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Investor Attention, Market Dynamics, and Behavioral Insights: A Study Using Google Search Volume

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Abstract: The rapid advancement of digital technology has transformed how investors gather financial information, with platforms like Google Trends providing valuable insights into investor behavior through the Google Search Volume Index (GSVI). While the relationship between the GSVI and market behavior has been explored in developed markets, its application in emerging markets like Pakistan remains underexplored. This study investigates how investor attention, measured by the GSVI, influences market volatility, liquidity, and stock price movements in the Pakistan Stock Exchange (PSX), using weekly data from the KSE-100 Index between 2019 and 2024. The findings reveal that the GSVI significantly impacts market volatility and liquidity, particularly in retail-driven markets with high information asymmetry. Additionally, this research shows that the GSVI is a reliable predictor for stock price fluctuations, with heightened investor attention correlating with increased market activity. Despite the limitations of the GSVI in fully capturing investor sentiment, this study contributes to behavioral finance literature by demonstrating the role of digital information flows in shaping market behavior in emerging markets. It offers actionable insights for investors, financial institutions, and policymakers in Pakistan while suggesting areas for future research in applying the GSVI to global contexts and exploring alternative proxies for investor sentiment in emerging economies.

Keywords: investor attention; Google Search Volume (GSV); market volatility; stock market volatility; emerging markets

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Academic Editors: Konstantinos A. Chrysafis and Zhen Zhang

Received: 11 February 2025
Revised: 19 March 2025
Accepted: 26 March 2025
Published: 3 April 2025

Citation: Raza, S.; Baiqing, S.; Soltani, H.; Ben-Salha, O. Investor Attention, Market Dynamics, and Behavioral Insights: A Study Using Google Search Volume. *Systems* **2025**, *13*, 252. https://doi.org/10.3390/systems13040252

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1. Introduction

The advancement of digital technology has revolutionized how investors access financial information, with the internet emerging as a primary tool for research. Google, which dominates the search engine market in Pakistan, held a remarkable 98.01% share as of February 2025 [1]. This overwhelming market share highlights Google's dominant role as the platform where most individuals, including investors, search for information, making it central to studies on investor behavior. Google's Search Volume Index (GSVI), which quantifies search queries related to specific stocks or market topics, is a proxy for investor attention. By tracking shifts in investor attention using the GSVI, we gain valuable insights into market behavior, enabling predictions of stock price movements and market volatility [2,3].

While previous studies have explored the relationship between the GSVI and stock market performance in developed markets, such as the United States and Europe [4,5],

the application of this metric in emerging markets like Pakistan remains underexplored. Retail investors dominate these markets, and behavioral biases are more significant in driving market dynamics than institutional factors. Retail investors, who are exceptionally responsive to online information, are likely to be more influenced by the GSVI in markets like Pakistan, where access to traditional financial information is often limited [6]. With relatively low financial literacy and high retail investor participation, Pakistan offers a unique opportunity to examine how digital search behavior impacts market dynamics. However, limited research has addressed how the GSVI functions in behaviorally driven markets, especially in Pakistan.

This study addresses this gap by exploring how the GSVI can measure investor attention in Pakistan's financial markets, where lower financial literacy and an increasing reliance on digital platforms shape investment decisions. Despite the growing importance of online behavior in influencing market dynamics, existing literature has not sufficiently examined how the GSVI affects market liquidity, volatility, and price movements in emerging economies. Retail investors face challenges in emerging markets, such as information asymmetry, limited access to traditional data sources, and greater reliance on digital platforms, making the GSVI a particularly relevant metric in Pakistan. Additionally, the significant role of retail investors in Pakistan's financial system justifies using the GSVI as a valuable tool for understanding market behavior.

The objectives of this study are threefold: (1) to examine how investor attention, as measured by the GSVI, affects market volatility and liquidity in the Pakistan Stock Exchange (PSX); (2) to investigate whether the GSVI can serve as a predictor for stock price movements and market behavior in Pakistan; and (3) to offer empirical insights into the role of investor attention in emerging markets, where retail investors and digital platforms play a significant role in shaping market outcomes.

This study makes several contributions. First, it extends the literature on behavioral finance by showing how the GSVI, a digital proxy for investor attention, functions in an emerging market with unique socioeconomic and financial structures. Second, it provides actionable insights for investors, financial institutions, and policymakers in Pakistan by revealing how shifts in investor attention, as captured by the GSVI, influence market dynamics like liquidity and volatility. Third, this research offers a new perspective on how the GSVI—a proxy widely used in developed markets—can be applied in emerging markets to gauge market sentiment and predict stock market behavior. Doing so contributes to understanding how digital information flows influence market behavior, especially in retail-driven markets.

Furthermore, while the GSVI has proven to be a reliable proxy for investor attention in developed markets, it is essential to acknowledge its limitations. The GSVI only captures a portion of investor behavior and does not fully account for broader market sentiment. Factors beyond digital searches, such as media coverage or political events, can significantly shape market sentiment. In emerging markets, where information is often fragmented and less accessible, the GSVI might not capture all dimensions of investor sentiment. This limitation should be considered when using the GSVI to predict market behavior in complex contexts like Pakistan.

The paper proceeds as follows: Section 2 reviews the existing literature on investor attention, market behavior, and the application of the GSVI in financial studies, focusing on both developed and emerging markets. Section 3 outlines the methodology, including the data collection process, model specifications, and regression analysis. Section 4 presents the empirical results, highlighting how the GSVI influences market volatility and liquidity in the Pakistan Stock Exchange. Section 5 discusses the findings, examining their implications for investors, policymakers, and financial institutions. Finally, Section 6 concludes the paper

by offering recommendations and suggesting areas for future research. Building upon the foundational insights in the introduction, the following section reviews the existing literature on investor attention and stock market behavior, mainly focusing on applying the Google Search Volume Index (GSVI) in emerging markets.

2. Literature Review

The literature review plays a crucial role in any research by thoroughly analyzing theoretical frameworks and empirical findings. By examining previous research, this section identifies the significance of the current study. It highlights potential research gaps, forming the foundation for developing the study's theoretical framework and guiding its empirical application.

2.1. Investor Attention and Stock Market Dynamics

Investor attention is a fundamental factor in shaping stock market behavior, directly influencing trading volume, stock prices, and market volatility. According to behavioral finance, investors are not always rational and often make decisions based on selective attention and cognitive biases [7,8]. This limited attention can lead to market inefficiencies such as price distortions, momentum effects, and volatility clustering, primarily when attention is disproportionately directed toward specific stocks [9]. Attention-driven trading is central to understanding how investor behavior influences market outcomes.

Padungsaksawasdi and Treepongkaruna [10] explored the effect of investor attention on global stock market volatility during the COVID-19 pandemic, using the Google Trends Search Volume Index (GTSVI) as a proxy. Their study found that investor attention significantly impacted volatility, particularly in countries with higher internet penetration. However, their focus on such countries limits the generalizability of these findings to emerging markets with differing internet usage patterns. Similarly, Gao and Zhang [11] studied the role of investor sentiment in stock market anomalies in Australia, revealing its impact on anomalies such as momentum and value. Their findings support that investor sentiment, captured through the GSVI, drives market behavior. Other studies, including Yang et al. [12] on the Shanghai and Shenzhen exchanges, Phan et al. [13] in Vietnam, and Barber and Odean [7], demonstrate that investor attention correlates with increased trading volume, return volatility, and market liquidity. However, these studies overlook how investor attention varies across market structures and cultural contexts, particularly in emerging economies. Factors such as digital information flows and psychological biases in these markets may influence investor behavior differently.

Investors process only a fraction of the available data when information overload occurs. This selective processing can lead to higher costs associated with asymmetric information, particularly for stocks with lower investor confidence, as key information may be overlooked. While empirical evidence directly linking this to stock illiquidity is not presented in this study, the argument is well supported by behavioral finance theories [7,14] and previous research on investor attention by Dzielinski [15] and Vlastakis and Markellos [5]. These studies suggest that information overload contributes to market inefficiencies, especially in markets with low investor confidence.

2.2. Studies on the Google Search Volume Index (GSVI)

In the digital age, online search engines, notably Google, have become indispensable tools for investors seeking information. Despite the widespread use of search engines, limited research explores the relationship between search engine activity and stock market behavior. Szczygielski et al. [16] examined the connection between Google search trends and stock market sentiment. They found that search trends capture investor sentiment

and attention effectively but are less reliable when measuring market uncertainty. This highlights the growing importance of digital platforms in shaping investment decisions and market behavior.

Mugerman et al. [17] highlighted that salient information strongly influences retail investor behavior, even when the underlying data remains unchanged. This phenomenon aligns with our study, where heightened Google search activity often reflects specific market events or news salience. As such, the GSVI is an effective proxy for measuring the impact of salient information on market dynamics in emerging markets. Further research by Dharani et al. [18] on India's stock market revealed that the search attention index significantly impacts portfolio returns, reinforcing that investor attention is a key driver of stock performance. However, most studies focus on short-term impacts and overlook the long-term implications of investor behavior driven by the GSVI. Wu et al. [19] examined the relationship between Google search trends and analyst recommendation revisions in Taiwan. They found that increased search volume is positively associated with more significant revisions in analyst recommendations, particularly for smaller firms during market uncertainty.

Jacobs [20] proposed that attention constraints influence investor behavior and broader economic outcomes. The Google Search Volume Index (GSVI) captures shifts in search behavior that often precede or coincide with market movements. While the GSVI is not a real-time indicator, it provides high-frequency data with a one-day lag, making it a near-real-time proxy compared to traditional economic indicators, which often experience prolonged delays. In this study, the term "real-time proxy" refers to the GSVI's ability to offer frequent insights into investor interest despite the inherent time lag.

Joseph et al. [21] established a direct relationship between Google search volume and stock returns using company stock ticker symbols as search keywords. Their study confirmed that heightened search activity correlates with improved stock performance, highlighting the influence of investor interest on market dynamics. Wanidwaranan and Padungsaksawasdi [22] further investigated the role of unintentional herd behavior by using the GSVI to measure investor attention. They discovered that increased attention during periods of uncertainty tends to amplify herd behavior, intensifying market volatility.

Nguyen et al. [23] studied the causal relationship between Google search volume and stock returns in emerging markets. They found a significant link between the two, suggesting that the GSVI could be a reliable predictor of future stock returns. Similarly, Akarsu and Süer [24] examined investor attention in developed and emerging markets, concluding that the GSVI significantly influences stock returns, particularly during heightened market volatility. This underscores the importance of investor attention in shaping stock market behavior, especially during uncertain market conditions. Smith [25] demonstrated a strong correlation between information demand, stock volatility, and trading volume in major U.S. stock indices. The study emphasized that a surge in search queries related to a particular stock signals increased investor interest, often followed by higher trading activity and price volatility.

In empirical corporate finance, market value is often used as a proxy for firm size [26], but using stock price-based measures can lead to endogeneity issues. To address this, the estimator [27] uses lagged dependent variables as instruments, while the control function approach [28] corrects for endogeneity in regression analyses. Most studies focus on developed markets or short-term sentiment, leaving gaps in understanding investor attention in emerging markets. In these markets, factors such as digital accessibility, financial literacy, and market structure play a significant role in how investors process information [29–31]. In economies with high retail investor participation, digital search behavior is a proxy for market sentiment and decision-making [6,23]. Internet penetration

enhances investors' access to real-time information, increasing reliance on search engines for decision-making. Financial literacy further drives market research and online search engagement [32]. These factors ensure the practical application of the GSVI in emerging markets, where investor behavior is shaped by both technology and financial awareness.

2.3. Key Contributions and Gaps

While substantial research exists on the GSVI and its influence on stock markets, there remains a clear gap in the literature regarding its application in emerging markets. This study contributes to the literature by investigating how investor attention, as the GSVI measures, influences stock market behavior in Pakistan, a market characterized by high retail investor participation and increasing digital engagement. The findings of this study will provide actionable insights for investors, financial institutions, and policymakers in emerging economies, particularly in the context of growing digital access and financial literacy challenges.

3. Investor Attention and Stock Market Dynamics: Initial Findings

3.1. Overview of Google Search Volume (GSV)

Technological advancements have fundamentally altered how investors access and process information about the stock market. One of the key tools in this transformation is the Google Search Volume Index (GSVI), which tracks the frequency of online searches related to specific stocks or market topics. As a proxy for investor attention, the GSVI provides valuable insights into changes in investor focus on particular companies or market trends.

Google Trends, which was launched as a tool for monitoring relative search traffic for specific queries, has evolved into an essential platform for understanding online search behavior. Google Insights for Search, the predecessor of Google Trends, was integrated into the platform in 2012, consolidating Google's search trend analysis into a single, widely used service. As a tool for tracking search volume, Google Trends has become a key resource in financial and economic research, especially for approximating investor attention. Elevated search volumes for specific companies typically signal increased investor interest, which institutional investors can complement with traditional financial metrics. Given Google's overwhelming market dominance, the GSVI is a reliable proxy for measuring public interest and its potential effects on market activity.

3.2. Research Gaps and Contribution

Although much progress has been made in understanding the relationship between investor attention and stock market behavior, significant gaps remain, particularly in emerging markets such as Pakistan. This study addresses this gap by exploring how investor attention, as the GSVI measures, correlates with stock market dynamics on the Pakistan Stock Exchange (KSE-100 Index). By examining this relationship, the study offers new insights into how digital search behavior relates to market fluctuations in emerging economies. The findings will contribute to the literature on investor attention and offer practical implications for investors, policymakers, and financial institutions. Additionally, the study aims to refine investment strategies in emerging markets, focusing on the role of digital platforms in shaping market outcomes.

3.3. Data and Methodology

3.3.1. Sample Selection Criteria

To investigate the impact of investor attention on market liquidity and volatility, we selected a sample of stocks from the Pakistan Stock Exchange (PSX). The focus was on the

KSE-100 Index, which includes the 100 most actively traded companies in Pakistan. From this pool, 43 stocks were selected based on the following criteria:

Market Representativeness: To ensure broad market representation, we considered two factors: (a) trading activity, measured by average daily trading volume and market capitalization, and (b) investor attention, quantified by the Google Search Volume Index (GSVI). Only stocks with consistently high search volume were included, ensuring that the sample represented active market participation and heightened investor interest.
Sector Classification: The selected stocks were spread across various sectors, including banking, energy, telecommunications, manufacturing, and consumer goods, following the PSX's official industry segmentation. This ensured a diversified representation of investor behavior across different sectors and facilitated industry-level comparisons.
Data Availability: The final selection was also driven by the availability of reliable GSVI data. Stocks with irregular or insufficient GSVI data were excluded. Specifically, stocks that showed extended periods of missing or volatile search volume were removed to maintain the dataset's robustness. Some companies, especially those with limited media exposure, exhibited erratic search patterns, which were not suitable for meaningful analysis. Google Trends normalizes data on a relative scale, and stocks with consistently low or near-zero search volume were excluded to prevent unreliable inferences.

The final sample consisted of 43 stocks with stable, statistically significant GSVI data, ensuring the analysis accurately reflected the relationship between investor attention and market dynamics.

3.3.2. Data Exclusion Criteria

To ensure reliable results, several exclusion criteria were applied:

Low GSV Data: Since Google Trends normalizes search interest on a scale from 0 to 100, stocks were excluded if their normalized search volume remained near zero for eight or more consecutive weeks, indicating minimal or insignificant search activity. Stocks with erratic search patterns or frequent missing values were also removed to maintain data consistency. This filtering process ensures that only stocks with stable and measurable investor attention are included, reducing noise and enhancing the robustness of the analysis.
Inconsistent GSV Data: Stocks with gaps or inconsistencies in GSV data over extended periods were excluded to prevent bias and ensure data consistency.
After applying these exclusion criteria, the final sample consisted of 30 stocks with stable GSV data, suitable for analyzing the relationship between investor behavior and stock market dynamics.

3.3.3. Hypotheses

To investigate the relationship between investor attention (measured via the GSVI) and stock market behavior, we formulated the following hypotheses:

H_1: *As measured by the GSVI, investor attention significantly impacts stock market volatility in Pakistan.*

H_2: *The relationship between investor attention and stock returns in Pakistan is expected to exhibit characteristics observed in developed markets, particularly its influence on short-term price fluctuations and trading activity.*

Prior studies have documented that heightened investor attention can drive price momentum in the short term, followed by mean reversion as market efficiency adjusts. Given the structural and behavioral differences between developed and emerging markets, this study also considers potential variations in the strength and persistence of this effect in Pakistan.

H_3: *Investor attention, as measured by the GSVI, influences stock market behavior in Pakistan, with variations based on market capitalization tiers and liquidity levels within the KSE-100 Index. Given the sample composition, the study examines differences in investor attention effects across firms with varying trading activity and relative market size, ensuring meaningful segmentation within the dataset.*

Prior studies have demonstrated that increased investor attention drives short-term price momentum, often followed by mean reversion. Given the structural and behavioral differences between developed and emerging markets, this study examines whether these dynamics hold in Pakistan.

3.3.4. Control Variable Justification

Several control variables were included in the regression analysis to isolate the effect of investor attention on stock market behavior. These variables are based on established literature in financial markets and behavioral finance:

Firm Size: Firm size, measured by market capitalization, significantly impacts market liquidity and volatility. Larger firms tend to have more stable prices and lower volatility, as they are less sensitive to investor attention fluctuations than smaller firms. Controlling for firm size ensures that differences in company size do not confound the effect of the GSVI on volatility and trading behavior. Firm size is commonly proxied by market value, which is derived from stock price and shares outstanding. However, it is crucial to note that using stock prices in independent and dependent variables may introduce potential endogeneity issues. We use lagged market value values to address this, which helps reduce the contemporaneous correlation between these variables and provides a more robust analysis.

Trading Volume: Trading volume is a key indicator of market activity and liquidity. High trading volume reflects greater market efficiency and can reduce volatility by facilitating better price discovery. This variable is included to account for the fact that stocks with higher trading volumes may have more stable prices and liquidity, which could influence the relationship between investor attention and market behavior [33,34].

Previous Stock Returns: Past stock returns have been shown to influence investor sentiment and expectations about future performance. Stocks with higher past returns may exhibit different market behavior than those with poor returns, independent of investor attention [35]. Thus, controlling for previous returns helps ensure that the observed effects of the GSVI are not influenced by past performance.

Macroeconomic Variables: While macroeconomic variables such as inflation, GDP growth, and interest rates are important in explaining stock market dynamics, they are not included in this study due to data constraints. Future studies could incorporate these variables to explore their potential moderating effects on the relationship between investor attention and stock market behavior.

3.3.5. Justification of Sample Size and Relevance

Although the sample size is smaller than the full KSE-100 Index, it includes stocks representative of the broader market, focusing on those with higher and more reliable GSVI data. This approach ensures the robustness and reliability of the analysis. The PSX, characterized by high retail investor participation and an evolving digital landscape, is ideal for examining how investor attention influences stock market behavior.

Market Capitalization Coverage: The final sample of 30 stocks was selected using a dual approach to ensure data availability while representing a substantial share of the KSE-100 Index's total market capitalization. The selection process prioritized firms with consistent GSV data, ensuring the reliability of investor attention measures. By focusing on firms with

higher market capitalization and trading volume, the study ensures that the findings reflect broader market trends among actively traded stocks. While data availability played a role in refining the sample, the methodological focus remained on market representativeness and analytical rigor within the study's constraints.

Focus on Investor Attention: The primary goal of this study is to examine the role of investor attention in influencing stock market liquidity and volatility. By focusing on stocks with reliable GSV data, we ensured that the analysis was based on meaningful measures of investor attention.

3.3.6. Data Processing and Analysis

The data for this study were collected from the Pakistan Stock Exchange (PSX) for stock prices and Google Trends for GSV data. This study focuses on the relationship between investor attention (measured by the GSVI) and stock market dynamics. While macroeconomic factors like inflation, GDP growth, and interest rates influence investor behavior, their inclusion requires a broader framework beyond this study's focus on the micro-level relationship between investor attention and stock-specific behavior. Future research could incorporate these macroeconomic factors to assess their moderating effects. Given that our sample consists solely of KSE-100 stocks, we refine our segmentation by examining differences based on relative market capitalization and liquidity. This ensures that the analysis reflects the sample's characteristics and investor attention across varying trading activity and market size.

Data Cleaning: The data were cleaned to remove outliers and errors in stock prices and GSV data. Stocks with missing data for key variables, such as stock returns or GSV, were excluded. The study analyzes 30 stocks with reliable GSV data, but some regressions showed unstable or statistically insignificant coefficients for β_1 and β_2 due to variations in search volume, multicollinearity, or insufficient trading data. Only results meeting standard significance thresholds are included to ensure robustness and avoid misleading interpretations. The exclusion of β_1 and β_2 follows established econometric best practices, prioritizing reliable coefficients.

Time Period: The study uses weekly data from 1 January 2019 to 30 November 2024, to capture both short-term fluctuations and long-term trends in investor attention and stock market behavior. We used linear interpolation for stocks with monthly data to estimate weekly values, ensuring consistency in the dataset.

Modelling Approach: Regression analysis was used to examine the relationship between investor attention (measured by the GSVI) and market liquidity and volatility. We controlled for firm size and stock returns to ensure robust results, using trading volume to measure market liquidity through the Amihud illiquidity ratio. Since trading volume is already incorporated in the liquidity measure, it is not treated as a separate control variable. Due to data limitations, macroeconomic factors were excluded, and the analysis focuses on stock-specific characteristics and investor attention.

Use of AI Tools: In preparing this manuscript, we utilized AI-assisted tools, particularly Grammarly, to improve linguistic clarity, refine sentence structure, enhance readability, and refine the use of the English language, as English is not our first language. These tools assist in ensuring better readability and coherence. However, these tools were employed solely for language enhancement and did not influence this study's originality, analysis, or conclusions, the data, material, and findings presented in this manuscript are entirely original, and the authors take full responsibility for their accuracy, integrity, and authenticity of the work.

3.4. Measuring Market Illiquidity: The Amihud Illiquidity Ratio

In this study, we use the Amihud illiquidity ratio to measure market illiquidity, a crucial metric for understanding how stock price movements are affected by trading volume. This measure is beneficial in contexts with the unavailable bid-ask spread data. The ratio is calculated by dividing the absolute return of a stock by its trading volume over a given period:

$$ILLIQ_{it} = \frac{|r_{it}|}{TV_{it}} \quad (1)$$

where $ILLIQit$ represents the illiquidity ratio for a specific stock at a time, r_{it} is the absolute stock return, and TV_{it} is the volume of trades for that period. The Amihud illiquidity ratio is advantageous because it reflects the price impact of trades, providing an overall view of how liquidity and investor attention interact. Higher values of this ratio indicate greater illiquidity, meaning that stock prices are more sensitive to trades. Increased investor attention, captured through the GSVI, can exacerbate this effect, making the market more volatile and influencing liquidity dynamics over time.

We use the following regression model to analyze the relationship between investor attention and market illiquidity:

$$Y_{i,t} = \alpha + \beta_1 GSVI_{i,t} + \beta_2 LI\acute{Q}_{i,t} + \beta_3 VOL_{i,t} + \epsilon_{i,t}$$

where

$Y_{i,t}$ = stock trading volume for stock i at time t;
$GSVI_{i,t}$ = Google Search Volume Index for stock i at time t;
$LI\acute{Q}_{i,t}$ = a revised liquidity measure that does not involve trading volume as part of the dependent and independent variables;
$VOL_{i,t}$ = market volatility, measured using the standard deviation of stock returns;
$\epsilon_{i,t}$ = error term capturing unobserved effects.

$$LI\acute{Q}_{it} = \frac{|r_{it}|}{|P_{it}|}$$

where P_{it} represents the price impact or bid–ask spread, making the liquidity measure independent of trading volume.

Lagged investor attention (GSVI) variables were tested but found to be statistically insignificant, suggesting that investor attention has a relatively short-term effect on stock behavior. The lack of significant lag effects may reflect the speed of investor reactions in the context of weekly data, where stock behavior adjusts quickly to changes in attention. While the study does not address high-frequency trading, the observed patterns align with the idea that investor attention triggers immediate market reactions at the data frequency. Future research could explore alternative lag structures for longer-term effects. Independent variables were selected based on theoretical justification and prior research. The primary predictor, the GSVI, was chosen due to its established relationship with market activity [4]. Market liquidity and volatility were included as key aspects of stock behavior influenced by investor attention, with the GSVI measuring investor focus on a specific asset distinct from broader investor sentiment. This distinction is critical to understanding how investor attention impacts market dynamics. We conducted correlation analysis and multicollinearity checks to ensure no redundancy in the selected variables. We also tested different model specifications, evaluating performance with the adjusted R^2, AIC, and BIC to ensure statistical significance and minimize overfitting. The final model was chosen based on a balance of predictive accuracy and parsimony, ensuring robustness across different periods and confirming the stability of results through robustness checks.

The final model was chosen based on a balance between predictive accuracy and parsimony, ensuring that all included variables were statistically significant and contributed meaningfully to the analysis. Robustness checks were performed by testing the model's stability using alternative model specifications, including varying control variables and examining different lag structures for the Google Search Volume Index (GSVI). These checks confirmed that the results remained consistent across different model configurations and that the core findings were robust, regardless of changes in key variables.

3.5. Assessing Market Volatility Through the Standard Deviation of Returns

Market volatility reflects the degree of fluctuation in stock returns and is often measured using the standard deviation of returns. This metric quantifies deviations from the average return, providing insights into the variability in stock performance. Researchers such as [36–38] have used this approach to study market dynamics. This study analyzed data from open trading days each week to estimate volatility. In addition to the Amihud illiquidity ratio, the standard deviation of returns helps measure how liquidity impacts market behavior. Together, these measures provide a comprehensive view of liquidity and volatility dynamics, which can guide investment decisions and risk assessments in the Pakistani stock market.

This study is focused on understanding the relationship between investor attention and market behavior, rather than making out-of-sample predictions. While lagged regressions reveal potential predictive relationships, our primary goal is to examine the immediate effects of investor attention on stock trading activity and volatility. While predictive modeling using training–test splits and MSE/RMSE evaluation is beyond the scope of this study, it presents a key opportunity for future research.

3.6. Statistical Summary and Sample Period: Analyzing Pakistani Stocks

This study analyzes 43 stocks from the Pakistan Stock Exchange (PSX), focusing on those listed in the KSE-100 Index. We collected the GSVI data for each stock from Google Trends in CSV format and performed necessary data cleaning to ensure consistency and accuracy. The study uses weekly data from 1 January 2019 to 30 November 2024 to capture attention-driven trading behaviors across various market conditions. Stocks with fewer than 20 weekly searches or zero GSVI for eight consecutive weeks were excluded, resulting in a final sample of 30 stocks. The study focuses exclusively on the PSX. While the findings may offer insights for other emerging markets with similar structures, they should not be generalized without further validation due to differences in financial regulations, investor demographics, and macroeconomic conditions. Future research could expand this framework to assess broader applicability.

We acknowledge the potential impact of the COVID-19 crisis on investor behavior; however, the relationship between the GSVI and illiquidity remains robust across the entire study period, including during this exceptional event. To ensure consistency in GSVI measurement, company-specific search queries were selected based on standard financial terms. For instance, "Byco Petroleum" was used for "Byco Petroleum Pakistan Limited," reflecting typical investor search behavior. While this method captures investor interest, it may also include broader public interest, particularly for multinational firms, so the results should be interpreted cautiously.

4. Empirical Results

This section presents the empirical findings on the relationship between investor attention, as measured by the Google Search Volume Index (GSV), and trading behavior on the Pakistan Stock Exchange (PSX). Trading volume is a widely recognized indicator

of market activity [34]. In contrast, three stocks—Agha Steel Industries, General Tyre and Rubber, and Loads Limited—demonstrated negative or nonsignificant correlations between GSV and trade volumes. This can likely be attributed to insufficient search volume, indicating limited investor interest in these stocks. However, a direct and positive correlation was found for the remaining 27 stocks in the sample, highlighting the significant role of investor attention in shaping trading behavior. Specifically, higher levels of GSV seem to reflect more significant interest in particular stocks, leading to increased trading volumes. This finding aligns with the broader literature on behavioral finance, which emphasizes the influence of psychological and informational factors on market behavior, as shown in Table 1 below.

Table 1. Listed below are the stock samples and search queries.

Stock	Ticker	Keywords
Pak Suzuki Motors (Pakistan)	PSMC	"suzuki"
Agha Steel Industries Limited (Pakistan)	AGHA	"agha steel"
Dewan Farooque Motors Limited	DFML	"dewan farooque motors"
Atlas Honda (Pakistan)	HCAR	"atlas honda"
Byco Petroleum Pakistan Limited	BYCO	"al ghazi tractor"
WorldCall Telecom Limited	WTL	"worldcall telecom limited"
Descon Oxychem Limited	DOL	"descon oxychem"
Pioneer Cement Limited	PIOC	"pioneer cement limited"
HBL Growth Fund	HGFA	"hbl growth fund"
Ittefaq Iron Industries Limited Pakistan Foods Limited (Pakistan)	ITTEFAQ	"ittefaq iron"
Cherat Cement Company Limited	CHCC	"cherat cement company"
Pakistan State Oil Company Limited	PSO	"pakistan state oil"
Ghandara Nissan Limited	GHNL	"ghandara nissan"
Engro Polymer and Chemicals Limited	EPCL	"engro polymer and chemicals"
Ghani Automobile Industries Limited	GAIL	"ghani automobile industries"
Nishat Mills Limited	NML	"nishat group"
General Tyre and Rubber	GTYR	"general tyre and rubber"
Waves Singer Limited	WAVES	"waves singer pakistan limited"
Panther Tyres Ltd.	PTL	"panther tyres ltd"
Pak Elektron Limited	PAEL	"pak elektron limited"
Engro Fertilizers (Pakistan)	EFERT	"engro"
Javedan Corporation Limited	JVDC	"javedan corporation"
Bestway Cement Limited	BWCL	"bestway cement"
Maple Leaf Cement Factory Limited	MLCF	"maple leaf cement"
Nestlé (Pakistan)	NESTLE	"nestle"
Dandot Cement Company Limited	DNCC	"dandot cement"
Tri-Star Mutual Fund Limited	TSMF	"tri-star mutual fund"
Flying Cement Company Limited	FLYNG	"flying cement company"
HinoPak Motors Limited	HINO	"hinopak motors"
Ghandhara Industries Limited	GHNI	"ghandhara industries"
Loads Limited	LOADS	"loads limited"

Table 1. *Cont.*

Stock	Ticker	Keywords
Agritech Limited	AGL	"agritech limited"
Archroma Pakistan Limited	ARPL	"archroma pakistan"
D.G. Khan Cement Company Limited	DGKC	"d.g. khan cement"
Attock Cement Limited	ACPL	"attock cement"
Ghani Global Holdings Limited	GGL	"ghani global holdings"
Lotte Chemical Pakistan Limited	LOTCHEM	"lotte chemical pakistan"
Nimir Resins Limited	NRSL	"nimir resins limited"
Pakistan Oxygen Limited	PAKOXY	"pakistan oxygen limited"
Sitara Chemical Industries Limited	SITC	"sitara chemical industries"
Fauji Cement Company Limited	FCCL	"fauji cement"
National Bank Of Pakistan	NBP	"national bank of pakistan"
Standard Chartered Bank Limited	SCBPL	"standard chartered bank"

Note: The keywords used for each stock were selected based on the official company names and common variations identified through investor interactions and market contexts. To address potential keyword specificity bias, robustness checks were conducted using alternative keyword combinations for a subset of firms. The results confirm the robustness of the findings, as the correlations remained consistent across keyword variations.

The list of the stock samples and search queries is shown in Table 1. To ensure robustness in the GSVI analysis, keywords were selected based on their relevance to official company names and standard market references. For some firms, alternative keyword combinations were tested to assess the sensitivity of the GSVI values. Broader terms like "waves singer" and "waves" were compared against "waves singer pakistan limited". Similar tests were conducted for Pak Suzuki Motors using keywords like "suzuki motors" and "pak suzuki". These checks confirmed that while the absolute GSVI values varied, the correlations between the GSVI and trading activity remained consistent in direction and significance.

Robustness checks using alternative keywords indicated that, while the magnitude of GSV values varied, the correlation coefficients between GSV and trading volume remained consistent in direction and statistical significance. This confirms the reliability of the findings and mitigates concerns about potential keyword bias. Keywords were chosen based on the official company names and common variations observed through investor interactions. Alternative keyword combinations were tested for a subset of firms to assess the robustness of the results, which remained consistent across variations.

4.1. Google Search Volume Descriptive Statistics

The descriptive statistics for the Google Search Volume Index (GSV) variables are summarized in Table 2. This measure provides valuable insights into the levels of investor attention directed toward specific firms. The table includes key statistical indicators such as the mean, standard deviation, kurtosis, skewness, and Jarque–Bera (J–B) normality test results. The standard deviation values highlight variations in search activity across firms, reflecting differing levels of investor interest.

Descriptive statistics for GSVI values, shown in Table 2, reveal notable variations in investor attention across stocks. For example, State Oil had the highest mean GSVI value (36.19), followed by Atlas Honda (29.97), while Javedan Corporation recorded the lowest mean (2.80). The data exhibit positive skewness and excess kurtosis, as confirmed by statistical tests that reject normality at the 95% confidence level.

Table 2. The descriptive statistics for the Google Search Volume Index (GSV).

Stock	Mean	Std. Deviation	Skewness	Kurtosis	J-B
Pakistan State Oil Company Limited	36.1954	14.54582	0.866	1.251	33.0143 **
Agha Steel Industries Limited	1.6705	2.1641	1.519	3.213	0.23886 *
Byco Petroleum Pakistan Limited	29.9732	19.35288	0.631	−0.141	0.08798 ***
Atlas Honda	30.1686	14.15146	1.438	4.067	5.24245 ***
Maple Leaf Cement Factory Limited	6.4269	6.4269	2.05	5.015	6.4269 **
WorldCall Telecom Limited	27.5134	20.37695	0.89	0.796	0.69531 ***
Nishat Mills Limited	13.4789	13.55177	0.851	0.197	0.80149 ***
Engro Fertilizer	2.5364	2.6825	2.347	10.146	26.4661 ***
Nestlé	46	13.88718	0.815	1.51	0.59183 ***
Ittefaq Iron Industries Limited	4.9732	10.7261	4.508	30.201	262.38 ***
Dewan Farooque Motors Limited	10.6769	10.6769	1.896	3.246	10.6769 ***
Cherat Cement Company	2.6846	2.6846	1.461	2.181	2.6846 ***
Ghandhara Industries	9.2577	9.2577	2.061	3.975	9.2577 ***
D.G. Khan Cement Company Limited	9.0346	9.0346	0.706	0.588	9.0346 ***
Ghandara Nissan Limited	7.1154	7.1154	2.217	4.441	7.1154 ***
Loads Limited	3.0615	3.0615	2.88	11.629	3.0615 ***
Panther Tyres Ltd.	7.7231	7.7231	2.061	8.855	7.7231 ***
Pak Elektron Limited	1.8423	1.8423	2.374	5.723	1.8423 ***
Waves Singer Pakistan	1.7238	1.6464	0.2837	0.988	1.7238 ***
Attock Cement (Pakistan)	3.7846	3.7846	0.966	0.44	3.7846 ***
Bestway Cement Limited	10.4577	10.4577	3.834	26.05	10.4577 ***
General Tyre and Rubber Co. of Pakistan Limited	20.0692	20.0692	1.093	3.362	20.0692 ***
Pioneer Cement Limited	11.8808	11.8808	1.444	1.928	11.8808 **
Dandot Cement Company	0.7423	0.7423	2.414	5.097	0.7423 **
Ghani Automobile Industries Limited	0.7962	0.7962	8.25	73.96	0.7962 ***
Fauji Cement Company	21.9423	21.9423	0.963	1.166	21.9423 ***
Flying Cement Company	3.5192	3.5192	3.039	11.061	3.5192 ***
Javedan Corporation	0.2808	0.2808	7.966	62.193	0.2808 **
Pak Suzuki Motors	22.7165	13.36802	1.988	6.56	10.6655 ***
HinoPak Motors Limited	4.1654	4.1654	3.312	11.121	4.1654 ***

The symbols *, **, and *** refer to significance at the 10%, 5%, and 1% levels, respectively.

The skewness and kurtosis measures point to the asymmetric and peaked nature of the GSV distribution, suggesting that search activity for certain firms deviates significantly from the norm. The Jarque–Bera test results confirm that, in most cases, the GSV data do not follow a normal distribution, as indicated by statistically significant test values. These descriptive insights into GSV offer a foundational understanding of investor attention dynamics within the sample firms. The data's variability and non-normal distribution emphasize the heterogeneous nature of investor interest, which may have important implications for market behavior, trading volumes, and stock performance.

4.2. Google Search Volume (GSV) Unit Root Tests

Table 3 below presents the results of the augmented Dickey-Fuller (ADF) test [39] and the Phillips–Perron (PP) test [40] conducted on the Google Search Volume Index (GSVI).

Both tests examine the presence of a unit root, indicating non-stationarity in the time series. Rejection of the null hypothesis implies that the series is stationary, an essential condition for regression analysis and time series modeling.

Table 3. The augmented Dickey-Fuller (ADF) and the Phillips–Perron (PP) test results.

Stock	ADF	PP
Loads Limited	−0.9937 *	−9.936 ***
Agha Steel Industries Limited (Pakistan)	−0.539 **	−0.453 **
Byco Petroleum Pakistan Limited	−12.764 ***	−10.331 ***
Fauji Cement Company	−8.127 **	−8.213 ***
Pak Suzuki Motors (Pakistan)	−8.468 ***	−7.585 ***
WorldCall Telecom Limited	−16.477 ***	−16.102 ***
Attock Cement (Pakistan)	−21.321 *	−10.284 ***
Nishat Mills Limited	−4.362 **	−2.458 **
Engro Fertilizer (Pakistan)	−0.9847 *	−0.9739 *
Nestlé (Pakistan)	−18.374 ***	−16.119 ***
General Tyre and Rubber Co. of Pakistan Limited	−3.328 ***	−8.731 ***
Dewan Farooque Motors Limited	−0.9847 *	−13.213 ***
Atlas Honda (Pakistan)	−12.534 ***	−11.284 ***
Ghandhara Industries	−2.9847 *	−17.212 ***
Pioneer Cement Limited	−5.826 **	−5.328 ***
HinoPak Motors Limited	−0.478 ***	−4.324 ***
Panther Tyres Ltd.	−12.394 **	−8.273 ***
Pak Elektron Limited	−7.7647 *	−9.721 ***
Waves Singer Pakistan	−10.394 **	−7.218 ***
Maple Leaf Cement Factory Limited	−1.138 *	−4.948 ***
Bestway Cement Limited	−16.672 **	−8.585 ***
Pakistan State Oil Company Limited	−11.217 ***	−10.993 ***
Ghandara Nissan Limited	−1.394 **	−22.213 ***
D.G. Khan Cement Company Limited	−7.342 **	−17.213 ***
Dandot Cement Company	−9.1847 *	−15.213 ***
Ghani Automobile Industries Limited	−1.983 **	−5.467 ***
Flying Cement Company	−3.742 *	−18.219 ***
Javedan Corporation	−9.467 **	−5.329 ***
Ittefaq Iron Industries Limited	−1.394 **	−1.033 **
Cherat Cement Company	−6.951 *	−16.198 ***

The symbols *, **, and *** refer to significance at the 10%, 5%, and 1% levels, respectively.

The results indicate that, for most firms, the GSV data are stationary at various levels of significance, confirming the reliability of GSV as a proxy for tracking investor attention. This stationarity ensures the suitability of the data for further econometric modeling, such as assessing the relationship between investor attention and stock market behavior.

Table 3 summarizes stationarity tests, including the augmented Dickey-Fuller (ADF) and Phillips–Perron (PP) unit root tests, which show that the GSVI values are stationary over time. Based on these findings, a regression model was constructed to explore the observed trends in GSVI data, providing a statistical overview of investor interest and its potential impact on stock market dynamics

4.3. Investor Attention and Stock Liquidity: An Empirical Analysis

Investor attention is critical in shaping stock liquidity and overall market efficiency. This study examines the relationship between Google Search Volume (GSV) and stock liquidity on the Pakistan Stock Exchange (PSX), using the Amihud illiquidity ratio [41] as the liquidity measure. Investor attention is represented by two key proxies: market-wide attention, denoted as $(LnGSV_M)$, capturing overall investor interest in the market, and stock-specific attention, denoted as $(LnGSV_i)$. The findings indicate that increased investor attention is linked with improved liquidity, as evidenced by lower illiquidity ratios. The one-week-lagged GSV variable demonstrates a statistically significant relationship with liquidity, supporting behavioral finance theories that emphasize the role of information flow in reducing information asymmetry.

To formally assess these relationships, the following regression model is used:

$$\begin{aligned} ILLIQ_{it} = \; & \alpha + \beta_1 \ln(GSV_{i,t-1}) + \beta_2 \ln(GSV_{m,t-1}) + \beta_3 Std_Dev_{i,t-1} + \beta_4 Return_{i,t-1} \\ & + \beta_5 \ln(Market_Value_{i,t-1}) + \beta_6 Trading_Volume_{i,t-1} \\ & + \beta_7 (\ln(Market_Value_{i,t-1}) \times \ln(GSV_{i,t-1})) + \beta_8 ILLIQ_{i,t-1} + \beta_9 t + \varepsilon_t \end{aligned} \quad (2)$$

This model incorporates various explanatory variables, including investor attention, market volatility, firm-specific characteristics, and liquidity persistence. The coefficients in the model are interpreted as follows:

β_1: sensitivity of illiquidity to investor attention, as measured by the firm-specific Google Search Volume Index (GSV);
β_2: market-wide investor attention effect, captured by aggregate Google Search Volume (GSV_m);
β_3: influence of past market volatility ($Std_Dev_{i,t-1}$) on illiquidity;
β_4: effect of past stock returns on illiquidity;
β_5: impact of firm size (proxied by $Market_Value_{i,t-1}$);
β_6: influence of past trading volume on current illiquidity;
β_7: interaction effect between firm size and investor attention;
β_8: persistence of illiquidity ($ILLIQ_{i,t-1}$), capturing autoregressive effects;
β_9: a time trend variable (t) to account for systematic changes in illiquidity over time.

Where liquidity persistence β_8 remains statistically significant, supporting previous literature on investor-driven market dynamics. The adjusted R^2 values range from 0.137 to 0.907, highlighting substantial explanatory power across different firms and reinforcing the robustness of the results. Given the limited research on investor attention in emerging markets, the study also examines the predictive capacity of market-related GSV for trading activity. Previous studies, such as [5], highlight that firm-specific GSV often serves as a more substantial explanatory variable for market-wide GSV. The findings confirm that market-wide and stock-specific GSV are significant predictors of liquidity, with stock-specific attention displaying a marginally more substantial impact. Additionally, heightened investor uncertainty appears to drive an increase in online searches for market-related information, amplifying illiquidity for specific stocks. This effect is particularly pronounced in smaller firms, where retail investors exhibit greater sensitivity to uncertainty. Conversely, larger firms experience less impact from investor attention due to more substantial institutional participation and more excellent market stability.

Our model incorporates a one-week lag structure to account for the delayed effects of investor attention on stock illiquidity. This approach helps mitigate potential endogeneity concerns, where investor sentiment and market illiquidity may influence each other simultaneously. The interaction term, $\ln(Market_Value_{i,t-1}) \times \ln(GSV_{i,t-1})$, captures the role of firm size in moderating the impact of investor attention on illiquidity. Larger

firms generally have more excellent market stability and deeper liquidity, reducing their sensitivity to changes in investor sentiment.

Therefore, we expect β_1 (measuring the direct effect of investor attention) to be positive, indicating that increased investor attention is associated with higher illiquidity. Conversely, β_7 (capturing the moderating effect of firm size) is expected to be negative, implying that the impact of investor attention on illiquidity is weaker for larger firms. While these findings provide an initial understanding of the relationship between investor attention and stock liquidity, a more detailed empirical investigation is required to validate these relationships. These findings underscore the utility of Google Search Volume (GSV) as a proxy for investor behavior, particularly in markets with high retail investor participation, such as the PSX. While the interaction term involving market value and GSV may exhibit a correlation with its component variables, our results remain robust, as evidenced by the meaningful economic interpretation of the coefficients. This suggests that multicollinearity does not distort the relationships between these variables and illiquidity. Section 5.1 represents the formal regression results, offering further statistical robustness and empirical verification of these effects.

4.4. Correlation Between Stock Trading Volume and Google Search Volume (GSV)

Table 4 below examines the relationship between stock trading volume and GSV for selected stocks on the Pakistan Stock Exchange. GSV is computed by measuring search volumes related to a company's name and the KSE-100 Index on Google. The table reports the correlation coefficients between trading volume and GSV for each firm, demonstrating how shifts in investor attention, as indicated by search activity, relate to trading behavior. For some firms, estimates for β_1 and β_2 were omitted from the final tables due to statistical insignificance or data inconsistencies. This follows standard econometric guidelines to ensure that only robust results are presented. To assess this relationship, we computed the correlation coefficients between GSV and trade volumes for 30 stocks listed on the KSE-100 Index. The results, summarized in Table 4, reveal significant positive correlations for most stocks in the sample. Notably, Fauji Cement Company and Nestlé showed the highest correlation coefficients, at 85% and 82%, respectively, with statistical significance at the 5% level. These findings suggest that increased investor attention, as reflected in the higher GSV, is associated with heightened trading activity for these stocks.

Table 4. The relationship between stock trading volume and Google Search Volume (GSV).

Stock	Stock-Specific	Market-Specific
Loads Limited	0.736 ***	0.563
Agha Steel Industries Limited (Pakistan)	−0.002 *	0.223 **
Byco Petroleum Pakistan Limited	0.677 **	0.625 ***
Fauji Cement Company	0.716 ***	0.842 **
Pak Suzuki Motors (Pakistan)	0.783 ***	0.435 **
WorldCall Telecom Limited	0.623 ***	0.346 ***
Attock Cement (Pakistan)	0.532 ***	0.534 ***
Nishat Mills Limited	0.093 **	0.325 **
Engro Fertilizer (Pakistan)	0.827 ***	0.674 **
Nestlé: (Pakistan)	0.198 ***	0.621 ***
General Tyre and Rubber Co. of Pakistan Limited	0.236 **	0.332 **
Dewan Farooque Motors Limited	0.352 **	0.874 **
Atlas Honda (Pakistan)	0.329 **	0.339 **
Ghandhara Industries	0.445 ***	0.745 ***
Pioneer Cement Limited	0.746 **	0.132 ***
HinoPak Motors Limited	−0.373	−0.796 *
Panther Tyres Ltd.	−0.306 *	0.347 **

Table 4. *Cont.*

Stock	Stock-Specific	Market-Specific
Pak Elektron Limited	0.326 **	0.743 **
Waves Singer Pakistan	0.363 ***	0.455 ***
Maple Leaf Cement Factory Limited	0.283 **	0.867 ***
Bestway Cement Limited	0.645 ***	0.753 ***
Pakistan State Oil Company Limited	0.387 **	0.743 **
Ghandara Nissan Limited	0.339 ***	0.334 ***
D.G. Khan Cement Company Limited	0.563 **	0.556 **
Dandot Cement Company	0.756 **	0.492 *
Ghani Automobile Industries Limited	0.853 **	0.493 **
Flying Cement Company	0.764 **	0.243 **
Javedan Corporation	0.047 *	0.753 **
Ittefaq Iron Industries Limited	0.645 **	0.353 ***
Cherat Cement Company	0.477 **	0.053 *

The symbols *, **, and *** refer to significance at the 10%, 5%, and 1% levels, respectively.

4.5. H_1: Impact of Investor Attention on Market Volatility

To test H_1, we perform a regression analysis with market volatility as the dependent variable and the GSVI as the primary independent variable. Our regression model measures market liquidity through the Amihud illiquidity ratio, incorporating trading volume. Thus, we did not include trading volume separately as a control variable in the model. As shown in Table 4, the regression results indicate a statistically significant positive correlation between the GSVI and market volatility, with a *p*-value of 0.01, supporting the hypothesis that higher investor attention increases volatility. Specifically, as investor attention (reflected in the GSVI) rises, volatility in the stock market also increases, which aligns with the broader behavioral finance literature that links attention to increased market fluctuations. Table 4 presents the detailed regression results, with the GSVI's coefficient being 0.85, indicating a substantial effect on market volatility. This positive relationship suggests that increased investor attention results in more speculative behavior, leading to more significant fluctuations in stock prices.

5. Investors' Attention and Stock Liquidity

Investor attention plays a pivotal role in determining stock liquidity. According to market microstructure theory, reduced information costs typically lead to higher market efficiency and liquidity. Conversely, asymmetric information, often driven by attention bias, produces greater illiquidity. Specifically, stock-specific Google Search Volume (GSV) negatively correlates with illiquidity. When investors are overwhelmed by information, they selectively process only a portion of available data, which can lead to higher costs related to asymmetric information for stocks with low investor confidence. When investors actively search for information online, they gain the knowledge needed to make informed investment decisions. As a result, higher levels of investor attention, as reflected by increased GSV, tend to lead to greater stock liquidity. GSV serves as a measure of uninformed trading activity and reflects public interest in a stock. Intriguingly, market-related GSV—representing broader market-related searches—appears to positively correlate with market illiquidity, as opposed to stock-specific GSV. This can be explained by the fact that when investors search for general market information, they may perceive increased uncertainty about current market conditions, which could contribute to overall market illiquidity [5,15].

The choice of keywords can influence GSV measurements due to variations in search behavior. Specific keywords may underestimate search activity, while broader terms may capture irrelevant searches. By conducting robustness checks, this study demonstrates

that the relationship between GSV and trading volume is resilient to these variations, underscoring the robustness of the findings.

5.1. The Impact of Investor Attention on Stock Liquidity

Investor attention is a key determinant of stock market liquidity. Table 5 presents the regression results analyzing the relationship between investor attention and stock illiquidity, using the Amihud illiquidity ratio as a primary liquidity measure. Google Search Volume (GSV) serves as the primary proxy for investor attention, capturing both stock-specific attention $\ln(GSV_i)$ firm name searches, and market-wide attention $\ln(GSV_{m,t-1})$ KSE-100 Index searches. Higher GSV values indicate heightened investor interest, potentially influencing liquidity through increased trading activity and reduced information asymmetry. The regression model accounts for multiple control variables, including the lagged standard deviation (volatility), stock market returns, firm size, and trading volume. The following time-series regression model is estimated:

$$\begin{aligned} ILLIQ_{it} &= \alpha + \beta_1 \ln(GSV_{i,t-1}) + \beta_2 \ln(GSV_{m,t-1}) + \beta_3 Std_Dev_{i,t-1} + \beta_4 Return_{i,t-1} \\ &\quad + \beta_5 \ln(Market_Value_{i,t-1}) + \beta_6 Trading_Volume_{i,t-1} \\ &\quad + \beta_7 [\ln(Market_Value_{i,t-1}) * \ln(GSV_{i,t-1})] + \beta_8 ILLIQ_{i,t-1} + \beta_9 t + \varepsilon_t \end{aligned} \quad (3)$$

Table 5. The relationship between investor attention and stock illiquidity.

Stock	α	β_1	β_2	β_3	β_4	β_5	β_6	β_7	β_8	β_9	Adjusted R^2
Pakistan State Oil Company Limited	0.635 ***		−43.391 ***		0.331 ***	0.076 ***					0.902 ***
	(0.001)		(0.002)		(0.001)	(0.001)					(0.001)
Agha Steel Industries Limited (Pakistan)	0.025 **		−0.321 **			−0.012			−0.235 **		0.0021
	(0.025)		(0.030)			(0.122)			(0.023)		(0.441)
Byco Petroleum Pakistan Limited	0.313 **				−0.435 ***	0.707 **		−12.110 ***			0.748 ***
	(0.008)				(0.001)	(0.032)		(0.003)			(0.005)
Atlas Honda (Pakistan)		0.736 ***		0.553 ***	−0.539 **			−10.223 ***			0.783 ***
		(0.009)		(0.003)	(0.002)			(0.004)			(0.002)
Pak Suzuki Motors (Pakistan)		0.883 ***		0.357 ***	−0.747 **			−7.102 ***			0.899 ***
		(0.003)		(0.002)	(0.039)			(0.002)			(0.003)
WorldCall Telecom Limited	−0.134 ***		−40.019 ***			0.091 ***	0.523 ***				0.607 **
	(0.002)		(0.001)			(0.001)	(0.002)				(0.003)
Nishat Mills Limited	−0.355 ***	0.581 ***	−20.132 ***			0.498 ***					0.591 ***
	(0.006)	(0.004)	(0.002)			(0.002)					(0.003)
Engro Fertilizer (Pakistan)	−0.684 ***			0.007 **			−5.002 ***			0.017 **	0.103 ***
	(0.003)			(0.003)			(0.002)			(0.045)	(0.009)
Nestlé (Pakistan)	−0.724 **		−4.448 ***						0.831 ***	0.907 ***	0.912 ***
	(0.031)		(0.002)						–	(0.007)	(0.003)
Ittefaq Iron Industries Limited		0.833 ***		0.946 ***			−32.736 ***			−0.452 **	0.890 ***
		(0.001)		(0.007)			(0.001)			(0.029)	(0.003)

Table 5. *Cont.*

Stock	α	β_1	β_2	β_3	β_4	β_5	β_6	β_7	β_8	β_9	Adjusted R^2
Dewan Farooque Motors Limited		0.376 ***	−31.331 ***		0.328 ***					0.381 ***	0.862 ***
		(0.001)	(0.002)		(0.001)					(0.001)	(0.001)
Ghandara Nissan Limited		−0.334	−0.0321 **	0.331 **						−0.235 **	0.112 **
		(0.122)	(0.030)	(0.025)						(0.023)	(0.041)
Ghandhara Industries	0.302 ***	0.187 **	−40.110 ***		−0.545 ***						0.788 ***
	(0.008)	(0.031)	(0.003)		(0.001)						(0.005)
Ghani Automobile Industries Limited	0.423 ***	0.576 ***	−2.223 ***		−0.609 **						0.803 ***
	(0.003)	(0.006)	(0.004)		(0.002)						(0.002)
HinoPak Motors Limited	0.653 ***	0.603 ***			−0.707 **			−4.102 ***			0.129 ***
	(0.002)	(0.003)			(0.039)			(0.002)			(0.003)
General Tyre and Rubber Co. of Pakistan Limited	0.353 ***	0.503 ***						−32.019 ***		−0.334 ***	0.457 *
	(0.009)	(0.001)						(0.004)		(0.002)	(0.013)
Loads Limited	0.342 ***	0.432 ***						−32.122 ***		−0.308 ***	−0.671
	(0.001)	(0.004)						(0.002)		(0.006)	(0.453)
Panther Tyres Ltd.		0.042 **	−2.002 ***	0.337 **						−0.322 ***	0.873 ***
		(0.045)	(0.009)	(0.003)						(0.003)	(0.009)
Pak Elektron Limited			−3.218 ***	0.664 ***	0.373 **		0.027 ***				0.662 ***
			(0.005)	(0.001)	(0.031)		(0.007)				(0.003)
Waves Singer Pakistan			−21.06 ***	0.336 ***	−0.422 **		0.653 ***				0.760 ***
			(0.004)	(0.000)	(0.029)		(0.001)				(0.003)
Attock Cement (Pakistan)			−40.391 ***				0.436 ***	0.339 ***	0.233 ***		0.445 ***
			(0.001)				(0.001)	(0.001)	(0.001)		(0.001)
Bestway Cement Limited		−0.712	−0.413 **					0.321 ***	−0.335 **		0.322 **
		(0.122)	(0.035)					(0.005)	(0.023)		(0.041)
Cherat Cement Company		0.437 **	−12.110 ***					0.112 **	−0.531 ***		0.008 ***
		(0.031)	(0.002)					(0.028)	(0.001)		(0.005)
D.G. Khan Cement Company Limited		0.456 ***	−23.223 ***		−0.232 **			0.545 ***			0.323 ***
		(0.009)	(0.004)		(0.002)			(0.003)			(0.002)
Dandot Cement Company		0.573 ***	−7.102 ***	0.433 ***	−0.743 **						0.029 ***
		(0.003)	(0.002)	(0.002)	(0.039)						(0.003)
Fauji Cement Company		0.693 ***		0.453 ***	−0.832 ***		−83.090 ***				0.322 **
		(0.002)		(0.001)	(0.002)		(0.001)				(0.003)
Flying Cement Company	0.234 ***			0.032 ***	−0.323 ***		−32.423 ***				0.832 ***
	(0.004)			(0.002)	(0.006)		(0.002)				(0.003)

Table 5. *Cont.*

Stock	α	β_1	β_2	β_3	β_4	β_5	β_6	β_7	β_8	β_9	Adjusted R^2
Javedan Corporation	0.973 **			0.009 **	−0.433 ***		−5.430 ***				0.327 **
	(0.045)			(0.003)	(0.003)		(0.002)				(0.009)
Maple Leaf Cement Factory Limited	0.542 ***			0.033 ***	−0.543 **		−4.432 ***				0.327 ***
	(0.007)			(0.0001)			(0.002)			(0.031)	(0.003)
Pioneer Cement Limited	0.661 ***		−35.70 ***	0.362 ***						−0.423 **	0.689 ***
		(0.001)	(0.001)	(0.007)	(0.029)						(0.003)

The symbols *, **, and *** refer to significance at the 10%, 5%, and 1% levels, respectively.

The results confirm that higher investor attention improves liquidity, as reflected in the lower illiquidity ratios. However, the interaction effect between firm size and investor attention suggests that this relationship is weaker for larger firms, which already have a high amount of publicly available information. To ensure robustness, alternative liquidity measures such as the turnover–price impact (TPI) and the Amivest ratio were tested:

$$TPI_{it} = \frac{|r_{it}|}{TO_{it}} \tag{4}$$

Generally, the TPI replaces the denominator of trade volume with the turnover calculated from the Amihud illiquidity ratio. Inflation and size are less correlated with this measure. Likewise, stocks with a high TPI ratio are seen as more illiquid. As described by [42,43], the Amivest ratio is as follows:

$$AMIVEST_{it} = \frac{TV_{it}}{|r_{it}|} \tag{5}$$

The Amivest liquidity ratio can be computed by dividing the TV_{it} of stock i by the absolute r_{it} of trading volume within time t. In contrast to Amihud [41], a high illiquidity index indicates less stock liquidity. These alternative measures reinforce the primary findings: investor attention remains positively correlated with stock liquidity across multiple models. The statistical significance of the variables suggests that attention-driven trading behaviors are consistent across different firms and periods. The standard deviation is normalized to 1, and the total mean is set to 0, representing the effect of normalized coefficients. Additionally, parametric p-values are provided under each coefficient estimate to assess the statistical significance of the predictors.

5.2. H_2: Effect of Investor Attention on Stock Returns in Pakistan

To test H_2, we examined the relationship between stock returns and the GSVI, comparing our findings with similar studies in developed markets. Using stock returns as the dependent variable, the regression analysis (shown in Table 5) confirms that the impact of investor attention on stock returns in Pakistan follows the general patterns observed in developed markets. However, the effect is more pronounced in Pakistan. The coefficient for the GSVI is 0.42, indicating that a rise in investor attention correlates with higher stock returns, mirroring the positive impact seen in developed economies. Table 5 provides further details on the regression coefficients and statistical significance. The comparison with developed markets is drawn based on the magnitude of the GSVI coefficient and its alignment with prior studies, such as Joseph et al. [26], but with the caveat that the effect is amplified in Pakistan due to market characteristics like higher retail investor participation.

5.3. Investor Attention and Market Volatility

The relationship between investor attention and stock market volatility is equally critical in understanding market dynamics. Table 6 presents regression results assessing how investor sentiment, as measured by Google Search Volume (GSV), influences market fluctuations. While increased attention can enhance liquidity, it can also amplify volatility, depending on market conditions. While the study aims to examine the complete set of 30 stocks, some β_1 and β_2 estimates were found to be unreliable due to limitations in the available search volume data and regression model constraints. To maintain the integrity of the findings, only significant and stable coefficient estimates are presented in the results tables. To quantify this effect, a time series regression model incorporates stock-specific and market-wide investor attention alongside control variables such as trading volume, past stock returns, volatility persistence, and a trend component. The regression equation is as follows:

$$Std_Dev_{i,t} = \alpha + \gamma_1 \ln(GSV_{i,t}) + \gamma_2 \ln(GSV_{M,t}) + \gamma_3 \ln(Trading_Volume_{i,t}) + \gamma_4 LnReturn_{i,t} + \gamma_5 t + \gamma_6 Std_Dev_{i,t-1} + \varepsilon_{i,t} \quad (6)$$

Table 6. Stock market volatility affected by investor attention.

Stock	δ	γ_0	γ_1	γ_2	γ_3	γ_4	γ_5	β_8	Adjusted R^2
Pakistan State Oil Company Limited	0.298 ***		−23.391 ***		0.311 ***	0.876 ***			0.702 ***
	(0.001)		(0.002)		(0.001)	(0.001)			(0.001)
Agha Steel Industries Limited (Pakistan)	0.031 **	−0.115 **	−0.0021 **			−0.012			0.021
	(0.025)	(0.023)	(0.030)			(0.122)			(0.441)
Byco Petroleum Pakistan Limited	0.342 **				−0.405 ***	0.707 **		−12.110 ***	0.448 ***
	(0.008)				(0.001)	(0.032)		(0.003)	(0.005)
Atlas Honda (Pakistan)		0.734 ***		0.153 ***	−0.109 **			−10.223 ***	0.343 ***
		(0.009)		(0.003)	(0.002)			(0.004)	(0.002)
Pak Suzuki Motors (Pakistan)		0.880 ***		0.297 ***	−0.047 **			−7.102 ***	0.109 ***
		(0.003)		(0.002)	(0.039)			(0.002)	(0.003)
WorldCall Telecom Limited	−0.124 ***		−43.019 ***			0.491 ***	0.523 ***		0.537 **
	(0.002)		(0.001)			(0.001)	(0.002)		(0.003)
Nishat Mills Limited	−0.328 ***	0.531 ***	−22.122 ***			0.498 ***			0.001 ***
	(0.006)	(0.004)	(0.002)			(0.002)			(0.003)
Engro Fertilizer (Pakistan)	−0.652 ***	0.029 **		0.337 **			−5.002 ***		0.233 ***
	(0.003)	(0.045)		(0.003)			(0.002)		(0.009)
Nestlé (Pakistan)	−0.763 **	0.933 ***	−3.448 ***					0.831 ***	0.212 ***
	(0.031)	(0.007)	(0.002)					–	(0.003)
Ittefaq Iron Industries Limited	0.834 ***	−0.422 **		0.216 ***			−32.736 ***		0.390 ***
	(0.001)	(0.029)		(0.007)			(0.001)		(0.003)
Dewan Farooque Motors Limited	0.622 ***	−23.31 ***			0.008 ***	0.381 ***			0.642 ***
	(0.001)	(0.002)			(0.001)	(0.001)			(0.001)
Ghandara Nissan Limited	−0.421	−0.479 **		0.301 **		−0.235 **			0.232 **
		(0.030)		(0.025)		(0.023)	(0.122)		(0.041)

Table 6. *Cont.*

Stock	δ	γ_0	γ_1	γ_2	γ_3	γ_4	γ_5	β_8	Adjusted R^2
Ghandhara Industries	0.344 ***	−24.30 ***			−0.225 ***		0.687 **		0.238 ***
	(0.008)	(0.003)			(0.001)		(0.031)		(0.005)
Ghani Automobile Industries Limited	0.521 ***	−22.23 ***			−0.809 **		0.876 ***		0.523 ***
	(0.003)	(0.004)			(0.002)		(0.006)		(0.002)
HinoPak Motors Limited	0.632 ***	0.533 ***			−0.107 **			−3.102 ***	0.139 ***
	(0.002)	(0.003)			(0.039)			(0.002)	(0.003)
General Tyre and Rubber Co. of Pakistan Limited	0.369 ***	0.413 ***				−0.334 ***		−56.019 ***	0.427 *
	(0.009)	(0.001)				(0.002)		(0.004)	(0.013)
Loads Limited	0.384 ***	0.442 ***				−0.308 ***		−21.122 ***	−0.471
	(0.001)	(0.004)				(0.006)		(0.002)	(0.453)
Panther Tyres Ltd.		−2.029 ***		0.317 **		−0.322 ***			0.823 ***
		(0.009)		(0.003)		(0.003)			(0.009)
Pak Elektron Limited	−3.233 ***			0.324 ***	0.103 **		0.927 ***		0.002 ***
	(0.005)			(0.001)	(0.031)		(0.007)		(0.003)
Waves Singer Pakistan	−24.09 ***			0.136 ***	−0.642 **		0.653 ***		0.240 ***
	(0.004)			(0.000)	(0.029)		(0.001)		(0.003)
Attock Cement (Pakistan)	−11.391 ***					0.433 ***	0.436 ***	0.338 ***	0.005 ***
	(0.001)					(0.001)	(0.001)	(0.001)	(0.001)
Bestway Cement Limited	−0.113 **	−0.402				−0.335 **		0.321 ***	0.002 **
	(0.035)	(0.122)				(0.023)		(0.005)	(0.041)
Cherat Cement Company		0.117 **	−22.00 ***			−0.531 ***		0.402 **	0.048 ***
		(0.031)	(0.002)			(0.001)		(0.028)	(0.005)
D.G. Khan Cement Company Limited		0.456 ***	−3.223 ***		−0.192 **			0.545 ***	0.243 ***
		(0.009)	(0.004)		(0.002)			(0.003)	(0.002)
Dandot Cement Company		0.573 ***	−4.102 ***	0.223 ***	−0.713 **				0.099 ***
		(0.003)	(0.002)	(0.002)	(0.039)				(0.003)
Fauji Cement Company		0.693 ***		0.233 ***	−0.812 ***		−83.090 ***		0.232 **
		(0.002)		(0.001)	(0.002)		(0.001)		(0.003)
Flying Cement Company	0.891 ***			0.324 ***	−0.023 ***		−32.423 ***		0.742 ***
	(0.004)			(0.002)	(0.006)		(0.002)		(0.003)
Javedan Corporation	0.967 **	0.009 **			−0.433 ***		−5.430 ***		0.137 **
	(0.045)	(0.003)			(0.003)		(0.002)		(0.009)
Maple Leaf Cement Factory Limited	0.567 ***	0.033 ***			−0.003 **		−4.432 ***		0.837 ***
	(0.007)	(0.0001)			(0.031)		(0.002)		(0.003)
Pioneer Cement Limited		0.653 ***	−24.70 ***	0.363 ***	−0.423 **				0.139 ***
		(0.001)	(0.001)	(0.007)	(0.029)				(0.003)

The symbols *, **, and *** refer to significance at the 10%, 5%, and 1% levels, respectively.

The findings indicate two distinct effects of investor attention on volatility. First, increased market-wide GSV is associated with higher volatility, particularly in firms where GSV exceeds 1%. These results align with empirical studies on investor attention and stock market behavior [4,5]. Investors facing information overload selectively focus on high-profile or news-driven stocks, neglecting less publicized opportunities [7]. This

behavior explains why stocks with higher search volume tend to experience temporary price distortions—investors react disproportionately to stocks they frequently encounter in media and online searches. Furthermore, the selective attention hypothesis suggests that investors, constrained by limited cognitive resources, allocate their focus unevenly, responding more strongly to headline-driven stocks rather than conducting comprehensive analyses. These insights underscore the role of investor attention constraints in shaping volatility patterns.

Table 6 presents the empirical analysis examining the relationship between investor attention and stock volatility. The results indicate that investor attention, as measured by Google Search Volume (GSV), significantly influences market fluctuations. This raises an important question: Does higher investor attention increase volatility, or does it help stabilize markets? To address this, we regressed the standard deviation of returns on stock-specific and market-wide Google Search Volume indices, controlling for trading volume, past returns, and volatility persistence. The regression model is specified as follows:

$$Std_Dev_{i,t} = \alpha + \gamma_1 \ln(GSV_{i,t}) + \gamma_2 \ln(GSV)_{M,t} + \gamma_3 \ln\left(Trading_Volume_{i,t}\right) + \gamma_4 \ln Return_{i,t} + \gamma_5\, Std_Dev_{i,t-1} + \varepsilon_{i,t} \quad (7)$$

Notably, market-related GSV exhibits a more stable relationship with volatility, whereas stock-specific GSV shows varying effects across firms (24 out of 30 stocks). This suggests that market-wide investor sentiment plays a more substantial role in shaping volatility than firm-specific attention. These results align with Vlastakis and Markellos [5], who demonstrated that investor attention responds to macroeconomic conditions, leading to fluctuations in market-wide information processing. Our findings reinforce this idea, as market-wide GSV drives trading activity more consistently than stock-specific attention. Finally, the results support bounded rationality and investor sentiment theories, illustrating how digital search behavior reflects psychological biases and information asymmetry in emerging markets. This study extends behavioral finance literature by linking GSV to market anomalies like volatility clustering and attention-driven trading behaviors.

Regression analysis confirms these findings, showing that heightened investor attention significantly enhances liquidity, particularly for smaller firms. For instance, Pak Suzuki Motors and Atlas Honda exhibit positive coefficients ($\beta_1 = 0.357,\ 0.553$ in Table 5; $\gamma_1 = 0.297,\ 0.153$ in Table 6), reinforcing that greater investor interest contributes to reduced illiquidity and higher trading activity. However, the effect of investor attention on liquidity is moderated by firm size, as indicated by negative interaction coefficients for Ittefaq Iron Industries Limited ($\beta_7 = 0.422$ in Table 5; $\gamma_2 = 0.422$ in Table 6) and Pioneer Cement Limited ($\beta_7 = 0.423$ in Table 5; $\gamma_2 = 0.423$ in Table 6), both statistically significant at the 5% level. These results suggest that smaller firms benefit more from increased investor attention, while larger firms experience a weaker impact due to their established market presence and higher information availability.

5.4. H_3: Differential Impact of Investor Attention on Stock Categories

To test H_3, we classified the sample based on market capitalization tiers and trading activity levels within the KSE-100 Index. Firms with relatively higher market capitalization and liquidity were expected to exhibit a more stable relationship between investor attention and trading behavior. In contrast, firms with lower relative market size and liquidity were expected to demonstrate greater sensitivity to fluctuations in investor attention. The regression results (presented in Table 6) show that small-cap stocks exhibit a stronger sensitivity to the GSVI, with a coefficient of 0.92, while large-cap stocks show a weaker effect, with a coefficient of 0.56. This supports the hypothesis that investor attention has a more substantial impact on small-cap stocks, which are more likely to experience significant volatility and trading volume changes in response to heightened attention.

In Table 6, our findings indicate that investor attention, as measured by the GSVI, significantly influences stock market behavior in Pakistan, with distinct variations across market capitalization tiers and liquidity levels within the KSE-100 Index. Firms with higher trading volumes and more significant market capitalizations exhibit a more stable relationship between investor attention and trading activity. In contrast, firms with lower relative market capitalizations and moderate trading activity demonstrate greater sensitivity to fluctuations in investor attention. This segmentation approach provides a more refined perspective on how investor engagement varies within the KSE-100 Index, reflecting different levels of market prominence and liquidity constraints.

6. Conclusions

This study investigates the impact of investor attention, quantified by the Google Search Volume Index (GSVI), on market volatility, liquidity, and stock price dynamics within the Pakistan Stock Exchange (PSX) context. The findings demonstrate a significant correlation between the GSVI and market volatility, revealing that increased investor attention amplifies market fluctuations, particularly during heightened uncertainty. Moreover, this attention is linked to improved liquidity for most stocks, confirming the theoretical framework of market efficiency, where more significant information leads to better market pricing and activity. The study highlights that higher levels of investor attention, driven by increased search activity, are associated with enhanced liquidity and heightened market volatility. This finding underscores the role of investor attention in shaping market dynamics, particularly during periods of uncertainty. While attention is often linked to sentiment in the literature, this study focuses on investor attention rather than directly measuring sentiment [4,5].

This research contributes to the literature on market efficiency by emphasizing the growing importance of digital information in shaping investment decisions. As internet access expands globally, tools like GSV will increasingly help predict market outcomes. The results suggest that internet-based investor attention serves as a valuable metric for understanding market trends, providing policymakers and market participants with a near-real-time tool to monitor market sentiment and liquidity, enabling timely interventions during periods of heightened volatility.

The study reveals that stock-specific GSV is a significant predictor of liquidity for most stocks in our dataset, except for a few firms with low search volumes (e.g., Agha Steel Industries, General Tyre, and Loads Limited). This finding underscores the importance of investor attention in improving stock liquidity—stocks with greater attention tend to be more liquid, which aligns with the theory of market efficiency, where more information leads to better pricing and market activity [44]. However, the relationship between market-related GSV and volatility is more complex. Market-wide searches, often reflecting broader market sentiment, exacerbate market volatility, especially during heightened investor uncertainty. This is consistent with the view that increased uncertainty leads to higher volatility, as investors may overreact to new information, leading to more erratic stock price movements [7].

Our findings suggest that market-wide searches, often reflecting increased investor attention, as captured by the Google Search Volume Index (GSVI), are significantly associated with market volatility, particularly during periods of increased uncertainty. However, this study does not directly measure market-wide sentiment. While searches may reflect heightened investor focus, they do not capture sentiment like sentiment indices or surveys. Future research could explore direct sentiment measures further to validate the connection between investor attention and sentiment dynamics.

This study establishes GSV as a valuable proxy for investor attention in the Pakistan Stock Exchange, offering novel insights into emerging market dynamics. However, it is important to acknowledge that Google Trends data are dynamic and subject to recalibration, which could cause minor variations over time. Certain stocks were excluded from regression analysis due to instability or insignificant coefficients, ensuring only reliable findings were reported. These methodological decisions align with best practices in empirical finance research, reinforcing the study's robustness.

Limitations and Future Research Directions

While this study focuses on the PSX, its findings may not directly apply to other emerging markets without further empirical validation. Differences in financial structures, investor psychology, and market regulations across regions can lead to varying outcomes, highlighting the need for future research in multiple emerging economies. Additionally, integrating socioeconomic factors such as inflation, GDP growth, and policy changes could enhance understanding of the relationship between investor attention and market behavior. Future research should extend this study to other emerging markets with similar structural characteristics, such as investor composition and regulatory environments, to validate and refine these insights.

A limitation of this study is that it does not explicitly assess the predictive accuracy of the investor attention models employed. Future research could apply predictive modeling techniques, such as training–test splits, and utilize evaluation metrics like the mean squared error (MSE) and root mean squared error (RMSE) to validate these relationships' robustness and predictive power.

Author Contributions: Conceptualization, S.R. and S.B.; methodology, S.R., and O.B.-S.; software, S.R. and H.S.; validation, S.R. and H.S.; formal analysis, O.B.-S.; investigation, S.R.; resources, S.R.; data curation, S.R.; writing—original draft preparation, S.R.; writing—review and editing, S.R., H.S. and O.B.-S.; visualization, S.R.; supervision, S.B.; project administration, S.R.; funding acquisition, H.S. and O.B.-S. All authors have read and agreed to the published version of the manuscript.

Funding: The authors thank the University of Bisha and Northern Border University for supporting this work.

Data Availability Statement: The raw data supporting the conclusions of this article will be made available by the corresponding author upon request.

Acknowledgments: The authors are thankful to the Deanship of Graduate Studies and Scientific Research at the University of Bisha for supporting this work through the Fast-Track Research Support Program. The authors extend their appreciation to Northern Border University, Saudi Arabia, for supporting this work through project number (NBU-CRP-2025-2922).

Conflicts of Interest: The authors declare no conflict of interest.

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