Investors' Biases & Stock Return Volatility: A Systematic Literature Review

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ABSTRACT

Purpose:
Literature is scarce on the possible relationship between investors' biases, risk tolerance attitude, and stock return volatility. The researcher investigated what are the investor biases, and how they contribute to the risk-averse and risk-seeking attitudes and developed a taxonomy model of investors' biases in the form of a causal framework that impacts stock return volatility.

Methodology:
The study employs a systematic literature review approach. The analysis of literature includes 65 articles from impact factor journals including three seminal papers in the fields of traditional and behavioral finance. The time frame ranges from 2008 to 2022.

Findings:
The findings suggest that investors encounter certain biases such as cognitive, emotional, cultural, religious, financial, macroeconomic, demographic, etc. Literature has identified positive, negative, and mixed impacts of investors' biases on stock return volatility. The systematic analysis of literature helps in identifying recently evolving biases such as individualism, uncertainty avoidance, a religious adherence, investor mood, weather bias, fear sentiments, sports sentiments, power distance, masculinity, social media sentiments so on and so forth.

Conclusion:
The study has proposed an integrated taxonomy model comprised of possible investors' biases as independent variables along with mediating, controlling, and moderating variables that impact stock return volatility. Moreover, investors' risk tolerance profile is also constructed which indicates the role of behavioral biases in shaping investors' attitudes as risk seekers and risk-averse.

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1. Introduction

The stock markets consist of organized exchanges in which shares of publicly held companies are issued and traded. The effective functioning of financial markets reflects an optimistic outlook to investors about profitable investment opportunities and diversified portfolios (Shah et al., 2018). The characteristics of equity markets include information availability, price volatility, risk, and rewards for investors. Volatility refers to the increase or decrease in stock prices if the price of stocks fluctuates often this will indicate a high level of risk to the investors therefore, it is considered to be one of the most vital characteristics of the stock market which directly influences investors' portfolio performance and cannot be determined in rational context only (Białkowski et al., 2022). Portfolio performance refers to the overall assessment of investment value responding to the changes in the stock market. Investors always strive to maximize their financial well-being because a trade-off exists between their risk tolerance and wealth maximization therefore the central assumption of a market efficiency becomes unattainable (Goel et al., 2022).

Theoretical Developments & Emergence of Behavioral Finance; over, the past years stock markets have experienced massive breakdowns in the form of the Brazilian Market Crash, Internet Bubble Crash, East Asian Financial Crises, and Global Financial Crunch which have highlighted the significance of certain behavioral biases as important determinants of stock return volatility (Ni et al., 2015). The dynamic nature of equity markets has made it difficult to understand its behavior, despite many efforts to forecast stock price movement consistently, financial markets remain mysterious and deny the traditional finance theories hence the behavioral explanation of market irregularities is centered on various social and psychological biases (Litimi et al., 2016). Traditional finance theories consider investors as rational beings who trade in well-organized financial markets (Ahmad & Shah, 2020). The Modern Portfolio Theory proposed that investors behave wisely and prefer low-risk portfolios (Markowitz, 1952). Fama (1970) proposed Efficient Market Hypothesis by assuming that stock prices are fairly valued therefore abnormal returns cannot be earned. On the contrary, the advent of Prospect Theory criticized the assumption of rationality and proposed that individuals behave irrationally and their decisions rest on certain biases (Kahneman & Tversky, 1979). Similarly, Transaction Utility Theory stated that individuals define the utility as a difference between the actual price and expected price thus their choices are restrained by some reference point (Thaler, 1985).

The above-mentioned theoretical advancements led to the development of 'Behavioral Finance' as a field of interest. Behavioral finance explains how individuals make financial decisions in real life and why their decisions do not seem to be coherent always (Jokar & Daneshi, 2018). It advocates that people make their financial decisions grounded on certain cognitive and emotional biases therefore the outcomes associated with such decisions become unpredictable.

Behavioral biases & Risk Tolerance Attitude; the existence of cognitive and emotional factors provide opportunities for earning abnormal returns and disturbs the functioning of stock markets. A cognitive bias is a mental error in which individuals form their subjective reality and misinterpret the given information whereas emotional biases are comprised of an individual's feelings. These biases contribute substantially to the risk tolerance attitude of investors. Risk tolerance can be defined as the extent to which individuals are willing to bear the potential loss. Understanding risk appetite help investors in portfolio diversification. Individuals can be classified as risk averse and risk seekers, those who prefer low return portfolios with known outcomes are risk averse on

the contrary risk seekers look for high return portfolios with unknown outcomes. Individuals who possess individualism, overconfidence, neuroticism, openness, and optimism, can be characterized as risk taker whereas uncertainty avoidance, loss aversion, fear, and endowment bias make investors risk averse (Broihanne et al., 2014; Fernandez-Perez et al., 2021; Kahneman & Tversky, 1979; Aren & Nayman Hamamci, 2020). Overconfidence, optimism, miscalibration, hindsight bias, and mental accounting are found to have a positive impact on stock returns on the contrary herding, loss aversion, isolation effect, and emotional tendency negatively impacts stock prices. These empirical contradictions indicate a complex relationship between investors' biases, risk tolerance, and stock return volatility. Investors vary in terms of their needs, skills, goals, and risk appetite therefore one solution can't be generalized for all. Thus, the presence of biases influences investment decisions, and stock performance and substantially contributes to the risk tolerance attitude. Literature is limited regarding the impact of investors' biases on stock return volatility and risk tolerance attitude furthermore there is no cohesive framework that can be used to understand the relationship between individuals' behavior and stock return volatility.

1.1. Problem Statement

Ideally, stock markets are efficient as investors behave rationally therefore, no one can beat the market (i.e.) abnormal returns are not possible. The proponents of the Efficient Market Hypothesis state that investors are well informed, and all the publicly and privately available information is being held by them which makes stock markets efficient (Fama, 1970;1991). Individuals make rational choices that can help them to maximize their self-interest; they incorporate all the available information, perform a cost-benefit analysis and make decisions based upon certain rational calculations (Samuelson, 1954). However, the stock market crash of 2008 refuted the rationality assumption thus the irrational behavior of investors led to the historical stock market collapse. The financial crisis witnessed various behavioral biases such as overconfidence, disposition effect, sentiments, and loss aversion (Liu et al., 2022; Trejos et al 2019; Dash & Maitra, 2018). These biases influence investors' decision-making and significantly contribute to the risk tolerance attitude and stock return volatility. Consequently, markets do become inefficient which promotes abnormal market returns through arbitrage and speculative trading (Curatola et al., 2016). Despite the presence of investors' irrational behavior in the context of stock markets volatility & risk appetite, literature is scarce on the possible relationship between investors' biases, risk tolerance attitude, and stock return volatility hence there is lacking comprehensive & unified framework comprised of different types of biases which impact stock return volatility & risk tolerance attitude of investors. This study aims to provide a taxonomy model by identifying the biases which substantially contribute to risk tolerance attitude and stock return volatility.

1.2. Research Objectives

The followings are the main research objectives of this study:

i. To synthesize the available literature on various types of investors' biases.
ii. To construct a taxonomy comprised of different biases and how they impact stock return volatility.
iii. To construct investors' risk profiles based on various biases.

1.3. Significance of the Study

Stock markets depict an imperative role in a country's economic progression; they promote liquidity, help in raising capital, and provide investment options. The proposed taxonomy will be pertinent to the financial experts, and policymakers to perform suitability assessments, categorize the investors based on their risk appetite, enhance the

quality and trustworthiness of expert advice, and achieve a comprehensive understanding of the role of potential biases in shaping investors risk attitude and stock returns volatility. The provided synthesis will help to identify future research avenues that can be studied in the context of investors' biases, risk tolerance, and stock return volatility.

2. Literature Review

2.1. Impact of Investors' Biases on Risk Tolerance Attitude & Stock Return Volatility

In this section, the theoretical background has been discussed. A new discipline named 'Behavioral Finance' emerged in the 1980s. It studies the impact of investors' psychology on financial markets. The advent of Prospect Theory, Transactional Utility Theory, and Economic Theory of Herd Behavior discovered the fact that investors do not behave rationally, their decisions are influenced by various biases such as cognitive, emotional, religious, cultural, personality traits so on and so forth, these predispositions shape their risk tolerance attitude and make stock returns volatile. For instance, countries that possess lower individualism and a higher degree of uncertainty avoidance were found to have greater stock return volatility during the initial phase of COVID-19 whereas a high level of individualism positively contributes to risk-seeking attitude and stock returns (Fernandez-Perez et al., 2021). Similarly, those countries which have a high level of uncertainty avoidance were found to have a significant negative impact on stock return and resulted in risk aversion during the initial phase of COVID-19 (Ashraf, 2021).

Investor Sentiments; Ni et al., (2015) identified a significant impact of investors' sentiments such as overconfidence and overreaction in the context of the Chinese A-share market, findings revealed that investors are loss averse thus their sentiments are positive for the stocks which have a high return in short-run instead in long run, they are more risk seeker to avoid potential loss and risk-averse to skip any potential gains. The sentiments or mood of investors play an important role in determining the concurrent stock return, particularly in the short-run (Finter et al., 2012).

Social Media Sentiments; technological advancement has also influenced the way investors feel and react to the given information, social media is considered an influential platform. Duz Tan & Tas (2021) studied the impact of social media sentiments on stock returns in the context of U.S, European & emerging countries, the findings revealed that the optimistic language on Twitter positively influences investor sentiments which results in high trading volume for the subsequent trading day and positively impact stock returns.

Fear sentiment can also influence stock returns both in the short-run and long-run, a stock with a high return is more likely to be affected as compared to stocks with lower returns, overconfidence and optimism result in a risk-seeking attitude of investors thus their preference shift from safer to speculative stocks in contrast pessimism results in investors' risk aversion attitude (Dash & Maitra, 2018; Qadan, 2019; Schmeling, 2009).

The literature has identified an evident role of investors' biases in shaping risk attitude as well as stock return volatility, it is also apparent that with time the nature of biases has evolved greatly, consequently, the rationality assumption becomes insignificant. Therefore, the assessment of the complex relationship between possible biases, risk tolerance attitude, and stock return volatility is significant to be studied.

3. Research Methodology

This research study has executed a systematic literature review for the analysis of relevant research articles in the context of investors' biases, risk tolerance attitude, and stock return volatility. The time frame ranged from 2008 to 2022. The year 2008 was taken as the base year due to the advent of the global financial crunch. Moreover, the review articles include three seminal papers which highlight the major theoretical contribution made by Fama (1970), Kahneman and Tversky (1979), and Thaler (1985) in the field of traditional & behavioral finance. Harzing-Publish or Perish software has been used as a searching tool; keywords such as risk tolerance, risk attitude, behavioral biases, investors' biases, stock return volatility, prospect theory, and behavioral finance were used. The research articles were selected from renowned databases such as Elsevier, Taylor & Francis, Springer, JSTOR, Emerald & Wiley Online Library. The search strategy comprised of keywords identification, time frame, distinguished databases, and inclusion and exclusion measures.

3.1. Inclusion & Exclusion Criterion

The following inclusion criterion for articles has been followed:

i. Impact Factor Journals.
ii. Research articles with mentioned keywords publish in the English language.
iii. Seminal papers published in the disciplines of behavioral & traditional finance.
iv. Year of publication.
v. Articles based on qualitative, quantitative, mixed approaches.
vi. Reputable databases.

Exclusion criteria include:

i. Non-impact factor journals
ii. Articles published in other languages except for English.
iii. Duplicate Articles.
iv. M.Phil & Ph.D. Thesis.
v. Conference Proceedings.

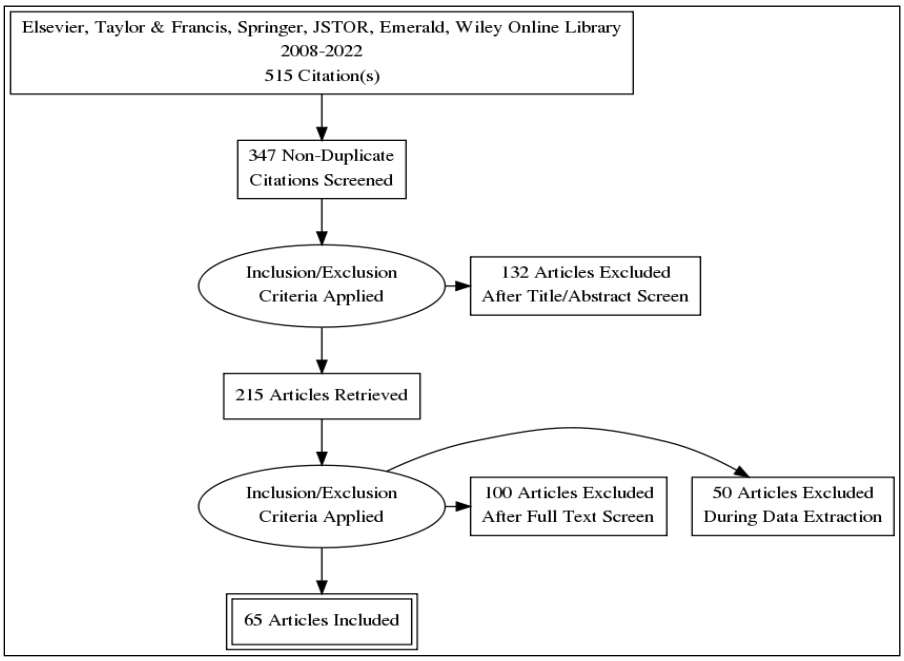

Figure.1.PRISMA Diagram
Source: Author's own elaboration

4. Results and Analysis

In this section, the selected articles have been categorized based on publication year, publication journals, country of study, type of research, type of data, statistical techniques, theoretical developments, types of biases & their possible impact on stock return volatility.

4.1. Publication Year, Databases & Research Journals

The research study includes articles from various renowned journals; Figure 2 shows the details of the years of publication. Figures 3 and 4 depict the details of selected research journals and databases. It can be seen that over the past years behavioral biases have gained importance from the research perspective, the total of 65 articles were selected from 39 renowned research journals including the Journal of Finance, Finance Research Letters, Journal of Behavioral and Experimental Finance, Econometrica, Journal of Financial Economics, Journal of Asian Finance, Economics, and Business, International Review of Financial Analysis, Economic Modelling, The Financial Review, Journal of Banking & Finance, Research in International Business and Finance, Borsa Istanbul Review. An increasing trend in terms of the number of publications can be seen particularly after the Global Financial Crunch 2008, the increasing number of publications highlights the significance of biases in the context of risk tolerance attitude and stock return volatility.

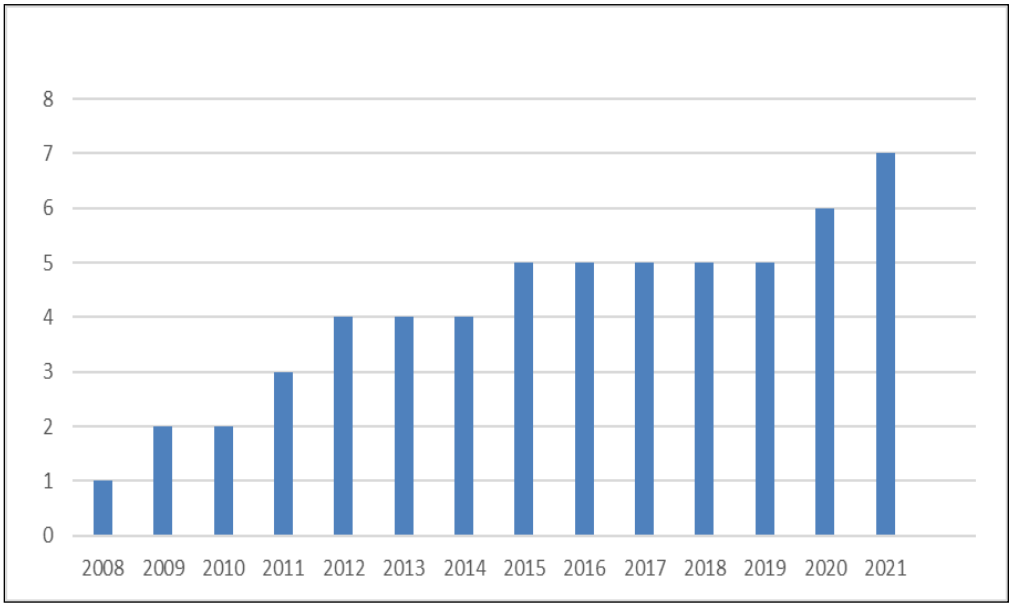

Figure.2.Research Publication Trend Regarding Investors' Biases & Stock Return Volatility During 2008-2021
Source: Author's own elaboration

In terms of research journals, Finance Research Letter includes the majority of articles in the area of interest followed by Journal of Behavioral and Experimental Finance, Journal of Finance, Journal of Financial Economics, Journal of Asian Finance, Economics, and Business, Journal of Banking and Finance, International Review of Financial Analysis.

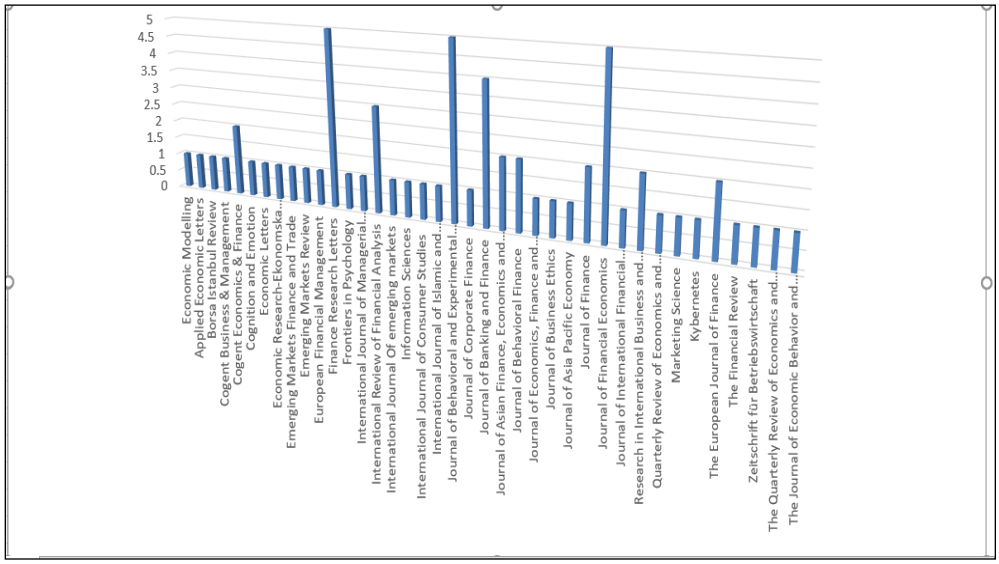

Figure.3.Research Journals
Source: Author's own elaboration

Out of 65 research articles, 34 have been published in Elsevier, followed by 12 in Taylor & Francis, 4 in Wiley, 2 in Springer, 3 in JSTOR, 5 in Emerald & 5 in other journals. The analysis of literature also includes three seminal papers that were published in the years 1970, 1979 & 1985. Fama (1970) proposed the Efficient Market Hypothesis which emphasized investors' rational behavior and considered stock markets efficient whereas Kahneman and Tversky (1979) proposed 'The Prospect Theory' which was the first attempt to recognize the irrational phenomena in the form of behavioral biases such as loss aversion and certainty effect. In 1985 another substantial theoretical contribution was made by Thaler who proposed the 'Transactional Utility Theory' and added further behavioral biases named mental accounting, status quo bias & endowment effect.

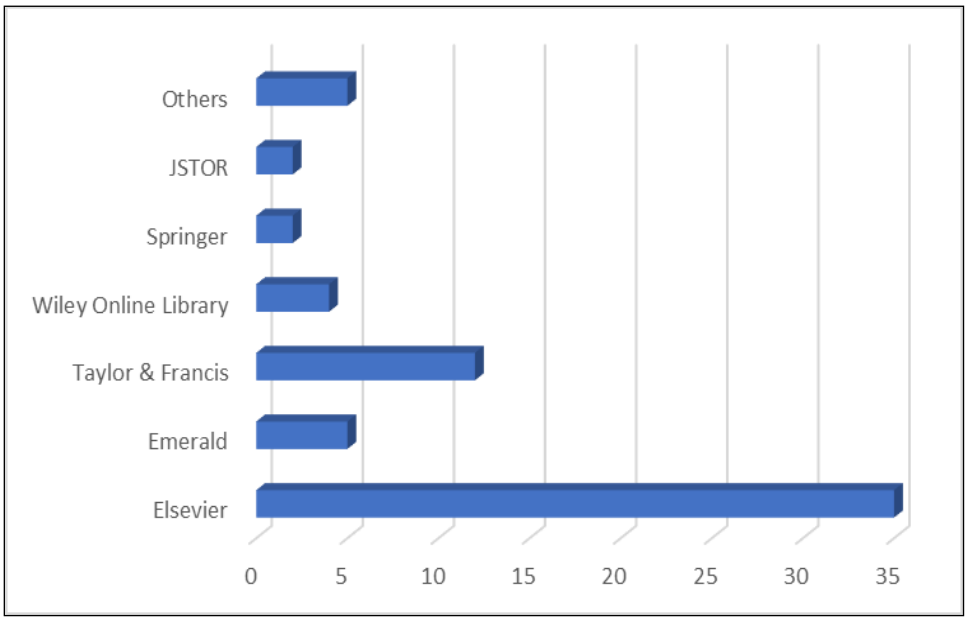

Figure.4.Research Databases
Source: Author's own elaboration

4.2. Context of Research Study

Figure 5, depicts the country-wise trend of publication on investors' biases and stock return volatility, it can be seen that majority of the research publications have been done

in the United States of America followed by China and multiple cities including GCC countries, Emerging Countries Index, European Countries. Since USA is comprised of the world's largest stock exchanges such as the New York Stock Exchange & NASDAQ with a market capitalization of more than 27.7 trillion US dollars. Despite being the world's largest equity market holder USA has experienced various historical stock market crashes. In the 2008 global financial crunch, Dow Jones Industrial Average fell by 777.68 points, similarly in 2010 the stock market witnessed another massive crash named as 'flash crash' in which stock indices such as Dow Jones, NASDAQ, and S&P 500 collapsed massively, and high-frequency trading, gambler's fallacy bias and changes in market structure were identified as main factors of stock return volatility. In 2011, the fear sentiment of investors falsified the rational perspective of stock markets when the concerns regarding debt crisis and slow economic growth made investors pessimistic in terms of trading activity. The advent of COVD-19 (2019-2020) had traumatized economic well-being globally. The uncertainty avoidance bias dominated different equity markets and resulted in panic selling; Dow Jones Industrial Average witnessed a 37% decline in its overall value moreover trading activities at New York Stock Exchange were suspended many times. Similarly, China has recently witnessed an abrupt stock market crash. These events highlight the element of irrationality which exists in stock markets.

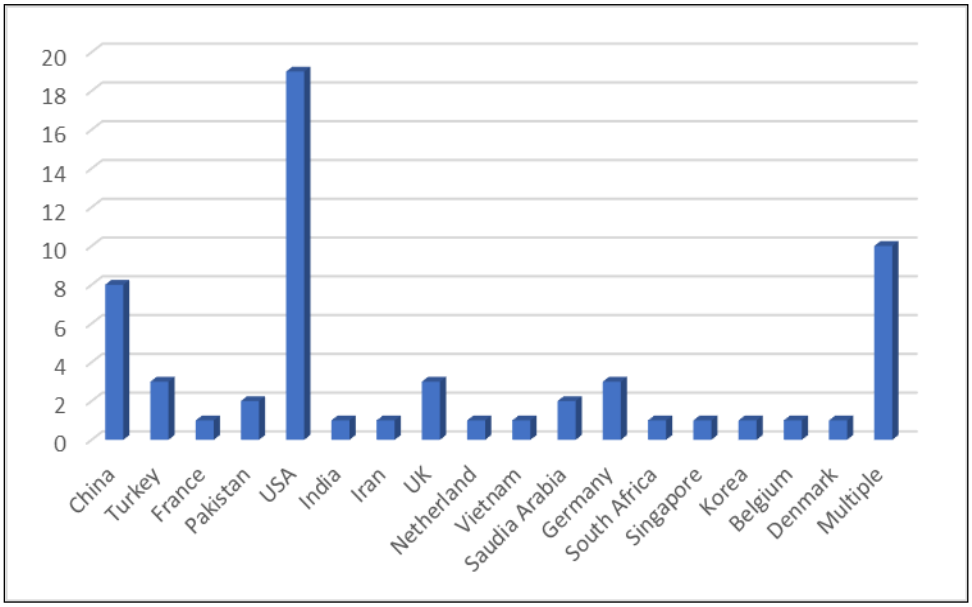

Figure.5.Country-Wise Trend of Publication on Investors' Biases & Stock Return Volatility
Source: Author's own elaboration

4.3. Theoretical Developments in the Context of Investors' Biases & Stock Return Volatility

Out of 65 articles, 06 research papers include theoretical contributions while the remaining papers comprised methodological contributions with the existing theoretical framework. Two seminal papers in the field of behavioral finance by Kahneman & Tversky (1979) & Thaler (1985) were also analyzed in which substantial theoretical developments named Prospect theory & Transaction Utility theory have been proposed, both theoretical frameworks identified different cognitive and emotional biases such as loss aversion, certainty effect, isolation effect, mental accounting, status quo bias, endowment effect & reference point. Table 1 shows the theoretical developments in the context of investors' biases and stock return volatility.

Table.1. Theoretical Developments in the Context of Investors' Biases and Stock Return Volatility

Theoretical Developments	Explanation
Prospect Theory	Individuals are less sensitive and prefer certain gains over a probabilistic loss, they focus on differences between the options instead of similarities. They behave as risk-averse in the gain domain and risk seekers in the loss domain[1].
Transaction Utility Theory	Individuals perceive the value of money subjectively which results in irrational behavior. They evaluate objects in relative terms instead of absolute terms and often fail to consider trade-offs between the different options and encounter loss aversion & status quo biases[2.]
Cultural Dimensions & Stock Return Volatility	There is a strong association between cultural biases and stock return volatility, individualism, masculinity & long-term orientation positively impact stock return whereas power distance and uncertainty avoidance negatively influence stock returns[3]. Countries which are marked with individualism traits are more confident and optimistic in terms of stock trading whereas in those countries where uncertainty avoidance trait is more evident, investors are found to be pessimistic and trade with panic[4].
The Only Game in Town Effect	The presence of local bias decreases stock prices relative to the aggregate book value of the firm in the investors' region. Investors overweight local equity markets in their portfolio holding[5].
Earnings Forecast Herding	Through extensive experimental settings, it was observed that individuals' risk tolerance is an important determinant of herd behavior. Individuals with less risk tolerance are found to give less confident financial forecasts and vice versa. Moreover, individuals react intuitively towards uncertainty[6].

References

[1]Kahneman & Tversky (1979), [2]Thaler (1985), [3]Galariotis & Karagiannis (2021), [4]Fernandez-Perez et al. (2021), [5]Hong et al., (2008), [6]Christoffersen & Stæhr (2019)

Source: Author's own elaboration

4.4. Types of Data, Research Design & Unit of Analysis

Table 2, depicts the types of data, research design, and unit of analysis used in various research articles. The majority of the research articles have employed secondary data followed by primary and mixed. Similarly, most of the research articles have executed quantitative research design while very few articles have employed qualitative & mixed research approaches. The unit of analysis has been primarily individual investors.

Table.2. Types of Data, Research Design & Unit of Analysis

Type of Data	No. of Papers
Primary	12
Secondary	42
Mixed (both primary & secondary)	11
Total	65
Research Design	No. of Papers
Quantitative	61
Qualitative	01
Mixed	03
Total	65

Unit of Analysis	No. of Papers
Individual Investors	51
Non-Professionals	07
Professionals	07
Total	65

Source: Author's own elaboration

4.5. Statistical Techniques/ Data Analysis Methods

Table 3 indicates different statistical techniques and methods of data analysis that have been used in research studies; it can be seen that most of the research articles have employed Panel Regression Analysis while others have used some contemporary data analysis techniques such as Panel Quantile Regression, Multivariate Analysis, Experimental Design, GARCH/ E-GARCH, Logit Regression, Structural Equation Modeling Simulation Method of Moments, PLS-SEM, Bag of Words Content Analysis Model. The majority of the research articles have been centered on measuring the impact of cognitive biases on stock return volatility. It is also notable that few articles have examined the biases which influence investors' risk tolerance attitudes also the use of contemporary data analysis techniques such as GARCH/ E-GARCH, SEM-SMM, Logit Regression, GMM, ARIMA, and ARDL is found to be limited.

Table.3. Statistical Techniques/ Data Analysis Methods

Data Analysis Technique	**Focus of Research**	**Variables**
Panel Quantile Regression	Non-linear effect of investors' sentiments on stock return volatility[1], determinants of investors' risk-taking attitude[18]	Investors Sentiments, Overconfidence, Miscalibration, Optimism, Risk perception, Subjective Financial Risk Attitude, Herding, Local Bias, Uncertainty avoidance, Religious Affiliation, Religious Adherence, Religious Beliefs, Underdog Bias, Hindsight Bias Disposition effect, Familiarity bias, Representativeness Heuristic, Status quo bias, Hindsight bias, Herding Optimism, Risk Tolerance Individualism, Uncertainty Avoidance, Risk tolerance attitude, Power Distance, Long-Term orientation
Panel Regression/Pooled Ordinary Least Square	Non-linear effect of cognitive, religious, cultural and emotional biases on stock return volatility[2],[4,7,14,17,19,20,21,22]	
Multivariate Analysis	Relationship between cognitive biases and level of risk tolerance[3] Cultural Dimensions, stock return volatility & risk tolerance[6, 13]	
Experimental Design	Relationship between cognitive biases, investors' decisions, and risk tolerance attitude[8,9]	Overconfidence, Loss Aversion, Investment Choices, Risk Attitude
PLS-SEM	Impact of cognitive biases on investment decision[5]	Overconfidence, Represent heuristics, Extrapolation Bias, Conjunction Fallacy
GARCH Model	Herding bias and stock return volatility[10]	Herding

Bivariate vector autoregression & EGARCH Model	Investor sentiments, self-attribution bias, and stock return volatility[11,12]	Investor sentiments, self-attribution bias
Bag of Words Model-Based Content Analysis	Cognitive biases among non-professional investors[15]	Self-enhancement bias, Overconfidence
Structural Equation Modeling Simulation	Pricing anomalies caused by cognitive biases[16]	Overconfidence, Over extrapolation
Method of Moments Logit Regression	Impact of cognitive, cultural & emotional biases on stock return volatility and investors' risk tolerance[21],[22]	Geographic Bias, Home bias, Overconfidence, Disposition Effect

References

[1]Ni et al., (2015), [2]Tekçe & Yilmaz (2015), [3]Broihanne et al., (2014), [4]Tekçe et al., (2016), [5]Parveen et al., (2020), [6]Fernandez-Perez et al., (2021), [7]Pikulina et al., (2017), [8]Kahneman & Tversky (1979), [9]Thaler (1985), [10]Litimi et al (2016), [11]Chen & Haga (2021), [12]Mushinada & Veluri (2018), [13]Galariotis & Karagiannis (2021), [14]Merkle (2017), [15]Czaja & Röder, (2020), [16]Alti & Tetlock (2014), [17]Fei & Liu (2021), [18]Duy Bui et al., (2021), [19]Seasholes & Zhu (2010), [20]Hong et al., (2008), [21]Kiymaz et al (2016), [22]c, [21]Ashraf (2021), [22]Blau (2017)

Source: Author's own elaboration

4.6. Classification of Investors' Biases in the Context of Stock Return Volatility

Literature has explained various investors' biases in the context of stock return volatility, however, after reviewing the available literature six themes have been identified that elucidate different types of biases encountered by investors. Most of the research work is centered on cognitive and emotional biases; overconfidence is the most studied cognitive bias. In terms of emotional biases in investors' sentiments and herding are widely studied. The key insights obtained from the literature review discovered that stock return volatility also depends on cultural, religious, demographic, investors' moods, personality traits, and other types of biases. Investors' biases can also emerge from the advent of information, social media sentiments, sports sentiments, weather biases, and relevant news. The moods of investors can also be influenced by pleasant weather, sports sentiments, a religious adherence, etc. Investors' traits such as gender, experience, individuality, and subjective financial literacy may positively influence stock returns whereas political uncertainty, pessimism, and loss aversion result in panic selling and negatively impact stock return.

Table.4. Investors' Biases in the Context of Stock Return Volatility & Their Possible Impact

Types of Investors' Biases/ Other Facets	Variables	Possible Impact
Cognitive Biases	Overconfidence[1,2,3,7,10,12,13,16,25,26, 32,50], Optimism[3, 38, 40], Representativeness heuristic[4,5], Overextrapolation[5,16,50], Self-Attribution[10,14], Hindsight[13], Overestimation[13,50], Investor Perception[15], Risk Perception[15], Anchoring[21,42], Limited Investor Attention[21], Reference Point[30], Underdog Bias[30], Isolation Effect[30], Mental Accounting[31],	Positive
Emotional Biases	Miscalibration[50], Gambler Fallacy[50], Utility Realization[50] Investors' Sentiments[1,9,22,25,33, 38], Disposition effect[4,20,26,46], Familiarity bias[4], Status quo bias[4], Loss Aversion[7,30, 32], Herding[8,12,17,20,29,4,45], Self-Enhacement[14], Fear[27], Certainty Effect[30], Endowment Effect[31], Pessimism[38, 40], Mood[40],	Mixed Mixed

Cultural Biases	Fear[48], Sport Sentiments[44], Social-Media Sentiments[23]	Positive
	Individualism[6], [36] Uncertainty Avoidance[6,28, 36],	Mixed
Religious Bias	Individualism[11], Power Distance[11], Masculinity[11], Long	
Financial/	Term Orientation[11], Local bias[18,19]	
Macroeconomic	Religion affiliation[24,35], Religious Belief[34,41]	
Facets	Market performance indicators[9], Market Transaction	Mixed
	Indicators[9], Market Activity	
	Indexes[9], Market leverage[9], Advanced decline ratio[27], Put	
Others	call ratio[27], Foreign institutional investors' inflow[27], Firm	
	size[32], Market capitalization[32, 35], Spread[35], Illiquidity[35],	
	GDP[35], Price of closing stock[35], Unemployment rate[35], Firm	
	Characteristics[40], Political Uncertainty[37, 49]	
	Information availability[15,18,50], News[39,40], Weather Bias[43],	
	Subjective Financial Literacy[47]	

References

[1]Ni et al (2015), [2]Tekçe & Yilmaz (2015), [3]Broihanne et al (2014), [4]Tekçe et al. (2016), [5]Parveen et al (2020), [6]Fernandez-Perez et al (2021), [7]Pikulina et al (2017), [8]Litimi et al (2016), [9]Chen & Haga (2021), [10]Mushinada & Veluri (2018), [11]Galariotis & Karagiannis (2021), [12]Jokar & Daneshi (2018), [13]Merkle (2017), [14]Czaja & Röder (2020), [15]Hoffmann et al (2012), [16]Alti & Tetlock (2014), [17]Fei & Liu (2021), [18]Seasholes & Zhu (2010), [19]Hong et al (2008), [20]Liu et al (2021), [21]Li & Yu (2012), [22]Alnafea & Chebbi (2022), [23]Duz Tan & Tas (2021), [24]Abro et al (2021),[25]Finter et al (2012), [26]Trejos et al (2019), [27]Dash & Maitra (2018), [28]Ashraf (2021), [29]Javaira & Hassan (2015),[30]Combrink & Lew (2020), [31]Thaler (1985), [32]Bouteska & Regaieg (2020), [33]Stambaugh et al (2012),[34]Białkowski et al (2012), [35]Blau (2017), [36]Nguyen & Truong (2013), [37]Goodell & Vähämaa (2013), [38]Chen et al (2013), [39]Krishnamurti et al (2013), [40]Li et al (2014), [41]Canepa & Ibnrubbian (2014), [42]Verousis & Ap Gwilym (2014), [43]Shim et al (2015), [44]Curatola et al (2016), [45]Mezghani & Boujelbène (2018), [46]Wu et al (2018), [47]Bellofatto et al (2018), [48]Goel et al (2022), [49] Białkowski et al (2022), [50]Liu et al., (2022)

Source: Author's own elaboration

4.7. Investors' Biases & Risk Tolerance Attitude

The presence of behavioral biases significantly influences investors' risk tolerance attitude, investors may behave as risk seekers or risk-averse while taking investment decisions. Broihanne et al (2014) found overconfidence and optimism as key determinants of investors' risk-seeking attitudes as they overestimate their skills, knowledge & private information. Similarly, overconfidence results in excessive trading, less diversification, and high risk-taking behavior as investors have strong believe on their subjective financial knowledge however loss aversion and pessimism lead to risk avoidance moreover the presence of overconfidence and optimism also result in hindsight bias in which investors start estimating the future return of stock based on past performance (Pikulina et al., 2017; Merkle, 2017; Weinstock & Sonsino, 2014). Investors are risk-averse in the gain domain and risk seeker in the loss domain, particularly in uncertain situations the perception of individuals about future outcome substantially influence their risk-taking and trading behavior (Hoffmann et al., 2012).

Investors' perception, miscalibration, overconfidence, and herd behavior lead to risk-seeking attitudes moreover individuals' goals related to profit maximization also influence their risk appetite (Linh et al., 2021). Investors who are inclined towards self-attribution bias are more likely to encounter underdog bias which shapes their attitude towards risk-seeking; investors who are exposed to underdog bias often remember their difficult times and how they successfully managed those critical situations based on these perspectives they start overvaluing their skills and expertise and tend to behave, risk seeker, because they believe that they can handle the complex situation effectively (Combrink & Lew, 2020). Apart from cognitive and emotional facets, certain cultural biases impact the risk tolerance attitude of investors; those countries where individualism

is strongly rooted make investors optimist and overconfident in terms of investment decisions thus they behave as risk seekers furthermore geographical biases also play an important role in terms of risk tolerance attitude; investors are more risk seeker when they invest in home country based companies, on the contrary, those countries where uncertainty avoidance is high investors become pessimist and loss-sensitive thus they tend to be risk-averse furthermore masculinity and low level of trust may also negatively influence the risk-seeking attitude of investors (Breuer et al., 2014; Kiymaz et al., 2016).

The presence of fear also shapes investors' risk-taking behavior when investors encounter an exciting and gamble-based stimulus the fear sentiment leads to a risk-seeking attitude on the contrary when an incidental stimulus is present, investors tend to behave risk-averse (Lee & Andrade, 2015). Demographic characteristics such as gender also influence risk-taking behavior as males are more risk seekers and females are risk-averse while taking investment decisions moreover the difference between perceived and actual financial literacy also plays an important role in determining investors' risk tolerance level surprisingly sophisticated financial decisions are based on perceived financial literacy instead of actual financial literacy (Montford & Goldsmith, 2016; Bannier & Neubert, 2016). Overconfidence in female investors increased their trading frequency however this resulted in a certain loss on the contrary male investors who encountered overconfidence were successful to earn certain gains on their investment (Michailova et al., 2017). Lastly, personality traits, herding, emotional intelligence & locus of control also have a significant impact on investors' risk tolerance attitude (Aydemir & Aren, 2017; Christoffersen & Stæhr, 2019; Rabbani & Wang, 2019).

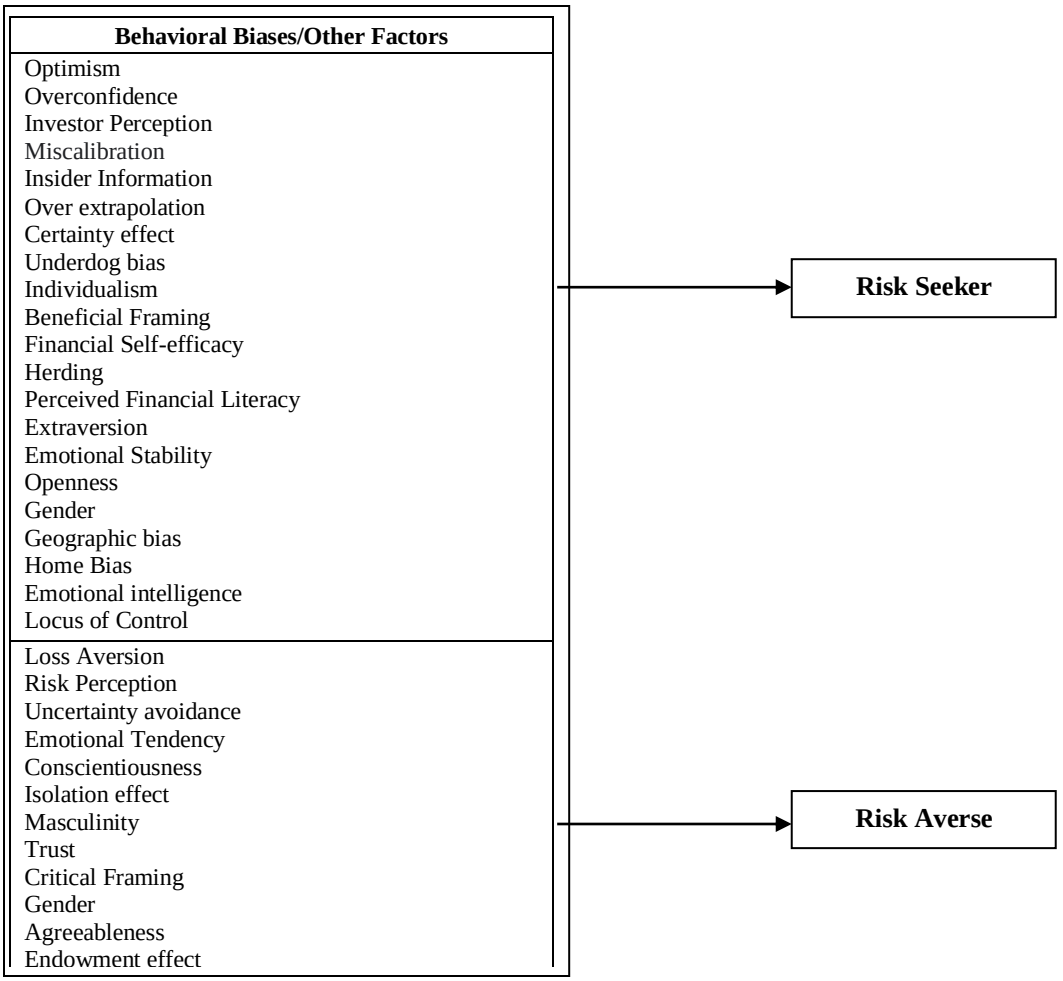

Figure.6. Investors' Biases & Risk Profiling
Source: Author's own elaboration

4.8. Content Analysis

In this section, the synthesis of selected research articles has been presented in the context of investors' biases and stock return volatility. The time ranges from 2008 to 2022. The content analysis has been performed based on identifying themes extracted from the analysis of literature. Following are the main themes that have been identified:

4.8.1. Cognitive, Emotional Biases & Stock Return Volatility

Kahneman & Tversky (1979) developed 'Prospect Theory' in which different behavioral biases were identified; individuals are loss averse in the gain domain whereas risk seekers in the loss domain, prefer certain outcomes instead of probable ones moreover they seek differences between the objects rather than similarities. This historical theoretical perspective was endorsed by Thaler in 1985 in his theory of 'Transactional Utility'; individuals have their subjective value of money which is termed as mental accounting bias, the utility is the difference between the actual price and individuals' reference price which they expected to pay. Loss aversion and fear sentiment negatively impact market performance because investors become pessimistic about the future outlook (Bouteska & Regaieg, 2020; Goel et al., 2022). Overconfidence and representative heuristic significantly impact investment decision; the presence of these biases result in excessive trading since investors believe unduly in their knowledge & skills, they heuristically think that past events can accurately predict future events; overconfident investors excessively rely on private information and underestimate public information the presence of overconfidence combined with self-attribution bias results in excessive trading and contributes to stock return volatility (Apergis, 2021; H. Liu et al., 2022; Merkle, 2017; Mushinada & Veluri, 2018; Parveen et al., 2020). Even the finance professionals also encounter cognitive biases such as overconfidence and extrapolation, agents cannot directly determine the firm's productivity they overreact to soft signals which makes the return on value stocks higher as compared to growth stocks (Alti & Tetlock, 2014).

Likewise, herding was also found to be the positive significant determinant of stock return volatility in the context of US & China stock markets, the financial turmoil has promoted herding behavior among investors, and in the presence of uncertainty, investors may become pessimistic and ambiguous (Fei & Liu, 2021; Litimi et al., 2016). Liu et al (2021) found that herding may cause disturbance in stock markets liquidity because of order imbalance whereas overtrading helps in improving market liquidity however disposition effect can only be significant when investors can easily distinguish between up and down-market trends. Literature also identifies the role of other cognitive biases such as anchoring and investor's limited attention; individuals' attention is limited and their valuation of a given stock is dependent upon certain anchor or reference points which result in stock return volatility both biases were found to have a significant impact on stock prices and aggregate market returns (Li & Yu, 2012; Verousis & Ap Gwilym, 2014).

4.8.2. Cultural, Religious Biases & Stock Return Volatility

National culture is an important determinant of stock return volatility; countries marked with individualism performed better during health disaster crises such as Covid-19 & SARS investors with individualism traits were found to be confident and optimistic which in turn positively impact stock returns whereas those countries where uncertainty avoidance was more evident experienced sharp decline & greater volatility in stock markets (Nguyen & Truong, 2013). Local bias is found to be another important cultural facet as it decreases stock price in the ratio to the aggregate book value of firms (Hong et al., 2008). Moreover, investors are also exposed to certain religious bias; during Ramadan, the trading activity of investors leads to greater stock return volatility in UAE

and Saudia Arabia since the month of Ramadan brings pleasure for Muslims around the world ultimately affect their behavior positively and result in optimistic stock trading (Abro et al., 2021; Białkowski et al., 2012).

4.8.3. Financial, Macroeconomic, Other Facets & Stock Return Volatility

The irrational behavior of investors is also gets influenced by different political, economic, financial, and other factors. The relationship between uncertain political situations and stock return volatility gets weaker if differences in investors' opinions, expectations, and bullish market trends exist (Białkowski et al., 2022). The trading activities are greatly influenced by the arrival of news if the information favors investors' goals then it can bring a positive impact on stock return volatility and vice versa, similarly electronic and print media embedded information impact investors' mood either positively or negatively; when investors are pleased and happy they usually trade with confident and optimistically thus it impacts stock prices positively however mood swings, a pessimistic gesture of investors leads to negative stock return and result in low implied volatility (Li et al., 2014; Fang & Peress, 2009). Furthermore, the subjective financial literacy of investors positively impacts stock returns; investors with appropriate financial knowledge trade smartly through portfolio diversification (Bellofatto et al., 2018). Apart from the discussed variables there are also some macroeconomic and financial facets that may impact stock return either positively or negatively such as market capitalization, gross domestic product, unemployment, advanced decline ratio, put-call ratio, turnover, foreign institutional investor‘s inflow, book value/ aggregate income of households, per capita income, region population density, region income growth (Hong et al., 2008; Dash & Maitra, 2018; Bouteska & Regaieg, 2020; Blau, 2017).

Table.4.1. Content Analysis

Author Name	Country	Methodology	Sample	Technique	Conclusion
Ni et al., (2015)	China	Quantitative	The sample size included 366 public listed companies comprised of 11,500 observations, the period ranged from January 2005 to September 2013.	Panel Quantile Regression	Ni et al (2015) studied the impact of investor sentiments on stock return volatility in the context of the Chinese A-share market, it was found that investors' overreaction is an important determinant of stock return volatility; investors seem to be optimistic about the gain on stocks in short-run however they become loss averse for the return on the stock in the long run thus investors sentiments impact positively on stock return in the short run and vice versa
Dash & Maitra (2018)	India	Quantitative	The sample size comprised of weekly stock returns ranging from 1st April 2002 to 30th May 2014. The public-listed companies listed in value-weighted index returns of the National Stock Exchange (NSE) of India (Nifty 50) were included in the sample.	Wavelet Decompositio n, Regression Analysis	The empirical findings revealed that stocks with higher returns are more affected by investors' sentiments as compared to stocks with lower returns. Furthermore, a substantial causal relationship between investor sentiments and returns of smallcap and midcap stocks was observed.
Qadan (2019)	US	Quantitative	The sample comprised daily stock returns and market capitalization	Ordinary Least Square, Quantile Regression	The empirical findings suggest that investor sentiments are also get influenced by risk appetite therefore the risk-seeking attitude of investors positively mediates the relationship

			values of all corporations listed on the NYSE and NASDAQ. The period ranged from January 1980 to December 2016. Moreover, Fama French 5 factor model data were also included.		between investors' sentiments and stock returns. An increase in investors' risk appetite brings a shift in their preferences from safer to more volatile stocks which brings a positive impact on stock returns in terms of their expected volatility.
Stambaugh et al., (2012)	US	Quantitative	The sample included Baker and Wurgler monthly market-based sentiment series to measure investor's sentiments, the first-day returns of IPOs & NYSE turnover. The BW index covered a time span of 42 years i.e., from July 1965 to December 2007.	Panel Regression	The findings suggest that overpricing can occur for numerous equities during moments of high sentiment due to market-wide fluctuations in investor mood. The high level of investors' sentiments led to strong anomalies presence however sentiments did not have any significant impact on returns in the long run.
Curatola et al., (2016)	US	Quantitative	The sample included Data stream Global Equity Indices (DGEI), 10,958 trading days covering the period of January 1973 to December 2014. Daily returns were compounded and summarized. 11 FIFA world cup with 234 event effect days were included.	Panel Regression	The other dimension of emotional biases emerges in the form of sports sentiments, the impact of sports sentiments was found to be significant on stock returns of financial sectors during the FIFA world cup in the context of the US; the liquidity of the financial sector attracts foreign investors who are more likely to be affected by sports sentiments as compared to local investors. The findings further supported the fact that arbitragers were successful to earn abnormal profits through short selling during the FIFA world cup.
Duz Tan & Tas (2021)	US, European States	Mixed	The sample included 1,063 stocks from S&P 500, S&P Europe, and S&P Emerging Markets Core Index. The period ranged from January 2015 to December 2017. Furthermore, content analysis was also performed to examine a number of tweets related to trading activities.	Panel Contemporaneous regressions	Duz Tan & Tas (2021) found a positive and significant impact of investors' social media sentiments on trading activity and stock return volatility; individuals like to post positive comments on social media platforms such as Twitter to inform others about their trading performance and gain certain reputation on their achievement.
Tekçe & Yilmaz (2015)	Turkey	Quantitative	The sample included nationwide data comprised of 305,546 investor sets, the period included 253 trading days of the ISE 100 index for the year 2011.	Panel Regression Analysis	Another cognitive bias named overconfidence was also found to be common among Turkish investors and negatively impact stock return; male investors were found to be more overconfident as compared to female investors, moreover, investors of developed states were found to be less overconfident as compared to underdeveloped states.
Tekçe et al., (2016)	Turkey	Quantitative	The sample included nationwide data comprised of 244,146 investor sets, the period included 253 trading days of the	Panel Regression Analysis	Investors also encounter certain emotional & cognitive biases such as disposition effect, familiarity bias, status quo bias & representative heuristic; a study conducted in the Turkish stock market affirmed the significant impact of disposition effect on stock

			ISE 100 index for the year 2011.		return volatility while familiarity bias was found to be a significant determinant of overconfidence among investors
Jokar & Daneshi (2018)	Iran	Quantitative	The sample included public listed companies registered on Tehran Stock Exchange by March 2008 with an ending financial year in the same month thus the final data set included 1400 companies. The period ranged from 2010 to 2016.	Multiple Linear Regression	The empirical findings suggested that the impact of herding, overconfidence and emotional tendency on stock return was found to be negative in the context of the Tehran stock exchange; overconfidence, and herding behavior may lead to excessive demand for given stocks and increase their prices therefore short selling occurs which led to the emergence of stock anomalies
Javaira & Hassan (2015)	Pakistan	Quantitative	The sample included daily and monthly stock closing prices and trading volume extracted from KSE 100 index, the period ranged from June 2004 to July 2007. Thus, the study included 774 observations.	CSSD CSAD Regression	The empirical findings refuted the impact of herding on stock market volatility. Moreover, dispersion is found to be increased when the market experienced negative returns & vice versa.
Mezghani & Boujelbè ne (2018)	GCC countries	Quantitative	The sample included monthly stock returns of Islamic & Conventional stock markets & oil markets for the period ranged from December 2006 to November 2016. DJIGCC & DJGCC indices were employed.	ARCH & GARCH	The empirical findings concluded a significant impact of herding bias on stock volatility in the context of the oil market, Islamic & Conventional stock markets particularly during the oil turmoil i.e., in 2008 when oil prices increased significantly & 2014 when prices dropped drastically.
Liu et al., (2022)	China	Quantitative	The sample included survey responses gathered from 12,856 investors however after the filtration of data main sample was reduced to 4,671 investors, the survey was conducted in September 2018. The second part of the sample included the trading volume of selected investors for the period ranging from January 2018 to June 2019.	Survey Design, Multivariate Cross-Sectional Regression	The empirical findings suggest that investors' financial goals and trading activities get affected by overconfidence, perceived information, and gambling preference thus leading to excessive trading.
Fernande z-Perez et al., (2021)	Multiple	Quantitative	Hofstede et al. (2010) culture index was employed which comprised 63 countries. MSCI index was used to obtain the total return of each country furthermore, cumulative abnormal stock	Panel Regression	The empirical findings affirm the impact of cultural biases on stock return volatility. Stock returns experienced greater volatility in the countries with a high level of uncertainty avoidance and lower level of individualism during the initial three weeks of COVID 19, investors became pessimistic and traded stock in panic which resulted in asymmetric returns.

			return and abnormal stock market return were computed for the year 2019.		
Ashraf (2021)	Multiple	Quantitative	House et al. (2004). & Hofstede et al. (2010) culture indices were employed which comprised 43 countries. Daily stock returns were obtained for the period ranging from January 22 to April 2020. The final sample included 1,769 observations.	Pooled Panel Ordinary Least Squares Regression	The findings concluded that during COVID 19 countries with a high level of uncertainty avoidance witnessed greater stock return volatility as compared to countries with a low level of uncertainty avoidance.
Galariotis & Karagiannis (2021)	Multiple	Quantitative	Hofstede culture index was employed which comprised 07 countries. MSCI index was used to obtain the total return of each country. The period ranged from 1999 to 2015.	Principal Components Analysis, Panel Least Squares model, and Panel VAR	Galariotis & Karagiannis (2021) studied different cultural dimensions in terms of profit momentum; the findings suggested the negative impact of uncertainty avoidance and power distance on stock return whereas individualism, masculinity, and long-term orientation had a positive impact on stock return.
Canepa & Ibnrubbian (2014)	Saudia Arabia	Quantitative	The sample included daily closing prices of stocks listed on the TASI Index for the period ranged from January 2002 to April 2008. The observations were taken from five sectors listed on the TASI index.	Stochastic dominance Analysis, Regression	Canepa & Ibnrubbian (2014) found that Shariah-compliant stocks earned higher returns and were more volatile as compared to non-Shariah compliant stocks since the presence of religious adherence motivates investors to trade as a group bounded by collectively held beliefs.
Goodell & Vahamaa (2013)	US	Quantitative	The implied volatility index VIX was employed to calculate stock market uncertainty. The period ranged from 1992 to 2008. Moreover, the likelihood of the ultimate winning presidential candidate's victory was obtained from IEM presidential contracts.	Panel Regression (Random Effect)	Goodell & Vahamaa (2013) studied the impact of political uncertainty during US presidential elections and found greater stock return volatility when the expectations about the winning party get certain. The findings suggest that market anxiety is induced by the presidential election process, as investors construct and adjust their expectations for future macroeconomic policies.
Shim et al., (2015)	South Korea	Quantitative	The sample included four weather-related variables obtained from Climate Data Service System. KOSPI200 spot index was used to assess the impact of weather bias on stock returns, the index comprised 200 companies. The period ranged from 2003 to 2007	GJR-GARCH	Pleasant weather may also influence investors' moods which ultimately influences their trading activities; stock return volatilities tend to be high in cloudy, raining, and windless weather thus investors disproportionately respond to extremely high weather conditions as compared to low weather conditions

Source: Author's own elaboration

4.8.4. Key Contribution

The key insights extracted from the literature analysis affirm the presence of several biases that influence stock return volatility besides cognitive and emotional biases there could be cultural, religious, demographic, macroeconomic, financial, personality traits, and other forms of biases which can impact stock return volatility either positively or negatively. The analysis of the literature reveals many less explored biases such as weather bias, social media sentiment bias, availability of news, fear sentiments, sports sentiments, and home and geographical biases. Thus, the fundamental contribution of this research is the development of taxonomy in the form of the causal framework which identifies the possible biases as independent variables along with mediating, controlling & moderating variables that impact stock return volatility. Moreover, the classification of investors' risk tolerance attitude based on identified biases is also presented.

4.8.5. Future Research Avenues

The following areas revealed a lack of focus and have been identified for future research studies:

i. Qualitative Perspective in the Context of Stock Return Volatility

Most of the research articles have employed quantitative research design in the context of stock return volatility thus it will be valuable to explore the qualitative aspect of a possible relationship between investors' biases and stock return volatility; why investors encounter certain biases, what are the factors which contribute towards formation of different biases.

ii. Cultural, Religious, and other types of Biases

Literature has been primarily focused on measuring the impact of cognitive and emotional biases on stock return volatility such as overconfidence, investors' sentiments, herding, and disposition effect however other types of biases for instance cultural, religious, personality traits, social media sentiments, weather bias, investors mood, religious affiliation, etc. have not been explored sufficiently moreover the role of gender has not been explored on a greater extent for example which type of biases is more evident for males and female and how it influences stock return volatility; the role of religion and ethical values in shaping investor's decision, how investors respond to any news, how investors employ social media tools such as Twitter, Facebook, Instagram to evaluate the potential of company's stocks and its correlation with stock return volatility these are potential areas for future researches.

iii. Contemporary Statistical Data Analysis Techniques

Since the stock return volatility can be measured through secondary data; most of the research articles have employed Panel Regression Analysis and the focus has been on measuring the non-linear impact of investors' biases on stock return volatility, the use of other contemporary statistical analysis techniques such as GARCH Model, EGARCH Model, Generalized method of moments (GMM), Autoregressive Distributed Lag (ARDL) cointegration technique, Auto-Regressive Integrated Moving Average is found to be limited.

iv. Role of Investors' Biases in Shaping Risk Tolerance Attitude

The risk tolerance attitude of investor is a key determinant of stock return volatility, the analysis of the literature reveals that risk seeker investors behave optimistically and trade excessively on the contrary risk-averse investor behaves pessimistically and trades with panic both attitudes lead to stock return volatility thus literature has been more focused on cognitive biases thus it will be more interesting to explore cultural, emotional, religious, demographic, incident-based sentiments and other types of biases which contribute towards risk tolerance attitude, the impact of different moderators such as

reference group, expert opinion, age, experience, etc. can also be examined in future studies.

v. Households & Professionals Investors as Unit of Analysis

Most of the work has been done on individual investors thus the aspect of biases is also significant in the context of entrepreneurial, households, and institutional investors, it will be interesting to explore to what extent the impact of biases differs between professional and nonprofessional investors. Furthermore, there is no criterion that can explain which types of biases are evident for male and female investors and how it contributes to stock return volatility.

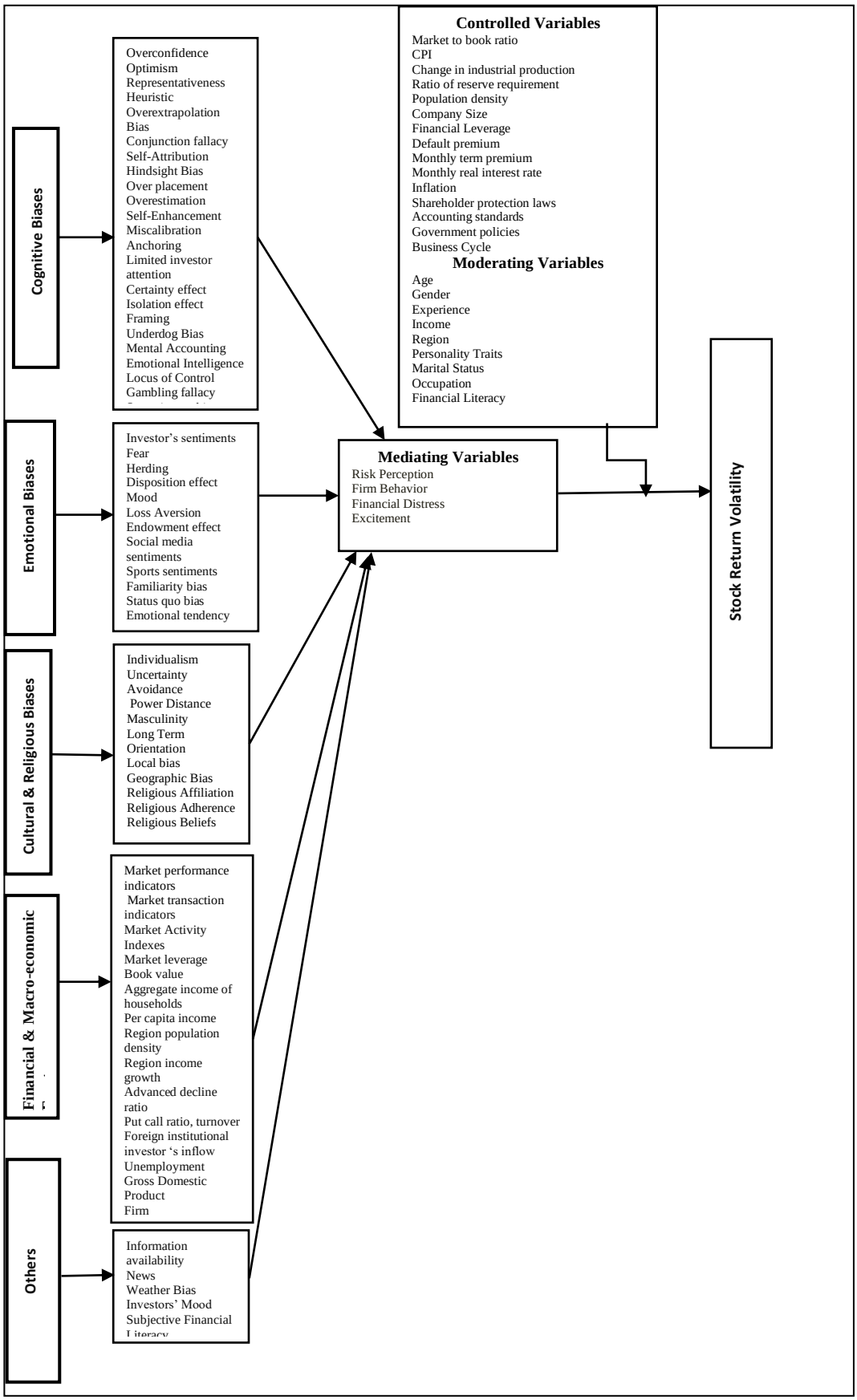

Figure.7. Taxonomy Model of Investors' Biases & Stock Return Volatility
Source: Author's own elaboration

5. Conclusion

The primary objectives of this research were to review and synthesize the available literature on individual investors' biases concerning stock return volatility. The review of literature discloses that a unified framework that identifies the possible relationship between investors' biases and stock return volatility is deficient. Moreover, there is no sufficient literature available that recognizes the role of biases in shaping investors 'risk tolerance attitude thus this research study contributes to filling the discussed gaps by proposing a taxonomy model which includes the possible investors' biases as independent variables along with mediating, controlling and moderating variables that impact stock return volatility furthermore the role of biases in shaping investors' risk tolerance attitude as risk seeker and risk-averse is also discussed. The literature analysis affirms the presence of investors' irrational behavior in stock markets. The findings suggest that investors do encounter cognitive, emotional, cultural, religious, demographic & other types of biases that make stock return volatile. Moreover, the analysis also revealed some evolving biases such as the arrival of news, fear-based sentiments, social media, sports sentiments, weather biases, investors' mood, and macroeconomic and firm-specific financial facets which have a substantial impact on stock return volatility. Literature has identified a positive, negative, and mixed impact of identified biases on stock return volatility the possible reason for the divergence in empirical results would be the different contexts of study, use of different data analysis techniques, and research designs. Most of the work has been centered on cognitive biases, quantitative approach, the use of secondary data, and traditional statistical techniques. Different mediating and moderating variables play a significant role in the context of investors' biases and stock return volatility such as risk perception, personality traits, financial literacy, excitement, age, gender, income, experience, region, etc.

5.1. Practical Implications

The findings of the research provide insightful implications for portfolio managers, government, and financial experts to assess the possible impact of inherent investors' biases on stock return volatility. Furthermore, the proposed taxonomy model will be helpful to perform suitability assessment and construct investors' profile based on their risk appetite so that investors can be offered the most pertinent financial products; this will ultimately enhance the creditability of financial experts' advice, maximize investors' wealth and protect their financial well-being.

5.2. Limitations & Areas for Future Research

This study encounters certain limitations; firstly, the analysis of literature is centered on individual investors' biases future studies can be done on institutional, entrepreneurial investors, and households. Secondly, the focus of the study rest on the behavioral perspective of individual investors other variables like personality traits, gut feeling-based decision making, and experiential learning can also be studied in future research moreover comparative study between developed and developing countries can also be done to examine the regional difference in terms of biases formation and their impact on stock return volatility. Thirdly the individual investor's biases have been analyzed mainly in the context of conventional stock markets future studies may explore investors' biases in the context of hedge funds, Islamic stock market, pension, real estate market, etc.

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