What Explains the Volatility in Pakistan's Sovereign Bond Yields?

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Abstract

This paper, using a combination of volatility models i.e. GARCH, TGARCH, and EGARCH, tries to explain the domestic and external factors, responsible for volatility in Pakistan's sovereign bond yield-to-maturity of various bond tenors. The paper finds out that within domestic factors, apart from the macroeconomic fundamentals, political changes such as the one that took place in April 2022 did also significantly impact the yields. In addition to the domestic factors, the general riskiness perception of emerging market bonds as measured by Emerging Market Bond Index (EMBI) spreads does also have meaningful repercussions on the yields of Pakistani bonds. Besides, sovereign defaults in the regional economies such as Sri Lanka do also greatly influence the yields by causing an uptick in them.

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1. Introduction

The Sri-Lankan's debt default in May 2022 and the tightening global financial conditions due to monetary policy tightening by central banks in advanced economies have made it difficult for many commodity importing emerging and developing economies, like Pakistan, to tap international capital and financial markets to meet their external financing needs.

The widening current account deficits of commodity importing emerging and developing economies due to confluence of shocks have been further aggravated by and Russia-Ukraine war, which stoked food and energy prices globally in 2022. This accompanied by servicing of existing sovereign dollar-denominated bonds and commercial borrowings have sent the sovereign bond yields of many emerging market economies to elevated levels that have effectively shut 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 as shown at Annexure-I had been persistently rising since March 2022 and had more than doubled by July 2022 in case of many. Further, yields on Pakistan2 bonds of above discussed tenor were trading close to 45 percent by the end of July 2022; standing at third highest place behind only to Ukraine and Sri Lanka in the sample of countries mentioned at *Annexure-I*. Broadly, a substantial uptick has been witnessed in the Emerging Market Bond Index (EMBI) spreads.[3] Due to this perceived risk, investors demand higher compensation on emerging economy sovereign bonds as has been reflected in the rising yields on these bonds. Within this context, the objective of this paper is investigate various factors, both global and domestic, which explains the volatility of Pakistan's sovereign bonds yields over sample span of daily data from January 2019 to October 2022.

Literature on sovereign bond yields suggest that the yields are influenced by a number of economic and non-economic factors pertaining to both global as well as country-specific fundamentals of the bond issuing economies. Investors tend to monitors 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 level can affect the bond yields (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 change may also impact the yields (see, Moser (2007); Packer and Woolridge (2003); Cevik and Jalles (2022), and Kaminsky and Schmukler (1999)).

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[2] Pakistan has historically availed financing from a variety of sources and the multilateral financing has dominated while sovereign bonds have remained relatively smaller portion of the overall borrowings. Pakistan first tapped the sovereign bond market in 1994 with its first ever issue; subsequently, remained cutoff for a period of roughly seven years from 1997 to 2004 mainly owing to the sanctions due to 'the Nuclear Tests in 1998'. Moreover, the country issued first-ever Islamic bonds i.e. 'Sukuk' in 2005.

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

Literature also presents ample evidence that global factors also influence sovereign bonds yields (see, Kariyawasam and Jayasinghe (2022)). Key global factors are: shock(s) in major economies and policy response to these shocks in the form of interest rates changes in advanced economies and fiscal stimulus as has been witnessed recently. Moreover, contagion and shock spillovers could affect investor's sentiments and could result into reversal of capital flights from emerging economies due to flight to safe assets of advanced economies particularly the US treasuries (see, Johri et al. (2022) and Li (2021)).

More recent contribution, Paule-Vianez et al. (2021) [4] 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. Paule-Vianez et al. (2021) used the search volume, which is selected as the proxy for COVID-induced fear, extracted from Google Trends to explore the influence of COVID-induced fear on sovereign bond markets.

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

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

2. Data

In our research, we use the daily data of the following variables: yield-to-maturity of Pakistan sovereign bonds of various tenors as mentioned in the Table No. 01 below; Emerging Market Bond Index (EMBI) spread; Marked-to-market exchange rate PKR/USD; Interest Rate (KIBOR[5]); The data source for the first two variables is Bloomberg; later two variables is State Bank of Pakistan while the last variable is Pakistan Stock Exchange. Yield-to-maturity data has been extracted for all the available tenors i.e. 5-year (5Y); 10-year (10Y); and 30-year (30Y). The *Table No. 01* below provides a snapshot of the bonds of various tenors currently being traded. Alongside the above-noted variables, we also introduce four other explanatory variables: two of which are dummies while the remaining two namely are import cover and sovereign rating. We have computed import cover as the months of total imports that are covered by the available net reserves of the central

[4] (Germany, Canada, the United States, France, Italy, Japan, and the United Kingdom)

[5] Karachi Interbank Offer Rate (Interbank Benchmark Borrowing/Lending Rate)

bank. Besides, sovereign ratings have been quantified from the available ratings of the sovereign ratings agencies as provided at *Annexure II* by assigning them equal weights.

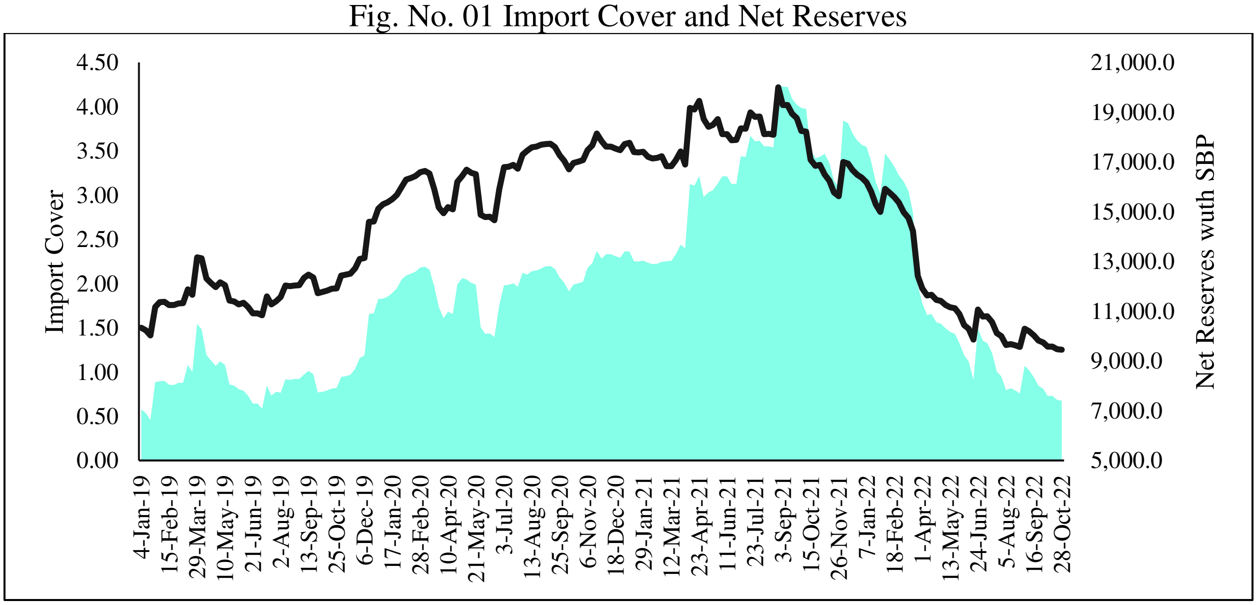
Table No. 01: Current Sovereign Bond Issues as of July 2022

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

Source: State Bank of Pakistan

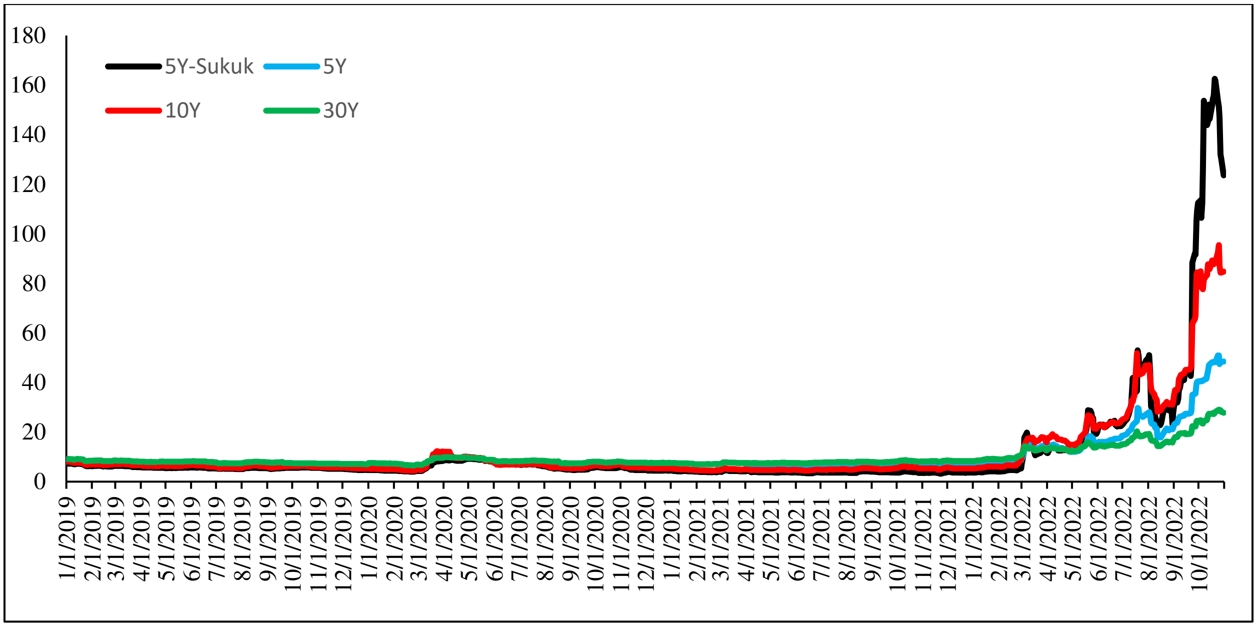
There has been noticed a visible and unprecedented increase in the yields of bonds of various tenors recently as witnessed in the *Fig No. 02* below due to a number of factors discussed earlier. In our sample, prior to the current huge increase, a noteworthy surge in the yields was observed during March 2020 due to the COVID-19 outbreak. We see that 2019 was a calm year for the yields as the domestic economy was doing fairly well, and there was not any issue of global concern. Thereafter, yields rose in March 2020 momentarily and later settled down while remaining steady until March 2022. Moreover, these yields seem to have very strong co-movements across bonds of distinct maturities. For our empirical analysis involving the use of volatility models our sample ranges from January 2019 to October 2022.

Fig. No. 01 Import Cover and Net Reserves



Source: Author's calculations

Fig. No. 02: Yield-to-Maturity Pakistan Sovereign Bonds



Data Source: Bloomberg

The *Table No. 02* below shows the correlations between yields of various tenors, and we can observe that these yields tend to be highly correlated. Further, yield of 5Y-Sukuk are 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 compared with its correlation with other bonds.

Table No. 02: Pairwise Correlations of Bond Yields

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

Source: Author's estimates

Additionally, in *Table No. 03*, which shows quarterly statistics of yields, we can observe a substantial increase in the yields in 2022Q2 followed by a drastic increase in 2022Q3.

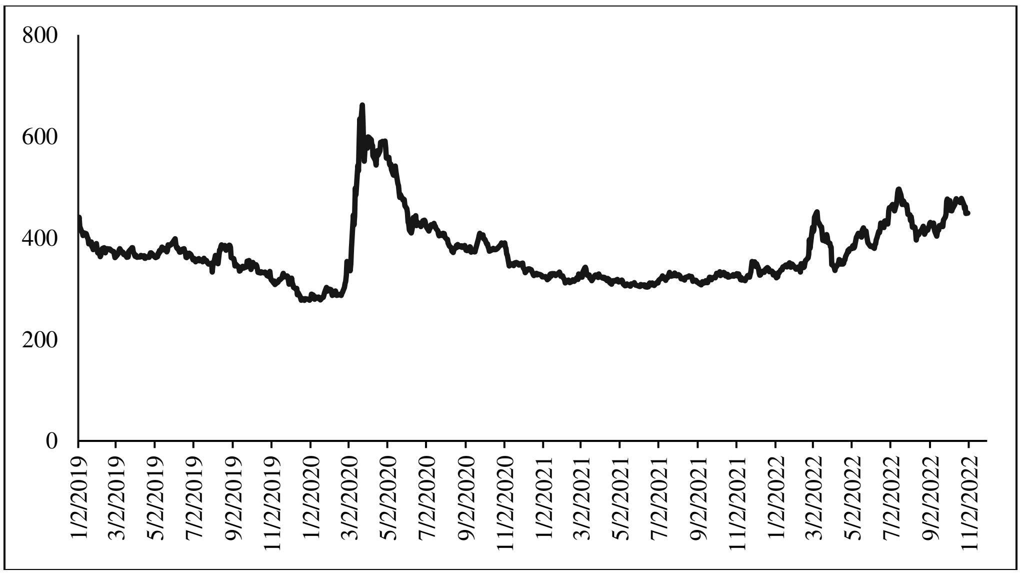
In July 2022, apart from the global contributors to the rising yields as seen in the rise in the EMBI Spreads as Shown in the *Fig No. 03*, there was enormous economic policy uncertainty in the country as reflected in the monthly Economic Policy Uncertainty index of Pakistan shown in the *Fig No. 04* below. The domestic factors that may have given rise to yields could be political chaos; current account deficit; IMF program related uncertainty; 2nd highest-ever economic policy uncertainty on record. On account of these myriad factors, Pakistan sovereign bond ratings had been downgraded by all the major rating agencies during June and July 2022 as shown at *Annexure-II.*

Table- 03: Descriptive Statistics of Bond Yields									
Five-Year (Sukuk)									
2019Q1	**2019Q2**	**2019Q3**	**2019Q4**	**2020Q1**	**2020Q2**	**2020Q3**	**2020Q4**	**2021Q1**	**2021Q2**
6.47	5.60	5.35	5.27	5.11	8.20	5.73	5.04	4.13	3.74
0.45	0.11	0.16	0.34	1.36	0.86	0.84	0.54	0.21	0.18
5.85	5.35	5.06	4.72	4.06	6.83	4.73	4.40	3.73	3.35
7.38	5.84	5.61	5.77	8.46	9.84	7.03	5.96	4.61	4.27
Five-Year									
2019Q1	**2019Q2**	**2019Q3**	**2019Q4**	**2020Q1**	**2020Q2**	**2020Q3**	**2020Q4**	**2021Q1**	**2021Q2**
…	…	…	…	…	…	…	…	…	5.47
…	…	…	…	…	…	…	…	…	0.12
…	…	…	…	…	…	…	…	…	5.22
…	…	…	…	…	…	…	…	…	5.82
Ten-Year									
2019Q1	**2019Q2**	**2019Q3**	**2019Q4**	**2020Q1**	**2020Q2**	**2020Q3**	**2020Q4**	**2021Q1**	**2021Q2**
7.11	6.38	5.91	5.81	6.18	8.85	6.21	5.92	4.84	4.72
0.43	0.16	0.32	0.33	2.53	1.60	0.67	0.50	0.26	0.10
6.59	6.01	5.44	5.28	4.43	6.79	5.37	5.32	4.43	4.45
8.06	6.77	6.56	6.39	12.31	12.08	7.16	7.00	5.31	4.97
Thirty-Year									
2019Q1	**2019Q2**	**2019Q3**	**2019Q4**	**2020Q1**	**2020Q2**	**2020Q3**	**2020Q4**	**2021Q1**	**2021Q2**
8.54	8.06	7.65	7.26	7.58	9.08	7.96	7.73	7.34	7.51
0.30	0.11	0.21	0.12	0.93	0.67	0.43	0.18	0.24	0.08
8.07	7.82	7.34	7.05	6.55	8.13	7.33	7.55	7.00	7.39
9.17	8.32	8.04	7.46	9.63	9.88	8.51	8.17	7.77	7.70

2021Q3	**2021Q4**	**2022Q1**	**2022Q2**	**2022Q3**
3.79	3.71	7.43	18.45	41.18
0.20	0.20	4.62	5.26	20.85
3.52	3.19	3.69	11.55	22.73
4.21	4.22	19.76	28.82	112.44
2021Q3	**2021Q4**	**2022Q1**	**2022Q2**	**2022Q3**
5.82	6.19	9.46	15.02	24.89
0.15	0.25	3.34	1.94	14.98
5.58	5.75	6.06	12.06	17.82
6.17	6.83	15.13	18.49	40.47
2021Q3	**2021Q4**	**2022Q1**	**2022Q2**	**2022Q3**
5.10	5.49	9.82	20.20	40.65

0.21	0.28	5.01	3.63	13.18
4.74	4.82	5.33	14.86	25.21
5.52	6.14	18.04	26.73	84.42
2021Q3	**2021Q4**	**2022Q1**	**2022Q2**	**2022Q3**
7.88	8.31	10.57	13.87	17.98
0.11	0.14	1.96	0.93	2.40
7.66	7.94	8.35	12.29	14.41
8.14	8.64	14.22	15.89	24.53

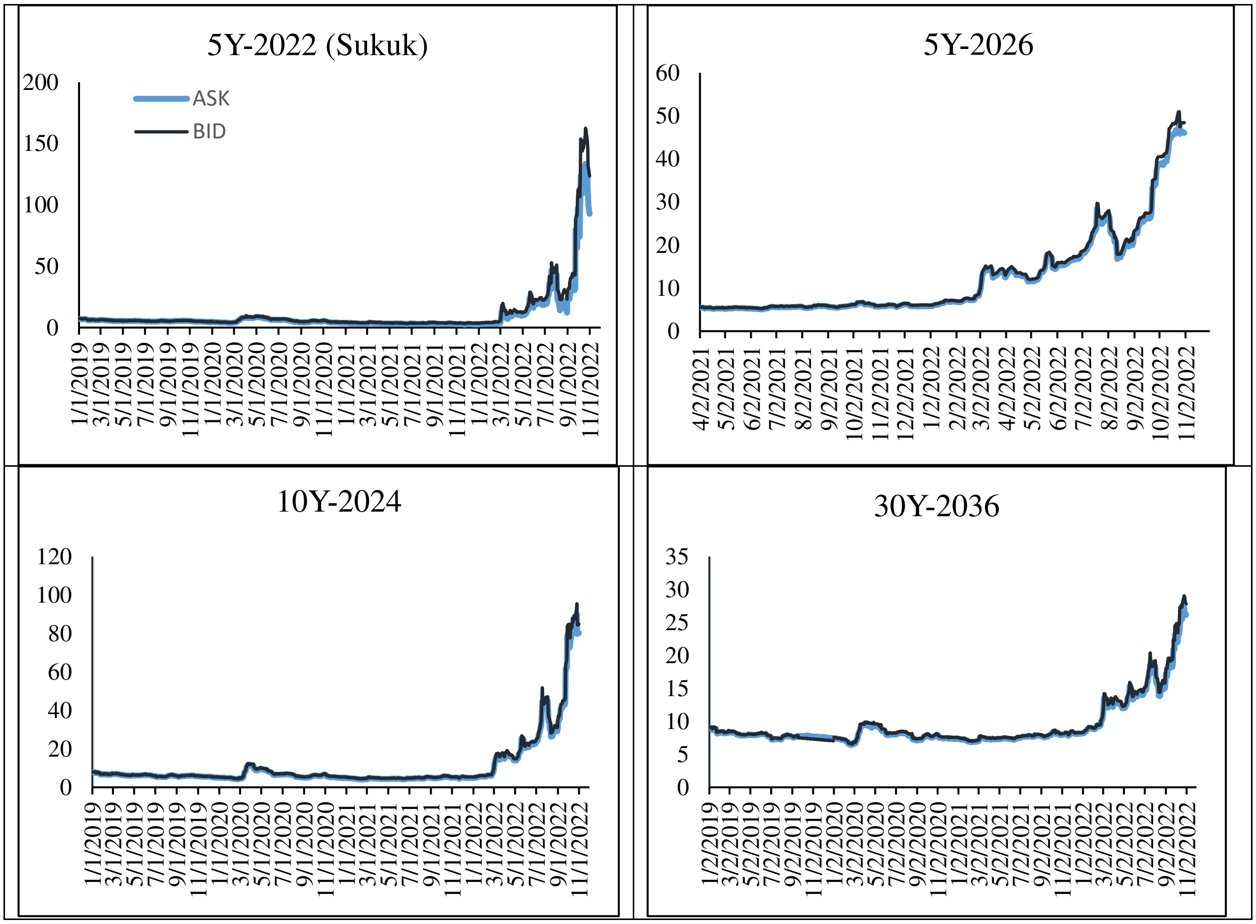
Fig No. 03: Emerging Market Bond Index (EMBI) Spread



Source: Bloomberg

Additionally, the *Fig No. 05* below shows that the Bid-Ask spread between yields has been extremely narrow for all other bonds except Sukuk implying lower liquidity in the Sukuk Market.

Fig No. 05: Sovereign Bond Bid-Ask Spread



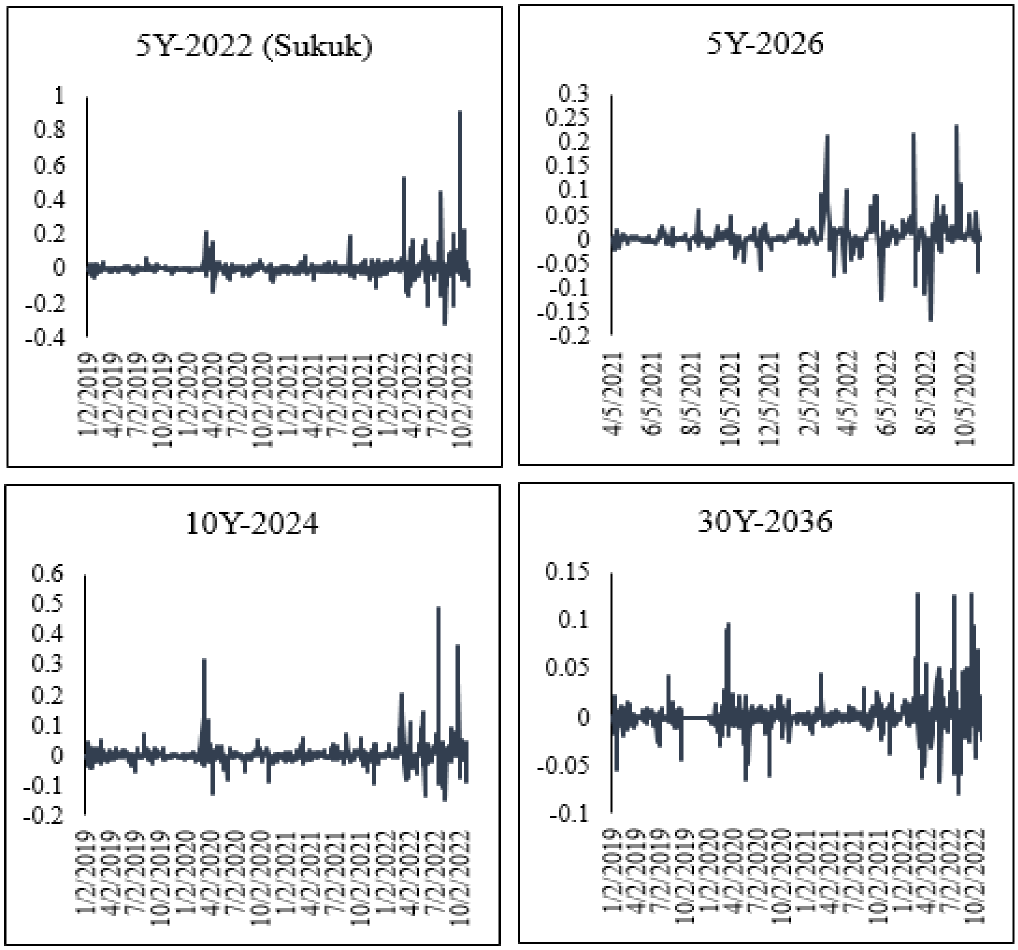
Data Source: Bloomberg

3. Methodology

An important measure in Finance is the risk associated with an asset, and asset volatility is the most commonly used risk measure. 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 at the following graphs of daily percentage changes.

First of all, we establish presence of the volatility clusters by arguing that volatility has some inertia as it does not fade away quickly. Subsequently, making use of a variety of volatility models i.e. ARCH, GARCH, TARCH, and EGARCH. First, we shed light on some of the domestic factors that cause volatility. Second, 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. Third, we try to explain whether bad news shocks have any bearing on the yields. Fourth, we compute model-driven structural breaks based on the Bai-Perron methodology and later incorporate the structural break as a dummy to find out the impact. Finally, we introduce some other explanatory variables in the mean and variance equations in the volatility models to check whether these variables do cause a surge in volatility and to what extent.

Fig No. 06: Sovereign Bond Volatility



Data Source: Bloomberg

We observe the presence of ‘Volatility Clusters’ (i.e. volatility is high for certain time periods and low for other periods). For example, there had been volatility during the initial days of the pandemic in March 2020. In addition, there has been volatility of a large scale since March 2022 due to a variety of factors discussed before. Moreover, we also notice that volatility evolves over time in a continuous manner (i.e. volatility jumps are rare), and that volatility does not diverge to infinity (i.e. volatility varies within some fixed range, statistically speaking this means that the volatility is often stationary)

In order 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, so the presence of volatility clusters is problematic.

3. 1 Testing for ARCH effects

ARCH effect helps us determine if a series has volatility clustering. First of all, we generate Autocorrelation and Partial Autocorrelation graphs attempting to look for significant autocorrelation in the squared residuals. Large changes in the returns tend to cluster together, and small changes tend to cluster together. That is, the series exhibits conditional heteroscedasticity. The graphs at *Annexure-III* show signs of volatility clustering as depicted through various graphs, but we can formally test it 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 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 No. 04: 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

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

Based on the above results, we can suggest for the presence of ARCH effects for all of bonds noted above except for the 10Y bond.

3.2 Determining the Volatility on Account Domestic and Global Factors

3.3.1 Domestic Factors: Change of Government in April 2022

In line with the literature that stresses upon the fact that political turmoil increases sovereign bond yields, we try to assess if this holds true for a noteworthy recent episode of tremendous political anarchy i.e. Change of Government through the vote of no-confidence that took place on April 10, 2022.

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

If γ is significantly positive, we can conclude that change of government did in fact increase the volatility of bond yields. Interestingly enough, in line with our premise, the change of government has a catastrophic impact on the volatility; it caused volatility to increase for all the bonds as can been seen in the results below. These results have important lessons to draw on for Pakistan—there is a tremendously high borrowing cost of political uncertainty. During the times of political anarchy, investors may find that a change of government course reverse the ongoing policies that may exacerbate the economic landscape.

Table No. 06: Volatility on Account of the Govt. Change

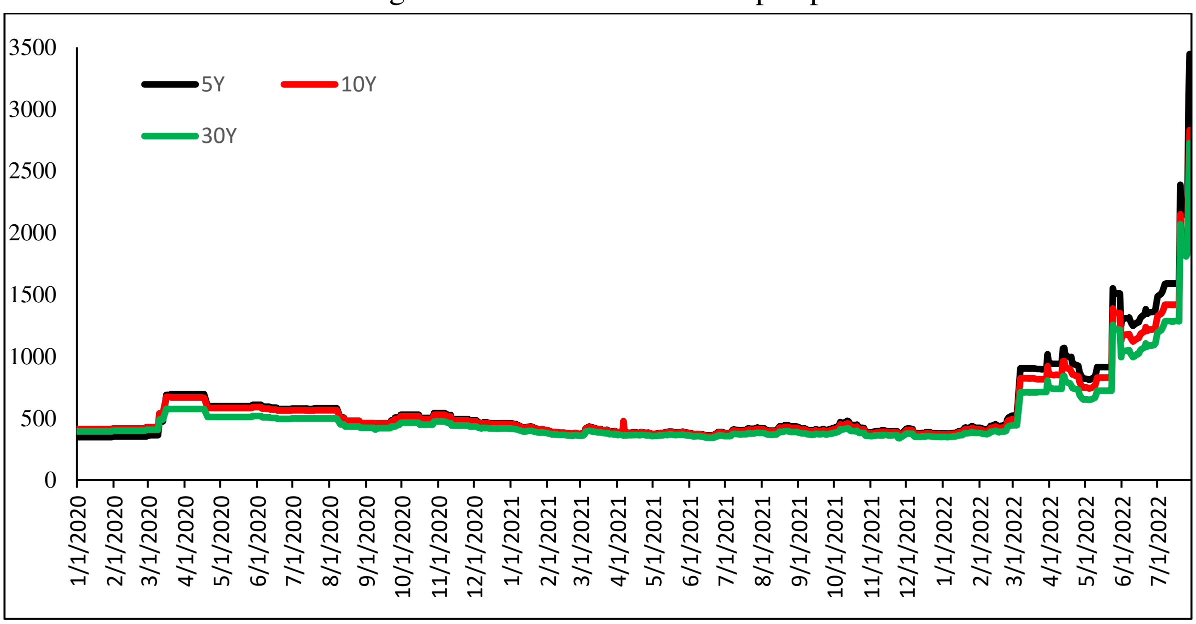
TARCH L1.	Coef.	Std. Err.	[95% Conf. Interval]	
5Y-Sukuk	24.17143***	.0535777	24.066	24.276
5Y	2.138176***	.0817357	1.978	2.298
10Y	2.93113***	.0592307	2.815	3.047
30Y	3.521***	.1656237	3.197	3.846

Source: Author's estimates

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

Furthermore, we can notice in the *Fig No. 07* below that Credit Default Swaps spreads[6] on Pakistani bonds have been persistently rising since March 2022, and the change of government that caused the volatility to increase as mentioned above may have engendered massive amount of uncertainty amongst investors to demand higher premium on Pakistani bonds.

Fig No. 07 Credit Default Swaps Spreads



Source: Bloomberg

Moreover, the other three domestic variables we use are the interest rate (KIBOR), Marked-to-Market PKR/USD exchange rate and KSE 100 Index all in the growth form. Using the GARCH

[6] 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.

(1, 1) model as per the description below. We introduce these as explanatory variables for the increase in bond yields. The results are provided at *Annexure-IV*; the results are statistically significant for exchange rate for the 5Y and 10Y bond, but not the 5Y-Sukuk, or 30Y bond which implies that appreciation of the exchange rate serves to lower the yields as the exchange rate depreciation further aggravates debt burden, so an appreciation is viewed positively by the investors. Furthermore, an improvement in the stock performance improves (lowers) the yield of the bond maturing soon i.e. 5Y-Sukuk; this improvement shows signs of improving economic outlook in the short-run and hence raises confidence of the bond investors as well.

<u>A Description of GARCH (1, 1) Model</u>

$$h_t = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 \alpha_1 \varepsilon_{t-2}^2 + {\beta_1}^2 \alpha_1 \varepsilon_{t-3}^2 + \ldots$$

Add and subtract $\beta_1 \alpha_0$ and rearrange the terms as follows:

$h_t = (\alpha_0 - \beta_1 \alpha_0) + \alpha_1 \varepsilon_{t-1}^2 + \beta_1(\alpha_0 + \alpha_1 \varepsilon_{t-2}^2 + \beta_1 \alpha_1 \varepsilon_{t-3}^2 + \ldots)$ Since, $h_{t-1} = \alpha_0 + \alpha_1 \varepsilon_{t-2}^2 + \beta_1 \alpha_1 \varepsilon_{t-3}^2 + {\beta_1}^2 \alpha_1 \varepsilon_{t-4}^2 + \ldots$ We may simplify to $h_t = \delta + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 h_{t-1}$

This is called GARCH (1, 1) model. The model is a very popular specification because it fits many data series well. One reason why this model is so popular is that it can capture long lags in the shocks with only a few parameters. One of the shortcomings of an ARCH(q) model is that there are 'q + 1' parameters to estimate '¡' If q is a large number, we may lose accuracy in the estimation '¡' The generalized ARCH model, or GARCH, is an alternative way to capture long lagged effects with fewer parameters.

3.3.2 Global Factors:

3.3.2.1 COVID-19

The COVID-19 pandemic caused sovereign bond yields of several emerging market economies to increase due to the perceived risk. The first case of the pandemic in Pakistan was reported on February 26, 2020. We try to test this assumption whether on the yields of Pakistan sovereign bond yields of different by introducing a dummy variable named 'Pandemic' which assumes the value of '1' after the reporting of the first case as detailed above and '0' before

Table No. 07: Volatility on Account of the Pandemic

	Coef.	Std. Err.	z	[95% Conf. Interval]	
5Y-Sukuk	2.801***	.094	29.94	2.618	2.985
10Y	1.327***	.084	15.73	1.162	1.492
30Y	2.680***	.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.

The Table No. 07 has an interesting finding: volatility did increase for relatively shorter-duration bond of ten years compared with the longer duration bond of 30Y.

3.3.2.2 Surge in EMBI post Russia-Ukraine War

For the other global factor which is felt across an array of emerging economies, I use the EMBI spreads as a control variable and the results are provided at *Annexure-III.* Canuto (2022) suggest that a rise in EMBI spreads aftermath the Russian invasion of Ukraine has created outflows from emerging economies and has caused the yields on emerging markets bonds to increase and our finds do also resonate with theirs. This is plausibly due to interest rate hike introduced by the advanced economies owing 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 that investments in the former ones are safer; this particularly happens during shocks of global scale such as the Pandemic; the Great Recession; and the Taper Tantrum[7] of 2013.

Further to reinforce our findings above due to domestic and global factors, we next investigate whether bad news have any bearing on the yields in the context of Pakistan. Caporale et al. (2018) show the abrupt impact of bad news on the yields. Below, we use the T-GARCH model to come up with findings for the aforementioned case.

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

TARCH or Threshold ARCH and Threshold GARCH were introduced independently by Zakoïan (1994) and Glosten, Jaganathan, and Runkle (1993); it lets good and bad news to affect volatility differently. Volatility increases with negative information: "Bad" news have more noticeable effect on volatility of asset prices than "good" news do. 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

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

If $\lambda_1 > 0$ Volatility increases

Where

$$d_{t-1} = 1 \;\; if \;\; \varepsilon_{t-1} < 0 \qquad \rightarrow \text{Bad news} \tag{3}$$

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

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

This is very intuitive as follows

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 then positive shocks.

If the coefficient is statistically significantly different from zero, we conclude there is a threshold effect. The *Table No. 05* below shows that the bad news shocks do increase volatility of yields of bond of different tenors; results are statistically significant for all the tenors; the results of the coefficients are highly statistically significant. In addition, we can also see in *Fig No. 04* that uncertainty rises in times of distress such as the initial period of COVID-19 and the recent domestic and international economic chaos triggered by rising commodity prices, depreciating currencies, and recessionary fears.

Table No. 05: Volatility Due to 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

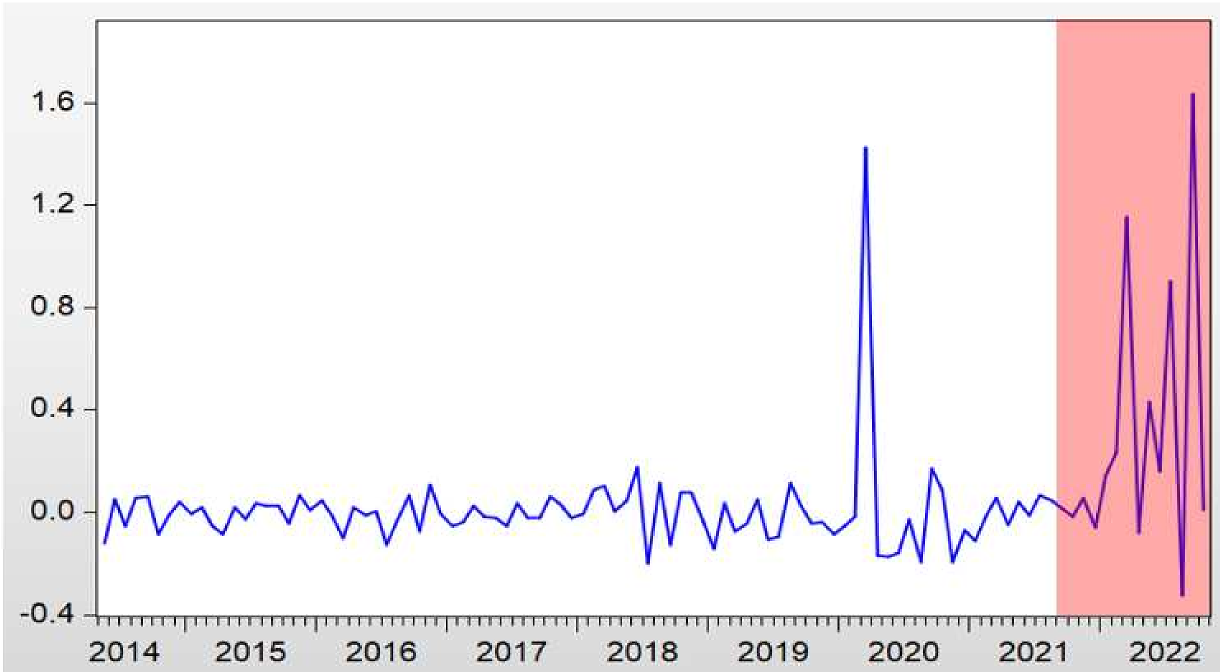
In order to look for structural break, we take a 10-year bond as detailed in the *Table No. 06* below. We determine structural break in the bond yields using Bai and Perron (Econometrica 66:47–78, 1998, J Appl Econ 18:1–22, 2003) as adopted by Tamakoshi and Hamori (2013), which accommodates endogenous identification of break dates. We observe one break in volatility 2021M08 as depicted in the *Fig No. 08*; thereafter, the yields continuously increased to unprecedented proportions. 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 No. 06: Ten Year Sovereign Bond Maturing in 2024

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

Source: State Bank of Pakistan

Fig No. 08: Identifying the Structural Break



The *Table No. 07* sheds light on the descriptive statistics. 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 implies that the data are not normally distributed.

Table No. 07: Descriptive Statistics

Overall Sample

	Mean (%)	Min (%)	Max (%)	SD	Skewness	Kurtosis	Jarque-Bera
b_t	4.55	-32.38	163.41	0.27	4.16	19.29	1874.57

Author's calculation

We first employ the Autoregressive (AR) model for the bond return series. Using the Bayesian Information Criterion (BIC), we select the AR (1) process for the conditional mean equation denoted by

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

For the conditional variance of returns, we use the EGARCH model for these 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 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 in the following analysis

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

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 ten-year Pakistan sovereign bond yields. First, we apply the Bai and Perron approach mentioned above to the AR (1) model in Eq. (7) to find multiple structural breaks for the mean of b_t. We obtain the residuals "b_t from this estimation process. Next, following Cecchetti et al. (2006), we identify breaks in the variance.

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

Incorporating dummies in the mean and variance equation

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

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

3.5 Introducing More Explanatory Variables

In addition to the above factors, we introduce some explanatory variables in the mean and variance equation of GARCH/ARCH models namely interest rate; exchange rate; import cover; sovereign rating; September' 22 dummy; Sri Lanka' 22 default dummy. Our results as shown at *Annexure IV* suggest that an increase in domestic interest rate causes a decrease in the sovereign bond yields which might be because of the central bank's response to curb inflation. In addition, a depreciation of exchange rate causes the yields to increase because of the perception that depreciation of the domestic currency causes the external debt to increase. Further, an improvement in the import cover helps lower the yields 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 in the sovereign rating causes a substantial reduction in the sovereign yield to maturity. Concerning the use of 'Sri Lankan Default Dummy' and 'September'22 Dummy' our results are compelling in a sense that both significantly push the yields in an upward direction. The later dummy exemplifies a period marked by noticeable rise in domestic uncertainty.

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 a number of factors both domestic and global. Alongside, we also have discussed that volatility is clustered during particular periods such as the initial period of the pandemic and a recent episode starting March 2022. Regarding the later episode we have further argued that domestic political chaos 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 yields arguably due to the reasons that currency depreciation increase 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 instead of the 30Y longer-term maturity bond.

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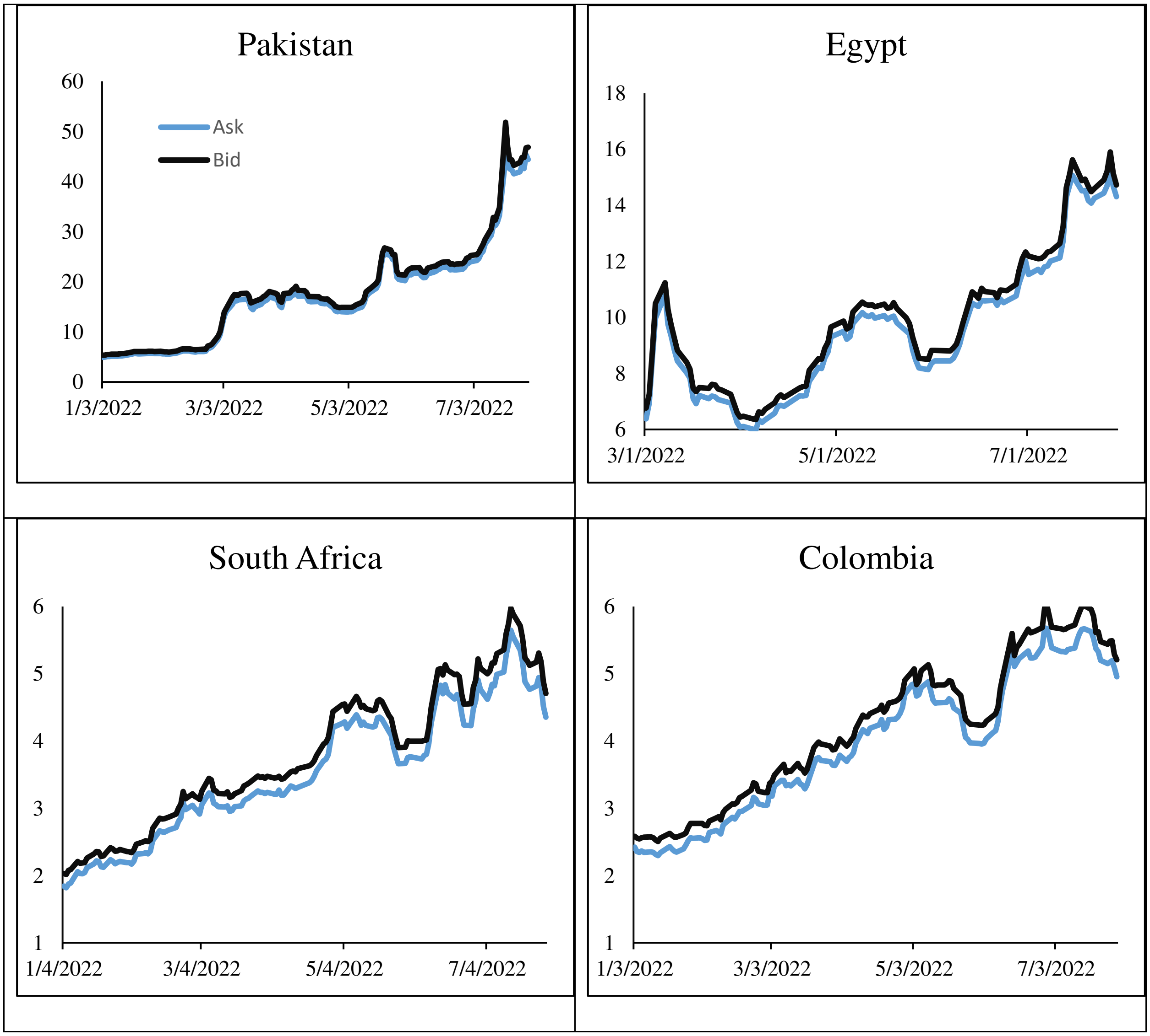
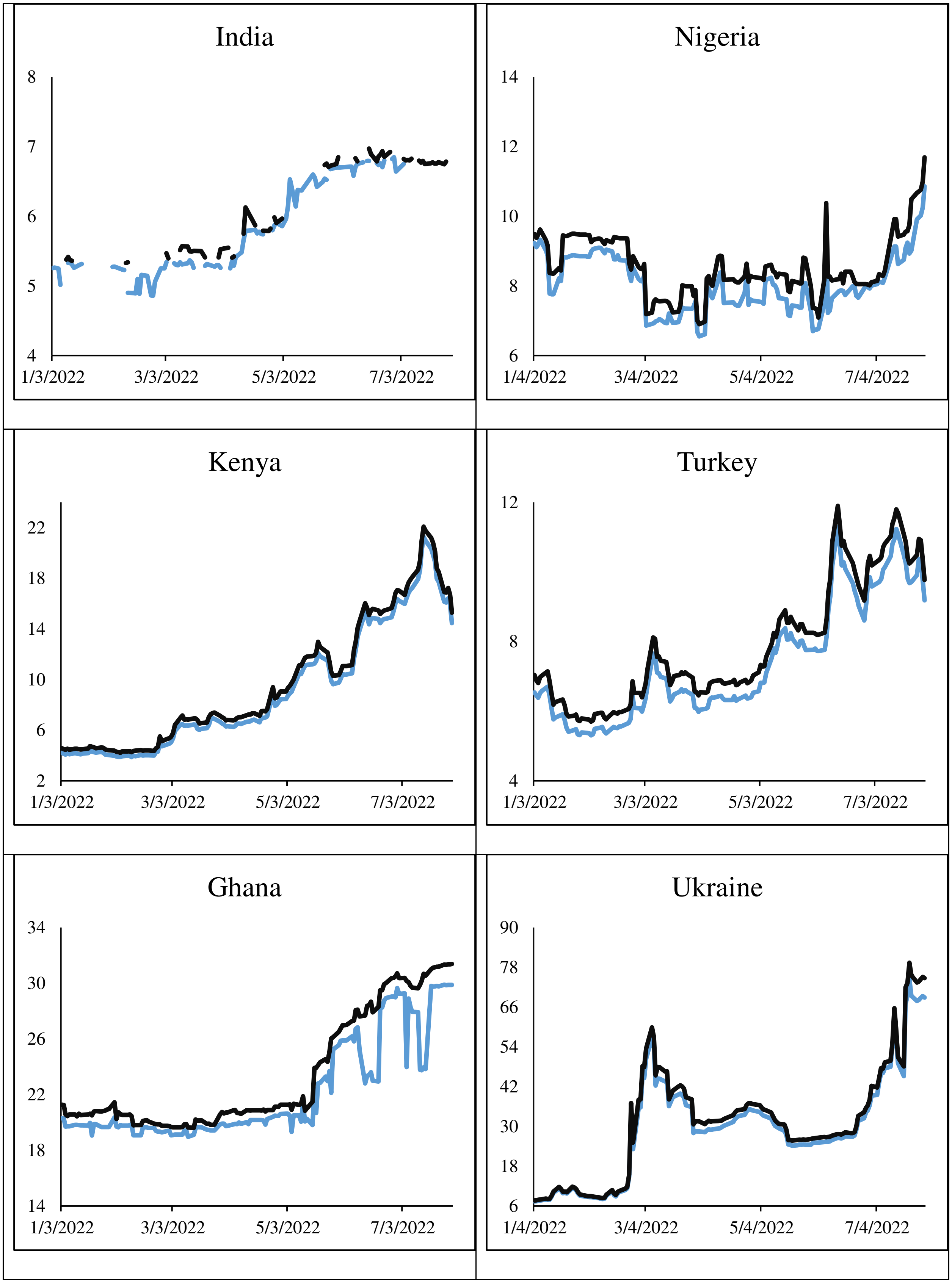
Annexure-I: 10Y Sovereign Bond Yields of Some Emerging Economies




India
8
7
6
5
4
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3/3/2022
5/3/2022
7/3/2022
Nigeria
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8
6
1/4/2022
3/4/2022
5/4/2022
7/4/2022
Kenya
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6
2
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3/3/2022
5/3/2022
7/3/2022
Turkey
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Ghana
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5/3/2022
7/3/2022
Ukraine
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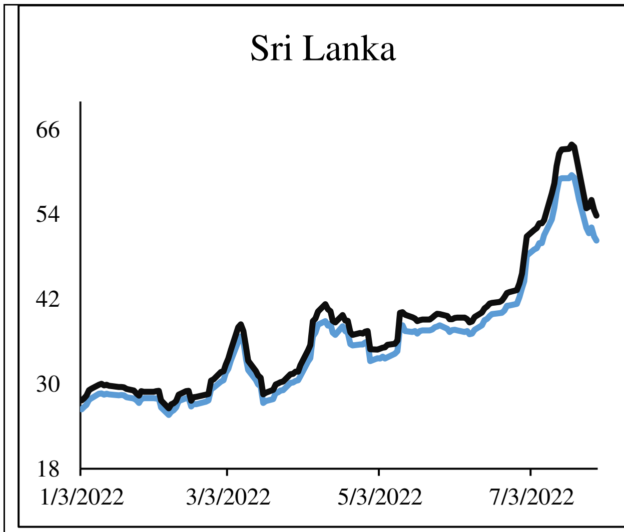
7/4/2022



Annexure-II: Pakistan Sovereign Bond Ratings

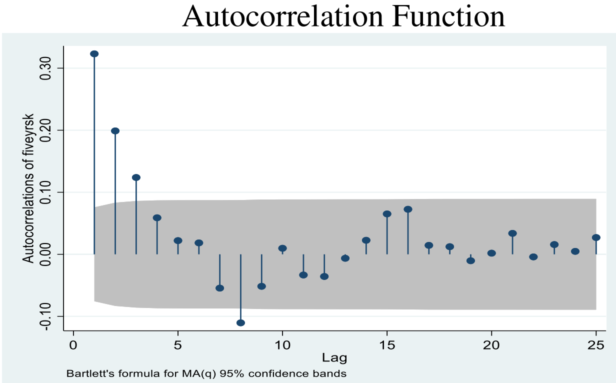
Pakistan's Sovereign Ratings Since 1994								
S&P			**Moody's**			**Fitch**		
Date	**Rating**	**Outlook**	**Date**	**Rating**	**Outlook**	**Date**	**Rating**	**Outlook**
28-Jul-22	B-	Negative	06-Oct-22	Caa1	Negative	21-Oct-22	CCC+	N/A
04-Feb-19	B-	Stable	02-Jun-22	B3	Negative	18-Jul-22	B-	Negative
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			

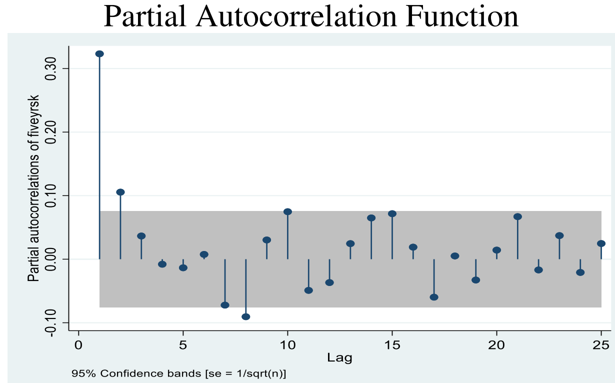
Annexure-III: Autocorrelation and Partial Autocorrelation Graphs

5Y-Sukuk

Autocorrelation Function

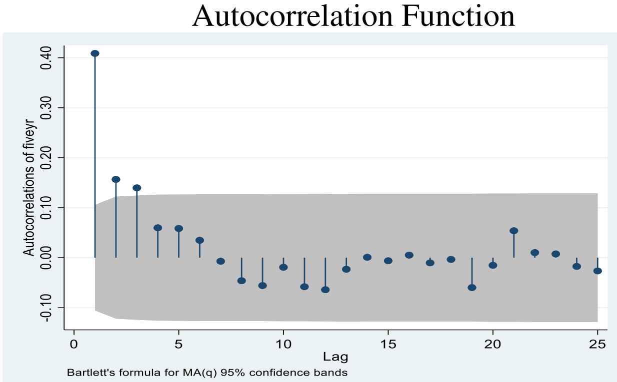


Partial Autocorrelation Function

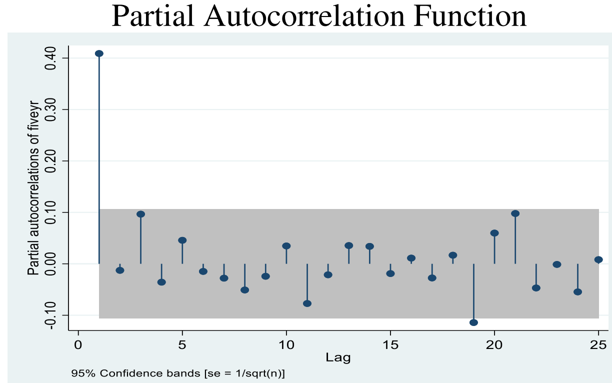


5Y

Autocorrelation Function



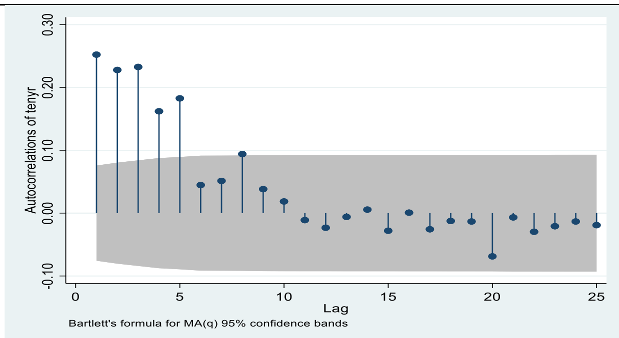
Partial Autocorrelation Function

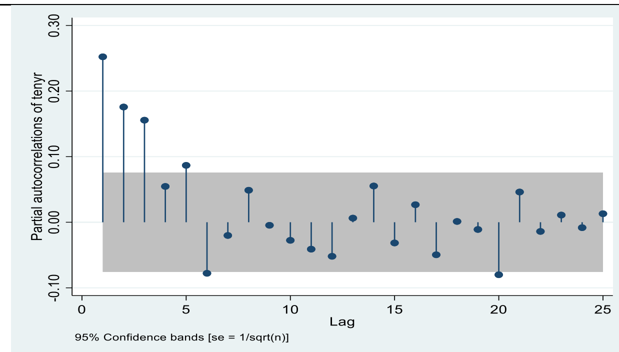


10Y

Autocorrelation Function

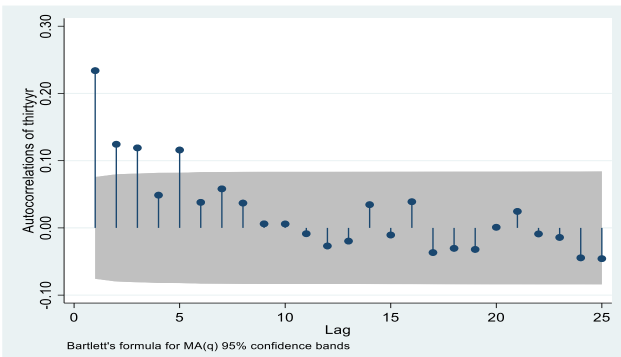
Partial Autocorrelation Function



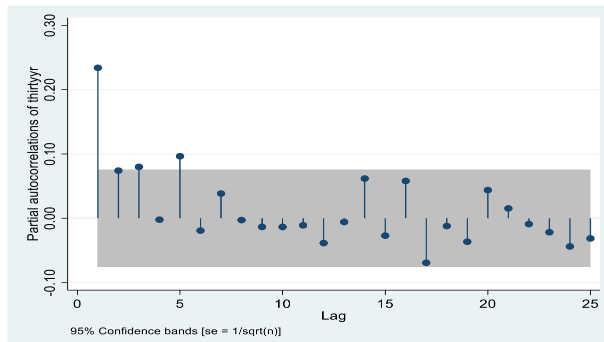


30Y

Autocorrelation Function



Partial Autocorrelation Function



Annexure-IV: Daily Change

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.
C	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

C	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) (-0.01)	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
Rating	-2.9*** (-0.46)	-6.24	-0.44*** (-0.13)	-3.27		
September'22 Dummy			-0.95	-0.18		

			(-0.51)			
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.

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:		
	$\log(\sigma_t^2) = \omega + (\alpha_1 \lvert z_{t-1} \rvert + \gamma_1 z_{t-1}) + \beta_1 \log(\sigma_{t-1}^2)$		
	Estimate	SE	*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		

$Q(12)$ and $Q^2(12)$ are the Ljung-Box Q statistics up to the 12th orders
[a]Significant at the 5 % level

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		

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

[a]Significant at the 5 % level

Empirical Results of Bai-Perron (1998, 2003) tests

Panel A: Structural Break test 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)