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Research Article

Modelling of Volatility of G-sec Bond indices of Various Maturity Periods: A Study of Indian Bond Market

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ABSTRACT

The study has presented the risk-return behaviour and volatility of bond indices of various maturity periods. In this research paper, we have modelled the various parameters of the volatility of bond indices of maturity of 5 years, 10 years, 15 plus years, 4 to 8 years, 8 to 13 years, 11to15years, and composite index as well. We have utilized the daily data of various bond indices of Various maturity periods namely Nifty G-SEC COMPOSITE, Nifty 5years Benchmark G-sec Index, Nifty G-Sec 4 to 8 years, Nifty G-Sec 8 to13 years, Nifty G-Sec 10years, Nifty G-Sec 11to15 years, and Nifty G-Sec 15 years plus. The sample period has been taken from 1st April 2019 to 30th March 2022. This period includes the covid period also. In order to portray the volatility behaviour of indices, various econometrics tools have been deployed, namely GARCH (1,1), Threshold GARCH (TGARCH), Exponential GARCH(EGARCH) and Component GARCH (CGARCH) Models. The study revealed that the long term bond index viz 15year plus maturity shows the highest return and risk both. It is also seen that the benchmark index shows good performance in the comparison of interval indices. Further, all the indices are affected by information broadcasted in the market and by the volatility of the previous day. All the indices are showing indefinite persistence of volatility also. The leading benchmark maturity indices viz. 5years and 10 years do not show the leverage effect of negative news. The study also revealed that only long-term indices viz 15plus years and D11 to 15 years indices show persistence asymmetry in the time series. Utilizing these results, managers and venture capitalist can make smart decisions about the creation of portfolios by difference maturity debt investment alternatives.

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INTRODUCTION

The G-secs are the most leading category of debt markets and form a major part of the market in terms of outstanding issues, market capitalization, and trading value. It sets a benchmark for the rest of the market. G-Secs are the are the most safe securities in every economy in comparison to all other debt securities issued by other entities in that economy. G-Secs are widely held by Banks, Insurance Companies, Pension Funds, Mutual Funds, Trusts and Individuals. An Inter-institutional market for G-Secs makes it highly liquid. Hence, the G-Sec is the benchmark security in every economy and every other security in the economy are relatively riskier.

Although the G-Sec market in India is well established, some gaps still remain. Over the years, T-Bills have been issued for various tenors ranging from 14 to 364 days. However, in the case of long dated securities the market, at any given point in time, does not have outstanding stocks of G-Secs ranging from 2 years to 30 years. This makes it difficult or even impossible to construct a yield curve for the entire range of maturities from 2 years to 30 years. Moreover, the G-Sec yield curve being the benchmark yield curve for other debt instruments including corporate bonds is an important price discovery mechanism for corporate bonds. Market perceives 5-7 year part of the yield curve as the liquid part of the market. At present, it becomes difficult for any corporate bond issuer to price an issue for a tenor of 4 years or 7 years because there may be no outstanding G-Secs of these maturities. However, there are some indices available for the bonds of various maturity periods. Thus, it is a need to understand how they are volatile and what are the components which can affect volatility of those indices.

REVIEW OF LITERATURE

Review of literature is as under

Brennan and Schwartz (1979) constructed an arbitrage model of the term structure interest rate. They have considered assumption as the whole term structure at any point in time may be expressed as a function of the yields on the longest and shortest maturity default free instruments and that these two yields follow a Gauss-Wiener process. The result revealed that arbitrage arguments are used to derive a partial differential equation which must be satisfied by the values of all default free bonds. Further they have also estimated the joint stochastic process for the two yields by using Canadian data and the model is used to price a sample of Government of Canada bonds.

Mitchell (1993) analysed the determinants of choice of maturity of debt instruments namely monitoring, signalling and bankruptcy. They have utilised the daily data of corporate bonds for the period of 1982 to 1986. The results revealed that firms use bond maturity to ease monitoring by outsiders and firms with high-quality projects does not use bond maturity to signal project quality. Furthermore, it is also revealed that firms do not use bond maturity to achieve an optimal trade-off between interest tax shields and bankruptcy costs.

Munnik and Scotman (1994) examined volatility of bond prices and short-term interest rate for the Netherland. they have employed Vasicek and CIR term structure model on daily data set. The results revealed that both models are giving identical results with respect to the cross-sectional term structure parameter estimates and implied bond option values. Further it is also revealed that for some maturities the data reject the constant volatility Vasicek model and show the occurrence of the CIR volatility effects.

Baker, Greenwood and Wurgler (2003) analyzed the power of maturity of a bond to influence the future returns. The study revealed that when contribution of long term maturity debt is higher in total debt, future returns are low. This projecting power comes in two chunks. One is inflation rate and term spread predicts the returns of the bond. The second is, the same variable explain the long-term share and its own ability to predict excess bond returns. The results are unswerving with survey evidence that firms use debt market conditions in an effort to determine the lowest-cost maturity at which to borrow.

Buera and Nicolini (2004) examined the G-sec contingent debt on the parameter of maturity. The authors said that G-sec contingent debt can be created using non-contingent debt of different maturities. A main policy implication of this principle is that the Ramsey allocation with complete markets can be sustained with non-contingent debt only by properly managing its maturity structure. The empirical analysis of this study suggest that this policy implication should apply with care. Furthermore, results revealed that the debt positions that sustain the Ramsey allocation are very high and increasing in the number of states. In addition, they are very sensitive in the parameters of the model.

Bali and Skinner (2006) examined the factors of the new issue maturity of corporate bonds. They have also analysed the variation of new issue maturity within credit classes. The study revealed that asset maturity, security covenants, and macroeconomic conditions influence the new issue maturity of bonds within rating categories.

Arellano and Ramanarayanan (2012) examined the default of government security bonds of emerging economies in the respect of their maturity period. It is observed that there is an inverse relationship between interest rate spread and maturity of bond. Furthermore, they have also constructed models which consist of international borrowing with endogenous default and multiple debt maturities. The results revealed that long-term debt provides a hedge against future fluctuations in spreads, whereas short-term debt is more effective at providing incentives to repay.

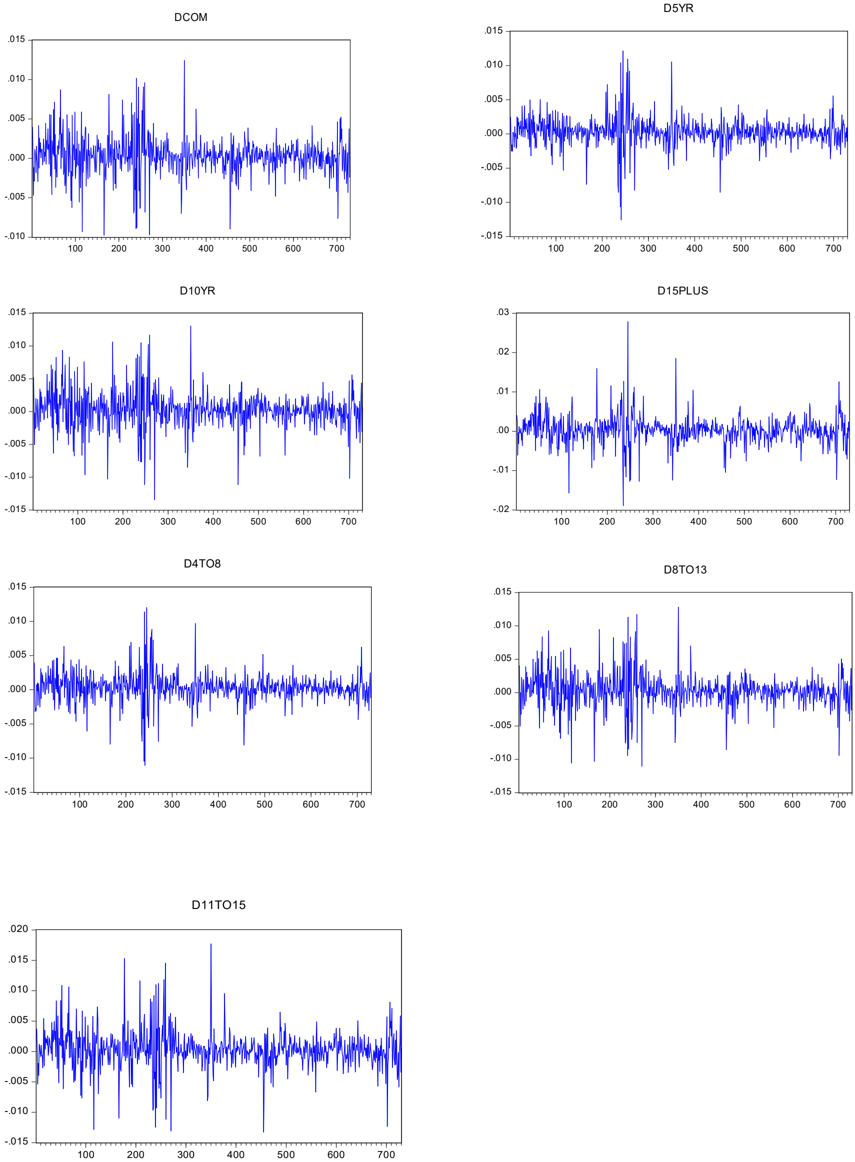
Chung, Wang and Wu (2019) analysed the volatility risk and idiosyncratic volatility of corporate bond returns. The sample time frame is taken from year 1994 to 2016. As per the results of the study shows adverse relationship between volatility beta and expected returns of the bonds. Further, bonds with high idiosyncratic bond volatility have high (low) expected returns, and this relation strengthens as ratings decrease and conventional risk factors and bond/issuer characteristics does not show any impact on these cross-sectional relations.

We have reviewed numerous papers related to various parameters like signaling monitoring, bankruptcy and terms structures. Few papers also discussed about the impact of interest rate, maturity and credit ratings on the values of bond. But in the entire review of literature, there is no paper who modelled the volatility for the bond indices of various maturity period. Thus, in the study we have used advance volatility model of GARCH family to understand the various factors of risk of bond indices.

RESEARCH METHODOLOGY

In order to understand the performance and volatility of government security bonds of various maturity, we have utilized the daily data of various bond indices of Various maturity periods, namely, Nifty G-Sec COMPOSITE, Nifty 5years Benchmark G-sec Index, Nifty G-Sec 4 to 8years, Nifty G-Sec 8 to13 years, Nifty G-Sec 10years, Nifty G-Sec 11to15 years, and Nifty G-Sec 15 years plus. The data has been extracted from the official website of NSE India.The sample period has been taken from 1st April 2019 to 30th March 2022. This period can measure the impact of HR Khan Committee report as well as the most volatile period i.e. covid 19 pandemic.

FIGURE: 1


DCOM
.015
.010
.005
.000
-.005
-.010
100 200 300 400 500 600 700
D5YR
.015
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.005
.000
-.005
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100 200 300 400 500 600 700
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Figure 1 shows the graphical representation of inconsistency of returns. We can see with a cursory look in the figure that most of the return of the indices are volatile between the 100th observation to 400th observation which is covid period mainly. But we can't accurate comment on volatility of returns with this figure only. So that in order to understand the volatility behavior and its components, we have used superior models viz GARCH family models. Models are mentioned below with equations:

(GARCH 1,1) :

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

EGARCH: LOG(GARCH) = C(2) + C(3)*ABS(RESID(-1)/@SQRT(GARCH(-1))) + C(4)*RESID(-1)/SQRT(GARCH(-1)) + C(5)*LOG(GARCH(-1))……………………..…………………………...(2)

CGARCH:

Q= C(2) + C(3)* (Q(-1)-C(2))+ C(4)*RESID(-1)^2- GARCH(-1))…………………….……(3)

GARCH = Q + C(5) * (RESID(-1)^2 - Q(-1)) + C(6)*(GARCH(-1) - Q(-1))…………..… (4)

TGARCH:

GARCH = C(2)+C(3)*RESID(-1)^2 + C(4)* RESID(- 1) ^2*(RESID(-1)<0)+ C(5)*GARCH(-1)...(5)

RESEARCH QUESTION

1. Is there any difference between risk and return of various maturity bond indices?
2. Is there volatility persistence exist in various maturity bond indices?
3. Is there a leverage effect in various maturity bond indices?
4. Is there any effect of negative news on various maturity G-sec bond indices?

EMPIRICAL ANALYSIS

Descriptive statistics

In order to understand the basic characteristics of various bond indices of different maturities, we have seen descriptive statistics of their returns and presented in table 1.

We can see in the table that D5yr index is showing a return (0.000311) which is higher than D10yr bond index (0.000334 but lower than D15plus years index, which indicates that among the benchmark indices, the highest maturity bond shows the highest returns. In the context risk of benchmark indices, we can see that the standard deviation is highest for D15plus (0.003586), after that D10 yr(0.002795) and the least risky index isD5yr(0.0021) among the benchmark maturity period indices.

Further, the index consists of bonds whose maturity is between 4 to 8 year (D4to8), showing the highest mean value (0.000314) of the returns among the class of maturity period (D8to13:0.00028 and D11to 15: 0.000311). As well, Dto8 shows characteristics of good investment by having the least standard deviation (0.0021) in the comparison of D8to13years(0.002567) and D11to15(0.003161).

Table 1: Descriptive Statistics

	DCOM	D5YR	D10YR	D15PLUS	D4TO8	D8TO13	D11TO15
Mean	0.000296	0.000311	0.000234	0.000334	0.000314	0.00028	0.000311
Median	0.000273	0.000282	0.000223	0.000341	0.000279	0.00026	0.000224
Std. Dev.	0.002402	0.0021	0.002795	0.003586	0.0021	0.002567	0.003161
Skewness	-0.00146	0.0667	-0.06993	0.400786	0.083741	0.020065	0.149619
Kurtosis	7.180101	11.40091	6.830195	11.64507	9.554397	7.436747	8.306458
Jarque-Bera	530.75	2144.265	446.2073	2289.66	1305.766	597.9724	858.0341
Probability	0	0	0	0	0	0	0
Sum	0.215584	0.226834	0.170409	0.243573	0.229008	0.204483	0.227079
Sum Sq. Dev.	0.004199	0.003211	0.005689	0.009361	0.003211	0.004798	0.007276
Observations	729	729	729	729	729	729	729

UNIT ROOT TEST:

In order to forecast any characteristics of time series, we need to check the stationarity of data. We have utilized the Augmented Dickey-Fuller test and prepared table 2. As per the table, all the series are not stationary at the level. But after having the first difference, the series becomes stationary. So now we can proceed with further volatility modeling by these time series data.

Table 2: ADF Test for Unit root

	At levet			At first difference		
	Lag length	t_stats	Probability	Lag length	t_stats	Probability
Dcom	0	-2.42644	0.1348	0	-27.3962	0
D5yr	0	-1.89817	0.3333	0	-27.0232	0
D10yr	0	-2.78616	0.0607	0	-28.2577	0
D15plusYr	2	-2.26305	0.1845	1	-15.7566	0
D4to8 yrs	0	-2.06926	0.2574	0	-27.4603	0
D8to13 Yrs	0	-2.68544	0.077	0	-27.7609	0
D11to15 Yrs	0	-2.5515	0.1038	0	-26.4244	0

GARCH (1,1)

Further we have measured the volatility of these indices separately. We have applied the GARCH (1,1) model to analyze volatility persistence for each index and created Table 3 and 4. Table 3 shows GARCH (1,1) results for Benchmark indices and table 4 shows the result for interval indices. In the table we can see the Garch and Arch terms are significant for each benchmark index, which shows that volatility of all benchmark indices are affected by information broadcasted in the market and by the volatility of the previous day. Further, all the indices are showing indefinite persistence of volatility as the value of the sum of Arch and Garch terms is about to one. Further, the same results are depicted in table 4 for the interval indices.

Table 3: GARCH (1,1) for Benchmark Maturity Indices

	Dcom		D5yrs		D10yrs	
	Coefficient	Prob.	Coefficient	Prob.	Coefficient	Prob.
C	2.39E-07	0	2.43E-07	0	2.65E-07	0
Arch: RESID(-1)^2	0.086523	0	0.101287	0	0.096982	0
Garch: RESID(-1)^2	0.86904	0	0.829079	0	0.870048	0
(RESID(-1)^2+ RESID(-1)^2)	0.9555		0.9302		0.9669	

Table 4: GARCH (1,1) for Interval Maturity Indices

	D4to8yrs		D8to13yrs		D11to15yrs		D15plus yrs	
	Coefficient	Prob.	Coefficient	Prob.	Coefficient	Prob.	Coefficient	Prob.
C	1.95E-07	0	1.83E-07	0	4.05E-07	0	5.83E-07	0
Arch: RESID(-1)^2	0.093125	0	0.093802	0	0.093692	0	0.111935	0
Garch:								
RESID(-1)^2	0.853737	0	0.878944	0	0.868611	0	0.846934	0
Arch+Garch:								
(RESID(-1)^2+RESID(1)^2)	0.9468		0.9719		0.9622		0.9588	

EGARCH :

To measure conditional volatility in the advanced model, we have applied E-Garch Model. By applying this model, we can determine the market leverage effect. Here, the existence of leverage depicts the negative correlation of past return with the future volatility of return. We applied the same model for both indices viz benchmark and interval indices and prepared tables 5 and 6, respectively. We can see in table 5 that C4 is negative and significant only for Dcom, which indicates that in the benchmark indices, only the volatility of returns of the composite bond index is affected by bad news. Further, in the interval group, all the indices have a value of C4 that is negative and significant, which shows all the indices are affected by bad news more than good news.

Table 5: EGARCH for Benchmark Maturity Indices

	Dcom		D5Yrs		D10yrs	
	Coefficient	Prob.	Coefficient	Prob.	Coefficient	Prob.
C(2)	-0.591076	0	-0.89836	0	-0.66397	0
C(3)	0.174412	0	0.219563	0	0.223609	0
C(4)	-0.034433	0.0138	-0.00451	0.7557	0.014964	0.4381
C(5)	0.961573	0	0.94104	0	0.957728	0

Table 6: EGARCH for Interval Maturity Indices

	D4to8yrs		D8to13yrs		D11to15yrs		D15plus yrs	
	Coefficient	Prob.	Coefficient	Prob.	Coefficient	Prob.	Coefficient	Prob.
C(2)	-0.63737	0	-0.71631	0	-0.59527	0	-0.71631	0
C(3)	0.188187	0	0.223672	0	0.194413	0	0.223672	0
C(4)	-0.03328	0.01	-0.03677	0.0082	-0.04217	0.0025	-0.03677	0.0082
C(5)	0.959866	0	0.950704	0	0.960223	0	0.950704	0

CGARCH:

In CGARCH, we have endeavoured to model future conditional variance with the support of momentary and continual elements of mean and variance equation. We have modelled the CGARCH for both kinds of indices and prepared the tale 7 and table 8. We have seen in the table that C3 is significant and falls between 0.9 to 1 for all the indices, indicating long-term elements' persistence toward conditional variance. Further, C4 is also positive and significant, which suggests the presence of a perpetual element in conditional variance. C5 is significant and negative only for D5years and D10yrs in benchmark indices and for D15yrsplus and D8to13 years in interval indices, which indicate that the volatility of these indices is primarily influenced negatively by the news in the transitory term.

Table 7: CGARCH for Benchmark Maturity Indices

	Dcom		D5Yrs		D10yrs	
	Coefficient	Prob.	Coefficient	Prob.	Coefficient	Prob.
C(2)	5.50E-06	0	3.55E-06	0	8.55E-06	0
C(3)	0.952129	0	0.919717	0	0.956234	0
C(4)	0.100057	0	0.133697	0	0.166808	0
C(5)	-0.050916	0.0986	-0.08823	0.0072	-0.13751	0
C(6)	-0.187102	0.752	0.441435	0.1319	0.90841	0

Table 8: CGARCH for Interval Maturity Indices

	D4to8yrs		D8to13yrs		D11to15yrs		D15Plus Yrs	
	Coefficient	Prob.	Coefficient	Prob.	Coefficient	Prob.	Coefficient	Prob.
C(2)	3.77E-06	0	7.30E-06	0	1.09E-05	0	1.36E-05	0
C(3)	0.942921	0	0.969469	0	0.960941	0	0.944536	0
C(4)	0.108232	0	0.125716	0	0.100068	0	0.15843	0.0009
C(5)	-0.04979	0.1075	-0.07748	0.0005	-0.0346	0.253	-0.0956	0.0287
C(6)	-0.20777	0.7121	0.749843	0	-0.25415	0.7536	0.884003	0

TARCH:

How will the market react when there is a negative threshold in the market? This question can be answer by TARCH. We have applied the model on both indices and prepared table 9 and Table 10. We have seen that C4 term is not significant for any indices except than D15plus years and D11 to 15 years, which indicate that Dcom, D5yrs, D10yrs, D4to8 yrs and D8 to 13 years do not show persistent asymmetry in the time series.

Table 9: TARCH for Benchmark Maturity Indices

	Dcom		D5Yrs		D10yrs	
	Coefficient	Prob.	Coefficient	Prob.	Coefficient	Prob.
C	2.29E-07	0.0001	2.35E-07	0	2.80E-07	0
(C3)	0.079007	0.0001	0.09017	0	0.113814	0
(C4)	0.012909	0.5503	0.01741	0.436	-0.03131	0.2212
(C5)	0.872225	0	0.833952	0	0.866359	0

Table 10: TARCH for Interval Maturity Indices

	D4to8yrs		D8to13yrs		D11to15yrs		D15plus yrs	
	Coefficient	Prob.	Coefficient	Coefficient	Prob.	Prob.	Coefficient	Prob.
C	1.75E-07	0	1.78E-07	5.41E-07	0	0	5.41E-07	0
(C3)	0.071828	0.0001	0.089436	0.08144	0	0	0.08144	0
(C4)	0.033075	0.0998	0.007699	0.055371	0.0066	0.0127	0.055371	0.0066
(C5)	0.864396	0	0.880443	0.853252	0	0	0.853252	0

CONCLUSION

The study has presented the risk-return behavior and volatility of bond indices of various maturity periods. The results are expected to furnish an insight into the volatility of bond indices in the minds of investors of debt capital market. In this research paper, we have modelled the various parameters of the volatility of bond indices of the maturity of 5 years, 10 years, 15 plus years, 4to 8 years, 8 to 13 years, 11to15 years and composite. W have utilized the daily data of various bond indices of Various maturity periods Nifty G-Sec COMPOSITE, Nifty 5years Benchmark G-sec Index, Nifty G-Sec 4 to 8years, Nifty G-Sec 8 to13 years, Nifty G-Sec 10years, Nifty G-Sec 11to15 years, and Nifty G-Sec 15 years plus. The sample period has been taken from 1st April 2019 to 30 th March 2022. In order to portray the volatility behaviour, various econometrics tools have been deployed, namely GARCH (1,1), Threshold Garch (TARCH), Exponential GARCH(EGARCH) and Component GARCH(CGARCH) Models. As per the result of descriptive statistics, we can see that the long-term bond index viz 15year plus maturity shows the highest return and risk. It is also seen that benchmark indices show good performance in comparison to interval indices.

As per the GARCH (1,1) model, we can see that both Arch and Garch terms are significant for each benchmark indices and interval indices, which indicate that all indices are affected by information broadcasted in the market by the volatility of the previous day. Further, all the indices are showing indefinite persistence of volatility.

Further EGARCH Model shows that the composite bond index has a leverage effect of bad news in the benchmark indices. In contrast, all the interval indices have a leverage effect, indicating they are affected by bad news more than good news. Moreover, CGARCH shows that all the indices have the persistence of long-term elements toward conditional variance. Returns of 5 years, 10 years,15 years plus and 8 to13 years indices are primarily influenced negatively by the news in the transitory term. As per the TARCH Model, only long-term indices viz D15plus years and D11 to 15 years show persistence asymmetry in the time series. Utilizing these results, managers across the globe can make smart decisions about the creation of portfolios, especially in the Indian context

REFERENCES

Alam, M. Z., & Rahman, M. A. (2012). Modelling volatility of the BDT/USD exchange rate with GARCH model. *International Journal of Economics and Finance,* 4(11), 193-204.

Arellano, C., & Ramanarayanan, A. (2012). Default and the maturity structure in sovereign bonds. *Journal of Political Economy,* 120(2), 187-232.

Baker, M., Greenwood, R., & Wurgler, J. (2003). The maturity of debt issues and predictable variation in bond returns. J*ournal of Financial Economics,* 70(2), 261-291.

Bali, G., & Skinner, F. S. (2006). The original maturity of corporate bonds: The influence of credit rating, asset maturity, security, and macroeconomic conditions. *Financial Review,* 41(2), 187-203.

Brennan, M. J., & Schwartz, E. S. (1979). A continuous time approach to the pricing of bonds. *Journal of Banking & Finance,* 3(2), 133-155.

Buera, F., & Nicolini, J. P. (2004). Optimal maturity of government debt without state contingent bonds. *Journal of Monetary Economics,* 51(3), 531-554.

Chung, K. H., Wang, J., & Wu, C. (2019). Volatility and the cross-section of corporate bond returns. *Journal of Financial Economics,* 133(2), 397-417.

de Munnik, J. F., & Schotman, P. C. (1994). Cross-sectional versus time series estimation of term structure models: Empirical results for the Dutch bond market. *Journal of Banking & Finance,* 18(5), 997-1025.

Guirguis, M. (2018). Application of a GARCH, TGARCH, and EGARCH, Models to Test the Spot GBP/USD Exchange Rate Volatility. *TGARCH, and EGARCH, Models to Test the Spot GBP/USD Exchange Rate Volatility.(September 22, 2018).*

Mitchell, K. (1993). The debt maturity choice: an empirical investigation. *Journal of Financial Research,* 16(4), 309-320.