Does Cognitive Biased Knowledge Influence Investor Decisions? An Empirical Investigation using Machine Learning and Artificial Neural Network

Abstract

Purpose: Current research in the field of behavioural finance has attempted to discover behavioural biases and their characteristics in individual investors' irrational decision-making. The goal of this research is to find out how biases in information based on knowledge affect decisions about investments.

Design/methodology/approach: In step one, through existing research and consultation with specialists, thirteen relevant items covering major aspects of bias were determined. In the second step, multiple linear regression (MLR) and artificial neural network (ANN) were used to analyse the data of 337 retail investors.

Findings: The investment choice was heavily impacted by regret aversion, followed by loss aversion, overconfidence, and the Barnum effect. It was observed that the Barnum effect has a statistically significant negative link with investing choices. The research also found that investors' fear of making mistakes and their tendency to be too sure of themselves were the most significant factors in their decisions about where to put their money.

Practical implications: This research contributes to the expansion of the knowledge base in behavioural finance theory by highlighting the significance of cognitive psychological traits in how leading investors end up making irrational decisions. Portfolio managers, financial institutions, and investors in developing markets may all significantly benefit from the information offered.

Originality/value: This research is a one-of-a-kind study since it analyses the emotional biases along with the cognitive biases of investor decision-making. Investor decisions generally consider the shadowy side of knowledge management.

Keywords: Cognitive biases; Knowledge; Information; Investment decision; Regret aversion; Loss Aversion; Barnum effect.

1. Introduction

Investing may help in establishing a more secure social future. Financial planning is vital and everyone should be aware of how to invest, protect, and develop their money. The rationale for investing varies from person to person (Novianggie and Asandimitra, 2019). The unpredictable and unstable behaviour of people in daily activities makes it difficult to define reason; it is therefore of great benefit to study how the human brain makes financial decisions. Behavioural finance has emerged as a growing field, explaining how investors make irrational investment decisions and how the components of behavioral finance influence individuals' abilities to make irrational investments. The idea came from three disciplines: psychology, sociology, and economics. These contribute to the behavioral finance theory explaining irrational behaviour, irrational reasoning, and how it affects financial choices (Parveen et al., 2020). In traditional finance, everyone carefully evaluates all potential outcomes before making a choice. Therefore, traditional finance believes people are sensible. But "behavioural finance" is a deviation from traditional financial planning. Investment decision-making, long considered by

many models, assumes the decision-making process is rational in different investment avenues. Markovitz model, Capital Asset Price Model (CAPM), as well as Arbitrage pricing theory are all based on rational decision models in financial planning. They focus on how investors behave to ensure a certain return (Sharpe 1964; Markovitz 1959). But these studies mainly look at the rational decision model and pay less attention to the irrational decision model. Irrational investors are unable to follow a logical theory since they defy reason (Jain et al., 2020). Investors in the behavioural finance market are not completely free. They hope to make lucrative financial decisions. To do so, they must avoid investing based on emotions or intuition (Singh et al., 2021). Behavioural finance has identified many theories in the context of investment decision making. But in many studies, it is noted that the prospect theory is rarely applied to investor investment decision making. Investors are said to be vulnerable to a variety of cognitive and psychological errors when making investing decisions. There is a gap between how traditional economics is taught and how psychology is used in the real world. While estimating the risk of an event, specialists explain the probability and severity levels of that event. This is the reason for using prospect theory in this study to discover the probability and severity indices (Ilbahar et al., 2022). According to researchers, prospect theory (Kahneman and Tversky, 1979a) explains that choosing the best and rational decision from various risky and uncertainty situations always depends upon human behaviour rather than maximum utility value due to the imbalance between gains and losses (De Souza et al., 2020; Sharma et al., 2019). When it comes to equity investments, Saivasan et al. (2022) found that an individual's investment choice is influenced by the time frame, expectation of returns, and loss aversion that define the risk. There is a link between risk and demographic factors, which may also impact on behaviour. The decisions of individual Tanzanian stock market investors are highly impacted by their levels of optimism, self-control, and perspective thinking, according to research by Kasoga et al (2022). This kind of asymmetric behaviour and characteristic traits how cognitive constructs as defined by prospect theory. This has limited appearance in previous literature. Several studies (Kartini and Nahda, 2021; Al-Dahan et al., 2019) have shown that cognitive and emotional biases affect how people choose investments (Kartini and Nahda, 2021; Al-Dahan et al., 2019). Few studies have found that cognitive and emotional biases play a vital role (Jain et al., 2019; Haron at al., 2016; Kartinin et al., 2021; Kumar et al., 2016; Mittal, 2019).

This research was carried out based on prospect theory to investigate human cognitive biases and emotional biases to gain an understanding of their respective roles and how they impact investing decisions. The Barnum effect is a cognitive bias in which individuals are more likely to believe generic claims and personalise them after being encouraged to do so. The Barnum effect and how it may impact the choices made by individual investors are not extensively established in the relevant literature (Gaidai, 2021). This is the missing piece that needs further examination. However, literature on Barnum effect as a cognitive bias is scarce and thus, there is a need to explore the role of the Barnum effect concerning cognitive biases and investment decisions (Kasoga, 2021; Ahmad, 2020). This research takes into account the Barnum effect in addition to other cognitive biases like overconfidence, regret aversion, and loss

aversion to bridge the gap. The assumptions from all of these constructs describe the prototype prospect theory value which tends towards the imbalance between profit and losses. Further, the current study has attempted to explore the non-linearity relationship among the variables, an area which has not been explored by previous studies and to fill the knowledge gap in contributing to the existing literature by examining the Barnum Effect to impact investment decisions. This study investigates the impact of cognitive biases on investment decisions using the theoretical perspectives of behavioural finance theory. It is possibly the first study to examine the Barnum effect on investment decisions, and it could serve as a starting point for future academic research. In terms of theory enhancement, the research addressed the topic of cognitive biases, specifically the addition of the Barnum effect, a feature that is frequently overlooked in the context of investment decisions. To begin, this study shifted from rational to irrational decision making by incorporating behavioural biases into the reasoning process. Secondly, it analysed several variables involved in investment decisions in the Indian environment with the goal of building a decision-making framework that could also be applied for investment in an emerging market. Thirdly, it stressed the Barnum effect as a determinant influencing decision making.

Considering the above factors, this study sets out to accomplish the following objectives:

1. To explore and identify the biases that affect investment decisions in the Indian Stock market.
2. To incorporate a suitable framework for investment decision-making based on cognitive thinking within Indian investors.
3. To investigate the influence of the Barnum effect as a cognitive bias on investment decision making.
4. To demonstrate the practicability of the framework for practitioners, researchers, and decision-makers working in the area of cognitive investment decision making.

Section (1) explains the role of behavioural bias on investment decisions. Section (2) details the literature background, including an overview of behavioural bias connected to investment decisions. Section (3) discusses the study's conceptual framework and theoretical development. Section (4) elaborates on the methodology section. Section (5) describes the analysis of the results found in the preceding section. Section (6) discusses the results of the hypotheses. Section (7) suggests the managerial implications, which include both theoretical and practical aspects. Section (8) explains the conclusions and provides limitations of the study.

2. Literature review

This section focuses on the development of behavioural finance and how it differs from conventional finance in terms of applicability. To be more specific, it demonstrates how mainstream financial theories have failed to explain human behaviour and how biases influence their judgments, causing individuals to reach incorrect conclusions. Another consideration was, given that a big hole has appeared in the market, how to bridge the gap between the conventional

way of doing things and how people think. According to Singh et al. (2021), behavioural finance theories can assist investors in identifying their own investment blunders and avoid bias while making investment decisions. This study looked into the influence of behavioural biases on investment decisions using samples drawn from the Indian state of Punjab. The biases investigated include overconfidence, loss aversion, regret aversion, mental accounting, herding, and availability bias; these were all found to be present to some degree. In particular, it focuses on the insights provided by behavioural bias with the purpose of supporting investors in making better investment decisions. Quaicoe and Eleke-Aboagye (2021) performed survey-based research using questionnaires in the stock exchange in Ghana. They found herding aspect as the most influential component with a significant impact on the choice of investments. The findings of this research also revealed that cognitive biases like regret aversion, the gambler's fallacy, mental accounting, overconfidence, and anchoring can lead to people making bad decisions when they are investing. A study conducted in Kerala by Antony and Joseph (2017) looked into how psychological aspects are influenced by other factors. According to the findings of the research, when compared to all other components, overconfidence bias had the biggest influence on the decision-making of investors. Researchers Paisarn et al. (2021) investigated the trading behaviour of Thai retail investors, with the goal of identifying personality factors and behavioural pattern biases that have an impact on investors' trading behaviour. They hoped to improve trading performance. According to the study, it was shown that men are more prone to overconfidence than women. Investors with better trading expertise, according to the data, are less likely than other investors to hold onto their shares for an extended period. Another point from the study was that demographic features played a major role in decision making and could be an inspiration for investors. Garcia et al. (2021) in their study examined herding behaviour in investors' attitudes acquired from a variety of sources, such as news outlets, journals, and other publications. They confirmed that shareholders' emotions are linked to herding behaviour. Adomdza et al. (2016) investigated the relationships between the planning fallacy, optimism, and overconfidence, as well as the amount of money received by investors. They conducted a thorough investigation and discovered that while overconfidence is not associated with funding, planning errors and optimism are associated with investor financing.

Parveen et al. (2020) conducted a study on the influence of overconfidence and representative heuristics on investors' choice of investment using data collected from investors at the Pakistan Stock Exchange. They discovered that investors who are overconfident in the face of uncertainty rely on representative heuristics to make their investment decisions. Experiments revealed that overconfidence acts as a mediator between representative heuristics and the investment decision; biases that were identified had a significant impact on investments made. Parhi et al. (2021) researched the overconfidence bias and the impact of biases on the investments of high net-worth individuals (HNWIs). Their findings revealed that overconfidence bias had only a minor impact on investors' day-to-day lives as well as their decision-making processes. In the long run, investors were able to better understand their own biases and the consequences of these biases in order to avoid losing money in the future.

Novianggie et al. (2019) in their research examined the influence of behavioural bias, cognitive bias, and emotional bias on investment decisions across a wide range of businesses. This study took into account 'financial literacy' as a moderating variable; this served as a buffer between these biases when making investment decisions in the stock market. According to the research, investing decisions are influenced by a variety of factors, including herding bias, risk perception, overconfidence, representativeness, and financial literacy. In their research, Kumar and Goyal (2016) investigated the association between decision making processes and behavioural biases. Specifically, they discovered that demographic characteristics had an impact on the rational decision-making process. According to their research, when it comes to the rational decision-making process in the workplace, there is also a statistically significant difference between elements such as gender and amount of money. According to the findings of the study, male investors are more vulnerable to overconfidence and herding biases than women. According to a study conducted in Malaysia, retail investors are extremely important for economic growth and development. In this study, Jaiyeoba and Haron (2016) investigated the psychology of Malaysian retail investors in order to determine their decision-making processes and the influence of their psychology on their decisions. The findings show that these retail investors were more influenced by the information they were given, allowing then to learn more about new things. To better understand the relationship between biases and their influence on investment decisions, Tekce et al. (2016) looked at individual stocks held by Turkish investors and examined multiple biases such as the disposition effect, familiarity bias, representative bias, the heuristic, the status quo, and overconfidence. This assisted them in better understanding the relationships between biases and their influence on investment decisions. After conducting research in the context of the Pakistan Stock Exchange and studying behavioural factors, Javed et al. (2017) discovered that herding effects, overconfidence, availability bias, and representative bias were all associated with investors' perceptions of their investment performance; this was positive and statistically significant. They developed a well-thought-out model that took into account many different factors and their effects. According to recent theories, investor psychology is being influenced by behavioural finance, causing people to make illogical investment decisions. This was explored by Trejos et al. (2019) who used both qualitative and quantitative approaches to investigate the effects of overconfidence and disposition effects in order to better understand how people deviate from rationality in their decisions. According to their findings, the disposition effects of investors are more negatively disposed to being overconfident than upward oriented. The findings of another study conducted by Akhtar and Das (2020) focused on two psychological biases, namely financial risk tolerance (FRT) and financial overconfidence. They tried to determine whether there is a mediation effect between the personality traits of investors and perceived investment success. The findings revealed that these two biases have a mediating role in the relationship between psychological characteristics and investment decisions. According to the findings of the study, these biases have a negative relationship with investment results. According to Zahera and Bansal (2018), the conventional notion of money has a substantial impact on people's emotions, attitudes, and behaviour and also

has a big impact on their decision-making process. Individual investors, institutional investors, and financial advisers were all consulted by the researchers in this study. They found seventeen different types of cognitive biases and how these biases affect investment decision-making. Pandey and Jessica (2018) conducted a study to determine how hindsight bias influences the decision-making process of institutional investors. The researchers looked at eight behavioural biases that were divided into two categories: heuristic theories and prospect theories. Heuristic theories were the most commonly encountered. The researchers discovered that regret aversion bias and other prospect theory biases such as anchoring, representativeness, and availability, played a significant role in influencing the behaviour of real estate investors. Regret aversion bias and other prospect theory biases such as anchoring, representativeness, and availability also played a substantial role.

3. Conceptual framework and theoretical development

Individual behaviour in investment decisions is usually rational according to classical economic theory, and from this rationality, Bernoulli (1738) created the Expected Utility Theory (EUT), based on the economic elements of investment decisions. This theory describes how decisions are made by methodically analysing the probability of different outcomes under risky conditions. People tend to favour results that are the most useful. However, academics Kahneman and Tversky (1971, 1979) questioned the rationality assumption and identified divergence in real behaviour, leading to the establishment of behavioural finance. Based on portfolio principles, Markowitz et al. (1952) created a framework based on the examination of risk and return and their connection. According to the standard theory of finance, individuals value wealth and act rationally when making financial decisions in order to maximise their expected utility, whereas Kahenman (1971) criticised the traditional theory of finance, leading to the development of the study of irrationality in investment decisions. Thus, behavioural finance borrows from psychology, finance, and sociology and is focused on the psychology of investors, seeking to understand the influence of psychological mistakes on decision making (Kahneman and Tversky, 1979; Kishor, 2020). Behavioral scientists have identified human emotions, attitudes, and psychological biases as variables influencing investors' inefficient and illogical investing choices (Kahneman and Tversky, 1982). Behavioural finance is a sub-field of behavioural economics that proposes psychologically based explanations for stock market anomalies such as service price rises or declines (Sharma, 2019). The goal of behavioural finance is not to undermine the basic research undertaken by the architects of the efficient-market hypothesis; it investigates specific investor behaviours that separate them from rational decision makers as defined by traditional economic theory, as well as deviations from a market hypothesis that a behavioural model may be capable of explaining (Mittal, 2019). Prospect theory defines how people frame and weigh their decisions; individuals contemplate in terms of gain or loss in consideration of a given point, while heuristic theory invokes the most essential behaviours of cognitive bias and emotional bias.

3.1 Behavioural biases and hypothesis formulation

Heuristic and Biases: A heuristic is a form of instruction that encourages students to learn by doing. It also supports the view that the human mind is a template device that is very biased towards believing that a causal element is at work behind any remarkable set of events (Riepe and Kahneman, 1998).

Over confidence: An investor's abilities and knowledge are required in order to make the best investment decision feasible. The issue arises when investors believe that their talents, skills, and expertise are greater than they actually are (Budiarto and Susanti, 2017; Barber andOdean, 2001). Overconfidence is a bias that influences their trading skills because they overreact to irrelevant information and underreact to good information (Hirshleifer and Daniel, 2015). Overconfidence arises as a result of previous success (Gervais and Odean, 2001). Evidence of overconfidence has been found in the supply chain innovation scenario (Du et al., 2021), retail investor and individual investor investment decisions (Talwar et al., 2021; Jain et al., 2019; Kumar and Dudani, 2021; Kishor, 2020); stock market reaction (Praveen et al., 2020; Ahmad et al., 2020; Liang et al., 2022) and corporate sector (Hatoum, 2021). As a result, overconfidence bias should be studied during the decision-making process. Studieshaveaddressed the shift from traditional finance to behavioral finance, linked to cognitive and emotional factors. According to previous research, overconfidence has a major impact on investment decisions (Kartini and Nahda, 2021). Therefore, we hypothesise that:

H1: Overconfidence has a substantial impact on the choice to invest

Prospect theory and biases: This concept describes the asymmetrical manner in which people assess their perspectives on loss and gain. Prospect theory should be regarded as an approximation, an imprecise and a condensed description of a risky prospect evaluation (Tversky and Kahneman, 1981). Loss aversion stems from the prospect theory, explaining how people react when they lose something. When this bias exists, investors are very concerned about potential losses. Investors are always more concerned with avoiding losses than with profiting (Kahneman and Tversky, 1979). It explains the nature of the individual investor; this is to avoid risk during times of profit, preferring to take risk during times of loss, where the value of losses is twice that of profits (Tversky and Kahneman, 1991; Benartzi and Thaler, 1995). Investors who suffer from this bias prioritize capital preservation over capital growth (Jain et al., 2019; Barberis and Huang, 2001). Research also mentions traders' loss aversion being greater during bullish market phases than during bearish market phases. The reasoning is that investors react differently when market value changes are positive opposed to when they are negative (Coval and Shumway, 2001; Kumar and Dudani, 2021). Loss-averse investors avoid investing in high-risk portfolios to minimize the possibility of loss (Duxbury and Summers, 2004); this affects investors' risk-taking abilities when making investment decisions (Dhar and Wertenbroch, 2000; Kishor, 2022; Jain et al., 2019; Akinkoye and Bankole, 2020). Therefore, it's important to think

about loss aversion bias before making any choices. Iram et al. (2021) discovered that loss aversion, mental accounting, and self-control had a substantial effect on investment decisions. They discovered that loss aversion, herding, and fear of missing out all had a considerable influence on retail investors' decisions, with the mediating role of fear of missing out. Many researchers claim that there is a positive and substantial relationship between loss aversion bias and the investment decision-making process (Lim, 2012; Jain et al., 2020; Zat and Khan, 2017). So, we propose the hypothesis:

H2: Loss aversion has a significant effect on investment decisions

The term "regret aversion" refers to a situation in which an investor refuses to make any type of decision because he or she is afraid that the outcome will be negative, resulting in regret on the investor's part. As a result of this regret, the investor feels emotional distress, which may influence his or her future actions (Tversky and Kahneman, 1979). The emotion of regret is triggered by negative outcomes and perceptions of better outcomes that could have been obtained through different choices (Fogel and Berry, 2006). Investors who suffer from this bias make irrational decisions as a result of regret, fear, and the outcome of their decisions (Shiller, 2003; Odean, 1998). Prior research measured the neurological brain activity of regret aversion during a continuous process of lottery choices and discovered that the experience of regret leads to the bias of regret aversion while making decisions. Regret aversion has been carefully studied and analysed to explain investment behavior (Frydman and Camerer, 2016; Quaicoe and Eleke-Aboagye, 2021); disposition effect (Shefrin and Statman, 1985); stock market behavior (Barberis et al., 2006); currency hedging decisions (Michenaud and Solnik, 2008; Korn and Rieger, 2019) and insurance coverage (Huang et al., 2016). Thus, before making any decisions, it is critical to measure and analyse regret aversion. Many studies have shown that regret aversion has a positive influence on decision-making (Kengatharan and Kengatharan, 2014; Lim, 2012; Zat and Khan, 2017; Jain et al., 2020). Quaicoe and Eleke-Aboagye (2021) conducted a study among Ghana Stock Exchange investors to examine the association between psychological aspects and investment decisions. They discovered that regret aversion bias and the gambler's fallacy had a significant influence on investor decisions. Malik et al. (2021) investigated the impact of behavioural biases on financial decisions in the context of Pakistan's real estate sector. They discovered that overconfidence bias, gamblers' fallacy, and regret aversion bias had a greater impact on real estate pricing than herding and regret aversion bias. So, we define the hypothesis:

H3: Regret aversion has a significant effect on investment decisions.

At the time of the fallacy of the personal validation experiment, psychologist Bertram Forer discovered the Barnum effect, which he named after the entrepreneur Barnum. The Barnum effect is also referred to as the Forer effect. It is explained by the conviction that broad knowledge, which may apply to everyone, is misinterpreted by individuals, who assume that general information relates only to them personally. Numerous people nowadays believe in horoscopes and follow them on a daily basis via media such as newspapers, television and other

sources; they may take investment decisions based on their horoscope predictions. The Barnum effect is a term used in psychology literature to allude to the fact that descriptions of people are made up and that the comments made about them are relevant to practically everyone in almost every situation (Claridge et al., 2008). Thus, measurement and analysis of the Barnum effect as a new construct is crucial before making any decisions.

H4: The Barnum effect has a substantial impact on the choice to invest.

Based on the above discussion, the conceptual hypothesised framework for this study is shown in Fig.1.

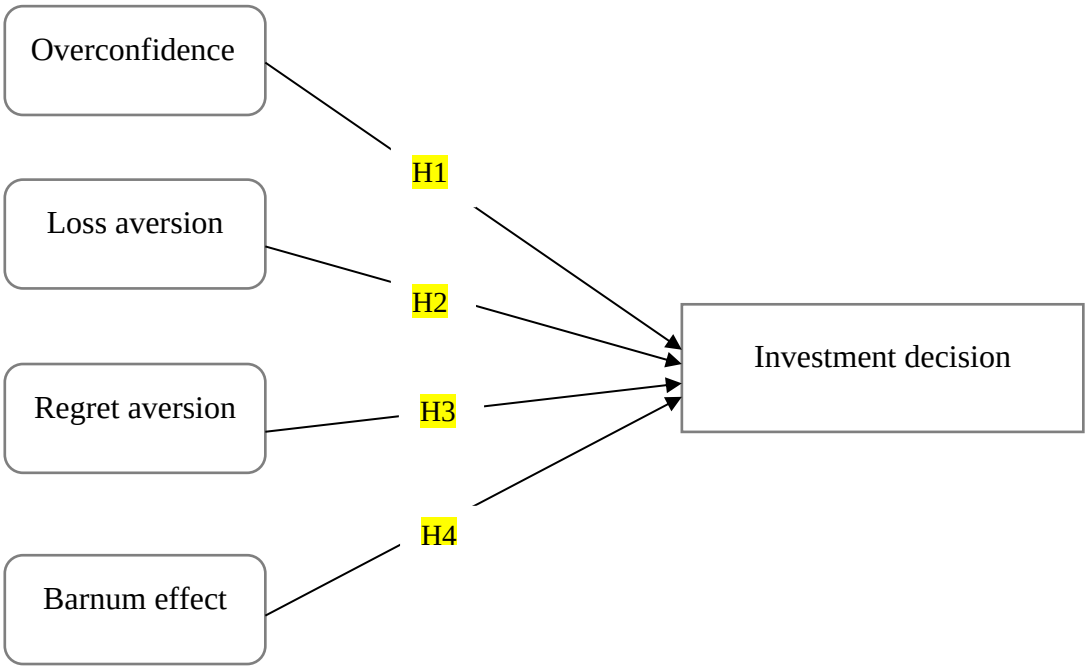

Fig. 1: Conceptual framework

4. Research methodology

Research in many contexts have identified different types of biases; these include overconfidence, mental accounting, loss aversion, representativeness, the status quo, regret aversion etc. Emotional and cognitive biases were taken into consideration for this study's conceptual framework of the research model and research methodology process was presented in Fig.2.

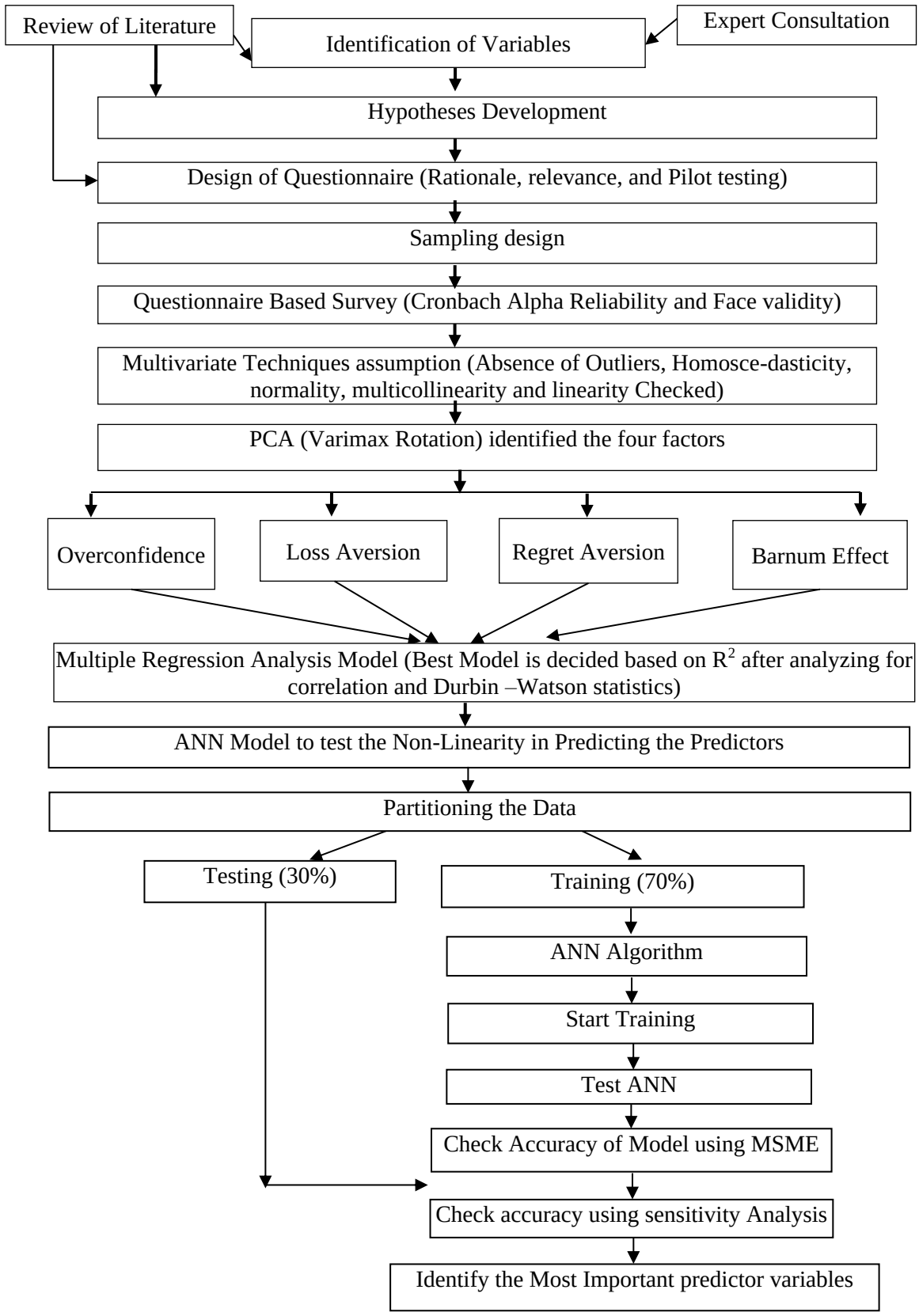

Fig.2. Research methodology process

They were chosen from previous studies which looked at their influence on investment decisions in different countries. The four biases included are overconfidence, loss aversion, regret aversion, and the Barnum effect. The study investigates how investing decisions are influenced by cognitive biases. Using a focus group of experts from the stock market and financial institutions, a structured questionnaire was developed to investigate the cognitive biases that can influence investment decisions. The questionnaire was developed primarily in the English language to allow for easy translation. A five-point Likert scale was used ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). For pilot testing, a non–probability, convenient sampling strategy was employed to gather 100 respondents in order to assess the reliability and validity of the proposed instrument. The questionnaire was created using Google forms; a link was sent to all of the respondents who completed the questions in the questionnaire. The ethical process was strictly followed. For example, on the first page of the questionnaire we declared the statement that collected data would be used confidentiality and personal information of the respondent would be protected. The study was carried out during the months of April – May of the following year to allow pilot testing to identify the biases. The Cronbach alpha was used to assess the reliability of the constructs; results for Cronbach alpha are provided in Table3. According to the Cronbach alpha guidelines, the value should be more than 0.7 (Hair et al., 2010). The internal consistency of Cronbach's alpha of all the constructs exceeded 0.7, showing the reliability of our measurement scale. The study collected data through an online survey. Investors who are active in stock market investment and investing in different avenues were among those who were deemed eligible to participate. The questionnaire was sent out to around 900 investors, with 357 responses coming back. This gave a response rate of 40%. A total of 337 replies was collected after the data filtering process eliminated 20 responses. Table1 contains information on the demographic profiles of those who responded to the survey. Between the months of 4thOctober2021 and24thDecember 2021, data was gathered from investors. About 80.4% of respondents are male. The study of Barber and Odean(2001) provided evidence of greater trading by males than females, supporting the demographic profile of our study; it is dominated by male respondents.

The age groups of participants varied; those between 27-32 years showed a maximum of 26.4%, and those between 51-55 years showed a minimum 5%. Over 65.9% of participants have at least a graduate qualification and 49.6% of investors had investment experience between 1-3 years.

Table1: Demographics profile of respondents

	Frequency	Percentage (%)
Gender		
Male	271	80.4 %
Female	66	19.6 %
Age		
21-26	61	18.1 %
27-32	89	26.4 %
33-38	79	23.4 %
39-44	60	17.8 %
45-50	31	9.2 %
51-55	17	5.0 %
Education		
Graduate	222	65.9 %
Above Graduate	115	34.12%
Investment Experience		
1-3 Years of Experience	167	49.6 %
4-7 Years of Experience	135	40.1 %
More Than 7 Year of Experience	35	10.4 %

5. Data analysis and results

The normality of the data utilized in the study was assessed inTable2.Multivariate assumptions were fulfilled through several tests of normality, multicollinearity and linearity. Validity of the questionnaire was carried out using content, construct and discriminant validity. Normality assumption has been fulfilled in terms of standard deviation, skewness and kurtosis specified in Table2; the P-P plots and Q-Q plots verified the existence of normality. Table 3 shows Cronbach's alpha and composite reliability of all the constructs which exceeded the threshold limit of 0.7. An investigation into the dimensions that explain the link between the variables was carried out using Principal Component's Analysis (PCA). The levels of adequateness were determined using exploratory factor analysis (EFA). Cronbach alpha was found to be acceptable for the items within each factor. The KMO (Kaiser –Meyer-Olkin) measure of sampling adequacy was found to be 0.696; this is considered to be adequate for the factor analysis.

Table2: Descriptive statistics of variables

Variable	Mean	SD	Skewness	Kurtosis
Overconfidence	4.86	1.43	0.62	0.07
Loss aversion	4.31	1.77	0.67	0.06
Regret aversion	4.46	1.45	0.56	0.03
Barnum Effect	4.26	1.76	0.54	0.04
Investment Decision	4.37	1.55	0.67	0.06

Table 3: Results of reliability

Factor	Items	Standard loading	Cronbach's alpha	CR	AVE
Investment decision	ID1	0.867	0.892	0.923	0.798
	ID2	0.889			
Barnum effect	BE1	0.793	0.81	0.823	0.701
	BE2	0.815			
Regret Aversion	RA1	0.892	0.867	0.889	0.745
	RA2	0.881			
	RA3	0.815			
Overconfidence	OC1	0.793	0.855	0.871	0.732
	OC2	0.842			
	OC3	0.744			
Loss aversion	LA1	0.764	0.856	0.862	0.751
	LA2	0.897			
	LA3	0.824			

PCA was employed to find out the minimum factors accounting for maximum variance in the data; varimax rotation was used in optimizing the number of variables with high loading on each factor in interpretation of the factor. A total of five useful factors were extracted when a PCA analysis was performed on regret aversion, loss aversion, overconfidence, the Barnum effect, and investment decision. The total explained variance was 79.88%. The communities of each measurement were greater than 0.5, meeting the guidelines as recommended by Hair et al. (2010). Multiple regression analysis is used to understand the linear relationship between the dependent variable and investment decision in relation to four independent variables considered in this study. The result of the analysis of the MLR model will be compared with the non-linear neural network model. The general model of MLR is written as follows:

$$Y = \beta_0 + \beta_1 OC + \beta_2 RA + \beta_3 LA + \beta_4 BE + \varepsilon$$

Y represents investment decision; the explanatory variables are as follows:OC is overconfidence; RA is regret aversion;LA is loss aversion; BE is Barnum Effect.$\beta_0$is a constant term followed by

the slope coefficients for OC, RA, LA, and BE; these are represented byβ_1; β_2; β_3; β_4, respectively. The slope coefficients are expected to have a non-zero value as the researchers believe that there is a certain degree of impact on the behaviour of the decision makers on investment. The constant β_0 can be interpreted if and only if the slope coefficients have no impact on investment decision. Last but not least,ε represents the model's error or residuals.As shown in previous literature, there are certain variables that impact investment decision. Therefore, there will be no interest in interpreting the constant. The correlation matrix is given in Table 4, with goodness of fit of the model summary presented in Table 5.

Table 4: Correlation Matrix

	OC	LA	BE	RA	ID
OC	-				
LA	0.342				
BE	0.458	0.482			
RA	0.225	0.388	0.537		
ID	0.267	0.237	0.258	0.406	-

Table 5: Goodness of Fit of the model

Model	*R*	R^2	Adjusted R^2	Std error of Estimate	Durbin-Watson
1	0.818	0.669	0.609	0.24869	1.774

a: Predictors: (Constant), BE, RA, OC, LA

Adjusted R^2 is a corrected goodness of fit i.e. model accuracy for measuring linear models. The adjusted R^2value of 0.609 obtained in the model indicates that it explained 60.9% of variance in the dependent variable. Table 6 shows the regression result.

Table 6: Regression results for Investment decision and Collinearity Diagnostics

Model	***β***	***t***	**Sig.**	**Tolerance**	**VIF**
(Constant)	1.234	13.523	0.000		
Overconfidence	0.193	1.153	0.003	0.961	1.041
Loss Aversion	0.227	2.664	0.002	0.841	1.189
Regret Aversion	0.245	3.371	0.001	0.812	1.231
Barnum Effect	-0.163	-0.537	0.592	0.977	1.024

Except for the Barnum effect, the results show that at 5% level, the input variable regret aversion has beta = 0.245, *t*-value 3.371 with 0.001 sig. Hence, hypothesis H3 is strongly supported. The

most important predictor of the investment decision, followed by loss aversion variable, has beta = 0.227, *t*-value 2.664, with 0.002sig. This affects the investment decision, supporting hypothesis H2. By following the sequence, the next variable is overconfidence with beta = 0.193, *t*-value 1.153 with 0.003sig; this supports the first hypothesis, H1. The new variable, Barnum effect, has a beta value of -0.163 and a *t*-value of -0.537 with 0.592. So, the fourth hypothesis, H4, is not supported.

$$Investment\ Decision = 1.234 + 0.193 * Overconfidence + 0.227 * Loss\ Aversion + 0.245 * Regret\ Aversion - 0.163 * Barnum\ Effect + \varepsilon$$

5.1 ANN approach

The study uses multi-explanatory results by combining MLR and neural network analysis. ANN is a powerful technique of artificial intelligence that is helpful in identifying non-linearity relationships in solving complex problems; this is in contrast to MLR techniques. Different types of neural network systems exist, but in this study, feed-forward back propagation multilayer perception was used. The model represents the human brain neuron, synapse, and axon. The network has the ability to gain knowledge through learning procedures. “ANN is a massively parallel distributed processor made up of simple processing units, which have a natural propensity for storing experimental knowledge and making it available for use" (Haykin, 2001, p.2). Multilayer perception has the ability to capture the nonlinearity and learning input and output mapping. The ANN model and the MLR model were used in this study, with the findings compared in terms of the investor's biases with regard to the investment choice made. Using SPSS 20 software, the ANN model was developed, with the multilayer perceptron training algorithm used in training the model. Cross-validation was performed in order to overcome any over fitting. RMSE (Root Mean Square Error) was used in measuring the accuracy of the ANN model. Hyperbolic tangent activation is used and hidden nodes vary from 1 to 10. The number of nodes was varied. Ten-fold cross-validation was used where 70% of the data points were used in the training network model and 30% of the data points were used to test the model. Four variables, namely overconfidence bias, regret aversion bias, loss aversion bias and the Barnum effect were used; investment experience was also included in the input layer of the network model. The dependent variable, investment decision, was included in the output layer of the model. The input layer involved four independent significant factors from SEM (i.e. overconfidence, regret aversion, loss aversion, and Barnum effect), whereas the output layer was comprised of one output variable (investment decision). This model was examined by using an ANN multi-layer perceptron with an algorithm of a feed-forward back-propagation. (Hew et al., 2019; Leong et al., 2020; Xiong et al., 2022). Root Mean Square of Error (RMSE) of both training and testing values for all ten neural networks, along with averages and standard deviations, were computed to check the accuracy of our model (Lee et al., 2016; Leong et al., 2015; Hew et al., 2018). The framework was tested using the MLR model to understand the

relationships between independent variables that predict the investment decision. MLR analysis was used to perform the modelling of the linear relationship between dependent variables. ANNs deliver better model fit and capture non-linear relationships between independent variables with respect to the dependent variable investment decision. Firstly, this study examines multiple regression analysis which presumes that when one component decreases, then another can be compensated by increasing another component. This helps investors to simplify their decision (Tan et al., 2014). Secondly, this current study adopted the ANN model which not only can examine the non-linear relationships but can also validate the linear relationship (Chan and Chong,2012). ANN can examine both linear and non-linear relationships, meaning that the ANN model is more suitable for prediction (as shown in Fig.3)

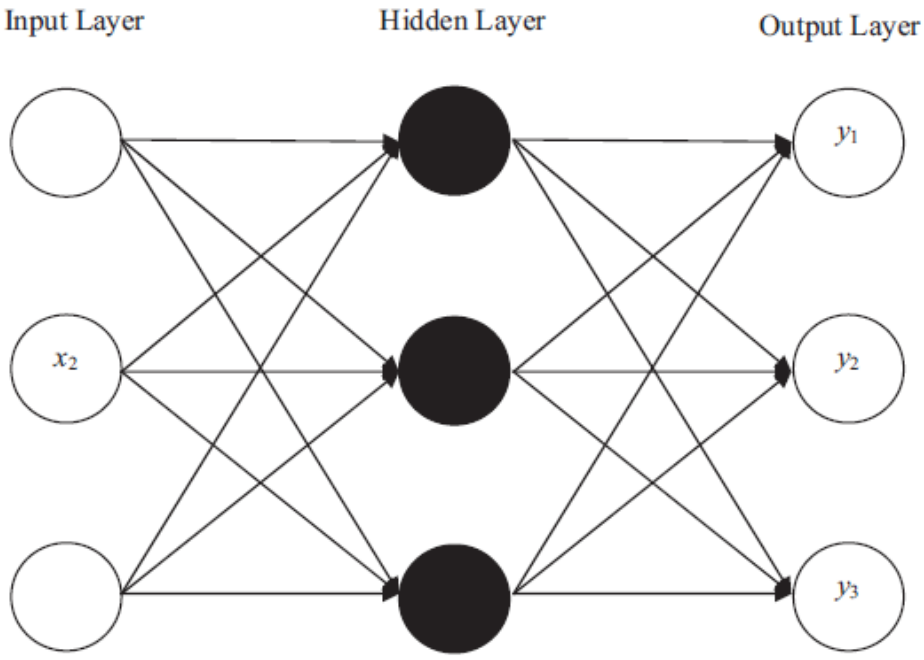

Fig.3: FFBP- MLP with five input three hidden layers and one output neuron

The formula proposed by Sim et al.,2014 in evaluating the activation function for ANN is given below:

$$A_j(\overline{p},\overline{w}) = \sum_{n=0}^{n} q_i\, w_{ij} \quad \text{.....(1)}$$

where q_i is the input and w_j is the output

$$H_j(\overline{q},\overline{w}) = \frac{1}{1+e^{B_j(\overline{q},\overline{w})}} \quad \text{.....(2)}$$

(Where Equation2 evaluates the activation function for the hidden and output layer.)

Prediction of the models' accuracy based on the RMSE values, calculated using Equation (3)

Prediction of the model accuracy is based on the following equation.

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n}(O_i - P_i)^2}{n}} \quad \text{.....(3)}$$

ANN and RMSE for the neural network are shown in Fig.4 and Table 7

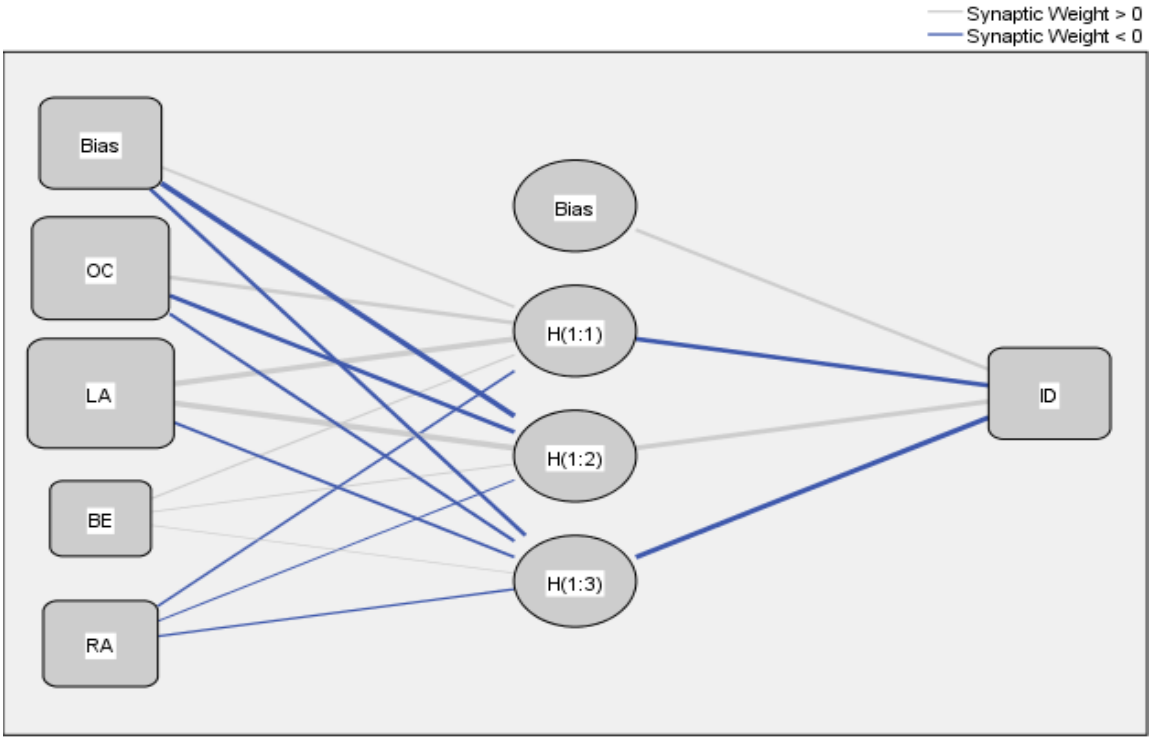

Fig. 4: Artificial Neural Network diagram

Table 7: RMSE for the Neural Network

Neural Network	Training	Testing
ANN1	0.0915	0.0967
ANN2	0.0787	0.0807
ANN3	0.0823	0.0891
ANN4	0.0887	0.0957
ANN5	0.0879	0.0827
ANN6	0.0851	0.0881
ANN7	0.0864	0.0890
ANN8	0.0769	0.0897

ANN9	0.0889	0.0926
ANN10	0.0940	0.0914
Average	0.0866	0.0917
Standard Deviation	0.0031	0.0072

RMSE of the validation in which the average cross-validated of the training model was found to be 0.0866 while the testing model was 0.0917.

5.2 Sensitivity analysis

The sensitivity analysis explained the normalized importance which was estimated as the ratio of the relative importance of input variables to its maximum relative importance. Table 8 describes the variables' percentage of average and normalized relative importance acquired from the ANN model. The investment decision was the strongest factor influenced by regret aversion (87.10%), overconfidence (82.22%), loss aversion (82.10%), and Barnum effect (65.51%). So, the ANN model found that regret aversion is the most influential factor in the investment decision. The findings of the ANN model thus have higher predictive power (Xiong et al., 2022).

Table 8: Sensitivity analysis

Network	OC	LA	BE	RA	ID
1	0.164	0.186	0.133	0.168	0.207
2	0.145	0.172	0.151	0.167	0.189
3	0.158	0.169	0.162	0.163	0.205
4	0.183	0.154	0.134	0.169	0.209
5	0.159	0.162	0.149	0.158	0.199
6	0.167	0.174	0.139	0.165	0.214
7	0.161	0.138	0.142	0.182	0.217
8	0.147	0.167	0.166	0.156	0.223
9	0.181	0.171	0.159	0.162	0.214
10	0.154	0.121	0.144	0.181	0.188
Average	0.162	0.161	0.147	0.163	0.204
Normalized importance	82.22%	82.10%	65.51%	87.10%	100%

6. Discussion

This study provides an important contribution to the existing literature of behavioural finance theory. This study expresses the role of cognitive bias along with emotional biases such as regret aversion, loss aversion, overconfidence, and Barnum effect that were considered for analysis. Normality of the data was tested by measuring their mean, standard deviation, and skewness. The construct reliability was checked by Cronbach's alpha which exceeded the threshold limit of 0.7; AVE and CR values were also checked for validity. After analysing the reliability of constructs, MLR and ANN models were used to discover important biases that impact investment decisions. The MLR model was used and found that R^2 accounts for 66.9 % of the variation in biases that lead an investor in decision making. The MLR model is unable to capture the non-linear relationship, so the non-linear relationship between the independent variable, which is comprised of various types of cognitive biases, and the dependent variable, which is comprised of investment decisions, is captured using the ANN model while keeping the error to an absolute minimum. The ANN model exhibited different biases in order of their predictive relevance. Attributes like overconfidence, loss aversion, regret aversion, and the Barnum effect, all have a substantial impact on an investment decision. The RMSE and sensitive analysis of the neural network show that regret aversion (87.10%) is the most influential factor, followed by loss aversion, overconfidence and the Barnum effect in affecting an investment decision. According to the ANN's findings, there is a statistically significant association between the Barnum effect and investment decisions. The influence of independent variables, such as loss aversion, overconfidence and regret aversion, on people's ability to make investment decisions, is also significant.

The study discovered that according to ANN, regret aversion is the most powerful predictor of all emotions; this is a common cognitive bias, that connects all of the emotions. This significant positive finding is also consistent with Antony and Joseph (2017); Buiarto and Susanti (2017); Jain et al. (2020); Kengatharan and Kengatharan, (2014); Lim, (2012) and Zat and Khan, (2017). Loss aversion is another major predictor, meaning that the power of losses has an asymmetrically greater impact on an investor than the power of equal gains on the same investment. To counteract this tendency, investors are more likely to sell successful stocks when they anticipate future losses. These results were similar to prior findings of Jain et al., (2020); Zat and Khan, (2017); Coval and Shumway, (2001); Kumar and Dudani, (2021); Dhar and Wertenbroch, (2000); Kishor, (2022); Jain et al., (2019); Akinkoye and Bankole, (2020). When it comes to making an investment decision, overconfidence has a favorable and significant impact on the outcome. This is consistent with previous research by Antony and Joseph (2017); Budiarto and Susanti (2017); Jain et al., (2020) and Javed et al., (2020). However, the conclusions disagreed with those of Kengatharan and Kengatharan, (2014); Ahmad and Shah, (2022); Waweru et al., (2008) and Park et al., (2009). The current study has added real-world evidence to the literature already out there. It has enriched the existing body of knowledge making it more interesting and valuable for other researchers.

The Barnum effect is included as an additional variable in the model; it has been found to be a poor predictor of investment decisions in the past. Some well-educated people are now beginning to believe in fortune-telling, as well as other supernatural phenomena described by Mason and Budge, (2011) and Gaidai, (2021). Some investors may do badly due to a lack of information, experience or confidence as well as historical failure ratios. However, the context of our study reveals that the Barnum effect is a separate and poor predictor of investment decisions in general. Thus, the Barnum effect has made a substantial contribution to the setting and culture of investment choice literature, particularly in the fields of bias and investment decision-making.

7. Theoretical and practical contributions

7.1 Theoretical contribution

Among many biases, we considered regret aversion, loss aversion, overconfidence, and the Barnum effect in our research model. Characteristics describe the prototype prospect theory related to behavioural finance theory assumptions, providing a theoretical contribution to academic work on investors' behavior in their decision-making. The study also looked into how cognitive biases influence investment decision-making. This is perhaps the first study to examine the Barnum impact on investment decisions, and it could serve as a starting point for future academic research on innovation resistance. This work investigates the impact of cognitive biases on investment decisions using the theoretical perspectives of prospect theory. In terms of theory enhancement, the research addressed the topic of cognitive biases, specifically the addition of the Barnum effect, a feature that is frequently overlooked in the context of investment decisions. This area, on the other hand, requires greater proactive attention to ensure the effectiveness of investment decisions. Many previous studies have looked at cognitive biases but the addition of the Barnum effect made this work different. When these findings were put together in the context of making investment decisions, a new and fresh perspective has emerged.

7.2 Implications for practice

Investors who are acting irrationally in their financial decisions will find this study to be extremely useful. The implementation of the ANN model enables the prediction of biases in the establishment of a causal association between two variables. The application of the two-staged ANN and MLR models is relatively new. This can be considered an important tool for academics who wish to investigate behavioral biases that influence investment decisions in future in more detail. The outcomes of this study indicate that regret aversion is the most significant factor in determining how individuals choose to invest their money. After the loss aversion factor, the next two factors of influence are the overconfidence factor and the Barnum effect, in that order. To improve the behavior of investors who are behaving in an unreasonable manner, financial institutions or portfolio managers should pay close attention to cognitive and emotional biases.

When deciding how to allocate their capital, businesses should make a concentrated effort to mitigate the Barnum effect to the greatest extent possible. The government should take the steps that are needed, such as starting "investor awareness" programs, to help investors understand how biases affect them and how they can avoid making irrational decisions about their investments. The human neurological method, in conjunction with the social, economic and cultural aspects of the holistic perspective, will accurately depict the irrational decision-making process of investors. Investors, financial advisors, and policymakers in the financial sector can all benefit from having an awareness of the cognitive biases that have been uncovered. These biases play a role in irrational decision making on the part of investors, which in turn affects their returns. Knowledge of investor biases, in addition to knowledge of global and local economic market dynamics, will enable practitioners to formulate and redesign their strategy; this will ultimately lead to an improvement in their financial security. The Barnum effect, which is a one-of-a-kind contribution, should be treated with discretion; a statement that is generic for all investors might not be appropriate for individual investors. Because the biases of individual investors are a leading cause of market volatility, it is important for strategists to make intelligent use of the fact that overconfidence bias has an impact on their ability to invest profitably.

8. Conclusion

The study has focused on individual behaviour and its impact on the financial choices made. To fulfil our first objective, we conducted a review of literature to gain in-depth understanding regarding behavioural finance, updated the prospect theory and confirmed four cognitive behavioural biases which are dependent on the framework of prospect theory i.e. overconfidence, loss aversion, regret aversion, and Barnum effect. Their impact on investment decisions was assessed. After identifying the constructs, we incorporated a framework to measure the role of biases on investment decision, satisfying our second objective. In addition, a novel bias, known as the "Barnum effect," was introduced as a cognitive bias for this study. It was determined by research findings that confirmed that investment decisions are positively associated with all the constructs which are considered. The Barnum effect was the factor that was found to have least influence on the investment decision. The influence of the Barnum effect on the investor's decision process satisfies the third objective. The ANN model outperforms the MLR model in terms of performance. After evaluating the data, it was shown that regret aversion is the most powerful predictor of investment decision-making. Following regret aversion, loss aversion is the second most important predictor with overconfidence being the third most important. The Barnum effect was the least important predictor of investment decisions. ANN helps in identifying the non-linear relationship of the complexity in the investment decision as compared to the MLR model, which simplified the complex decision-making process. ANN performs better in non-linear dependencies in data than MLR (Sim et al.,2014; Dash et al., 2021). After analysing the techniques, the most important predictors and their impact were determined. This helps investors to improve their financial judgments, thus fulfilling the fourth objective.

The study has several limitations, the first of which is that the sample size is insufficient to generalize the findings across the entire country. Behavioural finance is a relatively new idea,

with the majority of studies being conducted in industrialized countries. Hence, future studies could focus on analysis of data collected from several developing countries in order to achieve more in-depth and comprehensive outcomes. This research also provides a foundation for additional investigation by taking into account emotional biases and other potential cognitive biases that were not included in the current study.

References

Adomdza, G. K., Åstebro, T., and Yong, K. (2016), "Decision biases and entrepreneurial finance", *Small Business Economics*, Vol.47 No.4, pp.819-834.

Ahmad, M. and Shah, S.Z.A. (2022), "Overconfidence heuristic-driven bias in investment decision-making and performance: mediating effects of risk perception and moderating effects of financial literacy", *Journal of Economic and Administrative Sciences*, Vol.38 No.1, pp.60-90.

Akinkoye, E. Y., and Bankole, O. E. (2020), "Effect of emotional biases on investor's decision making in Nigeria", *International Journal of Business and Management Future*, Vol.4 No.1, pp.33-39.

Akhtar, F., and Das, N. (2020), "Investor personality and investment performance: from the perspective of psychological traits", *Qualitative Research in Financial Markets*, Vol.12 No.3, pp.333–352.

Almansour, B. Y., and Arabyat, Y. A. (2017), "Investment Decision Making among Gulf Investors: Behavioural Finance Perspective", *International Journal of Management Studies*, Vol.24 No.1, pp.41–71.

Al-Dahan, N. S. H., Hasan, M. F., and Jadah, H. M. (2019), "Effect of cognitive and emotional biases on investor decisions: An analytical study of the iraq stock exchange", I*nternational Journal of Innovation, Creativity and Change*, Vol.9 No.10, pp.30-47.

Antony, A., and Joseph, A. I. (2017), "Influence of Behavioural Factors Affecting Investment Decision—An AHP Analysis", *Metamorphosis: A Journal of Management Research*, Vol.16 No.2, pp.107-114.

Barber, B. M., and Odean, T. (2001), "Boys will be boys: Gender, overconfidence, and common stock investment", *Quarterly Journal of Economics*, Vol.116 No.1, pp.261-292.

Barberis, N., Huang, M., and Thaler, R. H. (2006), "Individual preferences, monetary gambles, and stock market participation: A case for narrow framing", *American economic review*, Vol.96 No.4, pp.1069-1090.

Bashir, T., Azam, S. N., Butt, S. A. A., Javed, S. A., and Tanvir, S. A. (2013), "Are Behavioral Biases Influenced by Demographic Characteristics & Personality Traits? Evidence From Pakistan", *European Scientific Journal*, Vol.9 No.29, pp.277-293.

Bell, D. E. (1982), "Regret in Decision Making Under Uncertainty", *Operations Research*, Vol.30 No.5, pp.803-1022.

Benartzi, S., and Thaler, R. H. (1995), "Myopic loss aversion and the equity premium puzzle", *The quarterly journal of Economics*, Vol.110 No.1, pp.73-92.

Blavatskyy, P., and Pogrebna, G. (2008), "Risk aversion when gains are likely and unlikely: Evidence from a natural experiment with large stakes", *Theory and Decision*, Vol.64 No.2–3, pp.395-420.

Budiarto, A., and Susanti. (2017), "Pengaruh Financial Literacy, Overconfidence, Regret Aversion Bias, Dan Risk Tolerance Terhadap Keputusan Investasi", *Jurnal Ilmu Manajemen (JIM)*, Vol.5 No.2, pp.1-9.

Chandra, A. (2008), "Decision Making in the Stock Market: Incorporating Psychology with Finance", Conference Proceedings: FFMI 2008 IIT Kharagpur, 1-28.

Chan, F. T. S., and Chong, A. Y. L. (2012), "A SEM-neural network approach for understanding determinants of interorganizational system standard adoption and performances", *Decision Support Systems*, Vol.54 No.1, pp.621–630.

Charles, A., and Kasilingam, R. (2016), "Impact of selected behavioural bias factors on investment decisions of equity investors", *Ictact Journal on Management Studies*, Vol.2 No.2, pp.297-311.

Chen, G., Kim, K. A., Nofsinger, J. R., and Rui, O. M. (2007), "Trading performance, disposition effect, overconfidence, representativeness bias, and experience of emerging market investors", *Journal of Behavioral Decision Making*, Vol.20 No.4, pp.425-451.

Chong, A. Y.-L. (2013), "Predicting m-commerce adoption determinants: A neural network approach", *Expert Systems with Applications*, Vol.40 No. 2, pp.523–530.

Chu, W., Im, M., and Jang, H. (2012), "Overconfidence and emotion regulation failure: How overconfidence leads to the disposition effect in consumer investment behaviour", *Journal of Financial Services Marketing*, Vol.17 No.1, pp.96–116.

Claridge, G., Clark, K., Powney, E., and Hassan, E. (2008), "Schizotypy and the Barnum Effect", *Personality and Individual Differences*, Vol.44 No.2, pp.436–444.

Coricelli, G., Critchley, H. D., Joffily, M., O'Doherty, J. P., Sirigu, A., and Dolan, R. J. (2005), "Regret and its avoidance: a neuroimaging study of choice behavior", *Nature neuroscience*, Vol.8 No.9, pp.1255-1262.

Coval, J. D., and Shumway, T. (2001), "Expected option returns", *The Journal of Finance*, Vol.56 No.3, pp.983–1009.

Daniel, K., and Hirshleifer, D. (2015), "Overconfident investors, predictable returns, and excessive trading", *Journal of Economic Perspectives*, Vol.29 No.4, pp.61–88

Dash, M., Shadangi, P. Y., Muduli, K., Luhach, A. K., and Mohamed, A. (2021), "Predicting the motivators of telemedicine acceptance in COVID-19 pandemic using multiple regression and ANN approach", *Journal of Statistics and Management Systems*, Vol.24 No.2, pp.319-339.

Dennis, P. J., and Strickland, D. (2002), "Who blinks in volatile markets, individuals or institutions?", *Journal of Finance*, Vol.57 No.5, pp.1923-1949.

Dhar, R., and Wertenbroch, K. (2000), "Consumer choice between hedonic and utilitarian goods", *Journal of marketing research*, Vol.37 No.1, pp.60-71

Dickson, D. H., and Kelly, I. W. (1985), "The 'Barnum Effect' in Personality Assessment: A Review of the Literature", *Psychological Reports*, Vol.57 No.2, pp.367-382.

Dsouza, D. D., Quadros, S., Hyderabadwala, Z. J., and Mamun, M. A. (2020), "Aggregated COVID-19 suicide incidences in India: Fear of COVID-19 infection is the prominent causative factor", *Psychiatry research*, Vol.290, pp.113145.

Du, X., Zhan, H., Zhu, X., and He, X. (2021), "The upstream innovation with an overconfident manufacturer in a supply chain", *Omega*, Vol.105, pp.102497.

Duxbury, D., and Summers, B. (2004), "Financial risk perception: Are individuals variance averse or loss averse?", *Economics Letters*, Vol.84 No.1, pp.21-28.

Duxbury, D. (2015), "Behavioral finance: insights from experiments II: biases, moods and emotions", *Review of Behavioral Finance*, Vol.7 No.2, pp.151–175.

Edelen, M. O., and Reeve, B. B. (2007), "Applying item response theory (IRT) modeling to questionnaire development, evaluation, and refinement", *Quality of Life Research*, Vol.16(SUPPL. 1), pp.5-18.

Fang, H. C., Siau, K. L., Memili, E., and Dou, J. (2019), "Cognitive antecedents of family business bias in investment decisions: A commentary on risky decisions and the family firm bias: An experimental study based on prospect theory", *Entrepreneurship: Theory and Practice*, Vol.43, No.2 pp.409-416.

Fogel, S. O. C., and Berry, T. (2006), "The disposition effect and individual investor decisions: The roles of regret and counterfactual alternatives", *The Journal of Behavioral Finance*, Vol.7 No.2, pp.107–116.

Frydman, C., and Camerer, C. (2016), "Neural evidence of regret and its implications for investor behavior", *The Review of Financial Studies*, Vol.29 No.11, pp.3108-3139.

Gaidai, A. S. (2021), "Factors of The Barnum Effect: Analysis and Prospects", *Psychological journal*, Vol.42 No.2, pp.61–70.

Garcia, J. (2021), "Analyst herding and firm-level investor sentiment," *Financial Markets and Portfolio Management*, Vol.35 No.4, pp.461-494.

Gervais, S., and Odean, T. (2001), "Learning to be overconfident", *The review of financial studies*, Vol.14 No.1, pp.1-27.

Grether, D. M. (1980), "Bayes Rule as a Descriptive Model: The Representativeness Heuristic", *The Quarterly Journal of Economics*, Vol.95 No.3, 537-557.

Grinblatt, M., Titman, S., and Wermers, R. (1995), "Momentum investment strategies, portfolio performance, and herding: A study of mutual fund behavior", *The American economic review*, Vol.85 No.5, pp.1088-1105.

Gupta, S., and Shrivastava, M. (2021), "Herding and loss aversion in stock markets: mediating role of fear of missing out (FOMO) in retail investors", *International Journal of Emerging Markets*, Vol.17 No. 7, pp. 1720-1737.

Hair, J. F., Gabriel, M., and Patel, V. (2014), "AMOS covariance-based structural equation modeling (CB-SEM): Guidelines on its application as a marketing research tool", *Brazilian Journal of Marketing*, Vol.13 No.2, pp.44-55.

Harris, M., and Raviv, A. (2005), "Allocation of decision-making authority", *In Review of Finance*, Vol. 9 No.3, pp.353-383.

Hatoum, K. (2021), "Theoretical model on CEO overconfidence impact on corporate investments", *The Quarterly Review of Economics and Finance*, Vol.80, pp.545-552.

Hassan, T. R., Khalid, W., & Habib, A. (2014). Overconfidence and loss aversion in investment decisions : A study of the impact of gender and age in Pakistani perspective. Research Journal of Finance and Accounting Www.Iiste.Org ISSN, 5(11), 148-157.

Haykin, S. (2001). Neural networks: principles and practice. Bookman, 11, 900.

Hew, J.-J., Leong, L.-Y., Tan, G. W.-H., Ooi, K.-B. and Lee, V.-H. (2019), "The age of mobile social commerce: An artificial neural network analysis on its resistances", *Technological Forecasting and Social Change*, Vol.144, No.311–324.

Hew, J.-J., Leong, L.-Y., Tan, G., Wei-Han, L., and Voon-Hsien, O. (2018), "Mobile social tourism shopping: A dual-stage analysis of a multi mediation model", *Tourism Management*, Vol.66, pp.121–139.

Howard, C. T. (2013), "Behavioral Portfolio Management", *In SSRN*, 1-34 https://doi.org/10.2139/ssrn.2210032

Huang, R. J., Muermann, A., and Tzeng, L. Y. (2016), "Hidden regret in insurance markets", *Journal of Risk and Insurance*, Vol.83 No.1, pp.181-216.

Harry Markowitz (1952), "Portfolio selection", *The Journal of Finance*, Vol.7 No.1,pp.77-91

Ilbahar, E., Kahraman, C., and Cebi, S. (2022), "Risk assessment of renewable energy investments: A modified failure mode and effect analysis based on prospect theory and intuitionistic fuzzy AHP", *Energy*, Vol.239, pp.121907.

Iram, T., Bilal, A. R., and Latif, S. (2021), "Is awareness that powerful? Women's financial literacy support to prospects behaviour in prudent decision-making", *Global Business Review*, https://doi.org/10.1177/09721509219961.

Jain, J., Walia, N., and Gupta, S. (2019), "Evaluation of behavioral biases affecting investment decision making of individual equity investors by fuzzy analytic hierarchy process", *Review of Behavioral Finance*, Vol.12 No.3, pp.297–314.

Jaiyeoba, H. B., Adewale, A. A., Haron, R., and Ismail, C. M. H. C. (2018), "Investment decision behaviour of the Malaysian retail investors and fund managers A qualitative inquiry", *Qualitative Research in Financial Markets*, Vol.10 No.2, 134–151.

Jaiyeoba, H. B., and Haron, R. (2016), "A qualitative inquiry into the investment decision behaviour of the Malaysian stock market investors", *Qualitative Research in Financial Markets*, Vol.8 No.3, pp.246–267.

Javed, H., Bagh, T., and Razzaq, S. (2017), "Herding Effects, Over Confidence, Availability Bias and Representativeness as Behavioral Determinants of Perceived Investment Performance: An Empirical Evidence from Pakistan Stock Exchange (PSX)", *Journal of Global Economics*, Vol.6 No.1, pp.1-13.

Kahneman, D., Knetsch, J. L., and Thaler, R. H. (1990), "Experimental tests of the endowment effect and the Coase theorem", *Journal of political Economy*, Vol.98 No.6, pp.1325-1348.

Kahneman, D., Knetsch, J. L., and Thaler, R. H. (1991), "Anomalies: The endowment effect, loss aversion, and status quo bias", *Journal of Economic perspectives*, Vol.5 No.1, pp.193-206.

Kahneman, D., and Tversky, A. (2013), "Prospect theory: An analysis of decision under risk", In Handbook of the fundamentals of financial decision making: Part I (pp. 99-127).

Kallinterakis, V., Munir, N., and Radovic-Markovic, M. (2010), "Herd behaviour, illiquidity and extreme market states: Evidence from Banja Luka", *Journal of Emerging Market Finance*, Vol.9 No.3, pp.305-324.

Kanagasabai, B., and Aggarwal, V. (2021), "Personality traits and irrational decision-making of individual investors: evidence from India using PLS-SEM approach", *International Journal of Indian Culture and Business Management*, Vol.23 No.1, pp.1-22.

Kartini, K., and NAHDA, K. (2021), "Behavioral Biases on Investment Decision: A Case Study in Indonesia", *The Journal of Asian Finance, Economics and Business*, Vol.8 No.3, pp.1231-1240.

Kengatharan, L., and Kengatharan, N. (2014), "The Influence of Behavioral Factors in Making Investment Decisions and Performance: Study on Investors of Colombo Stock Exchange, Sri Lanka", *Asian Journal of Finance & Accounting*, Vol.6 No.1, pp.1-24.

Kishor, N. (2020), "Development and validation of behavioral biases scale: a SEM approach", *Review of Behavioral Finance*, Vol. 14 No. 2, pp. 237-259.

Kishor, N. (2022), "Risk preferences for financial decisions: Do emotional biases matter?", *Journal of Public Affairs*, Vol.22 No.2, pp.e2360.

Kourtidis, D., Sevic, Z., and Chatzoglou, P. (2011), "Investors' trading activity: A behavioural perspective and empirical results", *Journal of Socio-Economics*, Vol.40 No.5, pp.548–557.

Kumar, S., and Goyal, N. (2016), "Evidence on rationality and behavioural biases in investment decision making", *Qualitative Research in Financial Markets*, Vol.8 No.4, pp.270-287

Kasoga, P.S. and Tegambwage, A.G. (2022), "Psychological traits and investment decisions: the mediation mechanism of financial management behavior – evidence from the Tanzanian stock market", *Journal of Money and Business*, Vol. ahead-of-print No. ahead-of-print. https://doi.org/10.1108/JMB-05-2022-0028

Lee, Y. T., Liu, Y. J., Roll, R., and Subrahmanyam, A. (2004), "Order imbalances and market efficiency: Evidence from the Taiwan Stock Exchange", *Journal of Financial and Quantitative Analysis*, Vol. 39 No.2, pp.327-341.

Leong, L. Y., Hew, T. S., Ooi, K. B., and Chong, A. Y. L. (2020), "Predicting the antecedents of trust in social commerce - a hybrid structural equation modeling with neural network approach", *Journal of Business Research*, Vol.110, 24–40.

Leong, L. Y., Hew, T. S., Ooi, K. B., and Dwivedi, Y. K. (2020), "Predicting trust in online advertising with an SEM-artificial neural network approach", *Expert Systems with Applications*, Vol.162, pp.113849.

Leong, L. Y., Hew, T. S., Lee, V. H., and Ooi, K. B. (2015), "An SEM-artificial-neural-network analysis of the relationships between SERVPERF, customer satisfaction and loyalty among low-cost and full-service airline", *Expert Systems with Applications*, Vol.42 No.19, pp.6620–6634.

Lim, L. C. (2012), "The relationship between psychological biases and the decision making of investor in Malaysian share market", In *In Unpublished Paper International Conference on Management, Economics & Finance (ICMEF 2012) Proceeding.*

Loomes, G., and Sugden, R. (1982), "Regret Theory: An Alternative Theory of Rational Choice Under Uncertainty", *The Economic Journal*, Vol.*92* No.368, pp.805-824.

Lowies, G. A., Hall, J. H., and Cloete, C. E. (2016), "Heuristic-driven bias in property investment decision-making in South Africa", *Journal of Property Investment \& Finance*,

Vol.34 No.1, pp.51–67.

Lee, V. H., Foo, A. T. L., Leong, L. Y., and Ooi, K. B. (2016), "Can competitive advantage be achieved through knowledge management? A case study on SMEs", *Expert Systems with Applications*, Vol.65, pp.136–151.

Malik, M. A. S., Zafar, M., Ullah, S., and Ullah, A. (2021), "Role of Behavioral Biases in Real Estate Prices in Pakistan", *Real Estate Management and Valuation*, Vol.29 No.1, pp.41-53.

Markovitz, H. M. (1959). *Portfolio selection: Efficient diversification of investments*. John Wiley.

Mason, O. J., and Budge, K. (2011), "Schizotypy, self-referential thinking and the Barnum effect", *Journal of Behavior Therapy and Experimental Psychiatry*, Vol.42 No.2, pp.145–148.

Mittal, S. K. (2019), "Behavior biases and investment decision: theoretical and research framework", *Qualitative Research in Financial Markets*, Vol. 14 No. 2, pp. 213-228.

Michenaud, S., and Solnik, B. (2008), "Applying regret theory to investment choices: Currency hedging decisions", *Journal of International Money and Finance*, Vol.27 No.5, pp.677-694.

Muermann, A., and Wise, J. V. (2011), "Regret, Pride, and the Disposition Effect. *SSRN Electronic Journal"*, 1-26 https://doi.org/10.2139/ssrn.930675

Muradoglu, G., and Harvey, N. (2012), "Behavioural finance: the role of psychological factors in financial decisions", *Review of Behavioral Finance*, Vol.*4* No.2, pp.68–80.

Nofsinger, J. R., and Sias, R. W. (1999), "Herding and feedback trading by institutional and individual investors", *Journal of Finance*, Vol.54 No.6, pp.2263-2295.

Novianggie, V., and Asandimitra, N. (2019), "The Influence of Behavioral Bias, Cognitive Bias, and Emotional Bias on Investment Decision for College Students with Financial Literacy as the Moderating Variable", *International Journal of Academic Research in Accounting, Finance and Management Sciences*, Vol.9 No.2, pp.92-107.

Paisarn, W., Chancharat, N., and Chancharat, S. (2021), "Factors Influencing Retail Investors' Trading Behaviour in the Thai Stock Market", *Australasian Accounting, Business and Finance Journal*, Vol.15 No.2, pp.26-37.

Pandey, R., and Jessica, V. M. (2018), "Measuring behavioural biases affecting real estate investment decisions in India: using IRT", *International Journal of Housing Markets and Analysis*, Vol.11 No.4, pp.648–668.

Parhi, S. P., and Pal, M. K. (2021), "Impact of overconfidence bias in stock trading approach: a

study of high net worth individual (HNI) stock investors in India", *Benchmarking-an International Journal*, Vol. 29 No. 3, pp. 817-834.

Park, J., Konana, P., Gu, B., Kumar, A., and Raghunathan, R. (2010), "Confirmation bias, overconfidence, and investment performance: Evidence from stock message boards", *McCombs Research Paper Series No. IROM-07-10, 1-59*.

Parveen, S., Satti, Z. W., Subhan, Q. A., and Jamil, S. (2020), "Exploring market overreaction, investors' sentiments and investment decisions in an emerging stock market", *Borsa Istanbul Review*, Vol.20 No.3, pp.224-235.

Quaicoe, A., and Eleke-Aboagye, P. Q. (2021), "Behavioral factors affecting investment decision-making in bank stocks on the Ghana stock exchange", *Qualitative Research in Financial Markets*, Vol.13 No.4, pp.425-439.

Rasheed, M. H., Rafique, A., Zahid, T., and Akhtar, M. W. (2018), "Factors influencing investor's decision making in Pakistan: Moderating the role of locus of control", *Review of Behavioral Finance*, Vol.10 No.1, pp.70–87.

Ritter, J. R. (2003), "Differences between European and American IPO Markets", *European Financial Management*, Vol.9 No.4, pp.421-434.

Rizzi, J. V. (2011), "Behavioral Basis of the Financial Crisis. In *Lessons from the Financial Crisis: Causes, Consequences, and Our Economic Future*, Vol.18 No.2, pp.113

Sadi, R., Asl, H. G., Rostami, M. R., Gholipour, A., and Gholipour, F. (2011), "Behavioral Finance: The Explanation of Investors' Personality and Perceptual Biases Effects on Financial Decisions", *International Journal of Economics and Finance*, Vol.3 No.5, pp.234-241.

Sharma, S. K., Al-Badi, A., Rana, N. P., and Al-Azizi, L. (2018), "Mobile applications in government services (mG-App) from user's perspectives: A predictive modelling approach", *Government Information Quarterly*, Vol.35 No.4, pp.557–568.

Sharma, A. (2019), "Influence of behavioual bias on investment decisions of individual investors in Delhi Ncr", *Journal of Public Administration, Finance and Law*, Vol.16, pp.117-126.

Sharpe, W. F. (1964), "Capital asset prices: A theory of market equilibrium under conditions of risk", *The journal of finance*, Vol.19 No.3, pp.425-442.

Shiller, R. J. (2003), "From efficient markets theory to behavioral finance", *Journal of Economic Perspectives*, Vol.17 No.1, pp.83-104.

Singh, J. E., Babshetti, V., and Shivaprasad, H. N. (2021), "Efficient Market Hypothesis to Behavioral Finance: A Review of Rationality to Irrationality", *Materials Today: Proceedings*. https://doi.org/10.1016/j.matpr.2021.03.318

Saivasan, R. and Lokhande, M. (2022), "Influence of risk propensity, behavioural biases and demographic factors on equity investors' risk perception", *Asian Journal of Economics and Banking*, Vol. 6 No.3, pp. 373-403.

Talwar, S., Talwar, M., Tarjanne, V., and Dhir, A. (2021), "Why retail investors traded equity during the pandemic? An application of artificial neural networks to examine behavioral biases", *Psychology & Marketing*, Vol.38 No.11, pp.2142-2163.

Tan, W. H., Ooi, K. B., Leong, L. Y., and Lin, B. (2014), "Predicting the drivers of behavioral intention to use mobile learning: A hybrid SEM-neural networks approach", *Computers in Human Behavior*, Vol.36, pp.198–213.

Tavor, T. (2013), "Investors' short term decision making and review of the hindsight bias effect", *Mediterranean Journal of Social Sciences*, Vol.4 No.11, pp.176.

Tekce, B., Yilmaz, N., and Bildik, R. (2016), "What factors affect behavioral biases? Evidence from Turkish individual stock investors", *Research in International Business and Finance*, Vol.37, pp.515–526.

Thaler, R. H. (2008), "Mental accounting and consumer choice", *Marketing Science*, Vol.27 No.1, pp.177-266.

Trejos, C., van Deemen, A., Rodriguez, Y. E., and Gomez, J. M. (2019), "Overconfidence and disposition effect in the stock market: A micro world based setting", *Journal of Behavioral and Experimental Finance*, Vol.21, pp.61–69.

Trueman, B. (1994), "Analyst Forecasts and Herding Behavior, "*Review of Financial Studies"*, Vol.7 No.1, 97-124.

Tversky, A., and Kahneman, D. (1981), "The framing of decisions and the psychology of choice", *Science*, Vol.211 No.4481, 25-41.

Waweru, N. M., Munyoki, E., and Uliana, E. (2008), "The effects of behavioural factors in investment decision-making: a survey of institutional investors operating at the Nairobi Stock Exchange", *International Journal of Business and Emerging Markets*, Vol.1 No.1, pp.24-41.

Wang, Y.M. and Elhag, T. (2007), "A comparison of neural network, evidential reasoning and multipleregressionanalysisinmodellingbridgerisks", *Expert Systems with Applications*, Vol.32 No.2,pp.336-348

Xiong, L., Wang, H., and Wang, C. (2022), "Predicting mobile government service continuance: A two-stage structural equation modeling-artificial neural network approach", *Government Information Quarterly*, Vol.39 No.1, pp.101654.

Zahera, S. A., and Bansal, R. (2018), "Do investors exhibit behavioral biases in investment decision making? A systematic review", *Qualitative Research in Financial Markets*,

Vol.10 No.2, 210–251.

Zat, M., and Khan, U. (2017), "Impact Of Availability Bias And Loss Aversion Bias On Investment Decision Making, Moderating Role Of Risk Perception", *IMPACT: Journal of Modern Developments in General Management & Administration (IMPACT: JMDGMA)*, Vol.1 No.1, pp.17-28.