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Spanish regulation for labeling of financial products: a behavioral-experimental analysis

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Abstract This paper assesses the impact of the Spanish Ministry of Economy and Competitiveness' (Board of Executives (BOE) Order ECC/2316/2015. Economy and Competitiveness Ministry, Spain, 2015) new regulation for financial product labeling. We design and conduct an economic experiment where subjects make risky investment decisions under three different treatments: a control group where subjects have only objective information about the key features of the products they must select and two treatment groups introducing visual labels resembling the labels required under the new Spanish regulation. The results of the experiment are analyzed within the framework of rank-dependent utility theory. While visual labels do not change the utility function of the subjects, they do significantly affect the subjects' weighting functions. The introduction of numerical and color-coded labels significantly increases the concavity of the weighting functions and increases pessimism and risk-aversion in cases where the probability of obtaining the best outcome is high. Labels widen the difference between real subjects' behavior and that of the perfectly rational agents described by expected utility theory. Consequently, our empirical findings raise doubts as to whether the new regulation actually achieves its objectives. The regulation seeks to empower retail investors by enhancing their understanding of financial products. Introducing the visual labels, however, seemingly increases the differences between actual risk levels and the decision weights applied by subjects when making decisions. Moreover, labels

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increase investors' pessimism and risk-aversion when the best outcome is likely and fail to alter investors' risk-aversion when the worst outcome is likely.

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JEL Classification D81 (Criteria for Decision-Making under Risk and Uncertainty) · G28 (Government Policy and Regulation) · D18 (Consumer Protection)

1 Introduction

Understanding financial products is often difficult for retail investors with low financial literacy. Empirical evidence shows that consumers express a lack of confidence and knowledge when choosing financial instruments such as investment or pension products (Beckett et al. 2000). These difficulties are due to a variety of reasons, including behavioral biases (Tversky and Kahneman 1974; Northcraft and Neale 1987), self-control (Gathergood 2012; Thaler and Shefrin 1981), mental accounting (Thaler 1985), cognitive biases and limitations (Bertrand and Morse 2011), and poor financial literacy (Banks et al. 2010; Hoelzl and Kapteyn 2011; Lusardi 2008; Van Rooij et al. 2011). These difficulties may negatively affect the quality of retail investors' financial decisions. For instance, consumers with low financial literacy are less likely to invest in stocks (Van Rooij et al. 2011), while self-control problems lead to suboptimal retirement savings (Thaler and Benartzi 2004). A relevant example is the case of preference shares[1] in Spain, where over 700,000 people with poor financial literacy fell victims of financial fraud due to the sale of this complex investment product (López and Gónzalez 2012). The incident became so grave that it led the European Commission (EC 2015) to release a report in 2015. The report revealed that most consumers were not duly informed by banks about the risks associated with such investments. As a result, consumers purchased risky financial instruments without even realizing they were doing so. The report highlighted the need to include user-friendly information in the description of financial products to allow citizens to make sound financial decisions. This recommendation, however, is not the only one of its kind, with many scholars also advocating better regulation of information about financial products (Agarwal et al. 2013; Barr et al. 2008; Brunnermeier et al. 2009; Harrington 2009; Posner and Weyl 2013).

In 2015, the Spanish Ministry of Economy and Competitiveness (2015) launched a new regulation for the presentation of information on financial products. This legal document explains that despite the efforts of the Spanish Government and the European Commission, the availability of comprehensible, comparable information on financial products is poor. The document also reports that a major concern for

[1] Shares, often with no voting rights, whose holders are paid their dividend before all other shareholders and are repaid first at face value if the company goes into liquidation. This complex financial product was extensively sold to customers with low financial literacy who were unaware of the product's features and who ultimately lost a large part of their investment.

financial customers is that the available information is confusing or incomplete. In many cases, the different formats used to present information are incomparable and use overly technical language. The Spanish Government also claims that pre-contractual and advertising documents contain too much information presented in a way that prevents readers from finding the most relevant features of the product. These deficiencies highlight the need to provide financial customers with standardized documentation that clearly and visually explains the essential information for each product. The goal of the new regulation—as stated in the regulation document itself—is to guarantee that the most relevant information is presented in a standard format using simple graphical or numerical representation. The regulation seeks to ensure that financial services customers have all the information they need to make informed judgments regarding investment services and understand the risks associated with these services.

Introducing visual labels is common in other product areas such as nutrition or energy efficiency, where the European Commission regulates labeling formats and contents. Recent studies suggest that such labels do actually nudge consumers toward making better decisions (Balcombe et al. 2010; Codagnone et al. 2013; Hieke and Wilczynski 2012; Houde 2012; Jones and Richardson 2007; Newell and Siikamäki 2013), although some authors report mixed or even contradictory results (Aron et al. 1995; Codagnone et al. 2016; Koenigstorfer et al. 2014, Sacks et al. 2009). In its new regulation, the Spanish Ministry of Economy and Competitiveness (2015) claims that introducing a labeling system similar to those applied in nutrition or energy could affect decision-making under risk and improve customers' understanding of financial products and investment decisions. To the best of our knowledge, however, studies fail to provide empirical evidence of the effectiveness of visual labels in improving financial decision-making.

To fill this research gap, this paper assesses the impact of visual labels on customers' investment decision-making under risk. We test the two types of visual labels proposed by the Spanish Ministry of Economy and Competitiveness' (2015) regulation: (1) a numerical label that rates the product from lowest risk to highest risk; and (2) a graphical label applying different colors from green (lowest risk) to red (highest risk), imitating traffic lights. Although both labels show the financial product's risk level, they differ in how the information is presented. Using behavioral economics and experimental methods, we analyze whether introducing this type of label actually improves decision-making by making investors' decisions more similar to the decisions of perfectly rational agents. This research question is relevant for policy because it empirically tests the rationale behind the Spanish Ministry of Economy and Competitiveness' (2015) regulation. Moreover, to the best of our knowledge, no study has addressed the impact of labeling on decision-making under risk, so the question is also empirically relevant for the literature on framing effects under uncertainty.

The paper is organized as follows. Sections 2 and 3 present a literature review and the behavioral theoretical model applied in the study. Section 4 describes the economic experiment applied to test the hypotheses. Section 5 summarizes the main results of the experiment. Finally, Sect. 6 discusses the practical and theoretical implications of these results.

2 Literature review

Economists have long known that Homo Oeconomicus is a fictional concept. Individuals' preferences are not complete and transitive, actual people are not fully rational, and it is costly for people to acquire and process information. Consequently, people do not behave as assumed in rational choice theory. An abundance of literature highlights and explores the differences between actual human behavior and that predicted by rational choice theory models (e.g., Kahneman 2003; Kahneman and Tversky 1984; Simon 1955; Thaler 1985). These differences led to the development of behavioral economics. Behavioral economics not only provides new tools to analyze economic behavior, but also advocates new ways to design effective public policies and change citizens' and consumers' behavior (Bogliacino et al. 2015a; Shafir 2013; Sunstein 2014; Thaler and Sunstein 2008).

Public policy has often relied on the assumption of rationality in human behavior. This flawed assumption may have led to suboptimal policy design. For example, the amount of information passed on to consumers (through product labeling or mass media campaigns) has steadily increased under the assumption that they will be able to process it to their advantage. This approach has often failed, as exemplified by public policies to prevent smoking. Besides increasing taxes or banning smoking in public places, placing visceral warning messages on cigarette packets seems to be the most effective measure, as shown by Bogliacino et al. (2015a, b), who illustrate how introducing pictorial warnings may reduce the willingness to pay for a tobacco product by 80 %. Studies show that certain emotions behave differently from others. Shame, anger, or distress are more effective in reducing smoking than fear and disgust, which have been the emotions most commonly appealed to by past anti-tobacco campaigns. If smokers were rational, a label with clear information about the hazards of smoking might be a good idea. But smokers are not rational, so alternatives need to be considered and tested in different product areas.

Behavioral economics considers not only the role of emotions, but also the way cognitive biases work and can be managed to promote a desired behavior. Thaler and Sunstein (2008) present a framework for applying experimental-behavioral economics in the public sector. Such a framework is based on what they define as a nudge approach for policy-making. The concept of choice architecture is central in the nudge approach, where choice architecture refers to the way options are presented to people. The number of choices presented, the way attributes are described, and the presence of default options are elements of the choice architecture. The strategic management of choice architecture could be used in policy-making to nudge consumers toward personally and socially desirable behaviors like saving energy or choosing healthier foods.

The implications of behavioral economics and nudging in public policy-making are far reaching, and insights from behavioral economics have been applied to various domains, including personal and public finance, health, energy, public choice, and marketing (Samson 2014). In 2010, the UK government set up the Behavioural Insights Team (BIT), a special unit dedicated to applying behavioral

science to public policy and services. One of the most influential reports by the BIT is MINDSPACE (Dolan et al. 2012). The report explores how behavioral economics can help meet current policy challenges in areas such as health, finance, and climate change. Echoing the UK government's initiative, Van Bavel et al. (2013) summarize the European Commission's strategy of using experimental-behavioral economics to enhance its policy-making. The authors describe how the European Commission began to formally apply behavioral insights in 2009, when the Consumer Rights Directive recognized the power of default options. The European Commission proposed limiting the use of pre-checked boxes in consumer contracts (the kind that made consumers purchase travel insurance even if they did not want it) to save consumers money by default. In 2010, the Directorate-General for Health and Consumers (DG SANCO) conducted a pilot study entitled *Consumer Decision-Making in Retail Investment Services*. Through a series of laboratory experiments, the study showed how consumers behaved when faced with different investment products. People struggled to make optimal investment choices, even in the simplest environments. Subjects were also prone to biases and framing effects (i.e., the way choices were presented). One of the conclusions of the study was that simplifying and standardizing product information would significantly improve investment decisions. Encouraged by the success of this study and responding to interest throughout the European Commission, DG SANCO set up the Framework Contract for the Provision of Behavioral Studies in 2012. At the World Bank, the 2015 World Development Report (World Bank 2015) discusses how a more realistic understanding of choice and behavior using experimental-behavioral methodology can make development interventions more effective. Accordingly, the experimental-behavioral approach has proven an effective way of studying people's behavior and testing which stimuli cause a desired change in behavior (Hernandez et al. 2015). The experimental-behavioral approach can help to (1) identify the best choice, (2) yield experimental evidence to predict the choices subjects would make under different policy treatments, (3) and quantify the gap between the policy objective and the empirical reality (Codagnone et al. 2014).

Finances and financial regulation have also been addressed by behavioral economics. The application of behavioral economics to finances has given rise to a new field: behavioral finance. Like behavioral economics, behavioral finance explains and increases our understanding of investors' reasoning patterns, including emotional processes and the degree to which such processes affect decision-making (Ricciardi and Simon 2000). Behavioral finance has its roots in different fields, such as prospect theory, cognitive errors, problems of self-control, and the pain of regret. According to behavioral finance, investors are often affected by frames and are swayed by temptation and regret (Statman 1995). Several authors have shown these systematic biases in the finance domain and have incorporated them in their models. Hirshleifer and Teoh (2003) developed a behavioral model that addresses investors' limited attention levels. They empirically showed that the way financial information is presented (i.e., the frame) can affect the investor's perception. Brown et al. (2015) found that expected social security claiming ages are sensitive to the way the information about actuarial adjustments is framed. Hastings et al. (2010) showed how different ways of presenting pension management fees shape consumer

choices. Zhou and Pham (2004) report that investors' goals may be affected by the investment opportunities under evaluation rather than being independent of these alternatives, as assumed in standard finance theory. Statman (1995) argues that behavioral finance is built on a broader model of human behavior than standard finance and allows economists to deal effectively with many puzzles that have traditionally plagued standard finance (e.g., investors' preference for cash dividends, investors' reluctance to realize losses, the determination of expected returns, the design of securities, and the nature of financial regulations). According to Statman (1995), behavior and psychology affect individual investors' and portfolio managers' financial decision-making processes in terms of risk assessment and framing (i.e., the way investors process information and make decisions depending on its layout). These related components provide a deeper understanding of the empirical evidence on finance, including investors' preferences, the design of modern financial products, and financial regulations. Shefrin and Statman (1993) suggest that behavioral considerations are indispensable when designing financial products. A relevant example in behavioral finance and nudging is Thaler and Benartzi's (2004) SMarT Plan. The authors propose a prescriptive savings program, using elements of behavioral economics to nudge employees toward increasing their retirement savings. In this vein, Blake and Boardman (2014) created SPEED-OMETER (or Spending Optimally Throughout Retirement), which shows how behavioral economics can be used to improve pensioners' spending decisions.

Understanding financial products is difficult for many consumers, and numerous authors have called for regulations governing the information provided on financial products (Agarwal et al. 2013; Barr et al. 2008; Brunnermeier et al. 2009; Harrington 2009; Posner and Weyl 2013). Accordingly, the Spanish Ministry of Economy and Competitiveness (2015) has released a new regulation in Spain that requires financial companies to introduce a standardized information label for all financial products. This label's format is similar to the format used for energy or nutrition products. The regulation claims that introducing these new labels will reduce the number of purchases of undesired, highly risky financial assets and will improve consumers' understanding of financial products.

Some authors have recently assessed the effect of visual labels in other areas such as nutrition and energy efficiency. In nutrition, Jones and Richardson (2007) used eye-tracking technology to observe that color-coded labels reduce the number of purchases of high fat products by highlighting key nutrients. Balcombe et al. (2010) designed a choice experiment to determine that many subjects avoid choosing products bearing the red code in labeling systems that simulate traffic lights. Hieke and Wilczynski (2012) confirmed the signaling effect of color, reporting that color helps reduce the complexity of decision-making. Koenigstorfer et al. (2014) report that color-coding on nutrition labels affects food purchase behavior. This effect, however, is contingent on consumers' self-control. Consumers with low self-control make healthier food decisions in response to color-coded labels, whereas the effect is weak among consumers with high self-control. Aron et al. (1995) examined the influence of nutrition information, concluding that nutrition labels have no positive effect on food choices and, for certain subgroups, even have a negative effect. Their

results reveal the importance of assessing consumers' motivational characteristics when developing nutrition education programs.

To study energy-efficiency product labeling, Newell and Siikamäki (2013) experimentally tested the extent to which different types of information and intertemporal behavior (i.e., discounting) affect consumers' behavior regarding energy efficiency. They conclude that labels and information content may help consumers make more energy-efficient decisions. Houde (2012) provides evidence that the Energy Star program substantially affects purchase decisions. Specifically, the effect of the Energy Star label alone could increase sales of a particular refrigerator model by as much of 35 %. Codagnone et al. (2013) experimentally tested the effectiveness of car eco-labels and promotional material. Running a series of laboratory and online experiments, the authors tested the effectiveness of different information and layouts such as different CO_2 classification systems. The most effective label was the vertical colored layout with the absolute CO_2 emissions classification system, which is extremely similar to the label currently used in European energy regulation and the proposed label for financial regulation in Spain. Interestingly, however, labels make consumers believe that goods consume more energy than they actually do (Sahoo and Sawe 2015). Codagnone et al. (2016) found that consumers change their behavior in response to labels focusing on running costs or fuel economy when environmental friendliness messages are combined with messages regarding fuel economy. When this cost-saving frame (i.e., fuel economy) is omitted, no such change in behavior occurs. The authors also showed that large, expensive cars tend to be undervalued once fuel economy is highlighted.

Despite empirical evidence suggesting that the layout of information on financial products affects consumers' perceptions and decisions (Brown et al. 2015; Hastings et al. 2010; Hirshleifer and Teoh 2003; Statman 1995), the way the new financial labeling system will affect consumers is unclear. While the Spanish Ministry of Economy and Competitiveness (2015) claims that this new financial labeling system will improve consumers' understanding of financial products, the effects of similar labeling systems on consumers have been mixed. Some studies show that product labeling nudges consumers toward making better decisions (Balcombe et al. 2010; Codagnone et al. 2013; Hieke and Wilczynski 2012; Houde 2012; Jones and Richardson 2007; Newell and Siikamäki 2013), whereas others report negative effects or show that positive effects are contingent on consumer factors (Aron et al. 1995; Codagnone et al. 2016; Koenigstorfer et al. 2014; Sacks et al. 2009; Sahoo and Sawe 2015).

Accordingly, the objectives of this study are both theoretical and policy oriented. From a theoretical viewpoint, we analyze how numerical and visual labels affect decision-making under risk. Specifically, this paper provides and interprets experimental empirical evidence to answer an open question: Do simple labels narrow or widen the gap between investors' actual behavior and the behavior predicted by rational choice theory? Likewise, if these labels do have an effect on decision-making, what is the nature of this effect and what are the implications in terms of the subjects' risk attitudes? From a policy-oriented viewpoint, we analyze the new Spanish financial labeling system and test whether the policy meets its objectives and achieves the desired consumer behavior.

3 The model

In rational choice theory, the shape of the utility function determines risk attitude. In real decision-making, however, risk attitude also depends on other more complex issues such as how probabilities are processed and applied during the decision-making process. Behavioral economics offers a more realistic approach to modeling the role of probabilities in decision-making. Behavioral economics also lets us model experimental phenomena that expected utility is unable to explain (Tversky and Kahneman 1992; Abdellaoui et al. 2011; Alventosa et al. 2015). This section presents a formalization of the way probabilities are transformed from the viewpoint of rank-dependent utility theory (Quiggin 1982). Rank-dependent utility theory extends Expected Utility theory and is a specific case of cumulative prospect theory (Tversky and Kahneman 1992; Wakker 2010) when restricted to the domain of the gains. Rank-dependent utility models are widely used to quantify the difference between the risk levels known by decision-makers and the weights they actually apply to each uncertain event in the decision-making process (Wakker 2010; Abdellaoui et al. 2011). Since this study examines how this difference and its effect on risk attitude change with the introduction of the new labels, Rank Dependent Utility offers an appropriate theoretical framework to assess the impact of the new labeling regulation.

Investment decisions always imply some degree of uncertainty regarding the final return on the investment. For the sake of simplicity, let us consider that the performance of an investment can be described as a series of potential returns or outcomes $x_1 > x_2 > \cdots > x_n$, where outcome x_i takes place with probability p_i. The key concept when analyzing decision-making under risk and uncertainty is that of the risk attitude of the decision-maker. Under rational choice theory (expected utility paradigm), risk attitude is characterized solely by the decision-maker's utility function, which determines the psychological "value" of each of the potential returns of the investment. The utility function represents the decision-maker's preferences, which are established according to the absolute outcome rather than the gains or losses from a previous situation or reference point (i.e., asset integration).[2] Assuming that each decision-maker knows these probabilities, she or he will invest in a fund if only if the utility of the money invested is lower than the expected utility of the outcomes. Formally, if I denotes the amount to be invested and $U(x)$ the utility of outcome x, the investor will invest in the fund if and only if $U(I) < \sum_{i=1}^{n} p_i U(x_i)$. A decision-maker is considered risk-averse (or, conversely, risk-seeking) if her or his utility function is concave (or, conversely, convex).

In expected utility models, although the psychological value of an outcome does not coincide with the actual value of the outcome (in general, $U(x) \neq x$), the psychological value of each probability p_i always equals the probability p_i, which is the value used when making an investment decision. No additional

[2] Asset integration refers to the idea that individuals decide about risky prospects by considering the effect of decisions on their final wealth rather than on specific gains and losses (Kahneman and Tversky 1979). Extensive empirical evidence shows that this assumption does not hold (Andersen et al. 2011).

transformation[3] is made. In the rank-dependent utility model, it is assumed that the psychological value of a probability used when deciding whether to invest in a fund—or *decision weight* as it is usually called—is a function of the probabilities of all potential outcomes of the investment. In this conceptual framework, a *rank*—or more intuitively a *good-news probability*—for any potential outcome x of the investment is defined as the probability that the fund yields an outcome strictly larger than x. Formally, $rank(x) = \sum_{x_i > x} prob(x_i)$. Ranks are numbers between 0 and 1, where 0 (or, conversely, 1) is the rank associated with the best (or, conversely, the worst) possible outcome of the fund. Let us define $x_{n+1} = -\infty$. Then, the probability of outcome x_i can be written as $p_i = rank(x_{i+1}) - rank(x_i)$ for $i = 1, \ldots, n$. Before decision-making, ranks are transformed according to a non-decreasing function $w : [0, 1] \rightarrow [0, 1]$ named the *weighting function*. Given a weighting function w, the *decision weight* of outcome x_i is defined as $\pi_i = w(rank(x_{i+1})) - w(rank(x_i))$. If the weighting function is the identity function (i.e., $w(p) = p$), then the decision weights will equal the probabilities of the outcomes ($\pi_i = p_i$). Decision weights are positive numbers less than 1, but they are not required to add up to 1. Decision weights are related to the slope of the weighting function: the steeper the weighting function, the larger the difference between $w(rank(x_{i+1}))$ and $w(rank(x_i))$, and hence the larger the corresponding decision weight π_i. Under rank-dependent utility theory, an investor with utility function $U(x)$ and weighting function $w(p)$ will buy a fund if and only if $U(I) < \sum_{i=1}^{n} \pi_i U(x_i)$. The interpretation of the weighting function and the computation of the decision weights is greatly simplified in cases with only two uncertain events $x_1 > x_2$. In such cases, $\pi_1 = w(rank(x_2)) - w(rank(x_1)) = w(p_1) - w(0) = w(p_1)$ and $\pi_2 = w(rank(x_3)) - w(rank(x_2)) = w(1) - w(p_1) = 1 - w(p_1) = 1 - \pi_1$.

Example (adapted from Wakker 2010). Let us consider a fund with four potential outcomes $x_1 > x_2 > x_3 > x_4$ with identical probabilities $p_1 = p_2 = p_3 = p_4 = 0.25$. Let us assume that the weighting function for an investor is given by $w(p) = p^{0.5}$. Then, the decision weights for each outcome are given by $\pi_1 = w(rank(x_2)) - w(rank(x_1)) = 0.25^{0.5} - 0^{0.5} = 0.50$, $\pi_2 = 0.21$, $\pi_3 = 0.16$ and $\pi_4 = 0.13$. Note that although the probabilities of all four outcomes are identical, the investor decides whether to invest in the fund based on the decision weight (subjective probability) for the best outcome x_1 (i.e., $\pi_1 = 0.50 > 0.25 = p_1$) and the decision weight for the worst outcome x_4 (i.e., $\pi_4 = 0.13 < 0.25 = p_4$). *Even if the potential investor knows the actual probability of obtaining high returns,* she or he behaves as if the probability of obtaining high

[3] The axiom of the independence of irrelevant alternatives by Von Neumann and Morganstern formalizes this basic assumption in expected utility theory. If a decision-maker is indifferent to the choice between two possible outcomes, then she or he will be indifferent to the choice between two lotteries with equal probabilities, if the lotteries are identical in every other way (i.e., the outcomes can be substituted). So, if the decision-maker is indifferent to the choice between outcomes x and y, then the decision-maker is indifferent to the choice between a lottery yielding x with probability p and z with probability (1 − p) and a lottery yielding y with probability p, and z with probability (1 − p). Likewise, if x is preferable to y, then a lottery yielding x with probability p and z with probability (1 − p) is preferable to a lottery yielding y with probability p, and z with probability (1 − p).

returns were higher than it actually is and as if the probability of obtaining low returns were lower than it actually is.

Recall that ranks are good-news probabilities. An outcome with a small rank means that the probability of getting a higher outcome is small. In other words, the lower the rank, the better the outcome. Figure 1, adapted from Wakker (2010), illustrates how two kinds of deviations from additive probabilities combine to create the common probability weighting functions. Figure 1a depicts traditional expected utility with probabilities weighted linearly (i.e., $w(p) = p$). However, most empirical research conducted since Preston and Baratta's (1948) study reports inverse S-shapes, as in Fig. 1b. Since decision weights are given by $\pi_i = w(rank(x_{i+1})) - w(rank(x_i))$, the slope of the weighting function can be interpreted as an approximation of the sensitivity of the decision weights. The usual inverse S-shape in Fig. 1b thus shows how decision weights are larger for ranks at the two extremes (i.e., ranks close to 0 and 1) than for intermediate ranks.

4 Method and experimental design

An economic experiment was designed and implemented to test the impact of applying the two label formats. In the experiment, each subject was asked to reveal the minimum certain return they would require to sell 12 risky investment funds. Funds were represented by binary lotteries, where the investor randomly obtained one of two different return levels with given probabilities. A total of 150 subjects were recruited from a database administered by the University of Valencia. The subjects volunteered to participate in the experiment. The profile of the participants, in terms of age and sex, is presented in "Appendix 2". The experiment was implemented at the University of Valencia in December 2015. Subjects were randomly assigned to a computer in the laboratory, informed that they could leave the experiment at any moment, and asked to sign a consent form. The experiment software was a web application developed using the Yii PHP framework. Following a between-subjects design, 50 participants were assigned to each treatment. The actual payoff for each subject was the sum of a constant show-up fee and the payoff obtained by the subject in one of the 12 decisions. The decision used to calculate the

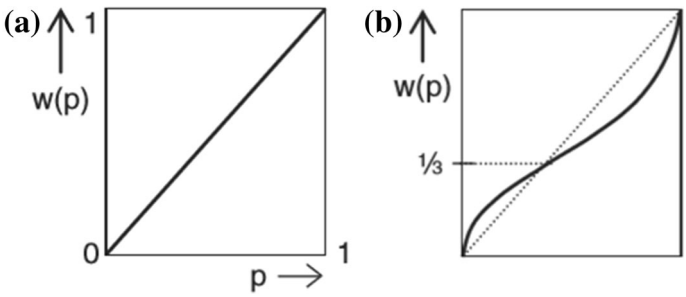


Fig. 1 Common weighting functions (adapted from Wakker 2010)

payoff was selected uniformly at random. The underlying decision problem was adapted from Abdellaoui et al. (2011). Table 1 shows the 12 investment funds used in the experiment, along with their outcomes and probabilities. Subjects were told that they had 12 variable income investment funds they could sell. They were instructed to state the minimum quantity of money they would accept to sell the variable income investment fund. For each investment fund, subjects were asked, "What is the minimum return you would require to sell your variable income investment fund?" Screenshots of the experiment appear in "Appendix 1".

To guarantee that subjects had an incentive to reveal their actual certainty equivalent for each lottery, we followed the Becker–DeGroot–Marschak (BDM) mechanism (Wakker and Deneffe 1996). This mechanism is widely used in experimental economics because the dominant strategy for a subject is to reveal her or his minimum return honestly. Under this mechanism, once a subject reveals the minimum return required to sell each fund, a market return is determined at random:

- If the subject's minimum return is equal to or lower than the market return, the subject sells the investment fund. In this case, the subject's payoff is the market return.
- If the subject's minimum return is greater than the market return, the subject keeps the fund. The fund then attains its high or low outcome at random according to the probabilities shown to the subject. The outcome determines the subject's payoff.

The uncertainty level of each fund reflects the variance of the lottery. Investment funds are then classified into three sequential levels (denoted 1, 2, and 3) in terms of their uncertainty level, as shown in Table 1.

Following a between-subject design, the experiment was run in three separate sessions—one per treatment. Subjects in the first session made their 12 decisions after receiving information about the outcomes and probabilities of each binary

Table 1 Funds presented to the subjects

Investment fund	High outcome	Low outcome	Probability of high outcome	Variance	Uncertainty level
1	100	0	25	1875	2
2	200	50	25	4218.75	3
3	200	100	25	1875	2
4	50	0	25	468.75	1
5	150	100	25	468.75	1
6	200	150	25	468.75	1
7	200	0	25	7500	3
8	200	0	75	7500	3
9	200	0	5	1900	2
10	200	0	95	1900	2
11	200	0	25	7500	3
12	200	0	50	10,000	3

lottery (control group). Subjects in the other two sessions received the same information as well as an adaptation of the label required under the new Spanish regulation, as presented in Fig. 2. Treatment 2 saw the label in graphical format, while Treatment 3 saw the label in numerical format. The labels of each level and treatment appear in "Appendix 1".

5 Results

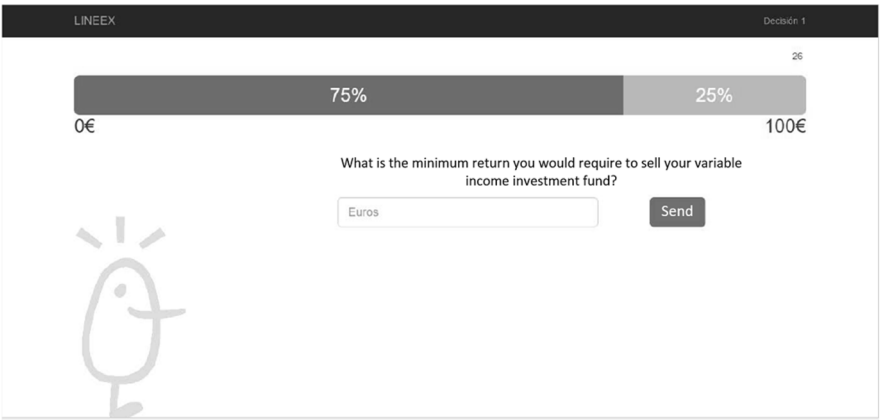
The method used to estimate the utility and weighting functions of each subject was adapted from Abdellaoui et al. (2011). Subjects were asked to state the minimum return they would require to sell the 12 funds in Table 1. Thus, each of the 150 subjects made 12 decisions, thereby providing the minimum returns for 1800 different investment funds. The descriptive statistics for this outcome variable appear in "Appendix 2". Funds 1–7 were used for parametric estimation of the utility function, and funds 8–12 were used for non-parametric estimation of the decision weights for each subject.

Following Abdellaoui et al. (2008), we applied a power function as a parametric specification for utility and assumed that $U(x) = x^{\alpha}$. This function is concave if $\alpha < 1$, linear if $\alpha = 1$, and convex if $\alpha > 1$. Under this assumption, for investment funds $i = 1, 2, \ldots, 7$, $I_i = [w(0.25)x_{i,1}^{\alpha} + (1 - w(0.25))x_{i,2}^{\alpha}]^{1/\alpha}$, where I_i denotes the certainty equivalent of lottery i and $x_{i,1}$ and $x_{i,2}$ are the high and low outcomes of the lottery. For each subject, once the certainty equivalents had been revealed, $w(0.25)$ and the parameter α in the non-linear expression for I_i were estimated using nonlinear least squares. The estimation was carried out using the NLS function in R. Table 2 presents the results of the estimation of α. The parameter α was not significantly different for subjects in each treatment (p value = 0.481), implying that labeling had no effect on the utility function of the subjects.

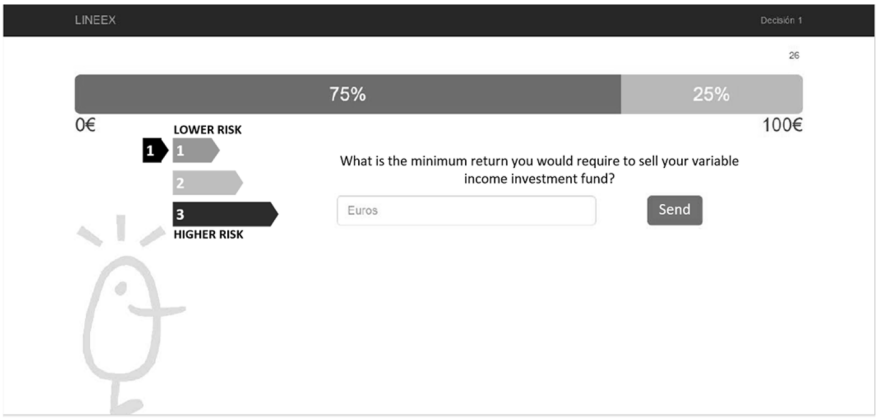
The weighting function for each subject was then estimated using the minimum return the subject required to sell investment funds $i = 8, \ldots, 12$ and the value of α, which had already been calculated. Accordingly, $w(p_i) = \left(\frac{I_i}{200}\right)^{\alpha}$. Table 3 shows the results of the estimation of the weighting function for each treatment. Table 3 also shows that the weighting functions were always significantly different among treatments, except in the case with the smallest probability. Thus, both types of labels affected subjects' decisions regarding financial products.

Figure 3 presents the weighting functions (median values) for each treatment (i.e., for each labeling format). Since the diagonal in this figure represents the weighting function under expected utility theory, the area between the weighting function and the diagonal provides a measure of how much the subjects differ from rational agents in their ability to process actual probabilities when making decisions under risk. When a weighting function coincides with the diagonal it represents linear processing of probabilities, as in rational choice theory (i.e., the subjects display a proper understanding of the probabilities associated with the different

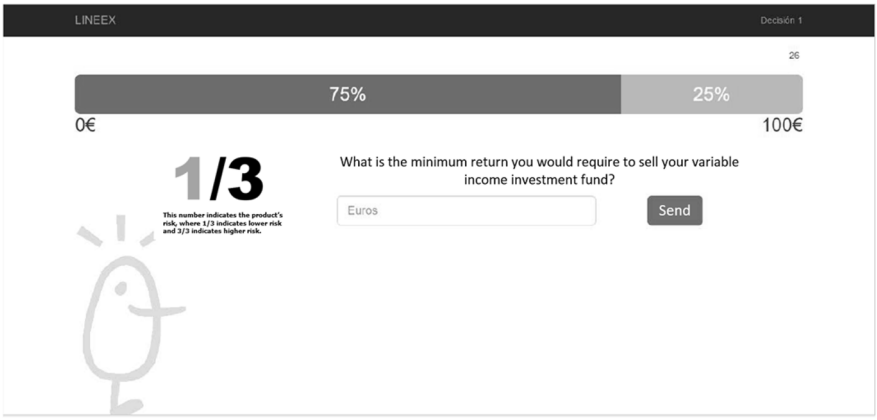
(a) *Treatment 1: Control*



(b) *Treatment 2: Color*



(c) *Treatment 3: Number*



◀**Fig. 2** Screenshots of the decision screen of the experiment for each treatment. **a** Treatment 1: control. **b** Treatment 2: color. **c** Treatment 3: number

Table 2 Estimation of α by treatment

	Control	Number	Color
Median	0.856	1.030	0.853
Average	1.083	1.204	0.987
Standard deviation	1.155	0.589	0.591
ANOVA (p-value)	0.481		

Significance codes: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

Table 3 Estimation of $w(p_i)$ by treatment

	Labeling	$w(0.05)$	$w(0.25)$	$w(0.50)$	$w(0.75)$	$w(0.95)$
Median	Control	0.291	0.334	0.548	0.711	0.890
Average	Control	0.357	0.369	0.549	0.699	0.776
Standard deviation	Control	0.317	0.162	0.236	0.194	0.294
Median	Number	0.240	0.277	0.400	0.322	0.580
Average	Number	0.328	0.281	0.350	0.376	0.551
Standard deviation	Number	0.256	0.164	0.197	0.273	0.356
Median	Color	0.383	0.299	0.468	0.402	0.740
Average	Color	0.394	0.331	0.463	0.434	0.662
Standard deviation	Color	0.273	0.191	0.248	0.284	0.305
ANOVA (p-value)	Control-color-number	0.618	0.021**	0.000***	0.000***	0.001***
T-test (p-value)	Control-color	0.566	0.317	0.103	0.000***	0.079*
T-test (p-value)	Control-number	0.641	0.016**	0.000***	0.000***	0.002**
T-test (p-value)	Color-number	0.239	0.192	0.018**	0.330	0.116

Significance codes: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

outcomes). Conversely, when the weighting function does not coincide with the diagonal, the area between the diagonal and the weighting function offers a measure of how far the subjects' understanding of risk strays from the proper understanding assumed under expected utility theory. The introduction of labels significantly increased the area between the weighting function and the diagonal, representing a worsening in subjects' understanding of the lotteries' risk. The area between the weighting function and the diagonal was greatest for the numerical label in Treatment 3. Hence, the results of the experiment fail to confirm that the regulation accomplishes its objective of enhancing consumers' understanding of financial product information.

The existence of significant differences between the weighting functions for the groups with and without labels raises two questions: How does the new Spanish regulation change consumers' understanding of uncertainty? Moreover,

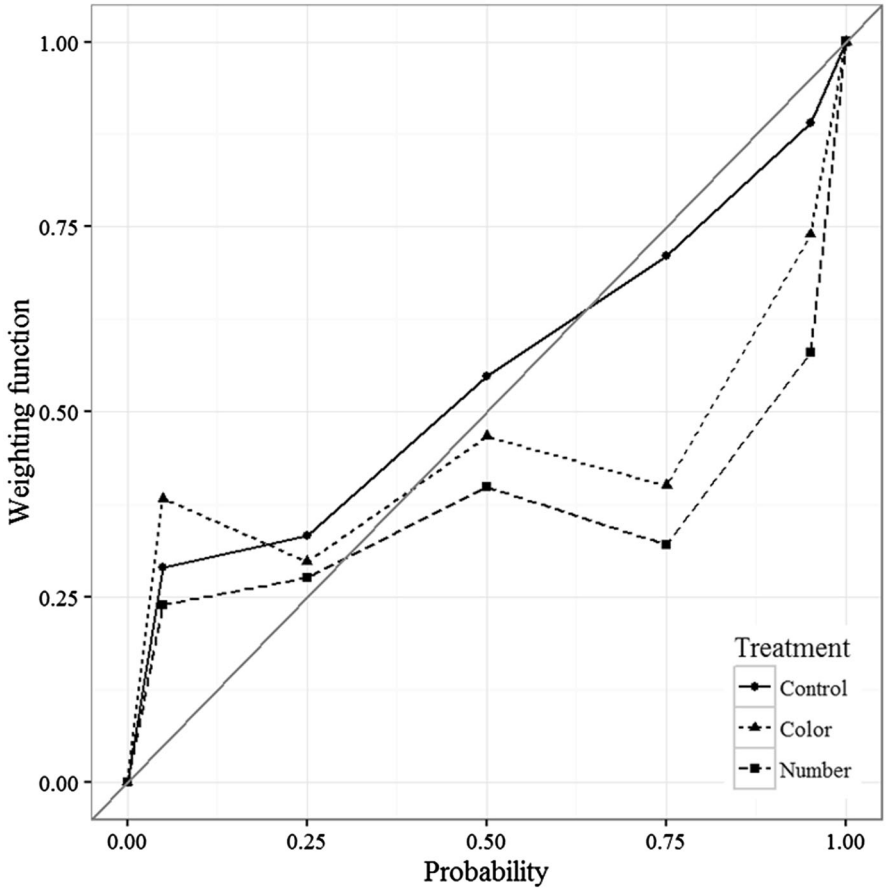


Fig. 3 Median values of the weighting function by treatment

how does the new Spanish regulation change the behavior of retail investors? While the utility function was seemingly unaffected by the introduction of the labels, the regulation affected consumers' risk attitudes, as observed in the change in the shape of the consumers' weighting function (Fig. 3). For probabilities of less than 0.25, the labels did not generate significant changes in the weights (Table 3). Once the weighting functions for the color and number treatments crossed the diagonal, however, these two functions became much more concave than the weighting function for the control treatment. Moreover, the difference between the weights in the control and numerical label treatments was significant for all probabilities (Table 3). In the cumulative prospect model (Wakker 2010), the concavity of the weighting function can be interpreted as pessimism on the part of the decision-maker because the decision weights associated with good-news probabilities are lower than the actual probabilities of

obtaining the best outcomes. This interpretation is easy to understand with binary lotteries, as in our experiment. As previously explained, with only two outcomes, the decision weight equals the value of the weighting function when applied to the probability ($\pi_1 = w(p_1)$). In our experiment, the weighting functions for the treatments with labels became concave after crossing the diagonal. Hence, the decision weights corresponding to the best outcome were lower than the actual probabilities of obtaining the best outcome. This difference was significant for all values in Treatment 3 and one value in Treatment 2 (Table 3). This behavioral-cognitive effect occurred even though the subjects knew the real value of the probability. This phenomenon can be interpreted as pessimism because the subjects behaved as if the chances of good news occurring were lower than they actually were. Pessimistic decision-makers behave with greater risk aversion than either optimistic (convex weighting function) or neutral (linear weighting function) subjects with the exact same value function.

In summary, subjects in Treatments 2 and 3 had the same utility function as those in the control group, but they were more pessimistic when the actual probability of obtaining the best output was greater than 0.25.

6 Conclusions

This paper empirically assesses the impact of the Spanish Ministry of Economy and Competitiveness' (2015) new regulation regarding the labeling of financial products. We designed and conducted an economic experiment where subjects made risky investment decisions under three treatments. The first treatment was a control group where subjects were informed only of the value of the outcomes and the probabilities of each lottery. As well as being told the value of the outcomes and the probabilities of each lottery, subjects in the other two treatments received additional information in the form of labels—numerical for one group and color-coded for the other. We analyzed the results of the experiment within the rank-dependent utility theory framework. Under rank-dependent utility theory, decision weights (i.e., the subject's assessment of probabilities in the decision-making process) may differ from the actual probabilities of events occurring, even when the decision-maker knows the real value of these probabilities. In the rank-dependent utility model, probabilities are transformed into decision weights through a weighting function, as described in Sect. 3.

The main finding from this experiment is that while labels do not affect utility functions, visual labels do significantly affect weighting functions. In all groups, the weighting functions exhibit the typical inverse S-shape, but introducing the visual labels significantly increases the concavity of the weighting function in the control group. Accordingly, under rank-dependent utility theory, introducing the labels increases subjects' pessimism, and consequently, their risk-aversion in cases where the probability of the best outcome is high. The increase in concavity also shows that introducing labels augments the difference between the diagonal and the

weighting function. In other words, the labels increase the differences between subjects' actual behavior and the behavior predicted by rational choice theory. Although these finding apply to both numerical and color-coded labels, the effect is larger with numerical labels. Differences between decision weights in the control group and the numerical label treatment group are significant for all probabilities greater than 0.25. In contrast, differences between decision weights in the control group and the color-coded label treatment group are significant only for a probability of 0.75. In summary, visual labels affect subjects' understanding of risk levels. Visual labels cause subjects' understanding to diverge from that of perfectly rational agents. Furthermore, labels make subjects more risk averse in cases where the probability of the best output is high.

This finding has both theoretical and policy-making implications. From a theoretical viewpoint, this paper helps to fill the gap in the literature on how labeling affects individuals' decision-making capabilities under risk. This paper also presents an innovative approach to analyzing the impact of label regulation. Scholars have analyzed the impact of labeling in consumer behavior without analyzing the cognitive and decision models behind such behavior. In contrast, we analyzed and estimated the utility and weighting functions after observing subjects' decisions. This approach allowed us not only to measure the impact of labeling, but also to understand the reasons behind such an impact, yielding powerful insights for effective policy design.

Besides its theoretical implications, this paper contributes by assessing the labeling regulation recently introduced by the Spanish Ministry of Economy and Competitiveness (2015). This regulation is designed to empower retail investors by ensuring they have a better understanding of financial products and making it easier to compare financial products offered by competing financial entities. In an environment where investors with low financial literacy must make decisions involving financially complex products, the regulation advocates the use of simple visual and numerical labels as a way of improving the quality of investors' decision-making. As discussed in Sect. 2, behavioral-experimental analysis has provided useful insights to help design better regulations in energy consumption and nutrition. Empirical evidence does not always confirm the effectiveness of the proposed labeling systems but nonetheless provides valuable information for adapting and optimizing such labels. For this reason, together with the fact that these labels codify complex information such as uncertainty levels, the effectiveness of the Spanish Ministry of Economy and Competitiveness' regulation must be empirically tested.

The behavioral experiment presented in this paper shows that the labels proposed under the new regulation are seemingly a long way from achieving their goal. Taking decisions made by the rational agents described in rational choice theory as a benchmark, our experiment shows that both graphical and numerical labels actually worsen subjects' decision-making. Introducing labels makes retail investors' decisions less rational. Estimation of the utility and weighting functions shows that this difference is not a consequence of a

variation of the utility function but rather a result of the change in the shape of investors' weighting functions. Notably, changes in the weighting function occur mainly in the part of the function corresponding to high probabilities of obtaining the best outcome. Labels reduce the decision weights for financial products where the probabilities of obtaining the best outcome are high. Accordingly, the regulation increases investors' pessimism and risk-aversion in situations where the best outcome is likely, yet it has no effect in situations where the worst outcome is likely. This conclusion is consistent with discussions between one of the authors of this paper and practitioners working in the Spanish financial sector. The practitioners claimed that introducing labels has increased the perception of risk associated with the safest products (for instance, bank deposits), mainly among investors with low financial literacy. This greater risk-aversion may be due to an increase in the salience of risk caused by the presence of the labels and the assignation of a risk level (level 1) to products that consumers previously thought of as risk free. Consistent with findings reported by Campbell et al. (2011), differences between the goals and outcomes of the regulation highlight the need to establish beforehand whether proposed regulations will actually deliver on what they are supposed to. Contrary to what is best for the Spanish retail investment market, the labels studied in this paper may actually be nudging investors toward riskier investment decisions than those made by perfectly rational agents, as described by rational choice theory.

Finally, we must acknowledge that our study has some limitations. The sample used for the experiment consisted of only 150 participants, and it might not have been representative of the population of consumers of financial products. The nature of the sample may therefore limit the external and ecological validity of the experiment, although the experimental design and implementation guarantee its internal validity and utility for studying the role of labeling. In the future, scholars should replicate this experiment using larger samples, allowing for the inclusion of control variables such as financial literacy, age, and education.

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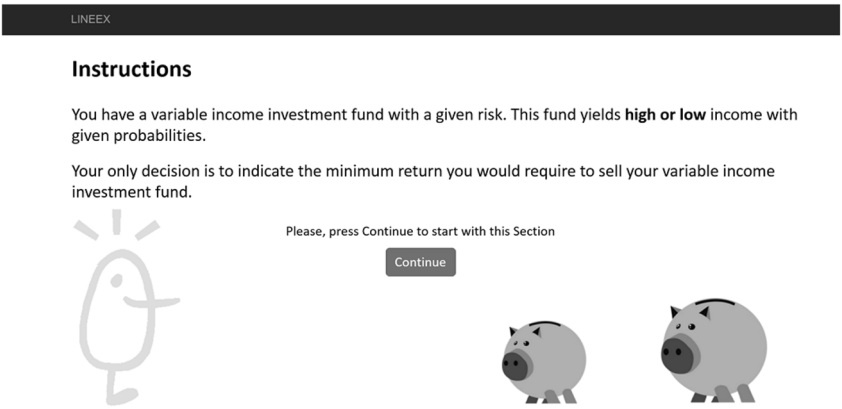
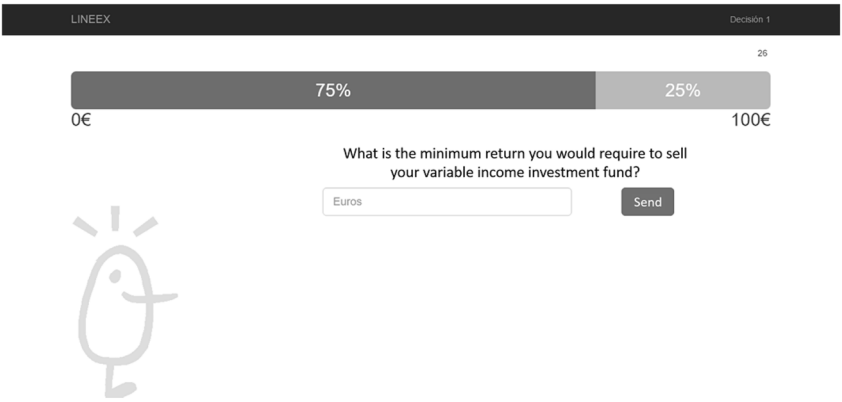
Appendix 1: Description of the experiment

See Figs. 4 and 5.

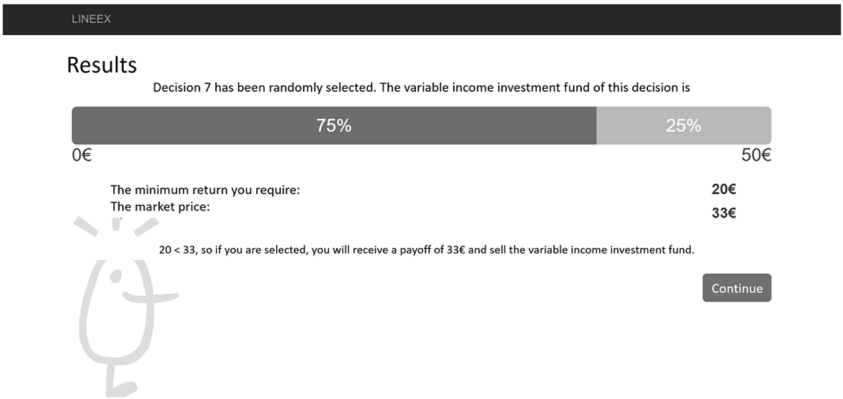
(a) *Instructions*



(b) *Decision*



(c) *Results*



◀**Fig. 4** Screenshots of control treatment. **a** Instructions, **b** decision, **c** results

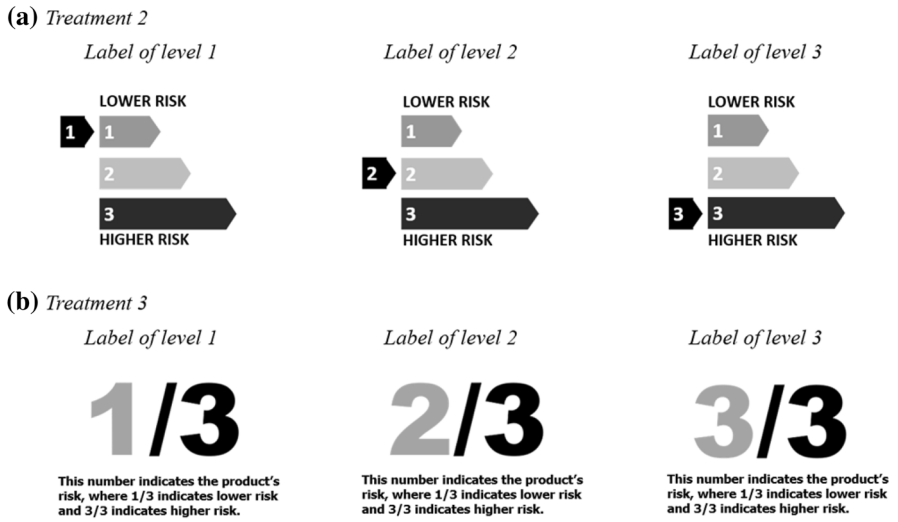


Fig. 5 Labels applied in treatments 2 (**a**) and 3 (**b**)

Appendix 2: Description of subjects and the minimum return to sell each fund (outcome variable)

See Tables 4 and 5.

Table 4 Descriptive statistics for the participants

Treatment	Gender (%)		Age (years)			
	male	female	mean	SD	median	SE
Control	56.10	43.90	20.63	1.92	20	0.30
Color	56.52	43.48	20.72	2.23	20	0.33
Number	54.55	45.45	20.59	1.59	20	0.24

Table 5 Descriptive statistics for the outcome variable

Treatment	Id	Median	Mean	SD	SE	CI
Control	1	30.00	35.46	14.76	2.31	4.66
Control	2	100.00	101.46	26.20	4.09	8.27
Control	3	140.00	145.00	20.91	3.27	6.60
Control	4	20.00	21.98	9.56	1.49	3.02
Control	5	115.00	118.68	10.72	1.67	3.38
Control	6	165.00	169.27	10.87	1.70	3.43
Control	7	140.00	131.07	43.92	6.86	13.86
Control	8	40.00	63.10	63.55	9.92	20.06
Control	9	50.00	61.56	32.97	5.15	10.41
Control	10	100.00	99.32	40.36	6.30	12.74
Control	11	140.00	131.07	43.92	6.86	13.86
Control	12	175.00	150.34	63.95	9.99	20.18
Color	1	40.00	39.50	18.96	2.80	5.63
Color	2	80.00	91.09	28.09	4.14	8.34
Color	3	140.00	140.33	24.00	3.54	7.13
Color	4	21.00	25.70	12.23	1.80	3.63
Color	5	120.00	121.74	12.91	1.90	3.83
Color	6	170.00	169.89	13.06	1.93	3.88
Color	7	72.50	76.50	46.84	6.91	13.91
Color	8	50.00	67.39	51.42	7.58	15.27
Color	9	50.00	55.11	33.41	4.93	9.92
Color	10	90.00	86.37	35.07	5.17	10.41
Color	11	72.50	76.50	46.84	6.91	13.91
Color	12	145.00	128.07	57.50	8.48	17.08
Number	1	40.00	43.98	16.88	2.55	5.13
Number	2	90.00	85.86	22.87	3.45	6.95
Number	3	140.00	139.30	18.95	2.86	5.76
Number	4	25.00	26.86	10.93	1.65	3.32
Number	5	120.00	118.64	11.17	1.68	3.40
Number	6	170.00	169.34	12.50	1.88	3.80
Number	7	75.00	76.52	48.08	7.25	14.62
Number	8	51.50	70.75	52.08	7.85	15.83
Number	9	55.00	59.20	28.39	4.28	8.63
Number	10	72.50	73.30	36.88	5.56	11.21
Number	11	75.00	76.52	48.08	7.25	14.62
Number	12	125.00	113.34	67.50	10.18	20.52

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