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ASSESSMENT OF BOND PRICE VOLATILITY IN EMERGING ECONOMIES: A UNIVARIATE GARCH APPROACH

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Abstract

This paper examines the volatility of bond returns in emerging economies with particular case of India and Canada. The study used daily data from 02/01/2012 to 01/01/2018 for India, and 1/03/2012 12/29/2017 for Canada. The univariate GARCH model was employed in estimating the variance equation. Our findings revealed that there were ARCH effects as well as volatility clustering over the period for India and Canada. We observed that endogenous shocks have significant influence on bond price volatilities in both economies. On the other hand, shocks from the stock market return, which is included in the model as exogenous variable, also exerted significant influence on the volatilities of our variable of interest for India whereas the effect was insignificant in the case of Canada. Diagnostic tests on the mean and variance equations showed that our ARCH and GARCH models were correctly specified. We concluded that both the bond return and stock market return shows visible signs of volatilities which are significantly affected by both internal and external shocks.

Keywords: *bond volatility; bond return, emerging economies; ARCH, GARCH*

Introduction

Significance of bond price movements underscores why the relationship between interest rates and bond prices is of paramount importance to investors, and financial institutions and intermediaries. According to Lyuu (2008), Volatility measures how bond prices respond to interest rate changes, and is critical to the risk management of interest-rate-sensitive securities. Nearly all financial institutions retain a portfolio of bonds that attract fixed payments over time. Because the sensitivity of market values of bonds and other securities to interest rate movements, it has become pertinent that financial institutions and the institutional investors must be conversant with the relationship between interest rates and prices of security. Hence, it is very critical to determine both the source and direction of bond prices in the previous years.

Experience has shown that a large number of financial institutions have a portfolio of bonds that generate fixed payments over time. And if prices of existing bonds have increased, it is basically as a result of interest rate decline. Conversely, increase in the prices of existing bonds is normally attributed to increase in interest rates. Likewise, term structure of interest rates equally captures a considerable fraction of the total variability in realized bond risk (Viceira, 2007). Investors are not unaware of the price fluctuations in the bond market and recognizing such risk often cause them to ask for compensation in the form of spread in higher yield which ideally should be over the risk free rate (Campbell and Taskler, 2002). A systematic investigation may however lead to the identification of exact factors that caused fluctuations in bond prices vis-à-vis other determinants of such volatility.

Generally, bond price is quite sensitive to various economic factors. As s result, any such factor that has effect on affect inflationary expectations at any given time may as well affect interest rate expectations, which will hugely affect the demand for bonds. Increase in oil prices, increases in money supply money supply to the economy, and strong economic growth all brings about higher inflationary expectations. Like volatility in interest rates and the stock markets, exchange rate volatility may provoke uncertainties about future business outcomes, hence impairing long term business decisions (Becketti and Sellon, 1989).

2 REVIEW OF RELATED LITERATURE

2.1 Theoretical Review

Bond value and prices is also susceptible to the changes in macroeconomic fundamentals. For instance, variation in inflation rate and interest rate influence bond price. Borio and Maccauley (1996) argue that variations in inflation are probable to be dominant influence on bond rate. They contend that low inflation leads to a decline in interest rate and, as a result, it would be recommended that investors increase hold of more long-term bonds than in the period of rising inflation. Increase in inflation has direct/positive effect on interest rate, which will ultimately lead to a reduction in bond prices.

Furthermore, when we expect interest rates to rise, it is expected that bond prices would decline in the future. As a result, from the investors' point of view, it is only recommended that they do not purchase bonds today. On the other hand, forecasted decrease in interest rates can give the fore knowledge that bond prices would rise in the future, and therefore suggest that investors purchase bonds today. The impact of a decline in interest rates on an investor's required rate of return is such that it would lead to a decrease in an investor's required rate of return. In the same token, the present value of existing bonds will increase while the prices of existing bond will increase.

Hopewell and Kaufman (1973) emphasized that maturity, coupon and the starting level of yield are the key factors that affect the volatility of high-grade bond. Yakob, Yusfff and Nor (2002) also explained that Key determinants of bond price volatility are interest rate, duration and coupon rate. From a maturity point of view, prices of long-term bonds are more responsive to interest rates fluctuations compared to the prices of short-term securities. It is already embedded in theory and practice that the former provides fixed payments for a longer period of time; however, the fixed payment is never a function of interest rate variation. In other words, the provision will continue whether interest rates rise or decline. The advantage of fixed payments during a period of declining interest rates is more evident for longer maturities. Expectedly, the drawback of fixed payments during a period of rising rates holds true.

Coupon rate is yet another strong component of bond, with significant influence on bond value and bond prices as well as the investors' required rate of return. In his study, Mele (2003) buttressed that the connection between bond prices and volatility is key to explain the origins of given associations between bond prices and the short-term rate. Essentially, the price of the bond would be above its par value if a bond's coupon rate is above the required rate of return. This is for the reason that the coupons provide higher than the return required. Moreover, a change in interest rates and, or, a change in the risk of the bond equally causes a change in the required rate of return

For oil dependent countries like Nigeria, the effect of oil price fluctuations on prices of bond cannot be overemphasized. Arguably, reduction in oil production and export would trigger an upward shift in oil price, and consequently leads rise in inflation rate, increase in interest rate and a fall in bond prices.

2.2 Empirical literature

Basically, the value of equity stocks, fixed-income securities and such other investments is derived from the cash flows they are expected to generate to the investor. The cash flow is not received immediately but over certain periods in the future. Therefore to arrive at a present value or fair price of the security, the cash flows must be discounted. In other words, the present value of the streams of expected cash flow represents the fair value of any security. Phillipe *et al*., (2013) assert investors are switching to emerging market bonds as the fixed-income securities demonstrate low yield and discouraging return expectation. For bonds, these streams of cash flows consist of the coupon payments.

We have to understand that price of a bond is inversely related to its required yield. Thus, when the required yield of bonds changes, bond prices also adjust to that change (Lwabona, 1999). Bario and MacCauley (1996) write that little is known in literature about the underlying forces that drive volatility. While Johnson *et al* (2013) drew from their work on stock-bond correlation that a significant percent of volatility long-term nominal yield on bonds is mainly caused by inflation. However, Volatility in essence usually varies with the type and characteristics of bonds. Thus In order to have more insight into the variability in bond prices, we will review some empirical studies on this very discourse.

Huang and Lu (2009) used principal components of analysis to evaluate the effect of macroeconomic variables on the volatility of Treasury bond returns. The results show that macroeconomic factors have a significant impact on the volatility of bond returns. It was also revealed that real activities have effect on the volatility of treasury bonds across all maturities. But whereas monetary variables are strongly related to return volatility of short-term bonds, same variables have weak relation to the return volatility of medium-term bonds.

Downing and Zhang (2002) made use of comprehensive data base of transactions in municipal bonds and explored the relationship between the number of transactions and volatility of bonds in the municipal market. The study found that there exists a positive relationship between volume of bonds traded and price volatility of bonds. The authors however admitted that this finding is not consistent with current theoretical models that explain the volume-volatility relationship of bonds.

Bao and Pan (2008) investigated the relation among corporate bonds, stocks, and Treasury bonds from 2002-2006. The study adopted the Merton model with stochastic interest rate. It was found that variables with connections to bond liquidity are essential in explaining the cross-sectional variations in excess volatility thereby giving further evidence of a liquidity problem in corporate bonds. With the exclusion of treasury and equity exposures, the study found that there are within the bond residuals, there are non-trivial systematic components that cause excess volatility in the bond market.

Viceira (2007) explored the volatility of bond returns and time variation in bond risk. The empirical evidence shows that shifts in short-term nominal interest rate and yield spread are positively correlated with changes in bond risk and bond return volatility. Using short rate as proxy for economic uncertainty and yield spread as proxy for business condition, the results revealed that yield spread is positively related with declining cash-flow risk for bonds and equally have offsetting effects in real cash flow risk components and discount rate risk component.

Chen (2009) employed bivariate Markov-switching GARCH in determining the correlation and volatilities of the bond and stock markets. The results indicated that low-to-high switching in bond volatility appear to be related with equal switching in correlation. It was shown that correlation between bond and stock are significantly high when the bond volatility is at its peak.

Yakob, Yusfff and Nor (2002) investigated the Relationship Between Price Volatility, Maturity and Volume of Trade of the Malaysian Bond Market. The study applied the ordinary least square (OLS) and the regression results reveal that corporate bond price higher the crisis period compared to before the crisis. It was also discovered that the higher the term to maturity of Corporate bonds, the more volatile the price, however there was no relationship between bond price volatility and maturity of bonds.

3 DATA AND METHODOLOGY

Historical daily data on bond price and stock market returns were collated for the period, 1/01/2012 to 1/01/2018 from https://www.investing.com/rates-bonds/india-10-year-bond-yield-historical-data. The times series include 1488 observations. We estimated volatility using the Generalised Autoregressive Conditional Heteroscedasticity (GARCH) model. We employed three approaches in determining the ARCH effects (or volatility cluster) in the model namely: graphical approach, autocorrelation in the (correlogram) squared residuals and the Heteroscedasticity LM test.

The use of the GARCH model in forecasting volatilities have been widely demonstrated in finance literature (see Lama, *et al.*, 2015; Bodart and Reding, 1999; Marcek, 2011; Teresienė, 2009; Hou and Suardi, 2011; Ahmed and Suliman, 2011; Lux, *et al.*, 2015; Goeij and Marquering, 2012). The full GARCH (*p*,*q*) model in Pilbeam and Langeland, (2014) is given by:

$$y_t = \beta_0 + \beta_1 x_{1t} + \beta_2 x_{2t} + \beta_3 x_{3t} + u_t - - - - - - - - - - - - - - - (1)$$

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$$h_t^2 = \alpha_0 + \sum_{i=1}^{q} \alpha_i u_{t-i}^2 + \sum_{j=1}^{p} \beta_j \sigma_{t-j}^2 -----------------(2)$$

In the GARCH model, the conditional variance depends upon the p lags of the conditional variance and the q lags of the squared error. From the equation (2), the fitted variance denoted as h_t (σ_t) is a weighted function; the information about the volatility from the previous periods.

But Specifically, the univariate GARCH(1,1) and conditional variance model for this study was adopted in modified form from Reider (2009) and represented as;

$$\sigma_t^2 = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2 -------------------(3)$$

Where $\alpha_0 > 0$, $\alpha_1 > 0$, $\beta_1 > 0$, and $\alpha_1 + \beta_1 < 1$, so that our next period forecast of variance is a blend of our previous period forecast and previous period's squared return (Reider, 2009).

σ_t^2 = unconditional variance

α_0 = constant term,

ε_{t-1}^2 = ARCH term; the news about volatility from the previous period,

σ_{t-1}^2 = GARCH term; the last period's forecast variance.

Our mean equation can be expressed as;

$$BND\_RTN_t = \alpha_0 + \alpha_1 STK\_RTN_t + \varepsilon_t -------------------(4)$$

Where BND_RTN = bond return, STK_RTN = stock market return (exogenous variable), and ε = residual.

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4 RESULTS AND DISCUSSIONS

4.1 ARCH Effect Results

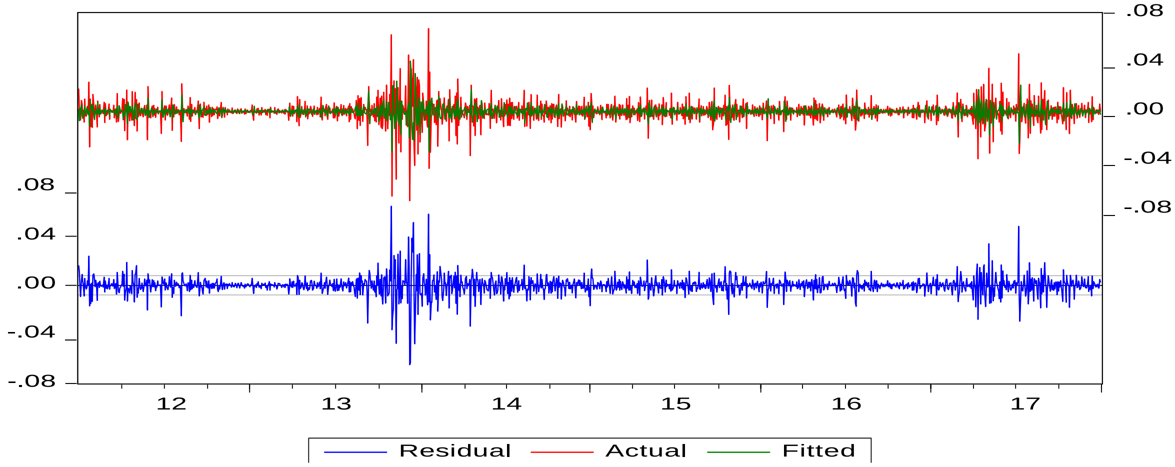

Figure 1. Testing for ARCH Effect: Plot of squared residual for India.

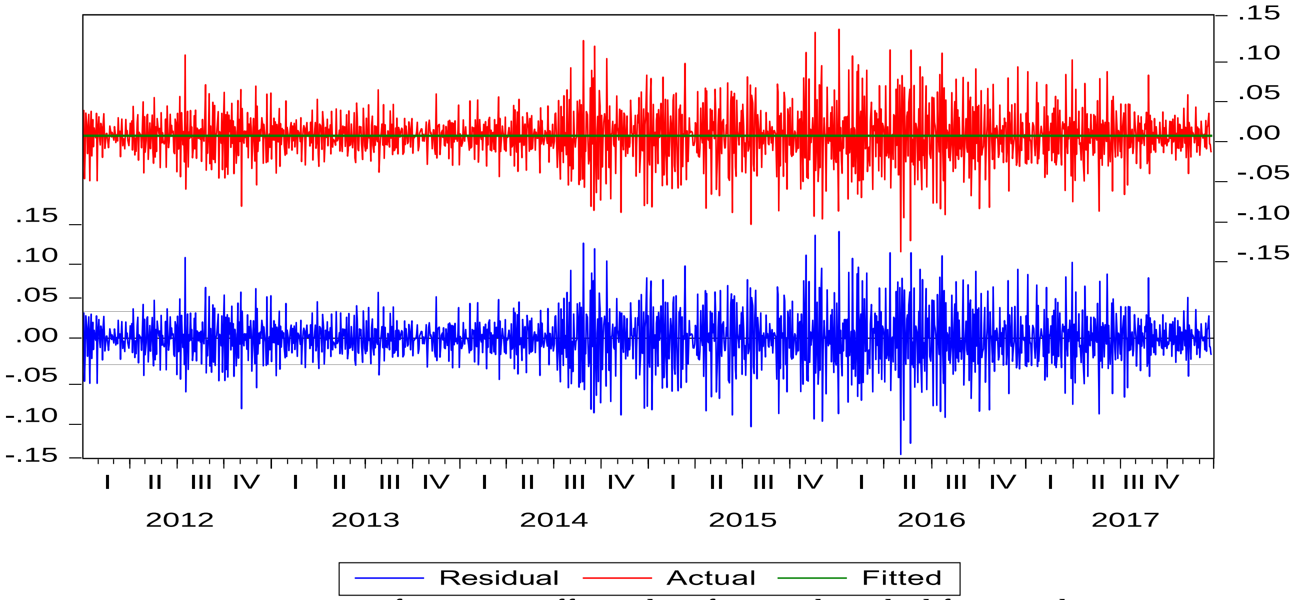

Figure 2. Testing for ARCH Effect: Plot of squared residual for Canada.

In order to test the ARCH effect, we plotted a graph of the residual (or error term) derived from Equation (4) which provided evidence that the error term is conditionally heteroscedastic (see Figure 1 and 2) as prolonged periods of low volatility are followed by periods of high volatility and therefore, the ARCH and GARCH model can be estimated. We can observe that the series are stationary with the returns being located around zero.

Table 1. Testing for ARCH Effect: Correlogram of the Squared Residual

***India:**

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
|* |	|* |	1	0.170	0.170	43.074	0.000
|* |	|* |	2	0.168	0.144	85.333	0.000
|* |	|* |	3	0.143	0.099	115.70	0.000
|* |	|* |	4	0.168	0.118	157.93	0.000
|* |	| |	5	0.097	0.029	172.00	0.000
|* |	|* |	6	0.159	0.101	209.80	0.000
|** |	|* |	7	0.220	0.158	282.10	0.000
| |	*| |	8	0.032	-0.074	283.66	0.000
| |	| |	9	0.064	-0.011	289.83	0.000
| |	| |	10	0.032	-0.036	291.39	0.000

****Canada:**

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob*
|* |	|* |	1	0.186	0.186	52.351	0.000
| |	*| |	2	-0.047	-0.084	55.620	0.000
*| |	| |	3	-0.079	-0.056	65.062	0.000
| |	| |	4	-0.024	-0.001	65.920	0.000
| |	| |	5	-0.012	-0.017	66.154	0.000
| |	| |	6	-0.015	-0.016	66.481	0.000
| |	| |	7	0.010	0.014	66.635	0.000
| |	*| |	8	-0.060	-0.072	72.135	0.000
| |	| |	9	-0.051	-0.028	76.053	0.000
| |	| |	10	-0.027	-0.018	77.139	0.000

*Sample: 1/02/2012 1/01/2018, Included observations: 1488.
** Sample: 1/03/2012 12/29/2017, Included observations: 1504

In Table 1, we further tested for ARCH effect using the autocorrelation in squared residual approach. Autocorrelation (correlogram) squared residual test on the output of the structural model shows that the autocorrelation at many lags are significantly different from zero. We therefore reject the joint null hypothesis of no ARCH effect.

Table 2.

India:			
F-statistic	49.99065	Prob. F(1,1485)	0.0000
Obs*R-squared	48.42772	Prob. Chi-Square(1)	0.0000
Canada:			
F-statistic	54.01915	Prob. F(1,1501)	0.0000
Obs*R-squared	52.21208	Prob. Chi-Square(1)	0.0000

Heteroskedasticity Test: ARCH Effect

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In Table 2, the Heteroscedasticity LM test on the residual indicates the presence of ARCH effect as the squared residuals have coefficient values that are significantly different from zero.

4.2 Result of GARCH Model.

Table 3. Result of the GARCH

Dependent Variable: BND_RTN

*GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*GARCH(-1)*

India:

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	-0.000275	0.000107	-2.570682	0.0101
STK_RTN	-0.028410	0.012051	-2.357404	0.0184
		Variance Equation		
C	1.13E-07	2.19E-08	5.169110	0.0000
RESID(-1)^2	0.058175	0.002504	23.22969	0.0000
GARCH(-1)	0.945370	0.001695	557.5919	0.0000

Canada:

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.002728	0.004812	0.566981	0.5707
STK_RTN	-2.14E-07	3.48E-07	-0.614119	0.5391
		Variance Equation		
C	1.84E-06	1.19E-06	1.547584	0.1217
RESID(-1)^2	0.044540	0.009096	4.896834	0.0000
GARCH(-1)	0.951947	0.009575	99.41597	0.0000

Table 3 presents the GARCH model estimation for India and Canada. From the Variance equations, it is shown that both the ARCH and GARCH terms are significant in explaining the volatility of the bond return in both economies. The result further revealed that while volatilities in the stock market return significantly influence the bond return volatilities in India, the influence was insignificant for Canada. The ARCH (Resid) and GARCH terms are both internal (and endogenous) shocks that influence the dependent variable while stock market return (STK_RTN) is an exogenous shock.

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4.3 Diagnostic Tests

Table 4. Correlogram of Standardized Squared Residuals

India:

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob*
		1	0.001	0.001	0.0032	0.955
		2	-0.011	-0.011	0.1835	0.912
		3	0.005	0.005	0.2251	0.973
		4	0.003	0.003	0.2375	0.993
		5	-0.015	-0.015	0.5841	0.989
		6	-0.003	-0.003	0.6015	0.996
		7	0.012	0.012	0.8117	0.997
		8	-0.016	-0.016	1.1850	0.997
		9	-0.009	-0.009	1.3091	0.998
		10	-0.024	-0.025	2.2001	0.995

Canada:

Autocorrelation	Partial Corelation		AC	PAC	Q-Stat	Prob*
		1	0.002	0.002	0.0073	0.932
		2	-0.024	-0.024	0.8598	0.651
		3	0.028	0.028	2.0513	0.562
		4	-0.020	-0.020	2.6308	0.621
		5	0.007	0.009	2.7145	0.744
		6	-0.039	-0.041	4.9998	0.544
		7	-0.006	-0.005	5.0634	0.652
		8	-0.024	-0.027	5.9074	0.658
		9	-0.025	-0.022	6.8333	0.654
		10	0.012	0.009	7.0426	0.721

Table 4 indicates that the GARCH model with normal distribution has no serial correlation at different lags with *p values* > 0.05. We therefore reject the null hypothesis that our GARCH(1,1) has autocorrelation.

India:			
F-statistic	0.003162	Prob. F(1,1485)	0.9552
Obs*R-squared	0.003166	Prob. Chi-Square(1)	0.9551
Canada:			
F-statistic	0.025507	Prob. F(1,1502)	0.8731
Obs*R-squared	0.025540	Prob. Chi-Square(1)	0.8730

Table 5. **Breusch-Godfrey Serial Correlation (ARCH) LM Test Result.**

We further tested, in Table 5, for ARCH effect in our GARCH(1,1) to ascertain if our model has correctly specified variance equation. If our model is correctly specified, then there will be no ARCH effect left in the standardized residuals. With p value of the Chi-Square > 0.05, we cannot reject the null hypothesis that there is no ARCH effect in the residuals.

5 CONCLUSION

This paper examines the volatility of bond returns in emerging economies with particular case of India. It was found that ARCH effects as well as volatility clustering over the period. We observed that endogenous shocks have significant influence in bond price volatilities. On the other hand, shocks from the stock market return, which is included in the model as endogenous variable, also exerted significant influence on the on bond price return in India while the influence was found to be insignificant for Canada. The findings further showed that there is negative relation between stock market return and bond price return both in India and China. We conclude that both the bond return and stock market return shows visible signs of volatilities which are relatively affected by both internal and external shocks in the emerging economies.

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