Heuristic Bias and Herding Behavior for Predicting Investor Decision in Cryptocurrency Trading

Bambang Leo Handoko[1*] ![ID], Mohammad Hamsal[1] ![ID], Arta Moro Sundjaja[2] ![ID], Willy Gunadi[2] ![ID]

[1] Management Department, Binus Business School, Doctor of Research in Management, Bina Nusantara University, Jakarta 11480, Indonesia
[2] Management Department, Binus Business School, Master Program, Bina Nusantara University, Jakarta 11480, Indonesia

Corresponding Author Email: bambang.handoko@binus.ac.id

ABSTRACT

In the age of Business 4.0, cryptocurrencies have emerged as a popular alternative investment vehicle. Despite significant risks, they offer attractive perks. Poor decision-making can lead to investment losses, prompting this study to explore factors influencing cryptocurrency investment decisions. Using a quantitative methodology, data was collected from 106 respondents through questionnaires on popular bitcoin brokerage forums. The analysis employed structural equation modeling partial least squares with Smart PLS 4 software. Multiple group analysis was conducted based on investment experience (less than two years vs. more than two years). The results show that risk tolerance significantly affects investment decisions in cryptocurrency. For respondents with over two years of experience, heuristic bias impacts both risk tolerance and investment decisions, while herding behavior only affects risk tolerance. For those with less than two years of experience, heuristic bias influences investment decisions but not risk tolerance, and herding behavior has no significant effect on either.

1. INTRODUCTION

Industry 4.0 has penetrated all sectors, including investment. If people previously invested in capital markets, such as shares, virtual currency, namely cryptocurrency, has become a new choice for investing [1]. Cryptocurrency as an investment instrument in the Industrial Revolution 4.0 era [2]. The highly fluctuating value of cryptocurrency is an opportunity for investors to gain profits in the form of capital gains, which is the difference between the increase in the market price of Crypto sold and the price obtained when purchasing [1]. Many investors experience profits in the form of large capital gains when, for example, investing in Bitcoin [3]. Bitcoin, the cryptocurrency with the highest value and the largest market capitalization in the world, has experienced drastic fluctuations in value. At the end of 2015, one Bitcoin was less than IDR 6 million. In September 2021, it reached IDR 900 million, and currently, it is in the range of IDR 400 million [4]. However, apart from many investors who gain profits, many investors experience losses when investing in this cryptocurrency. Many of them bought Crypto, then went down, sold at a loss, and then went up. Or there may even be a crypto crash, where crypto prices suddenly fall like Terra Luna in 2022 [5].

Investors are often biased in making trading decisions to buy or sell investment instruments. One cause is heuristic bias. Heuristic bias often appears when investors receive too much information and do not have time to process the information [6]. Information about cryptocurrency can be quickly and easily accessed by investors via cryptocurrency trading mobile phone applications, which provide real-time data regarding price movements for each cryptocurrency listed, as well as news on the internet [7]. This is what can make the information obtained biased. Apart from heuristic bias, another indication that causes errors in making investment decisions by investors is herding. Herding behavior is irrational investor behavior, because investors base their investment decisions not on the economic fundamentals of a risky asset, but by looking at the actions of other investors in the same situation or following market consensus.

Behavioral finance in the context of cryptocurrency investment shows that heuristic bias and herding behavior greatly influence investor decisions, especially due to fast access to information and extreme price fluctuations, compared to stock trading. Heuristic bias occurs when investors rely on rules of thumb or popular information without in-depth analysis, while herding behavior occurs when investors follow the actions of the majority without considering fundamental data. According to Xin et al. [8] experienced investors are better able to control these biases through better risk evaluation and learning from past mistakes, whereas novice investors are more susceptible to both of these biases due to a lack of knowledge and tend to react based on emotions or social pressure.

Previous research has discussed a lot about heuristic bias and herding behavior in stock trading as in previous studies [1, 9] but studies examining how these biases influence investment decisions in cryptocurrency are still limited.

Additionally, the impact of investment experience on investors' ability to overcome these biases has not been widely studied in the context of cryptocurrencies.

This research will specifically examine how heuristic bias and herding behavior influence investment decisions in cryptocurrency, as well as exploring the role of investment experience in reducing the negative impact of these biases. This research will provide new insights into the psychological dynamics in the highly volatile and rapidly changing cryptocurrency market.

The aim of this research is to identify and analyze how heuristic bias and herding behavior influence investment decisions in cryptocurrency. Additionally, this research aims to understand how investment experience influences investors' ability to overcome these biases and make more rational investment decisions.

This research will benefit individual investors by providing insight into the psychological biases that may influence their decisions in cryptocurrency investments. Additionally, the results of this research can be used by financial educators and trading platform providers to develop educational strategies and tools that help investors recognize and reduce the impact of bias in their investment decisions.

2. LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

2.1 Integration herding behavior and heuristic bias in the context of cryptocurrency

Behavioral finance is a field of study that combines psychology with economics to understand how human behavior and biases influence financial decisions. One of the important concepts in behavioral finance is herding behavior, which is the tendency of individuals to follow the actions of the majority. Introduced by Schumpeter and Keynes [10], herding behavior can be seen in various aspects of life, such as consumer habits, social trends and investment decisions. Herding behavior in the context of cryptocurrency investment often occurs when investors follow the actions of the majority, such as buying or selling digital assets [11], often based influencer or other investors' decisions, rather than based on personal or fundamental analysis of the asset [12].

Apart from herding behavior, heuristic bias also plays an important role in investment decisions. Heuristics are rules of thumb or mental strategies that individuals use to simplify complex decision making [13]. In general, heuristic bias can lead individuals to make quick and efficient decisions, but often ignore important information or produce incorrect conclusions [14]. In cryptocurrency investments, heuristic bias can appear in the form of excessive reliance on easily accessible or recently acquired information, as well as a tendency to rely too much on personal experience or intuition [15].

Herding behavior and bias heuristics have their respective shortcomings in influencing investment decisions. Preliminary research that combines the two in a different context, namely in Chinese stock market investment [16, 17]. Also in the context of Islamic Investor in real and financial market [18]. Herding behavior does not take into account individual analysis and can result in investors following others decision that are not always rational or profitable [19]. On the other hand, heuristic bias can lead to decisions based on limited information or incorrect interpretations, ignoring important factors that should be considered [20].

Combining herding behavior and heuristic bias in investment decision analysis allows for a more comprehensive understanding of investor behavior. By considering these two factors, analysis can capture the various psychological dynamics that influence investment decisions, thereby providing more complete and in-depth insight. This is important for formulating more effective strategies and reducing risks associated with investor behavior and bias.

2.2 Importance of investor experience in investment decision

The importance of investor experience in investment decisions, especially in the context of cryptocurrencies, cannot be ignored. Experience allows the investor to analyze trading data more effectively, using tools such as candlesticks and charts to identify significant trends and patterns. They are better able to understand technical indicators and market signals, so they can make more informed and strategic decisions [21]. In contrast, investors with less experience tend to be more influenced by heuristic bias and herding behavior, which can lead to less-than-optimal decisions [22]. Therefore, we divided investors into two groups based on their experience: above two years and below two years, to assess the impact of experience on investment decision-making ability.

Experienced investors can utilize oversold and overbought signals to buy and sell Bitcoin and Ethereum more effectively [23]. These findings suggest that a deep understanding of technical analysis tools and the ability to use big data visualization are critical for experienced investors to increase profitability and make better investment decisions.

2.3 Heuristic bias

Investors often simplify the process of making investment decisions using possible heuristic behavior, which causes systematic errors in judgment and leads to poor investment choices that are satisfying but do not have maximum utility value. Some behavioral heuristics that are used by investors to reduce the risk of loss in uncertain situations include overconfidence, anchoring and adjustment, availability, and representativeness [24-26]. Investor use technical analysis to do price prediction [27]. When individual investors use heuristic biases, they reduce mental effort in the retrieval process decisions that lead to errors in judgment, and the consequences of investors' errors can cause the market to become inefficient.

Cryptocurrencies such as Bitcoin and others (altcoins) have high fluctuations, and they occur in very fast periods. In less than a day, the price of a cryptocurrency can change drastically compared to the local currency. This is what makes heuristic behavior greatly influence online cryptocurrency trading decisions. Research conducted by Ahmad and Shah [28] found results that availability bias has a negative and significant relationship to investment decisions, which means investors cannot choose appropriate investment opportunities or they make judgment errors, causing loss of potential profits and reducing market efficiency. Research conducted by Khan et al. [24], Dangol and Manandhar [25], and Siraji [29] reveals that heuristic bias has a significant influence on investment decisions, with heuristic bias being the strongest predictor in decisions taken by decision makers according to Siraji [29].

However, the results of research by Ikram [30] show different results, namely that availability bias, as part of the heuristic bias, does not have a significant influence on investment decisions. On the other hand, research by Xia and Madni [16] and Kasoga [14] found that heuristic bias has a significant effect on risk tolerance, and that risk tolerance then has a significant influence on investment decisions [31]. These findings suggest that although heuristic bias is generally considered a major factor influencing investment decisions, its components such as availability bias may not always have a direct influence. Conversely, heuristic bias can influence investment decisions indirectly through increasing or decreasing risk tolerance. According to those definitions and previous studies results, we formulate our first hypothesis as follows:

H1: Heuristic bias has a significant effect on investor decisions in cryptocurrency trading.

H2: Heuristic bias has a significant effect on risk tolerance.

2.4 Herding behavior

When the value of a crypto coin increases, we will see investors flocking to buy the crypto coin. This is an example of behavior that, in the investment world, is called herding behavior [32]. Herding behavior, often called herd instinct, is a phenomenon where investors follow what they think other investors are doing, rather than their own analysis. In other words, investors who exhibit a herd instinct will gravitate towards the same or similar investments [33]. This is because many other people are buying these crypto coins. The need for quick decision-making can put investors in a vulnerable situation. Thus, they sometimes make themselves feel safer by following the decision of the majority.

Preliminary research conducted by Xia and Madni [16], Kimeu et al. [34], and Waweru et al. [35] found that herding behavior had a significant effect on investment decisions. Meanwhile, other research from Ah Mand et al. [36] states the opposite, namely that herding has no significant effect. Research by Ahmad and Wu [37] found that herding influenced investment but in a negative direction. In the study of Lin et al. [38], it was found that herding behavior also has a significant influence on risk tolerance, and risk tolerance was able to mediate herding to investment decisions. This is a contradiction of the results of previous research. Based on this understanding and preliminary research, we formulate the following hypothesis:

H3: Herding behavior has a significant effect on risk tolerance.

H4: Herding behavior has a significant effect on investor decisions in cryptocurrency trading.

2.5 Risk tolerance

Risk tolerance in investing in cryptocurrency is very necessary, this is because in investing in cryptocurrency investors must determine the extent of risk, they are willing to bear [39]. For example, if the coin purchased experiences a decline in market price, then to know what number the investor will cut the loss to avoid large losses.

Risk tolerance is the extent of an investor's ability to accept taking a risk investment [40]. Investors will expect a return on the chosen risk, but not before investors choose in advance what investment to choose according to their goals. In addition, the amount of funds invested will depend on the investor's

tolerance for risk [39]. Risk theoretical tolerance will influence an investment decision. With a high-risk tolerance, A person will tend to make bolder decisions compared to someone with a low level of risk tolerance. Research on risk tolerance is also strengthened by Salman et al. [31], Adielyani and Mawardi [41], which states that risk tolerance has a positive effect on investment decisions, but in contrast, Septi et al. [40] found that risk tolerance has a negative effect on investment decisions. Based on opinions and results from previous research, we formulate the following hypothesis:

H5: Risk tolerance has a significant effect on investor decisions in cryptocurrency trading.

H6: Risk tolerance is able to mediate the effect of heuristic bias on investor decisions in cryptocurrency trading.

H7: Risk tolerance is able to mediate the effect of herding behavior on investor decisions in cryptocurrency trading.
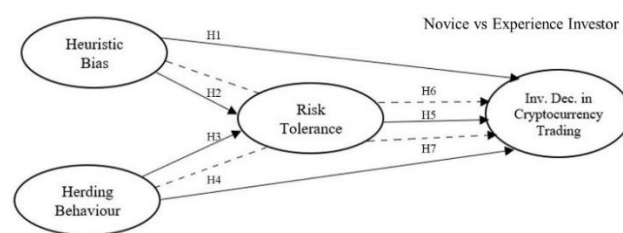
Model is presented in Figure 1.

Figure 1. Research model

3. RESEARCH METHODOLOGY

3.1 Research method and sample respondents

The type of our research is quantitative. In quantitative research, statistical tests are performed to evaluate the hypothesis. We conducted the structural equation modeling partial least squares (SEM PLS) test using the SMART PLS program. We use Multiple Group Analysis (MGA), which compares two groups of our respondents. The first group is respondents who have investment experience of less than two years; the second one is respondents who have investment experience of more than 2 years. In this article, we use primary data. The definition of primary data refers to the fundamental or core knowledge used in research. Any information that is directly obtained from the original source, such as through interviews, surveys, tests, and so on, is referred to as primary data [42]. Primary data is often always particular, mostly because it is customized to the needs of researchers. The respondents of our survey are cryptocurrency investors who frequently participate in popular cryptocurrency forums such as Bitcointalk, Reddit, Altcoin stalks, and Bitcoin Garden.

The population type in this research is an unknown population. This is because it is difficult to predict with certainty how many cryptocurrency investors are in Indonesia. This is also because an increasing number of investors sign up for cryptocurrency brokers every day. Due to this, we use the methods G-Power from Mayr et al. [43], G-Power analysis is a powerful freeware program for sample size determination in digital transformation research. The researcher used it for the sample size determination method because it can control the type 1 error probability and type 2 error probability [43]. Previous research as in the study of Ter Ji-Xi et al. [44] also used G-Power in cryptocurrency research for sample size.

Using G-Power sample we got proper number of minimum samples of 80 respondents. Then, the sample size for our study, which was 106 respondents, was an appropriate amount. We use a non-probability convenience sample method to choose our respondents and participants. The members' invites to participate were promoted via electronic forum posting, chat, and links to an e-questionnaire.

The procedure of data analysis in this research begins by carrying out confirmatory factor analysis (CFA) to test the quality of the data before conducting hypothesis testing. CFA is carried out through several stages, including convergent and discriminant validity tests to ensure that the constructs measured are valid and different from each other. In addition, composite reliability and Cronbach's alpha tests were used to measure the internal consistency of the constructs used in the research [45]. After the quality of the data is confirmed through CFA, the next step is to carry out hypothesis testing to evaluate the relationship between the variables studied.

3.2 Operation of variable

Our research is quantitative research, where the constructs in our research are adjectives. For this reason, we use operationalization variables, so that the construct can be measured.

Heuristic bias in the context of cryptocurrency investment refers to an investor's tendency to make decisions based on rules of thumb or intuition, rather than in-depth and rational analysis. This bias often arises due to the high complexity of the cryptocurrency market and its extreme volatility [46]. We compiled indicators of variable of heuristic bias from Al-Mansour [47] and Kasoga [14]. Investors may rely too heavily on historical patterns or popular trends without considering deeper fundamental factors [29].

Herding behavior in the context of cryptocurrency investment refers to the tendency of investors to follow the actions of the majority or crowd without conducting independent analysis [38]. We compiled herding behavior variable from the previous studies in the studies of Sood et al. [48], and Haryanto et al. [49]. This phenomenon often occurs in the cryptocurrency market which is highly influenced by sentiment and media hype.

Risk tolerance in the context of cryptocurrency investment refers to the extent to which an investor is willing to face fluctuations in the value of digital assets and potential losses [50]. Risk tolerance assessment involves evaluating personal finances, investment goals, and emotional reactions to market changes [51]. We complied risk tolerance variable based on previous studies in the studies of Doblas et al. [52], and Murugappan et al. [53]. By knowing the limits of acceptable risk, investors can make wiser decisions and avoid impulsive actions that can result in significant losses [54].

Investor decisions in cryptocurrency trading are influenced by various factors, including market analysis, risk tolerance, and investment goals. Experienced investors often use a combination of fundamental and technical analysis to determine when to buy or sell digital assets [55]. We compiled investment decision variable indicators based on research by Abdeldayem and Aldulaimi [20], and Kaur et al. [33]. Decisions in cryptocurrency trading are the result of complex interactions between internal and external factors that require vigilance and in-depth knowledge.

4. RESULT AND DISCUSSION

4.1 Demographic of respondents

We collected data by distributing questionnaires and getting answers from 105 respondents. We present data on the demographic distribution of our respondents in Table 1.

Based on the data we present in Table 1, it can be concluded that most of our respondents are female with ages between 21-30 years, profession as student and employee. While for investment experience, which we will divide into two groups, we have 65 respondents in total with experience for less than 2 years, and 40 respondents with experience more than 2 years.

Table 1. Demographic of respondents

Gender	Amount	Profession	Amount
Male	43	Student	57
Female	62	Employee	33
Age		Entrepreneur	9
21 – 30 years	70	Professional	6
31 – 40 years	27	Investment Experience	
41 – 50 years	5	0 – 2 years	65
> 51 years	3	> 2 years	40

4.2 Confirmatory factor analysis

Confirmatory Factor Analysis (CFA) is a statistical technique used to test the extent to which empirical data conforms to a hypothesized factor structure, with the aim of confirming or validating a previously determined measurement model. In this research we used the outer loading test, reliability test using Cronbach' alpha and composite reliability, convergent and discriminant validity tests. The results of confirmatory factor analysis are presented in Table 2.

Based on the results of outer loading test presented in Table 2, we can conclude that all outer loading of overall indicators have value more than 0.5, which we can consider as able to represent the variable.

Convergent validity is applied to evaluate each link between indicators and constructs or latent variables. Convergent validity occurs when there is a significant correlation between the findings from two different instruments measuring the same construct [56]. In this study, the Average Variance Extracted value describes convergent validity. If the AVE value exceeds 0.5, it is regarded as valid. Each variable, as shown in Table 2, has an AVE value greater than 0.5.

The reliability test evaluates how closely measurement outcomes using the same object will yield the same data, according to Sekaran and Bougie [57]. On a total of 106 respondents who were cryptocurrency investors, the reliability test was carried out using the questions that were determined to be valid in the validity test. Latent variables are considered as trustworthy if both Cronbach's alpha and the composite reliability score are more than 0.6. Table 2 shows the results.

Cronbach's Alpha and composite reliability of less than 0.6 are regarded as poor, according to Atif Sattar et al. [58]. As shown in Table 2, all variables in this model passed the reliability test since Cronbach's alpha and composite reliability all above 0.6, which indicates that they are suitable and passed the reliability test.

Table 2. Confirmatory factor analysis

Variable	Question	Loading	CA	CR	AVE
	Investor Decision in Cryptocurrency (IDC)		0.849	0.898	0.689
IDC.1	Rate of return	0.816			
IDC.2	Risk aversion	0.877			
IDC.3	Instrument selection	0.843			
IDC.4	Cryptocurrency choice	0.782			
	Risk Tolerance (RT)		0.782	0.864	0.622
RT.1	Risk as related to knowledge	0.712			
RT.2	Risk as level of comfort	0.744			
RT.3	Probability of gain or loss	0.882			
RT.4	Amount of potential gain or loss	0.719			
	Heuristic Bias (HB)		0.848	0.882	0.687
HB.1	Confidence in profit	0.690			
HB.2	Confidence in investment capabilities	0.771			
HB.3	Confidence in accuracy of prediction	0.771			
HB.4	Belief in specific boundaries in term of numbers	0.797			
HB.5	Probability of momentum	0.599			
HB.6	Knowledge that is already available	0.583			
HB.7	Sample bias	0.611			
HB.8	Prediction bias	0.722			
	Herding Behaviour (HE)		0.714	0.730	0.623
HE.1	Reputable person in cryptocurrency	0.712			
HE.2	Follow another person that can be trust	0.744			
HE.3	Abandonment of personal analysis	0.882			
HE.4	Neglect of information held	0.779			

4.3 Discriminant validity

Testing the discriminant validity using Heterotrait-monotrait Ratio of Correlations (HTMT), the first step is to calculate HTMT for each pair of constructs in the model. HTMT is the ratio between the correlation between two constructs and the square root of the product of the correlation between that construct and another construct in the model that is not the same as the pair being tested. If HTMT is smaller than 0.9, it can be concluded that there is discriminant validity between the constructs [59]. However, if the HTMT is greater than 0.9, then there is an indication that the construct may not have adequate discriminant validity. We present the discriminant validity test in Table 3.

Table 3. Discriminant validity using HTMT

	HB	HE	IDC	RT
HB				
HE	0.828			
IDC	0.806	0.741		
RT	0.897	0.842	0.788	

All variables in this study passed the discriminant validity test, as shown by Table 3, where the HTMT value is less than 0.900. We can conclude that the constructs in the model are quite different from each other and not highly correlated, thus confirming that they measure different concepts.

4.4 Coefficient of determination

A test called the Coefficient of Determination Test is used to figure out how much variation of the dependent variable the independent variable can explain. The coefficient of determination test may also be used to assess how well the regression line we have worked. If the coefficient value determination or R-square adjusted in an estimate is close to

one, it may be stated that the dependent variable is sufficiently explained by the independent variables [59]. The adjusted R-Square for this study was 0.676, or 67.6%, for the impact of heuristic bias and herding behaviour on risk tolerance, and 0.548, or 54.8%, for the impact of risk tolerance to investor decisions in cryptocurrency trading, as shown in Table 4.

This Table 4 results show that we have a proper model, since both of adjusted R Square have values more than 50%. It indicates that most factors that influence the endogenous variable can be explained properly in this model.

Table 4. Coefficient of determination

	R Square	R Square Adjusted
Investor Decision in Cryptocurrency Trading	0.686	0.676
Risk Tolerance	0.548	0.539

4.5 Hypothesis testing

A population's characteristics can be inferred from data obtained from a sample of that population using inferential statistics, which also involves hypothesis testing. The p value serves as the foundation for the hypothesis test in this study, which compares the t table and t arithmetic. If the t statistic is higher than the t table and the p value is less than 0.05, the alternative hypothesis is accepted. We use multiple group analysis, divided two groups of respondents, novice investor is for respondents' group that has investment experience less than two years, while experienced investor is for respondent group that has investment experience more than two years. Table 5 links the hypothesis testing for this research.

If we look at Table 5, The comparative analysis of novice and experienced investors reveals notable differences in the impact of heuristic bias and herding behaviour on cryptocurrency investment decisions.

Table 5. Hypothesis testing comparison between novice and experienced investor

Hypothesis	Novice Investor (N)				Experienced Investor (E)				Comparison
	OS	T-Stat	P-Value	f^2	OS	T-Stat	P-Value	f^2	
HB → IDC	0.196	1.124	0.261	0.036	0.309	2.249	0.025	0.200	N < E
HB → RT	0.771	7.414	0.000	0.852	0.327	1.987	0.047	0.135	N > E
HE → IDC	0.056	0.473	0.728	0.005	-0.200	0.937	0.349	0.075	N = E
HE → RT	0.035	0.347	0.636	0.002	0.457	3.214	0.001	0.263	N < E
RT → IDC	0.632	4.969	0.000	0.479	0.767	6.956	0.000	1.109	N < E
HB → RT → IDC		3.056	0.002			4.486	0.000		N < E
HE → RT → IDC		2.992	0.003			3.128	0.001		N < E

HB: Heuristic Bias, HE: Herding Behaviour, RT: Risk Tolerance, IDC: Investor Decision in Cryptocurrency Trading

For novice investors, heuristic bias (HB) does not significantly impact investment decisions in cryptocurrency (IDC) directly, with an OS of 0.196, T-stat of 1.124, and P-value of 0.261. However, for experienced investors, heuristic bias has a significant direct effect on investment decisions (OS: 0.309, T-stat: 2.249, P-value: 0.025), indicating a stronger direct influence (N < E). When examining the impact of heuristic bias on risk tolerance (RT), novice investors show a significant effect (OS: 0.771, T-stat: 7.414, P-value: 0.000) compared to experienced investors (OS: 0.327, T-stat: 1.987, P-value: 0.047), indicating that heuristic bias influences risk tolerance more in novice investors (N > E).

Herding behaviour (HE) does not significantly affect investment decisions directly in either novice (OS: 0.056, T-stat: 0.473, P-value: 0.728) or experienced investors (OS: -0.200, T-stat: 0.937, P-value: 0.349), showing no substantial difference between the two groups (N = E). However, herding behaviour significantly impacts risk tolerance in experienced investors (OS: 0.457, T-stat: 3.214, P-value: 0.001) but not in novices (OS: 0.035, T-stat: 0.347, P-value: 0.636), indicating a stronger effect in the experienced group (N < E).

Risk tolerance itself significantly affects investment decisions for both novice (OS: 0.632, T-stat: 4.969, P-value: 0.000) and experienced investors (OS: 0.767, T-stat: 6.956, P-value: 0.000), with a more substantial influence in experienced investors (N < E).

The mediation effects of risk tolerance between heuristic bias and investment decisions, and between herding behaviour and investment decisions, are also stronger in experienced investors. The Sobel test for the mediating effect of heuristic bias through risk tolerance on investment decisions shows a T-stat of 3.056 (P-value: 0.002) for novices and a T-stat of 4.486 (P-value: 0.000) for experienced investors, indicating a stronger mediation effect in the latter group (N < E). Similarly, the mediation effect of herding behaviour through risk tolerance on investment decisions has a T-stat of 2.992 (P-value: 0.003) for novices and a T-stat of 3.128 (P-value: 0.001) for experienced investors, again showing a stronger mediation effect for experienced investors (N < E).

In summary, heuristic bias directly affects investment decisions only in experienced investors, while herding behaviour directly affects investment decisions through risk tolerance in both groups, with a stronger mediation effect in experienced investors. Risk tolerance plays a crucial role in mediating these relationships, with a more pronounced impact in those with greater investment experience.

4.6 Discussion

The findings of this multi group analysis offer valuable insights into the differential impacts of heuristic bias and herding behaviour on cryptocurrency investment decisions, particularly when segmented by respondents' investment experience. For individuals with less than two years of cryptocurrency investment experience, the analysis reveals that only hypotheses 2, heuristic bias positively affects investment decision and hypothesis 5 risk tolerance positively affect investment decision. This result support previous studies [14, 60]. Heuristic bias is important because it allows quick, simple decisions to be made and are influenced by herding behaviour or the actions of other investors. Trend analysis also has a positive impact by helping to identify price movement patterns, reduce risk, and optimize profits. For investors with less than two years of experience, the use of bias heuristics combined with trend analysis can result in more informed and profitable decisions. Notably, heuristic bias demonstrates a considerable influence on risk tolerance, yet lacks a direct effect on investment decisions. Similarly, herding behaviour fails to directly impact either risk tolerance or investment decisions but indirectly influences them through the mediating variable of risk tolerance. Opposite the previous studies [33, 61] which show direct significant result. These results suggest that novice investors may exhibit altered risk perceptions due to heuristic biases and herding behaviour [58], which in turn shape their investment decisions within the cryptocurrency market.

In contrast, the examination of respondents with more than two years of investment experience reveals a distinct pattern of influence. Here, heuristic bias directly affects both risk tolerance and investment decisions, underscoring its enduring impact on seasoned investors' decision-making processes. This result is supported by previous studies [14, 28]. Experienced investors can analyse trading data using candlesticks and charts to make better investment decisions than novice investors. They understand candlestick patterns and formations that provide signals about trend reversal or continuation. Additionally, they are able to interpret technical indicators to assess market momentum and trend strength. With these skills, experienced investors can identify investment opportunities more accurately and make more informed decisions, reducing risks and maximizing profits

Meanwhile, herding behaviour manifests a significant effect on risk tolerance, as in line with the studies of Gautam and Kumar [62] and Kaur et al. [33], but does not directly influence investment decisions. This result opposite previous study [61]. Nevertheless, risk tolerance plays a crucial mediating role, significantly influencing cryptocurrency investment decisions as demonstrated by previous research [63, 64]. This underscores the lasting importance of risk attitudes in shaping investment behaviour, regardless of investors' experience levels. In the highly volatile and speculative market of cryptocurrencies, understanding an investor's risk tolerance becomes even more critical. It helps in predicting their likelihood to invest and sustaining their investments during

market fluctuations. Thus, regardless of whether an investor is a novice or an experienced trader, their risk tolerance fundamentally guides their decisions, making it a key factor in the broader landscape of cryptocurrency investment.

5. CONCLUSION

Practical implication for novice investors, leveraging heuristic biases and trend analysis can lead to quicker and simpler investment decisions, reducing risks and optimizing profits. Understanding basic technical analysis, such as candlestick patterns and market indicators, is crucial. Additionally, being aware of how biases and herding behavior influence risk perceptions can lead to more informed choices. Conversely, experienced investors should utilize advanced technical analysis techniques and implement sophisticated risk management strategies to enhance decision-making and profitability. Continuous learning and adapting to new tools and market trends, along with maintaining awareness of behavioral influences, are essential for both novice and experienced investors.

Going forward, investors and practitioners must adapt their approaches to take these nuances into account, thereby reducing the impact of collective cognitive and behavioral biases on investment outcomes in the ever-evolving cryptocurrency landscape.

This research enriches the theoretical understanding of heuristic bias and herding behavior in cryptocurrency trading by extending behavioral finance theory to this new field. It highlights the differential impact of these biases based on an investor's level of experience and identifies risk tolerance as a key mediator. This study provides insight into how market-specific factors such as volatility interact with psychological biases, contributing to a comprehensive understanding of investor behavior. These findings also have practical implications for financial educators and trading platform providers to develop strategies that help investors recognize and reduce bias for better decision making.

This study has several limitations. The sample size of 105 cryptocurrency investors, primarily students and employees aged 21-30, may not represent the broader investor population. The geographic focus on specific online forums might bias the sample towards tech-savvy investors. The cross-sectional design limits the ability to analyze changes over time and establish causal relationships. Self-reported data can introduce biases such as social desirability or recall bias. Additionally, the study does not account for other psychological factors influencing investment decisions, and the rapidly changing cryptocurrency market may quickly outdate the findings.

Several suggestions emerge from this study. Firstly, there is a need for continued research to deepen our understanding of the mechanisms through which heuristic biases and herding behaviors shape investment decisions in cryptocurrencies. Exploring additional factors, such as market sentiment and regulatory developments, could provide further insights into investor behavior dynamics.

ACKNOWLEDGMENT

REFERENCES

[1] Al-mansour, B.Y. (2020). Cryptocurrency market: Behavioral finance perspective. Journal of Asian Finance, Economics and Business, 7(12): 159-168. https://doi.org/10.13106/JAFEB.2020.VOL7.NO12.159

[2] Handoko, B.L., Marpaung, A.T., Ayuanda, N. (2021). Development of cryptocurrency in the indonesian economy. In ICEBA 2021: 2021 7th International Conference on E-Business and Applications, pp. 54-59. https://doi.org/10.1145/3457640.3457648

[3] Mattke, J., Maier, C., Reis, L., Weitzel, T., Maier, C., Reis, L. (2020). Bitcoin investment: A mixed methods study of investment motivations. European Journal of Information Systems, 30(3): 261-285. https://doi.org/10.1080/0960085X.2020.1787109

[4] Sadalia, I., Ilham, R.N., Khaddafi, M. (2021). Cryptocurrency risk determinant impact during COVID-19 pandemic moment: Emperical case from Indonesia. In Proceedings of the 6th Batusangkar International Conference, BIC 2021, Batusangkar-West Sumatra, Indonesia. https://doi.org/10.4108/eai.11-10-2021.2319582

[5] Briola, A., Vidal-Tomás, D., Wang, Y., Aste, T. (2022). Anatomy of a Stablecoin's failure: The Terra-Luna case. http://arxiv.org/abs/2207.13914

[6] Juwita, R., Dwianti, L., Mandang, J.Z., Yahya, M.S., Triadi, M.R. (2022). Investment decision of cryptocurrency in millennials and gen Z. In Proceedings of the International Conference on Applied Science and Technology Social Science 2022 (iCAST-SS 2022), pp. 725-731. https://doi.org/10.2991/978-2-494069-83-1_126

[7] Li, H., Dai, J., Gershberg, T., Vasarhelyi, M.A. (2018). Understanding usage and value of audit analytics for internal auditors: An organizational approach. International Journal of Accounting Information Systems, 28: 59-76. https://doi.org/10.1016/j.accinf.2017.12.005

[8] Xin, Z.Q., Wang, L.X., Li, Y. (2024). Differences in information processing between experienced investors and novices, and intervention in fund investment decision-making. Acta Psychologica Sinica, 56(6): 799-813. https://doi.org/10.3724/sp.j.1041.2024.00799

[9] Chishti, M.F., Bashir, R., Mancinelli, T., Hussain, R.T. (2023). Humanoid psychological sentiments and enigma of investment. Journal of Economic and Administrative Sciences, 39(4): 1260-1276. https://doi.org/10.1108/JEAS-05-2021-0100

[10] Schumpeter, J.A., Keynes, J.M. (1936). The general theory of employment, interest and money. Journal of the American Statistical Association, 31(196): 791-795. https://doi.org/10.2307/2278703

[11] Khanh, D., Hien, N., Danh, L. (2023). Impact of social media on cryptocurrency investing decisions – a behavioral finance perspective. Proceedings of the 8th World Conference on Media and Mass Communication, 7(1): 169-225. https://doi.org/10.17501/24246778.2023.7108

[12] Wanidwaranan, P., Termprasertsakul, S. (2023). Herd

behavior in cryptocurrency market: Evidence of network effect. Review of Behavioral Finance, 16(3): 406-423. https://doi.org/10.1108/RBF-03-2023-0079

[13] Tversky, A., Kahneman, D. (1974). Judgment under uncertainty: Heuristics and biases. Science, New Series, 185(4157): 1124-1131.

[14] Kasoga, P.S. (2021). Heuristic biases and investment decisions: multiple mediation mechanisms of risk tolerance and financial literacy—a survey at the Tanzania stock market. Journal of Money and Business, 1(2): 102-116. https://doi.org/10.1108/jmb-10-2021-0037

[15] Al-mansour, B.Y. (2020). Cryptocurrency market: Behavioral finance perspective. The Journal of Asian Finance, Economics and Business, 7(12): 159-168. https://doi.org/10.13106/JAFEB.2020.VOL7.NO12.159

[16] Xia, Y.Z., Madni, G.R. (2024). Unleashing the behavioral factors affecting the decision making of Chinese investors in stock markets. PLoS One, 19(2): 1-18. https://doi.org/10.1371/journal.pone.0298797

[17] Srinivasan, K., Karthikeyan, P. (2023). Investigating self-efficacy and behavioural bias on investment decisions. E&M Economics and Management, 26(4): 119-133. https://doi.org/10.15240/tul/001/2023-4-008

[18] Ramadhani, H., Masyita, D., Herwany, A., Faisal, Y.A. (2022). Individual Islamic investors' behavior on investment decisions: An empirical study from east Kalimantan province Indonesia. Iranian Economic Review, 28(2): 537-553. https://doi.org/10.22059/IER.2022.89059

[19] Kaiser, L., Stöckl, S. (2020). Cryptocurrencies: Herding and the transfer currency. Finance Research Letters, 33: 101214. https://doi.org/10.1016/j.frl.2019.06.012

[20] Abdeldayem, M., Aldulaimi, S. (2024). Investment decisions determinants in the GCC cryptocurrency market: A behavioural finance perspective. International Journal of Organizational Analysis, 32(6): 1073-1087. https://doi.org/10.1108/IJOA-02-2023-3623

[21] Hadan, H., Zhang-Kennedy, L., Nacke, L., Mäkelä, V. (2024). Gamification and gaming in cryptocurrency education: A survey with cryptocurrency investors and potential investors. Simulation & Gaming, 55(2): 196-223. https://doi.org/10.1177/10468781231223762

[22] Khalid, T., Al-Absy, M.S.M., Farooq, M.O. (2024). Factors affecting the trading performance of cryptocurrency investors in Bahrain. The AI Revolution: Driving Business Innovation and Research. Studies in Systems, Decision and Control, Cham: Springer Nature Switzerland, 437-451. https://doi.org/10.1007/978-3-031-54379-1_38

[23] Ni, Y., Chiang, P., Day, M.Y., Chen, Y. (2024). Using big data analytics and heatmap matrix visualization to enhance cryptocurrency trading decisions. Applied Sciences, 14(1): 154. https://doi.org/10.3390/app14010154

[24] Khan, H.H., Naz, I., Qureshi, F., Ghafoor, A. (2017). Heuristics and stock buying decision: Evidence from Malaysian and Pakistani stock markets. Borsa Istanbul Review, 17(2): 97-110. https://doi.org/10.1016/j.bir.2016.12.002

[25] Dangol, J., Manandhar, R. (2020). Impact of heuristics on investment decisions: The moderating role of locus of control. Journal of Business and Social Sciences Research, V(1): 1-14.

https://doi.org/10.3126/jbssr.v5i1.30195

[26] Shah, S.Z.A., Ahmad, M., Mahmood, F. (2018). Heuristic biases in investment decision-making and perceived market efficiency: A survey at the pakistan stock exchange. Qualitative Research in Financial Markets, 10(1): 85-110. https://doi.org/10.1108/QRFM-04-2017-0033

[27] Gollapalli, M., Rahman, A., Hakami, O., Alhashim, M., Arab, B., Almashharwai, F., Youldash, M., Saadeldeen, A., Alturkey, A., Alkhulaifi, D. (2023). Predictive modeling of NEAR cryptocurrency pricing using deep learning: Influence of Bitcoin market movements. Mathematical Modelling of Engineering Problems, 10(6): 2255-2264. https://doi.org/10.18280/mmep.100641

[28] Ahmad, M., 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, 38(1): 60-90. https://doi.org/10.1108/jeas-07-2020-0116

[29] Siraji, M. (2019). Heuristics bias and investment performance: Does age matter? Evidence from colombo stock exchange. Asian Journal of Economics, Business and Accounting, 12(4): 1-14. https://doi.org/10.9734/ajeba/2019/v12i430156

[30] Ikram, Z. (2016). An empirical investigation on behavioral determinantson, impact on investment decision making, moderating role of locus of control. Journal of Poverty, Investment and Development, 26: 44-50.

[31] Salman, M., Khan, B., Khan, S.Z., Khan, R.U. (2021). The impact of heuristic availability bias on investment decision-making: Moderated mediation model. Business Strategy and Development, 4(3): 246-257. https://doi.org/10.1002/bsd2.148

[32] Badlani, B., Yadav, R.A., Kumar, A. (2023). Psychological impact of cryptocurrency volatility on investor emotions and decision making. Journal for Re Attach Therapy and Developmental Diversities, 6(7s): 204-214. https://jrtdd.com/index.php/journal/article/view/784/550.

[33] Kaur, M., Jain, J., Sood, K. (2023). "All are investing in Crypto, I fear of being missed out": Examining the influence of herding, loss aversion, and overconfidence in the cryptocurrency market with the mediating effect of FOMO. Quality & Quantity, 58: 2237-2263. https://doi.org/10.1007/s11135-023-01739-z

[34] Kimeu, C.N., Anyango, W., Rotich, G. (2020). Behavioural factors influencing investment decisions among individual investors in Nairobi securities exchange. The Strategic Journal of Business & Change Management, 3(4): 253-264. https://doi.org/10.4324/9781315142876-21

[35] Waweru, N.M., Munyoki, E., 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, 1(1): 24-41. https://doi.org/10.1504/IJBEM.2008.019243

[36] Ah Mand, A., Janor, H., Abdul Rahim, R., Sarmidi, T. (2023). Herding behavior and stock market conditions. PSU Research Review, 7(2): 105-116. https://doi.org/10.1108/PRR-10-2020-0033

[37] Ahmad, M., Wu, Q. (2022). Does herding behavior

matter in investment management and perceived market efficiency? Evidence from an emerging market. Management Decision, 60(8): 2148-2173. https://doi.org/10.1108/MD-07-2020-0867

[38] Lin, W.T., Tsai, S.C., Lung, P.Y. (2013). Investors' herd behavior: Rational or irrational? Asia-Pacific Journal of Financial Studies, 42(5): 755-776. https://doi.org/10.1111/ajfs.12030

[39] Mubaraq, M.R., Anshori, M., Trihatmoko, H. (2021). The influence of financial knowledge and risk tolerance on investment decision making. Iurnal EKonomi Bisnis Clan Kewirausahaan, 10(2): 140. https://doi.org/10.26418/jebik.v10i2.47089

[40] Septi, N., Ainia, N., Lutfi, L. (2019). The influence of risk perception, risk tolerance, overconfidence, and loss aversion towards investment decision making. Journal of Economics, Business & Accountancy Ventura, 21(3): 401-413.

[41] Adielyani, D., Mawardi, W. (2020). The influence of overconfidence, herding behavior, and risk tolerance on stock investment decisions: The empirical study of millennial investors in semarang city. Jurnal Maksipreneur: Manajemen, Koperasi, Dan Entrepreneurship, 10(1): 89-101. https://doi.org/10.30588/jmp.v10i1.691

[42] Sekaran, U., Bougie, R. (2016). Research Methods for Business: A Skill Building Approach, 7th. John Wiley & Sons.

[43] Mayr, S., Buchner, A., Erdfelder, E., Faul, F., Universität, C.A. (2007). A short tutorial of GPower. Tutorials in Quantitative Methods for Psychology, 3(2): 51-59. https://doi.org/10.20982/tqmp.03.2.p051

[44] Ter Ji-Xi, J., Salamzadeh, Y., Teoh, A.P. (2021). Behavioral intention to use cryptocurrency in Malaysia: An empirical study. Bottom Line, 34(2): 170-197. https://doi.org/10.1108/BL-08-2020-0053

[45] Hair, J.F., Black, W.C., Babin, J.B., Anderson, R.E. (2014). Multivariate Data Analysis, 7th ed. Pearson New International Edition. https://doi.org/10.4324/9781351269360

[46] Samson, T.K., Onwukwe, C.E., Lawal, A.I. (2023). An examination of cryptocurrency volatility: Insights from skewed error innovation distributions within GARCH model frameworks. Mathematical Modelling of Engineering Problems, 10(4): 1297-1306. https://doi.org/10.18280/mmep.100423

[47] Al-Mansour, B.Y. (2020). Cryptocurrency market: behavioral finance perspective. The Journal of Asian Finance, Economics and Business, 7(12): 159-168. https://doi.org/10.13106/JAFEB.2020.VOL7.NO12.159

[48] Sood, K., Pathak, P., Jain, J., Gupta, S. (2023). Gauging investors' investment decisions in the crypto market through the PRISM of behavioral biases: A fuzzy AHP approach. International Journal of Emerging Markets, ahead-of-print. https://doi.org/10.1108/IJOEM-02-2022-0263

[49] Haryanto, S., Subroto, A., Ulpah, M. (2020). Disposition effect and herding behavior in the cryptocurrency market. Journal of Industrial and Business Economics, 47: 115-132. https://doi.org/10.1007/s40812-019-00130-0

[50] Gilliam, J., Chatterjee, S., Grable, J. (2010). Measuring the perception of financial risk tolerance: A tale of two measures. Journal of Financial Counseling and Planning, 21(2).

[51] Brunette, M., Jacob, J. (2019). Risk aversion, prudence and temperance: An experiment in gain and loss. Research in Economics, 73(2): 174-189. https://doi.org/10.1016/j.rie.2019.04.004

[52] Doblas, M.P., Becaro, J.M.G., Sankar, J.P., Natarajan, V.K., Yoganandham, G., Arumugasamy, G. (2024). Testing integrative models of the change behavior in the intention to adopt cryptocurrency. SAGE Open, 14(2): 1-13. https://doi.org/10.1177/21582440241253542

[53] Murugappan, M., Nair, R., Krishnan, S. (2023). Global market perceptions of cryptocurrency and the use of cryptocurrency by consumers: A pilot study. Journal of Theoretical and Applied Electronic Commerce Research, 18(4): 1955-1970. https://doi.org/10.3390/jtaer18040098

[54] Pompian, B.M.M. (2017). Pompian - 2017 - risk tolerance and behavioral finance. https://www.cfainstitute.org/-/media/documents/article/rf-brief/rfbr-v2-n1-1-pdf.ashx.

[55] Veerasingam, N., Teoh, A.P. (2023). Modeling cryptocurrency investment decision: Evidence from Islamic emerging market. Journal of Islamic Marketing, 14(7): 1817-1835. https://doi.org/10.1108/JIMA-07-2021-0234

[56] Hair, J.F., Risher, J.J., Sarstedt, M., Ringle, C.M. (2019). When to use and how to report the results of PLS-SEM. European Business Review, 31(1): 2-24. https://doi.org/10.1108/EBR-11-2018-0203

[57] Sekaran, U., Bougie, R. (2016). Research Methods for Business: A Skill Builing Approch, 7th Edition.

[58] Atif Sattar, M., Toseef, M., Fahad Sattar, M. (2020). Behavioral finance biases in investment decision making. International Journal of Accounting, Finance and Risk Management, 5(2): 69-75. https://doi.org/10.11648/j.ijafrm.20200502.11

[59] Ghozali, I. (2020). Partial least square concept techniques and applications using SMARTPLS 3 program for empirical research. Marketing Bulletin, 24(1): 1-32.

[60] Kala, D., Chaubey, D.S., Al-Adwan, A.S. (2023). Cryptocurrency investment behaviour of young Indians: Mediating role of fear of missing out. Global Knowledge, Memory and Communication, ahead-of-print. https://doi.org/10.1108/GKMC-07-2023-0237

[61] Rahyuda, H., Candradewi, M.R. (2023). Determinants of cryptocurrency investment decisions (study of students in Bali). Investment Management and Financial Innovations, 20(2): 193-204. https://doi.org/10.21511/imfi.20(2).2023.17

[62] Gautam, S., Kumar, P. (2023). Behavioral biases of investors in the cryptocurrency market. AIP Conference Proceedings, 2782(1): 20105. https://doi.org/10.1063/5.0154194

[63] Şenol, D., Onay, C. (2023). Impact of gamification on mitigating behavioral biases of investors. Journal of Behavioral and Experimental Finance, 37: 100772. https://doi.org/10.1016/j.jbef.2022.100772

[64] Ante, L., Fiedler, I., Von Meduna, M., Steinmetz, F. (2022). Individual cryptocurrency investors: Evidence from a population survey. International Journal of Innovation and Technology Management, 19(4): 1-24. https://doi.org/10.1142/S0219877022500080