Stock Liquidity and Returns: Evidence from the Zimbabwe Stock Exchange

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Abstract

This study extends the literature on the relationship between stock liquidity and returns by presenting evidence from the capital market of a developing economy. Using data from the Zimbabwe Stock Exchange, we apply a vector autoregression model in examining the impact of stock liquidity on returns over the period February 2009 to December 2012. The study employs four proxies as stock liquidity measures, namely; trading volume, turnover, relative bid-ask spread and relative spread. The analysis also applies Granger causality tests from the VAR models. We also enhance the robustness of the analysis by considering the impulse response functions and variance decompositions. Results from the study show that stock liquidity variation plays an important role in stock returns because investors tend to price liquidity premium in stocks. The main finding is that liquidity negatively affects stock returns for stocks listed on the ZSE.

Keywords; stock liquidity, stock returns, trading volume, turnover, relative spread, relative bid – ask spread, vector auto – regression, Granger causality

1. Introduction

Contemporary finance has witnessed renewed interest in the time series dynamics of stock liquidity and the associated effect on stock returns. This can be traced to the evolution of the global financial crisis from 2007, which saw a decline in the liquidity of assets of financial firms (e.g mortgage based securities) and in the liquidity of their stocks (Boehmer, Jones, and Zhang (2009).Only a few empirical studies have investigated the nexus between stock liquidity and returns in small developing economies such as Zimbabwe. To this end, this study should contribute in filling this gap in financial literature. In the context of this research, stock liquidity is defined as the ease with which the stock can be converted into cash, in a short period of time, without a significant decrease in its price or value. The vast amount of research on the stock liquidity/return relationship suggests that investors generally prefer to hold assets that are easily convertible and would therefore require a risk premium for securities that are relatively illiquid (Datar et al. (1998) and Marshal (2006). The Zimbabwe Stock Exchange has been described by several market participants as illiquid since the introduction of the multi-currency system in January 2009 and its subsequent reopening in February of the same year after a three month closure. The market has been characterised by fluctuating trade volumes, and some of the stocks have remained heavily discounted. This study therefore seeks to scientifically verify such assertions by examining the effect of liquidity on returns for all the stocks listed on the ZSE. It is noteworthy that the Zimbabwe Stock exchange currently has 73 stocks listed and its market capitalization hovers around US$5 billion.

2. Literature Review

Contributions to the literature on the relationship between stock liquidity and returns include the works of Amihud and Mendelson (1986), Constantinides (1996), Heaton and Lucas (1996), Brennan and Subrahmanyam (1996), Datar, Naik and Radcliffe (1998), Brennan et al. (1998), Vayanos (1998), Subrahmanyam (1998), Jones (2001), Amihud (2002), O'Hara (2003), Pastor and Stambaugh (2003), Acharya and Pedersen (2004), Baker and Stein (2004), Hasbrouck (2005), Archarya and Pedersen (2005), and Chan and Faff (2005). For example, Amihud and Mendelson (1986) investigate the role of liquidity in asset pricing. In their empirical study, they tested the hypotheses that the market-observed expected return is an increasing function of the relative bid-ask spread and that this function is concave. Through the cross-sectional tests, they find that a 1% increase in the relative bid-ask spread is associated with a 0.211% increase in the monthly risk-adjusted excess return. Also, they find that the slope coefficients of the spreads are positive and generally decreasing in the spread. This means that the results imply that there is an increasing and concave connection between returns and spreads.

Datar et al (1998) tested the role of liquidity in stock pricing using a different proxy for liquidity - the turnover rate. This rate is given by the number of shares traded as a fraction of the number of shares outstanding. They basically apply the same methodological framework as Amihud and Mendelson (1986) but with the addition of the book-to-market ratio of the stocks. An important difference between this study and most other empirical studies of stock returns is that the analysis is based on individual stocks rather than portfolios of stocks. For the empirical study, they consider monthly frequency data for all stocks of non-financial companies on the NYSE from July 1962 through December 1991. They find that there is a significantly negative relationship between liquidity and stock returns. Chan and Faff (2005) investigate the role of liquidity in stock pricing by adding the return on a mimicking liquidity portfolio to the Fama and French (1993) three-factor model. Liquidity is proxied by the share turnover rate. Their study employs monthly data for the period from 1989 through 1998 for listed Australian companies as of 2005. The main result of their study is that they find support for adding the liquidity factor to the Fama and French (1993) model. They identify an annualised turnover rate risk premium of more than 20%. Their findings are robust and provide strong evidence of the pricing of liquidity in the Australian equity market.

3. Methodology and Data

3.1. Stock Returns

In this study stock returns were calculated by using the following formula:

$$r_{i,t} = \ln\left(\frac{p_{i,t}}{p_{i,t-1}}\right)$$

Where:

- $r_{i,t}$ denotes the log return of stock i at time t,
- $p_{i,t}$ denotes price of stock i at time t,
- $p_{i,t-1}$ denotes price of stock i at time t-1

3.2. Stock Liquidity Measures

Trading volume, Turnover, Relative Spread, and Relative Bid - Ask spread are the stock liquidity measures employed in this study.

3.2.1. Trading volume

Trading volume per time interval (Qi,t) is incorporated in a lot of liquidity studies. Examples are: Chordia, Roll & Subrahmanyam (2001), Chordia, Subrahmanyam & Anshuman (2001), Hasbrouck & Saar (2002), and Hasbrouck & Seppi (2001. In this study, trading volume for time t −1 until time t is calculated as follows:

$$Q_{i,t} = \sum_{i=1}^{N_t} q_i$$

where:

- N_t denotes the number of trades between t−1 and t, and
- q_i is the number of shares of trade of stock i.

3.2.2. Turnover

Turnover is also widely used as a measure of liquidity as exemplified by studies such as Chordia, Roll and Subrahmanyam (2001), Chordia, Subrahmanyam and Anshuman (2001) and Chordia and Swaminathan (2000). In this study, turnover (Vi,t) is derived for a specific time interval using the following formula:

$$V_{i,t} = \sum_{i=1}^{N_t} p_i \times q_i$$

where:

- p_i denotes the price of trade of stock i, and
- N_t is the number of trades between $t-1$ and t.

3.2.3. Relative Spread

Studies that have made use of relative spread as a liquidity measure include Fleming & Remolona (1999). Relative spread is generally posited to account for changing market conditions because *pt* may be at the ask price in an upward moving market, whereas it will be at the bid price in a downward moving market. In this study the measure is estimated by the formula below;

$$Srelp_{i,t} = \frac{P_{Bid,i,t} - P_{Ask,i,t}}{p_{i,t}}$$

where:

- $P_{Bid,i,t}$ is the bid price for stock i at time t,
- $P_{Ask,i,t}$ is the ask price for stock i at time t.
- $p_{i,t}$ denotes price of stock i at time t,

It is instructive to note that the relative spread is extensively studied because it is easy to calculate and enables the comparison of spreads of different stocks.

3.2.4. Relative bid-ask spread

The relative bid-ask spread is the spread between the price that a stock can be sold for (the bid price) and the price it costs to purchase it (the ask price) through a market maker. Following Amihud and Mendelson (1986), the relative bid-ask spread is calculated as follows:

$$S_{i,t} = \frac{|P_{Bid,i,t} - P_{Ask,i,t}|}{0.5(P_{Bid,i,t} + P_{Ask,i,t})}$$

where:

- $P_{Bid,i,t}$ is the bid price for stock *i* at time *t*,
- $P_{Ask,i,t}$ is the ask price for stock *i* at time *t*.

3.3. Correlation in stock liquidity and returns

The study determines the correlation between stock returns and liquidity using the measure ρ defined as follows:

$$\rho = \frac{\mathrm{E}[(r_{i,t} - \mu_{r_{i,t}})(lm - \mu_{lm_{i,t}})]}{\sigma_{r_{i,t}}\sigma_{lm_{i,t}}}$$

where:

- $\sigma_{r_{i,t}}$ = the standard deviation of stock returns for stock *i*
- $\sigma_{lm_{i,t}}$ = the standard deviation of stock liquidity measures for stock *i*
- $\mu_{r_{i,t}}$ = the mean of stock returns for stock *i*
- $\mu_{lm_{i,t}}$ = the mean of stock liquidity measures for stock *i*

3.4. Vector Auto - Regression Model

In this study, vector auto-regression modeling was used in the analysis of the impact of stock liquidity on returns. It is noyeworthy that VAR modelling is normally used for forecasting systems of interrelated time series and for analysing the dynamic impact of random disturbances on the system of variables by making use of Granger causality tests, impulse response functions and variance decomposition techniques. For example George and Hwang (1998) use VAR to evaluate day-time and overnight order flows with its respective returns.

The study estimates the following VAR model:

$$r_t: x_{1,t} = c_1 + \Phi_{11,1}x_{1,t-1} + \Phi_{12,1}x_{2,t-1} + \Phi_{13,1}x_{3,t-1} + \Phi_{14,1}x_{4,t-1} + \Phi_{15,1}x_{5,t-1} + \varepsilon_{1t}$$

$$Q_t: x_{2,t} = c_2 + \Phi_{21,1}x_{1,t-1} + \Phi_{22,1}x_{2,t-1} + \Phi_{23,1}x_{3,t-1} + \Phi_{24,1}x_{4,t-1} + \Phi_{25,1}x_{5,t-1} + \varepsilon_{2t}$$

$$V_t: x_{3,t} = c_3 + \Phi_{31,1}x_{1,t-1} + \Phi_{32,1}x_{2,t-1} + \Phi_{33,1}x_{3,t-1} + \Phi_{34,1}x_{4,t-1} + \Phi_{35,1}x_{5,t-1} + \varepsilon_{3t}$$

$$Srelp_t: x_{4,t} = c_4 + \Phi_{41,1}x_{1,t-1} + \Phi_{42,1}x_{2,t-1} + \Phi_{43,1}x_{43,t-1} + \Phi_{44,1}x_{4,t-1} + \Phi_{45,1}x_{5,t-1} + \varepsilon_{4t}$$

$$S_t: x_{5,t} = c_5 + \Phi_{51,1}x_{1,t-1} + \Phi_{52,1}x_{2,t-1} + \Phi_{53,1}x_{3,t-1} + \Phi_{54,1}x_{4,t-1} + \Phi_{55,1}x_{5,t-1} + \varepsilon_{5t}$$

where:

- r_t are returns and is regressed upon its own lagged variables
- Q_t is the trading volume and is regressed upon its own lagged variables
- V_t is turnover and is regressed upon its own lagged variables
- $Srelp_{i,t}$ is the relative spread and is regressed upon its own lagged variables
- S_t is the relative bid-ask spread and is regressed upon its own lagged variables
- $\Phi_p (i = 0, 1, 2 \dots p)$denotes the $(k \times k)$ -parameter matrices with $\Phi_p = 0$

- c are constants which may be zeros
- ε_t is a white noise

The above system of equations can be summarized in a matrix format as:

$$\begin{bmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \\ x_5 \end{bmatrix} = \begin{bmatrix} c_1 \\ c_2 \\ c_3 \\ c_4 \\ c_5 \end{bmatrix} + \begin{bmatrix} \Phi_{11,1} & \Phi_{12,1} & \Phi_{13,1} & \Phi_{14,1} & \Phi_{15,1} \\ \Phi_{21,1} & \Phi_{22,1} & \Phi_{23,1} & \Phi_{24,1} & \Phi_{25,1} \\ \Phi_{31,1} & \Phi_{32,1} & \Phi_{33,1} & \Phi_{34,1} & \Phi_{35,1} \\ \Phi_{41,1} & \Phi_{42,1} & \Phi_{43,1} & \Phi_{44,1} & \Phi_{45,1} \\ \Phi_{51,1} & \Phi_{52,1} & \Phi_{53,1} & \Phi_{54,1} & \Phi_{55,1} \end{bmatrix} \begin{bmatrix} x_{1,t-1} \\ x_{2,t-1} \\ x_{3,t-1} \\ x_{4,t-1} \\ x_{5,t-1} \end{bmatrix} + \cdots + \begin{bmatrix} \Phi_{11,k} & \Phi_{12,k} & \Phi_{13,k} & \Phi_{14,k} & \Phi_{15,k} \\ \Phi_{21,k} & \Phi_{22,k} & \Phi_{23,k} & \Phi_{24,k} & \Phi_{25,k} \\ \Phi_{31,k} & \Phi_{32,k} & \Phi_{33,k} & \Phi_{34,k} & \Phi_{35,k} \\ \Phi_{41,k} & \Phi_{42,k} & \Phi_{43,k} & \Phi_{44,k} & \Phi_{45,k} \\ \Phi_{51,k} & \Phi_{52,k} & \Phi_{53,k} & \Phi_{54,k} & \Phi_{55,k} \end{bmatrix} \begin{bmatrix} x_{1,t-k} \\ x_{2,t-k} \\ x_{3,t-k} \\ x_{4,t-k} \\ x_{5,t-k} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1,t} \\ \varepsilon_{2,t} \\ \varepsilon_{3,t} \\ \varepsilon_{4,t} \\ \varepsilon_{5,t} \end{bmatrix}$$

Each equation is treated as a regression equation and we also compute the *t*-statistics for each coefficient to assess its significance. Granger causality probability is used to assess causal links between variables and impulse response for the underlying shocks to VAR model are orthogonalized using the Cholesky decomposition before variance decompositions are computed. For the specified VAR model, one can estimate the parameters using either the ordinary least squares method or the maximum likelihood method. The two methods are asymptotically equivalent. Under some regularity conditions, the estimates are asymptotically normal (Reinsel (1993). In this research, the ordinary least square method is going to be employed in the estimation of the regression models.

3.5. Granger Causality Test

In this research, Granger causality tests are going to be undertaken. VAR models themselves do not allow us to make statements about causal relationships. This holds especially when VAR models are only approximately adjusted to an unknown time series process, while a causal interpretation requires an underlying economic model. However, VAR models allow interpretations about the dynamic relationship between the indicated variables. The primary method for inferring causality in financial applications was developed by Granger (1969) to take two time series and determine whether one predicts, or causes, the other. Here, pairwise causality is defined by:

With Ω_t being all available (non-redundant) knowledge at time *t*, Y_t *Granger causes* X_{t+1} if

$$P(X_{t+1} \in A|\Omega_t) \neq P(X_{t+1} \in A|\Omega_t - T_t)$$

where A is some set of observations.

That is, *Yt* provides information about *Xt+1* that is not contained in the rest of the set. There is no mention of the magnitude of the probability or how much of a difference *Y*t makes to *Xt+1* (there may be better predictors or information that may be added to *Yt* to improve its predictive value). Further, there is no intrinsic method of representing complex factors such that their causal roles may be inferred automatically from the data. These statistics are more informative than the estimated VAR regression coefficients or s which usually goes unreported.In practice, Granger causality is frequently tested using linear regression and determining whether the use of the information in the possible cause leads to a smaller variance in the error term than when this information is omitted.

3.6. Impulse Response Function

To improve the robustness of the research, impulse response functions were also used. The impulse response functions show the effects of an exogenous shock on the whole process over time. One can therefore detect the dynamic relationships over time. More generally, an impulse response refers to the reaction of any dynamic system in response to some external change. The impulse response functions can be used to produce the time path of the dependent variables in the VAR, to shocks from all the explanatory variables. If the system of equations is stable, any shock should decline to zero whilst an unstable system would produce an explosive time path.

3.7. Variance Decomposition

Also, as a way of improving the robustness of the research, variance decompositions were done. Through conducting variance decomposition, it is possible to measure the proportion of the movements in dependent variables that stem from their own shocks and shocks of the other variables. This is an alternative method to the impulse response functions for examining the effects of shocks to the dependent variables. This technique determines how much of the forecast error variance for any variable in a system, is explained by innovations to each explanatory variable, over a series of time horizons. Usually own series shocks explain most of the error variance, although the shock will also affect other variables in the system. It is also important to consider the ordering of the variables when conducting these tests, as in practice the error terms of the equations in the VAR model will be correlated, so the result will be dependent on the order in which the equations are estimated in the model.

4. Summary of Results

The summarised returns and liquidity measures for all the stocks show a very strong negative correlation. This is in accordance with theory – stocks that are less liquid should yield higher returns to compensate for the higher degree of illiquidity, hence a liquidity premium. Thus, a stock with a low turnover, relative spread, relative bid-ask spread and trading volume should yield a high return. Datar, Naik and Radcliffe (1998) also find that there is a significantly negative relationship between stock liquidity and returns. Therefore, the identified relationship seems robust. The results are also in line with Irvine et al. (2000) who reported negative correlations between the market impact measures and depth. The empirical results are also consistent with the works of Amihud and Mendelson (1989) who conducted cross-sectional analyses of US stock returns and showed that risk-adjusted returns are decreasing with respect to liquidity, as measured by the bid-ask spread. Brennan et al. (1998) also investigated the relation between expected returns and several firm characteristics including market liquidity, as measured by trading volume. They find a significant negative relation between returns and trading volume for both NYSE and NASDAQ stocks, thus linking expected returns and liquidity. Chordia, Roll & Subrahmanyam (2001) document a negative correlation of spreads and trading volume. This further confirms the robustness of the results from the ZSE market. The vast quantum of research on the stock liquidity/return relationship suggests that investors generally prefer to hold assets that are easily convertible and would therefore require a risk premium for securities that are relatively illiquid. By extension, an inverse relationship has been shown to exist between the level of stock liquidity and returns on the ZSE market from the results presented in this research. Therefore, it can be said that investors are willing to forego higher returns for higher liquidity. It is important to note that the vector auto-regression models by themselves cannot fully bring out the causal relationship between returns and stock liquidity. The Granger causality tests conducted on all the stocks have shown that stock returns do not Granger cause stock liquidity. On the other hand, the null hypothesis that liquidity does not Granger cause stock returns is rejected at 5% level. The results are consistent with Chordia, Sarkar, and Subrahmanyam (2005) who explored liquidity spill-overs in market capitalisation-based portfolios of NYSE stocks.

4.1. Summary of stock Returns

Measure	Average
mean	0.0004
Standard deviation	0.0587
maximum	0.4885
Minimum	-0.7491
kurtosis	40.26
skewness	-0.6820

4.2 Summary of Stock Liquidity Measures

	S_t	Q_t	V_t	$Srelp_t$
Mean	0.114011	39199.43	1273421	0.089119
Median	0.095238	6111.000	152397.0	0.085714
Maximum	1.333333	1486070	48871845	0.666667
Minimum	0.000000	0.000000	0.000000	-1.600000
Std. Dev.	0.104378	107399.5	3375050	0.139494
Skewness	3.762653	7.006261	6.615106	-4.213377
Kurtosis	35.36774	68.94425	65.73743	48.58464
Jarque-Bera	43803.93	180284.8	163070.6	85242.44
Probability	0.000000	0.000000	0.000000	0.000000
Sum	108.5385	37317856	1.21E+09	84.84173
Sum Sq. Dev.	10.36087	1.10E+13	1.08E+16	18.50517
Observations	952	952	952	952

4.3 Summary of Correlation in stock liquidity and returns

	R_t	S_t	Q_t	V_t	$Srelp_t$
R_t	1.000000				
S_t	-0.614035	1.000000			
Q_t	-0.862496	-0.026090	1.000000		
V_t	-0.766527	-0.035341	0.821720	1.000000	
$Srelp_t$	-0.341832	0.527294	-0.007180	-0.036945	1.000000

4.4 Summary of vector auto - regression estimates

	R_T	S_T	Q_T	V_T	$Srelp_T$
R_{T-1}	-0.050498	0.080945	-807262.0	-4886355.0	0.065373
R_{T-2}	-0.127463	0.021595	1221220.0	10487134.0	-0.167080
R_{T-3}	0.029826	0.112385	-969673.7	-5259804.0	0.221019
R_{T-4}	-0.067817	0.070409	-175832.7	2389188.0	-0.069780
S_{T-1}	0.110549	0.659505	-1184565.0	-15501367	-0.037288
S_{T-2}	-0.031287	-0.018255	2153908.0	22808742	0.092987
S_{T-3}	-0.023567	-0.030446	-782154.7	-6306262.0	-0.199685
S_{T-4}	0.067193	0.054846	197555.8	3068962.0	0.150678
Q_{T-1}	4.52E-09	-2.10E-09	0.309849	0.689939	-3.04E-09
Q_{T-2}	-2.43E-09	-3.41E-10	-0.125529	-1.009516	2.39E-09
Q_{T-3}	6.31E-09	-1.41E-10	0.246038	0.649463	5.59E-10
Q_{T-4}	-1.80E-09	2.02E-09	0.010953	-0.661690	1.30E-09
V_{T-1}	-4.35E-10	3.17E-10	-0.021056	0.002185	3.45E-10
V_{T-2}	4.26E-10	3.05E-10	0.017235	0.179320	5.10E-11
V_{T-3}	-7.97E-10	-1.38E-10	-0.010559	0.073448	-6.74E-11
V_{T-4}	2.17E-10	-6.43E-10	0.006298	0.181164	-4.98E-10
$Srelp_{T-1}$	-0.152626	-0.125576	1136095.0	10759858	0.551066
$Srelp_{T-2}$	-0.021632	0.044532	-1915255.0	-22570818	0.104498
$Srelp_{T-3}$	0.056883	0.055606	247623.8	303269.6	0.018449
$Srelp_{T-4}$	0.014230	0.006840	127703.1	-2155424.0	-0.058666
C	-0.009000	0.037833	260038.7	2276345.0	0.033597
R-squared	0.072957	0.528878	0.099599	0.103326	0.401006
Adj. R-squared	0.052956	0.518714	0.080172	0.083980	0.388083
F-statistic	3.647677	52.03221	5.127043	5.341036	31.02977

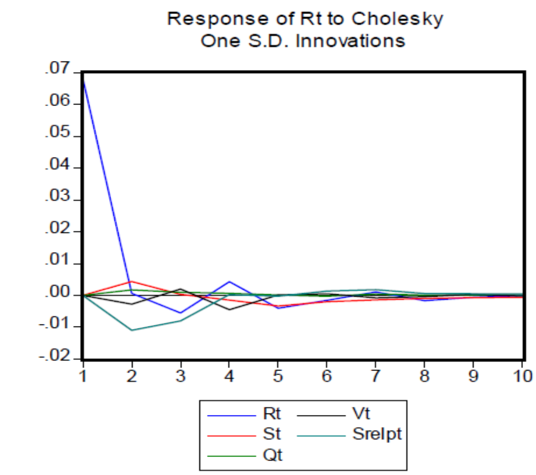
4.5 Granger Causality Tests

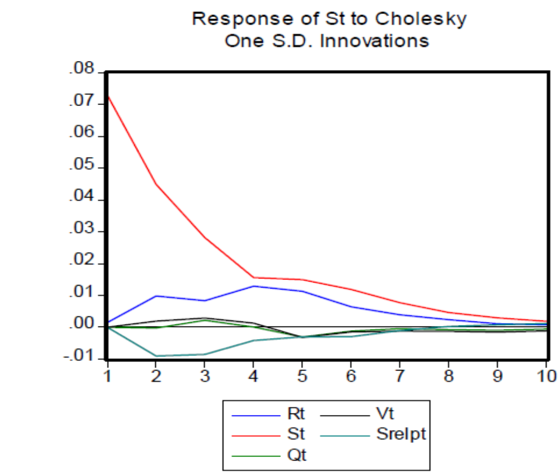
The table below presents the granger causality results. The null hypothesis that the stock liquidity measures causes stock returns is rejected at 5% level.

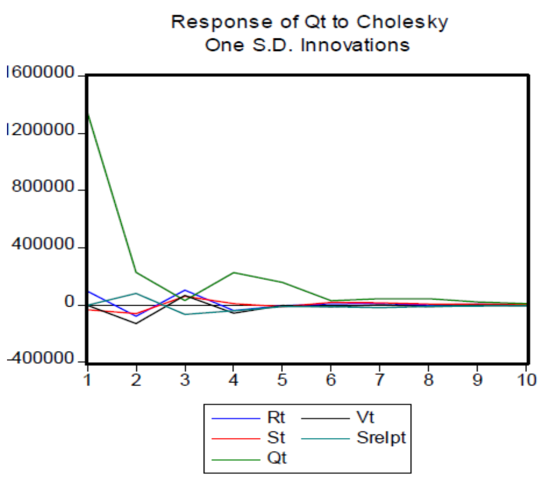
Null Hypothesis:	Obs	F-Statistic	Probability
S_T does not Granger Cause R_T	948	4.74415	0.00086
R_T does not Granger Cause S_T		1.96878	0.09721
Q_T does not Granger Cause R_T	948	1.10777	0.03149
R_T does not Granger Cause Q_T		0.98274	0.41599
V_T does not Granger Cause R_T	948	1.17589	0.03985
R_T does not Granger Cause V_T		1.65071	0.15941
$Srelp_T$ does not Granger Cause R_T	948	7.68399	4.3E-06
R_T does not Granger Cause $Srelp_T$		2.13425	0.07466

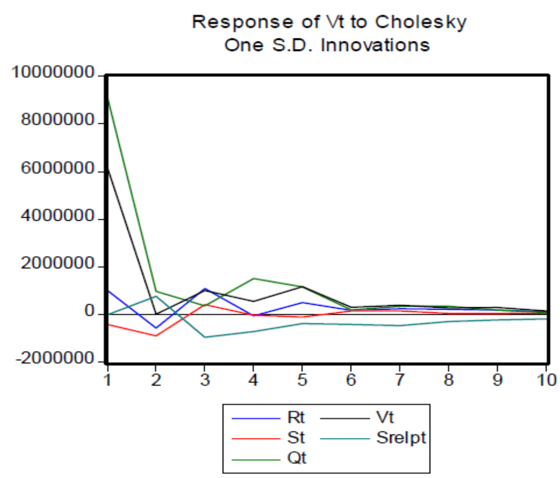
4.6 Impulse response functions

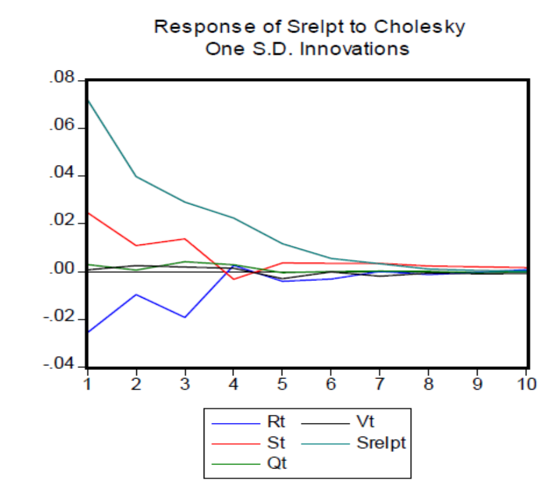
Impulse response analyses on the VAR models were conducted to improve robustness. The results shown below show the effects of an exogenous shock over the whole process over time.





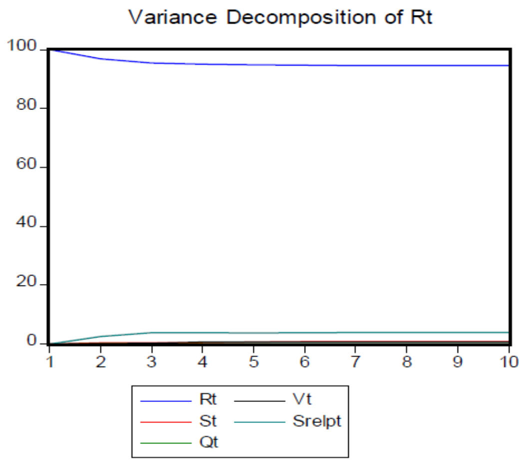


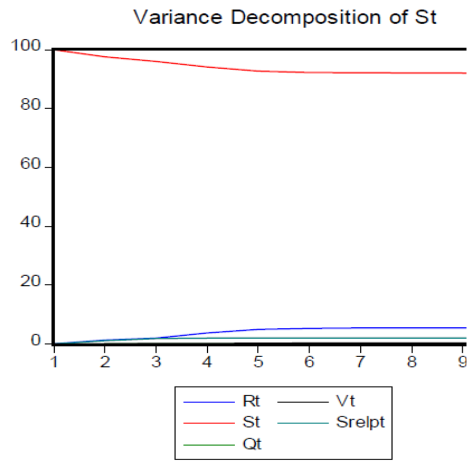


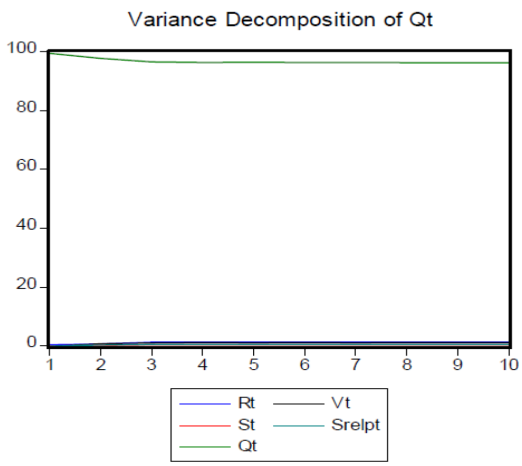


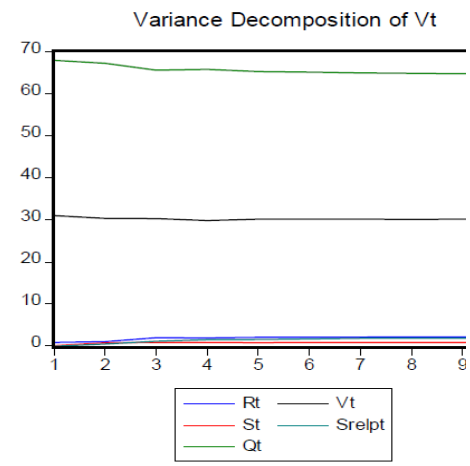
4.7 Variance Decomposition

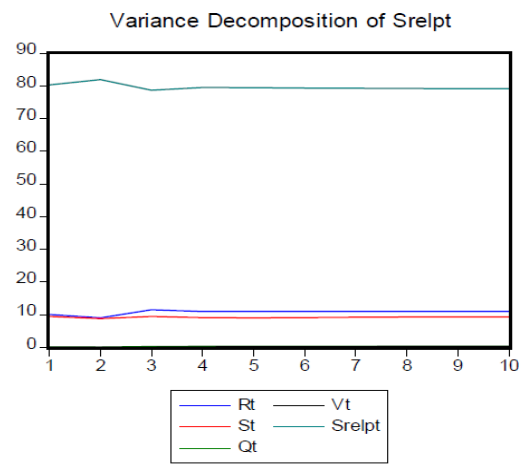
Variance decomposition results shown below enable the measurement of the proportion of movements in dependent variables that stem from their own shocks and shocks of other variables.











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