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Macroeconomic effects on individual JSE Stocks: a GARCH representation

ABSTRACT

A GARCH framework was invoked to investigate the effects of discount rate and gold price changes on individual stocks traded on the JSE Securities Exchange of South Africa. It was found that the discount rate was clearly important in describing the dynamics of mean returns, while gold price changes largely influenced return volatilities. The importance of both variables was bolstered when they were decomposed to capture asymmetric effects of news about them. In addition to supporting the hypothesis of symmetric effects, there was evidence of a substitution effect between non-resources and resources stocks in reaction to changes in the gold price.

1. INTRODUCTION

There is overwhelming evidence in the literature that a range of macroeconomic variables can influence stock prices and returns (Chen, Roll and Ross, 1986). Reports by van Rensburg (1999, 2000) and others provide similar evidence using data from the JSE Securities Exchange of South Africa (hereafter, the JSE). Within this context, prior research established that monetary policy and mining sector production had explanatory power for JSE stock returns (Mangani, 2007a). Using this evidence, the author subsequently investigated the impacts of the discount rate (as a measure of monetary policy) and the price of gold (as a proxy for earnings from mining sector investments) on JSE stock portfolios, and confirmed that the effects of positive and negative changes in the two variables were largely asymmetric (Mangani, 2008a). However, the evidence in this research was quite sensitive to the definition of the stock portfolio in that the reaction of the JSE All Share index tended to differ from that of an equally weighted portfolio of a sample of stocks from the market. This conflicting evidence is, therefore, inconclusive regarding the potential reaction of individual JSE stocks to changes in the two variables.

This paper extends the prior research by investigating the reaction of returns on individual JSE stocks to monetary policy and gold price changes within the framework of a generalised autoregressive conditional heteroscedasticity (GARCH) model. Specifically, the paper seeks to investigate: (a) the contemporaneous effects of changes in the discount rate and the gold price on returns of individual JSE stocks; (b) possible asymmetric effects of news about changes in the discount rate and the gold price on such returns; and (c) whether the dynamics of the stock portfolios reported in the aforementioned prior work reflected those of the individual stocks.

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The next section recalls the theoretical framework for investigating the effects of macroeconomic variables on the stock market, presents a selection of the literature, and locates the motivation for this paper. The methodologies pursued in the investigation are discussed in Section 3, while the results of the analysis are presented and discussed in Section 4. Section 5 summaries and concludes.

2. THEORY, LITERATURE AND MOTIVATION

The present value formula of stock prices postulates that stock prices inversely vary with interest rates, and positively vary with “earnings” or “numerator” factors. Therefore, an increase in the discount rate (i.e., contractionary monetary policy) should induce a decline in stock prices and returns, while a gold price increase implies increased earnings from investments in the gold sector, which should in turn increase stock prices. This simple theory of stock prices provides a basis for investigating the reaction of the stock market to macroeconomic shocks.

In addition to investigating the effects of macroeconomic variables on mean returns, which has been the preoccupation of most of the prior research pioneered by the widely cited work of Chen *et al.* (1986), Tarhan (1993) argues that such variables could also affect the volatility of returns. Gulley and Sultan (2003:200) posit that “if positive and negative changes are perceived to be conveying either a pessimistic or an optimistic outlook on the economy, then the market’s reaction to the information flows should be asymmetric”.

The empirical literature presents conflicting evidence on these issues. For instance, some studies report an inverse relationship between stock prices and the discount rate (Jensen and Johnson, 1993; Gulley and Sultan, 2003), while others find this relationship to be positive (Peace and Roley, 1983; Hafer, 1986;). A significant impact of the volatilities of inflation and interest rates on the volatility of the stock market is reported by Kearney and Daly (1998), while Hafer (ibid) confirmed the presence of asymmetric effects of policy on stock prices. Morgan (1993) found that policy had asymmetric effects on output growth, hence possibly on asset prices as well. In addition to policy, many studies establish that stock return variations could be explained by measures of real activity (e.g., Chen *et al.*, 1986; Barr, 1990; Fama, 1990; Chen, 1991), and that the effects of macroeconomic variables on stock returns could be time sensitive, disappearing as the market matured (Binswanger, 2000; Muradoglu and Metin, 2001).

Mangani (2008a) used an augmented GARCH(1,1) model to investigate the effects of the discount rate and gold prices on two JSE stock portfolios, namely the JSE All Share index (denoted ALSI) and an equally weighted portfolio of selected JSE stocks. The latter, denoted PORT, was constructed from a random sample of forty-two individual stocks with a long trading history. The results of this investigation showed that (a) both the discount rate and the gold price impacted on mean returns only (and not on the volatilities of returns), except when they were decomposed to capture asymmetric effects of positive and negative shocks; (b) the effects of both the discount rate and the price of gold on mean returns were consistent with theory: contractionary monetary policy could lower stock returns, and gold price increases tended to increase ALSI returns although they had no effect on PORT returns; (c) there was strong evidence of asymmetric effects of monetary policy: only positive discount rate changes inversely impacted on mean returns while only negative changes had strong volatility-dampening effects; and (d) the effects of gold price changes were largely symmetric on ALSI mean returns, and largely asymmetric on the volatility of PORT returns.

The foregoing evidence suggested that the two variables were quite important in explaining JSE return dynamics, especially when they were decomposed to capture asymmetric effects. However, the fact that the effects varied depending on whether ALSI or PORT was used suggested that the behaviour of individual stocks could be stock-specific. It is meriting, therefore, to extend the enquiry by analysing the reactions of individual JSE stocks to changes in the two variables.

3. RESEARCH METHODOLOGIES

3.1 Variables and data

The choice of the discount rate and the price of gold as appropriate measures of monetary policy and macroeconomic activity is supported by prior research which finds the two as important surrogates for priced factors on the JSE (see van Rensburg, 1999; Mangani 2005).

The implementation of the FTSE global classification system by the JSE in June 2002 induced a significant decline in the number of stocks constituting the ALSI. Therefore, by studying only a few companies in the new index, it is possible to capture a reasonable proportion of the truly trading segment of the market. This study used the sample of forty-two stocks that was used in the construction of PORT in the prior investigation (see Appendix 1). Nine of these were resources stocks, twenty-eight were industrial while five were financial. In addition to capturing 45 percent of the FTSE/JSE All Share index as at July 2002, the sample captured 48 percent of the Top 40 index and 52 percent of the Resi index. The sample also captured 48 percent, 35 percent and 42 percent of the Indi, Fini and Findi indices, respectively.

The data used were weekly close prices of the individual stocks, and weekly observations on the gold price and the discount rate. The sampling period was from 16 December 1983, coinciding with the implementation of the so-called classical cash reserve and repurchase agreement (repo) systems of monetary policy in South Africa, both of which explicitly employed the discount rate (i.e., the Bank/repo rate) as the key instrument of monetary policy (see Nattrass *et al.*, 2002). The repo system was still operational at the time of writing. For thirty-three of the forty-two stocks, the data extended to 25 May 2007. Data on the remaining nine stocks were available up to 5 April 2002, the date they were last downloaded from the data source by this author. These nine stocks had been delisted from the JSE (or significantly transformed in other ways) in the period between April 2002 and June 2007. Close price data on the individual stocks for the period up to 22 September 2001 were supplied by the Statistical Sciences Department of the University of Cape Town. The rest of the data, including gold prices in rand per kilogram, and data on the discount rate, were obtained from the Inet-Bridge online database. Returns were computed as first differences of logarithmic prices. Hence, in the sequel, the term “returns”, loosely means continuously compounded returns.

Using a longer realisation of the same stock price data, Mangani (2007b; 2008b) disputed the assumption that JSE returns were independently and identically distributed and jointly multivariate normal, and showed that the GARCH(1,1) model was a more suitable description of JSE returns than other complex alternatives in the ARCH class of volatility models. An exploratory analysis of the present data upheld these findings.

3.2 Modelling framework

To remain consistent with the prior portfolio-based investigation, the modelling framework adopted here is identical to that used in Mangani (2008a), whose recollection is as follows. Let R be uncorrelated or linearly filtered returns, where a tenth-order autoregression was used as a linear filter in the case of correlated returns. Let also DRATE be the discount rate; GPRICE be the natural logarithm of the price of gold; and t denote time. Using standard unit root testing procedures, it was established that R was stationary in levels while both DRATE and GPRICE were stationary after first differencing. As such, first differences of the variables are prefixed with a 'D'. To capture the effects of the two macroeconomic variables, the following augmented GARCH(1,1) model was used (say Model A):

$$R_t = \alpha_0 + \alpha_1 DDRATE_t + \alpha_2 DGPRICE_t + \mu_t , \quad \ldots (1)$$

$$\mu_t \left| \Omega_{t-1} \sim N(0, h_t) \right. , \quad \ldots (2)$$

$$h_t = \phi_0 + \lambda_1 \mu_{t-1} + \theta_1 h_{t-1} + \phi_1 DDRATE_t + \phi_2 DGPRICE_t \ldots (3)$$

where

α_i, φ_j, λ_1 and θ_1 are coefficients to be estimated ($i, j = 0,1,2$), and all other terms assume the usual interpretations of the GARCH model. Equation (1) is the conditional mean return expression, while Equation (3) gives an expression for the volatility of returns. Equation (2) gives the distribution of the error term, conditional upon available information. While confirming the presence of ARCH and GARCH effects through the significance of λ_1 and θ_1, this investigation was particularly interested in testing the following hypotheses:

H_0: DDRATE and DGPRICE had no impact whatsoever (i.e., $\alpha_i = \phi_j = 0$ for $i, j = 1,2$);

H_1: Not H_0;

H_2: DDRATE and/or DGPRICE impacted on both mean returns and return volatilities (i.e., $\alpha_i \neq 0$, and/or $\phi_j \neq 0$, for at least one $i, j = 1,2$);

H_3: DDRATE and/or DGPRICE only impacted on mean returns (i.e., $\phi_j = 0$ for both $j = 1,2$, but $\alpha_i \neq 0$ for at least one $i = 1,2$); and

H_4: DDRATE and/or DGPRICE only impacted on return volatilities (i.e., $\alpha_i = 0$ for both $i = 1,2$, but at least one $\phi_j \neq 0$ for some $j = 1,2$).

In order to investigate the hypothesis that the macroeconomic variables had asymmetric effects on JSE return dynamics depending on how the market interpreted news associated with changes in them, the variables were decomposed to reflect positive and negative changes. Adopting the notation that DPOS and DNEG were the decomposed variables for DDRATE while GPOS and GNEG were those for DGPRICE, these were defined as follows:

$$DPOS_t = DDRATE_t \text{ if } DDRATE_t \geq 0; \quad = 0 \text{ otherwise}$$

$$DNEG_t = DDRATE_t \text{ if } DDRATE_t < 0; \quad = 0 \text{ otherwise}$$

$$GPOS_t = DGPRICE_t \text{ if } DGPRICE_t \geq 0; \quad = 0 \text{ otherwise}$$

$$GNEG_t = DGPRICE_t \text{ if } DGPRICE_t < 0; \quad = 0 \text{ otherwise}$$

The new variables replaced DDRATE and DGPRICE in Equations (1) and (3) to yield the following model (say Model B):

$$R_t = \alpha_0 + \eta_1 DPOS_t + \eta_2 DNEG_t + \eta_3 GPOS_t + \eta_4 GNEG_t + \mu_t , \quad \ldots (4)$$

$$\mu_t \left| \Omega_{t-1} \sim N(0, h_t) \right. , \quad \ldots (5)$$

$$h_t = \varphi_0 + \lambda_1 \mu_{t-1} + \theta_1 h_{t-1} + \varphi_1 DPOS_t + \varphi_2 DNEG_t + \varphi_3 GPOS_t + \varphi_4 GNEG_t \quad \ldots (6)$$

In Model B, the effects of positive changes in the discount rate and the gold price were respectively measured by η_1 and η_3 in the conditional mean equation, and by φ_1 and φ_3 in the volatility equation. Similarly, the effects of negative changes in the discount rate and the gold price were respectively measured by η_2 and η_4 in the mean equation, and by φ_2 and φ_4 in the volatility equation. Note that, since they measured the effects of negative changes in the exogenous variables, the signs for the estimated values of η_2, η_4, φ_2 and φ_4 had to be reserved for usual interpretation. This study was particularly interested in testing the following null hypotheses as well as their natural alternatives:

H_{0A}: There were no exogenous variable effects whatsoever (i.e., $\eta_i = \varphi_j = 0$ for all $i = 1, \ldots, 4$ and $j = 1, \ldots, 4$);

H_{0B}: There were no DDRATE asymmetric effects on mean returns (i.e., $\eta_1 = \eta_2$);

H_{0C}: There were no DGPRICE asymmetric effects on mean returns (i.e., $\eta_3 = \eta_4$);

$H_{0D:}$ There were no DDRATE asymmetric effects on return volatilities (i.e., $\varphi_1 = \varphi_2$); and

$H_{0E:}$ There were no DGPRICE asymmetric effects on return volatilities (i.e., $\varphi_3 = \varphi_4$).

In the ensuing presentation of results, the natural alternatives to the above null hypotheses are respectively denoted H_{1A}, H_{1B}, H_{1C}, H_{1D} and H_{1E}. Apart from an examination of the signs, magnitudes and significance of the relevant individual coefficients, Wald tests for possible equality between the coefficients of DPOS and DNEG were conducted where this could be suspected. Similar equality tests were conducted for the GPOS and GNEG coefficients.

3.3 Estimation and diagnostic checking

In keeping with common practice, the above models were estimated using the maximum likelihood (ML) technique, employing the Marquardt algorithm within the EViews 5.0 package to improve the convergence rate of the iterative procedures. Throughout, robust standard errors and *z*-statistics were obtained as proposed by Bollerslev and Wooldridge (1992).

As a final check during the exploratory data analysis, the BDS test due to Brock *et al.* (1987) was applied on the standardised residuals from the above augmented GARCH(1,1) models to investigate whether the models could account for the non-linearities in JSE returns. A bootstrapping procedure involving 1000 repetitions was used to compute probability values for the test statistics, in EViews 5.0. Values for the embedding dimension (m) and the measure of closeness (l) were set at $m = 2,3,4$ and $l = 0,5\sigma, 1,0\sigma, 1,5\sigma$. The results of this investigation, which can be supplied upon request, buttressed the conclusion reached in Mangani (2008b) that the GARCH(1,1) model could account for the evident non-linearities in JSE returns.

In the ensuing discussions, only summaries of the actual regression results are provided in order to conserve space. Ardent readers may consult the author for the complete estimation results.

4. RESULTS AND DISCUSSIONS

4.1 Macroeconomic Effects on the JSE

Model A estimation results are summarised in Table 1 and Table 2. The summaries omit coefficients for the ARCH and GARCH terms, which were found to be significant in virtually all cases, providing unequivocal evidence of the prevalence of volatility. Therefore, this analysis progresses by focusing on the estimated coefficients for DDRATE and DGPRICE, based on the hypotheses presented in subsection 3.2.

Table 1 shows that the dynamics revealed by using ALSI and PORT, reported in Mangani (2008a), might not be fully reflective of the individual stock return dynamics. Firstly, neither DDRATE nor DGPRICE had any form of influence on seven of the forty-two stocks. Four of the stocks thus not influenced were in the industrial sector (i.e., AVI, NPK, OCE, PPC), two were in the financial sector and one (i.e., PAM) in resources. The fact that the macroeconomic variables influenced either the dynamics of mean returns and/or return volatilities for over eighty percent of the stocks rendered support for their usefulness in modelling JSE stock returns. It was further noted that in twelve stocks, DDRATE and/or DGPRICE influenced both the mean returns and the volatilities of such returns. On the other hand, the variables influenced return volatilities alone (but not mean returns) in twelve stocks, and mean returns alone (but not return volatility) in eleven stocks. These findings were in sharp contrast with those obtained when ALSI and PORT were used, where the macroeconomic variables solely impacted on expected returns. Evidently, aggregation into portfolios tended to misrepresent individual stock return dynamics, and could ill-guide investment decision-making.

Table 1: Hypothesis tests for exogenous factors in Model A

Unrejected Hypothesis	Stocks	No. of Stocks
H_0	AVI, NED, NPK, OCE, PAM, PPC, REM	7
H_1	All but those in H_0	35
H_2	AGL, ANG, BVT, GMF, HAR, IMP, JCM, MLB, PIK, TBS, TRE, WLO	12
H_3	AFE, ALT, BAW, DUR, ECO, HLH, HVL, LGL, RLO, SBK, TNT, WAR	12
H_4	AFX, ASR, CHE, CTP, DEL, ELH, FOS, JNC, MAF, SAB, SAP	11

Note: Hypotheses H_0 through H_4 are described in subsection 3.2. The second and third columns and show the stocks and numbers of stocks for which the corresponding hypotheses could not be rejected at 10% significance level, respectively.

Table 2 presents a further analysis of the estimation results for Model A. Based on the estimated values of the α_i coefficients, the inverse relationship between interest rates and asset prices could be upheld in thirty-six cases, although only sixteen of these showed that this relationship was statistically significant. In none of the remaining six stocks that showed a positive association was this association significant at all. Conversely, no clear pattern emerged regarding the impact of a change in the gold price on expected returns: there were just slightly more (significantly) positive coefficients than (significantly) negative ones. In total, the DGPRICE coefficient was significant in fifteen cases in the mean equation. All resources stocks for which the DGPRICE coefficient was significant, a total of six, showed that the association was positive. Logically, therefore, an increase in the price of gold tended to increase returns for resources stocks. For the industrial sector, the reaction tended to vary, being positive in three stocks and negative in five. Only one financial stock (i.e., SBK) showed a reaction to DGPRICE changes in the mean equation, and this reaction was necessarily negative. These findings could reflect substitution effects among the sectors: as mining sector returns increased, investors tended to re-allocate their wealth in favour of resources stocks, leading to a reduction in returns on some stocks from non-resources sectors and, potentially, to further increases in returns on resources stocks.

In terms of Equation (3), it was apparent that DGPRICE had a relatively higher impact on return volatilities than DDRATE, and that gold price increases were largely volatility-increasing rather than dampening. The ϕ_2 coefficient was positive in twenty-seven stocks, and significantly so in twelve of them. Most of the significant impact of DGPRICE on volatilities was on industrial stocks but yielded mixed reactions, once again. It was noted that ten of the twelve stocks that yielded significantly positive values for ϕ_2 belonged to the industrial sector, but an additional five stocks from this sector showed a negative association. On the other hand, DDRATE generally showed a (rather weak) dampening effect on volatilities, being negative in twenty-nine stocks, but significantly so in only seven of them. Of the remaining thirteen stocks for which this coefficient was positive, statistical significance could be confirmed in six. Apart from the observation that volatilities were significantly influenced by discount rate changes in most resources stocks (in terms of the sample, the thirteen significant coefficients for DDRATE constituted 56 percent of the resources stocks, 21 percent of the industrial stocks and 20 percent of the financial stocks), there were no other striking patterns associated with the estimated values for ϕ_1.

Table 2: Estimation results for Model A

C	Row	Value of C	Stocks	No.
	#1	Positive	ASR, AVI, FOS, JCM, NED, TRE	6
	#2	Significantly positive	None	0
α_1	#3	Negative	All stocks but those in Row #1	36
	#4	Significantly negative	AFE, AGL, ALT, ANG, BAW, ECO, GMF, HLH, HVL, IMP, LGL, MLB, RLO, TNT, WAR, WLO	16
	#5	Not significant	All stocks but those in Row #4	26
	#6	Positive	AGL, ANG, ASR, DEL, DUR, ECO, FOS, GMF, HAR, HVL, IMP, JCM, NED, PAM, REM, SAP, TNT, TRE, WAR	19
	#7	Significantly positive	AGL, ANG, DUR, GMF, HAR, HVL, IMP, JCM, TRE	9
α_2	#8	Negative	All stocks but those in Row #6	23
	#9	Significantly negative	BVT, HLH, PIK, SBK, TBS, WLO	6
	#10	Not significant	All stocks but those in Row #7 and Row #9	27
	#11	Positive	ANG, BVT, CHE, DEL, ECO, ELH, IMP, JNC, MAF, NPK, TBS, TRE, WAR	13
ϕ_1	#12	Significantly positive	ANG, BVT, IMP, JNC, MAF, TRE	6
	#13	Negative	All stocks but those in Row #11	29
	#14	Significantly negative	ASR, GMF, HAR, JCM, MLB, SAP, WLO	7
	#15	Not significant	All stocks but those in Row #12 and Row #14	29
	#16	Positive	All stocks but those in Row #18	27
	#17	Significantly positive	AFX, AGL, CTP, DEL, ELH, FOS, JCM, MAF, PIK, SAB, TBS, TRE	12
ϕ_2	#18	Negative	AFE, ALT, AVI, BVT, CHE, HAR, IMP, JNC, LGL, MLB, OCE, PPC, SBK, WAR, WLO	15
	#19	Significantly negative	BVT, CHE, IMP, JNC, MLB, WLO	6
	#20	Not significant	All stocks but those in Row #17 and Row #19	24

Note: C in the first column is the estimated coefficient, and could take any of the values indicated in the third column. For each such value, the stocks and numbers of stocks in the sample whose estimated value for C corresponded with that indicated in the third column are given in the forth and fifth columns, respectively. Statistical significance was evaluated at 10%.

4.2 Asymmetric Macroeconomic Effects on the JSE

This analysis continues to ignore the coefficients for the ARCH and GARCH terms, for reasons already stated. Table 3 shows that the DDRATE and DGPRICE decompositions were significant in thirty-three and twenty-nine mean equations respectively, as opposed to no more than sixteen for each of the variables when introduced as in Model A. In addition, the DDRATE and DGPRICE decompositions were significant in twenty-one and thirty-five volatility equations respectively (see Table 4), as opposed to thirteen and eighteen in Model A. These findings could reflect the fact that the decomposed variables captured more specific dynamics than the non-decomposed variables.

To focus closely on the significance of the decomposed variables as summarised in Table 3, it was noted that DPOS dominated in explaining changes in expected returns, yielding the hypothesised inverse relationship in forty stocks. Moreover, twenty-five of the DPOS coefficients in the mean equations were significant. The coefficients for DNEG, which generally also showed a negative association with expected returns, were significant in eight stocks only. Respecting the DDRATE decomposition, therefore, the mean equation asymmetric effects were quite unambiguous. This matter will be addressed later.

The blurry influences of DGPRICE on expected returns still surfaced when the multiplicative dummy variables were used, in that only slightly more coefficients were positive rather than negative. Hence, evidence of any asymmetric effects of DGPRICE on expected returns was less apparent, at least at this stage.

In terms of estimation results for Equation (6), Table 4 reveals that the DGPRICE decomposition seemed more influential than that of DDRATE: while DPOS and DNEG significantly impacted on the volatilities of only eight and thirteen stocks respectively, GNEG alone was influential in the volatility dynamics of twenty-three stocks. GPOS also contributed to the volatility dynamics of twelve stocks. The fact that most of the significant values of GNEG were positive showed that a negative change in the gold price was considered as “bad news”, and tended to increase volatility. However, volatility-dampening effects also seemed to emanate from this variable (five stocks) as well as GPOS (nine stocks). Additional dampening effects could be traced to DPOS (eight stocks) and DNEG (eleven stocks).

Table 3: Equation (4) estimation results

C	Row	Value of C	Stocks	No.
	#1	Positive	CTP, JCM	2
	#2	Significantly positive	None	0
η_1	#3	Negative	All stocks but those in Row #1	40
	#4	Significantly negative	AFE, AGL, ALT, ANG, ASR, AVI, BAW, CHE, ECO, ELH, GMF, HLH, JNC, LGL, MLB, NPK, PIK, PPC, RLO, SAB, SBK, TBS, TNT, WAR, WLO	25
	#5	Not significant	All stocks but those in Row #4	17
	#6	Positive	ASR, AVI, BVT, CHE, ELH, FOS, JCM, JNC, LGL, NED, NPK, SAB, SBK, TBS, TRE	15
η_2	#7	Significantly positive	ASR, FOS, JCM, JNC, TRE	5
	#8	Negative	All stocks but those in Row #6	27
	#9	Significantly negative	ANG, IMP, MAF	3
	#10	Not significant	All stocks but those in Row #7 and Row #9	34
	#11	Positive	All stocks but those in Row #13	23
	#12	Significantly positive	AGL, ANG, ASR, BAW, CHE, DUR, HAR, IMP, REM, SAP	10
η_3	#13	Negative	AFX, ALT, BVT, CTP, DEL, ELH, FOS, HLH, JNC, MAF, NED, NPK, OCE, PIK, PPC, RLO, SBK, TBS, WLO	19
	#14	Significantly negative	AFX, BVT, FOS, HLH, PIK, RLO, SBK, TBS, WLO	9
	#15	Not significant	All stock but those in Row #12 and Row #14	23
	#16	Positive	All stocks but those in Row #18	24
	#17	Significantly positive	ANG, CTP, DEL, DUR, FOS, HAR, RLO	7
η_4	#18	Negative	ALT, ASR, AVI, BAW, BVT, CHE, HLH, JNC, LGL, MAF, MLB, NPK, PAM, PIK, REM, SAP, SBK, WAR	18
	#19	Significantly negative	MLB, PIK, SBK	3
	#20	Not significant	All stocks but those in Row #17 and Row #19	32

Note: Entries are as defined in Table 2.

Table 4: Equation (6) estimation results

C	Row	Value of C	Stocks	No.
	#1	Positive	AFX, ALT, ANG, AVI, BVT, CHE, DEL, ELH, FOS, HLH, NED, NPK, 0CE, PAM, PPC, REM, RLO, SAB, SBK, TBS, WAR	21
φ_1	#2	Significantly positive	None	0
	#3	Negative	All stocks but those in Row #1	21
	#4	Significantly negative	AFE, CTP, DUR, HAR, JCM, LGL, MLB, WLO	8
	#5	Not significant	All stocks but those in Row #4	34
	#6	Positive	AGL, ANG, BVT, CHE, DUR, JCM, JNC, MAF, MLB, SAP, TBS, TRE, WAR	13
φ_2	#7	Significantly positive	JNC, MAF	2
	#8	Negative	All stocks but those in Row #6	29
	#9	Significantly negative	AFE, AFX, ALT, BAW, OCE, PIK, PPC, RLO, SBK, TNT, WLO	11
	#10	Not significant	All stocks but those in Row #7 and Row #9	29
	#11	Positive	AFX, AGL, BAW, CTP, DEL, DUR, ELH, FOS, GMF, IMP, JCM, NED, PAM, PIK, PPC, SAB, SAP, SBK, TBS, TNT, TRE	21
φ_3	#12	Significantly positive	DEL, PPC, SAB	3
	#13	Negative	All stocks but those in Row #11	21
	#14	Significantly negative	AFE, BVT, CHE, HLH, LGL, MLB, OCE, WAR, WLO	9
	#15	Not significant	All stocks but those in Row #12 and Row #14	30
	#16	Positive	All stocks but those in Row #18	28
	#17	Significantly positive	AFE, AFX, AGL, ANG, AVI, BAW, CTP, ECO, FOS, JCM, JNC, MAF, NPK, PIK, PPC, REM, TBS, WLO	18
φ_4	#18	Negative	ALT, BVT, CHE, DEL, ELH, IMP, NED, OCE, PAM, PPC, SAB, SBK, WAR, WLO	14
	#19	Significantly negative	DEL, NED, PPC, SBK, WLO	5
	#20	Not significant	All stocks but those in Row #17 and Row #19	19

Note: Entries are as defined in Table 2.

Table 5 further summarises the above estimation results in terms of hypotheses H_{0B} through H_{1E}. As indicated in the methodology, and in order to confirm any possible coefficient equalities suggested by a naïve inspection of the coefficients' values and *z*-statistics, Wald tests were conducted where appropriate. These tests were also conducted to establish whether positive and negative changes had opposite effects of equal magnitudes, if this could be suspected. From Panel I of the table, note that only three null hypotheses of coefficient equality were rejected by the Wald test, a result that is duly reflected in the last column of Panel II.

The results gave strong evidence of asymmetric effects of news on both the conditional mean returns and return volatilities, rendering JSE-based support to the assertions made by Tarhan (1993) and by Gulley and Sultan (2003). Specifically, positive and negative changes in both DDRATE and DGPRICE had no effects whatsoever on only two stocks (i.e., HVL, PAM). For the remaining forty stocks, there were varying degrees of evidence that the effects were asymmetric in the mean and/or volatility of returns. In the case of DDRATE, positive changes induced the hypothesised negative relation with expected returns, while negative changes were not that influential and generally yielded symmetric effects with positive changes whenever they had an impact. Such asymmetric effects could be detected in well over twenty stocks. In the case of stock JNC, asymmetric effects occurred due to the fact that the coefficient for DPOS was negative while that for DNEG was positive, but the hypothesis of equality of the impacts in absolute value terms could not be rejected (see Panel I of Table 5). In general, therefore, JSE investors were, rather rationally, concerned with discount rate increases but not decreases in seeking compensation for interest rate risk. This implies that stock market returns could be sticky during periods of expansionary monetary policy, but responsive to contractionary policy.

Less unequivocal results than the foregoing were obtained with respect to the DGPRICE decomposition in the mean equation. While some significant asymmetric effects emanated from GPOS and GNEG, the dominance of one over the other was not as plain as was the case of DPOS versus DNEG. Specifically, of the seventeen total asymmetric effects recorded for these variables, nine occurred due to the significance of GPOS when GNEG was not significant, and eight due to the converse. The conclusion regarding the impact of DGPRICE on expected returns, even after the decomposition, remained that it varied depending on the particular stocks being investigated. As already stated, the evidence suggested some substitution effects across sectors in the investment decision-making process.

The effects of the decomposed exogenous variables on return volatilities showed even stronger evidence of significant asymmetries than those documented for the mean equations. In fact, the decompositions of both macroeconomic variables showed asymmetric effects in virtually all cases where their impacts were significant. Of the eighteen cases in which DPOS and DNEG showed asymmetric effects on volatilities, five were on account of the significance of DPOS while eleven were on account of the significance of DNEG. Moreover, although symmetric effects could be suspected for stocks AFE and WLO, the hypothesis was rejected in the Wald tests, implying that the impacts of DNEG were greater in absolute terms than those of DPOS for both cases. It would continue to appear that DNEG, which was unimportant in describing conditional mean returns, was relatively more important that DPOS in describing return volatilities.

The dominance of DGPRICE in accounting for return volatility dynamics continued to show in the hypothesis of asymmetric effects. Of the twenty-eight asymmetric effects recorded for the decomposition of this variable, eighteen were on account of the statistical significance of GNEG, and seven on that of GPOS. Further, Wald tests rejected coefficient equalities for stock WLO, suggesting that the absolute impacts of GNEG on the volatilities of these stocks were greater than those of GPOS. Note also that the tests could not reject the hypothesis of opposing impacts of equal magnitudes in AFE and DEL. In a nutshell, it would appear unmistakable to conclude that GNEG was a more important variable in describing JSE return volatilities than GPOS.

Table 5: Hypothesis tests for exogenous factors in Model B

I. Wald tests

Stock	Null Hypothesis	χ^2	(p-value)
AFE	$\varphi_1 = \varphi_2$	3,507	(0,063)*
	$\varphi_3 = -\varphi_4$	0,109	(0,547)
ANG	$\eta_1 = \eta_2$	0,068	(0,800)
	$\eta_3 = \eta_4$	0,004	(0,948)
DEL	$\varphi_3 = -\varphi_4$	0,013	(0,901)
DUR	$\eta_3 = \eta_4$	0,063	(0,782)
JNC	$\eta_1 = -\eta_2$	0,296	(0,586)
PIK	$\eta_3 = \eta_4$	0,002	(0,967)
WLO	$\varphi_1 = \varphi_2$	9,098	(0,003)*
	$\varphi_3 = \varphi_4$	3,324	(0,068)*

II. Overall test results

Unrejected Hypothesis	*z*-Test		*z*-Test and Wald test	
	Stocks	No.	Stocks	No.
H_{0A}	HVL, PAM	2	All stocks selected using the *z*-test	2
H_{1B}	AFE, AGL, ALT, ASR, AVI, BAW, CHE, FOS, IMP, JCM, JNC, LGL, MAF, MLB, NPK, PIK, PPC, RLO, SAB, SBK, TBS, TNT, TRE, WAR, WLO	25	All stocks selected using the *z*-test	25
H_{1C}	AFX, AGL, ASR, BAW, BVT, CHE, CTP, DEL, FOS, HLH, IMP, MLB, RLO, SAP, TBS, WAR, WLO	17	All stocks selected using the *z*-test	17
H_{1D}	AFX, ALT, BAW, CTP, DUR, HAR, JCM, JNC, LGL, MAF, MLB, OCE, PIK, PPC, RLO, TNT	16	All stocks selected using the *z*-test, as well as AFE, WLO	18
H_{1E}	AFX, AGL, ANG, AVI, BAW, BVT, CHE, CTP, DEL, ECO, FOS, HLH, JCM, JNC, LGL, MAF, MLB, NED, NPK, OCE, PIK, PPC, REM, SAB, SBK, TBS, WAR	27	All stocks selected using the *z*-test, as well as WLO	28

Note: In Panel I, *implies statistical significance at 10% or lower. Panel II shows the stocks and numbers of stocks for which the corresponding hypotheses could not be rejected at 10%. Hypotheses H_{0A} through H_{1E} are described in subsection 3.2.

5. SUMMARY AND CONCLUSION

This paper extended the portfolio-based investigation of the impacts of the discount rate and the gold price on the JSE by analysing the reactions of forty-two individual stocks within an augmented GARCH(1,1) model. Weekly data from 1983 to 2007, a period that captures the implementation of the classical cash reserve and repurchase agreement systems of South African monetary policy, were used in the study. Diagnostic tests showed that the ARCH and GARCH terms in the model remained significant after the inclusion of the two exogenous factors, and the model could account for stochastic non-linearities in JSE returns.

Apart from investigating the effects of the two macroeconomic variables on conditional mean returns and return volatilities *per se*, the study also investigated the possibility that news about the variables had asymmetric effects on the JSE. This was accomplished by decomposing each of the variables into multiplicative categorical variables reflective of positive and negative changes. The following observations and conclusions could be made from the analysis, and in relation to the prior portfolio-based investigation:

Firstly, when the non-decomposed variables were used, the dynamics of stock portfolios did not appear to reflect those of individual stocks. Specifically, while the two macroeconomic variables only impacted on conditional mean returns of the portfolios, they impacted on mean returns and/or return volatilities in a good proportion of the individual stocks. This revealed that an analysis solely based on market aggregates could potentially mislead investors. This result was, however, challenged when the variables were decomposed, in which case both portfolio mean returns and return volatilities tended to be affected.

Secondly, the model with non-decomposed variables showed that the variables jointly impacted on expected returns and return volatilities in only a few individual stocks. However, where the discount rate was an important determinant of expected returns, the evidence showed that the hypothesised inverse relationship between interest rates and stock prices prevailed: contractionary monetary policy could lower stock returns. In addition, changes in the gold price also exhibited some effects on expected returns, and there was evidence of substitution effects: increased expected returns from mining sector investments resulting from gold price increases were associated with lower non-mining sector expected returns, possibly as investors traded non-resources for resources stocks. In terms of the effects of the non-decomposed variables on volatilities, the gold price was a more important determinant than the discount rate. A gold price increase had a largely volatility-increasing effect, particularly for resources stocks. However, some volatility-dampening effects of gold price increases were noted in a few non-resources stocks. In the few instances where the discount rate also impacted on volatilities, the relation was generally inverse.

The third observation was that the effects of the exogenous variables became more significant when the variables were decomposed to capture the possibility of asymmetric effects. Moreover, the hypothesised inverse relationship between interest rates and stock prices was strengthened in this decomposition, as was the observation of possible substitution effects between mining and non-mining investments. It would appear that such decomposition could significantly improve the predictability of JSE return dynamics.

Lastly, and more importantly, the evidence indicated that the effects of the two exogenous variables were strongly asymmetric. To be specific, positive discount rate changes inversely impacted on expected returns, while negative changes were largely inconsequential on expected returns. Thus, JSE investors were, rather rationally, more concerned with discount rate increases than decreases. On the other hand, negative discount rate changes had stronger volatility-dampening effects than positive changes, implying that market participants correctly perceived interest rate decreases as “good news”. Further, while both positive and negative gold price changes impacted on expected returns, the effects varied depending on the stock, but remained asymmetric. These results tended to bolster the evidence of substitution effects among the sectors. In addition, while both positive and negative changes in the gold price were also influential in describing stock return volatilities, most of the influences tended to emanate from negative changes and hand volatility-increasing effects. This implied that gold price decreases were considered to be “bad news” by market participants. The effects of the gold price decomposition on volatilities were generally stronger than those of the discount rate decomposition.

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Appendix 1 – Stocks in the study sample

#	JSE Code	Company Name	UMC (Rm)	WMC (Rm)	% of All Share Index
1	AFE	AECI Ltd (I)	2346	2346	0,16
2	AFX	African Oxygen Ltd (I)	4558	2279	0,15
3	AGL	Anglo American Plc (R)	273677	273677	18,11
4	ALT	Allied Technologies Ltd (I)	2383	1191	0,08
5	ANG	Anglogold Ltd (R)	74176	37088	2,45
6	ASR	Assore Ltd (R)	1820	0	0
7	AVI	Anglovaal Industries Ltd (I)	4581	4581	0,3
8	BAW	Barloworld Ltd (I)	14680	14680	0,97
9	BVT	The Bidvest Group Ltd (I)	15415	15415	1,02
10	CHE*	Chemical Services Ltd (I)	1427	571	0,04
11	CTP*	CTP Holdings Ltd (I)	1930	579	0,04
12	DEL	Delta Electrical Industries Ltd (I)	2409	2409	0,16
13	DUR*	Durban Roodepoort Deep Ltd (R)	9724	9724	0,64
14	ECO	Edgers Consolidated Stores Ltd (I)	2039	2039	0,13
15	ELH*	Ellerine Holdings Ltd (I)	1255	1255	0,08
16	FOS	Foschini Ltd (I)	2073	1555	0,1
17	GMF*	Gencor Ltd (R)	16802	0	
18	HAR	Harmony Gold Mining Co Ltd (R)	28572	28572	1,89
19	HLH*	Hunt Leuchars and Hepburn Holdings (I)	1824	0	0
20	HVL	Highveld Steel and Vanadium Corp (I)	1612	484	0,03
21	IMP	Impala Platinum Holdings Ltd (R)	38649	28986	1,92
22	JCM	Johncom Communications Ltd (I)	1354	0	0
23	JNC	Johnnic Holdings Ltd (I)	7309	7309	0,48
24	LGL	Liberty Group Ltd (F)	16526	8263	0,55
25	MAF	Mutual and Federal Insurance Co (F)	4432	0	0
26	MLB*	Malbak Ltd (I)	2333	1166	0,08
27	NED*	Nedcor Ltd (F)	32370	16185	1,07
28	NPK	Nampak Ltd (I)	7405	7405	0,49
29	OCE	Oceana Group Ltd (I)	1536	614	0,04
30	PAM	Palabora Mining Company Ltd (R)	1699	680	0,04
31	PIK	Pik n Pay Stores Ltd (I)	6736	3368	0,22
32	PPC	Pretoria Portland Cement Co Ltd (I)	3918	1567	0,1
33	REM	Remgro Ltd (F)	34541	34541	2,29
34	RLO	Reunert Ltd (I)	3999	3999	0,26
35	SAB	South African Breweries plc (I)	71864	71864	4,76
36	SAP	Sappi Ltd (I)	34068	34068	2,25
37	SBK	Standard Bank Group Ltd (F)	47001	47001	3,11
38	TBS	Tiger Brands Ltd (I)	12058	12058	0,8
39	TNT	The Tongaat-Hulett Group Ltd (I)	4789	2394	0,16
40	TRE	Trencor Ltd (I)	1383	0	0
41	WAR*	Western Areas Ltd (R)	4315	3236.25	0,21
42	WLO	Wooltru Ltd (I)	1792	1792	0,12
		Sample	803380	684941	45,30

Note: Letters in parentheses indicate the company sector: F for financial; I for industrial and R for resources. UMC is the market capitalisation before application of the investibility weighting, while the WMC is the market capitalisation after this application. UMC and WMC are in million rand. Data are as at July 2002. Close price data on the 9 stocks marked * were available from 16 December 1983 to 5 April 2002. For the remaining 33 stocks, the data used extended to 25 May 2007.
(Source: Adapted from Profile Media, 2002).