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The Macroeconomic Determinants of Stock Price Volatility in Pakistan: An Empirical Investigation

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ABSTRACT

Stock price volatility has been a source of prime interest in the capital markets because stock markets are crucial in any economy in terms of their implications. This study empirically investigates the factors influencing stock price volatility in Pakistan using monthly data (January 2015 to December 2021). This study uses the three-month moving standard deviation method to compute stock price volatility. The ARDL technique is used to analyze the factors of stock price volatility. In the long run, a significant and positive relationship exists between the exchange rate, supply of money, interest rate, and stock price volatility. Whereas, the industrial production index and money supply have a statistically significant and positive association with stock price volatility in the short run. However, the consumer price index, exchange rate, and rate of interest exhibit a significant and inverse association with stock price volatility in the short run. The diagnostic check of estimated coefficients is also done to ensure the best, most linear, and unbiased estimates. To check the sensitivity of the estimated coefficients concerning significance, sign, and magnitude the volatility of the stock prices is also calculated using the ARCH model. The empirical findings on average are moderately robust. It is strongly recommended that the central bank and government develop monetary and fiscal policies focused on exchange rate stability and monetary expansion stability.

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1 Introduction

Stock markets are crucial in any economy, influencing its growth in industries and commerce, which, in turn, has a significant effect on the entire economy. Given this government agencies, central banks, and industries closely monitor changes in the stock market. Volatility in the stock market measures the extent of price fluctuations and is a way to measure uncertainty and risk. Investors and investment firms assess risk based on the volatility of stock prices or assets (Kim & Won, 2018). Stock price variability has been a source of interest in the capital markets. When a stock return is extremely unpredictable, investors are never at ease. Pindyck (1983) and Schwert (1989) calculated price volatility by using the standard deviation method. Excessive volatility, on the other hand, can disturb the smooth operation of financial markets and have a detrimental influence on economic performance. For this reason, an in-depth analysis of the volatile behavior of the stock market is important for economists and finance analysts.

Unstable macroeconomic policies, stock returns, and volatile macroeconomic indicators are common challenges in developing nations, particularly Asian stock markets. The money supply, exchange rate, manufacturing output, interest rate, and consumer price index are examples of variables that influence stock price volatility. The KSE-100 Index was established in November 1991 with a base value of 1,000 points. The KSE-100 index, which measures the performance of the Pakistan Stock Exchange, has experienced repeated fluctuations in the last decade, resulting in severe value losses.

Figure 1

KSE100-Index Performance (2015-2021)

Source: Author's Compilation

Figure 1 displays that the index has risen from more than 32,000 points in 2015 to over 52,000 points in 2021. The graph also depicts the fluctuations of the KSE100 index over the last seven years, which in turn demands research on the subject matter to understand those factors that influence stock price volatility. The index has moved significantly up and down over this period. Various determinants that drive stock prices have been identified in the literature inflation is an

important predictor of stock price variability. Variations in the CPI can have a diverse effect on various sectors of the economy, subsequently influencing stock price volatility (Nawaz, Shakeel, & Tariq, 2019; Shakeel, Ahmed, & Sharif, 2020). Consumer Price Index has both a negative and positive association with stock price volatility. Several studies, such as Adjasi, Harvey, and Agyapong (2008), Mushtaq, Zia ur Rehman, Ali Shah, and Murtaza (2011), and Mostafa (2021) identified a direct CPI – CPI-stock price volatility linkage and the mechanism is that when inflation rises unexpectedly, it can create uncertainty about future price levels, interest rates, and overall economic conditions. Investors tend to be averse to uncertainty, and this can lead to increased stock price volatility as they react to changing economic conditions.

However, some studies, like Zaheer and Rashid (2014) found a negative association between inflation and stock exchange volatility. When inflation rises, stock prices can fall because of the negative link between inflation and anticipated real economic growth, causing investors to adjust their investment portfolios by choosing more real assets. Exchange rates also play a substantial role in stock price volatility due to their impact on trade dynamics, foreign investment, multinational corporations, monetary policies, and risk management practices. Exchange rates have a positive relationship with stock volatility because when the value of the home currency falls, imported goods and raw materials become more expensive for enterprises that rely on imports. This can drastically increase their production costs, thereby reducing profit margins. As a result, corporations may face uncertainty regarding future profitability, and investors may respond by trading stocks more frequently.

Ahmad, Rehman, and Raoof (2010) indicate exchange rate and interest rate as the determinants of stock price volatility because borrowing money becomes more expensive for businesses as interest rates rise so the profit of companies decreases. As a result, some investors' capital may migrate away from stocks and toward bonds, leading stock values to fall (Barakat, Elgazzar, & Hanafy, 2016). Studies conducted by Ahmad et al. (2010), Zaheer and Rashid (2014), and Hussain, Rafique, Khalil, and Nawaz (2013) find inverse interest rates – stock price volatility linkage because an increase in interest rate reduces the present value of future dividends, leading to investors being willing to pay less for stocks, thereby decreasing stock demand and causing their volatility to decline.

Another important determinant of stock price volatility is Money Supply. Buyuksalvarci (2010) and Zaheer and Rashid (2014), find a positive association between stock price variability and money supply. The mechanism is that a rise in the money supply may indicate financial instability, prompting investors to be more cautious and trade equities more frequently. This increased trading activity may result in larger price movements. Saleem, Hussain, and Ibraheem (2020) also found that banking sector specific indicators are associated with financial instability. The industrial production index is another important determinant of stock price volatility. Industrial production has a significant impact on stock values by influencing predicted future cash flows. Zaheer and Rashid (2014) examine the direct linkage between the industrial production index and the volatility of stock prices. An increase in industrial production can affect interest rates. If the economy is growing rapidly, central banks may respond by raising interest rates to prevent overheating and control inflation

Understanding the factors that drive stock price volatility in Pakistan can provide valuable insights for policymakers, shareholders, investors, and managers. When making investment decisions, both domestic and foreign investors rely on information regarding the factors impacting stock price volatility. An in-depth examination can serve as guidance for investors, allowing them to make informed decisions regarding their investment portfolios. The study findings can help

investors and financial institutions improve their risk management strategies. They may make better-informed decisions about asset allocation, portfolio diversification, and hedging methods to manage and limit the risks associated with stock market investments if they understand the primary drivers of stock price volatility. This study's findings help to improve knowledge of how macroeconomic factors influence stock price volatility. The Research Objectives are to calculate stock price volatility using a moving standard deviation method and to empirically examine determinants of stock price volatility in Pakistan.

Following the introduction, section 2 contains theoretical and empirical literature on stock price volatility. Section 3 provides the conceptual framework of stock price volatility. Section 4 provides in-depth insights into the description of data, model, and econometric methodology. Section 5 presents the empirical findings. Section 6 provides the key findings, discusses the policy implications, and discusses the study's limitations.

2 Literature Review

The linkage of macroeconomic indicators with stock price volatility has been a highly discussed and extensively researched area. Enormous studies are underway to measure the association between macroeconomic variables and the volatility of stock prices, primarily due to the rapid instability observed in international stock markets. In 1970, Fama introduced the Efficient Market Hypothesis (EMH), which posited that stock prices completely reflected all existing information, rendering it impossible to attain abnormal profits irrespective of the chosen investment strategies. The EMH can be described using the equation.

$$\Omega^*_t = \Omega_t$$

Where Ω^*_t denoted the relevant information accessible to individuals at a time 't', and Ω_t represented the information set employed for stock pricing at the same time. When these two sides were equal, it signified a competitive market.

According to the Efficient Market Hypothesis, the three classifications can be Weak Market Efficiency indicating that prevailing stock prices already encompassed all pertinent historical data. The semi-strong type asserted that present stock prices entirely incorporated all publicly available information, encompassing details about past stock prices, company performance, macroeconomic indicators, and other publicly accessible data like interest rates, money supply, and GDP. The strong form contended that, in addition to historical and publicly available information, stock prices also encompassed private, company-specific information.

Ross (2013) developed the Arbitrage Pricing Theory (APT), offering a framework for asset pricing. APT suggested that asset returns could be predicted by considering the linear return on an asset or portfolio in conjunction with several independent variables, such as the inflation rate and industrial output. Because it perfectly matches the Capital Asset Pricing Model (CAPM)[5] model's intuition, the APT is a good replacement for it (Roll & Ross, 1980). APT utilized the return on high-risk assets and the associated risk premium linked to macroeconomic factors (Kelsey & Yalcin, 2007). The linkage of the equity market with the foreign exchange market was explained by two conflicting theories: the portfolio balance and the goods market. The goods market theory contended that alterations in exchange rates influenced national real income, trade balances, and global competitiveness, subsequently impacting the stock market.

[5] Capital Asset Pricing Model (CAMP) states that there is a linear association between expected return of the investment and expected return.

Conversely, the portfolio balance theory posited that fluctuations in the stock market influenced exchange rates, suggesting a bidirectional relationship between the two markets. While the portfolio-oriented approach treated foreign exchange rates similarly to the supply and demand dynamics of stocks and bonds in the equity market, a more comprehensive examination of investment portfolio strategy revealed an inverse association between stock price and exchange rates, with financial markets typically exerting influence over exchange rates. Yau and Nieh (2006) proposed that a flow-oriented approach was better suited for long-term scenarios, as evident in the Taiwanese financial market, whereas the Japanese stock market gave more support to the portfolio method, particularly for short-term investments.

Hashemzadeh and Taylor (1988) revealed no statistically significant association between the S&P 500 and T-bills using monthly data (January 1982 – June 1988). Malliaris and Urrutia (1991) utilized Granger causality tests to investigate data from March 1970 to December 1989. The study used industrial production and money supply as explanatory variables and the S&P 500 as explained variables. However, the empirical findings revealed a causal association between the supply of money and the S&P 500. Abdullah and Hayworth (1993) revealed that inflation, money supply, interest rate, trade deficit, and budget deficit Granger cause stock prices. However, stock price volatility was positively related to inflation and the supply of money. Morelli (2002) examined data from January 1967 to December 1995 using the GARCH model and revealed that Industrial production, Exchange rate, and Inflation were insufficient to explain stock price volatility.

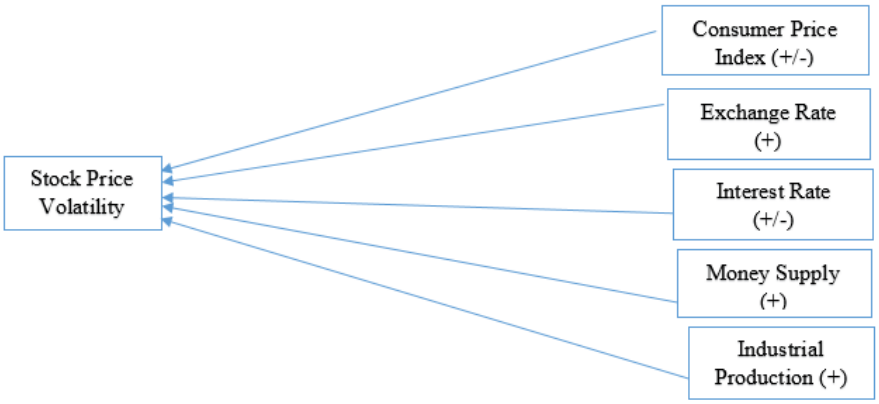
Nishat, Shaheen, and Hijazi (2004) revealed that inflation had an inverse association with stock price variability and industrial production is positively associated with stock price variability. Buyuksalvarci (2010) examined data from April 2002 to June 2009. Currency in circulation, industrial output, inflation, foreign exchange rates, and gold prices were the explanatory variables. The ISE-100 Index was the response variable. The empirical findings revealed that the currency in circulation had a positive association with stock prices, while the price of oil and while exchange rate had a negative impact. Ahmad et al. (2010) investigated the positive association of the nominal exchange rate and, the negative association of interest rate with stock prices in Pakistan from 1998 to 2009. Barakat et al. (2016) examined interest rate, exchange rate, money supply, and inflation as positive determinants of stock price volatility using data from 1998–2014 in Tunisia and Egypt. Mostafa (2021) investigated the macroeconomic factors that affect Bangladesh stock market, utilizing data from March 2005 to December 2018. Inflation, industrial output, industrial output, and foreign remittances were all included as independent variables in the study. The study found a positive association among inflation, foreign remittances, and stock return volatility.

Al-Rimawi and Kaddumi (2021) showed a direct linkage of Interest rate, Inflation, Economic growth, and FDI with the stock market in Amman using data from 1999 to 2018. Damiran, Dorjdagva, Sukhee, and Myagmarsuren (2022) utilized yearly data spanning from 1995 to 2020 and used economic growth, inflation rate, stock market returns, and economic freedom for estimation. The results revealed that economic growth and stock market returns had a direct linkage with stock price volatility. With a few exceptions, most of the empirical studies cited in the literature review section contain data from the 1990s to the early 2010s, and recent data is not used in the literature. The results from the existing literature also vary. In some studies, there has been a positive linkage between interest rates with the volatility of stock prices, and in some other studies, it is the opposite. The findings have been inconclusive, additional research is essential to gain a more comprehensive understanding of the factors influencing stock price volatility in Pakistan.

3 Conceptual Framework

The existing literature on stock price volatility identifies various macroeconomic factors that influence stock price volatility. Figure 2 offers a visual representation of these variables, and we are going to explore the connections between these attributes and stock price volatility individually:

Figure 2
Conceptual Framework



Source: Framework constructed by Authors

Inflation has both a positive and negative association with stock price volatility. Several studies, such as Adjasi et al. (2008), Mushtaq et al. (2011), and Mostafa (2021), identify a direct linkage between inflation with stock price volatility. When inflation rises unexpectedly, it can create uncertainty about future price levels, interest rates, and overall economic conditions. Investors tend to be averse to uncertainty, and this can lead to increased stock price volatility as they react to changing economic conditions. However, some studies, like Zaheer and Rashid (2014) found an inverse association between stock exchange volatility and inflation. When inflation rises, stock prices can fall because investors adjust their portfolios by choosing more real assets.

The exchange rate has a direct link with stock price volatility because when the value of the home currency falls, imported goods and raw materials become more expensive for enterprises that rely on imports. This can drastically increase their production costs, thereby reducing profit margins. As a result, corporations may face uncertainty regarding future profitability, and investors may respond by trading stocks more frequently. Ahmad et al. (2010) posited a direct linkage of exchange rate and Interest rates with stock price volatility because borrowing money becomes more expensive for businesses as interest rates rise so the profit of companies decreases. As a result, some investors' capital may migrate away from stocks and toward bonds, leading stock values to fall (Barakat et al., 2016).

An increase in the supply of cash may indicate economic insecurity or financial instability, prompting investors to be more cautious and trade equities more frequently. This increased trading activity may result in larger price movements. Buyuksalvarci (2010) and Zaheer and Rashid (2014), find a positive association between the supply of money and the volatility of the stock price. According to Zaheer and Rashid (2014), the linkage of industrial production and the volatility of stock prices was direct. An increase in industrial production can impact interest rates. If the economy is growing rapidly, central banks may respond by raising interest rates to prevent

overheating and control inflation.

4 Data, Model, and Econometric Methodology

4.1 Data Description

Monthly data from January 2015 to December 2021 has been used in this study to analyze the objectives. Moreover, the description of the variables is given in Table 1.

Table 1
Description of Variables

Variables	Symbols	Unit of Measurements	Expected Relationship	Sources
Stock Price Volatility, KSE-100 Index	SPV_t	Volatility is calculated via three three-month moving standard deviation	**Dependent Variable**	State Bank of Pakistan
Explanatory variables				
Inflation, Consumer Price Index	CPI_t	Index (2010=100)	Positive/ Negative	International Financial Statistics Database
Exchange Rate	ER_t	PKR/US$	Positive	State Bank of Pakistan
Discount Rate	IR_t [6]	Percentage	Positive/ Negative	International Financial Statistics Database
Broad Money	$M2_t$	Rs. Billion	Positive	State Bank of Pakistan
Industrial Production Index	IPI_t	Index (2010=100)	Positive	International Financial Statistics Database

4.2 Model Specification

To examine the determinants of stock price volatility in Pakistan, the following model is specified.

$$SPV_t = \beta_o + \beta_1 CPI_t + \beta_2 ER_t + \beta_3 IR_t + \beta_4 M2_t + \beta_5 IPI_t + \varepsilon_t$$

Where SPV_t is Stock Price Volatility, CPI_t is a log of the Consumer Price Index, ER_t is a log of Exchange rate, IR_t is Interest Rate, $M2_t$ is a log of Money Supply M2, IPI_t is a log of Industrial Production Index, βi's are the coefficients and ε_t captures the error term.

4.3 Econometric Methodology

4.3.1 Stationary Test

Stationarity tests are crucial because non-stationary variables lack consistent "mean and variance" characteristics over time. In simpler terms, it means that the average value and variability of the variable change as time progresses, making it unreliable for analysis. Among various stationarity tests, the Augmented Dickey-Fuller test (ADF) is widely used. Once the lag numbers

[6] Since interest rate is in percentage so log cannot be taken.

are chosen, we gauge the order of integration based on the significance of the p-value.

4.3.2 ARCH Models

Financial time series exhibit three key characteristics: volatility clustering, leptokurtosis, and a leverage effect. These characteristics make it challenging to assume constant variance (homoscedasticity), rendering ordinary least square models inadequate for analyzing data with changing variances over time. To address this issue, in 1982 Engle and Granger (1987) introduced the ARCH model. Engle approach involves modeling the conditional variance as a linear function of past squared innovations, represented by the equation;

$$h^2_t = \omega + \sum_{i=1}^{q} \alpha_i \, \varepsilon^2_{i-1}$$

Where ω and α_i are non-negative parameters ensuring positive conditional variance, and ε2t is the squared error from the mean.

4.3.3 ARDL Bound Test

The Autoregressive Distributed Lag (ARDL) originally introduced by Pesaran and Shin (1995), was further refined in 2001 with the inclusion of the bounds testing approach. Within the ARDL framework, a pivotal element is the F-statistic, which assumes a central role in the analysis. The bound test in ARDL analysis establishes four confidence intervals, with the F-value typically assessed at the 95% confidence level. Once cointegration is confirmed through the bound test, the estimation of both long-term and short-term coefficients is carried out using equations 1 and 2, respectively.

Long Run Equation

$$SPV_t = \beta_0 + \sum_{i=1}^{p} \beta_{1i} \, SPV_{t-i} + \sum_{i=m}^{q1} \beta_{2i} \, lnCPI_{t-i} + \sum_{i=m}^{q2} \beta_{3i} \, lnER_{t-i} + \sum_{i=m}^{q3} \beta_{4i} \, IR_{t-i} + \sum_{i=m}^{q4} \beta_{5i} \, lnM2_{t-i} + \sum_{i=m}^{q5} \beta_{6i} \, lnIPI_{t-i} + \varepsilon_t \quad (1)$$

Short Run Equation

$$\Delta SPV_t = \beta_0 + \sum_{i=1}^{p} \beta_{1i} \, \Delta SPV_{t-i} + \sum_{i=m}^{q1} \beta_{2i} \, \Delta lnCPI_{t-i} + \sum_{i=m}^{q2} \beta_{3i} \, \Delta lnER_{t-i} + \sum_{i=m}^{q3} \beta_{4i} \, \Delta IR_{t-i} + \sum_{i=m}^{q4} \beta_{5i} \, \Delta lnM2_{t-i} + \sum_{i=m}^{q5} \beta_{6i} \, \Delta lnIPI_{t-i} + \theta ECM_{t-i} + \varepsilon_t \quad (2)$$

Equation 1 provides the coefficients that pertain to the long-term perspective. It involves elements like βi's which represent the coefficients of regressors. Moving on to Equation 2, deals with the coefficients of the short-run and is established through the utilization of the error correction model (ECM) while "θ" represents the ECM coefficient, often referred to as the adjustment coefficient to equilibrium, which plays a crucial role in responding to shocks or disturbances. Equation 3 illustrates the speed at which the ECM readjusts to attain equilibrium.

$$ECM_t = SPV_t - \beta_0 - \sum_{i=1}^{p} \beta_{1i} \, SPV_{t-i} - \sum_{i=m}^{q1} \beta_{2i} \, lnCPI_{t-i} - \sum_{i=m}^{q2} \beta_{3i} \, lnER_{t-i} - \sum_{i=m}^{q3} \beta_{4i} \, IR_{t-i} - \sum_{i=m}^{q4} \beta_{5i} \, lnM2_{t-i} - \sum_{i=m}^{q5} \beta_{6i} \, lnIPI_{t-i} - \quad (3)$$

4.4 Diagnostic Tests

4.4.1 Jarque-Bera test

Jarque-Bera test has been applied to check the normality. Deviations from normality can complicate statistical inference.

4.4.2 Heteroskedasticity Test: Breusch-Pagan-Godfrey

In (ARDL) model, there is an assumption of constant variance in residuals, referred to as homoscedasticity. When this assumption is violated, and residuals exhibit varying variance, termed heteroscedasticity, the estimated coefficients are no longer (BLUE) and lack the minimum variance associated with unbiased estimators.

4.4.3 Breusch-Godfrey Serial Correlation LM Test

The Breusch-Godfrey test, introduced by Godfrey in 1978, is utilized to identify serial correlation. It's essential to note that serial correlation doesn't impact the unbiasedness of regression estimators but influences their efficiency.

4.4.4 Ramsey Regression Specification Error Test

Ramsey first introduced the Regression Specification Error Test (RESET) in 1969 to study the functional structure of a regression model. It investigates if non-linear combinations of the fitted values of the model may adequately explain the explanatory variable. Explanatory power in these nonlinear combinations shows model misspecification and the need for changes.

4.4.5 Stability Test

CUSUM and CUSUM of square tests, established by Brown et al. in 1975, can be used to measure the stability of the model. The stability of parameters is tested using cumulative sums of the recursive residuals, which is useful in identifying data bias and a crucial post-diagnostic test.

H_0: No structural breaks

H_1: Presence of structural breaks

4.5 Robustness Method

To check the sensitivity of empirical estimates concerning the sign, significance, and magnitude of the coefficient, the volatility of the dependent variable is also calculated using the ARCH model. If out of three criteria in terms of sign significance and magnitude, one has been fulfilled then results are weakly robust and if out of three criteria two have been fulfilled then results are moderately robust. If out of three criteria, all three have been fulfilled, then results are strongly robust.

5. Results and Discussions

5.1 Stationarity Test Results

The results show that only SPVt, and IPIt are stationary at their level [I (0)] because p-values of SPV_t, and IPI_t are 0.052 and 0.035 which is ≤ 0.05 so we reject H_0. While CPI_t, ER_t, IR_t and $M2_t$ are stationary at their first difference [I (1)]. The identification of this mixed order of integration is significant because it guides our choice of methodology. Since the results of the ADF test indicate a mixed order of integration, we have decided to use the ARDL approach.

Table 2

ADF Unit Root Test Results

Variables	Statistics	P-value
	At Level	
SPV_t	-5.255	0.052
CPI_t	2.550	0.999
ER_t	0.601	0.987

IR_t	-0.716	0.842
$M2_t$	0.030	0.961
IPI_t	-2.999	0.035
At First Difference		
Variables	**Statistics**	**P-value**
ΔCPI_t	-8.133	0.000
ΔER_t	-6.085	0.000
ΔIR_t	-5.852	0.000
$\Delta M2_t$	-12.819	0.000

Source: Author's Calculations

5.2 Bound Testing Approach

The results of the bound test show the F-statistic value as 6.529 which is greater than the upper bound value at a 90% confidence interval and 95% confidence interval. It confirms the existence of a long-run relationship among variables in a model.

Table 3
Bound Test Results

	F-statistics = 6.529	
Critical value	**Lower Bound I(0)**	**Upper Bound I(1)**
90 % Confidence Interval	2.08	3
95% Confidence Interval	2.39	3.38

Source: Author's Calculations

5.3 Long Run Results

Table 4 summarizes the results of our long-run estimations. The stock price volatility is the explained variable and volatility is calculated using the three-month moving standard deviation method. The results indicate that the consumer price index has an insignificant relationship with stock price volatility in the long run. The findings of Oluseyi (2015) also found no significant association between inflation and stock price volatility.

Table 4
Long Run Results

Volatility calculated via moving Standard Deviation			
Dependent Variable = SPV_t			
Regressors	**Coefficients**	**t-statistics**	**P-values**
CPI_t	-0.041	-0.633	0.531
ER_t	0.102	-2.892	0.006*
IR_t	0.008	6.004	0.000*
$M2_t$	0.065	2.733	0.009*
IPI_t	0.015	0.434	0.666
Constant	-0.028	-0.569	0.572
R-square = 0.884			
Adjusted R-squared = 0.793			

Notes: *sign indicates that variable is significant

The results reveal a highly significant and positive association between the volatility of stock prices and exchange rates in the long run. A 1% increase in exchange rates, on average, increased stock price variability by 0.10% assuming all other variables remain constant during the estimation period. When the value of the home currency falls, imported goods and raw materials become more expensive for enterprises that rely on imports. This can drastically increase their production costs, thereby reducing profit margins. As a result, corporations may face uncertainty regarding future profitability, and investors may respond by trading stocks more frequently. This increased trading activity may result in heightened stock price volatility. Companies that rely substantially on imported goods frequently risk profit uncertainty when their expenses grow as a result of currency depreciation. Investors may grow concerned about the businesses' future profitability, which may cause stock prices to fluctuate as investors react to changes in earnings expectations. The findings are consistent with Ahmad et al. (2010).

The results reveal a highly significant and positive relationship between the volatility of stock price and interest rate in the long run. A 1% increase in interest rate, on average, increased stock price variability by 0.008%, assuming all other variables remain constant during the estimation period. Interest rates, a pivotal macroeconomic determinant, have a positive influence on stock price volatility because borrowing money becomes more expensive for businesses as interest rates rise. This can have an impact on their ability to finance expansion, research and development, and other activities that are frequently connected with rising stock values. As a result, investors may perceive increased risk in the stock market, resulting in greater price volatility, and bonds and other fixed-income assets may be more appealing than stocks when interest rates rise. As a result, some investors' capital may migrate away from stocks and towards bonds, leading stock values to fall. These findings are consistent with Barakat et al. (2016).

The results reveal a highly significant and positive association between the volatility of stock price and money supply in the long run. A 1% increase in money supply, on average, increased stock price volatility by 0.06%, assuming all other variables remain constant during the estimation period. An increase in the money supply generally boosts liquidity in financial markets, simplifying the process of buying and selling stocks. When demand for stocks surges, stock prices tend to rise rapidly, accompanied by increased uncertainty. The empirical findings are consistent with Barakat et al. (2016). There exists a positive linkage of the industrial production index with stock price volatility in the long run but with insignificant coefficient value.

5.4 Short Run Results

The findings in Table 5 illustrate the short-term results, which are closely similar to the long-term outcomes, further confirming the accuracy of the long-term estimations. The findings reveal that stock price volatility and the consumer price index results are sensitive because when we take the lag there is an inverse association between CPI and volatility of stock price but when we do not take the lag the current variable turns to be positive.

Table 5

Short Run Results

ECM of the ARDL (6,2,6,7,7,6)				
Dependent Variable = SPV_t				
Regressors	**Coefficients**	**St.Errors**	**t-stats**	**P-values**
ΔSPV_{t-1}	1.761	0.324	5.426	0.000*
ΔSPV_{t-2}	1.134	0.277	4.094	0.000*
ΔSPV_{t-3}	0.944	0.224	4.216	0.000*

ΔSPV_{t-4}	0.359	0.154	2.323	0.025*
ΔSPV_{t-5}	0.520	0.124	4.196	0.000*
ΔCPI_t	0.365	0.323	1.129	0.266
ΔCPI_{t-1}	-0.634	0.320	-1.982	0.055*
ΔER_t	0.613	0.143	-4.276	0.000*
ΔER_{t-1}	0.726	0.171	4.234	0.000*
ΔER_{t-2}	0.159	0.158	-1.005	0.321
ΔER_{t-3}	0.121	0.171	0.708	0.483
ΔER_{t-4}	0.217	0.169	1.276	0.209
ΔER_{t-5}	0.545	0.166	3.282	0.002*
ΔIR_t	-0.026	0.007	-3.622	0.000*
ΔIR_{t-1}	-0.029	0.008	-3.673	0.000*
ΔIR_{t-2}	-0.014	0.009	-1.561	0.127
ΔIR_{t-3}	-0.030	0.009	-3.173	0.003*
ΔIR_{t-4}	-0.042	0.008	-4.800	0.000*
ΔIR_{t-5}	0.000	0.007	0.070	0.944
ΔIR_{t-6}	-0.016	0.007	-2.113	0.041*
$\Delta M2_t$	-0.090	0.164	-0.551	0.584
$\Delta M2_{t-1}$	0.069	0.123	0.561	0.577
$\Delta M2_{t-2}$	0.022	0.123	0.180	0.857
$\Delta M2_{t-3}$	0.193	0.126	1.535	0.133
$\Delta M2_{t-4}$	-0.230	0.146	-1.574	0.124
$\Delta M2_{t-5}$	-0.117	0.146	-0.798	0.429
$\Delta M2_{t-6}$	0.465	0.178	2.601	0.013*
ΔIPI_t	0.002	0.025	0.084	0.933
ΔIPI_{t-1}	0.001	0.025	0.068	0.945
ΔIPI_{t-2}	0.100	0.028	3.557	0.001*
ΔIPI_{t-3}	0.008	0.032	-0.257	0.798
ΔIPI_{t-4}	0.081	0.028	2.834	0.007*
ΔIPI_{t-5}	0.061	0.028	2.091	0.043*
CoinEq(-1)*	-2.658	0.364	-7.302	0.000*

Notes: *sign indicates that variable is significant

The results indicate a highly significant and positive association between stock price volatility and the exchange rate. A 1% increase in the exchange rate, on average, has increased 0.61% stock price volatility while keeping all other variables constant. The results are consistent with Mushtaq et al. (2011). Interest rates have a statistically significant and negative association with the volatility of stock prices. In the short run, a 1% increase in the interest rate, on average, has decreased by 0.02% in stock price volatility while keeping all other variables constant during the estimation period. The results are consistent with Ahmad et al. (2010) and Zaheer and Rashid (2014).

Money supply has a significant and positive association with stock price volatility, a 1% increase in the money supply, on average, has increased 0.46% in stock price volatility during the estimation period, keeping all other factors the same. The finding is consistent with Barakat et al. (2016), and Ramadan (2016). Short-term results show a significant and positive association between the industrial production index and stock price volatility. In the short term, a 1% increase

in the industrial production index, on average, has led to a notable 0.10% rise in stock price volatility during the estimation period, assuming all other variables remain constant. The findings are consistent with Zaheer and Rashid (2014).

According to Short run results error correction term is statistically significant at a 1% level of significance with a negative coefficient of -2.65. If CoinEq (-1) is greater than -1 than the lagged error term coefficient implies that the process of returning to the long-term equilibrium (the ideal balance) does not occur in a straight line when the economy deviates from it. Instead, it oscillates or varies in a way that gradually lessens such deviations from the long-term value. Once this process is over than the economy quickly and easily converges back to the long-term equilibrium Narayan and Smyth (2006).

5.5 Diagnostic Test Results

The results of the Jarque-Bera test show that the data is normally distributed. The White Heteroskedasticity test that there is no problem with heteroscedasticity. To check the autocorrelation problem, a serial correlation LM test has been applied which confirmed that there is no autocorrelation problem. The RESET test has been applied and concludes that the model is correctly specified.

Table 6

Post Estimation Results

Problems	Tests	Null Hypothesis	P-values	Decision
Non - Normality	Jarque-Bera test	H_0 =Normally Distributed	0.107	Do not reject H_0
Heteroskedasticity	White Heteroskedasticity Test	H_0 = Homo-skedasticity	0.521	Do not reject H_0
Autocorrelation	Breusch-Godfrey Serial Correlation LM Test	H_0 = No problem of autocorrelation	0.779	Do not reject H_0
Omitted Variable Test	Regression Specification Error Result Ramsey	H_0: Model is correctly Specification.	0.100	Do not reject H_0

Source: Author's Calculations

5.5.1 Stability Test Results

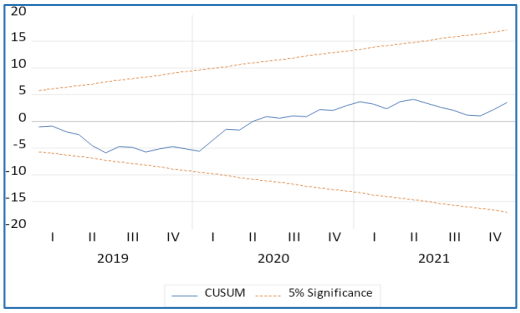
As depicted in Figures 3 and 4, it is evident that the CUSUM and CUSUMQ plots consistently stay within their respective boundaries. In simpler terms, there is no sign of structural instability impacting the model's performance throughout the entire study period.

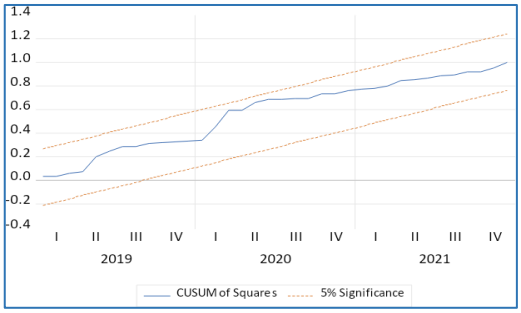
Figure 3

CUSUM Plot

Figure 4

CUSUMSQ plot





5.6 Robustness Analysis Results

In this study, we initially used the moving standard deviation method to compute volatility. However, to check the sensitivity of the estimation coefficient concerning significance, magnitude, and sign the volatility of the dependent variable is also calculated using the ARCH model. In Panel (b) of Table 9, we change the dependent variable calculation method. The results in Panel (b) indicate that the consumer price index significance and magnitude are the same as the results in Panel (a), so the findings are moderately robust because out of three criteria, two have been fulfilled. Similarly, the interest rate and exchange rate sign and magnitude are the same as the result in panel (a), so the findings are moderately robust. However, only the sign of industrial production index and magnitude of money supply is the same as the result in panel (a), so the findings are weakly robust. So, out of five variables, the findings of three variables are moderately robust, and the findings of two variables are weakly robust.

Table 7

Robustness Results

	Panel (a) Volatility calculated via Standard Deviation		**Panel(b) Volatility calculated via ARCH[7]**	
Long-Run Estimation	**Dependent Variable = SPV_t**		**Dependent Variable = SPV_t**	
Regressors	**Coefficients**	**t-statistics**	**Coefficients**	**t-statistics**
CPI_t	-0.041 (0.530)	-0.633	0.050 (0.445)	0.769
ER_t	0.102 (0.006*)	-2.892	0.020 (0.328)	0.003
IR_t	0.008 (0.000*)	6.004	0.007 (0.328)	0.986
$M2_t$	0.065 (0.009*)	2.733	0.003 (0.154)	1.443
IPI_t	0.015 (0.666)	0.434	-0.017 (0.000*)	-3.846
Constant	-0.028 (0.572)	-0.569	-0.009 (0.099)	-1.677

Notes: *sign indicates that variable is significant

Source: Author's Calculations

[7] Autoregressive conditional heteroscedasticity

6. Conclusion and Policy Recommendations

6.1 Conclusion

This study finds the macroeconomic factors that contributed to stock price volatility using monthly data of the KSE100 index in Pakistan from January 2015 to December 2021. This study utilizes the three-month moving standard deviation method to calculate stock price volatility. The ADF results show in mixed orders of integration. Further bound test results indicate that a long-run relationship is present between explained and explanatory variables. The study findings reveal that there is an insignificant association between the consumer price index, industrial production index, and stock price volatility in the long run. Moreover, a significant and positive relationship exists among the exchange rate, rate of interest, supply of money, and stock price volatility in the long run.

In the short run, the results reveal that there is a highly sensitive association between the consumer price index and stock price volatility. The results indicate a highly significant and positive association among the exchange rate, money supply, industrial production, and stock price volatility. However, the interest rate has a significant and inverse relationship with stock price volatility in the short run. To check the sensitivity of the estimation coefficient concerning significance, magnitude, and sign the volatility of the stock prices is also calculated using the ARCH model and the results show that out of five variables, the findings of consumer price index, interest rate, and exchange rate are moderately robust, and the findings of money supply and industrial production index are weakly robust.

6.2 Policy Recommendations

Understanding the factors that drive stock price volatility in Pakistan can provide valuable insights for policymakers. Policymakers can endeavor to make a more predictable economic environment that is beneficial for investment, economic growth, and financial market stability by recognizing and addressing these determinants. When making investment decisions, both domestic and foreign investors rely on information regarding the factors impacting stock price volatility. An in-depth examination can serve as guidance for investors, allowing them to make informed decisions regarding their investment portfolios. Given the daily variations in stock prices, understanding the trend of stock price changes is important for organizations. This emphasizes the need to research the factors influencing stock price volatility in Pakistan. M2, interest rates, industrial output, inflation, and the nominal exchange rate have all been studied about stock price volatility. The findings help to improve knowledge of how macroeconomic factors influence stock price volatility. Some policy recommendations are:

- Identifying that a rise in money supply increases stock price volatility in both the short and long run highlights the need for the central bank of Pakistan, the primary body in charge of managing money supply growth, to contemplate strategies to control such expansion.
- The central bank and government develop monetary and fiscal policies focused on exchange rate stability. This could include interfering in the foreign exchange market to prevent severe and unexpected variations in the value of the currency. The government and central bank can lessen stock market uncertainty by maintaining exchange rate stability. To ensure a stable and supportive macroeconomic environment, the government and central bank should collaborate.
- The exchange rate, rate of interest, and money supply all have a significant impact on the volatility of stock prices, it is critical that monetary policies are carefully handled by policymakers. Central banks should be especially attentive to how fluctuations in interest rates might affect stock markets, and they should seek to keep the money supply stable to reduce excessive volatility.

6.3 Limitations of the study

This study examines data from January 2015 to December 2021, with a focus on five key macroeconomic factors. The monthly data of the Industrial Production Index is only available until December 2021, so we use data up to December 2021 in this study. Future researchers can use various other macroeconomic variables that may be investigated over longer durations to find the determinants of stock price volatility in Pakistan as well as internationally.

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