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What is the effect of presenting prices vs returns on risk perception and risk assessment?

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Summary

This thesis focuses on the impact of presenting financial information as price graphs vs presenting it as return graphs and the impact of these different formats on individuals' risk perception and assessment. A survey was conducted involving 220 participants where price and return graphs of historical financial assets were viewed across two different levels of volatility: high and low. Contrary to previous literature, the data revealed that investors perceive lower instead of higher risk when viewing return graphs as opposed to viewing price graphs. For low volatility stocks, return estimates were found to be more accurate to the actual price at the end of the year and less variable than direct price estimates. However, for the high volatility stock, there was no significant difference in accuracy between the different formats. Financial literacy was also found to not have a significant effect on the impact of the presentation format on perceived risk. This thesis has implications for financial advisors, policy makers and investment platforms to make use of its findings in the future, and improve the quality of life for investors within financial industries.

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1 Introduction

Framing effects refer to the way information is presented and interpreted by individuals, significantly influencing their choices and actions. This concept, introduced by Tversky and Kahneman (1981), demonstrated through various experiments that people's choices can be systematically altered by changing the way options are framed, without altering the underlying outcomes. In their famous “Asian disease problem” experiment, they showed that when a decision problem was framed in terms of lives saved (positive framing), participants preferred a certain option. However, when the same problem was framed in terms of lives lost (negative framing), participants shifted their preference to a riskier option, despite the outcomes being mathematically equivalent. This highlights a particular anomaly that different presentations of the same information can lead to different decisions. This theory suggests that individuals are not always rational actors but are influenced by the context and way choices are framed.

Understanding framing effects in financial decision-making is crucial for several reasons. For example, Barberis, Huang, and Santos (2001) highlight how variations in risk perception can lead to significant changes in investment behaviour, as investors weigh the potential gains against the perceived risks. Together with this, Kunreuther, Pauly, and McMorrow (2013) explain that underestimating risk can lead to insurance avoidance, as people may underestimate the likelihood or impact of adverse events. Lusardi and Mitchell (2007) explore how a lack of understanding of financial risks can lead to insufficient retirement savings. In the world of digital finance, the way risk-related information is distributed has changed significantly, introducing new challenges and opportunities in managing risk perception among consumers and investors.

Building on insights from Huber and Huber (2019), this thesis seeks to explore how different presentations of the same financial information affect risk perception and decision-making. The main message of Huber and Huber (2019) was that if return and price charts have a smaller scale on the vertical axis, people tend to view the investment as riskier, no matter the actual risk level of the asset. This visual emphasis on fluctuations can influence viewers' perception, making the asset appear more volatile or riskier than it might seem on a chart with a broader scale. However, while they focused on the size of the scale of the axis, they also discovered that the people in their experiment perceive risk to be considerably higher when viewing return charts compared to

when they view price charts. This important and noteworthy finding could have significant implications for practitioners within the industry and will be the focus of this thesis.

From here, this thesis specifically aimed to delve into this specific relationship between the framing of risk information and financial decision making, by conducting an experimental investigation of the research question, *"What is the effect of presenting prices vs. returns on risk perception and risk assessment?*". This investigation aims to fully test the finding by Huber and Huber (2019) that presenting price graphs and return graphs to individuals will result in different levels of risk perception. The study aims to do this using a Qualtrics survey, where participants are exposed to both price and return graphs of historical financial assets to measure their risk perception and estimates of variance. This approach allows for a direct comparison of the impact of different information presentations on individuals, to explain how framing affects financial decisions.

The results of this investigation provide several insights. Contrary to the initial hypothesis, the findings reveal that investors perceive lower risk when financial information is presented as returns rather than prices. Additionally, the accuracy of investors' risk assessments improves when the information is presented as returns, especially under conditions of low volatility. Interestingly, the data shows that the level of financial literacy does not seem to have a significant effect or impact on perceived risk. These insights could stand to benefit financial advisors, investment platforms, policymakers, and individual investors, as understanding how framing effects influence the perception of risk could lead to investors making more informed decisions and help in the design of investment products and platforms that better align with investors' best interests (Thaler & Sunstein, 2008). Also, insights from this study could inform policy regulations aimed at protecting consumers from potentially misleading information presentations, which would protect their financial wellbeing. (Beshears, Choi, Laibson, & Madrian, 2009; Barber and Odean, 2001)

2 Literature Review

To begin with, the interaction between framing effects and financial decision-making is a significant concern within behavioural finance as it has huge implications for market dynamics and the functioning of financial markets. Barberis, Huang, and Santos (2001) discuss how investors' psychological biases, like those described by prospect theory can influence asset prices and investors' trading behaviour, highlighting the broader economic significance of these cognitive biases. The relation between prospect theory and framing effects found in the works of Tversky and Kahneman (1979 & 1981) introduces the idea that individuals evaluate outcomes relative to a reference point, rather than in absolute terms. How a problem is framed can alter this reference point, thereby affecting the decision-making process. For example, framing an outcome in terms of potential losses rather than potential gains can lead individuals to make different choices, even if the statistical outcome is the same.

As discussed previously, Huber and Huber (2019) provide insights into how visual presentation such as the scaling of charts, affect risk perception. Their primary focus was how different scales can alter perceived riskiness of assets, however, they also touched on the distinction between presenting financial information as prices versus presenting information as returns. In their experiment, they compared wide versus narrow vertical axis scales and their effects on risk perception across different presentation formats, these being return charts vs. price charts. Participants were also shown financial data with varying return trends such as positive stable, negative stable, increasing, and decreasing and low and high volatility levels. The results of this experiment show that participants perceived risk as significantly higher when viewing return charts compared to price charts. This difference was statistically significant in five out of eight comparisons, with all differences indicating higher perceived risk for return charts.

Although, their work is insightful, more work could be done to explore certain areas. For example, while they acknowledge the differences in risk perception between price and return charts, a deeper analysis on this specific aspect could yield more detailed insights. Specifically, by comparing risk perceptions, estimates of variance, and behavioural responses to these two types of presentations. The results of such an analysis could answer whether one framing effect may lead either to more conservative or aggressive assessments of risk. In Borsboom and Zeisberger's

(2020) paper they emphasize the importance of salient features in price paths such as highs, lows, and dramatic drops as key drivers of perceived risk. Their research argues that these visually striking elements, rather than traditional volatility metrics alone, play a significant role in shaping investors' risk assessments. This is particularly relevant when considering how price graphs can highlight such extreme values, potentially skewing risk perception based on their visual characteristics.

Expanding on this, Spiller, Reinholtz, and Maglio (2020) examined the impact of "stocks and flows" presentations in time-series data. They found that the choice between presenting data as stocks, consisting of accumulated quantity over time, versus flows consisting of changes in quantity from one period to the next, can significantly impact judgments, even leading to opposing inferences from the same underlying information. For instance, the same employment data could be perceived more positively when presented as flows; meaning jobs created or lost, highlighting recent improvements, as opposed to stocks showing the total number of jobs available, which might emphasize a weak outlook of the economy without reflecting on the positive trend of job creation.

Although Spiller, Reinholtz, and Maglio (2020) did not directly investigate financial return and price graphs, the underlying concept of framing effects which they explore, where different presentations of the same information can lead to different perceptions and actions, links with this thesis’ investigation into financial decision-making. Just as the presentation of health data could affect public behaviour, the framing of financial data, which could emphasize cumulative returns or fluctuating prices, can also have an impact on investment behaviours by influencing investors' risk assessments. In a similar manner, Reinholtz et al. (2021) demonstrated how different presentations of COVID-19 data influenced public risk perceptions and behaviours. This principle can again be applied to financial markets, where the framing of information as price graphs vs. return graphs can significantly impact investment decisions by shaping perceptions of market volatility. However, it must be noted that in a financial context, prices decrease as well as increase while Reinholtz et al. (2021) did not consider that people with Covid could recover from the disease and lower the number of active cases within the sample.

Furthermore, a paper by Glaser et al. (2007) provided early insights into how individuals' forecasts of financial outcomes differ based on whether they are asked to predict returns or prices. They found that individuals tasked with forecasting returns are more likely to extrapolate past trends into the future compared to those asked to forecast prices. In other words, if an asset has been rising in value, individuals predicting returns are more likely to expect this upward trend to continue. By contrast, when individuals were asked to forecast prices, mean reversion was more common in their predictions regardless of past market trends. This suggests that the format of financial forecasts has a significant influence on expectations and risk assessments.

Similarly, in Glaser et al. (2019) their study conducts three experimental investigations to determine how investors' expectations vary when they are asked to forecast returns as opposed to prices, and when they are shown return charts rather than price charts. They find significant differences in investors' expectations based on the format in which information is presented to them. When participants are asked to predict returns instead of prices, their expectations for future returns are higher. Conversely, when information is displayed in return charts as opposed to price charts, the presentation of past returns causes participants' expectations to become lower. This could be because return charts clearly illustrate the volatility and fluctuations in asset performance over time, making the risk and uncertainty more apparent to investors. As a result, when faced with a visual presentation of volatility through return charts, investors become more conservative in their forecasts of future asset performance.

These differences in expectations based on the presentation format of financial information show us one important point about risk perception and risk assessment, that we could speculate for our hypotheses, this being: the way investors perceive risk is significantly influenced by their expectations. Higher expectations might lead to lower risk perception, whereas lower expectations could result in more caution being exercised by participants due to higher risk perception. However, it is also possible that perceived risk can shape expectations. Investors who perceive higher risk might adjust their expectations downward to account for potential losses, while those perceiving lower risk might set higher expectations for returns. Following up on these works, Hanaki et al. (2023) explored further into how framing financial forecasts in terms of returns versus prices can influence investor behaviour with market stability being particularly

relevant. Their findings suggest that return forecasts lead to more speculative behaviour and contribute to financial bubbles.

While framing effects have a significant impact on financial decision-making, the effect of financial literacy must also be considered when interpreting financial information. In a study by Costa et al. (2021) their findings show that participants' decisions were significantly influenced by how the scenarios were framed. It was found that those with higher financial literacy were found to be more influenced by framing effects and less able to make rational decisions, which in this case was focused on gains and losses. This is relevant as it emphasizes the potential for different presentations of financial data to affect individuals differently due to varying levels of financial literacy. There is also the link between financial literacy and its effect on risk perception and risk behaviour. Aren & Canikli (2018) found that higher financial literacy leads to lower risk perception and higher risk tolerance, which leads to a preference for riskier investments, such as stocks. (Aren & Canikli, 2018; Korkmaz et al. 2021). This aligns with Korkmaz et al. (2021) who found that financial literacy affects the inconsistency between risk preference and risk behaviour. In other words, there can be a mismatch between what people say they prefer and what they do. For those with risk-seeking behaviour, higher financial literacy helps them to be more consistent and carry out this behaviour while in the case of risk-averse individuals, higher financial literacy increases this inconsistency, which causes individuals to take on more risk even if they risk-avoidant. The combination of these two factors increases risk-taking behaviour overall.

Other than financial literacy, Holzmeister et al. (2020) examine various factors, such as skewness and the probability of loss, and their impact on the risk perceptions of financial professionals compared to laypeople. Their study found that skewness is the only moment of return distributions that systematically affects both financial professionals' and laypeople's perception of financial risk. However, it must be noted that in this paper a distribution of potential returns was shown and not a time-series of returns. Interestingly, variance, the most common risk measure in finance, does not influence risk perception for both groups. This challenges the traditional financial models that equate risk with return volatility (Markowitz, 1952). In fact, the probability of experiencing losses emerged as the strongest predictor of what is perceived as being risky. (Zeisberger, 2023)

To summarize, this body of literature presents the large impact of framing effects on financial decision-making and risk perception. Starting with the effects of different presentation formats, the impact of financial literacy and the many different factors which determine risk perception amongst individuals. These variables show how a thorough understanding of behavioural finance is required to tackle the research question of this thesis. The literature review provides a solid foundation for the upcoming investigation into the effects of prices vs returns on risk perception and risk assessment and the many possible theoretical and practical applications which could spring from this study.

2.1 Derivation of Hypotheses

Based on the findings from the literature review, the following hypotheses have been derived to help further the investigation into the research question of the thesis which tries to discover how presenting information as price graphs versus return graphs affects risk perception and risk assessment.

Hypothesis 1 (H1): Individuals will perceive higher risk when financial information is presented as returns compared to when it is presented as prices. This statement comes from the assumption that return graphs will illustrate the volatility of an asset more clearly due to the emphasis of day-to-day percentage changes which may heighten perceived risk from individuals (Glaser et. al, 2019; Huber and Huber, 2019)

Hypothesis 2 (H2): Individuals' accuracy in assessing financial risk will differ when information is presented as returns rather than as prices. While Huber and Huber (2019) acknowledge the differences in risk perception between price and return charts, in their paper they do not directly compare the effects of presenting prices vs presenting returns on the accuracy of risk assessments. Furthermore, due to the lack of literature addressing this topic the thesis will adopt a neutral stance on the expected outcomes of this hypothesis, however a difference in the accuracy of risk assessment between different presentation formats is expected as a difference in risk perception was expected in the first hypothesis as well

In addition to addressing the thesis' primary research question regarding the different impacts of price versus return presentations on investors' risk perception and assessment, the

thesis will add an additional analysis to consider the role of individual differences, such as financial literacy, in influencing these effects. This is further explained in hypothesis 3 below.

Hypothesis 3 (H3): Individuals with higher financial literacy will perceive lower risk when evaluating both formats, compared to individuals with lower financial literacy. (Aren and Canikli, 2018) found that higher financial literacy leads to lower risk perception and higher risk tolerance, as financially literate individuals are better equipped to assess and understand the risks associated with various investments. This understanding reduces their overall perception of risk. Additionally, Korkmaz et al. (2021) suggested that financial literacy helps align risk perception with actual risk, thus lowering perceived risk.

3 Methodology

The methodology adopted in this thesis draws upon Huber and Huber's (2019) findings on the impact of chart scaling on risk perception. Further, inspired by Zeisberger (2023), the planned survey will investigate the nature of risk perception among individuals, by assessing how individuals' financial literacy levels moderate their interpretations of financial information which will be presented in two different formats across high and low volatility stocks.

3.1 Survey Design

This thesis adopted an experimental design conducted through a Qualtrics survey to investigate the impact of financial information presentation formats on investors' risk perception and to explore how financial literacy levels influence this relationship. The survey involved exposing each participant to both price and return graphs of historical financial assets, allowing for a direct comparison of their risk perceptions towards each presentation format within the same set of participants. This design is particularly chosen to minimize individual differences and isolate the effect of presentation format on perceived risk.

The price and returns graphs were constructed using 2 stocks with diverse volatility and performance histories, with 1 price graph and 1 return graph for each stock. One stock would have relatively low volatility and the other would have relatively high volatility. The survey was randomized evenly so that one group of participants would be presented the graphs for one stock

and the other group would be presented with graphs for the other, the order of the graphs was also randomized to eliminate any bias by participants if they were to always to see one type of graph first. Historical price data over one year was used to create price graphs, plotting closing prices against time, while return graphs depicted the daily percentage change in prices over the same timeframe to highlight volatility and trends. There were 252 datapoints in total and both graph types adhered to a consistent design aesthetic, including clear axis labels and titles, ensuring any differences in participants' responses are attributable solely to the information format and not to any other factors. While real data was used, participants were not given the name of the stocks to avoid the possibility of them searching the internet for answers. (See Appendix A)

The survey was disseminated to as many people as possible to include individuals with varying levels of financial literacy and demographics. Recruitment was performed through online survey sharing platforms such as Surveycircle.com, social media channels and e-mail contacts. Participants were informed about the study's voluntary nature and the confidentiality of their responses.

The main independent variable in this study is the presentation format, categorized into two groups: price graphs displaying the historical price levels of an asset and returns graphs showing the percentage change in the asset's value over time. The dependent variables include risk perception. Zeisberger (2023) demonstrated that risk perception is highly correlated with loss likelihood when examining the characteristics of an asset using return distributions. Although Zeisberger's (2023) study focused on return distributions, it can be argued that this relationship can extend to participants' future estimates of loss likelihood. Therefore, by asking participants for their estimated loss likelihood of the asset for the following year, their perceived risk is captured in a simple manner that aligns with established research findings. This method also avoids the potential biases and over-simplifications that might arise from a direct question to participants about how risky they perceive the asset to be (See Appendix A for more details about the survey.)

The survey also examined participants' range estimates to capture their expectations of the asset's future performance based on the graphs they viewed. For the price graphs, participants

were asked to provide three estimates: the expected price, the maximum price, and the minimum price of the asset at the end of the following year. Similarly, for the return graphs, participants were asked to estimate the expected average daily return, the highest daily return, and the lowest daily return for the asset over the following year. These price and return estimates were treated as measurements for the participants' assessments of the asset's risk. This approach was chosen to align with common investment horizons, where end-of-year projections are typical for assessing annual performance and risk. Asking for estimates at the end of the year, rather than throughout the year, helps with the comparison of participant responses later. (See Appendix A – Price/Return Graph Questions for more details.)

It was decided that asking participants for range estimates rather than directly questioning them about volatility would be a more accurate finding for the study to analyse. This is because volatility, a statistical measure of the dispersion of returns, might be a concept that many participants, especially those without a financial background, find difficult to understand or calculate accurately. Terms like "volatility" or "standard deviation" are often technical and can be confusing, potentially leading to inaccuracies in participants' responses due to a lack of comprehension.

In the case of the return graphs, when it came to asking questions about returns it was decided to ask participants for the expected average daily return for the whole year rather than ask them to provide a yearly return amount. This was done as the return graph shown to participants highlighted percentage return for every single trading day, for a total of 252 times. Therefore, asking for range of cumulative return estimates would have required a lot of mental calculation that could skew results as participants could have answered incorrectly.

3.2 Statistical Approach

Hypothesis 1 (H1) puts forward that investors will perceive higher risk when financial information is presented as returns compared to when it is presented as prices. Aligning with Zeisberger's (2023) findings mentioned in the previous section, this perception of risk was measured by asking participants for the estimated loss likelihood of the asset in the following year. Specifically, for price graphs, participants provided the likelihood that the stock's price

would be lower at the end of the next year compared to its current price. For return graphs, they estimated the likelihood that the average daily return would be negative for the next year. This estimated likelihood serves as a measurement for perceived risk. (See Appendix A for the detailed survey questions.)

To analyse these observations, three Wilcoxon signed-rank tests were conducted, two for the high and low volatility groups, and one for a combined sample. a regression analysis and two-way ANOVA was also conducted as robustness checks to account for both within-subjects (presentation format: returns vs. prices) and between-subjects (stock volatility: low vs. high) factors. This method is viable as it allows the opportunity to examine the interaction effect between presentation format and stock volatility on risk perception. The repeated measures component will account for the fact that each participant provides responses under both presentation formats.

Hypothesis 2 states that the accuracy of investors' risk assessments will differ when information is presented as returns rather than as prices. To operationalize this, participants were asked a series of questions for both price and return graphs. For the price graph, participants were asked to estimate the expected price, the highest price, and the lowest price of the stock at the end of the following year. For the return graph, participants were asked to estimate the expected average daily return, the highest daily return, and the lowest daily return of the stock for the following year.

To test Hypothesis 2, these estimates were compared against the actual outcomes for the following year. The estimated returns were converted to price estimates using the initial price at the start of the year and the daily return formula. This conversion allowed the comparison of the converted return estimates, along with price estimates, with the actual closing price at the end of the following year. This conversion also facilitated the calculation of the mean squared errors (MSE) for both price and return estimates. These MSEs were then compared against each other using the Mann-Whitney U Test to assess a possible difference in the accuracy of participants' risk assessments under different presentation formats. Additionally, participants were asked to provide their maximum and minimum return and price estimates. This data was used to determine the confidence of participants, as indicated by the range between these high and low

estimates. A narrower range would suggest higher confidence, while a wider range would indicate greater uncertainty. The visual representation of these ranges using boxplots enabled a clear comparison between the anticipated and actual values under both high and low volatility conditions, as well as for both price and return presentations. By examining the median values and the distribution of estimates around the actual outcomes, the precision and variability of participants' risk assessments was assessed.

Hypothesis 3 explores how financial literacy moderates the relationship between presentation format and risk perception. Following Zeisberger's (2023) procedure, the survey will assess participants' financial literacy levels through two questions designed to gauge their general understanding of financial concepts and ability to make informed financial decisions. These questions will contribute to the financial literacy variable which will serve as an extra independent variable. For example, if they get both correct, they will have a '1' value in the financial literacy variable and if they do not get both correct, they will have a '0' value. The moderating effect will be examined by introducing an interaction term between presentation format and financial literacy into the statistical model. (see Appendix C - Financial Literacy for more details)

By adopting this methodology, this research allows for a comprehensive investigation into how the different presentations of financial information, these being prices versus returns, and their influence on investors' risk perceptions and risk assessment accuracies. This approach allows the exploration of the subtle effects of information framing within a controlled experimental setting, including the additional analysis of examining the moderating role of financial literacy.

After the survey was completed, there were 109 complete entries in the high volatility group and 111 complete entries in the low volatility group, with 220 completed entries in total. The demographics of the participants were as follows: Most participants came from Malta (58.6%), the Netherlands (11.0%), the UK (10.1%), and the USA (5.29%) respectively. Most of the participants were men (74.4%). This was due to most of the emails being sent to business contacts. As a result, no analyses can be made regarding gender as there is simply a lack of sample size. The age distribution was as follows: 18-25 (15.9%), 26-35 (17.2%), 36-45 (10.1%), 46-55 (29.5%), 56-65 (16.7%), and 65+ (10.6%).

4 Results

To test Hypothesis 1 (H1), which states that individuals will perceive higher risk when financial information is presented as returns compared to when it is presented as prices. Three Wilcoxon signed-rank tests were conducted, two for the high and low volatility groups, and one for the combined sample.

The boxplot below illustrates the distribution of perceived risk for high and low volatility stocks. Here risk was measured by asking participants for their perception on the likelihood of the stock having a lower price in the next year (when shown the price graph) and the likelihood of the stock having a negative average daily return in the next year (for the return graph).

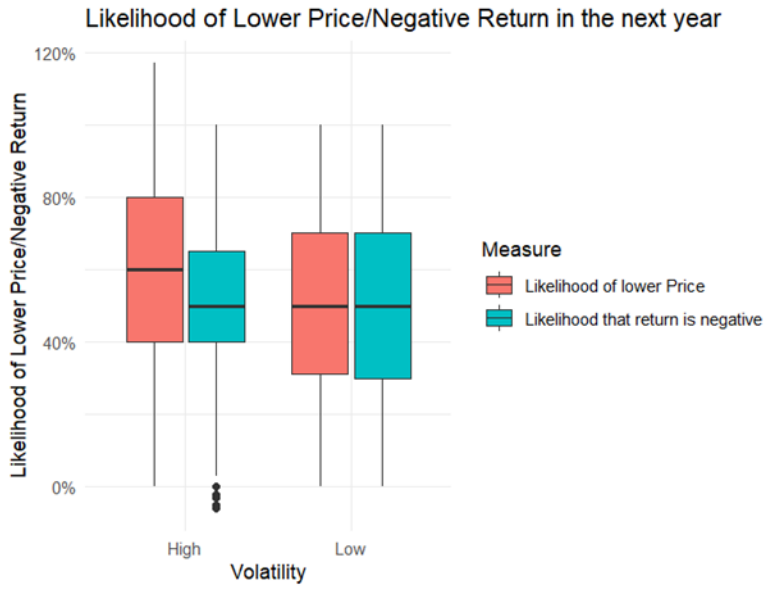

FIGURE 1. LIKELIHOOD OF LOWER PRICE/NEGATIVE RETURN IN THE NEXT YEAR

The Wilcoxon signed-rank test for the combined sample indicated a significant difference in perceived risk, V = 9053, p = 0.005463. For the high volatility group the test also indicated a significant difference in perceived risk between the two presentation formats, V=2570.5, p= 0.005481. However, for the low volatility group no significant difference was found between the two presentation formats, V=1979.5, p=0.2837.

For the high volatility group, the boxplot shows that the median likelihood of a lower price (depicted in red) is 60%, while the median likelihood that the return is negative (depicted in blue) is 50%. This indicates that participants perceived a higher risk with price information compared to return information. This finding aligns with the significant result of the Wilcoxon signed-rank test for high volatility, suggesting that price information may emphasize risk more strongly than return information for these stocks.

For the low volatility group, the boxplot shows similar medians for both likelihood measures, with the median likelihood of a lower price and the median likelihood of a negative return both being 50%. This consistency supports the non-significant Wilcoxon signed-rank test result for low volatility, indicating that the presentation format does not significantly alter risk perception for low volatility stocks.

Based on the results it seems that, for high volatility stocks, participants perceived higher risk with price information rather than return information. For low volatility stocks, participants perceived similar risks with both price and return information. If H1 states that returns should lead to higher perceived risk, but the data shows higher risk perception with prices for high volatility stocks, it suggests the hypothesis might not hold as initially expected. Participants might find price information more indicative of risk for high volatility stocks.

This outcome is somewhat unexpected when compared to previous literature. For instance, Huber and Huber (2019) found that participants generally perceived higher risk when viewing return charts compared to price charts. Similarly, Glaser et al. (2019) observed that return forecasts can make the variability and uncertainty in asset performance more evident, leading to higher risk perception. However, the findings align more closely with the insights provided by Borsboom and Zeisberger (2020). They argued that prominent features in price paths can be key drivers of perceived risk. These features in price graphs may capture more attention and amplify perceived risk, especially for high volatility stocks where such features are more pronounced. This could explain why participants in the study perceived higher risk with price information for high volatility stocks.

TABLE 1. OLS REGRESSION ANALYSIS

	Dependent variable:
	Perceived Risk (%)
Presentation Format (Return=1)	-0.076***
	(0.025)
Volatility (Low=1)	-0.049*
	(0.025)
`Investment Knowledge-Low	-0.004
	(0.041)
`Investment Knowledge-Normal	0.006
	(0.038)
`Investment Knowledge-Very high	-0.014
	(0.088)
`Investment Knowledge-Very low	0.022
	(0.052)
`Statistical Knowledge-Low	-0.171***
	(0.046)
`Statistical Knowledge-Normal	-0.033
	(0.033)
`Statistical Knowledge-Very High	-0.079
	(0.062)
`Statistical Knowledge-Very Low	0.064
	(0.074)
Constant	0.626***
	(0.035)
Observations	448
R^2	0.072
Adjusted R^2	0.051
Residual Std. Error	0.264 (df = 437)
F Statistic	3.403*** (df = 10; 437)
Note:	*p<0.1; **p<0.05; ***p<0.01

As a robustness check, an OLS regression analysis was conducted. As seen in Table 1, this model aims to determine how various factors influence the perceived risk. The perceived risk is captured through the variables "Likelihood of lower Price" for the price format and "Likelihood that return is negative" for the return format. These are measured as percentages ranging from 0% to 100%, representing participants' estimated likelihoods of a negative outcome in the next year.

The Independent Variables are as follows:

Presentation Format: This is a dummy variable which represents the return format and the price format. When the presentation format is return (as opposed to price), the perceived risk decreases by 0.076 percentage points, holding all other variables constant. This is significant at the $p<0.01$ confidence level.

Volatility: This is a dummy variable which represents low volatility and high volatility. When volatility is low, the perceived risk decreases by 0.049 percentage points holding all other variables constant. This is significant at the 10% confidence level

Investment Knowledge: This categorical variable is split into levels (low, normal, very high, very low), with the reference category 'high'. None of the categories of investment knowledge have a statistically significant effect on perceived risk at any level. With 36 low, 29 very low, 91 normal, 45 high, and 6 very high

Statistical Knowledge: This categorical variable is also split into levels (Low, Normal, Very High, Very Low), with the reference category being 'high'. Low statistical knowledge is associated with a decrease in perceived risk by 0.171 percentage points holding all other variables constant. This is the only level that is statistically significant at the 1% confidence level. With 9 very low, 33 low, 111 normal, 61 high and 13 very high.

Due to the small number of observations in some categories, particularly those with very high investment knowledge and very low statistical knowledge, the robustness of the statistical analysis for these categories is limited. One potential solution that future studies can do is to combine adjacent categories (e.g., combining 'very high' and 'high' into a single 'high' category). Both the Investment and Statistical knowledge variables were assessed based on the responses to questions where participants had to rate their own level of knowledge regarding the two

subjects. This rating ranged between very low to very high. (See Appendix B – Financial literacy measurement for more details)

As a further robustness check, a two-way ANOVA regression was also conducted to examine the effects of presentation format and volatility on perceived risk, as well as their interaction. The results are as follows:

TABLE 2. ANOVA RESULTS

Source	Df	Sum Sq	Mean Sq	F value	Pr(>F)
`Presentation Format`	1	0.710	0.710	9.881	0.002**
Volatility	1	0.115	0.115	1.603	0.206
`Presentation Format; Volatility	1	0.113	0.113	1.572	0.211
Residuals	466	33.506	0.072	NA	NA
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1					

It was found that the Presentation Format factor of price vs return significantly affects perceived risk, with an F (1, 466) = 9.881 and a p-value of 0.002, meaning that the difference in perceived risk between the price and return formats is statistically significant.

However, the effect of high vs low on perceived risk was not significant, with an F (1, 466) = 1.603 and a p-value of 0.206. Additionally, the interaction between presentation format and volatility did not significantly affect perceived risk, as indicated by an F (1, 466) = 1.572 and a p-value of 0.211.

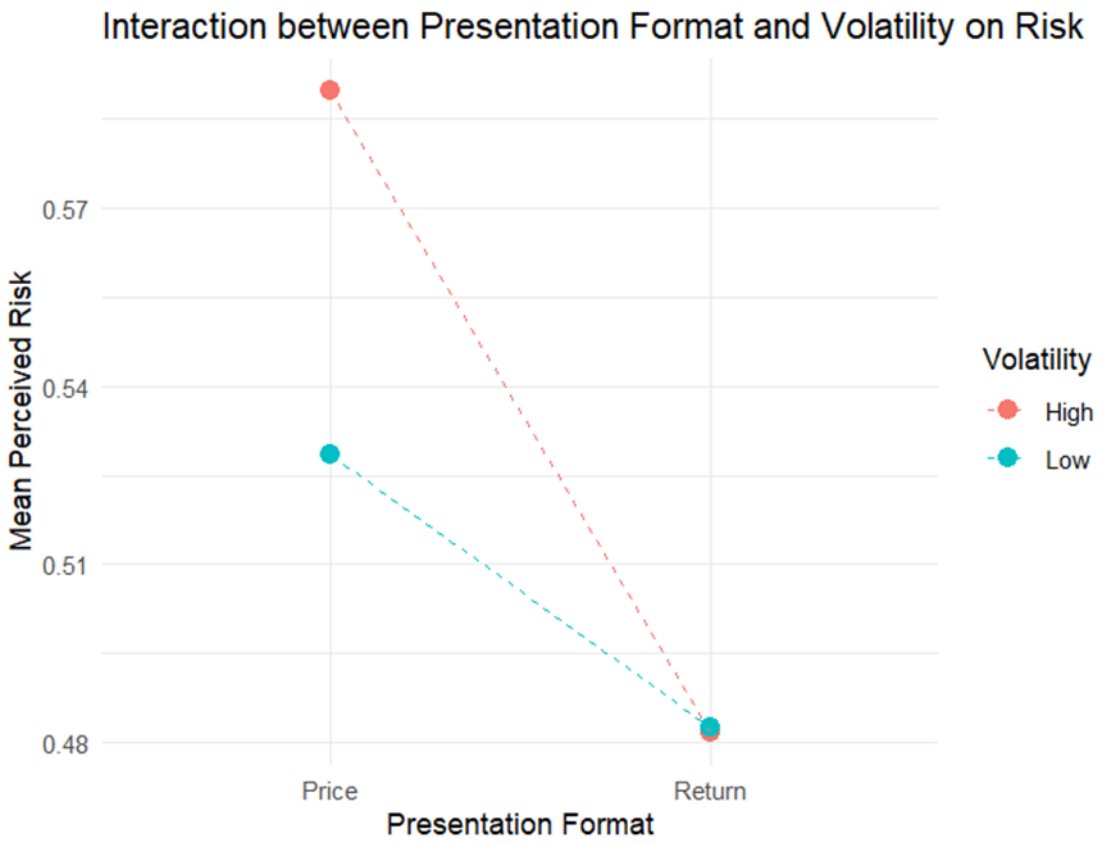

FIGURE 2. INTERACTION BETWEEN PRESENTATION FORMAT AND VOLATILITY ON RISK

Despite not being significant the Interaction plot above clearly shows that the perceived risk decreases significantly when switching from price to return format, with the decrease in perceived risk being less pronounced within the low volatility group than in the high volatility group. This supports the ANOVA findings, highlighting a significant main effect of presentation format on perceived risk but no significant interaction effect.

To summarize, the effect of Volatility is significant in the regression model but not in the ANOVA, suggesting possible interactions or complexities captured differently in each model. However, all three tests conducted so far combined with the supporting box-plot and interaction plot emphasize the robust influence of the presentation format on perceived risk.

Let us focus on the interaction variable and further investigate, as it is odd that there is no interaction effect when three out of the four cases are similar, with only the fourth case price format and high volatility being the exception.

TABLE 3. OLS REGRESSION WITH INTERACTION EFFECT BETWEEN PRESENTATION FORMAT AND VOLATILITY

	Dependent variable:
	Perceived Risk (%)
Presentation Format (Return=1)	-0.122***
	(0.035)
Volatility (Low=1)	-0.094***
	(0.035)
Investment Knowledge-Low	-0.004
	(0.041)
Investment Knowledge-Normal	0.006
	(0.038)
Investment Knowledge-Very high	-0.015
	(0.088)
Investment Knowledge-Very low	0.022
	(0.052)
Statistical Knowledge-Low	-0.171***
	(0.046)
Statistical Knowledge-Normal	-0.033
	(0.033)
Statistical Knowledge-Very High	-0.079
	(0.062)
Statistical Knowledge-Very Low	0.063
	(0.074)
Presentation Format*Volatility	0.091*
	(0.050)
Constant	0.648***
	(0.037)
Observations	448
R^2	0.079
Adjusted R^2	0.056
Residual Std. Error	0.263 (df = 436)
F Statistic	3.411*** (df = 11; 436)
Note:	*p<0.1; **p<0.05; ***p<0.01

In Table 3 above, an OLS regression has been conducted like in table 1 but now an interaction term has been included between Presentation format and Volatility. When comparing the two regressions we see that in both tables, presenting information as returns is associated with a lower level of perceived risk. Lower volatility is also associated with reduced perceived risk in both models, including the effect of low statistical knowledge which also significantly reduces perceived risk in both models while other levels of statistical knowledge do not show significant effects. In table 3, the new interaction variable between Presentation Format and Volatility is positive and significant with a value of 0.091, this indicates that the reduction in perceived risk when presented with a return graph, is less pronounced in the low volatility group then it is in the high volatility group.

These findings on the interaction effect coincide with the ANOVA results depicted in figure 2, which shows how the reduction in perceived risk when going from prices to returns has a more pronounced effect in the high volatility group.

In conclusion, we must reject hypothesis 1, the data does not support the hypothesis that investors perceive higher risk when financial information is presented as returns compared to when it is presented as prices. Instead, the results show that presenting information as returns lowers perceived risk across different levels of volatility.

For Hypothesis 2, which states that the accuracy of participants in assessing financial risk will differ when information is presented as returns rather than as prices. The hypothesis was tested using a comparative analysis which was conducted using boxplots to visually assess participants' estimated values against the actual values of the following year under different presentation formats and volatility conditions.

For the price presentation analysis, the participants' estimates were plotted against the actual stock price at the end of the following year. For the return presentation analysis, the participants' estimates were compared to the actual average daily return of the following year.

FIGURE 3. PRICE COMPARISON (LOW VOLATILITY).

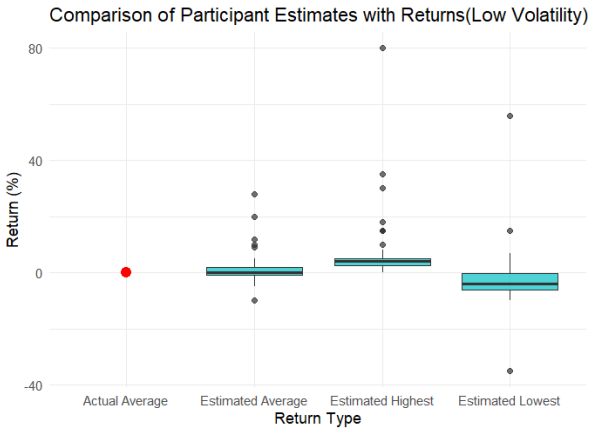

FIGURE 4. RETURN COMPARISON (LOW VOLATILITY)

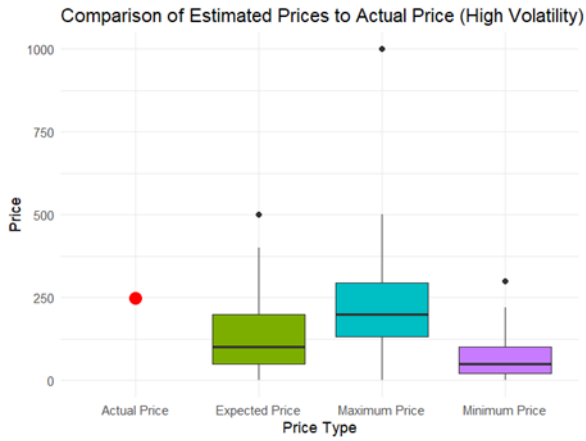

FIGURE 5. PRICE COMPARISON (HIGH VOLATILITY).

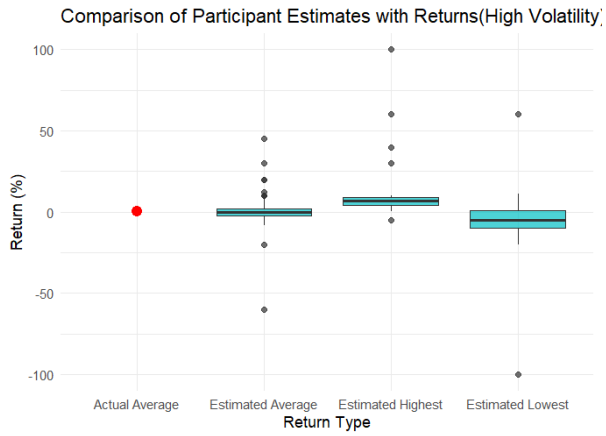

FIGURE 6. RETURN COMPARISON (HIGH VOLATILITY)

Low Volatility Price (Figure 3):

The actual price of the low volatility stock at the end of the following year was $144.54. The expected price estimates had a median of $150, very close to the actual price, indicating accurate estimation. Maximum price estimates had a median of $163, showing a substantial overestimation with an upper range extending to nearly $400. Minimum price estimates had a median of $120, somewhat below the actual price, indicating similar substantial underestimation.

Low Volatility Return (Figure 4):

The actual average daily return of the low volatility stock for the following year was approximately -0.00908%. The estimated average return had a median of 0%, which is accurate in terms of estimating no significant return. The estimated highest return had a median of 4%, and the

estimated lowest return had a median of -4%, showing a substantial range of over- and underestimations by the participants.

High Volatility Price (Figure 5):

The actual price of the high volatility stock at the end of the following year was $248.48. The expected price estimates had a median of $100, significantly lower than the actual price, indicating underestimation. Maximum price estimates had a median of $200, still lower than the actual price but closer, showing some overestimation variability. Minimum price estimates had a median of $50, far below the actual price, indicating substantial underestimation.

High Volatility Return (Figure 6):

The actual average daily return of the high volatility stock for the following year was approximately 0.389%. The estimated average return had a median of 0%. The estimated highest return had a median of 7%, The estimated lowest return had a median of -5%.

Based on the analysis and the resulting figures, it is evident that the participants' return estimates do not correspond to daily returns but rather to yearly returns. This is clear from the significantly high and low values reported, which are not typical for daily return estimates. The actual average daily return for the low volatility stock was approximately -0.00908%, and for the high volatility stock, it was approximately 0.389%. In contrast, participants' estimates included medians such as 7% for the highest return and -5% for the lowest return, which are more indicative of yearly returns.

When testing Hypothesis 2, the methodology should ideally follow the correct interpretation of daily returns. However, due to the apparent misunderstanding among participants, where they seem to have provided yearly return estimates instead of daily return estimates, the analysis has been adjusted accordingly. The new methodology involves treating the participants' return estimates as yearly return estimates instead of average daily return estimates. This approach helps to account for the participants' likely misinterpretation of the question.

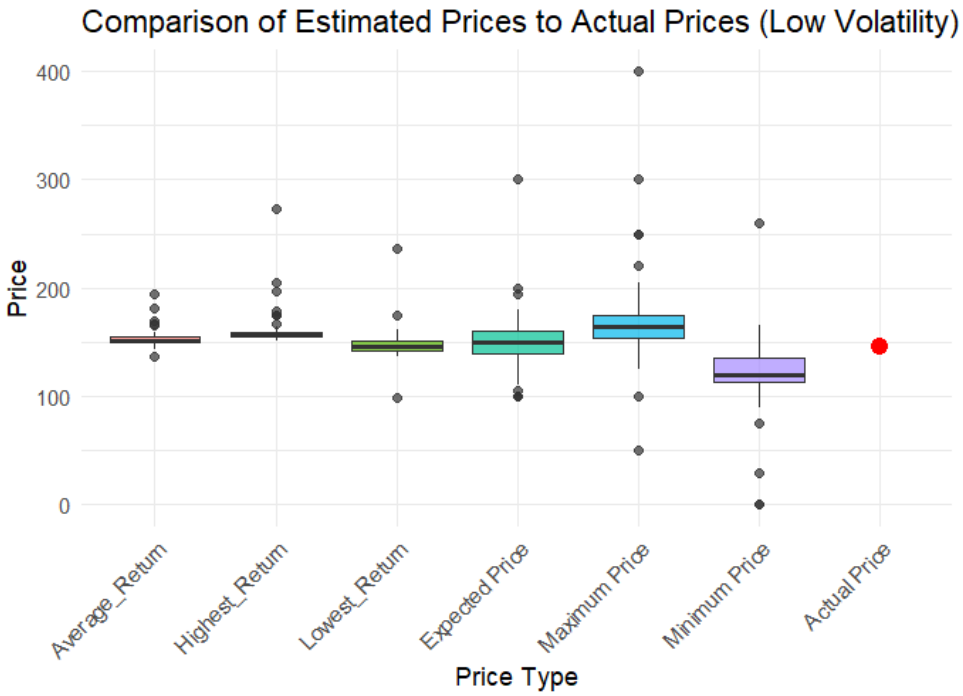

FIGURE 7. CONVERSION OF RETURN ESTIMATES TO PRICE (LOW VOLATILITY)

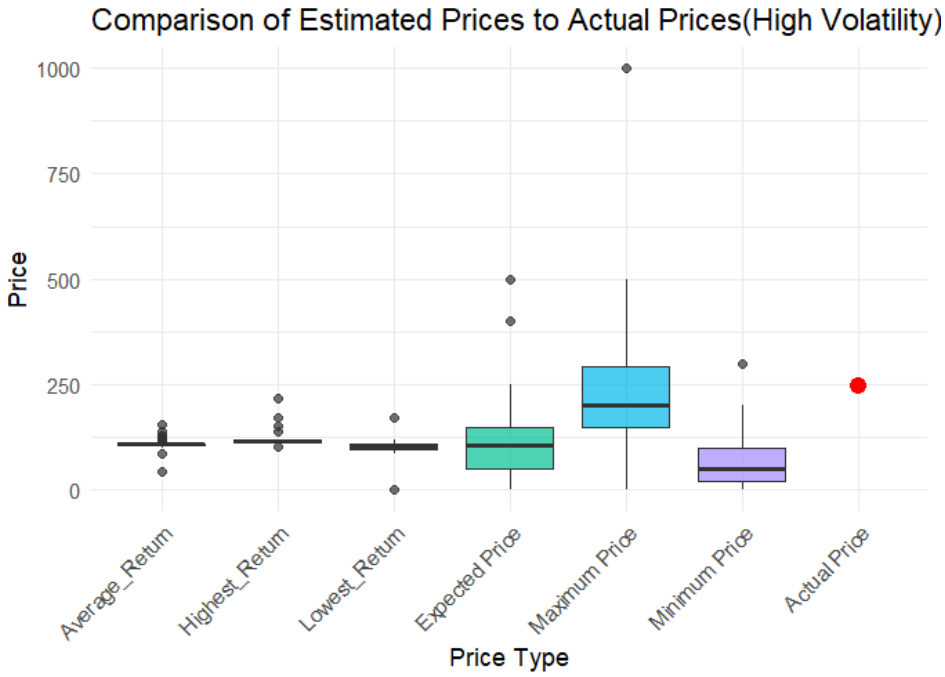

FIGURE 8. CONVERSION OF RETURN ESTIMATES TO PRICE (HIGH VOLATILITY)

To conduct a statistical comparison between the presentation format, return estimates were converted into price estimates (see figure 7 & 8 above). This allowed both types of data to be evaluated on the same scale, and tested using the Mann-Whitney U Test. The results of the boxplots are as follows:

Figure 7 (Low Volatility):
Price at the beginning of the year: $151.57 Price at end of year: $144.54
Converted Return Estimates:
Average Return Median: $151.57 * (1 + 0/100) = $151.57
Highest Return Median: $151.57 * (1 + 4/100) = $157.63
Lowest Return Median: $151.57 * (1 - 4/100) = $145.51

Figure 8 (High Volatility):
Price at the beginning of the year: $108.10. Price at end of year: $248.48
Converted Return Estimates:
Average Return Median: $108.10* (1 + 0/100) = $108.10
Highest Return Median: $108.10* (1 + 7/100) = $117.94
Lowest Return Median: $108.10* (1 - 5/100) = $103.83

For low volatility scenarios, the Mann-Whitney U test revealed a significant difference between the errors of price and return estimates ($W = 8239$, p-value = 0.00004875). The narrower range in all three of the return estimates, as shown by the boxplots, could indicate higher confidence within participants when making their risk assessments or it could also be attributed to the different scales used for returns and price graphs, where participants may perceive and estimate returns more consistently and with smaller variances than prices. These findings are reinforced by both visual and statistical analyses of the participants' estimates, which show tighter variability in the return estimates compared to the price estimates. The errors were calculated using the Mean Squared Error (MSE) formula, where MSE for price estimates is

calculated as (actual price−estimated price) ^2 and the MSE for return estimates is calculated as (actual price−converted estimated return) ^2.

Conversely, in high volatility situations, the Mann-Whitney U Test showed no significant difference between the errors of price and return estimates (W = 6347, p-value = 0.5293). The boxplot in figure 8 illustrates that return estimates are generally more centered around each other and exhibit a narrower range compared to the price estimates, which shows much wider variability. Despite the more centered return estimates, there is no significant difference in accuracy between the price and return estimates to accurately predict the actual price, as evidenced by the Mann-Whitney U Test results. This suggests that participants struggle to make accurate risk assessments under conditions of high volatility, regardless of whether they are presented with price or return data. The non-significant p-value supports the observation, that the presentation format does not notably influence the accuracy of risk assessments in such conditions. However, it can be noted that the return estimates in figure 7 & 8 both share narrower ranges compared to price estimates.

Hypothesis 2 is partially supported by these findings. The accuracy of investors' risk assessments does differ based on whether information is presented as returns or prices, but this effect is only significant in low volatility conditions. In this condition, it could be argued that returns lead to more precise and consistent estimates, aligning more closely with the actual price at the end of the year (shown by the red dot) and with tighter variability. However, in high volatility contexts, the advantage of the return format diminishes. Despite that, all three return estimates in both figures show narrower ranges than price estimates, this may be due to higher confidence by participants when estimating returns. Or it could be due to the difference in scales between price and return graphs which may lead to participants estimating tighter ranges due to smaller scales within return graphs. In conclusion, while presenting information as returns can enhance risk assessment accuracy in low volatility scenarios, its impact is significantly reduced in highly volatile scenarios.

The third hypothesis states that individuals with higher financial literacy will perceive lower risk than individuals with lower financial literacy, regardless of the presentation format. In other words, it suggests that the impact of presenting financial information with returns versus with prices on perceived risk, is influenced by the participants' level of financial literacy. To test this hypothesis, a regression analysis was conducted in a similar manner table 1 and 3 but now there were new independent variables. These being Financial Literacy (coded as 1 for those who answered both financial literacy questions correctly, and 0 otherwise) and the interaction term between Presentation Format and Financial Literacy. The distribution for Financial Literacy was 124 entries for those coded as 1 and 103 entries for those coded as 0. This distribution provides enough observations in both categories to robustly test the hypothesis.

TABLE 4. OLS REGRESSION WITH INTERACTION EFFECT BETWEEN FINANCIAL LITERACY AND FORMAT

	Dependent variable:
	Perceived Risk
Presentation Format (Return=1)	-0.112***
	(0.037)
Financial Literacy (Both tests correct=1)	-0.051
	(0.037)
Volatility (Low=1)	-0.048*
	(0.025)
Investment Knowledge-Low	-0.008
	(0.042)
Investment Knowledge-Normal	0.005
	(0.038)
Investment Knowledge-Very high	-0.011
	(0.088)
Investment Knowledge-Very low	0.012
	(0.055)
Statistical Knowledge-Low	-0.175***
	(0.046)
Statistical Knowledge-Normal	-0.034
	(0.033)
Statistical Knowledge-Very High	-0.078
	(0.062)
Statistical Knowledge-Very Low	0.058
	(0.075)
Presentation Format*Financial Literacy	0.065
	(0.050)
Constant	0.657***
	(0.043)
Observations	448
R^2	0.077
Adjusted R^2	0.051
Residual Std. Error	0.264 (df = 435)
F Statistic	3.015*** (df = 12; 435)
Note:	*p<0.1; **p<0.05; ***p<0.01

From table 4, both the financial literacy coefficient and the interaction term between financial literacy and presentation format were statistically insignificant, this suggests that the reduction in perceived risk due to presenting information as returns is not significantly different between financially literate and non-literate participants. Given these findings we must reject Hypothesis 3 as the data does not support the notion that individuals with different levels of financial literacy have significantly different levels of perceived risk.

In summary, the R^2 values across all three regression models is relatively low (ranging from 0.072 to 0.079), indicating that only about 7-8% of the variance in perceived risk is explained by the independent variables included in the models. The adjusted R^2 values are slightly lower (0.051 to 0.056), when accounting for the number of predictors. These values suggest that other factors not captured in these models are likely to influence perceived risk.

The Residual standard error values are consistent across all three models, around 0.263 to 0.264, indicating that the model's predictions typically deviate from the actual perceived risk by about 26.3% to 26.4%. This level of error represents a lot of unexplained variances in the model, which may call for additional variables or different types of models to better capture the relationship between perceived risk and the independent variables.

Meanwhile, the F-statistics for all models are significant at the 1% level, demonstrating that the models are statistically significant and are a better fit to the data than a model with no predictors. This supports the overall validity of the regression analyses and indicates that, despite the low R^2, the chosen predictors collectively contribute to explaining variations in perceived risk. Perhaps, expanding the sample size and diversity, by adding more demographic groups and participants with diverse levels of investment experience could enhance the significance of the findings.

5 Discussion and Conclusion

This thesis' study into how the presentation format (returns vs. prices) affects perceived risk revealed some intriguing findings, that both align with and diverge from previous literature regarding investor behaviour and risk perception.

Hypothesis 1 stated that investors would perceive higher risk when financial information is presented as returns rather than prices. This hypothesis comes from the assumption that since return graphs clearly illustrate the volatility of an asset through the emphasis on percentage changes throughout the year, then perceived risk would be heightened. However, the findings from the data have contradicted this expectation, showing that investors instead perceive lower risk when financial information is presented as returns. This goes against certain literature papers such as Glaser et. al, (2019) and Huber and Huber (2019).

Borsboom and Zeisberger's (2020) paper may provide a solution to these findings. Their research concludes that prominent and notable features within price paths, such as dramatic drops and jumps are key drivers of perceived risk. These factors can even overshadow the volatility metrics highlighted in return graphs. By looking at the price graphs presented to participants in Appendix A, we can see that even though the prices in the low volatility graph range from roughly 200$ to $100 and the prices in the high volatility graph range from $400 to $100, since the price graphs are not on the same scale, they seem to be equally volatile. In the case of the high volatility graph the price seems to trend downward the whole year. This could explain the results of hypothesis 1 where participants influenced by the downward trend in price, estimated the stock to be riskier than it actually is.

Regarding Hypothesis 2, which suggested that the accuracy of individuals in assessing financial risk would differ based on the presentation format, the results were mixed. There was only a significant difference between the price and return graphs with low volatility, where according to figure 7, all three return estimates medians where closer to the actual price at the end of year. With the high volatility graphs, no significant difference in the accuracy was found. However, in both cases, return estimates showed tighter variability than price estimates, this could have been either due to greater confidence among participants or due to the difference in scales between price and return graphs which may lead to tighter ranges of estimates on average.

Interestingly, the analysis revealed that there was no significant difference in perceived risk between individuals who were financially literate and those who were illiterate. Both financially literate and less literate participants perceived lower risk when presented with return graphs.

5.1 Implications

Here are the implications that can be taken from the results of this thesis. Take for instance, the levels of volatility within the assets used in the survey which have had a significant effect on the results. For example, the level of perceived risk was greater in high volatility conditions across both presentation formats. It was also more difficult for participants to accurately assess the actual price at the end of the following year for both price and returns graphs of the high volatility stock. This implies, that investment platforms and financial advisors catering to investors within highly volatile markets could grant the use of tools to enhance the understanding of investors and help them with the management of risk in these highly volatile assets. Future research could investigate different demographic groups and how they respond to volatility and presentation formats. They could also explore education and its effect on these variables.

Lastly, when it comes to implications for policymakers, since it was found that price presentations were found to increase perceived risk. Regulations could be considered that prevent investors from being misled by dramatic price graphs by presenting them with the ability to process the same information with different framing options, this will enable investors to access a balanced overall view of the asset’s risk.

5.2 Limitations

When it came to measuring the effect of perceived risk, the estimated loss probability of participants was used as a proxy. This could have been a potential limitation in the study as this requires participants to infer risk indirectly, which might not capture their perceived risk as accurately as a direct question would. Maybe the inclusion of these types of questions in future studies could provide a more accurate measure of participants' risk perceptions and enhance the robustness of the analysis.

When analyzing the results for hypothesis 2, through the creation of boxplots within figures 4 and 6, it was discovered that there was a lot of confusion among participants, as the estimates that they had supplied corresponded more closely to yearly return estimates than to daily return estimate and they were high even for yearly returns. Due to the likely chance that participants had misinterpreted the questions in the survey, the participant's daily return estimates were instead treated as yearly return estimates. The yearly return formula was used instead of the daily return formula to convert the return estimates into price estimates so that they could be compared on the same scale with the direct price estimates. The Mean squared errors were then calculated to test the hypothesis. To prevent the confusion that participants experienced in this study from happening in future research, ensuring that future questions are clearly defined and accompanied by examples to illustrate what is being asked would help mitigate confusion among future participants. For example, if daily returns estimates are requested, providing a sample calculation and answer could help clarify expectations. Additionally, if the research has the means for it, implementing a feedback mechanism during the survey could allow participants to give feedback, which if implemented properly, may enhance the clarity of the survey.

Another limitation was that the sample composition was also predominantly male and aged between 46-55, limiting the relevance and applicability of the findings. by increasing the sample size and diversity of the demographics, the findings of the thesis could be more generally applicable and robust. This problem was also present within the control variables, these being investment and statistical knowledge of participants. Here, there were not enough observations to conduct tests with statistical significance. A possible solution to this would have been to combine the categories of these variables, for example "very low" with "low" and "very high" with "high." This would combine the observations into three larger groups instead of being split across five groups, which would could be analyzed to have a greater significance due to a bigger sample size.

6 Bibliography

Aren, S., & Canikli, S. (2018). Financial literacy and financial behaviour: The mediating role of financial attitudes. Journal of Financial Education, 44(3), 213-227.

Barberis, N., Huang, M., & Santos, T. (2001). Prospect Theory and Asset Prices. The Quarterly Journal of Economics, 116(1), 1-53. https://doi.org/10.1162/003355301556310

Barber, B. M., & Odean, T. (2001). Boys will be boys: Gender, overconfidence, and common stock investment. The Quarterly Journal of Economics, 116(1), 261-292. https://doi.org/10.1162/003355301556400.

Beshears, J., Choi, J. J., Laibson, D., & Madrian, B. C. (2009). The importance of default options for retirement savings outcomes: Evidence from the United States. In Social Security Policy in a Changing Environment. University of Chicago Press.

Borsboom, C., & Zeisberger, S. (2020). What makes an investment risky? An analysis of price path characteristics. Journal of Behavioural Finance, 21(4), 365-383. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3392623

Costa, V. M., De Sá Teixeira, N. A., Cordeiro Santos, A., & Santos, E. (2021). When more is less in financial decision-making: financial literacy magnifies framing effects. Psychological Research, 85, 2036–2046. https://doi.org/10.1007/s00426-020-01372-7

Glaser, M., Langer, T., Reynders, J., & Weber, M. (2007). Framing Effects in Stock Market Forecasts: The Difference Between Asking for Prices and Asking for Returns. Review of Finance, 11(2), 325-357. https://doi.org/10.1093/rof/rfm008

Glaser, M., Iliewa, Z., & Weber, M. (2019). Thinking about Prices versus Thinking about Returns in Financial Markets. The Journal of Finance, 74(6), 2997-3039. DOI: 10.1111/jofi.12835

Hanaki, N., Hommes, C., Kopányi, D., Kopányi-Peuker, A., & Tuinstra, J. (2023). Forecasting returns instead of prices exacerbates financial bubbles. Experimental Economics, 26, 1185–1213. https://doi.org/10.1007/s10683-023-09815-9

Holzmeister, F., Huber, J., Kirchler, M., Lindner, F., Weitzel, U., & Zeisberger, S. (2020). What Drives Risk Perception? A Global Survey with Financial Professionals and Laypeople.

Management Science, 66(9), 3977-4002. https://doi.org/10.1287/mnsc.2019.3526

Huber, C., & Huber, J. (2019). Scale matters: risk perception, return expectations, and investment propensity under different scalings. Experimental Economics, 22, 76–100. https://doi.org/10.1007/s10683-018-09598-4

Kahneman, D., & Tversky, A. (1979). Prospect Theory: An Analysis of Decision under Risk. Econometrica, 47(2), 263-291.

Korkmaz, A. G., Yin, Z., Yue, P., & Zhou, H. (2021). Does financial literacy alleviate risk attitude and risk behavior inconsistency? International Review of Economics and Finance, 74, 293-310. https://doi.org/10.1016/j.iref.2021.03.002

Kunreuther, H., Pauly, M. V., & McMorrow, S. (2013). Insurance and Behavioral Economics: Improving Decisions in the Most Misunderstood Industry. Cambridge University Press. https://doi.org/10.1017/CBO9781139236363

Lusardi, A., & Mitchell, O. S. (2007). Financial Literacy and Retirement Preparedness: Evidence and Implications for Financial Education. Business Economics, 42(1), 35-44. https://doi.org/10.2145/20070104

Markowitz, H. (1952). Portfolio Selection. The Journal of Finance, 7(1), 77-91.

Tversky, A., & Kahneman, D. (1981). The framing of decisions and the psychology of choice. Science, 211(4481), 453–458.

Reinholtz, N., Maglio, S. J., & Spiller, S. A. (2021). Stocks, flows, and risk response to pandemic data. Journal of Experimental Psychology: Applied, 27(4), 657–668. https://doi.org/10.1037/xap0000395

Spiller, S. A., Reinholtz, N., & Maglio, S. J. (2020). Judgments Based on Stocks and Flows: Different Presentations of the Same Data Can Lead to Opposing Inferences. Management Science, 66(5), 2213-2231. https://doi.org/10.1287/mnsc.2019.3284

Thaler, R., & Sunstein, C. (2008). Nudge: Improving decisions about health, wealth, and happiness. Yale University Press

Zeisberger, S. (2023). What is risk? Available at SSRN 2811636.

7 Appendix A

7.1 Price Graphs and Questions

Below is a time series graph of the closing prices of a stock for 1 year. The closing price is the last price at which the stock trades during a regular trading session. Sharp peaks or valleys in the line represent significant increases or decreases in the stock price on those dates. A steady line suggests the stock price is relatively stable with little change from day to day.

The horizontal axis at the bottom, represents time, marked by dates.

The vertical axis on the left, shows the stock's closing price in U.S. dollars. Each point on the line corresponds to the stock's closing price for a given day. In this case, it is for 252 trading days in total.

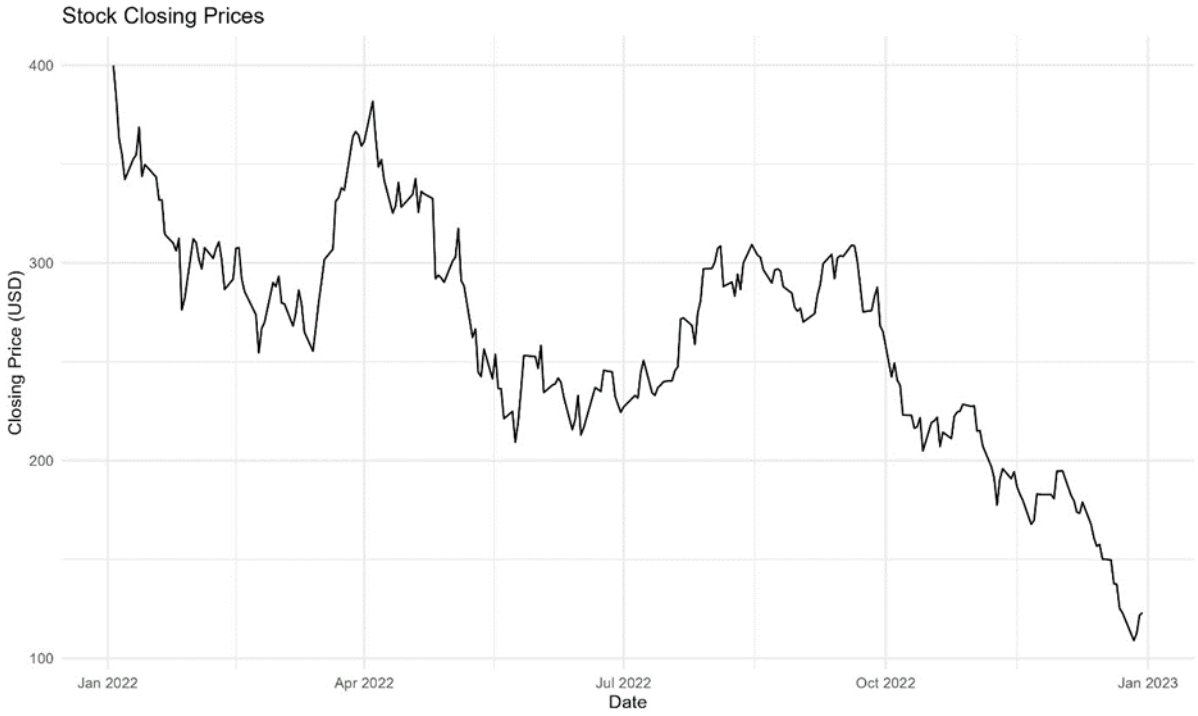

FIGURE 9. HIGH VOLATILITY STOCK PRICE GRAPH

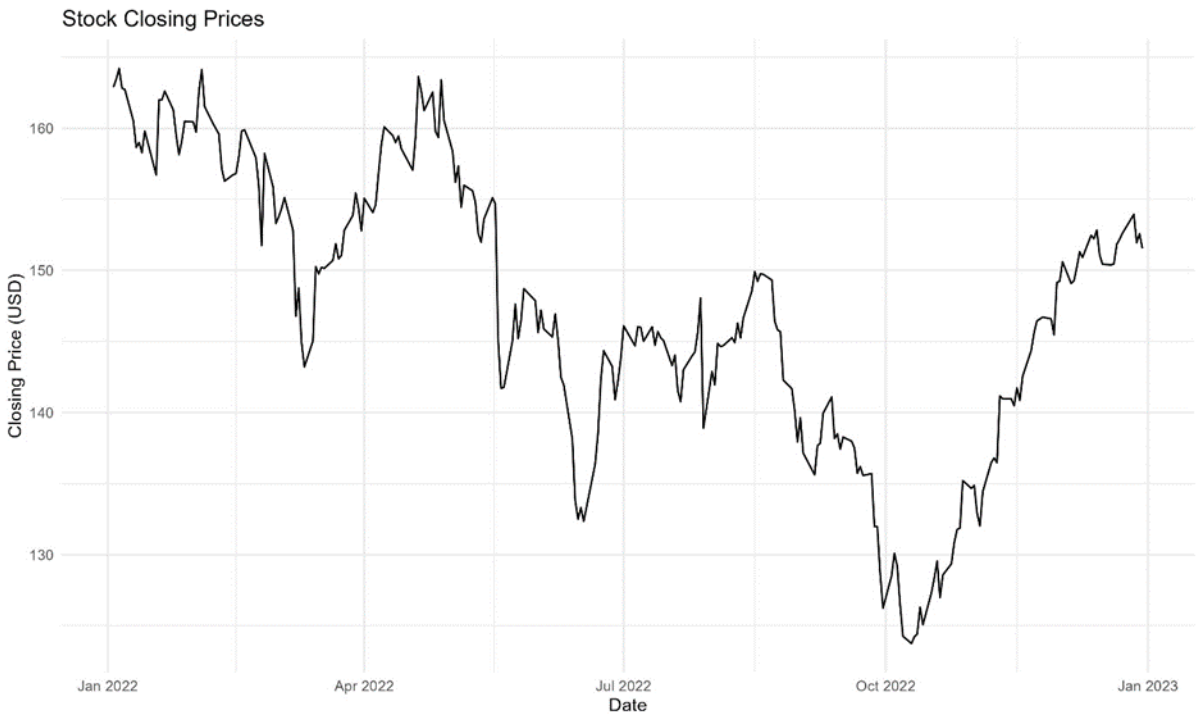

FIGURE 10. LOW VOLATILITY STOCK PRICE GRAPH

Q1: After looking at this price graph for 2022, what do you think could be the expected price of the stock at the end of 2023?

Q2: What do you think might be the highest price of the stock at the end of 2023?

Q3: What do you think might be the lowest price of the stock at the end of 2023?

Q4: By looking at this graph what is your estimated likelihood that the price at the end of 2023 will be lower than the price in January 2023? Please write your answer as a percentage. (Between 0 and 100)

7.2 Return Graphs and Questions

Below is a daily returns graph which represents the percentage change (return) in the price of a random stock from one day to the next, over 1 year. It is a way to visualize how much the value of the stock is going up or down each day.

Bars stretching upwards (above the zero line) represent days when the stock price increased. The higher the bar, the bigger the gain for that day. Bars stretching downwards (below the zero line) indicate days when the stock price decreased. The lower the bar, the more significant the loss for that day.

The horizontal axis at the bottom, represents time, marked by dates. In this case, it is for 252 trading days in total.

The vertical axis on the left side shows the returns, which are labelled as percentages. This indicates the daily gain or loss of the stock value.

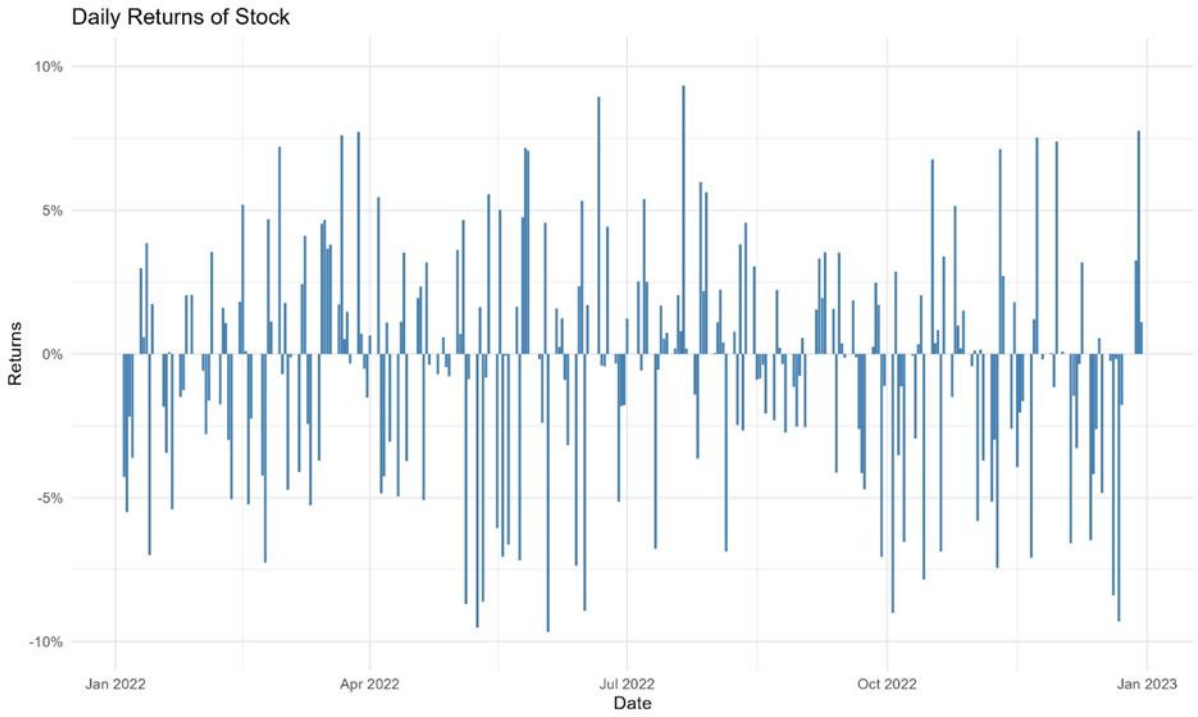

FIGURE 11. HIGH VOLATILITY STOCK RETURN GRAPH

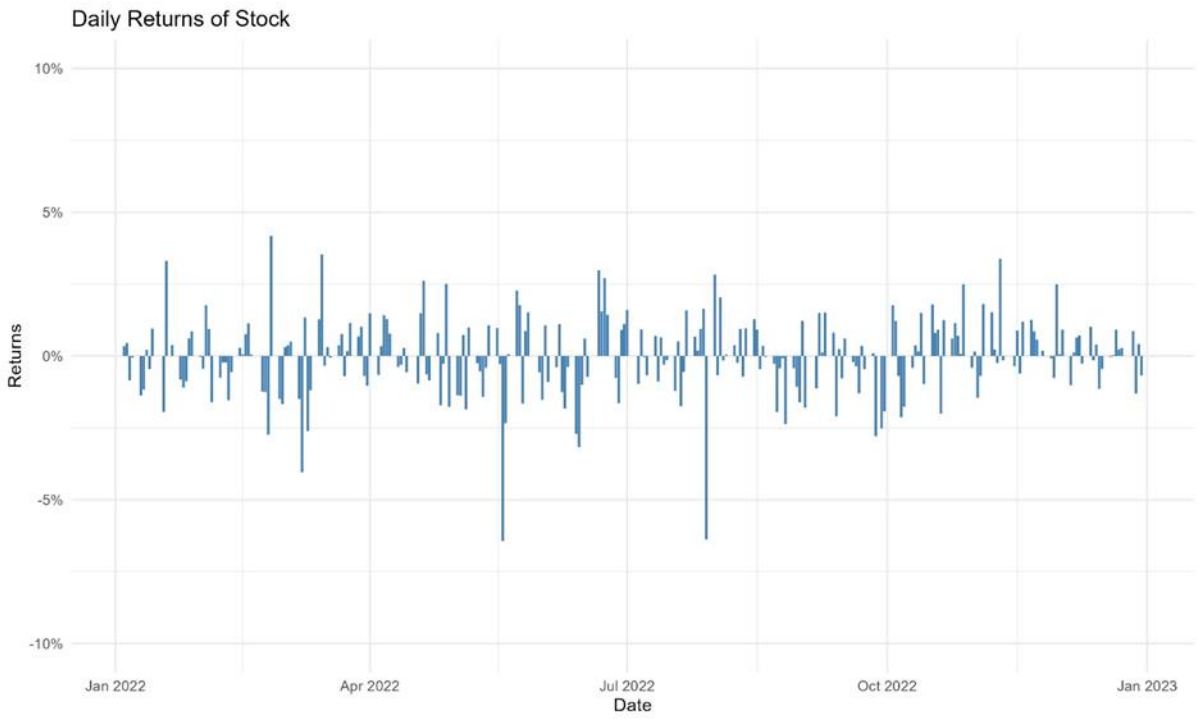

FIGURE 12. LOW VOLATILITY STOCK RETURN GRAPH

Q1: Given the daily returns graph for 2022, what do you think could be the expected average daily return of the stock for the following year (over the entire year of 2023)? Please provide your answer as a percentage. Note: Return unlike price can also be negative.

Q2: What do you think might be the highest average daily return of the stock for 2023? Please provide your answer as a percentage.

Q3: What do you think might be the lowest average daily return of the stock for 2023? Please provide your answer as a percentage.

Q4: What do you estimate is the likelihood that the average daily return for 2023 will be negative? Please write your answer as a percentage (between 0 and 100).

8 Appendix B

8.1 Demographic Questions

Q1: Which country are you from?

Q2: What is your gender?

- ○ Male
- ○ Female

Q3: what is your age range?

- ○ 18 - 25
- ○ 26 - 35
- ○ 36 - 45
- ○ 46 - 55
- ○ 56 - 65
- ○ 65+

Q4: What is your level of education?

- ○ Middle/Secondary School
- ○ High School/Sixth Form
- ○ Currently Undergrad
- ○ Undergraduate degree
- ○ Currently Postgrad
- ○ Postgraduate degree

8.2 Financial Literacy Measurement Questions

Q1: How would you describe your knowledge about investments compared to the average person?

	Very low	low	normal	high	Very high
※ Knowledge of Investments	○	○	○	○	○

Q2: How would you describe your knowledge about statistics compared to the average person?

	Very Low	Low	Normal	High	Very High
Knowledge of Statistics	○	○	○	○	○

Q3: Normally, stocks display lower price and return fluctuations than bonds over time. Is this statement true or false?

- ○ True
- ○ False
- ○ Do not Know

Q4: Considering a long-term period (for example 10 or 20 years), stocks normally give a higher return than bonds. Is this statement true or false?

- ○ True
- ○ False
- ○ Do not Know

9 Appendix C

9.1 Data Overview

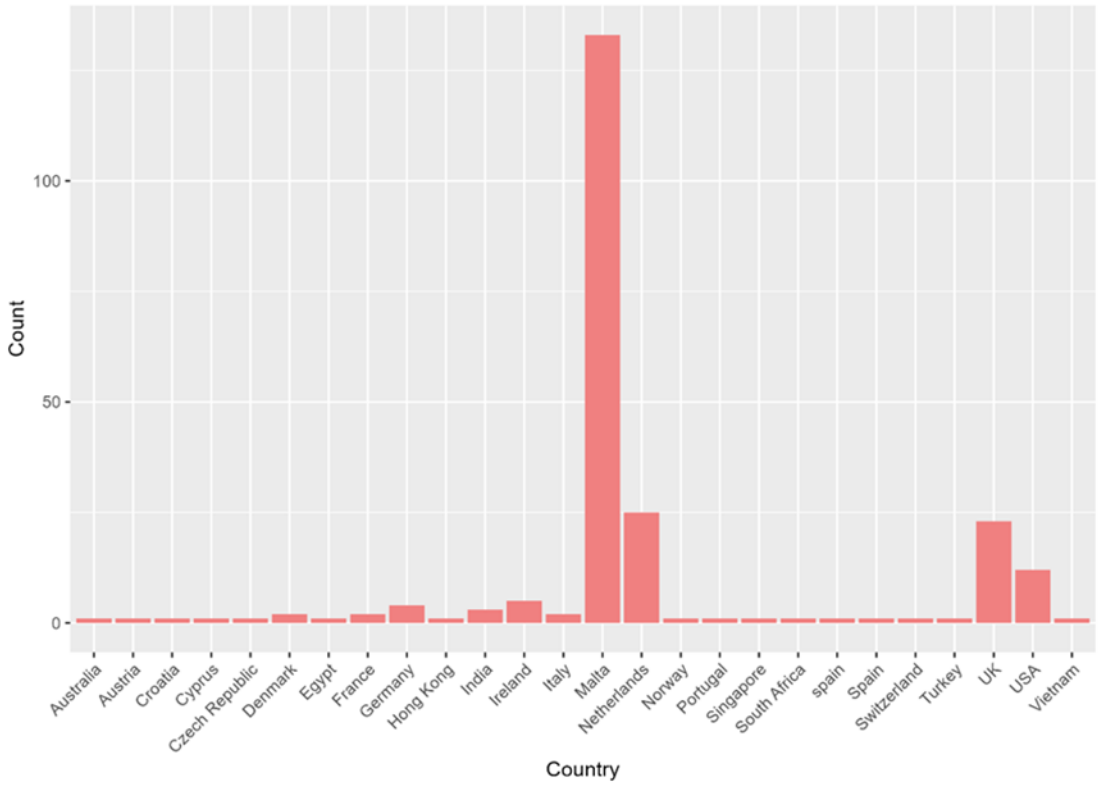

FIGURE 13. DISTRIBUTION OF COUNTRY

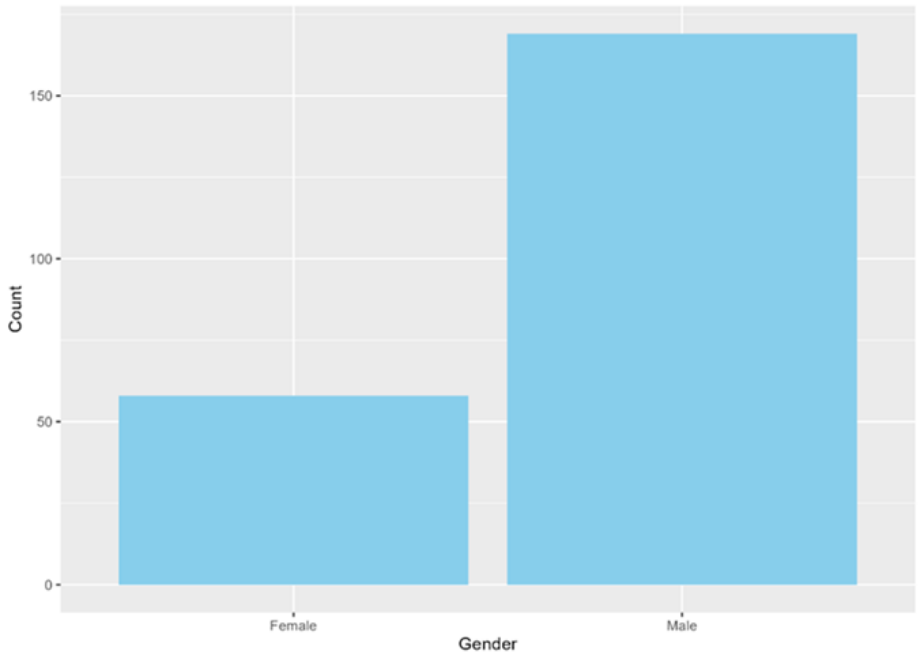

FIGURE 14. DISTRIBUTION OF GENDER

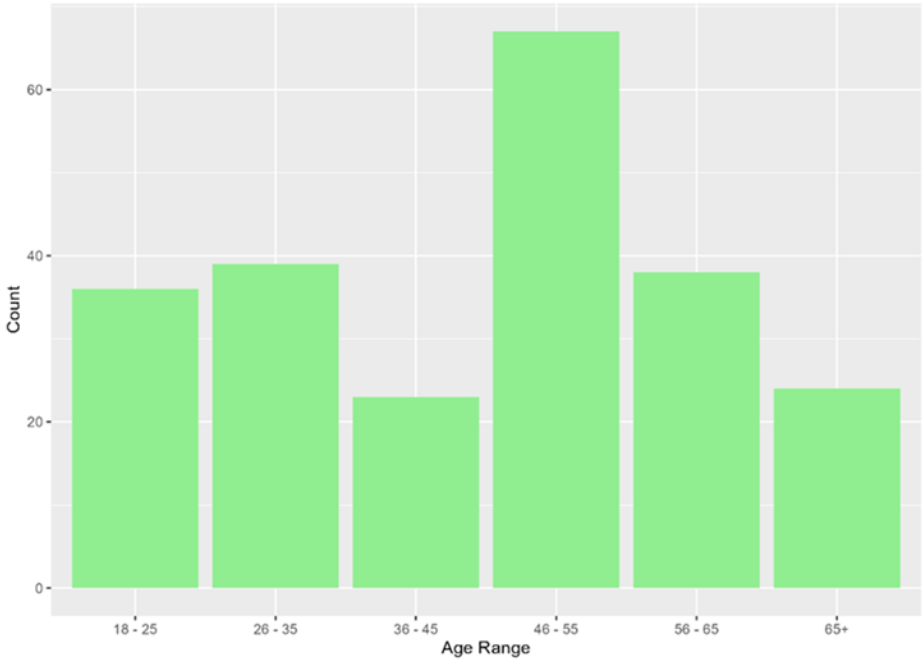

FIGURE 15. DISTRIBUTION OF AGE RANGE