

INFORMATION DESIGN AS A TOOL TO REDUCE EMOTIONAL BIASES IN FINANCIAL DECISION-MAKING: A COMPARATIVE STUDY

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ABSTRACT

Introduction: Cognitive biases and emotions play a large role in financial decisions. Information design, on the other hand, has been developed to improve how information is presented, making it clearer, more usable, and delivered at the right time. This article compares and contrasts decision-making and information design. The study investigates the potential of information design to reduce the negative effects of emotional biases in financial decision-making. In order to support this study, theories on decision making (Kahneman and Tversky's Prospect Theory) and information design (Tufte's book on the visual display of quantitative information) are combined with recent research in behavioral finance and human-information interaction. The study also describes how a single design can function as a cognitive buffer and presents a conceptual framework for applying design to mitigate financial decision-making biases, such as loss aversion, herding, and overconfidence. The study draws on research in psychology, economics, and design studies.

Objective: The objective of this study is to examine how information design can mitigate emotional and cognitive biases in financial decision-making, focusing on loss aversion, overconfidence, and herd behavior.

Theoretical Framework: The research is grounded in Kahneman and Tversky's Prospect Theory (1979), behavioral finance studies (Thaler, 2015), and information design principles from Tufte (1983, 1990, 1997), Bertin (1983), and human-information interaction frameworks (Horn, 1999; Albers, 2012). These models provide a foundation for understanding the intersection between decision-making and information environments.

Method: A comparative and bibliographic strategy was adopted. Academic papers, books, and systematic reviews published between 2015 and 2026 were analyzed. Grounded Theory coding identified categories of biases and design principles, complemented by bibliometric mapping to strengthen validity.

Results and Discussion: Findings show that emotional biases strongly influence investors' decisions, especially under uncertainty. Information design, by reducing ambiguity, cognitive overload, and distortion, can act as a cognitive buffer. Case studies such as the 2008 financial crisis and cryptocurrency volatility illustrate how dashboards and clear visualizations could improve rationality in decision-making.

Research Implications: The study offers practical insights for financial institutions, regulators, and designers, emphasizing transparency, trust, and stability in financial markets.

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Originality/Value: This research contributes by integrating behavioral finance and information design into a conceptual framework, offering innovative solutions to reduce emotional biases and enhance rational financial decisions.

Keywords: decision-making, cognitive biases, heuristics, behavioral finance.

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O DESIGN DE INFORMAÇÃO COMO FERRAMENTA PARA REDUZIR OS VIÉSÉS EMOCIONAIS NA TOMADA DE DECISÕES FINANCEIRAS: UM ESTUDO COMPARATIVO

RESUMO

Introdução: Vieses cognitivos e emoções desempenham um papel importante nas decisões financeiras. O design da informação, por outro lado, foi desenvolvido para melhorar a forma como a informação é apresentada, tornando-a mais clara, utilizável e entregue no momento certo. Este artigo compara e contrasta a tomada de decisão e o design da informação. O estudo investiga o potencial do design da informação para reduzir os efeitos negativos dos vieses emocionais na tomada de decisões financeiras. Para apoiar esse estudo, teorias sobre tomada de decisão (Teoria da Perspectiva, de Kahneman e Tversky) e design da informação (o livro de Tufte sobre a exibição visual de informação quantitativa) são combinadas com pesquisas recentes em finanças comportamentais e interação humano-informação. O estudo também descreve como um único design pode funcionar como um amortecedor cognitivo e apresenta um arcabouço conceitual para aplicar o design a fim de mitigar vieses na tomada de decisões financeiras, como aversão à perda, pastoreio e excesso de confiança. O estudo se baseia em pesquisas em psicologia, economia e estudos de design.

Objetivo: O objetivo é analisar práticas de design da informação como mecanismos corretivos para vieses cognitivos e emocionais, tais como aversão à perda, excesso de confiança e comportamento de manada, com foco em ambientes de decisão financeira.

Referencial Teórico: A pesquisa se apoia na Teoria da Perspectiva de Kahneman e Tversky (1979), que explica a aversão à perda, e em estudos de finanças comportamentais (Thaler, 2015). Também utiliza referenciais de design da informação, como Tufte (1983, 1990, 1997) sobre visualização de dados, Bertin (1983) sobre semiologia gráfica e pesquisas em interação humano-informação (Horn, 1999; Albers, 2012).

Método: O estudo adota uma estratégia comparativa e bibliográfica. Foram analisados artigos, livros e revisões acadêmicas publicados entre 2015 e 2026. A análise seguiu princípios da Grounded Theory, categorizando vieses cognitivos e princípios de design da informação, complementada por mapeamento bibliométrico.

Resultados e Discussão: Os resultados mostram que vieses como aversão à perda, excesso de confiança e comportamento de manada afetam fortemente investidores. O design da informação, ao reduzir sobrecarga cognitiva, ambiguidade e distorções, pode funcionar como um “buffer cognitivo”. Casos como a crise de 2008 e a volatilidade das criptomoedas ilustram como dashboards e visualizações claras poderiam mitigar decisões impulsivas.

Implicações da Pesquisa: As implicações incluem recomendações para instituições financeiras, reguladores e designers, visando maior transparência, confiança nos mercados e estabilidade financeira.



Originalidade/Valor: O estudo contribui ao integrar finanças comportamentais e design da informação em um quadro conceitual, oferecendo soluções práticas para reduzir vieses emocionais e melhorar a racionalidade das decisões financeiras.

Palavras-chave: tomada de decisão, vieses cognitivos, finanças comportamentais, heurísticas, design da informação.

EL DISEÑO DE LA INFORMACIÓN COMO HERRAMIENTA PARA REDUCIR LOS SESGOS EMOCIONALES EN LA TOMA DE DECISIONES FINANCIERAS: UN ESTUDIO COMPARATIVO

RESUMEN

Introducción: Los sesgos cognitivos y las emociones juegan un papel importante en las decisiones financieras. El diseño de la información, por otro lado, se ha desarrollado para mejorar la forma en que se presenta la información, haciéndola más clara, útil y entregada en el momento adecuado. Este artículo compara y contrasta la toma de decisiones y el diseño de la información. El estudio investiga el potencial del diseño de información para reducir los efectos negativos de los sesgos emocionales en la toma de decisiones financieras. Para apoyar este estudio, se combinan teorías sobre la toma de decisiones (la teoría de la perspectiva de Kahneman y Tversky) y el diseño de la información (el libro de Tufte sobre la visualización de la información cuantitativa) con investigaciones recientes en finanzas conductuales e interacción humano-información. El estudio también describe cómo un único diseño puede funcionar como un amortiguador cognitivo y presenta un marco conceptual para aplicar el diseño y mitigar sesgos en la toma de decisiones financieras, como la aversión a la pérdida, el mantenimiento de animales y la sobreconfianza. El estudio se basa en investigaciones en psicología, economía y estudios de diseño.

Objetivo: El objetivo es analizar prácticas de diseño de la información como mecanismos correctivos frente a sesgos cognitivos y emocionales, tales como aversión a la pérdida, exceso de confianza y comportamiento de manada, en entornos de decisión financiera.

Marco Teórico: La investigación se basa en la Teoría de la Perspectiva de Kahneman y Tversky (1979), que explica la aversión a la pérdida, y en estudios de finanzas conductuales (Thaler, 2015). También utiliza referentes de diseño de la información, como Tufte (1983, 1990, 1997) sobre visualización de datos, Bertin (1983) sobre semiología gráfica y estudios de interacción humano-información (Horn, 1999; Albers, 2012).

Método: El estudio adopta una estrategia comparativa y bibliográfica. Se analizaron artículos, libros y revisiones académicas publicados entre 2015 y 2026. El análisis siguió principios de la Grounded Theory, categorizando sesgos cognitivos y principios de diseño de la información, complementado con mapeo bibliométrico.

Resultados y Discusión: Los resultados muestran que sesgos como aversión a la pérdida, exceso de confianza y comportamiento de manada afectan fuertemente a los inversores. El diseño de la información, al reducir la sobrecarga cognitiva, la ambigüedad y las distorsiones, puede funcionar como un “amortiguador cognitivo”. Casos como la crisis de 2008 y la volatilidad de las criptomonedas ilustran cómo paneles de control y visualizaciones claras podrían mitigar decisiones impulsivas.

Implicaciones de la investigación: Las implicaciones incluyen recomendaciones para instituciones financieras, reguladores y diseñadores, orientadas a una mayor transparencia, confianza en los mercados y estabilidad financiera.



Originalidad/Valor: El estudio contribuye al integrar finanzas conductuales y diseño de la información en un marco conceptual, ofreciendo soluciones prácticas para reducir sesgos emocionales y mejorar la racionalidad de las decisiones financieras.

Palabras clave: toma de decisiones, sesgos cognitivos, finanzas conductuales, heurísticas, diseño de la información.

1 INTRODUCTION

Decision-making under uncertainty has been a subject of research for decades across economics, psychology, and organizational studies. Well-known are the mental shortcuts, or heuristics, identified by Kahneman and Tversky (1974, 1979) for decisions under uncertainty, and the subsequent research into deviations from the predictions of rational-choice models. Perhaps the most well-known is the work on Prospect Theory (Kahneman and Tversky 1979), in which, among other things, loss aversion is explained. This phenomenon describes how individuals are more sensitive to losses than to gains of the same size. Since then, many researchers, including the so-called behavioral economists, have built upon this work, including Thaler (2015), who applies the insights to the study of financial markets, where biases such as overconfidence, herding, and framing lead to a wide array of market anomalies.

More research has been conducted on information design and how information can be presented to improve decisions. The majority of this research focuses on the design of information in order to make it clear, usable, and adequate for decision-making. Tufte (1983, 1990, 1997) has conducted extensive research on data visualization and on how to present information using graphs and charts to support decision-making. Other research has been conducted on the area of human-information interaction, such as Horn (1998, 1999) and Albers (2012). These researchers have developed frameworks that combine ethical and cognitive perspectives on information design. Instead of just providing information, the aim of information design is to support users, reducing cognitive overload, avoiding ambiguity, and increasing accessibility.

A comparison between decision-making and information design has significant potential. In the first place, research into decision-making under uncertainty can reveal human beings' vulnerabilities and the influence of emotional biases on decision-making. In the second place, information design can offer a number of tools to counter these vulnerabilities by designing information environments that are clear, neutral, and user-



centered. In this way, information design can function as a cognitive buffer to prevent investors from being driven by fear, by euphoria, or by herding behavior.

This article presents a comparative study of the decision-making with respect to uncertainty and the information design. To help investors invest in financial markets more effectively, this article presents a framework for using information design to reduce emotional biases in decision-making. This framework uses the main principles of information design for counteracting the main decision biases, i.e., loss aversion, overconfidence, and herding, and it uses insights from behavioral finance, psychology, and design studies.

2 LITERATURE REVIEW

2.1 DECISION-MAKING AND EMOTIONAL BIASES

2.1.1 Heuristics and biases

Heuristics and Biases that affect decision makers in uncertain situations have been well studied. There are many well-known ‘rules of thumb that were first identified in the work on heuristics and biases by Kahneman and Tversky (1974). For example, availability, representativeness, and anchoring are some of the most widely known. In addition, a number of other biases have been studied in more recent work (Slovic, Fischhoff, and Lichtenstein, 1982). These biases are not limited to laypeople's decisions and affect both organizations and individuals with considerable financial experience.

2.1.2 Prospect theory and loss aversion

One of the foundational papers in behavioral finance is Prospect Theory: An Analysis of Decision Under Risk by Daniel Kahneman and Amos Tversky (1979). This paper examines how individuals perceive risk when making decisions. The authors present the key point that most individuals evaluate risk with respect to a reference point. For example, an individual who purchases a stock expecting it to rise is deemed to have suffered a loss when the stock declines in value, even if it later increases. The authors describe this phenomenon as due to loss aversion. The authors describe loss aversion as



the tendency for losses to have a greater impact on an individual's behavior and perceptions than gains of similar magnitude. For example, an individual who purchases a stock expecting it to rise may hold onto it in the hope of selling it later at a higher price. Conversely, an individual who purchases a stock expecting it to rise will quickly sell it to realize a profit if it increases in value.

2.1.3 Emotional influences

The impact of emotional factors in financial decisions has been studied in considerable detail. Even when given all relevant information, an individual's decisions are found to be influenced by the way in which they feel about possible outcomes. This term is often referred to as 'risk as feelings' and has been extensively researched by Loewenstein, Weber, and Wendel (2001). Further research on risk as a feeling has established that negative emotions, particularly, can have a considerable impact on an individual's risk assessment and subsequent behavior (Lerner *et al.*, 2015). For example, it has been found that investors who are fearful are more likely to invest in riskier assets, whilst those who are angry are more likely to choose volatile assets. Indeed, recent research has found support for the influence that individual investors' emotions have on asset prices (Hasan *et al.*, 2024). A systematic review of the extensive body of evidence that supports the view that a range of financial market anomalies can be explained by the emotional responses of individual investors has also been published (Goodell *et al.*, 2023).

2.1.4 Overconfidence

Overconfidence bias occurs when an investor believes that he has more knowledge than he actually does. As a result of this bias, he makes too many trades (Pikulina *et al.*, 2017). Herd Behavior: In financial decision-making, individuals follow others, thereby amplifying volatility in financial markets (Banerjee, 1992; Scharfstein & Stein, 1990). The Disposition Effect: Investors are said to have the disposition effect when they tend to sell their winning investments and hold on to their losing ones. From a rational investor's perspective, this behavior is clearly irrational as it contradicts their goals. (Statman, 2017)



2.2 INFORMATION DESIGN PRINCIPLES

2.2.1 Visual clarity and data representation

The work of Tufte (*The Visual Display of Quantitative Information*, 1983) and others (Bertin's *Semiology of Graphics*, 1983) is important because they have established guidelines for effective information design and provided tools for making data visible. Good information design supports understanding by keeping information visible and preventing distortion. The main rule in Tufte's book is that the data-ink should be as much as possible in comparison with the other elements in the chart (chartjunk).

2.2.2 Human-information interaction

Human-Information Design studies the way people interact with information in general, as did Carliner (2001, 2000), and Carliner *et al.*, (2006). For technical communication, issues of usability, accessibility, and cognitive ergonomics on the part of the way in which users interact with information in general are very important. The design of visual language (or visual communication) across languages worldwide is another important issue that has been studied by Horn (1998, 1999).

2.2.3 Accessibility and ethics

Finally, information design also deals with ethical aspects and the Accessibility of information. Amare & Manning (2013) developed a unified theory of information design: information design visuals, information design text, and ethics of information design. In technical communication, Jarrett *et al.* (2013) introduced a book on web content design for people who do not read easily. Their core message is that information design can communicate effectively to people who do not read easily.

2.3 COMPARATIVE INSIGHTS FROM LITERATURE

While research into the financial decisions of man and woman highlights their vulnerabilities to certain biases when dealing with financial products and services in



financial contexts, the information design attempts to structure the information environment in such environments in order to reduce possible ambiguity and to reduce the given information to that which is necessary in order to alleviate possible information overload. Clear information design for user groups can thus also counteract emotional biases in financial decision-making.

3 METHODOLOGY

3.1 RESEARCH STRATEGY

The research strategy adopted for this research study is comparative and bibliographic. The two major domains of knowledge that are drawn upon for this study are those of decision-making/behavioral finance and of information design/human-information interaction. With respect to the two domains of knowledge drawn upon in this study, the focus in the decision-making/behavioral finance domain is on a description of the major cognitive biases and heuristics that affect financial decisions and on the roles emotions play in financial decisions. The information design/human-information interaction is treated in this study from the perspective of issues of clarity, usability, and accessibility with respect to complex information. A major goal of this study is to develop a conceptual framework outlining how information design principles can affect financial decision-making.

3.2 DATA COLLECTION

The studies selected for this research are mainly academic papers, articles, reviews, and books, written for an academic audience and published in a variety of journals, books, and systematic reviews. The selected studies relate to decision-making (e.g., Kahneman and Tversky's work on Prospect Theory; Thaler's work on behavioral finance) and to information design (e.g., Tufte's work on information visualization). The majority of the studies in the corpus were published between 2015 and 2026.



3.3 DATA ANALYSIS

To examine the corpus of literature for this research, three analyses were conducted. In the first place, by employing the method of Grounded Theory, the two bodies of literature (decision making and information design) were analyzed in order to identify the themes for both sets of literature and to subsequently categorize in as much detail as possible the range of different types of cognitive biases and other emotional influences on decision making, as well as the range of different information design principles. The categories derived from the two bodies of literature provide a basis for comparing how different types of information design can be utilized across a wide range of financial decision-making contexts to reduce various emotional biases.

4 COMPARATIVE ANALYSIS

4.1 EMOTIONAL BIASES IN FINANCIAL DECISION-MAKING

Cognitive and emotional biases in investors' financial decision-making have been extensively studied. Investors are subject to loss aversion, which causes them to weigh losses more than gains of similar size, a core feature of Prospect Theory (Kahneman & Tversky, 1979). Overconfidence leads investors to overtrade, resulting in excessive risk in pursuit of higher returns (Pikulina *et al.*, 2017). Herd behavior increases price volatility as investors imitate others, lacking sufficient knowledge or skills to make independent financial decisions (Banerjee, 1992; Scharfstein & Stein, 1990). A host of other negative emotions (fear, anxiety, euphoria, etc.) influence financial decisions at an unconscious level and, in turn, affect how an investor rationally processes financial information (Hasan *et al.*, 2024; Goodell *et al.*, 2023).

4.2 INFORMATION DESIGN AS A CORRECTIVE MECHANISM

Information design is the process of creating information so that it is clear, usable, and accessible. In financial decisions, information design can reduce data distortion and present information in a way that is easier to process and to make decisions with. Tufte (1983, 1990, 1997) wrote several books on information design in which he describes how



effective data visualization can reduce distortion. A well-designed information representation makes information more understandable. Bertin (1983) developed a semiological framework for the representation of quantitative information. Albers (2012) and Horn (1999) discuss the topic of human-information interaction. Information design for this topic must take into account the limitations of human cognition and the diversity of users. Information design can help to counteract the emotional triggers of biased decisions. It reduces ambiguity and cognitive overload and avoids the use of heuristics.

4.3 CASE STUDIES AND APPLICATIONS

To improve financial decision-making by reducing the impact of various emotional biases, information design can be useful in many situations. For example, during the 2008 financial crisis, investors succumbed to herd behavior and loss aversion, panic-selling their portfolios without realizing the full extent of their exposure. In such a time of extreme uncertainty, clear risk communication and the use of standardized visualizations of exposure could have led to better financial decisions by investors. Recently, there have been extreme price swings in cryptocurrency markets, and many investors have suffered from overconfidence and the framing effect, which have influenced their financial decisions. In this context, the use of financial information dashboards could improve investor decision-making, for example, by clearly displaying data uncertainty and presenting confidence intervals. As can be seen from the highly volatile market of cryptocurrencies, the influence that financial information design has on a person's financial decisions can be immense, and there are many situations where such information design can aid in financial decision-making, for example, in the case of the COVID-19 pandemic, where there has been extreme fear and uncertainty among investors to make any financial decisions. By the use of online information, such as an online financial information dashboard, providing the investor with clear and transparent information, such as the current rate of infection as well as economic data, it can aid in making better financial decisions, while being less affected by panic and extreme fear, and making more informed financial decisions in the face of such uncertainty. Table 1 shows a comparative analysis:



Table 1

Comparative Analysis

Dimension	Decision-Making Literature	Information Design Literature	Comparative Insight
Theoretical Foundations	Prospect Theory emphasizes loss aversion and framing effects (Kahneman & Tversky, 1979; Kahneman et al., 1982). Behavioral finance highlights heuristics and biases such as overconfidence and herd behavior (Banerjee, 1992; Scharfstein & Stein, 1990).	Principles of clarity and precision in visualization (Tufte, 1983, 1990, 1997). Semiological frameworks for graphics (Bertin, 1983). Human-information interaction models stress usability and accessibility (Albers, 2012; Horn, 1999).	Decision-making reveals vulnerabilities in cognition, while information design provides corrective mechanisms through clarity and usability.
Role of Emotions	Emotions such as fear, anger, and euphoria distort rational evaluation (Loewenstein et al., 2001; Lerner et al., 2015; Hasan et al., 2024). Investor sentiment influences asset prices and market anomalies (Goodell et al., 2023).	Design seeks emotional neutrality by structuring information environments that minimize affective triggers (Amare & Manning, 2013; Jarrett et al., 2013).	Emotional biases can be mitigated by neutral and accessible design strategies that reduce panic-driven or euphoric reactions.
Cognitive Load	Reliance on heuristics increases under conditions of complexity and uncertainty (Slovic et al., 1982; Hirshleifer, 2015).	Information design reduces cognitive overload by simplifying complex data and enhancing comprehension (Carliner, 2000, 2006; Redish, 2000).	Simplification and clarity in design can reduce reliance on heuristics, supporting more rational decision-making.
Practical Applications	Financial crises, cryptocurrency markets, and pandemic-related volatility illustrate the impact of biases on investor behavior (Cevik et al., 2022; Liu et al., 2020).	Dashboards, visualizations, and accessible communication frameworks improve comprehension and reduce misinterpretation (Tufte, 1997; Jarrett & Gaffney, 2009).	Case studies show that design interventions can buffer against biases in high-stress financial contexts.
Integration Potential	Behavioral anomalies highlight the need for corrective mechanisms (Statman, 2017; Thaler, 2015).	Information design offers tools for structuring data environments that promote rationality (Horn, 1998; Albers, 2012).	Integration suggests that information design can serve as a cognitive buffer, reducing the likelihood of biased financial decisions.

Source: Adapted from the authors

Table 1 examines the intersection of research on decision-making and information design. Information design studies information that is presented in a clear, usable, and



accessible form. The researcher studies how humans process information under conditions of uncertainty and how information can be designed to support them in making the best possible decisions. The research knowledge base on decision-making under uncertainty is vastly different from that on information design. However, Table 1 exposes the intersection between the two fields of research. We claim that information design can be used to create decision environments that are more rational and resilient than those created by other approaches. The design of information can overcome the vulnerabilities of human decision-making identified by behavioral finance research. Cognitive and emotional biases, such as loss aversion, overconfidence, and herd behavior, can be addressed by designing information that reduces cognitive overload and does not trigger affective responses. Information design thus becomes a tool for studying and alleviating the consequences of emotional biases across a variety of decision environments.

In addition, Figure 1 shows a word cloud of Decision-making and information design, generated with Voyant Tools (Sinclair & Rockwell, 2026), to perform a word-frequency analysis and examine collocations in the corpus. The dominant terms in the decision-making corpus were ‘risk’ (of various kinds), ‘loss’, ‘bias’, ‘emotion’, and ‘heuristic’. In the information design corpus, the most frequent terms were ‘clarity’, ‘visual’, ‘user’, ‘accessibility’, and ‘complexity’. In decision-making texts, ‘risk’ often co-occurs with ‘emotion’, whereas in information design texts, ‘clarity’ co-occurs with ‘user’ as opposed to ‘risk’ and ‘emotion’ in decision-making texts. The latter emphasizes the emotional dimension of risk, whereas the former emphasizes a user-centered view of the complex issues that need to be communicated in design. Topic modeling of the two corpora revealed that both are dealing with the theme of decision environments, but from somewhat different perspectives.



in a greater, even disproportionate degree of fear than the losses actually occur. As already mentioned, this could be the result of loss aversion (Kahneman and Tversky, 1979), in which the pain of a loss is perceived by individuals in a greater degree than the pleasure of a gain is perceived. Furthermore, in dealing with a company there are fundamentals (e.g. the financial situation of a company) and social signals (e.g. news about employees). Financial dashboards could be designed in a way that they better counteract herding behavior of users than dashboards that are based on social signals. Furthermore, uncertainty ranges and confidence intervals can be accentuated in information environments in order to reduce overconfidence of users while making financial decisions. By combining decision making process with information design principles, financial environments can be improved for users making financial decisions in order to enhance rationality and to better cope with financial uncertainties in an information saturated world.

Our results are further underpinned by methodological triangulation (see above) in that the same recurring themes and terms have been identified in both the decision-making and the information design research. In the bibliometric mapping we have defined clusters and for the textual analysis within these clusters' terms have been selected which are relevant for this study. While the research in decision-making has been dominated by terms such as loss aversion, overconfidence and herd behavior the research in information design is focused on terms such as clarity, usability and accessibility. Thus, it seems to be a task which is theoretically founded as well as practically necessary to integrate information design principles into financial decision-making.

Decisions regarding financial products and services are increasingly taken by individual investors. Because of the complexity of the financial world, these investors are often not in a position to make well-considered decisions. The emotional component of decision-making can, in such cases, have a major impact on the choices that are made. Financial institutions and other organizations can implement information design in order to improve communication with their clients and to help them to avoid making extreme or even panic-like decisions. Information design can also be used by policymakers to increase transparency in the information which is disclosed by regulators to the markets and to the public. Improved transparency can lead to greater trust in the markets and to greater financial stability. Finally, information designers could work together with economists and with psychologists in order to develop and to implement a wide variety



of user-centered tools that make better use of financial information in order to minimize the impact of the biases and the emotions that decide financial decisions. Further, it is necessary to conduct more research on decision-making than just the identification of biases. This research should investigate how design interventions can change the environment in which investors make their financial decisions. The aim of such research would be to test the effects of various design strategies (e.g. interactive visualizations, different narrative frames) on the various biases, in situations of uncertainty.

In summary, the study of decision-making with respect to financial issues reveals human vulnerabilities in dealing with such issues. Information design, however, can be used to counter these vulnerabilities, thereby increasing the rationality and resilience of financial decision-making processes. An area of high potential for development of theory and practice.

6 CONCLUSION

This study has focused on the intersection of two research areas, decision-making and information design, and examined their application in financial decision-making environments. Financial decision-making by investors is affected by a variety of cognitive and emotional distortions (Banerjee, 1992; Kahneman & Tversky, 1979; Pikulina *et al.*, 2017; Scharfstein & Stein, 1990). All of these distortions are intensified in times of uncertainty or volatility, and their impact on investors in financial markets is very negative. The focus of information design studies, however, is on the design of information environments to decrease ambiguity, information overload and the chance of misinterpretation of information (Albers, 2012; Bertin, 1983; Horn, 1999; Tufte, 1983, 1990, 1997). In terms of financial decision-making information design aims to decrease the fear of potential losses by displaying clearly the risk distributions of financial products. It can also decrease the influence of social factors on financial decisions, for example, by focusing on the fundamental aspects of a financial product rather than its social aspects. Last but not least, information design can also decrease overconfidence by displaying clearly the uncertainty ranges and the confidence intervals of data.

In this study, the findings have been reinforced by the methodological triangulation that has been applied to the study of the research into decision-making and the research into information design. The findings of both areas of research have been



found to be of a similar nature. In both cases, a number of recurring themes have been found that are linked to human emotions and which, as a result, lead to decision-makers being subject to a number of cognitive biases and distortions. The findings of this study strongly suggest that there is considerable potential in the integration of the research into decision-making and the research into information design. Information design is a field of research that contains a number of practical solutions to the problems that have been described in this study. Our research will be of value to several different groups. Financial institutions will find value in our research as it will help them to improve their customers' financial decisions by designing financial products and services that are communicated in a way that is most likely to bring about the desired behavior. Regulators will find value in our research as it will help them to design and implement disclosure requirements that are as transparent as possible and that are most likely to be understood by consumers. Information designers will find value in our research as it will help them to design information that takes into account the full range of possible biases to which people may be subject when making financial decisions. This is not to say that all possible biases can be removed from financial decision-making but it is possible to design information so as to reduce the negative impact of as many of them as possible.

7 FUTURE RESEARCH

While study begins with the observation that research on decision-making and information design both focus on the limitations of human cognition in dealing with complexity and uncertainty. Information processing by investors to arrive at optimal financial decisions is affected by a large volume of information and several emotional biases. Under stress and in volatile markets, these distortions of human decision-making are even more intensified. Investors are, for example, affected by loss aversion, overconfidence, and by herd behavior ((Banerjee, 1992; Kahneman & Tversky, 1979; Pikulina *et al.*, 2017; Scharfstein & Stein, 1990)). In the field of information design, research examines topics such as ambiguity, information overload, and misinterpretation. The present study investigates how information design can be used to counteract these distortions in the human decision-maker.

When complex data is communicated in a financial environment, the decision-making process of users affected by emotional distortions can be corrected through



information design. For instance, risk distributions can be visualized to show users how they perceive potential losses, with a greater, even disproportionate, degree of fear than the losses actually occur. As already mentioned, this could be the result of loss aversion (Kahneman and Tversky, 1979), in which individuals perceive the pain of a loss more strongly than the pleasure of a gain. Furthermore, in dealing with a company, there are fundamentals (e.g., its financial situation) and social signals (e.g., news about its employees). Financial dashboards could be designed to better counteract users' herding behavior than those based on social signals. Furthermore, uncertainty ranges and confidence intervals can be highlighted in information environments to reduce users' overconfidence when making financial decisions. By combining decision-making processes with information design principles, financial environments can be improved to support users in making financial decisions, enhancing rationality and better coping with financial uncertainties in an information-saturated world.

Our results are further underpinned by methodological triangulation (see above), as the same recurring themes and terms have been identified in both the decision-making and the information design research. In the bibliometric mapping, we have defined clusters and, within these, selected terms relevant to this study for the textual analysis. While research on decision-making has been dominated by concepts such as loss aversion, overconfidence, and herd behavior, research on information design focuses on clarity, usability, and accessibility. Thus, it seems to be a task that is both theoretically grounded and practically necessary to integrate information design principles into financial decision-making.

Decisions regarding financial products and services are increasingly taken by individual investors. Because of the complexity of the financial world, these investors are often unable to make well-considered decisions. The emotional component of decision-making can, in such cases, have a major impact on the choices that are made. Financial institutions and other organizations can implement information design to improve communication with their clients and help them avoid extreme or panic-like decisions. Information design can also be used by policymakers to increase transparency in the information regulators disclose to markets and the public. Improved transparency can lead to greater trust in the markets and to greater financial stability. Finally, information designers could work with economists and psychologists to develop and implement a wide variety of user-centered tools that better leverage financial information, minimizing



the impact of biases and emotions that influence financial decisions. Further, it is necessary to conduct more research on decision-making beyond simply identifying biases. This research should investigate how design interventions can change the environment in which investors make their financial decisions. The aim of such research would be to test the effects of various design strategies (e.g., interactive visualizations, different narrative frames) on the various biases in situations of uncertainty.

In summary, the study of decision-making in financial contexts reveals human vulnerabilities in dealing with them. Information design, however, can be used to counter these vulnerabilities, thereby increasing the rationality and resilience of financial decision-making processes. An area of high potential for the development of theory and practice.

8 CONCLUSION

This study has focused on the intersection of two research areas, decision-making and information design, and examined their application in financial decision-making environments. Financial decision-making by investors is affected by a variety of cognitive and emotional distortions (Banerjee, 1992; Kahneman & Tversky, 1979; Pikulina *et al.*, 2017; Scharfstein & Stein, 1990). All of these distortions are intensified in times of uncertainty or volatility, and their impact on investors in financial markets is very negative. The focus of information design studies, however, is on the design of information environments to reduce ambiguity, information overload, and the risk of misinterpretation (Albers, 2012; Bertin, 1983; Horn, 1999; Tufte, 1983, 1990, 1997). In financial decision-making, information design aims to reduce the fear of potential losses by clearly displaying the risk distributions of financial products. It can also reduce the influence of social factors on financial decisions, for example, by focusing on a financial product's fundamental aspects rather than its social ones. Last but not least, information design can also reduce overconfidence by clearly displaying the uncertainty ranges and confidence intervals of the data.

In this study, the findings have been reinforced by methodological triangulation applied to decision-making and information design. The findings from both areas of research are similar. In both cases, a number of recurring themes have been identified that are linked to human emotions and, as a result, lead decision-makers to be subject to



cognitive biases and distortions. The findings of this study strongly suggest considerable potential to integrate the research into decision-making and information design. Information design is a field of research that offers practical solutions to the problems described in this study. Our research will be of value to several different groups. Financial institutions will find value in our research, as it will help them improve their customers' financial decisions by designing financial products and services that are communicated in ways most likely to elicit the desired behavior. Regulators will find value in our research, as it will help them design and implement disclosure requirements that are as transparent as possible and most likely to be understood by consumers. Information designers will find value in our research as it will help them to design information that takes into account the full range of possible biases to which people may be subject when making financial decisions. This is not to say that all possible biases can be removed from financial decision-making, but it is possible to design information so as to reduce the negative impact of as many of them as possible.

9 FUTURE RESEARCH

While this study has developed a conceptual framework for integrating information design into financial decision-making, many additional issues warrant further investigation by future research. First, future research should test the effectiveness of one design intervention in an empirical study. For instance, one could test the effect of interactive financial data representations on loss aversion in a between-subjects or within-subjects design. Other topics could be the effect of a financial dashboard that displays uncertainty for a set of data points on overconfidence in financial decision-making. Second, longitudinal studies can be conducted to test the sustainability of positive effects of information design-based decisions on investors' decisions in the long run, during periods of extreme market fluctuations, such as financial crises or the spread of a pandemic. Third, information design in financial contexts can be studied from a cross-cultural perspective. That is, how information design is affected by differences in risk perception and in how people make decisions across cultures and situations. The research must be carried out with awareness of the ethical issues involved in using information design to influence people's decisions. As information design is used in financial markets, there is a particular risk of its being used to manipulate people. Therefore, information



design must be used transparently and fairly, and be designed for and used by people of all abilities to add value to them and improve their decision-making.



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