SBP Working Paper Series

No. 112 April, 2023

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STATE BANK OF PAKISTAN

SBP Working Paper Series

Editor: Muhammad Farooq Arby

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Available online at:

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ISSN 1997-3810 (Online)

Published by State Bank of Pakistan, Karachi, Pakistan.

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Mohsin Waheed* and Zulfiqar Hyder†

Abstract

In this paper, we determine the significant domestic and external drivers of volatility in Pakistan's sovereign bond yield-to-maturity (YTM) across different tenors. We use a class of volatility models (GARCH, TGARCH, and EGARCH) on daily data starting from January 2019 to October 2022. We find that, in addition to domestic macroeconomic fundamentals, political factors also contribute substantially to the volatility in bond yields. Additionally, we also argue that foreign investors' risk perception is susceptible to exchange rate depreciation, import cover, and sovereign ratings. On the external side, we find that the general riskiness perception of emerging market bonds as measured by Emerging Market Bond Index Spreads significantly explains the volatility of Pakistan's sovereign bonds.

JEL Classification: B26, C01, C12, C32, C58, G12, G24
Keywords: Volatility, Sovereign bonds, Yield, Eurobond, Sukuk, Spreads

Acknowledgments: Authors would like to thank the Director, Research Department, for his comments and guidance on the paper and two anonymous referees.

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Non-technical Summary

Issuance of sovereign bonds is one of the ways a country can borrow from foreign creditors. Most common type of these bonds is Eurobond, which is a conventional interest-bearing bond widely traded worldwide. During the past two decades an Islamic variant of sovereign bonds called Sukuk has also gained popularity especially in the Muslim majority countries. Pakistan issued its first Eurobond in 1994 and first international Sukuk bond in 2005. As of July 2022, Pakistan's total outstanding sovereign bonds stood at $8.8 billion comprising of $2 billion Sukuk bonds and $6.8 billion Eurobonds.

Yields of sovereign bonds reflect how bondholders perceive risk of holding the bonds; a higher yield shows that investors demand higher premium for holding a particular bond and hence is a yardstick for measuring risk in these bonds. Pakistan's sovereign bonds had been trading fairly close to other emerging economies one year before the pandemic and the later year. However, these yields rose temporarily during the pandemic relative to the advanced economies. Uptick in the sovereign bond yields due to the onset of the pandemic was not uncommon across emerging economies; advanced economies are perceived to be more creditworthy and relatively stable in times of upheavals of global-scale.

Moreover, yields of Pakistani bonds have skyrocketed since April 2022. In this paper, we argue that factors such as political instability; soaring inflation expectations; forex reserves inadequacy; downgrading of bond ratings; and exchange rate volatility are some of the salient determinants of the yields of Pakistani bonds in recent times. In addition, we also argue that when general risk perception of emerging market bonds gains momentum, this does heighten yields of Pakistani bonds. This usually happens when advanced economies raise interest rates.

1. Introduction

The recent tightening of global financial conditions has made it difficult for many commodities importing emerging and developing economies, like Pakistan, to tap international capital markets to meet their external financing needs. The widening current account deficits of commodity importing emerging and developing economies, due to a confluence nature of shocks, have been further aggravated by Russia-Ukraine war which stoked food and energy prices globally in 2022. This phenomenon accompanied with servicing of existing sovereign dollar-denominated bonds and commercial borrowings have elevated the sovereign bond yields of many emerging market economies thereby effectively shutting down the global capital markets for these economies.

Due to debt sell-off by foreign investors and reversal of capital inflows from emerging and developing economies, sovereign bond yields on 10-year bonds maturing in 2024, or 2025 of more than a dozen of these economies had been persistently rising since March 2022; and had almost doubled by July 2022 in many cases (see, *Annexure-I*). Further, yields of Pakistan's[3] bonds of similar maturity were close to a 45 percent by the end of July 2022 – third highest and behind only to Ukraine and Sri Lanka in the current sample. Broadly, a substantial uptick has been witnessed in the Emerging Market Bond Index (EMBI) spreads.[4] Due to the perceived risk, investors demand higher compensation on emerging economy's sovereign bonds as has been reflected in the rising yields in these bonds. Within this context, the objective of this paper is to investigate various factors, both domestic and global, which explain the volatility in sovereign bond yields of Pakistan over the period of January 2019 to October 2022.

Literature on sovereign bond yields suggests that the yields are influenced by several economic and non-economic factors pertaining to both country-specific fundamentals as well as global factors that relate to the bond issuing economies. Investors tend to monitor these variables while making investment decisions in sovereign bonds. Major country-specific economic factors are economic growth; inflation; fiscal balance; public debt sustainability; current account balance; and foreign exchange reserve buffers [see, Tebaldi, Nguyen and Zuluaga (2018); and Jahjah, Wei and Yue (2013)]. Besides, non-economic variables such as changes in government; geo-political risks; economic policy uncertainty; or even vulnerability to climate

[3] Pakistan has historically availed financing from a variety of sources. The multilateral financing has dominated while the sovereign bonds have remained relatively a smaller portion of the overall borrowings. Pakistan, according to 'American Banker' via Cecile Gutscher (1994, December 05), first tapped the sovereign bond market in 1994 with its first ever issue; subsequently, it remained cutoff from this market for a period of roughly seven years from 1997 to 2004, mainly owing to the sanctions levied due to 'the Nuclear Tests in 1998'. Moreover, the country issued its first-ever Islamic bonds i.e. 'Sukuk' in 2005 according to Reuters News (2004, December 20).

[4] It is an index created by JP Morgan to gauge the spread between US treasuries and emerging markets bonds.

change may also impact the yields [see, Moser (2007); Packer and Woolridge (2003); Cevik and Jalles (2022); and Kaminsky, Lyons and Schmukler (1999)].

Literature also presents ample evidence to suggest that global factors also influence sovereign bond yields (see, Kariyawasam and Jayasinghe (2022)). Key global factors are shock(s) in major economies and policy response to these shocks in form of interest rates changes in advanced economies and fiscal stimulus as has been witnessed recently. Moreover, contagion and shock spillovers could affect investors' sentiments and could result into reversal of capital from emerging economies to safe assets of advanced economies, particularly the US treasuries [see, Johri et al. (2022) and Li (2021)]. In a more recent contribution, Paule-Vianez et al. (2021)[5] and Rout and Mallick (2022), argue that the impact of shock spillover of bond yields has magnified during Covid-19, regardless of their maturities compared to pre-Covid-19 period. The former study uses the search volume extracted from Google Trends, which is selected as the proxy for Covid-induced fear to explore its influence on sovereign bond markets.

This paper contributes to the existing literature by examining volatility, based on high frequency daily data, jointly in both conventional and Islamic bonds (Sukuk) on account of various domestic and global factors. The paper also gives a glimpse into the evolution of these bonds in case of Pakistan. To put things into perspective, the Sukuk bonds were first issued in Malaysia over two decades ago as noted by Wedderburn-Day (2010), and according to Fitch Ratings, as of July 2022, the total bond size amounted to a staggering figure of $734 Billion. Additionally, we ascertain the impact of bad news shocks on the yields of bonds of different tenors.

Our findings are in line with the literature cited above: domestic factors such as interest rate and exchange rate are prominent determinants of the volatility in the sovereign bond yields. Among the external factors, Emerging Markets Bond Index (EMBI) spread, which measures borrowing costs for emerging market economies, is also a noteworthy determinant of the volatility of yields of Pakistan sovereign bond.

2. Data

We use the daily data of the following variables: yield-to-maturity of Pakistan sovereign bonds of various tenors (see, *Table 1*), EMBI spread; Marked-to-market exchange rate of Pakistani rupee against the US Dollar (E); and interest rate (KIBOR)[6]. The data source for the first two variables is Bloomberg while later two variables is State Bank of Pakistan. Yield-to-maturity data has been extracted for all the available

[5] Countries include Germany, Canada, the United States, France, Italy, Japan, and the United Kingdom.

[6] Karachi Interbank Offered Rate (Interbank Benchmark Borrowing/Lending Rate), which is the benchmark interest rate used to lend funds to consumers and corporates in Pakistan.

tenors, that is, 5-year (5Y); 10-year (10Y); and 30-year (30Y). *Table 1* provides a snapshot of the bonds of various tenors currently being traded. Our analysis contains two other explanatory variables, that is, import cover and sovereign rating. It also contains two dummy variables, first one accounts for the change of Government in April 2022 while the other one accounts for the Covid-19 pandemic. Import cover is computed by dividing the current period net reserves[7] of the central bank by past twelve-month average of total imports; definition of total imports is in accordance with the IMF Balance of Payments Manual BPM6 (see, *Figure 1)*. Sovereign ratings variable has been quantified from the available ratings of the sovereign ratings agencies by assigning them equal weights and quantifying the alphanumeric ratings (see, *Annexure-II)*.

Table 1: Sovereign Bond Issues as of July 2022

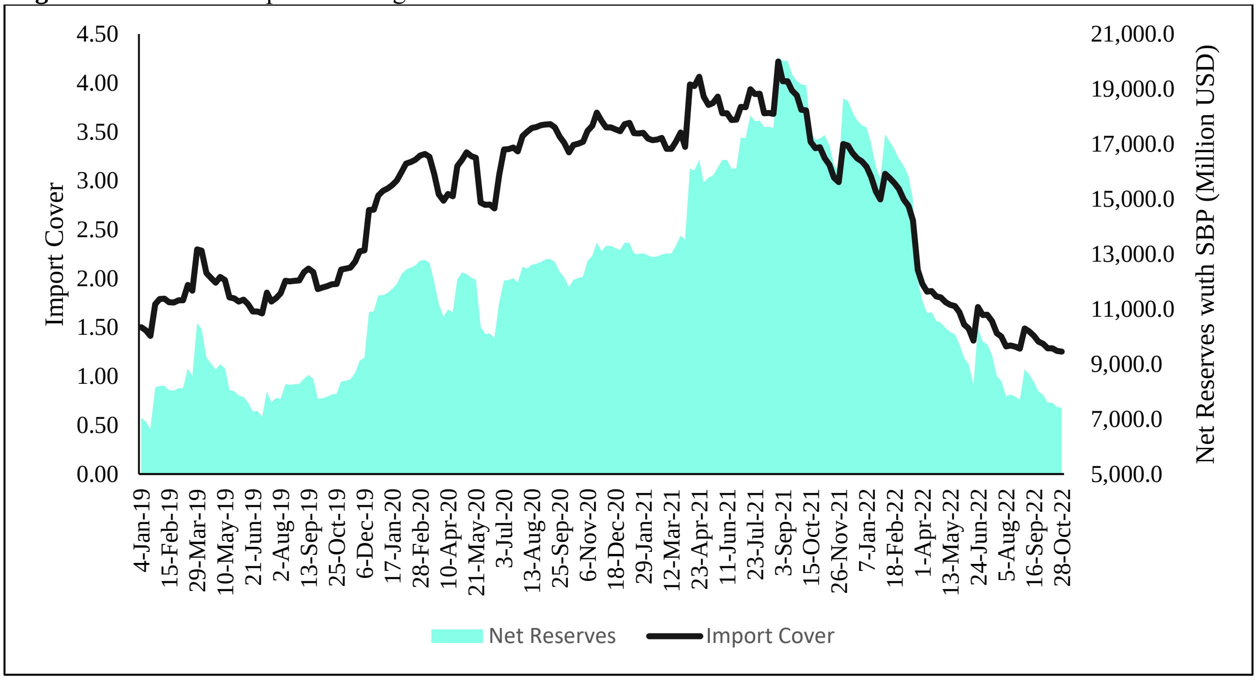
Issued	**Amount** (Millions)	**Type**	**Tenor**
23-Mar-06	$300	Eurobond	5
8-Apr-14	$1,000	Eurobond	10
24-Sep-15	$500	Eurobond	10
5-Dec-17	$1,000	Sukuk	5
5-Dec-17	$1,500	Eurobond	10
8-Apr-21	$1,000	Eurobond	5
8-Apr-21	$1,000	Eurobond	10
8-Apr-21	$500	Eurobond	30
7-Jul-21	$300	Eurobond	5
7-Jul-21	$400	Eurobond	10
7-Jul-21	$300	Eurobond	30
1-Feb-22	$1,000	Sukuk	7

Data Source: State Bank of Pakistan

Figure 2 shows an unprecedented increase in the yields of bonds of various tenors around March 2020 and 2022, respectively. In our sample, prior to the recent hike in yields, a noteworthy surge in the yields was observed during March 2020 amid Covid-19 outbreak. Further, we find that 2019 was a relatively calm year for the yields as the domestic economy was doing well, so was the global economy. Thereafter, yields rose in March 2020 momentarily and later settled down and remained steady until March 2022. This is because once the pandemic hit the economy, it was not a surprise anymore and the economic agents priced-in the possible effects of any new variants of the virus and emerging economic problems already. Moreover, the yields seem to have very strong co-movements across distinct maturities.

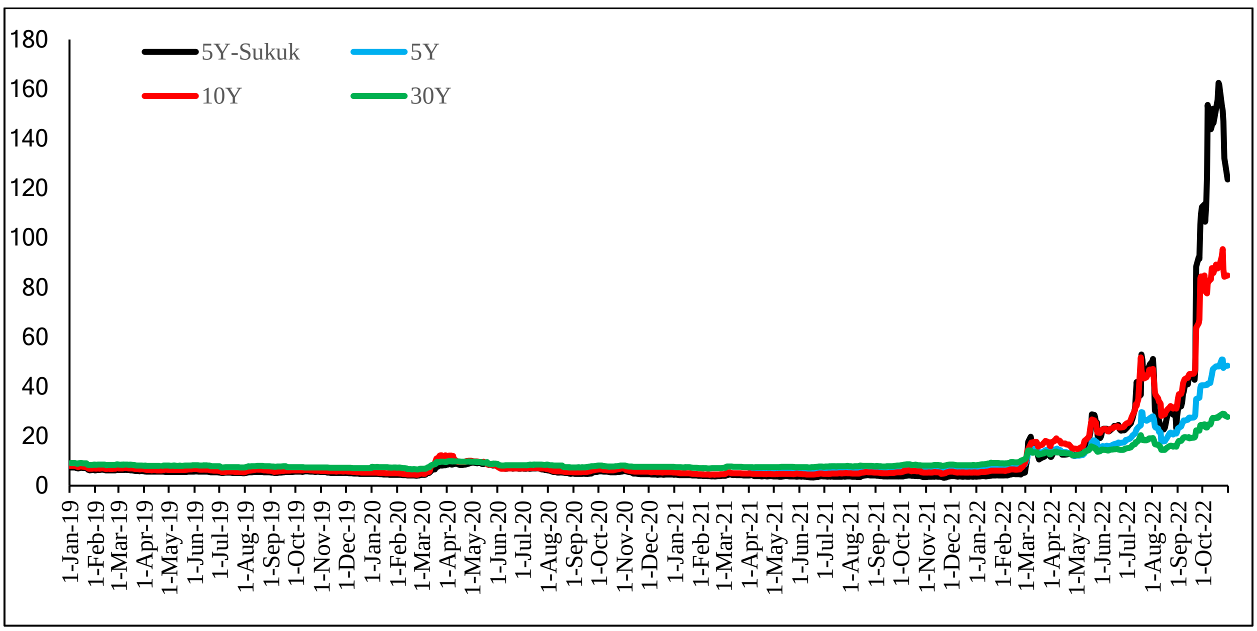
[7] Net international reserves (NIR) are defined as reserve assets (RA) minus predetermined net short-term foreign currency drains (FCD) as per IMF BPM6.

Figure 1: Pakistan's Import Coverage



Source: Author's calculations

Figure 2: Yield-to-Maturity Pakistan Sovereign Bonds



Data Source: Bloomberg

Table 2 contains correlations between yields of various tenors. We observe that these yields tend to be highly correlated. In particular, the yield of 5Y-Sukuk is more strongly correlated with 5Y and 10Y bonds compared with the 30Y bond, and that 10Y bond has also slightly lower correlation with 30Y bond than 5Y bond.

Table 2: Pairwise Correlations of Bond Yields

	5Y-Sukuk	5Y	10Y	30Y
5Y-Sukuk	1.000			
5Y	0.951*** 0.00	1.000		
10Y	0.968*** 0.00	0.993*** 0.00	1.000	
30Y	0.907*** 0.00	0.990*** 0.00	0.973*** 0.00	1.000

Source: Author's estimates

***, **, and * indicate that the coefficients are significant at 1%, 5%, and 10% levels, respectively.

Table 3 contains the descriptive statistics of bond yields on quarterly basis; rationale for adding this information is to provide a broader overview of the yields data. A substantial increase in the yields is visible in 2022Q2, which is followed by a drastic increase in 2022Q3. Specifically, in July 2022, apart from the global contributors to the rising yields, such as, a rise in the EMBI spreads, there was an enormous economic policy uncertainty in the country as reflected in the monthly Economic Policy Uncertainty Index of Pakistan Choudhary, Pasha and Waheed (2020)

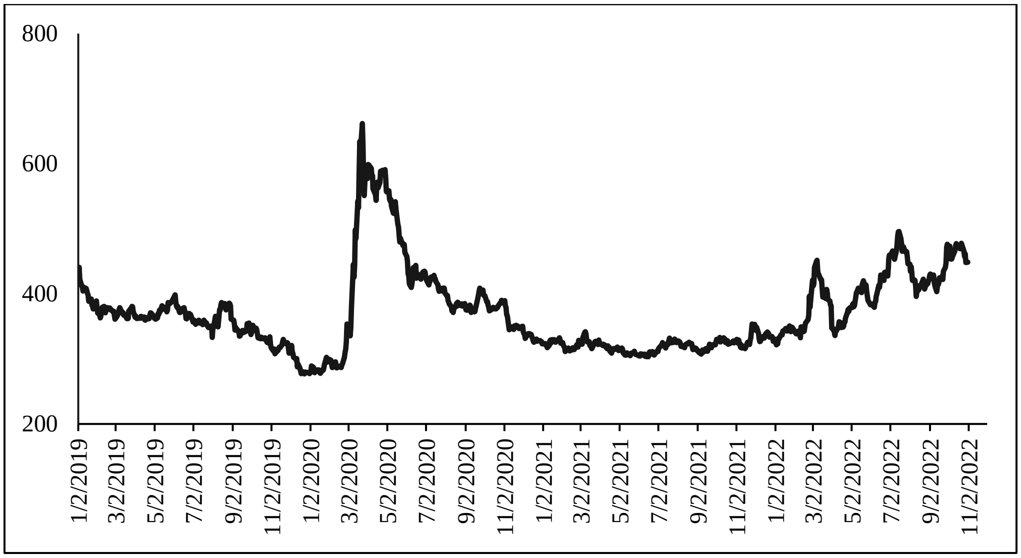
Table 3: Descriptive Statistics of Bond Yields

Statistic	2019Q1	2019Q2	2019Q3	2019Q4	2020Q1	2020Q2	2020Q3	2020Q4	2021Q1	2021Q2	2021Q3	2021Q4	2022Q1	2022Q2	2022Q3
	Five-Year (Sukuk)														
Mean	6.47	5.60	5.35	5.27	5.11	8.20	5.73	5.04	4.13	3.74	3.79	3.71	7.43	18.45	41.18
St. Dev	0.45	0.11	0.16	0.34	1.36	0.86	0.84	0.54	0.21	0.18	0.20	0.20	4.62	5.26	20.85
Min	5.85	5.35	5.06	4.72	4.06	6.83	4.73	4.40	3.73	3.35	3.52	3.19	3.69	11.55	22.73
Max	7.38	5.84	5.61	5.77	8.46	9.84	7.03	5.96	4.61	4.27	4.21	4.22	19.76	28.82	112.44
	Five-Year														
	2019Q1	**2019Q2**	**2019Q3**	**2019Q4**	**2020Q1**	**2020Q2**	**2020Q3**	**2020Q4**	**2021Q1**	**2021Q2**	**2021Q3**	**2021Q4**	**2022Q1**	**2022Q2**	**2022Q3**
Mean	…	…	…	…	…	…	…	…	…	5.47	5.82	6.19	9.46	15.02	24.89
St. Dev	…	…	…	…	…	…	…	…	…	0.12	0.15	0.25	3.34	1.94	14.98
Min	…	…	…	…	…	…	…	…	…	5.22	5.58	5.75	6.06	12.06	17.82
Max	…	…	…	…	…	…	…	…	…	5.82	6.17	6.83	15.13	18.49	40.47
	Ten-Year														
	2019Q1	**2019Q2**	**2019Q3**	**2019Q4**	**2020Q1**	**2020Q2**	**2020Q3**	**2020Q4**	**2021Q1**	**2021Q2**	**2021Q3**	**2021Q4**	**2022Q1**	**2022Q2**	**2022Q3**
Mean	7.11	6.38	5.91	5.81	6.18	8.85	6.21	5.92	4.84	4.72	5.10	5.49	9.82	20.20	40.65
St. Dev	0.43	0.16	0.32	0.33	2.53	1.60	0.67	0.50	0.26	0.10	0.21	0.28	5.01	3.63	13.18
Min	6.59	6.01	5.44	5.28	4.43	6.79	5.37	5.32	4.43	4.45	4.74	4.82	5.33	14.86	25.21
Max	8.06	6.77	6.56	6.39	12.31	12.08	7.16	7.00	5.31	4.97	5.52	6.14	18.04	26.73	84.42
	Thirty-Year														
	2019Q1	**2019Q2**	**2019Q3**	**2019Q4**	**2020Q1**	**2020Q2**	**2020Q3**	**2020Q4**	**2021Q1**	**2021Q2**	**2021Q3**	**2021Q4**	**2022Q1**	**2022Q2**	**2022Q3**
Mean	8.54	8.06	7.65	7.26	7.58	9.08	7.96	7.73	7.34	7.51	7.88	8.31	10.57	13.87	17.98
St. Dev	0.30	0.11	0.21	0.12	0.93	0.67	0.43	0.18	0.24	0.08	0.11	0.14	1.96	0.93	2.40
Min	8.07	7.82	7.34	7.05	6.55	8.13	7.33	7.55	7.00	7.39	7.66	7.94	8.35	12.29	14.41
Max	9.17	8.32	8.04	7.46	9.63	9.88	8.51	8.17	7.77	7.70	8.14	8.64	14.22	15.89	24.53

Source: Author's calculations

The domestic factors that may have given rise to yields could be the political instability; current account deficit; IMF program[8] related uncertainty; and 2nd highest-ever economic policy uncertainty on record. Consequently, Pakistan's sovereign bond ratings were downgraded by all the major rating agencies during June and July 2022 as shown at *Annexure-II*.

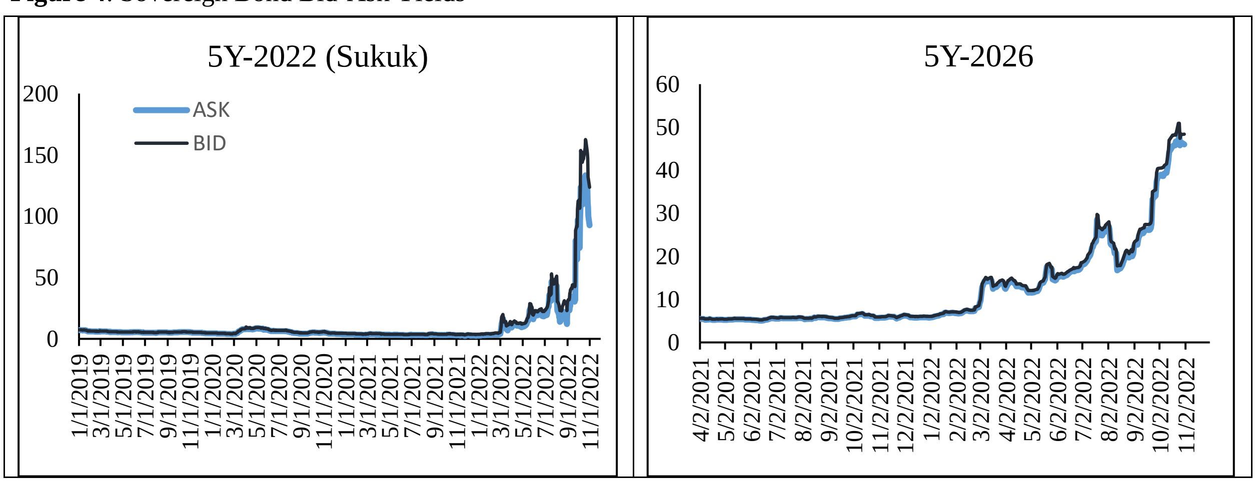
Figure 3: Emerging Market Bond Index (EMBI) Spread



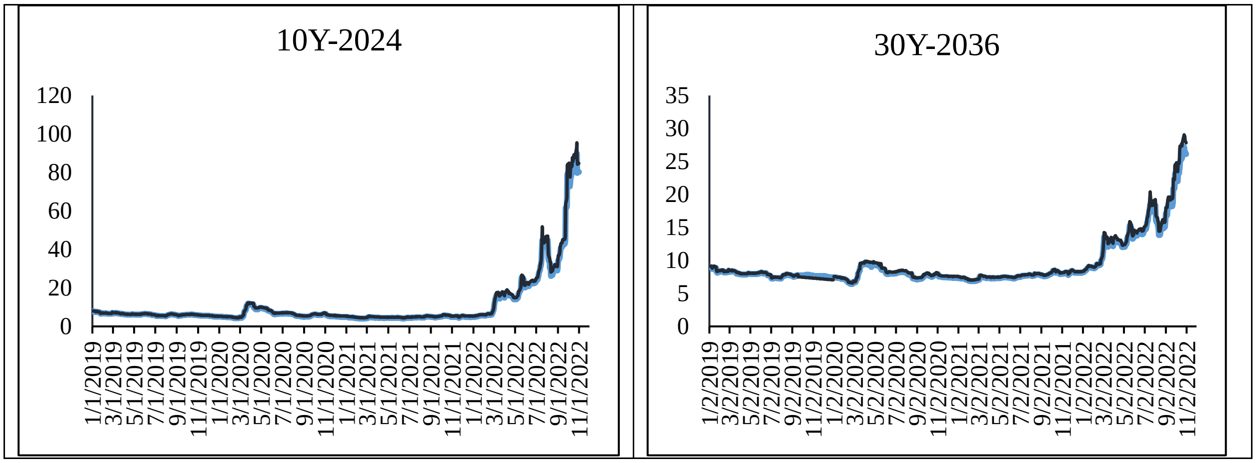
Source: Bloomberg

To further strengthen our case, we plot the bid and ask yields for the bonds in *Figure 4*. The figure shows that the spread remained extremely narrow for all other bonds except Sukuk bond. This may imply a lower liquidity in the Sukuk market.

Figure 4: Sovereign Bond Bid-Ask Yields



[8] Pakistan secured IMF's Extended Fund Facility in July 2019; uncertainty related to 7th and 8th reviews by the Executive Board.



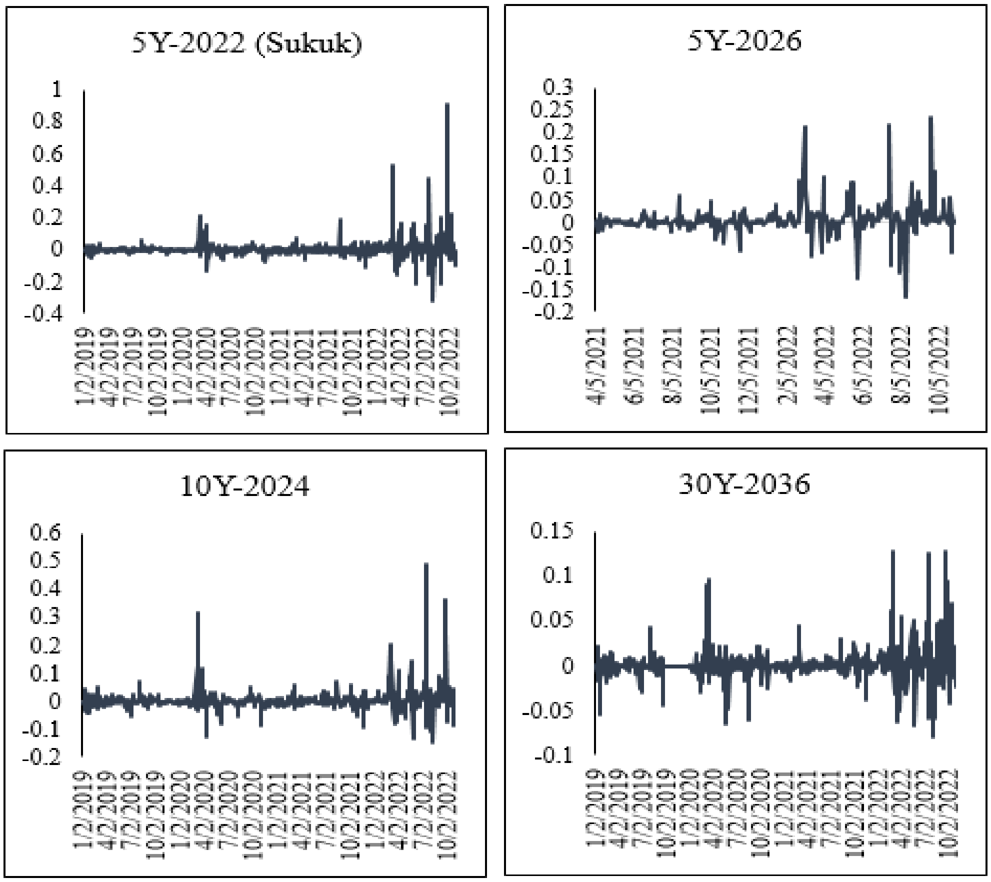
Data Source: Bloomberg

3. Methodology

Risk associated with an asset is one of the most important areas of research in finance, and asset volatility (risk) is the most used measure for quantifying the risk. Volatility is a key factor in options pricing and asset allocation. It plays an important role in value at risk (VaR) calculation for risk management. Many economic and financial series exhibit periods in which the variance is low, and other periods in which the variance of the series is relatively high. For example, let's look *Figure 5*, which shows that, with exception to 5Y-Sukuk, most returns have experienced a few episodes of high volatility over the sample period.

We follow the following steps in our analysis: first, we establish presence of the volatility clusters by arguing that volatility has some inertia as it does not fade away quickly. Second, we apply different models (ARCH, GARCH, TARCH, and EGARCH) to measure volatility. Third, we shed light on some of the domestic factors that turned out to be driver of volatility; besides, we introduce some explanatory variables in the mean and variance equations of the volatility models to check whether these variables increase the volatility in the yields significantly. Forth, we try to establish whether the events of global nature such as Covid-19, or a rise in EMBI spreads contributed to greater volatility in the yields. Fifth, we try to explain whether bad news shocks have any bearing on the yields. Sixth, we compute model-driven structural breaks and incorporate the structural break into our analysis to find out the impact of the break

Figure 5: Sovereign Bond Returns (Daily Percent Change)



Data Source: Bloomberg

We observe the presence of 'Volatility Clusters', that is, high volatility in certain time periods and low in others. For example, volatility was high during the initial days of the pandemic in March 2020. Post March 2022, volatility of a large scale is observed due to a variety of factors, such as, the political uncertainty, the Ukraine-Russia war, among others. Moreover, we also notice that volatility evolves over time in a continuous manner and that it does not diverge to infinity, that is, volatility varies within some fixed range, statistically speaking this means that the volatility is often stationary.

To test for the presence of volatility, we use the Langrage Multiplier test, which is a popular test for ascertaining the presence of volatility clusters. If the results are statistically significant, we can say that there exist ARCH effects and hence the presence of volatility clusters is problematic.

3.1 Testing for ARCH effects:

Introduced by Engle (1982), ARCH models can help us to determine if a series has volatility clusters, also known as the ARCH test. First, we generate the autocorrelation and the partial autocorrelation functions graphs attempting to identify the significant autocorrelation in the squared residuals. If large changes in the returns tend to cluster together, and small changes tend to cluster together, this means that the series exhibits conditional heteroscedasticity. The graphs in *Annexure-III* show this phenomenon with signs of volatility clustering as depicted for bonds of different tenors; however, we formally test for ARCH effects as detailed below:

Let $\varepsilon_t = r_t - \mu_t$ be the residuals of the mean equation. Then, the squared residuals ε_t^2 is used to check for conditional heteroskedasticity, which is also known as ARCH effect. We check the ARCH effect using Langrange Multiplier (LM) test which has the following specification: The Null hypothesis is $\alpha_i = 0\ (i = 1, \ldots, m)$ in the linear regression $\varepsilon_t^2 = \alpha_0 + \alpha_1\varepsilon_{t-1}^2 + \ldots \alpha_m\varepsilon_{t-m}^2 + e_t$. Where $t = m + 1, \ldots, T$ and e_t denotes the error term m is pre-specified integer. $LM = TR^2 \sim x^2$; $H_0 = \alpha_1 = \alpha_2 = \cdots \alpha_m = 0$

Table 4: LM Test for Autoregressive Conditional Heteroskedasticity

lags(p)-1	chi2	df	Prob > chi2
5Y Sukuk	21.97	1	0.00
5Y	28.907	1	0.00
10Y	10.58	1	0.00
30Y	31.028	1	0.00

Source: Author's calculations

Note: H_0: No ARCH effects vs. H_1: ARCH (p) disturbance

Table 4 contains the results of the LM test. We observe that the null hypothesis of No ARCH effects is rejected for all the tenors with a p-value less than the value of 0.05 (5 percent level of significance). Hence, we conclude that there are ARCH effects present in the yields for each tenor considered for this analysis.

3.2 Determining the Volatility on Account of Domestic and Global Factors

Domestic Factors

Change of Government in April 2022

In line with the literature that stresses upon the idea that political turmoil increases sovereign bond yields, we try to assess if this holds true for a noteworthy recent episode of political instability, which took place in April, 2022 with change of government. We specify the variance equation as:

$$h_t = \alpha_0 + \alpha_1\varepsilon_{t-1}^2 + \beta_1 h_{t-1} + \gamma D_t \qquad (1)$$

Where, take on the value of 0 up to March 2022 and 1 from April 2022 onwards implying a controversial change in Government. If γ is positive and statistically significant, we can conclude that change of government did in fact increase the volatility of bond yields.

Table 5 contains the estimates of γ and the standard error. If the point estimate is at least twice as big as the standard error, we conclude that the estimated coefficient is statistically significant. The results in *Table 5* are in line with our premise and we observe that the change of government had catastrophic impact on the volatility, that is, it caused volatility to increase for all the bonds manifolds, specifically, quite high for 5Y-Sukuk having near-term maturity in December 2022.[9] Yields on 5Y-Sukuk increased 24.17 percent; 2.14 percent on 5Y bond; 2.93 percent on 10Y bond; and 3.52 percent on 30Y bond. These results have important lessons to draw on for Pakistan, that is, there is a tremendously high borrowing cost of political uncertainty. Furthermore, during the times of political anarchy, investors may reckon that political changes could derail ongoing policies that may exacerbate the economic landscape; hence, a possibility of dwindling returns and an increase in repatriation issues.

Table 5: Volatility on Account of the Government Change in April 2022 (coefficients on the dummy)

TARCH L1.	Coef.	Std. Err.	[95% Conf. Interval]	
5Y-Sukuk	24.17143***	0.0535777	24.066	24.276
5Y	2.138176***	0.0817357	1.978	2.298
10Y	2.93113***	0.0592307	2.815	3.047
30Y	3.521***	0.1656237	3.197	3.846

Source: Author's estimates

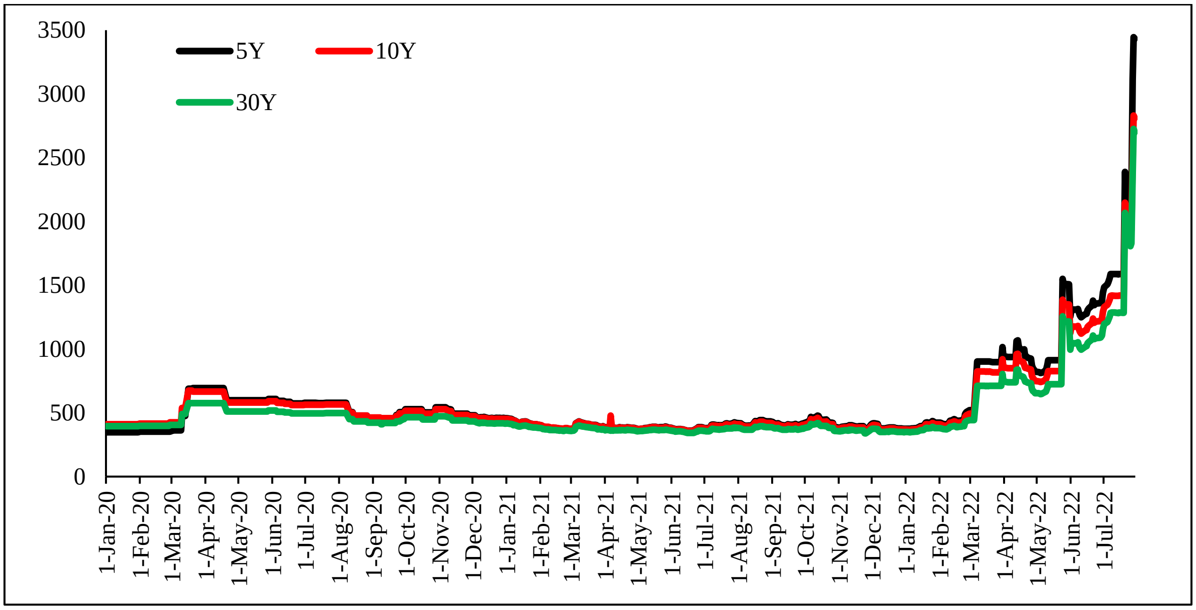
***, **, and * indicate that the coefficients are significant at 1%, 5%, and 10% levels respectively.

Figure 6 contains the Credit Default Swaps spreads[10] on Pakistani bonds. We observe that the spread has been persistently rising since March 2022, and the change of government that caused the volatility to increase as shown just above may have engendered massive amount of uncertainty amongst investors; thus, leading to a demand of higher premium on Pakistani bonds.

[9] At the time this work was under process, December of 2022 was still a few months away. Therefore, the results point towards the maturity of the 5Y-Sukuk in December 2022.

[10] Credit default swaps (CDS) are, by far, the most common type of credit derivative. They are financial instruments that allow the transfer of credit risk among market participants, potentially facilitating greater efficiency in the pricing and distribution of credit risk. It is a contractual agreement to transfer the credit exposure of fixed income products between parties.

Figure 6: Credit Default Swaps Spreads



Source: Bloomberg

Introducing domestic macroeconomic explanatory variables

In order to further our empirical investigation on the drivers of volatility in Pakistan's sovereign bonds, we introduce a few domestic macroeconomic variables as explanatory variables in the mean and variance equation of GARCH/ARCH models. These variables are interest rate; exchange rate; import cover; sovereign rating of Pakistan; and September' 22 dummy. Our results are contained in *Annexure-IV*. The results suggest that one percent exchange rate depreciation causes the volatility 5Y-Sukuk, 5Y, and 10Y bonds rise to 0.24, 0.01, and 0.18 percent respectively. Besides increase in domestic interest rate by one percentage point negatively influences sovereign bond yields volatility by a minuscule amount of 0.10, 0.34, and 0.07 percent for 5Y-Sukuk, 5Y, and 10Y bonds respectively. Negative relationship may arguably be because of the central bank's response to anchor inflation expectations which may be perceived to be a positive sign by investors. Further, an improvement in the import cover by a single unit helps lower the volatility by 0.69, 1.00, and 0.45 percent respectively for 5Y-Sukuk, 5Y and 10Y bonds which is plausible in a sense that an improvement in the net reserves shows the capability of the debtor to pay back the debts. Alongside, an improvement of one point in the sovereign rating causes a substantial reduction in the volatility of 18.21, 11.24, and 13.60 percent respectively for 5Y-Sukuk, 5Y and 10Y bonds. Concerning the use of 'September'22 Dummy', we notice that volatility rises as 71.36, 16.38, and 47.00 percent for 5Y-Sukuk, 5Y, and 10Y bonds. This enormous surge in volatility may be attributed to noticeable rise in domestic economic uncertainty coupled with floods of unprecedented magnitude and further fueled by resurgence of terror activities.

Global Factors:

The Covid-19 Pandemic

The Covid-19 pandemic caused sovereign bond yields of several emerging market economies to rise due to the perceived risk. The first case of the pandemic in Pakistan was reported on February 26, 2020. To test if this really is the case, we introduce a dummy variable called 'Pandemic', which takes on a value of '1' after the reporting of the first case and '0' before.

Table 6 contains the coefficients and significance indicators. There is interesting finding, that is, volatility substantially increase for bonds with a relatively shorter duration compared to the longer duration bond of 30Y. Yields increased by 2.80 percent on 5Y-Sukuk; 1.32 percent on 10Y bond; and 2.68 percent on 30Y bond. One plausible reason for lesser rise in 30Y bond yield compared with 5Y-Sukuk may be the aptly held notion that the harrowing impact of the pandemic would eventually subside in the longer run, however, lesser rise in 10Y bond maturing in 2024 in comparison with 30Y bond maturing in 2036 merits further careful analysis. Thus, it is in the short-run, the unexpected shock of the pandemic affects the yields, because in the long run rational economic agents base their decision pricing in the probable effects (end of Covid-19, or persistence) of the Covid-19 pandemic, or other such events.[11]

Table 6: Volatility on Account of the Pandemic (coefficients on the dummy)

	Coef.	Std. Err.	z	[95% Conf. Interval]	
5Y-Sukuk	2.801***	0.094	29.94	2.618	2.985
10Y	1.327***	0.084	15.73	0.162	1.492
30Y	2.680***	0.194	13.78	2.299	3.061

Source: Author's estimates
***, **, and * indicate that the coefficients are significant at 1%, 5%, and 10% levels respectively.

Surge in EMBI post Russia-Ukraine War

Ukraine-Russia war emerged as a global factor, whose economic effects were felt across an array of emerging economies, to which Pakistan is no exception. To account for this event in our analysis, we use the EMBI spreads as a control variable and the results are provided at *Annexure-IV*. Canuto (2022) suggests that a rise in EMBI spreads post Russian invasion of Ukraine has created outflows from emerging economies and has caused the yields on emerging markets bonds to increase and our findings also resonate with their finding. This is plausibly due to interest rate hike introduced by the advanced economies owing

[11] It is important to note that the pandemic was a medical phenomenon; however, it quickly transformed into an economic/financial crisis as Governments around the world took measures to contain the spread of the virus, especially the lockdowns.

to higher inflation mainly contributed by energy and food components. As discussed earlier, due to an increase in interest rates in advanced economies, investors pull out from the emerging economies as they deem investments in the former ones safer; this particularly happens during shocks of global scale such as the Pandemic; the Great Recession; and the Taper Tantrum[12] of 2013.

Sri-Lankan Default

We stipulate that sovereign default of a country may engender further risk perception of other economies in the region. With this premise, we include a 'Sri Lankan Default Dummy' to see the movements in the yields. The results at *Annexure IV* are in congruence with our premise of regional risk spillover: yields significantly rise to 3.38 and 5.21 percent respectively for 5Y and 10Y bonds.

3.3 Determining Volatility of Bad News through Threshold-GARCH (TGARCH)

Further to reinforce our earlier findings, we investigate whether bad news have any bearing on the volatility of yields in the context of Pakistan. Caporale et al. (2018) show that there is an abrupt impact of bad news on the yields and the magnitude is bigger during recent crisis. Below, we use the T-GARCH model to come up with findings for this case.

TARCH or Threshold ARCH and Threshold GARCH were introduced independently by Zakoïan (1994) and Glosten, Jaganathan, and Runkle (1993); this model allowed good and bad news to affect volatility differently. Volatility increases with negative information and "Bad" news has more noticeable effect on volatility of asset prices than "good" news. There is a strong negative correlation between current stock returns and future volatility. The tendency for volatility to decline when returns rise and to increase when returns fall is called 'Leverage Effect'. A positive ε_t shock will have a smaller effect on volatility than a negative shock of the same magnitude. The model is given by:

$$h_t = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \lambda_1 d_{t-1} \varepsilon_{t-1}^2 + \beta_1 h_{t-1} \qquad (2)$$

If $\lambda_1 > 0$ Volatility increases

Where,

$$d_{t-1} = 1 \quad if \quad \varepsilon_{t-1} < 0 \rightarrow \text{Bad news} \qquad (3)$$

[12] On May 22, 2013, Federal Reserve Chair Ben Bernanke announced that the Fed would start tapering asset purchases at some future date, which sent a negative shock to the markets, causing emerging market bond investors to start selling their bonds.

$d_{t-1} = 0 \quad if \quad \varepsilon_{t-1} \geq 0 \rightarrow$ Good news (4)

This is very intuitive:

If $\varepsilon_{t-1} \geq 0$, the effect of shock on h_t is $\alpha_1 \varepsilon_{t-1}^2$
If $\varepsilon_{t-1} < 0$, then $d_{t-1} = 1$ hence the effect of shock on h_t is $(\alpha_1 + \lambda_1)\, \varepsilon_{t-1}^2$
If $\lambda_1 > 0$ then negative shocks have greater effect on volatility than positive shocks.

If the coefficient is statistically significantly different from zero, we conclude that there is a threshold effect. *Table 7* shows that the bad news shocks do increase volatility of yields of bond of different tenors and the effects are statistically significant for all the tenors. A bad news shock increases volatility of the magnitude lesser than 1 percent for all other bonds except 10Y bond; in the latter case, it is 1.90 percent. Hence, we find that in case of Pakistan negative (bad) news increases volatility in the sovereign bond yields than the positive (good) news does.

Table 7: Volatility driven by the Bad News

TARCH L1.	Coef.	Std. Err.	z	[95% Conf. Interval]
5Y-Sukuk	.664***	7.33	.091	.486 .841
5Y	.4650499*	.2623708	1.77	049 .979
10Y	1.905514***	.0915892	20.81	1.726 2.085
30Y	.3847302 ***	.0653234	5.89	. 256 .513

Source: Author's estimates
***, **, and * indicate that the coefficients are significant at 1%, 5%, and 10% levels respectively.

3.4 Modeling the Structural Break and Volatility

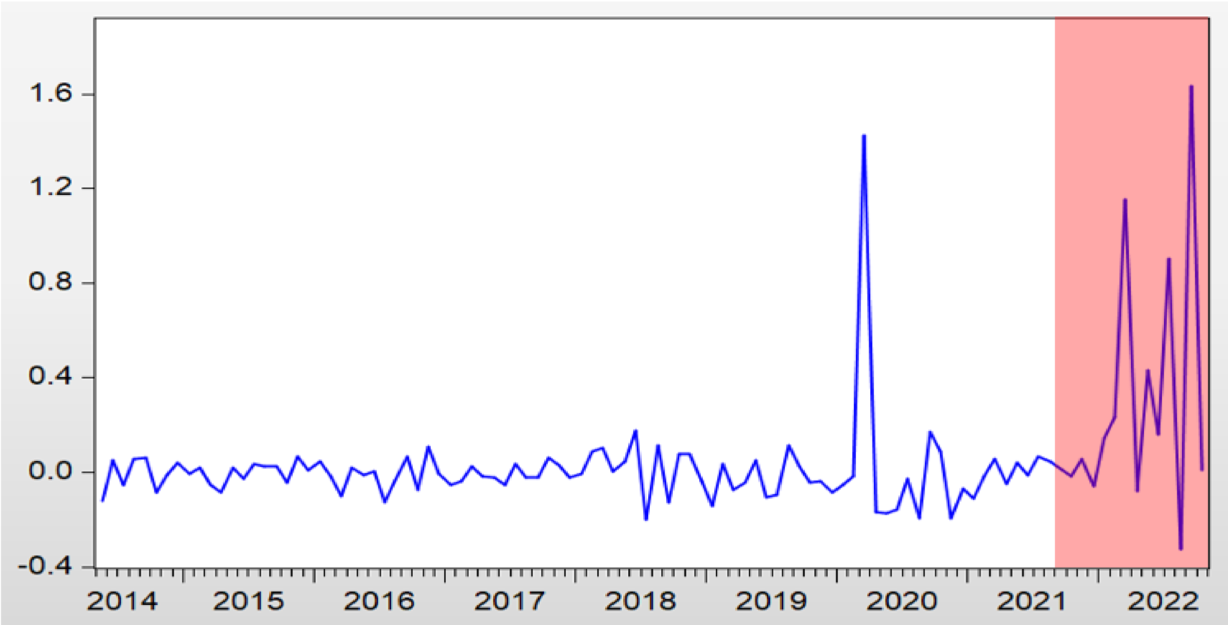
In the backdrop of mounting economic uncertainty and political instability discussed earlier, we now try to determine model-based structural breaks and later introduce them as a dummy variable in the model to find out their impact. For this analysis, we take the change 10-year bond yields (see, *Table 8)*. We determine structural break using Bai and Perron (Econometrica 66:47–78, 1998, J Appl Econ 18:1–22, 2003) as adopted by Tamakoshi and Hamori (2013), which accommodates endogenous identification of break dates. We observe one break in volatility at 2021M08 as depicted in the *Figure 7*; thereafter, the yields continuously increased to unprecedented proportions. Model-produced structural break i.e., August 2021 is convincing in a sense that the Taliban gained control of Kabul in the same month, so this created fresh wave of geopolitical concerns for neighboring countries predominantly Pakistan. This may have been perceived as a negative outcome for holders of Pakistan sovereign bonds. Once we incorporate a dummy in the equation to account for the structural break, we observe a marked improvement in the results as shown in *Annexure-V*.

Table 8: Ten Year Sovereign Bond Maturing in 2024

Issued	**Amount** (Millions)	**Type**	**Tenor**
8-Apr-14	$1,000	***Eurobond***	10

Source: State Bank of Pakistan

Figure 7: Visual depiction of the Structural Break



In *Table 9* we provide the descriptive statistics for the 10Y bond returns. There seems to be a noticeable variation in the data looking at the Min, Mean, and Max values; the positive value of skewness (4.16) suggests that large increases rather than decreases are more likely to occur. Moreover, a high value of kurtosis (19.29) shows that substantial changes are recurring. In addition, a large value of Jarque-Bera test statistic implies that the data are not normally distributed.

Table 9: Descriptive Statistics of the 10Y bond returns – Overall sample

Series	Mean (%)	Min (%)	Max (%)	SD	Skewness	Kurtosis	Jarque-Bera
10Y	19.294.55	-32.38	163.41	0.27	4.16	19.29	1874.57

Source: Author's calculation

In our analysis, we first employ the Autoregressive (AR) model for the bond return series. Using the Bayesian Information Criterion (BIC) due to Schwarz (1978), we select the AR (1) process for the conditional mean equation denoted by

$$b_t = a_0 + a_1 b_{t-1} + \varepsilon_t \qquad (5)$$

For the conditional variance of returns, we use the EGARCH model for the following reasons. First, the coefficients of the ARCH terms in the EGARCH model can capture the asymmetric effects caused by positive and negative shocks. Therefore, the EGARCH model is superior to a different form of asymmetric conditional volatility model such as the GJR-GARCH model suggested by Glosten et al. (1993), in which, our analysis is constrained by the signs of the coefficients. The EGARCH (1,1) model is described as follows

$$\log(\sigma_t^2) = \omega + (\alpha_1 |z_{t-1}| + \gamma_1 z_{t-1}) + \beta_1 \log(\sigma_{t-1}^2) \quad (6)$$

Here $z_t = \frac{\varepsilon_t}{\sigma_t}$. Due to the reason that the sample data exhibit high kurtosis, we estimate the model with the Maximum Likelihood Estimation (MLE) technique, assuming 't' distributed errors. It is worthwhile to emphasize that this EGARCH specification resulted in a very high value of our first-order volatility persistence measure whose validity we examine as follows:

$$\sigma_t^2 = \omega + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2 \quad (7)$$

Unlike the EGARCH framework, the GARCH model is constrained by the coefficients' signs (i.e., $\alpha_1 \geq 0$, $\beta_1 \geq 0$, and $\alpha_1 + \beta_1 < 1$. Following Fang and Miller (2009), we make use of a two-step method to determine structural break points in the volatility of 10Y sovereign bond returns. First, we apply the Bai and Perron approach mentioned above to the AR (1) model in Eq. (5) to find structural breaks for the mean of the returns. We obtain the residuals "b_t" from this estimation process. Next, following Cecchetti et al. (2006), we identify breaks in the variance.

$$\sqrt{\frac{\pi}{2}|\hat{\varepsilon}_t|} = c + u_t \quad (8)$$

Incorporating dummies in the mean and variance equation

$$b_t = a_0 + a_1 b_{t-1} + d_1 D_1 + \varepsilon_t \quad (9)$$

$$\log(\sigma_t^2) = \omega + (\alpha_1 |z_{t-1}| + \gamma_1 z_{t-1}) + \beta_1 \log(\sigma_{t-1}^2) + d_2 D_2 \quad (10)$$

4. Conclusion

This paper has demonstrated that Pakistan's sovereign bond yields have seen unprecedented surge in recent times and that the high volatility in the yields has been contributed by several factors both domestic and global. Alongside, we also have discussed that volatility is clustered during specific events such as the initial period of the pandemic and a recent episode starting March 2022. For the later episode we have further argued that domestic political instability and the Russia-Ukraine war have been two of the salient factors. Moreover, we have further argued that bondholders' perception of riskiness is susceptible to bad news shocks. Later, we have discussed the extent to which macroeconomic variables such as interest rate; exchange rate; and sufficient FX reserves influence the yields. We have noticed a substantial impact of exchange rate depreciation and depletion of reserves on the uptick in the returns arguably due to the reasons that currency depreciation increases external debt and dwindling FX reserves indicate inability of an emerging economy like Pakistan to pay back its foreign debts. Additionally, the impact of the macroeconomic variables is more pronounced on the bonds with sooner maturity such as 5Y- Sukuk, 5Y, and 10Y than the 30Y maturity bond.

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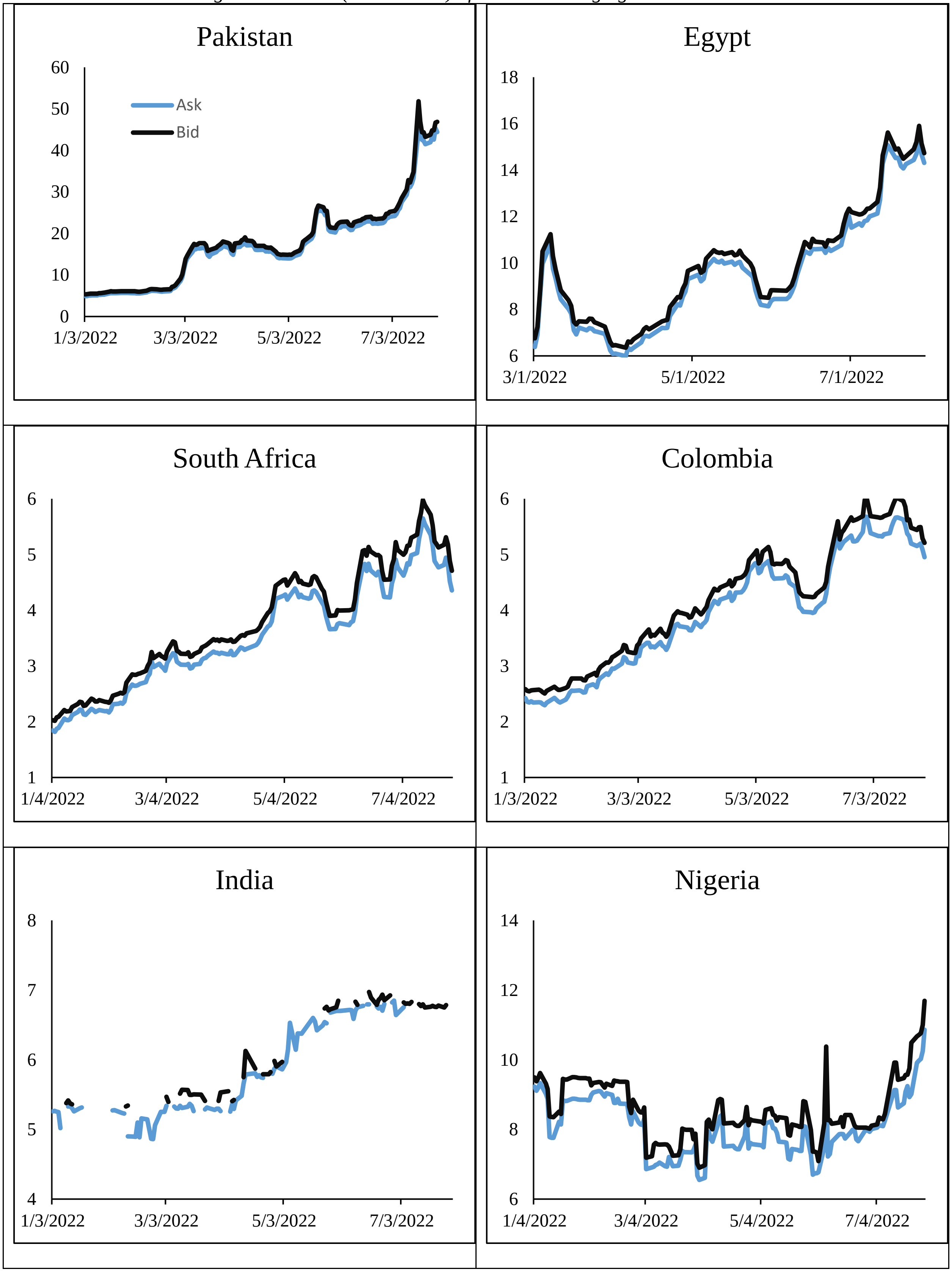
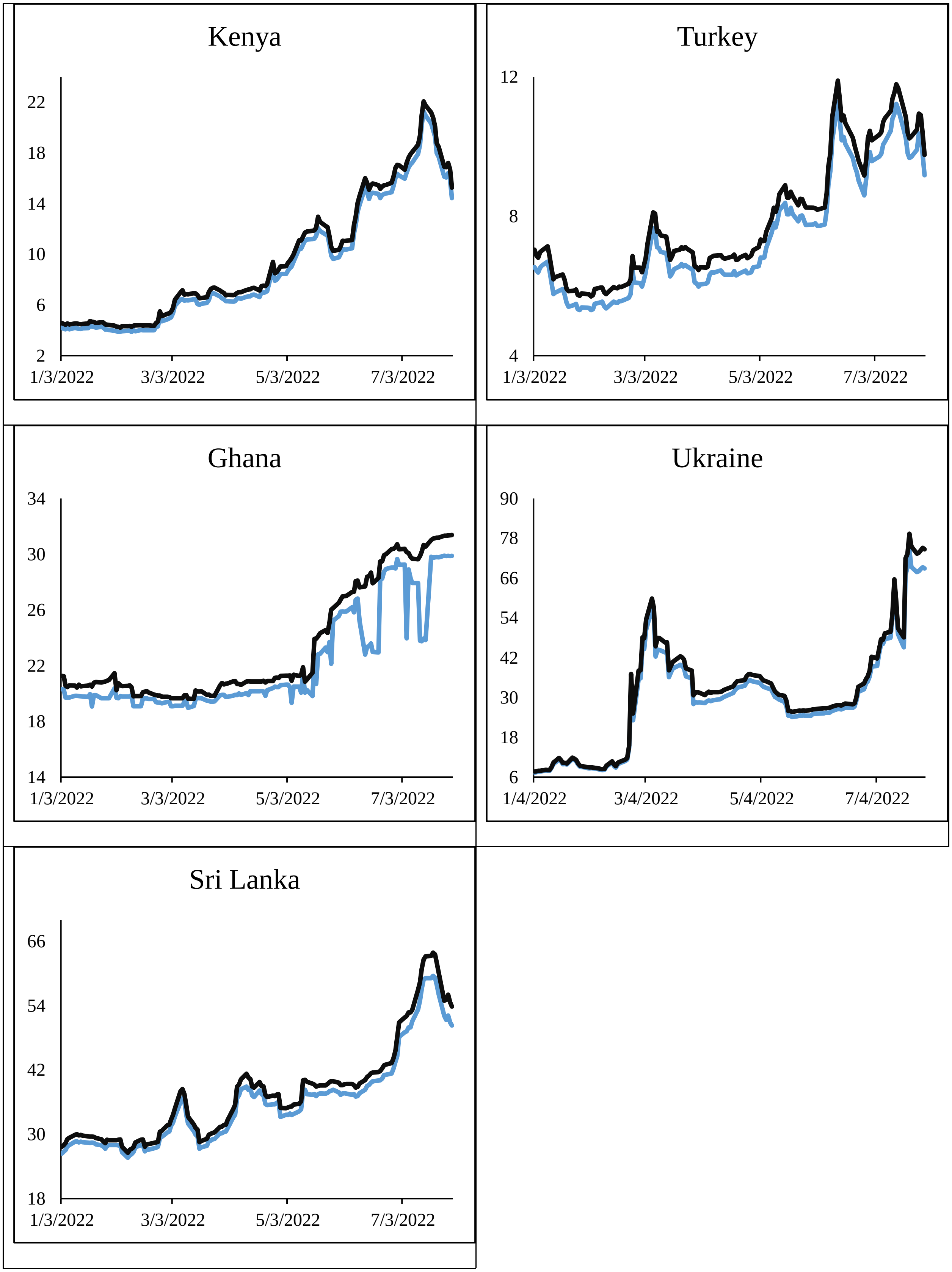
Annexure-I: *10Y Sovereign Bond Yields (Ask and Bid) of selected Emerging Economies*




Kenya
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Sri Lanka
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7/3/2022

`***Annexure-II:*** *Pakistan Sovereign Bond Ratings Since 1994*

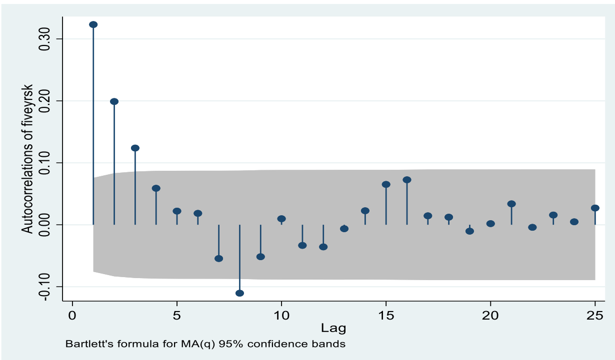
S&P			Moody's			Fitch		
Date	**Rating**	**Outlook**	**Date**	**Rating**	**Outlook**	**Date**	**Rating**	**Outlook**
28-Jul-22	B-	Negative	06-Oct-22	Caa1	Negative	21-Oct-22	CCC+	N/A
04-Feb-19	B-	Stable	02-Jun-22	B3	Negative	18-Jul-22	B-	Negative
30-Oct-16	B	Stable	08-Aug-20	B3	Stable	14-Dec-18	B-	Stable
5-May-15	B-	Positive	14-May-20	B3	Under Review	25-Jan-18	B	Negative
1-Aug-13	B-	Stable	02-Dec-19	B3	Stable	15-Sep-15	B	Stable
9-Jan-13	B-	Stable	20-Jun-18	B3	Negative			
20-Jul-12	B-	Stable	18-May-18	B2	Stable			
24-Aug-09	B-	Stable	11-Jul-17	B3	Stable			
19-Dec-08	CCC+	Developing	9-May-17	B3	Stable			
14-Nov-08	CCC	Developing	27-Apr-16	B3	Stable			
6-Oct-08	CCC+	Negative	11-Jun-15	B3	Positive			
15-May-08	B	Negative	25-Mar-15	Caa2	Positive			
6-Nov-07	B+	Negative	14-Jul-14	Caa2	Stable			
10-Jul-07	B+	Stable	25-Nov-13	Caa1	Negative			
12-Jun-07	B+	Positive	7-Feb-13	Caa1	Negative			
19-Dec-06	B+	Positive	13-Jul-12	Caa2	Negative			
28-Dec-05	B+	Positive	17-Aug-09	B3	Stable			
3-Nov-05	B+	Stable	12-Dec-08	B3	Positive			
1-Nov-05	B+	Stable	28-Oct-08	B3	Negative			
22-Nov-04	B+	Stable	29-May-08	B2	Negative			
2-Dec-03	B	Positive	21-May-08	B2	Stable			
12-Dec-02	B	Stable	11-Nov-07	B1	Negative			
21-Dec-99	B-	Stable	22-Nov-06	B1	Stable			
9-Jul-99	SD	Not Meaningful	8-Nov-06	B2	Positive			
29-Jan-99	SD	Not Meaningful	21-May-06	B2	Positive			
3-Dec-98	CC	Negative	24-Jan-05	B2	Positive			
12-Oct-98	CCC-	Negative	20-Oct-03	B2	Stable			
14-Jul-98	CCC	Watch Negative	7-Nov-02	B3	Positive			
1-Jun-98	B-	Watch Negative	13-Feb-02	B3	Stable			
22-May-98	B+	Watch Negative	6-Oct-01	Caa1	Stable			
14-Jan-98	B+	Negative	17-Jun-99	Caa1	Negative			
31-Jan-97	B+	Stable	23-Oct-98	Caa1	Negative			
3-Aug-95	B+	Stable	28-May-98	B3	Negative			
21-Nov-94	B+	Positive	14-Mar-97	B2	Stable			
			6-Nov-96	B2	Negative			
			23-Sep-96	B1	Negative			
			15-Oct-95	B1	Negative			
			11-Jul-95	B1	Negative			
			23-Nov-94	Ba3	Negative			

Source: State Bank of Pakistan

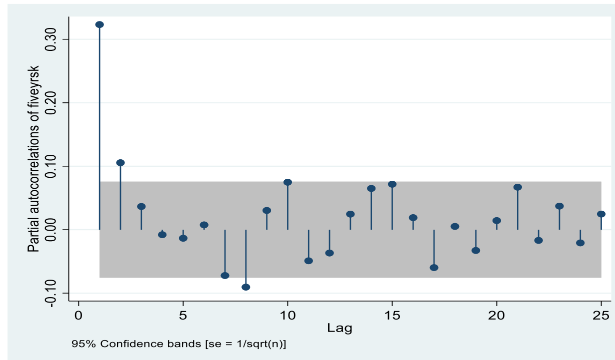
Annexure-III: *Autocorrelations and Partial Autocorrelations Functions for the Bonds*

5Y-Sukuk

Autocorrelation Function

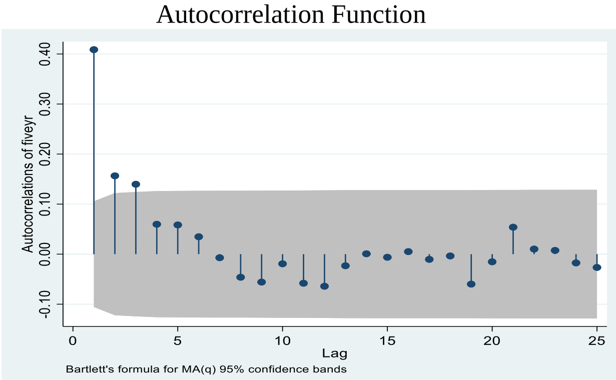


Partial Autocorrelation Function

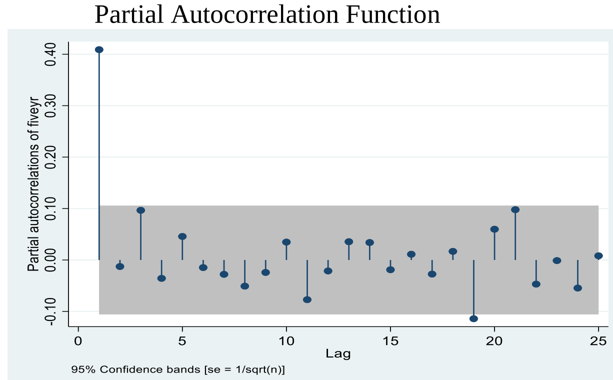


5Y

Autocorrelation Function

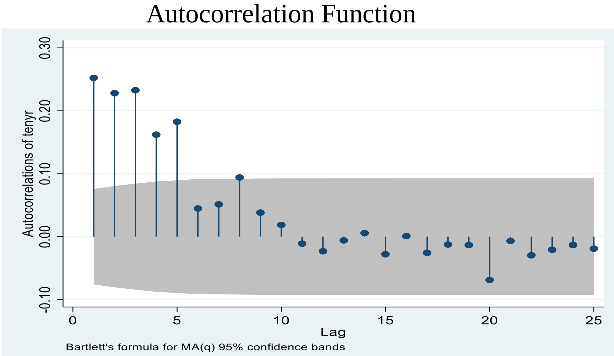


Partial Autocorrelation Function

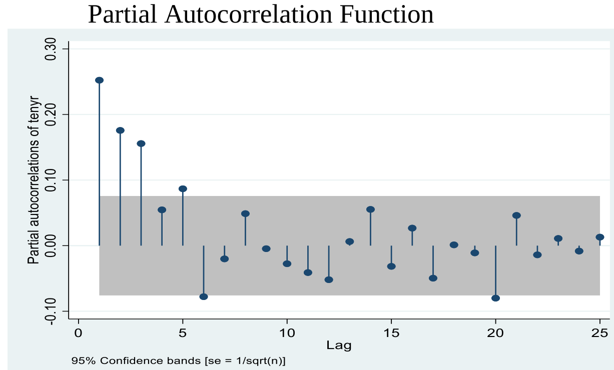


10Y

Autocorrelation Function



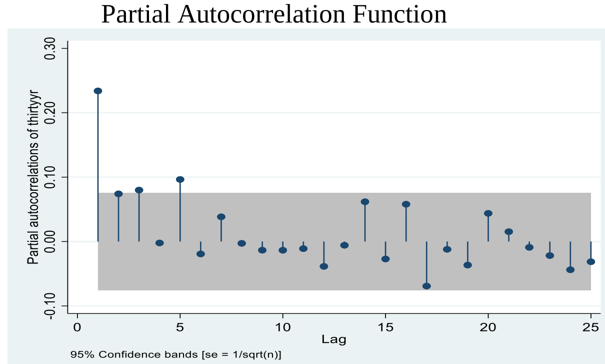
Partial Autocorrelation Function

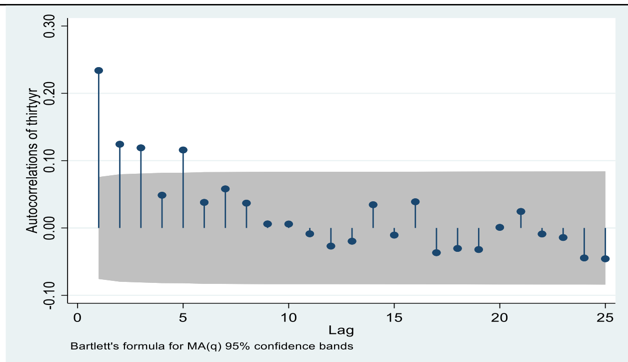


30Y

Autocorrelation Function

Partial Autocorrelation Function





Annexure-IV: *Results of the Volatility Model*

Mean Equation

	5Y-Sukuk (2022) GARCH (1,1)		5Y (2026) GARCH(1,0)		10Y (2024) GARCH(1,0)	
	Coefficient	Z-Stat.	Coefficient	Z-Stat.	Coefficient	Z-Stat.
Constant	14.21*** (-2.43)	5.84	30.16*** (-1.14)	26.54	8.99*** (-1.98)	4.52
Interest Rate	-0.100** (-0.04)	-2.57	-0.34*** (-0.03)	-11.67	-0.07** (-0.03)	-1.98
Exchange Rate	0.24*** (-0.01)	51.81	0.01*** (0.00)	2.93	0.18*** (0.00)	38.45
Import Cover	-0.69*** (-0.15)	-4.55	-1.00*** (-0.09)	-11.12	-0.45*** (-0.16)	-2.77
Sovereign Rating	-18.21*** (-0.83)	-21.98	-11.24*** (-0.24)	-45.87	-13.60*** (-0.69)	-19.46
September'22 Dummy	71.36*** (-0.6)	119.21	16.38*** (-0.2)	61.24	47.00*** (-0.61)	76.19
Sri Lanka'22 Default Dummy			3.38*** (-0.2)	16.73	5.21*** (-0.44)	11.75
EMBI Spreads	0.02*** (0.00)	29.07	0.04*** (0.00)	23.23	0.02*** (0.00)	34.9

Variance Equation

	Coefficient	Z-Stat.	Coefficient	Z-Stat.	Coefficient	Z-Stat.
Constant	15.39*** (-1.21)	12.66	0.92** (-0.43)	2.15	5.66*** (-1.06)	5.3
$Resid(-1)^2$	0.85*** (-0.1)	8.04	1.00*** (-0.17)	5.67	0.25*** (-0.01)	13.05
Import Cover	-1.26*** (-0.24)	-5.08	0.01 (-0.01)	0.94	-0.46* (-0.27)	-1.71

Sovereign Rating	-2.9*** (-0.46)	-6.24	-0.44*** (-0.13)	-3.27		
September'22 Dummy			-0.95 (-0.51)	-0.18		
Sri Lanka'22 Default Dummy					1.29* (-0.74)	1.73
EMBI Spread	-0.01*** (0.00)	-4.47	0.00*** (0.00)	6.37	-0.00*** (0.00)	-7.3

Source: Author's estimates
***, **, and * indicate that the coefficients are significant at 1%, 5%, and 10% levels respectively.
Note: The parentheses contains the standard error of the estimate.

Annexure-V: EGARCH Results

Model estimation: AR-EGARCH versus AR-GARCH

AR(1)-EGARCH(1,1) specification

Conditional mean equation: $b_t = a_0 + a_1 b_{t-1} + \varepsilon_t$

Conditional variance equation: $\log(\sigma_t^2) = \omega + (\alpha_1 |z_{t-1}| + \gamma_1 z_{t-1}) + \beta_1 \log(\sigma_{t-1}^2)$

Parameters	Estimate	S.E	*p-value*
a_0	0.054***	0.013	0.000
a_1	-0.619***	0.026	0.000
ω	-1.758***	0.385	0.000
α_1	-0.656***	0.302	0.029
γ_1	1.925***	0.215	0.000
β_1	0.985***	0.031	0.000
Log-likelihood	11.203		
$Q(12)$	16.717		
p-value	0.161		
$Q^2(12)$	2.186		
p-value	0.999		

AR(1)-GARCH(1,1) specification

Conditional mean equation: $b_t = a_0 + a_1 b_{t-1} + \varepsilon_t$

Conditional variance equation: $\sigma_t^2 = \omega + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2 + d_1 ffr$

	Estimate	SE	*p-value*
a_0	0.002	0.007	0.745
a_1	-0.846***	0.079	0.000
ω	0.007***	0.000	0.000
α_1	0.542**	0.088	0.000
β_1	0.351***	0.068	0.000
ffr	-0.068		
Log-likelihood	38.906		
$Q(12)$	19.041		
p-value	0.08		
$Q^2(12)$	1.693		
p-value	1		

Model estimation: AR-EGARCH versus AR-GARCH (Dummies in the Mean and Variance Equation)

AR(1)-EGARCH(1,1) specification

Conditional mean equation: $b_t = a_0 + a_1 b_{t-1} + d_1 D_1 + \varepsilon_t$

Conditional variance equation: $\log(\sigma_t^2) = \omega + (\alpha_1 |z_{t-1}| + \gamma_1 z_{t-1}) + \beta_1 \log(\sigma_{t-1}^2) + d_2 D_2$

	Estimate	SE	*p-value*
a_0	0.035***	0.016	0.029
a_1	-0.766***	0.049	0.000
dummy	0.116***	0.030	0.000
ω	-2.067***	0.404	0.000

α_1	-0.446	0.313	0.154
γ_1	1.723***	0.195	0.000
β_1	0.276***	0.082	0.000
dummy	0.927***	0.269	0.000
Log-likelihood	17.684		
$Q(12)$	25.078		
p-value	0.014		
$Q^2(12)$	2.195		
p-value	0.999		

Source: Author's calculation

***, **, and * indicate that the coefficients are significant at 1%, 5%, and 10% levels respectively.

Note: $Q(12)$ and $Q^2(12)$ are the Ljung-Box Q statistics up to the 12^{th} orders

Results of the Bai-Perron (1998, 2003) tests		
Panel A: Structural Break in the mean		
Number of breaks selected:		
Sequential:	LWZ:	BIC:
1 break	1 break	1 break
Break date:		
2021M08 (2014)		
Panel B: Structural Break test in volatility		
Number of breaks selected		
Sequential:	LWZ:	BIC:
1 break	1 break	1 break
Break date: 2021M08 (2014M11- 2022M10)		