income, TBR is treasury bill rate, CPI is inflation and LR is lending rate.

We ran a further system of equation with the first and third models by controlling for structural breaks observed in the time series. These breaks were identified as monetary regime change from macroeconomic aggregates to inflation targeting and the effect of global financial crisis in quarter 2 of 2007 to quarter 4 of 2009. Leaving these uncontrolled in tests would introduce spurious results. So, with controls, we wanted to re-estimate the coefficients reported as in tables 5 and 6: refer to Table 5 for monetary regime change and to Table 6 for global financial crisis as break-points.

Table 5: Comparing Results of System of Equations with Regime Changes

	Variables	Coefficients	t-statistic

Panel A - Results of 1st equation –Share Price

Equation 1	α	-67.01	[-1.04]
	LQ	-11.72	[-0.86]
	MS	6.92	[1.16]***
	IPI	6.92	[0.82]
	DUM	4.48	[1.06]

R-squared	-2.036521	Mean dependent var	3.711731
Adjusted R-squared	-2.132160	S.D. dependent var	0.708362
S.E. of regression	1.253652	Sum squared resid	199.5988
Prob(F-statistic)	0.466208		

Panel B: Results of second equation for liquidity with dummy

Equation 2	α	5.98	[3.76]***
	LRM2	-1.67	[-4.09]***
	LRGDP	2.08	[3.75]***
	LR	0.004	[0.97]
	DUM	0.17	[0.62]

R-squared	0.395343	Mean dependent var	-1.011329
Adjusted R-squared	0.376299	S.D. dependent var	0.147487
S.E. of regression	0.116478	Sum squared resid	1.723021
Prob(F-statistic)	0.424454		

Note: Numbers in square brackets are t-statistics and in parentheses are p-values. ***, **, * denote significance at the 1, 5 and 10 percent levels respectively. Dum is added to take into account regime changes with D=0 for 1976q3-2007q1, otherwise D=1.

The statistics in Table 5 indicate that the structural break due to monetary regime change is not significant. With this dummy (period after switching to inflation targeting is coded as 1; otherwise 0) the results could be considered as a robustness test to the results presented in the previous panel regression. The global financial crisis effect (dummy of 1 2007:2 and 2009:4) is statistically significant. So the results presented in the Table 6 still holds suggesting the liquidity effect from money supply.

Table 6: Results System of Equations with control for global financial crisis

	Variables	Coefficients	t-statistic
Panel A: Results of Equation 1 for Share Price with Dummy for Crisis			
Equation 1	α	-24.35	[-1.65]*
	LQ	-3.14	[-2.29]***
	MS	2.92	[1.81]***
	IPI	0.85	[0.56]
	DUM	2.88	[1.50]

R-squared	0.409450	Mean dependent var	3.424501
Adjusted R-squared	0.394778	S.D. dependent var	0.850324
S.E. of regression	0.661518	Sum squared resid	70.45458
Prob(F-statistic)	0.195945		

Panel B: Results of second equation for liquidity with Dummy

Equation 2	α	-1.23	[-0.71]
	LRM2	-0.31	[-0.63]
	LRGDP	0.72	[1.04]
	LR	0.008	[2.06]**
	DUM	0.49	[1.35]*

R-squared	0.538096	Mean dependent var	-1.064661
Adjusted R-squared	0.526620	S.D. dependent var	0.182817
S.E. of regression	0.125783	Sum squared resid	2.547239
Prob(F-statistic)	0.347061		

Note: Numbers in square brackets are t-statistics and in parentheses are p-values. ***, **, * denote significance at the 1, 5 and 10 percent levels respectively. Dum is added to take into account regime changes with D=0 for 1960:1-2007:1, otherwise D=1.

7. Conclusion

This paper is a report of an investigation on the (i) money supply effects on interest rate and (ii) liquidity as well as (iii) liquidity effect on asset price namely share price. The literature on money supply effect has been widely followed in policy circles, yet proposition (ii) and (iii) have yet been verified at all. By adopting all the refinements needed to obtain robust parameter estimates and by using system of equations developed for this study, the results reported in this paper are useful new findings on the money supply and asset pricing literature.

The Canadian economy data set used cover the period 1968:1 to 2011:2, which are quarterly series on all variables. The variables are transformed to ensure that there is no spurious parameter estimates as an improvement to prior studies. Friedman's 1969 propositions are used: we add an asset pricing equation to these propositions in order to extend the test for a liquidity– credit surge - effect on share prices. Further, we control monetary regime changes and the effect of global crisis by specifying dummy variables to correct structural breaks in the time series. The results reconfirm the already known evidence that money supply is endogenous and that there is bidirectional causality from Money to interest rate as already confirmed in studies on post-Keynesian endogenous money theory.

The new findings reported here relate to (i) the effect of money supply on liquidity that has yet been confirmed and (ii) the liquidity effect on share prices. We show that these effects are significant as tested using the system of equation modelling, thus, confirming Friedman's second proposition on money effect on liquidity. We have extended that proposition via an asset pricing equation (see Appendix C for reduced form equations) to test and confirm the liquidity effect on share prices. Our data limitation is simply that this research uses quarterly series since GDP data are only available as quarterly series.

Appendix 1: VIF Test for Multicollinearity

This table provides summary measure of the variables tested for multi-collinearity. There is no multi-collinearity among the variables, money supply, share price index and liquidity because the VIF is less than 5.

VARIABLES	VIF	
MS	1.3954	< 5 = no multicollinearity
P	2.2642	< 5 = no multicollinearity
LQ	2.954	< 5 = no multicollinearity

Appendix 2-A: Unit Root Tests Using ADF and Phillips-Perron

This table summarizes the tests results of the variables for non-stationary. They are often described as tests for unit roots. Two tests are conducted here - the Augmented Dickey Fuller (ADF) test and the Phillips Perron (PP) test to confirm the findings of stationary. The ADF and PP unit root tests are for the null hypothesis that a time series is *I(1)*. Stationary tests are for the null hypothesis that Y is *I(0)*. All the variables are stationary after taking their first difference at 0.01, 0.05 and 0.10 acceptance levels except for money supply, liquidity and industrial production index, which means these variables are integrated of order 1.

	Level		Difference	
Variables	ADF	PP	ADF	PP
MS	-2.213	-2.522	-4.782***	-9.455***
LQ	-2.469	-3.329	-3.046***	-32.137***
P	-4.038	-3.593	-11.294***	-10.984***
INF	-1.510	0.024	-2.544***	-6.601***
LR	-1.869	-1.971	-6.345***	-10.959***
TBR	-2.328	-2.085	-10.499***	-10.429***
Y	-2.047	-1.558	-11.163***	-6.599***
IPI	-1.730	-1.486	-8.946***	-8.232

Note: MS= log of real money supply, P = log of real stock prices; RGDP = Real GDP; INF = log of consumer price index; INT = lending rate; INT2= deposit rate; LQ= log of liquidity index.

Notes:

1. Test equation specification: <u>Both intercept and trend are included</u>
2. Lag length selection: <u>AIC</u>

Appendix 2-B: Cointegration Tests for IPI and RGDP for Canada

This table summarizes the tests results of IPI and RGDP for cointegration tests. They indicate that IPI and RGDP are cointegrated in the long run and therefore, IPI can be used as a proxy for earnings.

Null Hypothesis	Test Statistics		Critical Values (5%)	
	Trace	Max	Trace	Max
None	21.94*	17.03*	15.49	14.26
At most 1	4.9*	4.9*	3.84	3.84

Trace indicates 2 cointegrating equation at the 5% level.

Appendix 2-C: Maximum Trace and Eigenvalue Tests for Cointegration

Null Hypothesis	Alternative	λ_{trace}-statistic	5% crtical value	λ_{max}-statistic	5% crtical value
H_o: r = 0	H_1: r = 1	21.94	15.495	17.03	14.265
H_o: r ≤ 1	H_2: r =2	4.9	3.841	4.9	3.841

lag length p = 4   intercepts included   T = 200

Estimated eigenvalues: 0.08165, 0.0242

Trace indicates 2 cointegrating equation at the 5% level

Appendix 2-D: Cointegration Tests for Money Supply, Liquidity and Share Price

This table summarizes the tests results of Money Supply, Liquidity and Share Prices for cointegration tests. They indicate that Money Supply, Liquidity and Share Prices are cointegrated in the long run.

Null Hypothesis	Test Statistics		Critical Values (5%)	
	Trace	Max	Trace	Max
None	33.757 *	22.408*	29.797	21.132
At most 1	11.349	10.401	15.495	14.265
At most 2	0.9478	0.948	3.841	3.841

Trace indicates 1 cointegrating equation at the 5% level

Table   Maximum trace and eigenvalue tests for cointegration

Null Hypothesis	Alternative	λ_{trace}-statistic	5% crtical value	λ_{max}-statistic	5% crtical value
H_o: r = 0	H_1: r = 1	33.76	29.79	22.41	21.13
H_o: r ≤ 1	H_2: r =2	11.35	15.49	10.40	14.26

lag length p = 4   intercepts included   T = 200

Estimated eigenvalues: 0.133 0.064 0.006

Trace indicates 1 cointegrating equation at the 5% level

Appendix 3: Derivation of Reduced Form Equations for Two-equation Model

$lnP = \alpha_0 + \alpha_1 lnLQ + \alpha_2 MS + \alpha_3 lnIPI$ 1

$lnLQ_1 = \beta_0 + \beta_1 lnMS + \beta_2 lnRGDP + \beta_3 LR$ 2

From 1

$lnP = \alpha_0 + \alpha_1(\beta_0 + \beta_1 lnMS + \beta_2 lnRGDP + \beta_3 LR) + \alpha_2 lnMS + \alpha_3 lnIPI$

$lnP = \alpha_0 + \alpha_1\beta_0 + \alpha_1\beta_1 lnMS + \alpha_1\beta_2 lnRGDP + \alpha_1\beta_3 LR + \alpha_2 lnMS + \alpha_3 lnIPI$

$lnP = \alpha_0 + \alpha_1\beta_0 + lnMS(\alpha_1\beta_1 + \alpha_2) + lnRGDP(\alpha_1\beta_2) + \alpha_1\beta_3 LR + \alpha_3 lnIPI$

Reduced form equation is:

$lnP = \alpha_0 + \alpha_1\beta_0 + lnMS(\alpha_1\beta_1 + \alpha_2) + lnRGDP(\alpha_1\beta_2) + \alpha_1\beta_3 LR + \alpha_3 lnIPI$

$lnLQ_1 = \beta_0 + \beta_1 lnMS + \beta_2 lnRGDP + \beta_3 LR$

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