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Dynamic Effects of Inflation and Interest Rate Risks on Stock Market Returns in Ghana: Exploring non-linearities

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Abstract
This study examines the dynamic impact of inflation and interest rate volatilities on stock market returns in Ghana. In both the constructed base linear and extended non-linear models, market returns have negatively autoregressive in the short-run. Also, interest rate risk has a slight direct effect in the base linear model in the same time period. However, at equilibrium for the said model, both risks influence returns. For the non-linear model, only interest rate volatility and the interaction between the two risks affect market returns in the long run. Possibly, market inefficiency inhibits explanatory power of the non-linear model.
Keywords: error correction analysis, inflation volatility, interest rate risk, stock market returns
JEL classification: C32, C57, E43, G32.

1. Introduction

Ghana Stock Exchange (GSE) has, on average, earned returns far in excess of those of advanced and emerging economies since the year 2000 (Ghana Stock Exchange, 2015). Within the same time period, inflation and interest rates in the country have also remained relatively higher. However, there is a research gap on whether and how inflation and interest rate volatilities affect stock market returns in Ghana. Furthermore, as the GSE is relatively inefficient and illiquid, it would be a misnomer to assume it would be as efficient as developed or emerging stock markets (Tei Mensah, Adom & Pomaa-Berko, 2014).

This study makes original innovative contributions to understanding how inflation and interest volatilities affect stock market returns in Ghana. Firstly, it develops two theoretical models, where the second incorporates non-linear and interaction elements. Additionally, cointegration as well as error correction (ECM) methodologies are applied to both models for further short- and long-run analysis. The literature review, the second chapter, critically appraises relevant past research. Chapter three describes the data, underlying models and empirical methodology. The ensuing section presents and discusses the results, while the final chapter concludes.

2. Literature review

Sharpe (1964) developed the capital asset pricing model (CAPM), linking security returns to risk. This initial theory, despite its vital contribution, had some restrictive limitations. Consequently, Ross (1976) developed the arbitrage pricing theory (APT). The latter highlights multifactor models to accommodate two or more independent variables. Each of these theories stressed that increased risk raises expected asset returns.

The Efficient Market Hypothesis (EMH), also, holds that properly working financial systems adjust instantaneously to new information (Alagidede & Panagiotidis, 2009; Fama, 1970). The degree of such efficiency determines how risks influence asset prices by varying the present value of cash flows of the underlying resources (Bernanke & Kuttner, 2004). Two of such risks are inflation and interest rate volatilities. These can have deleterious effects on stock market returns (Osei, 2006; Spyrou, 2001).

Empirically, most research find a positive relation between the mentioned risks and stock returns (Arango, Gonzalez & Posada, 2002; Casola & Morana, 2004; Chang & Chiang, 1999; Humpe and Macmillan, 2014). This is especially true when market returns are most sensitive to such risks. Studies on developing markets, especially African countries, find a mixed result. Generally, they find a positive relation, while in one or two economies, such volatilities do not seem to filter through to market returns in a similar manner as in advanced economies (Frimpong, 2009; Loui & Maio, 2014; Spyrou, 2001).

3. Analytical model, data and methodology

The empirical analysis herein uses monthly time series from Bank of Ghana (Bank of Ghana, 2015). It covers the time period: January 2000 to July 2016. The relevant interest rate used is the monetary policy rate (MPR) determined by the afore-mentioned central bank. The latter is the rate at which the central bank lends wholesale to retail banks. The considered risk indicators are standard deviations of: inflation and monetary policy rate.

The first set of related studies use a cross-section or panel econometric approach, such as: Cassola & Morana (2004); Chang & Chiang (1999); Humpe & Macmillan (2014); Jensen, Mercer & Johnson (1996); Loui & Maio (2014) and Prasad & Rajan (1995). These mostly consider different economies. They examine whether there is a homogeneous relation between inflation and interest rate risks, on the one hand, and market returns, on the other, for different countries. The second group of associated studies use time-series methodologies, including: Alagidede and Panagiotidis (2009); Arango *et al.,* (2002); Bernanke & Kuttner (2005); Domain *et al.* (1996), Frimpong (2009), Longstaff & Schwartz (1992); Osei (2006); Sweeney & Warga (1986). These mostly use variations of autoregressive econometric regressions. This study uses a cointegration methodology, similar to Frimpong (2009).

The analytical model underpinning this study's empirical analysis borrows some APT and CAPM elements at the initial stages but departs significantly later on, especially when developing its non-linear specification. *A priori*, let β_t^i denote sensitivity of stock *i* to existing market risk, while r_t^m represents market return at time *t*. Then, the CAPM asserts that, r_t^i , return of stock *i* at time *t* is a function of the corresponding risk-free rate, r^f , and its market risk, $\beta_t^i *(r_t^m - r^f)$. According to Sharpe (1964), it is depicted in equation (1):

$$r_t^i = r_t^f + \beta_t^i \; (r_t^m - r^f) \tag{1}$$

Assume, also, that $\beta_t^m = \sum_{i=1}^{n} w_i \beta_t^i$, where β_t^m is the market beta and $\sum_{i=1}^{n} w_i \beta_t^i$ is a weighted average of all β_t^i . If $\sum_{i=1}^{n} w_i r_t^i$ is similarly defined for r_t^i , then, $r_t^m = \sum_{i=1}^{n} w_i r_t^i$. The CAPM for a stock market may be restated as:

$$r_t^m = r_t^f + \sum_{i=1}^{n} w_i \beta_t^i \, (\sum_{i=1}^{n} w_i r_t^i - r^f) \qquad \forall \; i = 1, \ldots, n \tag{2}$$

The APT, on the other hand, accepts other factors as critical determinants of stock returns. Equation (3) illustrates a two-factor APT model, where $\alpha_t = r^f$, a constant, and x_t^1 and x_t^2 are observations of the two independent variables with their respective coefficients: β_t^1 and β_t^2 . The residual error term is denoted as ε_t in equation (3):

$$r_t^m = \alpha_t + \beta_t^1 \, x_t^1 + \beta_t^2 \, x_t^2 + \varepsilon_t \tag{3}$$

Departing from equations (1) - (3), presume further that σ_{t-1} is the risk or volatility of the considered stock market one time period ago, then $r_{m,t}^{\pi}$, the excess market return at time *t*, may alternatively be modeled as:

$$r_{m,t}^{\pi} = r_t^f + (\sum_{i=1}^{n} w_i \; r_{t-1} - r^f) + \sigma_{t-1} \qquad \forall \; i = 1, \ldots, n \tag{4}$$

Subtracting r^f from both sides of equation (4) results in:

$$r_{m,t}^{\pi} - r^f = (\sum_{i=1}^{n} w_i \; r_{t-1} - r^f) + \sigma_{t-1} \tag{5}$$

According to modern portfolio theory, $\underset{\longrightarrow}{\lim} (\sum_{i=1}^{n} w_i \; r_{t-1} - r^f) = 0$ as $n \rightarrow \infty$ (Fama, 1970; Ross, 1976; Sharpe, 1964). Subjecting equation (5) to a difference operation yields:

$$\Delta \, \hat{r}_{m,t}^{\pi} = \Delta \, \hat{\sigma}_{t-1} \tag{6}$$

Equation (6) states that changes in excess market returns are due to variations in extant market risks. If $\hat{\sigma}_{t-1}^j$ and $\hat{\sigma}_{t-1}^k$ represent inflation and interest volatilities respectively, then:

$$\Delta \, \hat{r}_{m,t}^{\pi} = \Delta [\hat{\sigma}_{t-1}^j + \hat{\sigma}_{t-1}^k] \tag{7}$$

Equation (7) is the base model. However, in line with the findings and suggestions of Ellis (1994) and Sorin, Pascu & Morariu (2008), equation (7) is extended to model interactions between considered variables:

$$\Delta \, \hat{r}_{m,t}^{\pi} = \Delta [\hat{\sigma}_{t-1}^j + \hat{\sigma}_{t-1}^k + (\hat{\sigma}_{t-1}^j * \hat{\sigma}_{t-1}^k) + (\hat{\sigma}_{t-1}^j * \hat{r}_{m,t}^{\pi}) + (\hat{\sigma}_{t-1}^k * \hat{r}_{m,t}^{\pi})] \tag{8}$$

where $(\hat{\sigma}_{t-1}^j * \hat{\sigma}_{t-1}^k)$ is the interaction term between inflation and interest rate risks. $(\hat{\sigma}_{t-1}^j * \hat{r}_{m,t}^{\pi})$ and $(\hat{\sigma}_{t-1}^k *$

$\hat{r}^{\pi}_{m,t}$) are interactions between inflation volatility and market returns as well as interest rate risk and market returns respectively. Alagidede & Panagiotidis (2009), Arango, Gonzalez & Posada (2002); Chang & Chiang (1999) and Humpe & Macmillan (2014) also stress that the considered variables are aptly modeled in non-linear form. This study adapts elements of the non-linear models of Ellis (1994) and Sorin *et al.* (2008). If (1 - e^{a}) $\forall$ $a = \{\hat{r}^{\pi}_{m,t}, \hat{\sigma}^{j}_{t-1}, \hat{\sigma}^{k}_{t-1}\}$, then:

$$\Delta\, \hat{r}^{\pi}_{m,t} = \Delta\,[(1 - e^{\hat{r}_{t-1}}) + \hat{\sigma}^{j}_{t-1} + (1 - e^{\hat{\sigma}^{j}_{t-1}}) + \hat{\sigma}^{k}_{t-1} + (1 - e^{\hat{\sigma}^{k}_{t-1}}) + (\hat{\sigma}^{j}_{t-1} * \hat{\sigma}^{k}_{t-1}) + (\hat{\sigma}^{j}_{t-1} * \hat{r}^{\pi}_{m,t}) + (\hat{\sigma}^{k}_{t-1} * \hat{r}^{\pi}_{m,t})] \tag{9}$$

Equation (9) is the extended non-linear model. Both models assert that abnormal market returns are a function of risk. The empirical analysis tests both models to better understand the dynamic effects of the considered variables using cointegration and error correction model (ECM) methodologies. The latter analytical approach examines short-run effects, while the former explores long-term relations. The ECM base and non-linear regression models are posited in equations (10) and (11) respectively:

$$\Delta\, \hat{r}^{\pi}_{m,t} = \hat{\beta}_{1,r}\,\Delta\, \hat{r}^{\pi}_{m,t} + \hat{\beta}_{j}\,\Delta\,\hat{\sigma}^{j}_{t-1} + \hat{\beta}_{k}\,\Delta\,\hat{\sigma}^{k}_{t-1} + \alpha\ ECT + \varepsilon_{t} \tag{10}$$

$$\Delta\, \hat{r}^{\pi}_{m,t} = \hat{\beta}_{1,r}\,\Delta\, \hat{r}^{\pi}_{m,t} + \hat{\beta}_{2,r}\,\Delta(1 - e^{\hat{r}_{t-1}}) + \hat{\beta}_{1,j}\,\Delta\,\hat{\sigma}^{j}_{t-1} + \hat{\beta}_{2,j}\,\Delta\,(1 - e^{\hat{\sigma}^{j}_{t-1}}) + \hat{\beta}_{1,k}\,\Delta\,\hat{\sigma}^{k}_{t-1} + \hat{\beta}_{2,k}\,(1 - e^{\hat{\sigma}^{k}_{t-1}}) + \hat{\beta}_{jk}\,\Delta\,(\hat{\sigma}^{j}_{t-1} * \hat{\sigma}^{k}_{t-1}) + \hat{\beta}_{j,r}\,(\hat{\sigma}^{j}_{t-1} * \hat{r}^{\pi}_{m,t}) + \hat{\beta}_{k,r}\,(\hat{\sigma}^{k}_{t-1} * \hat{r}^{\pi}_{m,t}) + \alpha\ ECT + \varepsilon_{t} \tag{11}$$

Equations (12) and (13) denote the base and non-linear cointegration regression models respectively:

$$\Delta\, \hat{r}^{\pi}_{m,t} = \hat{\beta}_{j}\,\Delta\,\hat{\sigma}^{j}_{t} + \hat{\beta}_{k}\,\Delta\,\hat{\sigma}^{k}_{t} + \alpha\ ECT + \varepsilon_{t} \tag{12}$$

$$\Delta\, \hat{r}^{\pi}_{m,t} = \hat{\beta}_{1,j}\,\Delta\,\hat{\sigma}^{j}_{t} + \hat{\beta}_{2,j}\,\Delta\,(1 - e^{\hat{\sigma}^{j}_{t}}) + \hat{\beta}_{1,k}\,\Delta\,\hat{\sigma}^{k}_{t} + \hat{\beta}_{2,k}\,(1 - e^{\hat{\sigma}^{k}_{t}}) + \hat{\beta}_{jk}\,\Delta\,(\hat{\sigma}^{j}_{t} * \hat{\sigma}^{k}_{t}) + \hat{\beta}_{j,r}\,(\hat{\sigma}^{j}_{t} * \hat{r}^{\pi}_{m,t}) + \hat{\beta}_{k,r}\,(\hat{\sigma}^{k}_{t} * \hat{r}^{\pi}_{m,t}) + \varepsilon_{t} \tag{13}$$

4. Analysis, results and findings

4.1 Diagnostic tests

The level data were found to be severely autocorrelated, heteroscedastic, multi-collinear, non-normal as well as a poor fit for the non-linear model. As a result, the time-series was transformed by dividing through by the dependent variable.

i. Autocorrelation test

The results of the afore-mentioned test are reported and discussed in a later section.

Table 1: Pairwise Granger-causality asymptotic tests

Variables	F-statistic (asymptotic test)	Degrees of freedom	Null hypothesis	P-value
Inflation volatility ($\hat{\sigma}_t^j$)	1.09	F (2, 194)	H_0: Stock market return does not granger cause inflation volatility	0.338
	1.759	F (2, 194)	H_0: Inflation volatility does not granger cause stock market return	0.175
Interest rate risk ($\hat{\sigma}_t^k$)	0.698	F (2, 194)	H_0: Stock market return does not granger cause interest rate risk	0.499
	3.5292	F (2, 194)	H_0: Interest rate risk does not granger cause stock market return	0.031
Inflation volatility (non-linear)	0.007	F (2, 195)	H_0: Stock market return does not granger cause inflation volatility (non-linear)	0.99
	0.019	F (2, 195)	H_0: Inflation volatility (non-linear) does not granger cause stock market return	0.98
Interest rate risk (non-linear)	0.41	F (2, 195)	H_0: Stock market return does not granger cause interest rate risk (non-linear)	0.67
	0.14	F (2, 195)	H_0: Interest rate risk (non-linear) does not granger cause stock market return	0.875
Inflation*interest rate risks	0.72	F (2, 195)	H_0: Stock market return does not granger cause inflation*interest rate risks	0.486
	0.05	F (2, 195)	H_0: Inflation*interest rate risks does not granger cause stock market return	0.95
Return*inflation volatility	1.09	F (2, 195)	H_0: Stock market return does not granger cause return*inflation volatility	0.338
	1.75	F (2, 195)	H_0: Return*inflation volatility does not granger cause stock market return	0.175
Return*interest rate risk	0.698	F (2, 195)	H_0: Stock market return does not granger cause return*interest rate risk	0.499
	3.52	F (2, 195)	H_0: Return*interest rate risk does not granger cause stock market return	0.031

ii. Causality test:

Granger causality tests are used for both models. The results of this diagnostic test are presented in table 1. Stock market returns did not granger cause any of the independent variables. However, interest rate risk granger causes stock market return but not vice versa. There is no bi-causality relation between inflation volatility and stock market returns. Interest rate risk and the interaction between inflation and interest rate volatilities influence market returns.

Table 2: Multi-collinearity tests: r-squared, tolerance factors, VIFs

Variable	VIF	VIF Square root	Tolerance factor	R-squared	Eigen-value	Condition index
Inflation volatility	1.22	1.11	0.82	0.18	1.06	1.80
Interest rate risk	1.20	1.10	0.83	0.17	0.57	2.46
Inflation volatility (non-linear)	1.24	1.12	0.80	0.20	0.95	1.47
Interest rate risk (non-linear)	1.45	1.20	0.69	0.31	0.56	1.91
Stock market return	1.12	1.06	0.90	0.11	0.33	3.22
Inflation*interest rate risks						
Return*inflation volatility	1.59	1.26	0.63	0.37	1.56	1.14
Return*interest rate risk	1.43	1.20	0.70	0.30	2.04	1.00

Concerning exogeneity, reversing the dependent and independent variables and regressing them on each other in the base model indicates that stock market returns do not explain any variations in inflation and interest volatilities as the F-statistic is insignificant (p-value: 0.15) and the adjusted r-squared is very close zero, 0.02 (Enders, 2010; Gujarati, 2009). This implies that the afore-said independent variables are weakly exogenous to returns. For the non-linear model, using the same process discussed previously, it was found that the selected variables in equation (9) are all weakly exogenous to stock market returns, except the non-linear market return variable.

iii. Multi-collinearity test:

For the multi-collinearity test, the following are computed: condition index, eigenvalue, r-squared, tolerance factors and variance inflation factors (VIFs).

The results in table 2 illustrate that as the VIFs are greater than 0.10 but less than 10, there is no multi-collinearity in the examined time-series. This is further confirmed by the condition indices, eigenvalues, r-squared and tolerance factors (Enders, 2010; Greene, 2011; Gujarati, 2009).

iv. Stationarity test:

Table 3 presents the augmented Dickey-Fuller (ADF) test for both models. The underlying null hypothesis states that examined variable is not stationary. The variables are found to be first-difference stationary.

Table 3: Augmented Dickey-Fuller tests: first-differenced variables

Variables	Number of observations	Test statistic Z(t)	1% critical value	5% critical value	McKinnon P-value of test statistic
Inflation volatility	181	-13.25	-3.482	-2.884	0.000
Interest rate risk	194	-9.139	-3.482	-2.884	0.000
Stock market return	194	-10..60	-3.482	-2.884	0.000
Inflation*interest rate risks	185	-8.00	-3.482	-2.884	0.000
Inflation risk (non-linear)	186	-9.548	-3.482	-2.884	0.000
Interest rate risk (non-linear)	186	-6.038	-3.482	-2.884	0.000
Stock market return*inflation volatility	185	-10.99	-3.482	-2.884	0.000
Stock market return*interest rate risk	185	-13.53	-3.482	-2.884	0.000

4.2 Empirical analysis

i. Short-run (ECM) analysis:

The actual ECM regressions are preceded by lag order selection tests by computing: Akaike information criterion (AIC), final prediction error (FPE), Hannan-Quinn information criterion (HQIC), Log-likelihood statistic (LL), Lagrange indicator (LR) and Schwarz-Bayesian information criterion (SBIC). The ECM lag order criteria tests, in table 4 indicate that second and first-order lag regressions are appropriate for the non-linear and base models respectively.

The base model results, in table 5, indicate that stock market returns in Ghana are negatively autoregressive in the short-run, -0.26. This may be a form of market correction mechanism or mean reversion phenomena. It, however, violates the random walk hypothesis and confirms previous research findings that the GSE is weak-form inefficient (Ayentimi *et al.,* 2013; Osei, 2002; Tei Mensah *et al.*, 2014).

Table 4: ECM lag order criteria test (base and non-linear models)

LAGS	LL	LR	df	P-value	FPE	AIC	HQIC	SBIC
				BASE MODEL				
1	-1536.6		9		19661.1	18.40	18.47	18.57
2	-1509.6	54.00*	9	0.000	15873.3*	18.19*	18.32*	18.52*
3	-1502.3	14.65	9	0.101	16196.6	18.21	18.41	18.71
				NON-LINEAR MODEL				
1	185.26	10.86*	1	0.001	0.0070*	-2.115*	-2.06*	-1.967*
2	185.78	0.18	1	0.67	0.0071	-2.104	-2.04	-1.937
3	186.54	1.52	1	0.218	0.0072	-2.102	-2.03	-1.915

NOTE: * indicates lag order selected by the criterion.

While inflation volatility has no effect, interest rate risk was found to positively impact stock market return in the short-term. Increased interest rate volatility raises risk premia and the subsequent required return. This result agrees with predictions of the APT and CAPM theories (Fama, 1970; Sharpe, 1964). The non-linear model results are insignificant.

Table 5: ECM regression results (base and non-linear models)

VARIABLES	Regression Coefficient	Standard Error	Z-STATISTIC	P-VALUE
		BASE MODEL		
Inflation volatility	-0.00	0.001	-0.02	0.984
Interest rate risk	0.04	0.02	2.07	0.039
Stock market return (lag)	-0.26	0.09	-2.88	0.004
		NON-LINEAR MODEL		
Inflation volatility	0.00	0.01	0.33	0.74
Interest rate risk	0.03	0.03	1.20	0.23
Inflation* Interest rate risk	-0.95	2.03	-0.47	0.64
Inflation volatility (non-linear)	-0.04	0.07	-0.58	0.56
Interest rate risk (non-linear)	-0.03	0.15	-0.18	0.85
Return* Inflation volatility	-0.19	2.72	-0.70	0.49
Return*Interest rate risk	-0.32	1.12	-0.29	0.78
Stock market return (lag)	-0.46	0.09	-4.90	0.00

The ECM regression diagnostics of both models are presented in table 6. They indicate that the base model relatively explains more of the variations in market returns. However, both models are correctly specified and have an appropriate functional form as the chi-square (goodness-of-fit test) has a p-value of 0.00.

Table 6. ECM regression diagnostics (base and extended models)

INDICATOR	Base Model	Non-Linear Model
Adjusted r-squared	0.38	0.33
Chi-square indicator (ECM regression goodness-of-fit)	95.18	70.82
P-value (Chi-square indicator)	0.00	0.00
Error correction term	-18.17	-1.13
P-value of error correction term	0.00	0.29
Log likelihood	-634.62	2155.70
Akaike information criterion	7.98	-23.34
Hannan-Quinn information criterion	8.23	-21.77
Schwarz-Bayesian information criterion	8.58	-19.47
Lagrange multiplier chi-square statistic (H_0 : no autocorrelation)	16.14	81.39
P-value of Lagrange multiplier	0.06	0.07
Breusch-Pagan / Cook-Weisberg heteroscedasticity test (H_0 :constant variance) - chi-square statistic	0.01	3.12
P-value of Breusch-Pagan / Cook-Weisberg chi-square statistic	0.94	0.08
Jarque-Bera skewness test (H_0 : no skewness) - chi-square statistic	2.05	2.43
P-value of Jarque-Bera skewness chi-square statistic	0.61	0.79
Jarque-Bera kurtosis test ((H_0 : no kurtosis) - chi-square statistic	1.60	1.07
P-value of Jarque-Bera kurtosis chi-square statistic	0.79	0.30
Breusch-Godfrey LM autocorrelation test: chi-square statistic (H_0 : no serial correlation)	3.02	2.18
p-value	0.08	0.14
Ramsey RESET test ((H_0 : no omitted variables)	0.66	1.40
p-value	0.58	0.25

The base model has a stable adjustment or error correction process, -18.17. This implies that 18 percent of the deviation between short-run and equilibrium or long-term returns is corrected in the current month.

However, the pace of adjustment is relatively low, less than 20 percent.

Table 7. ECM eigenvalue stability test (base model)

EIGENVALUES	MODULUS
1	1
1	1
0.029401+0.6245462i	0.625263
-0.0299401-0.6245462i	0.625263
-0.6094239	0.609424
0.6049743	0.604974
-0.5753295	0.575329
0.02430175+0.5451529i	0.545694
0.02430175-0.5451529i	0.545694
-0.2672434+0.3983293i	0.479672
-0.2672434+0.3983293i	0.479672
-0.2686394	0.268639

NOTE: The VECM specification imposes a 2 unit moduli for the base model.

Added to these, there was no evidence of autocorrelation, heteroscedasticity, omitted variables or misspecification or non-normality for the ECM regression results of both models. Further, the eigenvalue stability test results in tables 7 and 8 illustrate that for both models the regression parameters are stable.

Table 8. ECM eigenvalue stability test (non-linear model)

EIGENVALUES	MODULUS
1	1
1	1
1	1
1	1
1	1
1	1
-0.623667+0.5388415i	0.82479
-0.623667-0.5388415i	0.82479
0.1785348+0.7526309i	0.773517
0.1785348-0.7526309i	0.773517
-0.1949678+0.7283583i	0.754001
-0.1949678-0.7283583i	0.754001
0.4077024+0.6045441i	0.729174
0.4077024-0.6045441i	0.729174
0.01042449+0.7261089i	0.726184
0.01042449-0.7261089i	0.726184
-0.0069326+0.442347i	0.442401
-0.0069326-0.442347i	0.442401
-0.3610316	0.3610316
0.1469902	0.1469902

NOTE: The VECM specification imposes a 7 unit moduli for the non-linear model.

ii. Long-term (cointegration) analysis

From the Johansen cointegration test results in table 9 in the appendix, it is found that the base and non-linear models are cointegrated of the second and third orders respectively. Table 10, in the appendix, has the cointegration equilibrium results for both models. For the base model inflation has a slight negative impact on stock returns, -0.006, in the long-term. This may be due to its distortionary effects as well as dampening of aggregate demand and real sector economic activity. These economic consequences decrease cash flows and incomes of enterprises (Domain *et al.*, 1996; Spyrou, 2001). Interest rate volatility, on the other hand, continues to positively affect stock market returns in the long-run. However, the effect is reduced, 0.14, as compared to 0.26 in the short-term. This may be due to market adjustment processes (Arango *et al.,* 2002).

Table 9: Johansen cointegration test

RANK	Parsi-monious equations	5% critical value	LL	Eigenvalue	Trace statistic	Maximum eigen statistic	AIC	HQIC	SBIC
				BASE MODEL					
1	32	11.44	-634	0.16	24.17	21.02	7.98	8.23	8.58
2	35	3.84	-624	0.12	3.15*	3.15	7.89	8.16*	8.55*
3	36		-622	0.02			7.88	8.16	8.56
				NON-LINEAR MODEL					
1	17	141.20	-12430	0.76	259.28	129.61	136.79	136.91	137.09
2	32	109.99	-12365	0.50	129.66	87.10	136.24	136.47	136.80
3	45	82.49	-12322	0.38	42.56*	31.14	135.90	136.22*	136.7*

NOTES: * indicates lag order selected by the criterion. The following abbreviations denote the respective indicators

The non-linear model results illustrate that interest rate risk is still significant. Added to this, the interaction between inflation and interest rate risks has a significant inverse impact on stock market return in the long run. This model may provide more insight as it is the interaction between the two forms of volatility that significantly dampens returns, while the base model lumps such together in the inflation risk variable. Consequently, the base model variables may be unable to pick up interaction and non-linear effects.

Table 10: Cointegrated regression results – base and extended models

VARIABLE	COEFFICIENT	STANDARD ERROR	Z-STATISTIC	P-VALUE
BASE MODEL: chi-square statistic (goodness-of-fit test): 30.96, p-value: 0.00				
Inflation volatility	-0.006	0.001	-4.36	0.00
Interest rate risk	0.14	0.039	3.48	0.00
NON-LINEAR MODEL: Chi-square statistic (goodness-of-fit test): 97.54, p-value: 0.00				
Inflation volatility	-0.002	0.004	-0.56	0.577
Interest rate risk	0.18	0.5	3.54	0.00
Inflation volatility (non-linear)	0.95	0.99	0.96	0.34
Interest rate risk (non-linear)	4.97	3.71	1.34	0.18
Inflation*interest rate risks	-366.40	43.79	-8.37	0.00
Stock market return* inflation volatility	1.10	14.70	0.08	0.94
Stock market return* interest risk	40.57	29.05	1.40	0.16

The other non-linear model results insignificant. This does not imply that they are inappropriate or irrelevant. Rather, it may be a consequence of relative inefficiency of the GSE (Bansal *et al.,* 2007). Such limitations may impair ability of the stock market to be completely stochastic as it may not appropriately respond to random new information. There are instances where new information takes days or weeks to filter through to the GSE (Ghana Stock Exchange, 2015). Delayed responses, like this, inhibit random walk of the stock market (Frimpong & Oteng-Abayie, 2008; Osei, 2002; Tei Mensah *et al.*, 2014). On the other hand, interactive and non-linear models were found to aptly explain stock market returns in more advanced and emerging markets (Alagidede & Panagiotidis, 2009, Arango *et al.,* 2002; Humpe & MacMillan, 2014). This may be due to architecture of their monetary policy systems, institutions as well as financial markets (Jensen *et al.,* 1996).

5. CONCLUSION

This study examines the dynamic effect of inflation and interest rate risks on stock market returns in Ghana. The paper develops its own base linear and extended non-linear models for the stated objectives. The latter model takes into cognizance the chaotic nature of considered variables. Cointegration and ECM regressions for both models are computed to ascertain long and short-run effects respectively.

The base model was found to have greater explanatory power. In the short-run, stock market returns were negatively autoregressive, depicting inverse momentum. This may be evidence of some underlying behavioral finance conduct by market participants (Bansal *et al.,* 2007). Further, interest rate risk had a mild positive effect. At equilibrium, however, inflation volatility had a slight negative impact, while interest rate risk, on, the other hand, had a direct influence.

Results of the extended model were relatively limited, especially in the short-run. However, it confirmed that stock market returns were autoregressive. None of the other variables influenced returns in the short-run. Its error correction was also unstable. Despite this, in the long-run, interest rate volatility, similarly, affected return. Interaction between inflation and interest rate risks had a more significant effect. Limitations of the GSE itself may explain the limited results of the non-linear model. It is hoped that this study will stimulate further research.

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