



Moderation Study In the Influence of Neurotransmitters on Investment Bias in Female Investors in Indonesia

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ABSTRACT

Purpose of the study: This study aims to meticulously explore the moderating effect of financial literacy on the influence of neurotransmitters on investment bias. As a pioneering effort in behavioral finance, this research highlights cognitive and psychological aspects of investors, focusing specifically on female investors, and represents the first study to integrate financial literacy as a moderating variable in the context of neurotransmitter effects.

Methodology: A quantitative approach was employed, targeting female stock investors in Indonesia. Purposive sampling was used alongside a semantic differential scale. Data were collected through the distribution of closed-ended questionnaires, preceded by instrument testing and a pre-survey. A total of 581 respondents participated, and data were analyzed using Structural Equation Modeling (SEM)

Main Findings: The main findings reveal that financial literacy negatively affects investment bias, indicating that greater financial knowledge tends to reduce behavioral bias. However, even financially literate individuals may still exhibit bias. Furthermore, neurotransmitter activity shows a significant positive effect on investment bias, suggesting that biological factors amplify biased decision-making. Importantly, financial literacy significantly moderates this relationship in a negative direction, meaning that higher levels of financial understanding weaken the influence of neurotransmitters on investment bias.

Novelty/Originality of this study: This research contributes novel insights to the development of behavioral finance theory by introducing financial literacy as a moderating factor in the biological–psychological pathway influencing investment behavior. The practical implications highlight the critical role of financial education in reducing behavioral biases in investment decision-making, especially among female investors.

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1. INTRODUCTION

Gender is one of the factors that often influences a person's behavior in determining investment decisions [1], [2]. The narrative that women are often associated with irrational actions or prioritizing feelings over reason is an interesting topic to continue discussing, partly due to their increasing involvement in the investment world. The concrete role of female investors in Indonesia's investment world is strengthening as the number of investors and the value of their invested assets grows.

Statistical reports released by the Indonesian Central Securities Depository (KSEI) over the past five years show an annual increase in the number of investors and asset value. By 2024, women will account for 37.65% of total Indonesian capital market investors. Female investors' assets will total IDR 439.39 trillion (C-Best) and IDR 71.46 trillion (S-Invest), representing 30.3% of total investor assets, as shown in Table 1.

Table 1. Asset Value of Female Investors (Processed Data)

	2020	2021	2022	2023	2024
	Asset Value	Asset Value ↑	Asset Value ↑	Asset Value ↑	Asset Value ↑
C-Best				240.22	439.39
S-Invest				69.61	71.46
Total Assets	181.79	239.30	31.63%	295.63	23.54%
				309.83	4.80%
				510.85	64.88%

Source:[3]-[6]

In the world of investment, female and male investors have different characteristics when viewed from a biological and psychological perspective. Male investors have a masculine character and tend to be braver and more confident in making decisions that have high risks, while female investors are identified with feminine characters and are more proficient in financial planning [7]. There is evidence that a lack of self-confidence, particularly among women, impacts how they make financial decisions [8], [9]. Female investors are more risk averse and less risk tolerant than men [10]- [12].

Gender differences are also present in behavioral bias, where behavioral bias is financial behavior that is influenced by psychology so that investors make unpredictable investment decisions [13]. Gender is a significant factor in an individual's tendency to exhibit behavioral biases such as self-attribution, illusion of control, confirmation, and regret avoidance bias [10]. The influence of excessive emotions makes investors lose control so they behave too confidently or even pessimistically [13]. Men tend to be more self-confident and show higher levels of self-attribution bias compared to women, whereas women show greater loss aversion, and often show a greater tendency towards the disposition effect than men [10].

The psychological side that occurs has been discussed in Behavioral Finance studies, where the basic assumption is that not all investors always think rationally [14]-[17]. Furthermore, the part of this study that addresses the psychological and cognitive aspects of an investor is Neurofinance. Neurofinance studies how we evaluate information about uncertain and risky financial choices, as well as how emotions, psychological biases, behavioral biases, and individual differences such as gender can influence financial decisions [18]. Neurofinance attempts to correlate brain processes with investment behavior and define the key role of emotions in financial decision-making [19].

The part of neurofinance that has an important role is neurotransmitters, known as neural circuits that function as data carriers for the brain, it is related to the behavioral elements of individual investors because with the presence of strong signals from the human brain, it shows how to confirm investment decisions [20]. The existence of psychological factors in investment activities further strengthens the idea that Behavioral Finance and Financial Literacy need to be understood well, in order to understand the nature and behavior of financial and economic problems, because a lack of consumer knowledge will have an impact on making wrong decisions [21], [22]. The level of financial literacy is a crucial indicator in determining a person's ability to make financial decisions.[8]If investors are able to make sound investment decisions in financial products and services among households, it will become a source of funds to develop and strengthen the resilience of Indonesia's financial system in facing financial shocks [23]. Other benefits are, To optimize investment success and mitigate risks, it is essential for finance companies to align investment strategies with investors' psychological characteristics, while providing value-added services that guide them towards optimal financial decision-making [24].

Discussions on neurofinance, particularly the involvement of neurotransmitters in investment bias and financial decision-making, remain scarce, especially when specifically related to female investors. Therefore, it is interesting to explore this topic as a topic for further discussion in the future. We aim to explore the impact of financial literacy's moderating role on the influence of neurotransmitters regarding investor investment bias. This study will further examine investors' cognitive activity and psychological aspects, specifically considering gender demographics. Notably, this research represents the first neurotransmitter study to develop a model incorporating financial literacy as a moderator and focusing on female investors as its primary subjects.

2. RESEARCH METHOD

The object of this research is neurotransmitters, financial literacy, and investment bias among female investors in Indonesia. The subjects in this study were stock investors with Single Investor Identification in Indonesia. This study used a quantitative approach, using the population of female stock investors in Indonesia. The population in this study was 5 million stock investors in Indonesia, SID. The number of respondents in the

quantitative research instrument trial should be at least 200 people to achieve data stability [25]. The following are the sample criteria that have been determined by the researcher: 1.) Female investors aged 20 – 50 years 2.) Have investments in the form of shares 3.) Have carried out investment activities for at least 2 years 4.) Have carried out buying and selling activities.

This study used purposive sampling, using a semantic differential scale. The semantic differential scale is an intuitive and universal method designed to evaluate cognitive perception across cultures. This method is highly effective in measuring dimensions of perception of non-living entities that are not related to biological capacities [26]. Data collection was conducted by distributing a questionnaire with closed-ended questions. Prior to distribution, the instrument was tested and a pre-survey was conducted. The questionnaire was distributed to various investment platforms and business labs at various universities in Indonesia, resulting in 581 respondents who contributed to this study. Data analysis was performed using SEM.

The first research procedure was primary data collection. Primary data collection was conducted by conducting a pre-survey with 30 respondents. After the instrument was deemed adequate, the questionnaire was distributed to various financial services platforms, including stockbrokers, banks, various universities with investment labs, as well as financial associations and other organizations where possible. Second, data processing was performed using Smart PLS 4, and finally, hypothesis testing

3. RESULTS AND DISCUSSION

Evaluation of Outer Model Measurement Model

Indicator Reliability

Outer Loading

Based on the results of the convergent validity test in Table 2, it can be seen that all indicators have an outer loading value ≥ 0.70 (Hair et al., 2022). Therefore, all indicators in this study can be stated to have met the criteria.

Table 2. Result of Outer Loading Test

	Financial Literacy	Investment Bias	Neurotransmitter	Financial Literacy x Neurotransmitter
FL1	0.850			
FL2	0.887			
FL3	0.891			
FL4	0.885			
IB1		0.902		
IB10		0.881		
IB2		0.871		
IB3		0.883		
IB4		0.834		
IB5		0.862		
IB6		0.863		
IB7		0.870		
IB8		0.881		
IB9		0.898		
N1			0.840	
N2			0.835	
N3			0.837	
N4			0.826	
N5			0.833	
N6			0.826	
N7			0.837	
N8			0.829	
Financial Literacy x Neurotransmitter				1.000

Cronbach's Alpha and Composite Reliability (Internal Consistency Reliability)

Test results in Table 3 show that all latent variables meet the reliability test criteria. This is based on the Cronbach alpha and composite reliability values of all latent variables having values >0.6 [27]. Therefore, all latent variables are declared reliable after meeting all measurement criteria.

Table 3. Result of Composite Reability, Cronbach Alpha and Average Variance

	Cronbach's alpha	Composite reliability (rho a)	Composite reliability (rho c)	Average variance extracted (AVE)
Financial Literacy	0.901	0.905	0.931	0.771
Investment Bias	0.966	0.966	0.970	0.765
Neurotransmitter	0.937	0.938	0.948	0.694

Average Variance Extracted (AVE)

Based on the Average Variance Extracted (AVE) value shown, all variables have a value of more than 0.5, which means that this construct shows very strong convergent validity (Hair et al., 2022).

Discriminant Validity**Fornell-Larcker Criteria**

Table 4 shows that the square root value of AVE for each construct is greater than the correlation with other constructs, which means that the figure meets the Fornell-Larcker criterion.

Table 4. Fornell-Larcker Criteria

	Financial Literacy	Investment Bias	Neurotransmitter
Financial Literacy	0.878		
Investment Bias	0.291	0.875	
Neurotransmitter	0.525	0.764	0.833

Cross-Loadings

The result is the value of each of the *outer-loading* higher than the *cross-loading* on other constructs.

Inner Model (Structural Model)**Path Coefficients**

The results of the Path Coefficients will be shown in Figure 1 and Table 5.

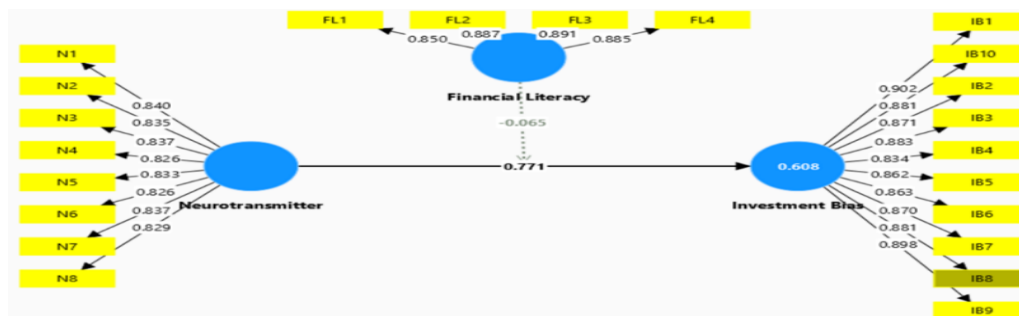


Figure 1. Graphical Output

Table 5. Path Coefficients

	Path coefficients
Financial Literacy -> Investment Bias	-0.211
Neurotransmitter -> Investment Bias	0.771
Financial Literacy x Neurotransmitter -> Investment Bias	-0.065

Table 5 shows that Neurotransmitters have a positive and significant effect on Bias Investment with a value of 0.771. Then, moderation by Financial Literacy on the relationship between Neurotransmitters and Bias Investment shows a significant negative effect with a value of -0.065, indicating that the effect of Neurotransmitters on Bias Investment decreases when moderated by Financial Literacy [44] [45].

R² (Coefficient of Determination)

The results of the Coefficient of Determination can be seen in Table 6.

Table 6. Tabel R-Square

	R-square	R-square adjusted
Investment Bias	0,608	0,606

The table 6 shows the R-square value for Investment Bias is 0.608. This value shows that the influence of the independent variable on Investment Bias is 60.8%, and the remaining 39.2% is influenced by other variables outside the model [46], [47].

Hypothesis Test

Financial Literacy → Investment Bias, The coefficient value is 0.062 with t-statistics of 14.150 and p-value of 0.000. Since the p-value is less than 0.05, H1 is accepted. Neurotransmitters → Investment Bias, The coefficient value is 0.723 with t-statistics of 21.715 and p-value of 0.000. Since the p-value is less than 0.05, H1 is accepted. Financial Literacy x Neurotransmitters → Investment Bias, The coefficient value is 0.019 with t-statistics of 7.012 and p-value of 0.000. Since the p-value is less than 0.05, H1 is accepted.

Financial literacy negatively impacts investment bias, meaning that higher financial literacy levels result in lower investment bias. This suggests that individuals with high financial literacy may be more aware of various aspects of investing, but they can still experience bias in their investment decisions. These results align with previous research, which found that financial literacy significantly influences investment decisions among both male and female investors [28]-[30]. With five million female investors in Indonesia, this understanding will undoubtedly impact various investment decisions and government policies, as well as business strategies in the investment sector regarding the role of female investors.

Neurotransmitters also have a significant and positive effect on investment bias. Neurotransmitter activity, which reflects the biological influence on emotions and decisions, increases bias in investment decision-making. This aligns with the theory that neurotransmitters such as dopamine and epinephrine have a significant relationship and role in emotional and sometimes biased financial decision-making [31]-[36]. This further demonstrates that women's role in the investment world is inseparable from cognitive activities involving emotions, which will impact their investment decisions.

The interaction indicates that financial literacy moderates the relationship between neurotransmitters and investment bias, with a negative effect [37]-[41]. The higher the level of financial literacy, the weaker the influence of neurotransmitters on investment bias. Simply put, financial literacy can help mitigate the effects of neurotransmitters on investment bias. Therefore, financial literacy can be a reference in considering strategies and policies [42]-[47]. By understanding financial literacy, investors will be encouraged to sort risks, calculate them, and even avoid them. It can also help them make better financial product preferences [48].

This study offers novel insights into behavioral finance through the development of a new research model, or an extension thereof, by employing financial literacy as a moderator to examine the influence of neurotransmitters on investment bias [49]. This research specifically elucidates how investor behavioral biases can be mitigated through enhanced financial understanding [50]. However, the study's limitations include its focus solely on stock investors and the uneven distribution of questionnaires, which resulted in inadequate representation from certain provinces, leading to a restricted number of, or even a complete absence of, respondents from those areas.

4. CONCLUSION

The involvement of women in the investment world—often associated with numbers, risk, and rational thinking—has not diminished their enthusiasm for participating in this field. This is evidenced by the consistent yearly increase in the number of female investors in Indonesia. They represent a significant force in the investment sector, generating substantial asset values. Their generally risk-averse and gentle personalities make them a compelling subject of study. This study reveals that the cognitive activity of female investors, particularly related to neurotransmitters, significantly influences the emergence of bias in financial decision-making. However, financial literacy has been shown to mitigate the impact of neurotransmitters that lead to such biases, resulting in more rational and accurate investment decisions. This research contributes novel insights to the field of behavioral finance by developing or extending a research model that incorporates financial literacy as a moderating variable in examining the effect of neurotransmitters on investment bias. Notably, it is the first study to specifically investigate neurotransmitter influences within the context of female investors. The findings clearly demonstrate that enhanced financial literacy can effectively reduce behavioral biases in investment decisions. Nevertheless, the study has several limitations. It focuses solely on stock investors and suffers from uneven distribution of the questionnaire, which led to limited or no representation from several provinces. This limitation affects the generalizability of the results and should be addressed in future research efforts.

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