The Effect of Volatility Spillover from Macroeconomic Factors on Stock Price Crash Risk Under Uncertainty Conditions Across Time Intervals and Structural Breaks Using BEKK-GARCH Models and the ICSS Algorithm

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Citation: Pouladi, A., Abedini, B., Ranjbar, M. H., & Amiri, A. (2025). The Effect of Volatility Spillover from Macroeconomic Factors on Stock Price Crash Risk Under Uncertainty Conditions Across Time Intervals and Structural Breaks Using BEKK-GARCH Models and the ICSS Algorithm. *Business, Marketing, and Finance Open*, 2(5), 1-10.

Received: 27 March 2025
Revised: 05 May 2025
Accepted: 19 May 2025
Published: 01 September 2025

Abstract: Financial markets, particularly stock markets, are consistently influenced by macroeconomic factors. The volatility of these factors can significantly impact investor behavior and stock price fluctuations. Among these, stock price crash risk, as one of the most critical concerns for investors and economic policymakers, is heavily affected by sudden and unexpected changes in macroeconomic indicators. The present study aims to apply the BEKK-GARCH model to examine the effect of volatility spillover from macroeconomic factors on stock price crash risk under uncertainty conditions across time intervals and structural breaks. In terms of purpose, this research is applied, and in terms of data collection, it is a descriptive, ex-post-facto study. Methodologically, it is analytical and quasi-experimental, and in execution, it is a time-series and cross-sectional study. The statistical population of this research includes companies listed on the Tehran Stock Exchange from 2011 to 2020. Since not all members of the population met the necessary criteria, a purposive sampling method was employed, and 119 companies were selected as the statistical sample. The collected data from the statistical samples, along with the proposed bivariate GARCH models, Granger causality test, Vector Autoregression (VAR) test, and the ICSS algorithm, were analyzed using EViews software (Version 11). The results of the data analysis indicated that macroeconomic variables—including inflation rate, exchange rate, gross domestic product (GDP), money supply, economic growth, interest rate, and liquidity volume—significantly influence stock price crash risk under uncertainty conditions across time intervals and structural breaks.

Keywords: Volatility spillover, structural breaks, uncertainty, macroeconomic variables, stock price crash risk.

1. Introduction

The relationship between macroeconomic factors and stock prices has long been a subject of interest in economic theory and empirical research. Studies have consistently identified stock prices and market indices as reliable indicators for assessing economic dynamics [1]. Over the past two decades, scholarly interest in this domain has surged, reflecting an increasing understanding of the complex interplay between real economic factors and stock market volatility [2, 3]. Government agencies and policymakers are particularly invested in such studies due to the pivotal role of stock markets in maintaining macroeconomic stability [4]. While, theoretically, stock markets correlate with a country's macroeconomic variables, higher returns in equity markets are influenced by specific macroeconomic indicators [5]. Domestic economic conditions significantly impact stock market prices [6]. Macroeconomic variables such as GDP, interest rates, exchange rates (ER), and inflation also exert substantial effects on stock markets [7]. Establishing long-term relationships between selected macroeconomic factors and stock returns remains critically important [8-10]. The existence of a stock exchange in a market is recognized as having sustainable implications for financial activities, particularly concerning government policies and macroeconomic indicators [11-13]. While many studies have examined the impact of individual macroeconomic factors on stock prices, fewer have explored the combined effects of multiple variables, often focusing on developed economies to the exclusion of emerging markets [12, 14-16].

Dynamic econometric models such as BEKK-GARCH, with their ability to simulate and analyze volatility spillovers between financial and economic variables, are effective tools for understanding the complexities of financial markets. In contexts where economic uncertainty and structural market breaks act as key drivers of stock price crash risk, such models enable precise analysis of how macroeconomic volatility and stock market indices influence risk behavior in financial markets. The BEKK-GARCH model, by examining volatility spillovers and simultaneous variable changes, plays a critical role in explaining dynamics across temporal intervals and structural breaks. This model allows researchers to identify cross-effects and nonlinear relationships between key variables and refine risk management tools under economic uncertainty [1, 2, 4-7, 11, 17-23]. Thus, this study employs the BEKK-GARCH model to analyze data across time intervals and structural breaks, aiming to deepen understanding of the linkages between economic volatility, financial indices, and stock price crash risk.

Black and Christie (2007) proposed the leverage effect theory to explain stock price crashes [24]. Volatility spillover refers to the propagation of financial market disruptions from one market or variable to another [23]. Pastor and Veronesi (2013) argued that stock prices crash when economic volatility uncertainty is high. They posited that investors demand additional returns for holding equities during heightened volatility, as uncertainty about corporate performance and profitability increases during such periods. Against this backdrop, the core objective of this study is to model the spillover effects of macroeconomic factors and stock market indices on stock price crash risk under uncertainty, temporal intervals, and structural breaks [25].

Lam et al. (2018) note that policy risk is a systematic pricing factor but remains understudied [26]. When uncertainty is high, investors face greater information asymmetry [27] and must rely more on managerial disclosures to assess firm value. Consequently, managers gain greater latitude to withhold bad news and manipulate earnings. As managerial incentives to accumulate bad news strengthen under high uncertainty, macroeconomic uncertainty is expected to correlate positively with stock price crash risk [28, 29]. Pastor and Veronesi (2012) argue that uncertainty's impact on real economic activities and financial markets is non-neutral [25]. Białkowski et al. (2008) further showed that stock market instability increases during national election weeks, suggesting economic policy uncertainty exacerbates market volatility [30].

The empirical study by Alaganar and Bhar (2007) found that exchange rate data significantly affect diversified U.S. stock portfolios at the first and second moments, with exchange rate valuations less likely to be influenced. However, exchange rate volatility significantly impacted investor portfolios and decisions [31]. Choi (2009), using a multivariate EGARCH model, measured volatility spillovers between New Zealand's stock and forex markets after the 1997 Asian financial crisis. The study revealed spillover effects across three stock indices [32].

Volatility spillovers and financial market linkages during pandemics and economic crises have also gained prominence in financial and economic literature. Studies show that intermarket volatility and spillovers are heavily influenced by environmental factors, economic policies, and global developments. Li et al. (2023) found that pandemics like COVID-19 increased volatility spillover network density while reducing network diameter, indicating faster global transmission of financial information [5]. Similarly, Rai and Garg (2022), analyzing BRIICS markets, observed significant risk contagion between stock and forex markets during early pandemic lockdowns, underscoring heightened correlations and spillovers during crises [19]. Wang et al. (2023) examined linkages between traditional finance (TFI) and fintech. Their findings showed fintech typically receives volatility under normal conditions but transmits it to TFI during pandemics. Macroeconomic determinants explained over 60% of spillovers, with time cycles, forecasting horizons, and lag lengths influencing spillover intensity [17]. Studies like Alqahtani et al. (2020) and Liew et al. (2022) highlighted the impact of U.S. economic policies and uncertainty on developing markets, noting that economic uncertainty exacerbates stock price crash risk, particularly for firms with higher information asymmetry [20, 33].

Thus, this study addresses the following research question: How does the BEKK-GARCH model explain the spillover effects of macroeconomic factors on stock price crash risk under uncertainty, temporal intervals, and structural breaks?

2. Methodology

This study is applied research in terms of purpose, as its findings can be utilized in decision-making processes. Given that the research relies on existing financial data from companies listed on the Tehran Stock Exchange in previous years without any intervention in controlling or altering variable values, it is classified as ex-post facto descriptive research in terms of data collection. Methodologically, it is analytical and quasi-experimental, and in execution, it is a time-series and cross-sectional study.

The statistical population of this research consists of companies listed on the Tehran Stock Exchange. The rationale for selecting this population is as follows:

First, financial data for listed companies are more readily accessible, particularly since some of this information is available in database formats on compact discs. Second, since the financial information of listed companies is subject to regulatory scrutiny, the quality of financial statements is presumed to be higher. Third, the mandatory compliance with accounting standards and financial regulations in preparing financial statements for listed companies ensures greater homogeneity and comparability of financial reports.

Variable Measurement

Inflation Rate

The most widely accepted definition of inflation among economists is a sustained and uncontrolled increase in the general price level of goods and services, ultimately leading to reduced purchasing power and economic instability (Azimi Arani, 2006). It is calculated as the weighted average price of a basket of goods, comprising a wide range of items (Shokrakhah & Ghasedi Dizaji, 2016), using the following formula:

Delta InflationRate_t = (InflationRate_t - InflationRate_t-1)/InflationRate_t-1

Where:

- Delta InflationRate_t = Change in inflation rate in year t
- InflationRate_t = Inflation rate in year t
- InflationRate_t-1 = Inflation rate in the previous year t-1

Exchange Rate

As a key macroeconomic factor, the exchange rate reflects a country's economic conditions and serves as a benchmark for comparing national economies. It represents the value of one country's currency relative to another. Exchange rate fluctuations impact domestic and international goods prices and are particularly significant for firms relying on foreign credit. The exchange rate is derived from the free-market rate (Shokrakhah & Ghasedi Dizaji, 2016) and is calculated as:

$\Delta \text{Exchange Rate}_t = (\text{Exchange Rate}_t - \text{Exchange Rate}_{t-1})/\text{Exchange Rate}_{t-1}$

Interest Rate

The interest rate is the amount paid by a borrower to a lender for the use of financial resources over a specified period. It plays a pivotal role in financial institutions and managerial decision-making. Data are sourced from the Central Bank of Iran and approved by the Money and Credit Council (Shokrakhah & Ghasedi Dizaji, 2016). The calculation follows:

$\Delta \text{Interest Rate}_t = (\text{Interest Rate}_t - \text{Interest Rate}_{t-1})/\text{Interest Rate}_{t-1}$

Economic Growth

Economic growth is measured either as:

1. An increase in real GDP at full employment over time, reflecting national output growth.
2. An increase in real GDP or GNP per capita, indicating living standards and cross-country comparability.

Data are obtained from the Central Bank, with growth rates computed as:

$\Delta \text{Economic Growth}_t = (\text{Economic Growth}_t - \text{Economic Growth}_{t-1})/\text{Economic Growth}_{t-1}$

Liquidity

The relationship between liquidity and stock prices is debated. In Iran, where interest rates are administratively set, liquidity changes primarily affect price levels. Data are sourced from the Central Bank of Iran, with changes calculated as:

$\Delta \text{Liquidity}_t = (\text{Liquidity}_t - \text{Liquidity}_{t-1})/\text{Liquidity}_t$

Money Supply

Defined as the sum of cash in circulation and demand deposits in commercial banks:

$M = CU + D$

Where:

- CU = Cash held by the public
- D = Demand deposits

Economic Uncertainty

Measured using ARCH and GARCH indices. For instance, the exchange rate follows an autoregressive process of order p:

$EXRT_t = \gamma_0 + \sum_{i=1}^{p} \gamma_i EXRT_{t-i} + \epsilon_t$

Where ϵ_t is normally distributed with mean zero and conditional variance h_t. The GARCH(1,1) model is specified as:

$h_t = \alpha_0 + \alpha_1 \epsilon_{t-1}^2 + \beta h_{t-1}$

3. Statistical Population and Sampling

The study covers companies listed on the Tehran Stock Exchange from 2011 to 2020. A purposive sampling method was applied, with the following criteria:

1. Listed by March 2011 and not delisted by March 2020.

2. Actively traded during the study period.
3. Fiscal year ending on March 20 (Iranian calendar) with no changes.
4. Excluding financial intermediaries (e.g., investment firms, banks).
5. Data availability.

Table 1. Sample Selection Process

Description	Count
Total listed companies (2020)	504
Delisted during study period	62
Newly listed during study period	41
Non-March fiscal year-end	72
Fiscal year changes	20
Financial intermediaries	31
Trading halts >3 months	83
Missing data	76
Final sample	119

The regression model for testing hypotheses is specified as:

Crash Risk_t+1 = alpha_0 + beta_1 Inflat + beta_2 ExRate + beta_3 GNP + beta_4 GDP + beta_5 SUP + beta_6 InterestRate + beta_7 Liquidity + epsilon_i,t

The BEKK-GARCH model is employed for hypothesis testing.

3. Findings and Results

The results of the model test using the ARCH method are presented in Table 2. The estimated coefficients for the main research variable indicate a statistically significant relationship, with a coefficient of 2.642923 (SE = 0.013680, t = 193.1944, $p < .001$). The model demonstrates an R-squared value of 0.086, suggesting that approximately 8.6% of the variance in the dependent variable is explained by the model. Additional diagnostics include a standard error of regression of 46.112, Akaike information criterion (AIC) of 10.500, Schwarz criterion of 10.502, and Hannan-Quinn criterion of 10.501. The Durbin-Watson statistic of 0.019 indicates potential autocorrelation in the residuals.

Table 2. Estimated Coefficients of the Main Research Variable Model

Variable	Coefficient	SE	t	p
Financial	2.642923	0.013680	193.1944	< .001

Note. R^2 = .086, Adjusted R^2 = .086, S.E. of regression = 46.112, AIC = 10.500, DW = 0.019.

The ARCH heteroskedasticity test results (Table 3) confirm the presence of volatility clustering, with an F-statistic of 119,410.8 ($p < .001$) and an Obs*R-squared value of 3,739.192 ($p < .001$). These findings strongly reject the null hypothesis of homoskedasticity, necessitating the use of GARCH-family models.

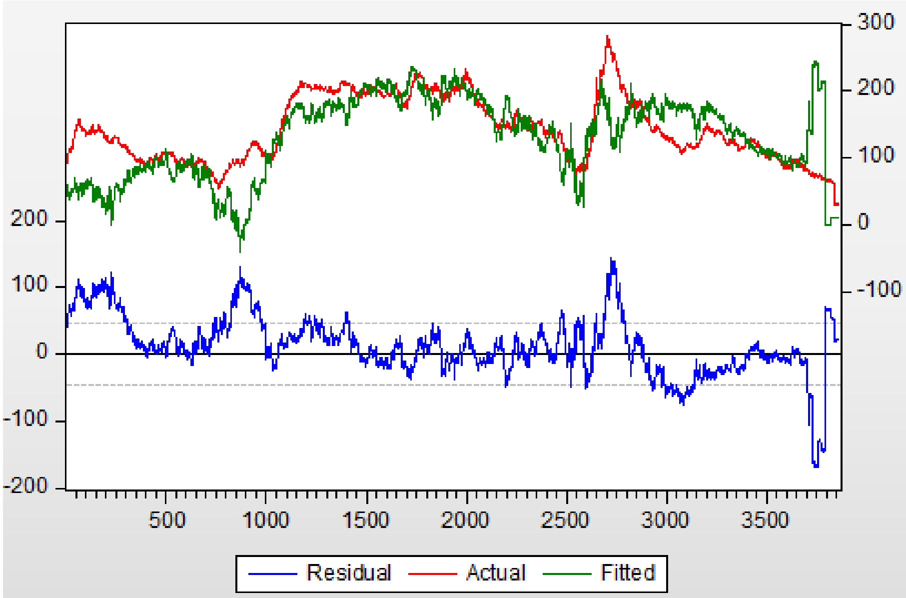

Figure 1. ARCH Correlation Results

Table 3. ARCH Heteroskedasticity Test Results

Test	Statistic	df	p
F-statistic	119,410.8	1, 3858	< .001
Obs*R-squared	3,739.192	1	< .001

Given the structural breaks identified, the BEKK-GARCH model was employed to analyze volatility spillovers. Table 4 presents the results for macroeconomic indicators. The inflation rate ($\beta = 1.552$, $z = 2.167$, $p = .001$), exchange rate ($\beta = 1.824$, $z = 2.102$, $p < .001$), and GDP ($\beta = 1.231$, $z = 1.993$, $p = .002$) exhibit statistically significant effects on stock price crash risk. Similarly, money supply ($\beta = 1.714$, $z = 3.167$, $p < .001$), economic growth ($\beta = 1.525$, $z = 3.005$, $p < .001$), interest rate ($\beta = 1.480$, $z = 2.339$, $p = .002$), and liquidity volume ($\beta = 1.370$, $z = 2.167$, $p = .020$) demonstrate significant influences. All variables meet the significance threshold ($p < .05$) with z-statistics exceeding ±1.96, confirming their material impact.

Table 4. BEKK-GARCH Estimates for Macroeconomic Indicators

Variable	β	z	p
Inflation rate	1.552	2.167	.001
Exchange rate	1.824	2.102	< .001
GDP	1.231	1.993	.002
Money supply	1.714	3.167	< .001
Economic growth	1.525	3.005	< .001
Interest rate	1.480	2.339	.002
Liquidity volume	1.370	2.167	.020

The analysis further confirms significant relationships between stock market indices and crash risk. The price index ($p < .001$), dividend yield index ($p = .010$), and free-float stock index ($p = .001$) all exhibit significance levels below the 5% threshold, with z-statistics supporting their volatility spillover effects. These results collectively underscore the sensitivity of stock price crash risk to macroeconomic and market-driven fluctuations under structural breaks and uncertainty conditions.

4. Discussion and Conclusion

The first hypothesis posited that inflation rate volatility affects stock price crash risk under uncertainty across time intervals and structural breaks. The analysis confirmed this hypothesis, aligning with prior findings [21, 33, 34]. Inflationary shocks influence stock price crash risk through dual mechanisms: rising inflation increases the replacement value of corporate assets, potentially elevating stock prices, while simultaneously eroding purchasing power and reducing consumer demand for equities. This duality creates volatility, as investors rebalance portfolios to hedge against currency devaluation, leading to asymmetric effects on stock valuations.

The second hypothesis proposed that exchange rate volatility affects stock price crash risk under uncertainty across time intervals and structural breaks. The analysis confirmed this hypothesis, consistent with prior studies [2, 33, 35]. Exchange rate fluctuations impact crash risk through conflicting channels: a depreciating currency raises input costs for import-dependent firms, reducing profitability and stock prices, while enhancing export competitiveness for domestic producers, which may boost equity valuations. The net effect depends on sectoral exposure and macroeconomic stability, creating heterogeneous spillover effects across industries.

The third hypothesis stated that gross domestic product (GDP) volatility affects stock price crash risk under uncertainty across time intervals and structural breaks. The analysis confirmed this hypothesis, corroborating [18, 19, 21, 24, 36]. GDP volatility amplifies systemic risk by destabilizing investor expectations, reducing equity demand, and increasing market beta. This macroeconomic uncertainty disproportionately affects cyclical industries, where earnings sensitivity to economic shifts heightens crash risk during structural breaks.

The fourth hypothesis argued that money supply volatility affects stock price crash risk under uncertainty across time intervals and structural breaks. The analysis confirmed this hypothesis, aligning with prior studies [1, 18, 25, 31, 37]. Monetary expansions exhibit short-term negative effects due to inflationary expectations dampening investor sentiment, while long-term liquidity injections align with asset price inflation theories. However, market inefficiencies in emerging economies like Iran amplify volatility, as asymmetric information delays price adjustments to monetary shocks.

The fifth hypothesis asserted that economic growth volatility affects stock price crash risk under uncertainty across time intervals and structural breaks. The analysis confirmed this hypothesis, resonating with prior findings [3, 14]. Growth surges temporarily elevate stock prices through optimistic earnings forecasts but increase crash risk during downturns as overleveraged firms face solvency pressures. This procyclicality is exacerbated in markets with weak corporate governance, where managers delay bad news disclosure until growth reversals trigger abrupt corrections.

The sixth hypothesis posited that interest rate volatility affects stock price crash risk under uncertainty across time intervals and structural breaks. The analysis confirmed this hypothesis, consistent with prior studies [36, 37]. Rising rates increase firms' cost of capital, compressing profit margins and equity valuations, while rate cuts stimulate speculative trading that inflates price bubbles. The dual transmission channels—direct cost effects and indirect disposable income adjustments—create nonlinear relationships, with crash risk intensifying during rapid policy shifts that outpace market expectations.

The seventh hypothesis proposed that liquidity volume volatility affects stock price crash risk under uncertainty across time intervals and structural breaks. The analysis confirmed this hypothesis, corroborating Safidbakht and Ranjbar (2017), Barkish (2015), Luo and Zhang (2020), Dahir and Ebali (2017), and Arora et al. (2011). Liquidity shocks asymmetrically impact markets: expansions disproportionately inflate prices due to herding behavior, while contractions trigger panic selling as margin calls cascade. This reflexivity is amplified in shallow markets, where limited depth exacerbates volatility during structural breaks.

Authors' Contributions

Authors equally contributed to this article.

Ethical Considerations

All procedures performed in this study were under the ethical standards.

Acknowledgments

Authors thank all participants who participate in this study.

Conflict of Interest

The authors report no conflict of interest.

Funding/Financial Support

According to the authors, this article has no financial support.

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