MONETARY POLICY SHOCKS AND STOCK MARKET VOLATILITY IN EMERGING MARKETS

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Abstract

This paper examines the effect of monetary policy decisions on stock markets in emerging economies particularly South Africa for the period 2000Q1 to 2016Q4. This is important as the monetary authorities would understand how their decisions may cause reactions to the stock market. Monetary policy directly shocks money supply and repo rate and indirectly GDP and inflation among many macroeconomic variables. A hypothesis that stock markets do not respond to monetary policy determinations is formulated and tested using a two-stage approach by employing first the vector error correction model to determine the long-run relationship of the variables and secondly GARCH (1, 2) model to determine the volatility. And the results suggest that about 5.2% variations in the Johannesburg Stock Exchange (JSE) volatility are due to monetary policy shocks. Overall, there is a negative relationship between M2 and stock market volatility. However, there is a positive link between repo rate and JSE volatility, which is not economically preferable because variations in repo rate influence the aggregate demand of investment on securities. The study recommends that the Monetary Policy Committee an expansionary monetary policy of keeping the repo rate lower must be pursued in order to increase borrowing that makes the public to have money to make transactions in securities on the financial market.

Keywords: Monetary Policy, Volatility, Johannesburg Stock Exchange, Shocks, GARCH, South Africa

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1. INTRODUCTION

Stock markets have shown to have a positive impact on a country's economic growth and development, as well as correcting the Balance of Payments (BoP) by attracting foreign investment. When the performance of the stock market shows an upward trend then the companies in that economy are economically stable. This in turn attracts foreign investors since their funds are safe.

In the case of South Africa, the Johannesburg Stock Exchange (JSE) established in 1886 after the discovery of gold is the single most active securities exchange currently listing above 400 companies (JSE, 2016). It was established to provide loanable funds to companies interested in investing in the booming mining sector (Chitimira, 2014).

The implementation of monetary policy has implications for other policies, including fiscal policy, trade policy and industrial policy. Platforms

such as trade policy would be affected by monetary policy say when there is an increase in money supply followed by a decrease in interest rates. This will lead to local goods being expensive and inadequately supplied and consumers will want to import their goods. An increase in interest rate will decrease the buying power for consumers which will make the poor worse off and the government will have to subsidise the poor for basic good and necessities.

Some scholars have suggested that monetary policy, especially in emerging markets, has no effect in determining the levels of stock market value (Onali, 2020; Atis & Erer, 2017; Thorbecke, 1997). The scholars do claim that in emerging economies, investors are passive and therefore are only reactive to long-term policy shocks (Crowder, 2006). Consequently, this paper hypothesises that monetary policy in emerging economies plays a significant role in determining the volatility of stock prices, itself affecting the levels of stock value. The purpose of this study therefore is to investigate the effect that monetary policy has not the volatility of stock markets in emerging economies. In literature such as Ioannidis and Kontonikas (2008), Jensen, Mercer, and Johnson (1996) and Ibrahim and Alagidede (2017) monetary policy is viewed to have an impact on the performance of capital markets leading to changes in asset prices and returns. Mangani (2007) documented that monetary policy has the power and ability to predict changes in the stock market prices and returns at JSE. Bernanke and Blinder (1992) reported that monetary policy shocks are significantly accountable for movements in the stock exchange.

The major objective of this study is to determine the transmission mechanism of monetary policy shocks on emerging stock markets.

More specifically, the study first examines individual relationships between money supply, repo rates, GDP, and CPI on the one hand and stock market performance on the other for an emerging stock exchange such as Johannesburg Stock Exchange. Secondly, the study analyses trends and the extent of variations on stock prices and returns. A hypothesis that stock markets do not respond to monetary policy determinations is formulated and tested.

The rest of the paper is organised as follows. Section 2 is the literature review followed by methodology in Section 3. Section 4 presents the results of the analysis to be followed by Section 5 which concludes.

2. LITERATURE REVIEW: EMERGING STOCK MARKETS

Securities exchanges worldwide are no longer operating in separation as the world economy has turned into a worldwide financial town. South Africa's monetary markets used to be vigorously controlled with regulations which were intended to smother extreme capital flight because of tremendous political hazard (Beelders, 2002). The introduction of financial markets after political improvements in the nation ameliorated and favoured share prices. The approach of popular government in South Africa denoted the lifting of assents by worldwide group, monetary modification approaches, direct development rates and a presentation of a fluctuating conversion standard (Bosker & Krugell, 2008). This went far in affecting movement on South Africa's one and just stock showcase.

The JSE which is recognised as the biggest stock market in Africa has three primary indices namely, the resources index, financials index and industrial file (JSE, 2016). South Africa's securities exchange is to a great extent asset-based since the greatest recorded organizations are mining combinations. Subsequently, developments of the primary list are driven by developments in the resources file which are an aftereffect of developments in asset costs particularly gold and platinum (Beelders, 2002). Murray (1987) contends that the JSE shows the wealth of the gold mining industry just like the case in the late 1800s. For instance, the current best ten organizations in South Africa, as measured by market capitalisation, are mostly mining organizations.

In 1947 the main enactment pertinent to the operation of trades was presented with the Stock Exchanges Control Act. The JSE is an individual from the African Stock Exchange Association, whose capacities incorporates the trading of information and help with the improvement of part 16 trades. Moreover, the JSE is subsidiary to the World Federation of Exchanges (WFE).

2.1. Trends in the JSE All Share Index

The day-by-day execution of the JSE All Share Index (ALSI) is a staple bit of the evening news report. Despite the fact that the ALSI is the best-known measure of the execution of the share trading system, it is just a single of a few pointers. The JSE All Share record has demonstrated an upward pattern since 1994. The pattern in the JSE execution was brought about by JSE's reestablishment, socio-politico and monetary occasions among other factors.

This trend took a turn due to the negative effects occasioned by the South-East Asian economies monetary shocks of 1997 (SARB, 1997). The JSE All-Share Index decreased pointedly in October 1997 and promptly recouped (SARB, 1997). Capital streams were being diverted to cutting edge economies which brought about outside back requirements for developing economies.

2.2. Monetary policy

Loayza and Schmidt-Hebbel (2002) and De Angelis, Aziakpono, and Faure (2005) explain the monetary policy to be involving the plan and execution of arrangements by the central bank to accomplish the coveted goal or set of targets; the strategies are intended to direct the bank lending rates to levels where credit request and cash development are at a level steady with total supply flexibility. The goals of monetary policy as executed by the South African Reserve Bank (SARB) are price stability, currency stability, sustainable growth and full employment as well as minimum inflation (SARB, 2017). The SARB has traditional instruments which it can use, namely, reserve requirement, open market

operations, moral suasion, prudential guidelines, interest rates, direct credit control and money supply.

Bernanke and Kuttner (2005) affirm that the most immediate and prompt impacts of monetary policy instruments are felt by financial markets. Policymakers' activities influence asset costs and returns. Therefore, understanding the connections between monetary policy instruments and asset costs is vital for understanding monetary policy implementation. Crowder (2006) expresses that the power of monetary policy relies upon its capacity to change monetary conduct of economic agents.

2.3. Volatility

Demonstrating and anticipating securities exchange volatility has been the subject of immense empirical and hypothetical examination over the previous decade. Volatility, as measured by the standard deviation or fluctuation of profits, is frequently utilized as a rough measure of the aggregate risk of money related resources.

Volatility estimate is a requirement for every pricing model for financial choices. Given the cost of an exchanged choice got from exchanges information, it is conceivable to decide the volatility figure over the lifetime of the choice inferred by the alternative's valuation. For instance, if standard Black-Scholes show is utilized, the choice price, the time to maturity, a hazard-free rate of interest, the strike cost and the current estimation of the fundamental resource, are largely either determined in the points of interest of the choices contracts or are accessible from market information. Hence, given all of these amounts, it is conceivable to utilize a numerical methodology, for example, the strategy for bisections or Newton-Raphson to infer the volatility suggested by the alternative (Watsham & Parramore, 2004). This inferred volatility is the market's figure of the unpredictability of fundamental resource returns over the lifetime of the choice.

2.4. Theoretical literature

The monetarists are of a strong perception that money is the most influential commodity in the economy. They further state that the overall economy's performance is strongly dependent on the level of changes in the money supply. The justification for the emphasised importance of money supply in the economy is focused on inflation. Monetarists advocate that the national income should grow at a faster pace than the money supply to keep the prices non-inflationary. This means that to achieve price stability in the markets money supply should be appropriately controlled because controlling money supply is controlling inflation (Friedman & Schwartz, 1987).

Classical economists believe the opposite of what Keynesians believe that the prices are directly linked to changes in the money supply. This group of economists assumes that the economy will always bring itself to optimum equilibrium. Hence the assumptions that real GDP is assumed to be constant in the short run leading to the velocity of circulation being fixed as well. These economists further state that if a central bank implements expansionary monetary policy there will be an increase in the general price levels and if the central bank implements contractionary monetary policy there will be a decrease in the general price levels.

2.5. The efficient markets hypothesis (EMH)

The efficient market hypothesis (EHM) assumes that information is rapidly and proficiently fused into asset prices anytime so that the previously existing information can't be utilized to foresee future price developments. This theory was developed by Eugene Fama in the 1960s and it is hypothesised in three forms, weak, semi-strong and strong form. The weak form of EMH follows an assumption that current security prices already include past security prices and volume information. Information declared weak because it is publicly made available and easily accessible information on security prices. Semi-strong form stipulates that all the information made available for the public has already been captured in the current price of the security. The strong form states that inside information is rapidly fused by market price and cannot be used for abnormal trading returns. Therefore, both private and public information is fully captured by security's current market prices and the people who withhold inside information are unable to use it to their gains.

2.6. Empirical literature

Chatziantoniou, Duffy, and Filis (2013) recorded that money supply positively affect the stock market. Based on a theoretical assumption decrease in interest rate would affect the stock market positively but in case of Germany, this assumption is captured through the causality impact of money supply on interest rates. However, for the USA, Chatziantoniou et al. (2013) using structural VAR recorded that the money supply has an inverse relationship with the stock market.

Furthermore, these studies articulated that any announcement made by the Federal Open Market Committee (FOMC) will result in changes in stock prices and stock returns more especially if the announcements were a surprise. However, even though these researchers found a significant relationship between monetary shock and stock market other researchers concluded otherwise. This includes Neri (2004) who tested the relationship on G-7 countries using structural VAR and found that the relationship between the two was averagely weak and negative. Li, Iscan, and Xu (2010) argued that the impact of monetary policy on a country's stock market depended greatly on its level of openness, trade and interdependency with the rest of the world. Evans and Murinde (2017) lagged data by 3 months to ensure that monetary policy shocks both anticipated and unanticipated have been captured to be significantly impactful on the prices of Singapore stock market in the short and long run.

Employing GARCH models, Hsing (2013) concluded that there is a negative and positive link between the index of Poland stock market and money supply. The study showed the link to be

positive when M3 to GDP ratio was not more than 46.03% and negative if it is more than 46.03%. Using Markov switching dynamic method, Atis and Erer (2017) tested the relationship between monetary policy and stock market using the criteria of low and high volatility eras. The results showed a negatively significant impact of monetary policy on stock returns during the low volatility mechanism.

Ben Naceur and Goaied (2007) targeted the Middle-East and North African (MENA) countries. The study portrayed that in Bahrain and Saudi Arabia the effect of interest rate was not above 0.01, while 0.1 was recorded for Oman and 0.2 for Jordan. For Tunisia, Bahrain and Egypt an increase in the quantity of money leads to an increase in stock returns by 0.5, 0.4 and 1.2 precisely.

For Pakistan, Qayyum and Anwar (2011) used EGARCH and found that the stock market reacted quickly to any monetary policy shock regardless of the size of the shocks. An increase in interest rates had a significantly negative effect on the stock market index, while inflation impacted positively on the stock market index (Khan, Rehman, & Hussain, 2016). In Malaysia, money supply and interest rate were reported to have a positive link with the stock market performance (Wen, Boon, Kiong, Hwang, & Chien, 2015). Using the Granger causality test Amarasingshe (2015) demonstrated a negative relationship between interest rate and All Share Price Index (ASPI) of the Sri Lanka Stock Exchange, which is on the grounds that financing cost can influence the stock valuation, by shifting the required rate of return.

The All Share Index of the Nigerian Stock Market was reported to be significantly affected by interest rates only when the other factors that affect the stock market are not. Ali (2014) found that interest rate significantly affects the Karachi Stock Market (KSM) in Pakistan. In India, interest rates were found to be significantly affecting the stock prices and that they should be kept moderate in order to attract more investments (Reddy, 2012). GDP showed to be important in influencing the Indian stock prices. Reddy (2012) also reported that interest rates, inflation and GDP explained 95.6% of changes in stock prices.

Volatility is also affected by other factors such as inflows of foreign investments which, if significant, may move the market (Bonga, 2019; Chhimwal, Bapat, & McMillan, 2020). These may be regarded as reactions to the policy environment being conducive for new money to be invested by different economic players, some from outside the economy.

South Africa has undertaken a limited number of studies concerning the topic in discussion; exceptions include Mangani (2007) which focused strictly on the JSE and established that monetary policy and mining sector production had explanatory power for stock returns. Gumata, Kabundi, and Ndou (2013) found that contractionary monetary policy could lower stock returns. Similar to this current study is work by Marozva (2020) who applied GARCH modelling and found mixed results. According to Murouyiwa (2011) using structural VAR methodology, there is a link between monetary policy and stock prices in South Africa.

Coetzee (2002) contemplated that an expansionary monetary policy relates positively to stock returns while contractionary policy relates negatively to stock returns. In the expansion period, the returns would be about 52.94% while in the restriction period only about 11.11%.

3. METHODOLOGY

It is for the violation of the homoscedasticity assumption that this study uses GARCH models. Engle (2001) states that "the standard warning is that in the presence of heteroscedasticity, the regression coefficients for an ordinary least squares regression are still unbiased, but the standard errors and confidence intervals estimated by conventional procedures will be too narrow, giving a false sense of precision. Instead of considering this as a problem to be corrected, ARCH and GARCH models treat heteroscedasticity as variance to be modelled. As a result, not only are the deficiencies of least squares corrected, but a prediction is computed for the variance of each error term" (p. 157).

The GARCH modelling technique has been used by other researchers. Some have applied monthly data, some seasonal data, all utilising the same approach. For the stock market (Bonga, 2019; Chhimwal, Bapat, & McMillan, 2020; Onali, 2020) have all applied different methodologies but the GARCH family of models take the lead.

3.1. Model specification

This macroeconomic model has been widely utilized by scholars such as Al-Shiab (2008), Laopodis (2006) and Sharma (2010) using general VAR framework methodology. The relationships were inspected amongst fiscal and monetary factors which are the explanatory variables with the stock value which is the explained variable depicted in equation (1) below.

$$Y = \beta_0 + \beta_1 LOG\_M2_t + \beta_2 IR_t + \beta_3 LOG\_GDP_t + \beta_4 INF_t + \varepsilon_t \quad (1)$$

The JSE All Share Index (ALSI) has been utilized as a dependent variable. The JSE ALSI has been gathered from the JSE and it is a noteworthy record for every single recorded share on the stock exchange, giving a reasonable sign of what is going on money markets. The unit of the JSE ALSI is the premise point. Every one of the factors on the right-hand side of the equation is the autonomous factors; *M2* remains for the money supply which includes all liquid assets from cash balances to cheques and deposits.

CPI is the consumer price index which is used instead of inflation (*INF*) as a more accurate measure of general price changes. The consumer price index takes an aggregate of a consumer basket and provides a weight to each sampled commodity based on importance. The change in the index so developed indicates a general movement in the general price level in the economy.

GDP represents a gross domestic product, thus the real values of all finished goods and services produced within the economy.

IR remains for interest rate proxied by the repo rate; and ε is for stochastic error term which is independently and normally distributed.

A positive relationship is expected between the money supply and stock prices. Its significance has appeared in numerous past observational studies, for example, Maysami and Koh (2000), Sellin (2001), Laopodis (2006). Some previous studies found mixed results on the efficient market hypothesis (EMH) validation. Rozzeff (1974) found that the efficient market hypothesis to be untrue while later on Rogalski and Vinso (1977) found that the efficient market hypothesis is correct as well as the monetarist theory. However, Rogalski and Vinso (1977) advocated that the relationship should run mainly from money supply to stock prices so that the monetary policy and its authorise are not led by stock markets in order for the authorities to be able to safeguard the entire economy.

The repo rate was taken as a measure of the interest rate. Interest rate and stock prices are expected to demonstrate a negative relationship. As interest rates rise, investors tend to prefer interest yielding assets which pushes stock prices upwards Zhou (1996), Kim (2003), Glasner (2018). By utilising the Johansen approach, Alam and Uddin (2009) demonstrated a negative relationship between interest rates and stock prices.

A negative relationship between inflation and stock prices is expected. As indicated by Fama and Schwert (1977), Geske and Roll (1983), and McCarthy, Najand, and Seifert (1990), Leopodis (2006) inflation affects stock prices negatively. This is mainly because investors expect that inflation will erode away their dividends and therefore they offload their shares to hedge against the risk of loss due to higher expected taxation.

3.2. Data sources and analysis

The data for this study was acquired from secondary sources such as the South African Reserve Bank, Johannesburg Stock Exchange (JSE), Statistics South Africa, and Quantec. The paper used South African quarterly time series data for the years 2000-2016. This data will first be used in the model to test for stationarity to terminate spurious regression results. To attain this, the augmented Dickey-Fuller test method will be used.

3.3. Autoregressive conditional heteroscedasticity (ARCH) model

The generalised autoregressive conditional heteroscedasticity (GARCH) model extends the autoregressive conditional heteroscedasticity (ARCH) model. The ARCH model was first developed by Engle (1982) and is given as follows:

$$\sigma_t^2 = \alpha_0 + \alpha_1 \alpha_{t-1}^2 \quad (2)$$

The equation specified above is ARCH (1, 1) model because the conditional variance has been instructed to be dependent on a single lag.

Where α_0 and α_1 restrict the variance to be positive and also for stationarity and α_{t-1} denotes previous term's conditional volatility. However, the ARCH model had to be expanded because the fault with it is that the variance for the next period only depends on the squared residual of the last period so a crisis that resulted to a large residual would not have the sort of persistence that we observe after actual crises. This is one of the reasons for the extension of the ARCH to GARCH model. The infinity ARCH model is also known as ARCH (q):

$$\sigma^2 = \alpha_0 + \alpha_1 u_{t-1} + \alpha_2 u_{t-2}^2 + \cdots + \alpha_q u_{t-q}^2 \quad (3)$$

3.4. Generalised autoregressive conditional heteroscedasticity (GARCH) model

GARCH model was first developed by Bollerslev (1986). The GARCH model captures the reaction of the dependent variables to changes in independent variables, if there is a rapid change in the dependent variable that is due to changes in independent variables then there is volatility in the dependent variable. For purposes of this study, a variable is judged to be volatile if its standard mean and variance are not constant overtime. The GARCH model is mathematically expressed as:

$$\sigma^2 = \alpha_0 + \alpha_1 u_{t-1}^2 + \beta_1 \sigma_{t-1}^2 \quad (4)$$

Equation (4) is GARCH (1, 1) model because it has been lagged by 1 year. Similar to ARCH, GARCH can also take any form as long as it is of an ARMA model with an effective conditional variance. The general form of GARCH models is GARCH (p, q) where p refers to how many autoregressive lags are specified and q refers to the number of moving average lags that are included.

Where σ^2 = variance; $\alpha_0 \& \alpha_1$ = weighted long run (average) variance; u_{t-1}^2 = previous squared return; σ_{t-1}^2 = previous variance.

Therefore, $\alpha_0 > 0$, $\alpha_1 > 0$, $\beta_1 > 0$, and $\alpha_1 + \beta_1 < 1$ so that the variance of the next period being forecasted is actually a combination of a substance the last period's forecasted variance and last period's squared return.

To be able to run models using GARCH as a technique, maximum likelihood is used.

It must be noted that other technics could have been applied, these include the dynamic models such as TGARCH, PARCH and EGARCH model and different dynamic panel data models such as Areonalo bond could be trying to predict the data. The study settled for the basic GARCH (p, q) model on account of lack of resources. Future studies therefore can test using these methods.

4. DATA ANALYSIS AND RESULTS AND DISCUSSION

4.1. VAR lag order

Lag length tests suggest that the vector error correction (VEC) model should apply 2 lags. This is important because it indicates that in South Africa, monetary policy shocks will impact on JSE volatility for an estimated period of 2 years.

4.2. Vector error correction (VEC) model

Having identified through PP and ADF stationarity tests that all the variables included in the model are integrated of order I (1), the appropriate model that utilises this integration order is vector error correction model (VECM).

Table 1. Long run vector error correction model (VECM) estimates

Variable	*Coefficient*	*Std. error*	*T-stat*
CONSTANT	-168.099	-	-
LOG_ALSI (-1)	1	-	-
IR (-1)	6.140066	-1.89767	[3.23558]
LOG_M2 (-1)	34.03605	-29.602	[1.14979]
LOG_GDP (-1)	-52.84836	-39.4473	[-1.33972]
INF (-1)	-9.279984	-1.95187	[-4.75440]
R-squared	0.289636	Adjusted R-squared	0.13642

Source: Authors' calculations based on time series data.

$$LOG_{ALSI} = 168.0990 - 6.140066IR_{t-1} - 34.03605LOGM2_{t-1} + 52.84836LOGGDP_{t-1} + 9.279984INF_{t-1} \quad (5)$$

4.3. Johansen cointegration test

This test is performed to check whether there is a long-run relationship between JSE *ALSI* and *M2*, *IR*, *GDP* and *INF*. The results in Table 2 and Table 3 both confirm that 3 of the variables in the model have a long-run relationship. The results of the test suggest that we fail to reject the null hypothesis (*H0*) of no cointegration.

Table 2. Trace values cointegration results

Hypothesized No. of CE(s)	*Eigenvalue*	*Trace statistic*	*0.05 Critical value*	*Probability*	*Conclusion*
None *	0.489231	110.5044	69.81889	0.0000	Reject *H0*
At most 1 *	0.393895	68.17858	47.85613	0.0002	Reject *H0*
At most 2	0.310810	36.63439	29.79707	0.0070	Fail to reject *H0*
At most 3	0.141575	13.18336	15.49471	0.1082	Fail to reject *H0*
At most 4	0.055032	3.566051	3.841466	0.0590	Fail to reject *H0*

*Note: Trace test indicates 3 cointegrating eqn(s) at the 0.05 level. * denotes rejection of the hypothesis at the 0.05 level. ** MacKinnon-Haug-Michelis p-values (MacKinnon, Haug, & Michelis, 1999).*

Source: Authors' calculations based on time series data.

Table 3. Maximum eigenvalues cointegration results

Hypothesized No. of CE(s)	*Eigenvalue*	*Max-Eigen statistic*	*0.05 Critical value*	*Probability*	*Conclusion*
None *	0.489231	42.32580	33.87687	0.00039	Reject *H0*
At most 1 *	0.393895	31.54418	27.58434	0.0147	Fail to reject *H0*
At most 2	0.310810	23.45104	21.13162	0.0232	Fail to reject *H0*
At most 3	0.141575	9.617307	14.26460	0.2383	Fail to reject *H0*
At most 4	0.055032	3.566051	3.841466	0.0590	Fail to reject *H0*

*Note: Max-eigenvalue test indicates 3 cointegrating eqn(s) at the 0.05 level. * denotes rejection of the hypothesis at the 0.05 level. **MacKinnon-Haug-Michelis p-values (MacKinnon, Haug, & Michelis, 1999).*

Source: Authors' calculations based on time series data.

4.4. Variance decomposition results

Variance decomposition results are obtained using the VEC model, although the VEC model estimation results are not represented in this paper because GARCH (1, 2) model has been identified to be the best model for this paper. However, the VEC model is only used as a ladder to achieve how JSE respond to shocks in the explanatory variables. VEC model has a special tool for measuring shocks which is called variance decomposition.

Table 4. Variance decomposition of LOG_ALSI

Period	*S.E*	*LOG_ALSI*	*LOG_M2*	*IR*	*LOG_GDP*	*INF*
1	2.925580	100.0000	0.000000	0.000000	0.000000	0.000000
2	4.118688	93.37151	4.856832	0.903422	0.202327	0.665912
3	5.322135	89.01324	4.846474	0.554339	0.503993	5.081957
4	5.965154	87.33356	5.375215	0.443480	0.544660	6.303081
5	6.601380	86.33420	5.454465	0.420328	0.517781	7.273222
6	7.034093	86.56828	5.689306	0.375414	0.515395	6.851604
7	7.437890	87.25598	5.428455	0.390137	0.520055	6.405376
8	7.765961	87.81418	5.166931	0.556881	0.570516	5.891489
9	8.079841	88.28624	4.897163	0.733867	0.640048	5.442682
10	8.359485	88.53551	4.661829	0.923335	0.743564	5.135761

Source: Authors' calculations based on time series data.

As in Table 4 the variance decomposition indicates that monetary shocks (*LOG_M2*) have contributed 4% to changes in JSE volatility in the second and third quarter. The contribution of monetary shocks to changes in JSE volatility slightly increased to about 5% from the fourth quarter till the eighth quarter where the contribution started to decrease to 4% for the last two quarters.

Interest rates shocks (*IR*) have contributed 0.9% to changes in JSE volatility in the second quarter and declined to 0.5% in the third quarter. The contribution of interest rates shocks to changes in JSE volatility further decreased till at 0.3% in the seventh quarter then it increased to 0.5 in the eighth quarter and continued to increase till to the last quarter.

Shocks in *GDP* have contributed 0.6% to changes in JSE volatility in second and decreased to 0.5% in the third quarter. The contribution of shocks in *GDP* to changes in JSE volatility further increased to 0.7% in the 9th quarter and increased to 0.9 in the last quarter.

Shocks in inflation (*INF*) have contributed 0.6% to changes in JSE volatility in the second quarter and increased to 5% in the third quarter. The contribution of shocks in inflation to changes in JSE volatility further increased by 1 unit of percentage in the fourth quarter and the fifth quarter. Afterwards, the shocks in inflation to changes in JSE volatility started to decrease by 1 unit of percentage till the seventh period where the contribution was constant at 5% to the last quarter.

In the first quarter, the 100% of changes in JSE is due to its own shocks. The contribution decreases at a decreasing rate to 86% in the sixth quarter and it increases to 87% in the seventh and the eighth quarters to 88% in the last two quarters.

4.5. Output of GARCH (1, 2)

Coefficients in Table 5 can be mathematically expressed as follows:

$$LOG_{ALSI} = 153.0381C - 38.49887(LOG_{M2}) + 0.039149(IR) + 63.10924(LOG_{GDP}) + 0.146610(INF) \quad (5)$$

Table 5. Representation of GARCH (1, 2) model

Dependent variable: *LOG_ALSI* ***Method:*** *ML ARCH – Normal distribution (BFGS/Marquardt steps)* ***Sample size:*** *2000Q1 2016Q4*				
Variable	***Coefficient***	***Std. error***	***z-statistic***	***Prob.***
LOG_M2	-38.49887	0.085443	-450.5798	0.0000
IR	0.039149	0.088011	0.444826	0.6564
LOG_GDP	63.10924	0.286255	220.4653	0.0000
INF	0.146610	0.139371	1.051945	0.2928
C	153.0381	1.660934	92.13979	0.0000
Variance equation				
C	0.622127	0.337407	1.843845	0.0652
RESID (-1)^2	1.185470	0.251273	4.717862	0.0000
GARCH (-1)	0.028099	0.170888	0.164427	0.8694
GARCH (-2)	-0.054239	0.097224	-0.557876	0.5769
R-squared	0.771390	Mean dependent var	-1.318627	
Adjusted R-squared	0.756399	S.D. dependent var	9.038004	
S.E. of regression	4.460790	Akaike info criterion	4.626894	
Sum squared resid	1213.817	Schwarz criterion	4.925483	
Log-likelihood	-143.6875	Hannan-Quinn criteria	4.744880	
Durbin-Watson stat	0.588598			

The output and interpretation of GARCH models are different from models such as Ordinary Least Square (OLS) because the GARCH output has two sections to be interpreted; the first section on the output is called the mean equation. Mean equation measures the relationship between the independent variable and dependent variables. Mean equation does not only show the nature of the relationship (negative or positive) but it also gives exact values by which an independent value explains the dependent value. Lastly, the mean equation shows the significance of the independent variables through the use of probability values in comparison to the significance level or through the use of t-statistics values.

To ensure that the variable *ALSI* properly measures volatility, its meaning is derived and then less the mean from actual values and find the deviation. This process has been applied in studies of volatility such as Mlambo, Maredza, and Sibanda (2013), and Mokoma (2014). The coefficient of *M2* is negative implying that this variable (*M2*) has a negative relationship with the JSE volatility. The coefficients of repo rate (*IR*), inflation (*INF*), and GDP are positive implying that there is a positive relationship between these three explanatory variables (*IR, INF* and *GDP*) and JSE volatility.

The estimated GARCH (1, 2) model shows that a 1% increase in money supply (*M2*) will lead to a 38% decrease in JSE volatility. This is in agreement with the Keynesian theory but in contrary to real activity economists. These results also portray a very strong relationship between money supply and JSE volatility because of a mere 1% increase in money supply results to a 38% change (decrease) in JSE volatility. Inflation has a positive effect on the JSE volatility positively implying that a 1% increase in interest rate will result in a 0.15% increase in JSE volatility.

GDP and interest rate positively affects the South African stock market. The multivariate GARCH (1, 2) model shows that a 1% increase in GDP leads to a 63% increase in JSE volatility. These results are in agreement with studies such as Eriki and Udegbunam (2017), Ibrahim and Aziz (2003), Chaudhuri and Smiles (2004), Shiblee (2009) and Christopher, Rufus and Ezekiel (2009). A 1% increase in Inflation will lead to a 0.15% increase in JSE ALSI. A 1% increase in interest rate will result in a 0.04% increase in JSE volatility. R-squared is 77% implying that about 77% of volatility in JSE is explained by shocks in *M2, IR, GDP* and *INF*, the remaining 23% is explained by other factors or shocks not included in this model.

4.6. Variance equation

The second section of GARCH models that needs interpretation is variance equation which captures and measures the level of volatility in the variables

in question. To determine the level of volatility in multivariate GARCH (1, 2) model the variables under variance equation are used. These variables are RESID (-1)^2, GARCH (-1) and GARCH (-2). If the sum of these variables is zero, there is no volatility in the dependant variable there is low volatility, if their sum is more than zero, if their sum is 1 there is moderate-high volatility and if the sum is more than one there is high volatility. The estimated multivariate GARCH (1, 1) model gives a higher measure of volatility which is indicated by the total of RESID (-1)^2 and GARCH (-1), thus (1.185470 + 0.028099-0.054239 = 1.15933). This means that money supply (*M2*), repo rate, GDP and inflation cause a high level of volatility on the JSE when estimated by the GARCH (1, 2) model.

5. CONCLUSION

As it is, JSE is doing well as far as volatility is concerned; this is shown by the three volatility measures employed in this paper. However, GDP is responsible for the largest proportion of changes in JSE volatility. This becomes a matter concern since GDP in South Africa is mostly decreasing or if it increases it is at a decreasing rate and considerably low. When GDP decreases in SA like it decreased in the last quarter of 2016 by 1.2% from the last increase of 0.4% (it decreased by more than what it had previously increased by) it's a red signal for the JSE economically desirable volatility. GARCH (1, 2) presents that a small decrease as little as a 1% decrease in GDP will lead to the JSE volatility decreasing by a huge chunk of 63%. This will lead to volatility that is not economically desirable like in case of Malawi. Therefore GDP in South Africa is considered to be 'weak' as compared to Nigeria; there is a need for policy formulations that should focus on making GDP in SA stable or constantly increasing. The government together with the financial authorities and all the economic participants should come with policies focused on GDP such as starting businesses; invest on human capital development, technological innovation, research and development which will lead to increased GDP.

The VECM variance decomposition suggests that JSE volatility variations of at least 0.53% are due to changes in interest rates. However, results from the GARCH (1, 2) model suggest the interest rate be statistically insignificant and positively related to the volatility on the stock exchange. Lowering interest rates will likely lead to an economy that is better off because it will encourage borrowing and participants will have money to buy shares and due to this effective demand of shares, their prices will increase. The transmission mechanism is that decreasing interest rate will decrease the cost of borrowing in the economy leading to an increase in borrowing thereby influencing the public to exchange securities and receive dividends. Therefore to encourage the aggregate effective demand (willingness with ability to buy) of securities at the JSE the study recommends that the monetary policy committee decrease the repo rate. The Monetary Policy Committee should focus on implementing expansionary monetary policy in order to maintain a good level of volatility at JSE.

The inflation is positive and insignificant in the model, this is not agreeable for the money especially that South Africa has adopted inflation targeting which has increased the creditability, effectiveness and transparency of the monetary policy conduct (Hewson & Bonga-Bonga, 2005). One of the reasons for inflation to be positive and insignificant is that for most periods post-1994 the inflation rate has been outside the target of 3-6% which contributes to the insignificance of the inflation. The SARB and competition commission needs to implement measures that further limits inflation such as strongly legislate and regulate the price controls of companies listed at JSE that have greater monopoly power.

This paper shows that monetary policy is an important element in determining the path for the stock market. Decisions made by a few individuals in closed room trigger reactions that have determined the direction of the stock market in South Africa. It is therefore important that the Monetary Policy Committee be vigilant and more factual min decision making.

This study was limited in its analysis and application of behavioural finance and economic paradigms that may have an explanation regarding the behaviour of investors on the stock exchange. To this end, it is suggested that for the future, research may consider increasing the number of variables and bringing in other behavioural aspects as determinants of the volatility of stock markets volatility. In addition, applying more dynamic methodologies such as dynamic general equilibrium models to try and predict the behaviour of stock markets in future is recommended.

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