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ANALYSIS OF COLLECTIVE INVESTMENT DECISIONS: A BEHAVIOURAL ECONOMICS APPROACH

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ABSTRACT

In the current global economic landscape, the development of collective projects is fundamental. Beyond generating economic growth, the undertaking of social ideas or investment projects contributes to technological advancement, innovation and the sustainable development of economies. Therefore, the central objective of this study is to advance and understand the effective factors that enhance cooperation for the development of collaborative projects. A behavioral economics approach is adopted to understand and determine the influence of information, the social environment and risk preferences on collective investment decision making. The results of this thesis are of great interest for understanding decisions in collective projects or ideas, such as crowdfunding, joint ventures or public goods.

To achieve the objective of this thesis, a study on the factors that determine investment decisions has been carried out. First, we empirically analyzed the factors that lead to overfunding (excess of total collected funding over the pre-determined target) of equity and rewards projects. Secondly, we focused on analyzing the strategies that allow to signal quality in investment projects according to their nature. Studying these strategies allows to determine the characteristics to attract a greater number of investors according to the type of project to be financed. Finally, we analyze through an experimental study the effectiveness of establishing a threshold, a provision point mechanism, in the development of a collective project. We analyze the effect of introducing a threshold in a setting without threshold and the impact between different threshold levels.

The results of this thesis have allowed to identify factors that determine investment decisions, such as offering information on risky projects or offering a greater variety of rewards to attract consumers with different profiles. However, we found differences in the determinants according to the nature of the project, commercial or social. The experimental study has determined the effect of different threshold levels on the development of collective projects, information aggregation and the formation of information cascades. In addition, we found evidence of the importance of forward-looking beliefs in collective investment decision making.

Keywords: Collective projects; Investment decisions; Quality signaling; Threshold.

RESUMEN

En el actual panorama económico mundial, el desarrollo de proyectos colectivos es fundamental. Además de generar crecimiento económico, el emprendimiento de ideas sociales o proyectos de inversión contribuye al avance tecnológico, la innovación y el desarrollo sostenible de las economías. Por ello, el objetivo central de este estudio es avanzar y comprender los determinantes que favorecen la cooperación para el desarrollo de proyectos colaborativos. Se adopta una perspectiva desde la Economía del Comportamiento para comprender y determinar la influencia de la información, el entorno social y las preferencias de riesgo en la toma de decisiones de inversión colectiva. Los resultados de esta tesis son de gran interés para entender las decisiones en proyectos o ideas colectivas, como el crowdfunding, las joint ventures o los bienes públicos.

Para lograr el objetivo de esta tesis, se ha llevado a cabo un estudio sobre los factores que determinan las decisiones de inversión. En primer lugar, analizamos empíricamente los factores que conducen a la sobrefinanciación (captación de fondos por encima del objetivo de financiación requerido) de proyectos de inversión y recompensas. En segundo lugar, nos centramos en analizar las estrategias que permiten señalar la calidad en los proyectos de inversión según su naturaleza. El estudio de estas estrategias nos permite determinar las características que permiten atraer a un mayor número de inversores según el tipo de proyecto a financiar, social o comercial. Por último, analizamos mediante un estudio experimental la eficacia de establecer un umbral, un punto de provisión, en el desarrollo de un proyecto colectivo. Analizamos el efecto de introducir un umbral en un contexto sin umbral y su impacto entre diferentes niveles de umbrales.

Los resultados de esta tesis han permitido identificar factores que determinan las decisiones de inversión colectivas, como ofrecer información sobre proyectos arriesgados u ofrecer una mayor variedad de recompensas para atraer a consumidores con diferentes perfiles. Sin embargo, hemos encontrado diferencias en el impacto de los determinantes según la naturaleza del proyecto, comercial o social. Por último, el estudio experimental ha permitido identificar diferencias en el efecto del punto de provisión según su nivel sobre la agregación de información, la correcta selección de proyectos y la formación de cascadas de información. Además, encontramos evidencia de la importancia de las creencias forward-looking en la toma de decisiones de inversión colectiva.

Palabras Clave: Proyectos colectivos; Decisiones de inversión; Señalización de calidad; Punto de provisión.

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CHAPTER 1. INTRODUCTION

1 INTRODUCTION

This Thesis examines the determinants of investment decisions in collective projects that require joint participation in financial decision-making. Specifically, it examines the role of project characteristics, social influence and strategic context to explain investment decision-making. To achieve this aim it is conducted an empirical and experimental analysis of the determinants in collective investment decisions. The research is based on the field of experimental and behavioural economics. This study establishes a foundation for comprehending the factors influencing collective investment decisions and their implications. It enables the examination of decisions that depart from the traditional assumptions of rational investors inherent in conventional models.

The introduction outlines the content of the doctoral thesis. The structure is as follows: firstly, the background and motivation research section provides an overview of the current state of the research topic and the need of the research. Secondly, the research questions and the specific objectives are presented. The third part explains the methodology used to address the research questions and specific objectives. Fourthly, the overall structure of the thesis is delineated. Lastly, it is included a comprehensive list of the publications already achieved from this thesis.

1.1. BACKGROUND AND MOTIVATION RESEARCH

The development of collective investment projects represents a mobilisation of financial resources that can have a significant impact on the economy. To analyse the investment decisions helps to understand the allocation of resources and how they affect economic growth, job creation and competitiveness. Investment projects involve uncertainty and risk, which require a clear understanding of how uncertainty impacts on efficiency and market outcomes. Studying how the benefits and costs of investments are distributed can help to identify potential inequalities and to design policies that promote a more equitable distribution of wealth and

economic benefits. For this reason, it is of great interest to analyse and study how investors make collective investment decisions.

The need for joint support for the development of projects or ideas is a pervasive pattern in our society. In fact, there has been a great deal of research on public goods (Isaac et al., 1985), public goods under uncertainty (Dickinson, 1998), public goods with provision points (Bagnoli and Lipman, 1989), or voting systems with imperfect information (Kartal and Tyran, 2022 or Anderson et al., 2022), among others. These issues are crucial to understand the factors that determine the collective decisions. In this study, we focus on the factors that affect the collective decisions in an investment context.

In particular, we are interested in analysing collective fundraising for projects launched on digital platforms, such as crowdfunding websites, that serve as virtual hubs where a variety of backers and investors come together with entrepreneurs seeking financial support. Crowdfunding platforms experienced a 2.4% growth in transactions in 2023 compared to 2022, a total of 1.2 billion (Statista, 2023). Recent data on European crowdfunding platforms indicates a rise from 16 million euros in 2021 to 19 million euros in 2022 (Shneor et al., 2024)

There are several reasons why the study of collective investment decisions, such as crowdfunding, arouses great economic and social interest. First, crowdfunding platforms are presented as an alternative financing tool, in special, for the development of small and medium-sized enterprises (SMEs). The SMEs comprise 99.7% of Spain's business sector (Arnáiz and Olmedo, 2016). Second, crowdfunding platforms play a relevant role in the development of the objective of the European Commission, which aims to modernize the EU Single Market for the digital era through the establishment of the Digital Single Market. The Digital Single Market Strategy underscores the critical role of nurturing the digital sector as a primary driver for economic growth[1]. In response, regulatory agencies such as the European Securities and Markets Authority (ESMA) and various other European entities are directing their focus towards alternative financing pathways. Their goal is to foster knowledge, stimulate innovation, and encourage socially sustainable entrepreneurship within the European Union (https://sdgfinance.undp.org/). Last, crowdfunding platforms are included as one of the financial solutions to achieve the Sustainable Development Goals (GSDs). The main reason is because the continued expansion of collective investment platforms has the capacity to diminish global inequalities and stimulate economic growth, aligning with the GSDs. In this vein, it is of great relevance to analyze and understand the determinants of collective investment decisions in order to achieve the social objectives and

[1] https://ec.europa.eu

economic growth.

Regarding previous literature, investors' decisions and their responses to incentives cannot always be explained by traditional economic models. These models are based on rational and utility-maximizing decision making. Behavioural economics challenges this rationality assumption, highlighting the impact of social, emotional and psychological factors on decision-making. Starting with the initial contributions on biases and heuristics in decision making by Kahneman and Tversky (1982). Subsequently, there has been a growing research in the field of behavioral finance that aims to integrate psychological insights to improve our understanding of financial decision making (Davis and Holt, 1993; Füllbrunn and Haruvy, 2022).

Recently, academic research on crowdfunding has undergone rapid expansion. Among the pioneers, Agrawal et al. (2014), Belleflamme et al. (2014), and Mollick (2014) have made notable contributions, empirically and theoretically, to understand the effectiveness of different mechanisms to signal quality and reduce moral-hazard, specially in situations of asymmetric information.

In this kind of contexts, characterized by a high degree of uncertainty, the available information regarding the project's quality becomes crucial (Mollick, 2014). In situations where information about a project is limited, as commonly observed in startups or emerging businesses, investors seek signals indicating the quality of the project. Previous studies demonstrate how factors which indicate quality and reduce the uncertainty play pivotal roles in shaping the outcome of the campaign (Skirnevskiy et al., 2017 and Zheng et al., 2014). Thürridl and Kamleitner (2016) indicates that increasing the range of reward levels to accommodate a diverse group of potential backers enhances the probability of achieving the target.

Another stream of research studies how the success of a fundraising campaign depends on the type of crowdfunding. Aspects such as investor motivation, the nature of the project, the funding target set and the duration of the campaign have been studied by different researchers (Mollick, 2014; Cumming et al., 2020; Colombo et al., 2014). Donation or reward crowdfunding projects are affected mainly by social or emotional factors, exerting a substantial impact on the success of such projects (Jank et al., 2019). This phenomenon contrasts with those campaigns that adopt a lending or equity model, where investors are motivated primarily by the expected return and assume different levels of risk .

Despite the burgeoning literature on crowdfunding in recent years, there remains a dearth of studies that delve into the phenomenon of overfunding (excess of total collected funding over the pre-determined target) in equity and rewards crowdfunding. The study of overfunding is especially important to understand

why projects are funded more than they need while others do not reach the funding target, causing mismatch in project financing. Regarding studies of equity crowdfunding platforms, Ahlers et al. (2015), Xiaoyu et al. (2017) and Vulkan et al. (2016) point out the negative relationship between overfunding with the share of equity offered by the campaigns. Cumming et al. (2019) suggest a negative relationship with the possibility of having decision making rights within the project. Considering the limited studies of rewards crowdfunding campaigns on overfunding, Koch (2016), and Kuppuswamy and Bayus (2018) show a positive effect of the number of rewards offered by the campaign, as well as a higher level of information (Dushnitsky and Marom, 2013). However, it is of interest to analyze in more detail factors that can cause overfunding in both rewards and equity campaigns. For instance, determinants such as social networks, activity sector of project, geographical location, among others, may drive fundraising campaign beyond the initial funding target, among other outstanding issues. These questions will be addressed in chapter 2 and 3 of this doctoral thesis.

Moreover, studies show strategic elements for the design of crowdfunding campaigns that can increase the attraction of investors, the market size. For instance, some research examines whether rewards can be strategically employed to implement price discrimination (Cornelli, 1996; Ellman and Hurkens, 2019). Establishing an appropriate reward level would allow charging the price willing to pay to each consumer while obtaining the benefits of consumer surplus. Funding target is also a strategic element to signal quality in the campaigns (Chakraborty and Swinney, 2020). However there remain unanswered questions, such as whether these determinants directly affect overfunding or market size or are mediated by other variables as the nature of the project. This question will be addressed in chapter 4 of this thesis.

Regarding the strategic context of collective investment decisions, investors are in a context where predecessors' actions are observable. In this setting, investors could succumb to herd behavior, a phenomenon well documented in the Behavioural Finance literature, in which individuals follow the actions of the crowd. Herd behavior is sometimes accompanied by information cascades, in which individuals base their decisions on the actions of others rather than on their private information. This behavior has been extensively studied in a variety of social contexts, highlighting its importance and impact on investment dynamics (Banerjee, 1992; Bikhchandani et al., 1992). Although the wisdom of the crowd can be beneficial, herd behavior could lead to counterproductive decisions in the financial market. Empirically, Vismara (2018) indicates the possible presence of information cascades in crowdfunding platforms that give rise to imitation behavior in individuals without providing information to the market.

Previous experimental studies have analyzed the formation of information cascades but not in investment contexts (Anderson and Holt, 1997; Hung and Plott, 2001; Goeree et al., 2007). Information cascades could affect crowdfunding project financing, information aggregation and thus market efficiency. In addition, theoretical studies suggest that establishing a funding threshold or target may impact on the formation of cascades in crowdfunding campaigns (Cong and Xiao, 2023). However, there are no previous experimental studies that analyze the effect of the threshold on crowdfunding decisions. This is a research objective that will be experimentally studied in chapter 5 of this thesis.

Hence, this thesis delves into the study of decisions of collective investment, beginning with an empirical approach and extending with the development of an economic experiment. This research project applies methodologies from experimental economics and statistics to a specific economic issue from a Behavioural perspective: the exploration of optimal conditions for securing funding in collective investment projects.

The results shown in this thesis are of great importance. Role of information in attracting more funding on equity and rewards platforms highlighted. In commercial projects the signaling of quality through the target level is greater, while in social projects the attractiveness of rewards is greater. Finally, experimental evidence provides significantly positive effects of threshold on market efficiency in terms of information aggregation and correct project selection.

1.2. RESEARCH QUESTIONS AND SPECIFIC OBJECTIVES

Three research questions are established in this thesis. The first research question is as follows:

Research Question 1: What are the determinants of overfunding in equity and reward crowdfunding platforms?

It is established the following two specific objectives to address the first research question.

Firstly, we focus on the analysis of determinants of overfunding in equity campaigns. Ahlers et al. (2015) and Vismara (2016) suggest that the founders' initial offering of ownership, known as equity, may serve as an indicator of the risk associated with the firm. Furthermore, professional investors negatively perceive a higher percentage of voting shares because it anticipates the involvement of more non-professional investors (Cumming et al., 2019). The social capital, information through internal or external networks can reduce the uncertainty for investors (Ralcheva and Roosenboom, 2016; Rossi and Vismara, 2018; Hornuf and Schwienbacher, 2017). Another factor that affects the financing process is the country where the campaign is

developed (Vismara, 2016; Zheng et al., 2014; Hornuf and Schwienbacher, 2017). Therefore, the following specific objective is proposed:

Specific Objective 1.1: To analyze the effects of key factors, i.e. the equity capital, voting right and social capital, on the level of overfunding and number of investors in equity crowdfunding campaigns.

Regarding rewards projects with overfunding, it is analyzed the factors that determine overfunding in this kind of projects. Entrepreneurs can offer information through different channels, among them we can find social networks, project descriptions, videos, entrepreneurs experience, etc. being the social capital, which can have a positive impact in reward-based crowdfunding as Mollick (2014), Koch (2016) or Dushnitsky and Marom (2013) indicated. Moreover, previous studies have indicated relationship between the target level, minimum amount of money needed for the project, called threshold, and the probability to success, i.e. to achieve the threshold. In addition, it is considered again the possible differences due to the nature of the project. Therefore, it is established the second specific objective:

Specific Objective 1.2: To study the determinants of overfunding: target, number of rewards, entrepreneurial experience, project information and project nature, in reward crowdfunding campaigns.

The second research question is focused on analyzing the quality signaling strategies for reward crowdfunding campaigns, through the target level (Chakraborty and Swinney, 2020), and price discrimination, considering the number of rewards (Ellman and Hurkens, 2019). It is analyzed how the factors can be determined to attract a larger number of backers in the market, increasing the market size (MS). We also consider their impact depending on the level of information available, willingness to pay and nature of the project. Therefore it is established the second research question:

Research Question 2: How and when does the target and number of rewards affect market size in rewards crowdfunding projects?

To answer this second question, the characteristics and the information of projects could indicate quality, and their effect is analyzed in the market size, through an empirical analysis. Ahlers et al. (2015) provide evidence that news or updates posted on the crowdfunding platform during the campaign are crucial for reaching and surpassing funding goals. These updates enhance project visibility. Commonly considered variables to measure internal social capital include the entrepreneurs' past support for successful projects, creating an internal community with other members, and the number of LinkedIn connections reflecting their professional contacts (Buttice et al., 2017). Moreover, the characteristics and the determinants of the project

could depend on the nature of the project. Social projects should consider their impact on the community and commercial projects will be more concerned with achieving a high demand for their product. Then, the specific objective 2.1 is established:

Specific Objective 2.1: To study the effect of target on market size as a quality signaling strategy, considering the mediating role of updates and the moderating role of the project nature.

The variety of rewards offered may be an indication of the degree of discrimination by the entrepreneur (Thürridl and Kamleitner, 2016). Projects published in front of a heterogeneous range of investors will try to attract as many backers as possible. Therefore, offering a wide variety of possible investments could capture a larger market size. Moreover, Cai et al. (2020) show a positive relationship between number of rewards (price discrimination) and the average pledge. For this reason is interesting to consider the mediating role of the willingness to pay between the price discrimination and MS. However, this effect should be considered according to the nature of the project, as it could affect its relevance according to the project's characteristics as previous empirical literature indicated (Bürger and Kleinert, 2021). We establish the following specific objective:

Specific Objective 2.2: To analyse how the variety of rewards affect market size as a price discrimination strategy, considering the mediating role of the willingness to pay and the moderating role of project nature.

The third and last research question deals with the effect of the funding mechanisms that campaigns may adopt, AoN (All or Nothing) which involves setting a minimum funding threshold, or KiA (Keep it All) in which it is not necessary to reach a minimum funding threshold. Previous studies from the literature and this thesis do not reach a consensus on the threshold effect. In a context of sequential decision-making with observable actions and private information, as can occur in campaign finance processes, social learning is present. In this context information cascades could explain why some projects are funded and many others are not. We ask how the threshold affects this social learning context. Therefore, the third research question is:

Research Question 3: What is the effectiveness of two funding models used by platforms, the AoN model (with a funding threshold) and the KiA model (with no threshold)?

To address this objective an economic experiment is involved to analyze the impact of the threshold on the market efficiency. In particular, we analyzed whether introducing a threshold could improve information aggregation, the formation of information cascades and improve project funding or non-funding. Therefore,

we establish the specific objective 3.1.:

Specific Objective 3.1.: To explore the effects of threshold on market efficiency compared to a setting without threshold at three dimensions: information aggregation, formation of correct information cascades and correct project selection.

However, the threshold level will have an effect on collective investment decisions. While some studies suggest that a higher threshold may attract more funding (Chung et al., 2021; Devaraj and Patel, 2016). Other studies point to a negative relationship between threshold size and campaign success (Mollick, 2014; Vismara, 2016). In fact, the chapter 3 and 4 of this thesis show a negative impact on the level of overfunding but a positive effect on the number of investors. However, these studies do not consider whether the project is good, the investor obtains the expected profit, or bad, the investor loses the investment. The last specific objective is established:

Specific Objective 3.2.: To study the effect of the threshold level on market efficiency at three dimensions: information aggregation, formation of correct information cascades and correct project selection.

1.3. RESEARCH METHODOLOGY

Four papers are carried out in this thesis. The first three articles, already published, follow an empirical methodology using databases of the two crowdfunding platforms. The fourth paper follows an experimental methodology.

Initially, an exhaustive documentary analysis was carried out covering the extensive literature of behavioural finance and experimental economics, both fields with more than half a century of research and numerous publications. This review not only delved into well-established fields, but also ventured into emerging areas of research characterized by a relatively minor state of the literature. The literature allowed us to identify possible factors that could affect both equity and rewards crowdfunding. In addition, the results of previous studies and the first chapters of this thesis indicate a strategic role of the threshold, which led to an experimental study of the threshold effect on collective investment decisions.

Specifically, to address the first research question, a rigorous review of the existing literature served as a foundational point to start across the extensive research landscape. This comprehensive review not only provided the theoretical underpinnings relevant to the research question, but also cleared the way for innovative proposals and practical applications, drawing the link between theoretical knowledge and real-world

application. To analyze the specific objectives proposed, an empirical analysis of crowdfunding platforms was carried out. Through the Crawler tool, a database with a great diversity of variables of interest was compiled for two crowdfunding platforms, Crowdcube and Verkami. It was created a comprehensive database capturing key variables and characteristics of investment, along with their overfunding rates (total funding achieved/ target) and the number of investors. Moreover, characteristics of the crowdfunding campaigns were collected, such as number of updates, experience of the promoters, nature of the project, level of equity or type of investment or rewards available. The reasons for the selection of these databases are as follows.

Crowdcube platform is of great interest for several reasons. First, it is an equity platform, where investors can become partners. Moreover, the same platform was found for Spain and the United Kingdom. Therefore, it allows to control the impact that could have the conditions established by the platform. The data collected from this platform allowed us to address to a large extent specific objective 1.1., analyzing the factors that determine overfunding in equity crowdfunding campaigns. For the analysis, quantiles regressions were carried out to determine the impact of every determinant for each quantile of the study variable, overfunding and number of investors.

The second platform from which we collected data was Verkami, a rewards platform. This platform is of great interest for its relevance in terms of volume of transactions and is one of the main rewards platforms in Spain. It also allows to differentiate by project category and the number of backers who supported each idea was public. The data from this platform allowed us to address the second specific objective from the first research question, specific objective 1.2. It was completed by analyzing the determinants of overfunding in rewards campaigns, through logistic regression. Subsequently, the research question 1 was completed, analyzing the determinants in equity and reward crowdfunding.

To carry out the second research question, the database obtained from Verkami was used. The great variety of projects and their classification according to the nature of the project allowed to analyze the differences in the impact of the determinants according to their typology. In addition, it allowed to analyze the effect of both the threshold and the updates on the market size. A mediation and moderation analysis was carried out in order to respond to the specific objectives. This analysis made it possible to answer how and when the factors considered affect the investment decision.

To address research question 3, related to the effect of the threshold on decision making under uncertainty, an experimental methodology was used. It was conducted a review of the literature to determine

the experimental design. Previous to the development of the experiment, a series of simulations were performed in RStudio that allowed to adjust the values of the experiment parameters with greater precision. Then, an artificial laboratory scenario was constructed to systematically reproduce the fundamental conditions of the economic problem posed at the theoretical level, all under controlled conditions. For the development of the experiment, a recruitment process was carried out through the Jaen laboratory website, Ujaeconlab. The experiment was developed during the first and second semester of 2023 in Ujaeconlab. A total of 420 subjects from different degree profiles participated in the 14 sessions that were carried out. The subsequent statistical analysis of the data derived from the decisions of the participants in the experiment facilitates the contrast of the predictions established in the study about the effect of the threshold and the threshold level. Firstly, the effect of the threshold on market efficiency was analyzed, considering several dimensions of measurement. Secondly, to better understand its impact, an individual analysis of investment decisions and the formation of subjective beliefs was carried out through an econometric analysis.

1.4. THESIS STRUCTURE

This thesis is composed of 6 chapters. The first chapter is an introduction where the justification of the research and the development of the thesis are explained. Chapters 2, 3, 4 and 5 present the main findings of the research project to answer the research questions. Specifically, chapters 2 and 3 address research question 1, chapter 4 achieves research question 2 and finally chapter 5 focuses on the research question 3. Finally, chapter 6 presents the conclusions and future research of the thesis. Figure 1shows a summary of the structure of the thesis, which relates objectives, methodology and results to each chapter.

Specifically, chapter 2, titled "Determinants of Overfunding in Equity Crowdfunding: An Empirical Study in the UK and Spain," focuses on answering the specific objective objective 1.1. The main results are: i) a positive signaling role is found for the low equity and the low issuance of voting shares, ii) factors that reduce information asymmetry are key to a higher level of overfunding, and iii) differences between Spain and UK, with the exception of the technology sector, appear to be due to country-specific factors.

Next, chapter 3, "Determinants of Overfunding in Rewards-based Crowdfunding". This study aims to address the factors that lead to higher overfunding in the case of rewards projects. It is analyzed how greater project information and a wider range of rewards can attract a higher overfunding. It completes the specific objective 1.2. which is focus on studying the impact of factors on overfunding in reward crowdfunding.

Chapter 4, titled "Attracting the Right Crowd under Asymmetric Information: A Game Theory

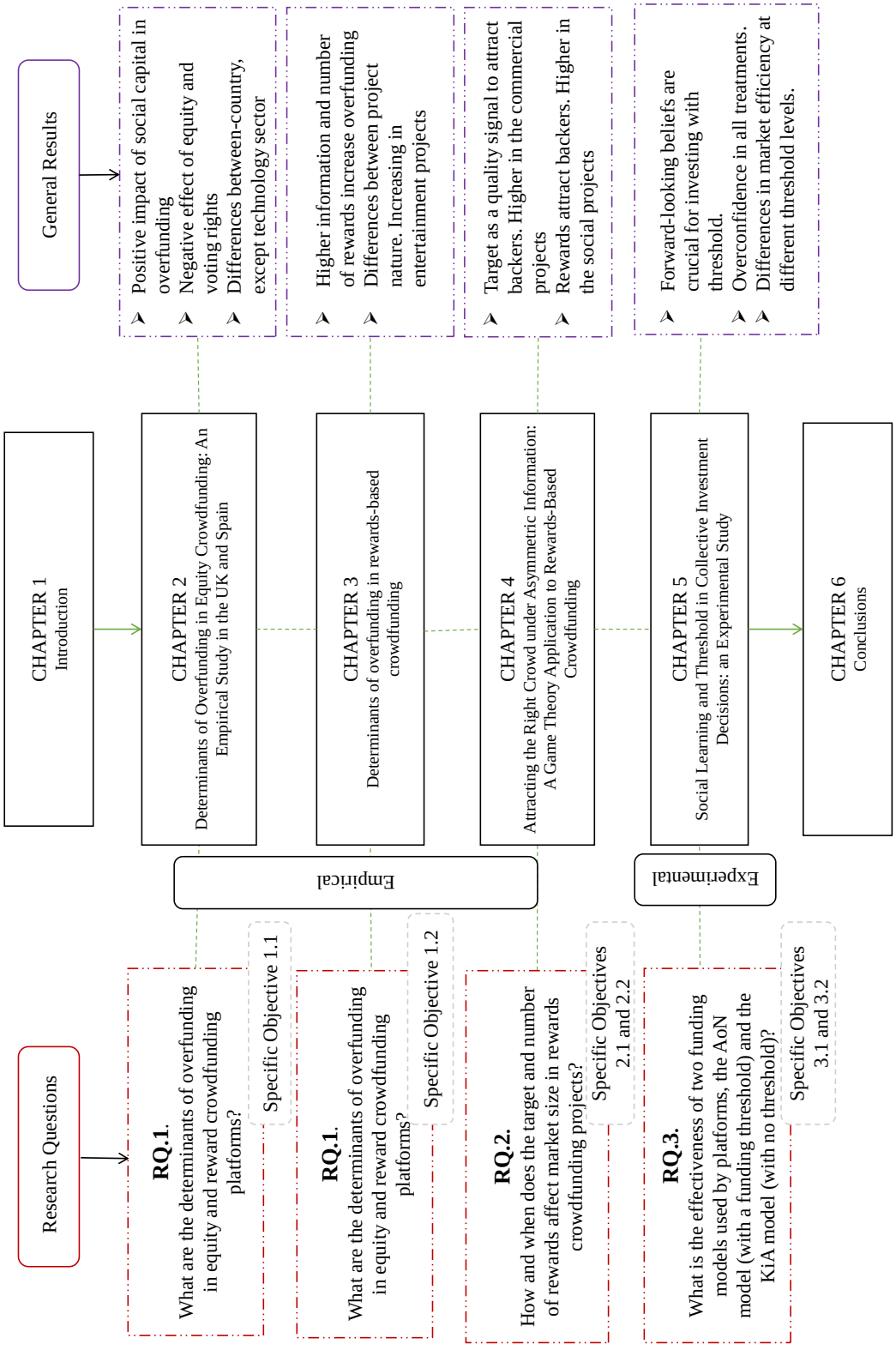

Figure 1: thesis Structure

Application to Rewards-Based Crowdfunding", addresses research question 2. The results show that both target and rewards influence market size significantly. Commercial projects are more effective at using funding threshold to attract investors, while rewards have a greater impact on social projects.

Last research chapter 5, "Social Learning and Threshold in Collective Investment Decisions: an Experimental Study", addresses the research question 3, which aims to analyze how the threshold mechanism affect to collective investment decisions. An economic experiment is carried out to control the context and analyze the effect of the mechanism. The main results point to an effect of the threshold on market efficiency, namely improved project selection and increased formation of correct cascades. In addition, an effect of threshold level on market efficiency is found.

The main conclusions and future lines of research are presented in the last chapter 6.

1.5. PUBLICATIONS

This thesis has led to a series of publications during the doctoral period. It is composed of a total of 3 publications. Specifically, two of them are found in International Journals indexed in the Journal Citations Reports (JCR), chapter 2 and 4. While a third publication is in Scopus category, the chapter 3. The latest work, chapter 5, is in progress for future publication. The publications are shown as follows:

Papers

Martínez-Gómez, C., Jiménez-Jiménez F. & Alba-Fernández, M.V. (2020). "Determinants of Overfunding in Equity Crowdfunding: An Empirical Study in the UK and Spain." *Sustainability*, 12, no. 23: 10054. In the special Issue *Financial Risk Management and Sustainability*. (JCR-Q2). DOI: https://doi.org/10.3390/su122310054.

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CHAPTER 2. DETERMINANTS OF OVERFUNDING OF IN EQUITY CROWDFUNDING: AN EMPIRICAL STUDY IN THE UK AND SPAIN

Abstract

Crowdfunding is a financial tool supporting sustainable development goals by promoting innovation and economic growth. This study analyzes successful equity crowdfunding campaigns in the UK and Spain using data from Crowdcube. Utilizing a quantile regression methodology on 299 overfunded campaigns (2015-2018), we identify significant campaign features influencing overfunding. Results reveal stronger effects at higher quantiles and notable cross-country differences, particularly in the technological sector.

Keywords: equity crowdfunding; overfunding; sustainable finance; United Kingdom; Spain.

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CHAPTER 3. DETERMINANTS OF OVERFUNDING IN REWARDS-BASED CROWDFUNDING

Abstract

This study examines the factors influencing overfunding in reward crowdfunding campaigns on the Spanish platform Verkami. We focus on projects that exceeded their initial funding targets. Our findings indicate that updates, videos, and the entrepreneurs' experience significantly enhance funding success by providing information and reducing perceived risk. Additionally, we analyze sectorial differences, revealing that projects in Entertainment and Literature attract more backers, highlighting diverse backer motivations and preferences in crowdfunding.

Keywords: rewards-based crowdfunding; overfunding; Verkami.

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CHAPTER 4. ATTRACTING THE RIGHT CROWD UNDER ASYMMETRIC INFORMATION: A GAME THEORY APPLICATION TO REWARDS-BASED CROWDFUNDING

Abstract

This paper investigates rewards-based crowdfunding as a financing method for startups using game-theory models. Analyzing 1613 projects on Verkami (2015-2018), we find that higher funding targets and more rewards positively impact market size. Social networks and backers' preferences mediate these effects. High funding targets benefit commercial projects, while more rewards are advantageous for social projects. This research offers insights into optimizing crowdfunding campaign design.

Keywords: asymmetric information; game theory; signaling; price discrimination; conditional process analysis; entrepreneurship; rewards-based crowdfunding.

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CHAPTER 5. SOCIAL LEARNING AND THRESHOLD IN COLLECTIVE INVESTMENT DECISIONS: AN EXPERIMENTAL STUDY

Abstract

This research experimentally studies the impact of a threshold, a minimum funding requirement, to undertake a collective investment project. Specifically, we examine the effectiveness of different threshold levels in three dimensions: information aggregation, formation of correct information cascades and correct projects selection. The laboratory experiment involves four treatments: one without threshold and three with threshold. The basic strategic environment (no threshold), characterized by a sequential game with imperfect information, allows the analysis of the role of social information and private information in investment behavior and belief formation. Three threshold levels are examined: i) a mid-level threshold, the most efficient according to our investment context, ii) a low-level threshold, which is achieved without the formation of information cascades, and iii) a high-level threshold, which is necessarily achieved with the formation of an UP cascade. A total of 420 students participated in the experiment, under a between-subject design. The preliminary results show that mid-level threshold leads to substantial improvement in market efficiency: correct project selection and formation of correct information cascades increase significantly compared to the no threshold treatment. Furthermore, different market efficiency results are obtained according to the threshold level. High-level threshold shows a worsening in the selection of good projects compared to mid-level threshold. In addition, low-level threshold shows a reduction in market efficiency in terms of information aggregation, formation of information cascades and correct project selection, compared to mid-level threshold. Finally, individual-level analyses reveal that agents tend to be overconfident in the use of private versus public information for investment decision-making and updating beliefs. Furthermore, in threshold treatments, we find strong evidence that forward-looking beliefs about subsequent subjects' actions are crucial to explain individual investment decisions.

Keywords: threshold; social information; information cascades; collective decisions.

Martínez-Gómez, C., Jiménez-Jiménez, F. and Alba-Fernández M.V. *In Process*

5.1. INTRODUCTION

The development of innovative digital finance offers entrepreneurs and investors new avenues to fulfill their respective targets. As enterprises seek capital resources to enhance their growth, investors actively look for investment opportunities. Notably, the rise of collective investment platforms, particularly crowdfunding platforms, has attracted a great deal of interest and attention. These platforms serve as conduits for bridging funding gaps between ventures and investors, when entrepreneurs need funding and investors seek investments. Crowdfunding platforms have been growing in recent years, reaching a total transaction value of $1.2 billion worldwide by 2023[1]. In fact, it has had a growth of 2.4% in 2023 compared to 2022. Consequently, the study of crowdfunding has attracted the attention of extensive academic research, focused on analysing operational mechanisms and the determinants of success of crowdfunding campaigns (Mollick, 2014; Vismara, 2016; Ahlers et al., 2015). In this chapter, we are interested in comparing the effectiveness of two financing models widely used by platforms, AoN model (All or Nothing) and KiA model (Keep it All).

In the AoN model, a project must reach its predetermined funding goal to be developed. If the funding goal is not met, entrepreneurs do not receive any payoffs, the investments are refunded to the investors, and the project does not move forward. On the other hand, in the KiA model, the proposer of the project receives the collected during the fundraising campaign regardless of the pre-specified goal. Each model carries significant economic implications: AoN provides greater security for investors and reduce moral-hazard problem, i.e. when investors are unsure whether the entrepreneur will keep his/her deal or run off with the money raised in the campaign (Strausz, 2017, Chang, 2020). On the contrary, KiA offers creators more flexibility, allowing them to use the funds even regardless of the amount achieved.

In this chapter we study experimentally the role of the threshold (KiA and AoN mechanism) in sequential investment decisions under uncertainty. Specifically, two research questions are addressed: i) which funding mechanism is more effective in terms of market efficiency?, ii) How does the threshold level affect collective investment decisions?

To answer theses questions, we design an experiment with four different treatments where the treatment variable is the threshold level. We design one treatment without threshold and three treatments with threshold: low, medium and high level, where the mid-level has the best theoretical properties with respect to the market efficiency in three dimensions: information aggregation, information cascades and correct project selection.

[1] Statista. (2024). Statista. Retrieved from https://www.statista.com/

This study is based on a context of sequential decisions where the true state of a project remains unknown and the agents have private information and social information. This context creates a setting conducive to the formation of information cascades, where investors follow their predecessors' actions, regardless of their private information. Theoretical models of Banerjee (1992) and Bikhchandani et al. (1992) provide the strategic framework for information cascades without threshold. Information cascades present possible adverse effects on market efficiency since once an information cascade begins the aggregation of private information halts. More recently, Cong and Xiao (2023) develop a theoretical model that integrates the threshold in a standard information cascade model. These authors show that the threshold may diminish information cascades and could improve information aggregation.

Prior experimental research on information cascades, conducted by Anderson and Holt (1997), Çelen and Kariv (2004), Hung and Plott (2001) or Goeree et al. (2007), has found significant evidence supporting the theoretical predictions for the formation of cascades. Furthermore, there are deviations from the Perfect Bayesian Nash Equilibrium (PBNE) due to errors or biases such as overconfidence or naive behavior. Previous studies analyse strategic contexts where agents face individual and independent payoffs. Nonetheless, our experimental study stands as the first experimental study of collective investment decisions where, using information cascades as a theoretical benchmark, agents' payoffs are interdependent.

In the empirical literature on crowdfunding, some studies provide support for the existence of herd behavior and information cascades. For instance, Burtch et al. (2018) indicate that threshold can reduce potential herd behavior by diminishing the association between past capital accumulation and visitor contributions. Moreover, Vismara (2018) suggests the existence of information cascades in equity crowdfunding projects, but his empirical study could not delve deeper into how these cascades form. In contrast, our experimental study allows us to analyze how the formation of information cascades affects market efficiency.

Regarding the threshold level, empirical studies in crowdfunding do not yield conclusive results. As indicated in chapters 3 and 4, it was analysed the effect of threshold level on overfunding and market size. Our empirical results showed that a high threshold/target attracts more investors (market size) but reduces the overfunding level. But, it should be mentioned that these results are based on dataset collecting only those projects that have already reached the pre-determined thershold.

Empirical results by Devaraj and Patel (2016) show a negative relationship between funding achieved and the threshold level. Moreover, other empirical studies find a negative link between the threshold level and campaign success (see Mollick, 2014, Frydrych and Koeck, 2014 and Dikaputra et al., 2019). While Chung

et al. (2021) show a positive effect of the target on the pledge decision. Then, the effect of threshold level on the funding process is not clearly determined from the empirical literature.

To the best of our knowledge, this is the first experimental study to analyse the effect of different threshold levels on sequential collective investment. First, a mid-level threshold improves correct cascade formation and correct project selection, as compared to a no-threshold scenario. A high-level threshold worsens market efficiency compared to a mid-level threshold. In concrete, the number of good projects that manage to reach the threshold decreases. On the other hand, the low-level threshold decreases market efficiency in terms of information aggregation, formation of correct cascades and correct project selection. In particular, the low-level threshold finances many projects, both *Good* and *Bad*, and is unable to select the right projects for financing. These findings have important implications for both development of theory and practical design of fundraising campaigns in digital platforms.

The paper structure is as follows: Section 2 presents the theoretical benchmark. Section 3 describes the experimental design. The main results are presented in Section 4, and, finally, Section 5 discusses the implications of experimental findings.

5.2. THEORETICAL BENCHMARK

We first present a standard model of information cascades (without threshold) based on Banerjee (1992) and Bikhchandani et al. (1992). Then, following Cong and Xiao (2023), we analyse the strategic setting when a threshold is introduced in the standard setting.

Consider an investment project of unknown quality ω that takes one of two possible states $\omega \in (G, B)$, *Good* or *Bad*, with the same probability, $\frac{1}{2}$. Agents $i = 1, 2, ...N$ decide sequentially between actions $a_i \in \{-1, 1\}$ either to invest $(a_i = 1)$ or not to invest $(a_i = -1)$ in the project. The ordering of agents is exogenous and is known to all. Each agent observes the decisions of all those ahead of him/her. We assume agents are rational and risk neutral.

All agents face the same investment incentives. The project provides a high payoff ϱ_3 if the state is *Good* and a low payoff ϱ_1 if the state is *Bad*. In case of not investing, agent i receives a fixed payoff ϱ_2 regardless of the true state of the project. We consider that $\varrho_3 > \varrho_2 > \varrho_1$.

Agents differ in their positions in the sequence. Before making investment decision, each agent i observes two types of information: i) public information (common knowledge), which is obtained from

the observation of all his/her predecessors' actions, i.e., the history of preceding actions H_i; and ii) private information, which consists of a conditionally independent informative signal $s_i \in \{-1, 1\}$ about the true state of the project ($s_i = -1$ for a *Bad* state and $s_i = 1$ for a *Good* state). We assume that the signal accuracy q is the same for all agents and for the two states, such that:

$$\mathrm{P}(s_i = 1 \mid \omega = G) = \mathrm{P}(s_i = -1 \mid \omega = B) = q. \tag{1}$$

Given payoff scheme and information technology, we have:

$$\mathrm{EV}(a_i = 1) = \pi_i^s \varrho_3 + (1 - \pi_i^s)\, \varrho_1 \tag{2}$$

$$\mathrm{EV}(a_i = -1) = \varrho_2 \tag{3}$$

where π_i^s is the posterior probability that the project is *Good*.

Thus, a rational agent i decides to invest if and only if $EV(a_i = 1) > EV(a_i = -1)$. Following the most common assumption as a tie-breaking rule, an agent indifferent between investing and rejecting always follows his/her own private signal (Banerjee, 1992).

Let $\rho = \frac{\varrho_2 - \varrho_1}{\varrho_3 - \varrho_1}$ be the relative payoff ratio between investing and rejecting actions. By normalizing payoffs between 0 and 1, we can redefine the optimal choice of investing for agent i as follows:

$$EV(a_i = 1) = \pi_i^s > \rho. \tag{4}$$

In this regard, the ratio ρ can be interpreted as the cost of investing in the uncertain project. It is worth mentioning that our payoff structure differs from that commonly used in previous experimental studies of information cascades, where $\rho = \frac{1}{2}$. As shown below, the parameter ρ influences the conditions for formation of cascades. An information cascade occurs if an agent's action does not depend on his/her private signal. If an agent i is in a cascade, then his/her action does not convey information to the other agents and information aggregation process stops. For low values of ρ, an UP cascade (a cascade in favour to investing) can be formed earlier. Conversely, when ρ is high enough, a DOWN cascade (a cascade in favour of rejecting) can start earlier.

The Perfect Bayesian Nash Equilibrium (PBNE) is defined by agents' strategies, $\{a_i^*(s_i, H_i, \rho)\}_{i=1,2,...,N}$ where $a^* \in \{1, -1\}$, and agents' beliefs such that:

- Given the payoff structure ρ and other agents' strategies a^*_{-i}, each agent i chooses the action a^* that maximises his/her expected utility.

- Agents' belief dynamics are formed according to the Bayes' rule whenever an action history is reached with positive probability in equilibrium.

Define k_i as the difference between the number of inferred good private signals and of inferred bad private signals up to agent i. Then, k_i depends on both the history of actions H_i and the agents' equilibrium strategies, i.e., how informative the history of actions is. Similar to Bikhchandani et al. (1992), a Bayesian rational agent i will form his/her prior belief that the project is *Good* as follows:

$$\pi_i = \mathrm{P}(\omega = \mathrm{G} \mid \mathrm{H}_i) = \frac{q^{k_i}}{q^{k_i} + (1-q)^{k_i}}. \tag{5}$$

After receiving s_i signal, agent i's will update his/her posterior belief that the project is *Good* in this way:

$$\pi_i^s \equiv P\left(\omega = G \mid H_i, s_i\right) = \frac{q^{k_i+s_i}}{q^{k_i+s_i} + (1-q)^{k_i+s_i}}, \tag{6}$$

Notice that the private signals can be correctly inferred from the observed action history just in equilibrium and when there is no cascade yet (informative actions).

Given payoff ratio ρ and signal accuracy q, we can define a minimum value of k, $\bar{k}$, above which investing in the project is optimal:

$$\bar{k}(\rho, q) = \min\left\{k \mid \pi_i^s > \rho, k \in \mathbb{Z}\right\}. \tag{7}$$

Consistent with the standard model of information cascades, the value of $\bar{k}$ determines the conditions in which an UP or DOWN cascade initiates. More specifically, depending on ρ and q, four different conditions for the formation of cascades can be distinguished:[2]

[2]We clarify three possible situations in which indifference between investing and rejecting may emerge: $\rho = 1 - q$, $\rho = 0.5$, and $\rho = q$. As mentioned above, agents follow their own private signal. Hence, if $\rho = 1 - q$, an UP cascade forms when $k_i = 1$, and a DOWN cascade starts when $k_i = -3$. If $\rho = 0.5$, UP and DOWN cascades start when $k_i = 2$ or $k_i = -2$, respectively. Finally, if

- If $\rho < 1 - q$, $\bar{k} < 0$ and an UP information cascade will occur from the first agent.
- If $1 - q < \rho < 0.5$, $\bar{k} = 0$ and an UP cascade will start when $k_i = 1$.
- If $0.5 < \rho < q$, $\bar{k} = 1$ and an UP cascade will start when $k_i = 2$, and a DOWN cascade will start when $k_i = -1$.
- If $\rho > q$, $\bar{k} > 1$ and it could delay the necessary conditions for the formation of an UP cascade, and a DOWN cascade will form from the first agent.

Therefore, in the PBNE, an UP information cascade will form when $k_i > \bar{k}$ and a DOWN cascade when $k_i < \bar{k} - 1$.

As it will be shown in the next section, our experiment is designed for parameters values of $\rho = 0.6$, $q = \frac{2}{3}$ and $\bar{k} = 1$. Therefore, our theoretical predictions fall into the scenario of $0.5 < \rho < q$. This parameter configuration allows us to establish conditions for formation of cascades which differ between UP and DOWN cascades ($k_i = 2$ for an UP cascade and $k_i = -1$ for a DOWN cascade). As compared to the most previous experimental studies (where $\rho = 0.5$), our design conditions lead to anticipate the formation of a DOWN cascade in the sense that if the first agent decides to reject, a DOWN cascade will start from the beginning. We focus on DOWN cascades because these are the type of cascades where the threshold exerts its main effects.

Theoretical Benchmark with Threshold

Here, the standard binary model is modified to incorporate "All-or-Nothing" thresholds commonly observed in crowdfunding campaigns. Agents receive the investment payoffs only if a pre-specified threshold level of support is reached, or the non-investment payoff otherwise. In other words, each agent i's payoffs of investing are conditional on reaching a minimum number of agents investing in the project, T. We assume threshold T is exogenous.

Threshold implementation introduces strategic complementarity of agents' actions. The resulting strategic setting with multiple equilibria is analysed by Cong and Xiao (2023). For any given pair of (ρ, T), the authors show that there is a PBNE in which all actions are informative before an information cascade, and this equilibrium is unique (see proposition 1 in Cong and Xiao (2023)). In such an equilibrium, called as informer equilibrium, for every agent i and history H_i, agent i's action differs for different signals, i.e, $a_i(1, H_i) \neq a_i(-1, H_i)$. In the analysis below, we focus on characterisation of the informer equilibrium.

$\rho = q$, an UP cascade begins when $k_i = 3$, and an DOWN cascade with $k = -1$.

Let A_i be the level of support (number of investors) up to agent i. In equilibrium, before reaching the threshold ($A_i < T-1$) and the formation of cascades, each agent i's optimal action consists of revealing his/her private signal, regardless of observed previous actions. Compared to the standard model without threshold, two important implications can be derived regarding formation of cascades.

First, before approaching the threshold ($A_i < T-1$), DOWN cascades disappear because an agent with a good private signal chooses to invest because his/her decision will be executed only if the project turns out to be *Good* (and does achieve enough number of investors to be implemented). The agent who actually makes the investment decision and determines the payoff of the whole group is the "gatekeeper", i.e., the agent i who is just before reaching the threshold and observe $T-1$ preceding investors ($A_i = T-1$). Therefore, because the gatekeeper observes a longer action history and makes a more informed decision, preceding agents delay their decisions and delegate the final decision to the gatekeeper. Thus, the formation of DOWN cascades is not possible since agents with good private signals will always invest.

Second, before the threshold ($A_i < T-1$) is reached and there is no UP cascade yet, agents with negative private signals always reject the project. If an agent with negative signals deviates to invest, his/her action will convey misinformation to all subsequent agents, who will form wrong posterior beliefs. The biased beliefs lead to either start an UP cascade too early or reach the threshold when the true posterior belief is not high enough.

Therefore, in equilibrium, the threshold is only implemented when there are a sufficient number of agents with good private signals such that the expected value of investment is higher than that of rejection. Before reaching the threshold, the aggregation of information will only stop with the formation of an UP cascade.

To characterise an informer SPNE, four situations can be possible:

- If $A_i \geq T-1$, the optimal decision is given by the standard model with no threshold described above. That is, when the threshold is achieved or the gatekeeper is about to make his/her decision, the theoretical predictions are given by the standard model.
- If $A_i < T-1$ and $k_i > \bar{k}$, the optimal decision is always to invest. That is, when there is an UP cascade before reaching the threshold, the subsequent agents will decide to invest regardless of their private signals.
- If $A_i < T-1$ and $k_i \in \{\bar{k}-1, \bar{k}\}$, the optimal decision is to follow the own private signal. That is,

when the threshold has not been reached and there is no UP cascade yet, agents invest if the signal is good and reject if the signal is bad.

- If $A_i < T - 1$ and $k_i < \bar{k} - 1$, the optimal decision is to follow the private binary signal. That is, when conditions for a DOWN cascade are given, agents disclose their own signal and convey such private information to the gatekeeper.

With all, in the informer equilibrium, agents are truth telling and the posterior beliefs update before any cascades according to the Bayes' rule given by expression 6.

Intuitively, before reaching the threshold, only UP cascades can be formed because the agents receiving good private signals will always decide to invest. Before an UP cascade, an observed action of investing indicates that the agent has received a good private signal. The gatekeeper, who decides whether the threshold is eventually reached, updates his/her beliefs in a Bayesian way taking all available information of preceding informative actions. Once the threshold is approached, the optimal actions will be obtained as in the model without threshold.

Finally, the pre-specified level of threshold can lead to different outcomes. To determine the optimal threshold level, in terms of information aggregation and project selection, Cong and Xiao (2023) propose the following one: $T^* = \frac{N+\bar{k}}{2}$, where N is the number of agents and $\bar{k}$ is the minimum number of excess of inferred good signals needed to invest, as previously defined.

A very high threshold level may result in not reaching the necessary funding for implementation of *Good* projects unless an UP cascade starts very early. This level of threshold may be appropriate for projects with high information accuracy, high q, or for low payoff ratio, ρ. On the other hand, a very small threshold level may be insufficient to generate an action history informative enough before the threshold is reached. In both situations, early formation of cascades may limit aggregation of information in the market and, thereby, lead to incorrect selection of projects.

In the next section, we will describe the threshold levels which allow to test our research hypotheses.

5.3. THE EXPERIMENT

5.3.1 Experimental Design

The experiment has four treatments under a between-subject design, where the treatment variable is the threshold level. The threshold levels are the following: level-1 (equivalent to no-threshold, NT hereafter), level-2 ($T2$, hereafter), level-6 ($T6$, hereafter) and level-8 ($T8$, hereafter). Groups of 10 subjects are formed at the beginning of each experimental session. We define a group size N of 10 members for several reasons. First, a high enough number of players is needed to analyse the effect of different threshold levels. Second, a sufficient number of agents is required to make the possible formation of incorrect DOWN cascades in the first few turns. Third, this number of players allows to compare our results with those of previous studies (Hung and Plott, 2001, Fiore and Morone, 2008 or Dominitz and Hung, 2009). The composition of each group remains fixed for 10 repetitions. At the beginning of each repetition, within group, the play order of each subject is randomly chosen.

In our design the parameter configuration is as follow: the accuracy of private information is $q = \frac{2}{3}$[3]. The payoff structure is: $\varrho_3 = €10$, $\varrho_2 = €6$ and $\varrho_1 = €0$. These parameter values result in a $\bar{k} = 1$, i.e., from a theoretical perspective, an UP cascade will form when the excess of inferred *good* signals is strictly greater than 1.

The three threshold levels are set based on the theoretical model of Cong and Xiao (2023). First, to analyse the impact of introducing a threshold, we compare NT to $T6$. As noted in the previous section, these authors obtain an optimal threshold level given by: $T^* = \frac{N+\bar{k}}{2} = 5.5$. Figure 2 in Appendix A plots the results from simulations[4] based on equilibrium predictions with respect to the outcome variables: correct formation of information cascades and information aggregation.

Many reasons lead us to choose a level-6 threshold instead of a level-5. We consider the results of simulations on information cascades between level-5 and level-6 threshold. To analyse the relative frequency of the information cascades, we compute the number of cascades that have included decisions with private signals opposite to the direction of the cascade. In the simulations, we observe that level-6 compared to level-5 threshold presents a higher percentage of correct cascades from 0.71 to 0.792 and decreases the

[3] Previous studies consider also the same accuracy, Anderson and Holt (1997), Hung and Plott (2001) or Dominitz and Hung (2009).

[4] Simulations were carried out with 1000 sequences performed in RStudio. The simulations have been performed according to the informer equilibrium SPNE proposed by Cong and Xiao (2023).

percentage of incorrect ones from 0.291 to 0.208. Moreover, level-6 threshold is the first threshold that makes the DOWN cascades disappear completely. Furthermore, to analyse the information aggregation we consider the IPQ (Information Production Quality) index introduced by Hung and Plott (2001). This index measures the difference between the probability that the project is *Good* given the whole history of chosen actions and the same probability given the sequence of private signals corresponding to such an action history. The IPQ is defined as:

$$\text{IPQ} = 1 - |P(G \mid a_1, \ldots, a_N) - P(G \mid s_1, \ldots, s_N)| \tag{8}$$

where, $a_i = \{1, -1\}$ indicates investing or not investing, and $s_i = \{1, -1\}$ represents good or bad private signals. The outcome is bounded within the interval $[0, 1]$, while values closer to 1 indicate a higher information aggregation, values closer to 0 indicate the opposite. Considering the informer SPNE and a Bayesian update of beliefs, the actions will match with the private signal as long as they are not in an information cascade. Therefore, IPQ equals to 1 will not be possible because information cascades may be formed that will result in non-disclosure the private information. Likewise, it will not be possible to reach a value of 0 because the turns prior to the formation of cascades will disclose private information. If we compare the simulations for the IPQ index, the information aggregation improves from 0.882, in the level-5 threshold, to 0.902 in level-6 threshold. This increased information aggregation allows to improve the formation of correct cascades at level-6 threshold.

Second, regarding the role of setting different threshold levels, we select two additional levels: a high (T8) and a low (T2). As a high threshold, we select the minimum level which can be reached only when an UP cascade is formed very early, that is, a level of 8 investors ($T8$). A summary of the experimental design and the proportions obtained from the simulations for information cascades, information aggregation and correct project selection, is shown in Table 1. The simulations show similar results in terms of information cascades and IPQ index compared to level-6 threshold. Although the simulations are carried out considering the tie-breaking rule of following the private signal, indicated in the theoretical benchmark section, it is possible that agents decide $Not\ Invest$ when the threshold is not possible to achieve. In this case, the results for $T8$, regarding information aggregation and the formation of correct cascades, will be lower compared to those obtained in the simulations. Table 1 also shows correct project selection, although the number of *Bad* projects funded decreases (correct project selection), the number of *Good* projects financed also decreases.

Table 1: Experimental design. Theoretical predictions based on simulations.

	NT	**T2**	**T6**	**T8**
Correct DOWN Information Cascades	0.413	0.374	0	0
Incorrect DOWN Information Cascades	0.222	0.167	0	0
Correct UP Information Cascades	0.277	0.372	0.792	0.771
Incorrect UP Information Cascades	0.088	0.088	0.208	0.229
Information Aggregation (IPQ index)	0.701	0.762	0.902	0.904
Good Projects Funded	0.316	0.393	0.440	0.364
Bad Projects not Funded	0.311	0.344	0.381	0.418

The fourth treatment corresponds to a level of 2 investors at least for the project implementation. This low level allows to reach the threshold without the formation of UP information cascades. In Table 1, the level of information aggregation is much lower and the number of correct UP cascades are also smaller compared to $T6$. Before reaching the threshold in $T2$, only DOWN cascades can form. Then, the relative frequency of correct and incorrect DOWN cascades will increase.

Along a sequence, each group member (in his/her own turn of play) has to make three decisions in the NT treatment or four decisions in the $T2$, $T6$ and $T8$ treatments. Figure 1 shows the timing of each participant's decisions[5]. The elicitation of the subjective beliefs is carried out according to the rule used by Nyarko and Schotter (2002)[6].

Before making the first decision, the participant observes the previous decisions of the other players and he/she has to indicate his/her prior belief. In the second decision the participant receives a private signal that only the he/she observes, indicating whether the project is *Good* or *Bad* with an accuracy $q = \frac{2}{3}$. In this second decision the player must indicate if he/she wants to *Invest* or *Not Invest*. In the third decision, the posterior belief is elicited in the same way as in the previous subjective prior belief. Finally, only in the threshold treatments, the forward looking belief is elicited to examine whether subjects' decisions depend on their beliefs about subsequent players' actions. These forward-looking beliefs are elicited only when the threshold has not been reached yet.

[5]The translated instructions are available in the Appendix C.

[6]It has been used by other experimental studies, for instance, Ziegelmeyer et al. (2010), Angrisani et al. (2021) and Kartal and Tyran (2022).

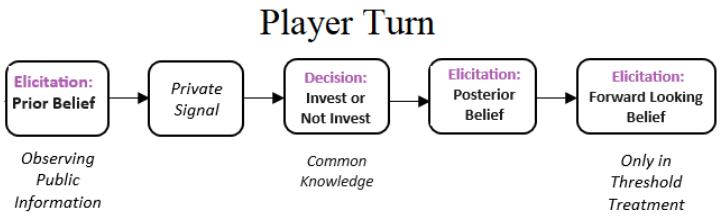

Figure 1: Decision timing

Finally, participants were asked to complete a questionnaire with a set of socio-demographic information as well as a simple question about their attitude toward risky decisions. This variable is used to measure risk preferences (Charness et al., 2020), on a scale of 1 to 10, with 1 being completely risk-loving and 10 being risk-averse[7].

5.3.2 Research Hypothesis

5.3.2.1. The Threshold Effect

Based on the theoretical literature on information cascades (Banerjee, 1992; Bikhchandani et al., 1992), experimental research were conducted by Anderson and Holt (1997), Çelen and Kariv (2004) or Goeree et al. (2007). One of the main findings concerns that deviations from the predictions of the Perfect Bayesian Nash Equilibrium (PBNE). Anderson and Holt (1997) show that some participants take into account all previous information when making decisions, regardless of whether or not they are in an information cascade. In case of being in a information cascade, they actions are not informative. Likewise, Grebe et al. (2008) demonstrates how most subjects do not recognise the cascade behaviour of predecessors. Kariv (2005) and Goeree et al. (2007) show the presence of overconfidence bias in the individual decisions, given a higher weight to the private information compared with the public information. Another important result deals with the experimental study by Hung and Plott (2001) that analyses the effect of different incentive systems on information cascades and on market efficiency. They find differences in the aggregation of information according to the payoff system applied. Specifically, the study shows that payoff depends on the decision of the majority, the information aggregation in the market increases compared to a payoff system that depends only on the decision at the individual level. However, no previous experimental studies have examined the role of the threshold in information cascades.

[7] In addition, three more phases were carried out and will be included in future research

The only theoretical work that analyses the effect of the threshold on sequential investment decisions is Cong and Xiao (2023). This work demonstrates the necessary conditions to be able to establish an *optimal* threshold that allows the improvement of the market efficiency.

Empirically, there are studies about the threshold effect on the investment decisions. Burtch et al. (2018) illustrates how the threshold mechanism in crowdfunding platforms can reduce the herd behavior in the market. Therefore, information aggregation can be increased by more frequent disclosure of private information. Correct project selection could be improved by reducing concerns about developing a project with insufficient funds. In addition, a threshold can signal quality to the investor by requiring greater support from multiple investors. In this way, investors' decisions are more informative compared to the scheme without threshold. Likewise, Cumming et al. (2020) show that threshold allows to signal the quality of the project, being more costly for the entrepreneurs as they will not gain anything if the threshold is not reached, but offering greater security for the investor. It consequently could increase the success of the projects, in terms of projects financed. Astebro et al. (2020) analyzes the differences between the campaigns that have been developed with and without threshold. They find that although crowdfunding campaigns allow aggregation of information, DOWN cascades are formed resulting in a considerable number of projects remaining unfunded with the threshold model.

In our study, we consider the $T6$ level as the threshold with the best properties to be compared to NT and to measure the threshold effect. In our context, $T6$ could be reached both with and without the formation of UP information cascades, affecting the aggregation of information and therefore the correct project selection. In this vein, we analyse the threshold effect on market efficiency through three measures:

Information Aggregation

The threshold allows the DOWN cascades to disappear by revealing agents' private information when it indicates that the project is *Good*. Similarly, adding more information before the formation of a cascade allows for a higher probability that the decision will be correct in the sense that the decision matches with the true state of the project. Even if the first agent decides $Not\ Invest$, when the project is *Good*, an enough number of correct signals will be generated and revealed before reaching the threshold, increasing the accumulation of informative actions. In fact, Hung and Plott (2001) demonstrates how information aggregation increases when the payoff depends not only on one's own decision, but also on the decision of others. In particular, the threshold reaches an aggregation of private information of 0.98 when the payoff depends positively on the majority decision. However, when the payoff only depends on the individual decision, the aggregate

information drops to 0.85. Therefore, information aggregation is expected to increase in the scheme with threshold compared to the situation without threshold.

Formation of Correct and Incorrect Information Cascade

The $T6$ can be reached in one of the two following ways: i) with an UP information cascade, under the same conditions as setting NT, ii) aggregating the private information in the market with or without the subsequent formation of an UP cascade. In $T6$ the DOWN cascades disappear, as an agent with *good* signals will invest. If the project does not reach the threshold 6, it could be because there be a greater amount of *bad* signals.

This prediction is based on our simulations, with no DOWN information cascades being generated. Regarding Figure 5 in Appendix A, the number of incorrect UP cascades increases slightly compared to NT. This is the result of making the DOWN cascades disappear, which causes the formation of information cascades to be distributed between only two types: up correct and up incorrect cascades. For this reason there is a slight increase in up incorrect cascades compared to NT, yet there is a greater increase in up correct cascades.

Correct Project Selection

If the aggregation of private information in the market improves before reaching the threshold, the probability of choosing a *Good* project or avoiding a *Bad* project will be higher. In this way, if there are not enough agents with *good* signals the threshold will not be reached. It would be the case of a *Bad* project, allowing it to be identified it in this way. In the opposite case, if the project is *Good*, even if the first agents receive a *bad* signal and decide $Not\ Invest$, subsequent agents who receive *good* signals will $Invest$, allowing them to reach the threshold.

Therefore, the first hypothesis is established:

Hypothesis 1: Compared to the non-threshold baseline, a level-6 threshold will enhance market efficiency in terms of information aggregation, formation of correct information cascades and correct project selection.

5.3.2.2. The Effects of Threshold Level

We have considered the threshold effect when setting the most efficient threshold according to our

simulations and the previous literature. However, what happens when another threshold level is set? To address this question, we establish a second research question of how the threshold level affects collective investment decisions.

In previous empirical literature there seems to be a mixed evidence between the results regarding the threshold level. One of the issues in a highly elevated threshold is its failure to fund the financing required (Astebro et al., 2020). Therefore, the threshold mechanism might not fund a non-negligible percentage of *Good* projects. Furthermore, Mollick (2014), shows the importance of the negative relationship between the level of the threshold and the probability of success of a project in the sense of getting the funding goal. Moreover, previous literature on crowdfunding investment projects also shows a similar relationship between the threshold level and achieve threshold due to the promoters' own confidence in their project (Ahlers et al., 2015; Vismara (2016)). It is expected that these results are sometimes due to the requirement of an UP cascade as a necessary requirement to reach the threshold when it is very high.

However, Chung et al. (2021) and Devaraj and Patel (2016) found a positive effect of higher thresholds which allow to disclose higher quality of the project. Higher thresholds offer greater confidence to investors and could attract more investments. In fact, in the two preceding chapters of this thesis, 3 and 4, a positive relationship is demonstrated between a larger threshold level and a larger number of investors. Therefore, empirical results do not reach a clear consensus.

Therefore, we analyzed the effect of other threshold levels, $T8$ and $T2$, on the market efficiency at the three previous measures indicated, compared to the $T6$ treatment.

T8 versus T6

Information Aggregation

Regarding the simulations, the level of information aggregation achieved in $T6$ is similar to $T8$. Note that this result has been obtained through the simulations which are performed according to the theoretical model of Cong and Xiao (2023). In case of indifference between $Invest$ or $Not\ Invest$, it will be decided to $Invest$ if a *good* signal is received even if it is not possible to reach the threshold. The possible realizations of the histories are as follows: i) an UP cascade could be formed under the same conditions in both treatments offering the same levels of information aggregation, ii) or no UP cascade is formed and therefore all private information is revealed in both treatments before the threshold is reached. In the latter case, level-6 threshold

could be reached, while threshold 8 would not be possible to reach. This difference, which is eliminated in the theoretical predictions of Cong and Xiao (2023), could affect the levels of information aggregation obtained from the simulations. While it is indeed possible that, in situations where reaching the threshold is not feasible, players may opt to $Not\ Invest$ instead of disclosing private information. If they decide $Not\ Invest$ independent on the private information, the information aggregation will be lower with $T8$.

Formation of Correct and Incorrect Information Cascades

According with our simulations, the DOWN information cascades are completely disappear with both thresholds. From $T6$ onwards, it is sufficiently large to be reached only through the aggregation of private information or the formation of an UP information cascade; in the latter case, the subsequent formation of a DOWN cascade would not be possible if players disclose their private information. However, these simulation results are due in part to the assumption that even if the threshold cannot be reached, agents will invest if a *good* signal is received. Agents are faced with indifference when, while not being able to reach the threshold, they receive a *good* signal.

On the other hand, the UP information cascades will form under the same conditions for both $T6$ and $T8$. Hence, no differences are expected between the correct and incorrect UP cascades.

Correct Selection Project

With $T8$ the average number of funded *Bad* projects is similar to $T6$ because they will only be reached if an incorrect UP cascade is formed in the first turns. Thus, this history can occur in the same way with no difference between $T6$ and $T8$. However, the selection of *Good* projects becomes worse. The *Good* projects achieved are lower because of the high coordination requirements and can only be reached if an UP cascade is formed in the first turns.

Therefore, we expect that:

Hypothesis 2: Compared to the level-6 threshold, a level-8 threshold will decrease the market efficiency in terms of the number of *Good* projects funded.

T2 versus T6

Information Aggregation

A lower threshold is analysed in the opposite case, i.e. one that can only be reached without the formation of a UP information cascade, $T2$. A very low threshold could cause an early achievement. The effect of disclosing private information that enables the threshold will be lost very quickly. It results in a lower information aggregation compared with higher threshold levels. In fact, our simulations confirm a IPQ index of 0.762 compared to an index of 0.902 for $T6$.

Formation of Correct and Incorrect Information Cascades

Likewise, $T2$ is not sufficiently high to make the DOWN cascades disappear, consequently both correct and incorrect DOWN cascades will be formed. This will cause a lower mean of UP cascades compared to $T6$. Although the number of incorrect UP cascades is lower for $T2$, the decrease of correct UP cascades is more accentuated. Since their formation will take place at times with less prior information aggregation.

These predictions are supported by the results obtained in the simulations. The mean number of correct DOWN cascades is 0.374 in $T2$ while the mean number of incorrect DOWN cascades is 0.167. On the other hand, the number of incorrect UP cascades is 0.088 for $T2$ compared to 0.208 for $T6$. However, threshold 2 decreases the number of correct UP cascades from 0.792 for threshold 6 to 0.372 for $T2$.

Correct Selection Project

The reduced information aggregation leads to a worsening of the correct project selection.

The avoidance of *Bad* projects worsens compared to T6 and higher threshold levels. In addition, DOWN cascades can form more quickly because if the gatekeeper is reached with an accumulation of *Not Invest* decisions, it will lead to a DOWN cascade for the rest of the history. Consequently, the average number of *Good* projects not funded is higher compared to $T6$. Likewise, if two positive signals are received in a sequence, the threshold will be reached. With the level of accuracy set in our design, $\frac{2}{3}$, two or more *good* signals could be generated when the project is really *Bad*. Therefore, the financing of *Bad* projects will be higher.

The third hypothesis is:

Hypothesis 3: Compared to the level-6 threshold, a level-2 threshold will reduce the market efficiency in terms of information aggregation, formation of correct cascades and correct project selection.

5.3.3 Procedures

The experimental sessions of this study took place at the Laboratory of the University of Jaén (Ujaeconlab.com) during the year 2023. The experiment was carried out using the Otree software. Recruitment was carried out through Orsee[8]. With a participation of 420 students from different academic profiles. In total, 14 experimental sessions were carried out with 30 subjects participants by session.

Four sessions were carried out for NT and $T6$ treatment, and three sessions for $T8$ and $T2$. The instructions were handed out at the beginning of each session. Before the start of the phase, the instructions were read aloud and any questions were resolved individually. During the experiment, the participants kept the instructions so that they could consult them at any time. Participants had no maximum response time.

Players did not get feedback on their payouts during the experiment. Each player is paid only for one of the ten investment decisions made and for one of the elicited belief, chosen randomly at the end of the experiment. Participants knew their payoffs only at the end of the 10 repetitions. The experiment lasted approximately 2 hours and the average payoff by participant was €22.57 including a participation fee of €5.

5.4. RESULTS

Statistical analysis is carried out at two levels: firstly, an analysis of the effects of the threshold and the threshold level on market efficiency, and secondly, an individual analysis of investment behavior and belief formation.

The Effects of Threshold and Threshold Level

The market efficiency will be analyzed using three measures: information aggregation, formation of information cascade and correct project selection.

Table 2 presents the main results regarding the IPQ index, information cascades and equilibrium behavior for the four treatments. Columns differentiate whether the threshold has been reached (4) or not (2 and 3). The first row presents the IPQ index for each treatment. The following rows, grouped in four blocks, analyze the information cascades considering: i) number and length, ii) correct and incorrect cascades, iii) DOWN or UP, and, iv) correct DOWN (UP) or incorrect DOWN (UP). The best results for the formation information cascades are shown in bold, which are discussed and compared below. The bottom block shows

[8](www.recruitment.com)

the behavior consistent with PBNE (NT treatment) and informer PBNE (treatments with threshold).

Table 2: Summary of main findings by treatment

	(1) Total				*(2) Before Threshold*			*(3) Before and possible Threshold*			*(4) After Threshold*		
	NT	*T = 2*	*T = 6*	*T = 8*	*T = 2*	*T = 6*	*T = 8*	*T = 2*	*T = 6*	*T = 8*	*T = 2*	*T = 6*	*T = 8*
IPQ Index	0.635	0.588	**0.682**	0.644	-	-	-	-	-	-	-	-	-
Information Cascades	71	57	78	55	33	74	55	32	47	19	24	4	0
Average length	4.07	4.649	4.218	4.873	-	-	-	-	-	-	-	-	-
Correct Cascades	0.268	0.351	**0.474**	0.382	0.364	**0.459**	0.382	0.375	0.490	**0.526**	0.333	**0.750**	-
(Incorrect Cascades)	(0.732)	(0.649)	(0.526)	(0.618)	(0.636)	(0.541)	(0.618)	(0.625)	(0.510)	(0.474)	(0.667)	(0.250)	-
DOWN cascades	0.845	0.912	0.821	0.836	1.000	0.865	0.836	1.000	0.787	0.737	0.792	0.000	-
(UP cascades)	(0.155)	(0.088)	(0.179)	(0.164)	(0.000)	(0.135)	(0.164)	(0.000)	(0.213)	(0.263)	(0.208)	(1.000)	-
Correct DOWN cascades	0.211	0.281	**0.372**	0.309	0.364	**0.392**	0.309	0.375	0.384	**0.421**	**0.167**	0.000	-
(Correct UP cascades)	(0.056)	(0.070)	**(0.103)**	(0.073)	(0.000)	(0.068)	**(0.073)**	(0.000)	**(0.106)**	(0.105)	(0.167)	**(0.750)**	-
Incorrect DOWN cascades	0.634	0.632	**0.449**	0.527	0.636	**0.473**	0.527	0.625	0.404	**0.316**	0.625	**0.000**	-
(Incorrect UP cascades)	(0.099)	**(0.018)**	(0.077)	(0.091)	**(0.000)**	(0.068)	(0.091)	**(0.000)**	(0.106)	(0.158)	**(0.042)**	(0.250)	-
$A_i \geq T-1$	0.654	-	-	-	0.702	0.578	**0.857**	-	-	-	-	-	-
$A_i < T-1$ *and* $k_i > \bar{k}$	-	-	-	-	0.529	0.563	**0.606**	-	-	-	-	-	-
$A_i < T-1$ *and* $k_i \in \{\bar{k}-1, \bar{k}\}$	-	-	-	-	0.678	**0.731**	0.716	-	-	-	-	-	-
$k_i < \bar{k}-1$ *and* $A_i < T-1$	-	-	-	-	0.615	0.641	**0.653**	-	-	-	-	-	-

We obtain the value of the IPQ for the experimental results using expression 8. The highest IPQ index is obtained in $T6$, while the lowest index corresponds to $T2$. A Mann-Whitney test reveals that this difference is significant (p-value = 0.023). However, the pairwise differences between the $T6$ and NT treatments, and the differences between $T6$ and $T8$ treatments are not significant (p-value=0.173 for NT vs. $T8$, and p-value=0.268 for $T6$ vs. $T8$).

An analysis of the IPQ index by turn is carried out in Table 7 in Appendix B. The results reinforce that $T6$ offers a higher information aggregation in nearly all the turns compared to the other three treatments. In addition, we find a decreasing pattern in the IPQ index along the sequence in all treatments. This means that as more public information is accumulated there is more information that does not reflect private information. This result is consistent with the high frequency of information cascades observed in our data, and then, with less informative sequences of actions.

In the following rows of Table 2, $T6$ gets the higher proportion of correct cascades compared with the other treatments. This result improves the correct project selection, as shown below. If we consider the percentage of DOWN and UP cascades, treatment $T6$ shows a lower percentage of DOWN cascades compared

to the other treatments. In a complementary way, $T6$ is the treatment that obtains more UP cascades in relative terms. These differences are not significant according to Fisher's exact test (see Table 3).

Next, we examine DOWN cascades as these are the type of cascades where the threshold exerts its main effects according to the theoretical predictions. The proportion of correct DOWN cascades is higher in $T6$ compared to NT and the other threshold treatments. Therefore, we observe that the results are better for $T6$ in terms of correct cascades and, more specifically, correct DOWN cascades compared to the other treatments.

As the column (2) of Table 2 shows, most cascades are formed before reaching threshold. The higher proportion of DOWN cascades before reaching the threshold is for $T2$. This result is expected since they are the only type of cascades that can form before reaching the low threshold of level 2. $T6$ remains the treatment with the highest percentage of correct cascades and correct DOWN cascades compared to the other treatments. Furthermore, column (3) presents the situation before the threshold is reached and is possible to reach it. This column excludes the DOWN cascades formed when the threshold cannot be reached, since the decision $Not\ Invest$ may be due to the impossibility of reaching the threshold. This situation is more likely in $T6$ and $T8$, leading to a decrease in DOWN cascades in both treatments.

In summary, $T6$ shows the best results for the correct information cascades, both DOWN and UP, compared to the other treatments. To determine which pairwise comparisons are significantly different, Table 3 shows the p-values obtained from the Fisher's exact test performed. We find significant differences in the proportion of correct cascades between treatments $T6$ and NT. Specifically, when comparing correct and incorrect DOWN cascades, $T6$ differ significantly from NT, as well as from $T2$.

Table 3: P-value Fisher's exact test

	DOWN/UP				**Correct/Incorrect**				**DOWN Correct/DOWN Incorrect**				**UP Correct/UP Incorrect**			
	NT	*T2*	*T6*	*T8*	*NT*	*T2*	*T6*	*T8*	*NT*	*T2*	*T6*	*T8*	*NT*	*T2*	*T6*	*T8*
T2	0.192	-	-	-	0.205	-	-	-	0.319	-	-	-	0.141	-	-	-
T6	0.429	0.102	-	-	**0.007**	0.104	-	-	**0.014**	**0.079**	-	-	0.265	0.366	-	-
T8	0.542	0.177	0.501	-	0.121	0.443	0.189	-	0.132	0.332	0.249	-	0.535	0.238	0.433	-

The bottom block of Table 2 shows the proportion of decisions consistent with the equilibrium behaviour. In the first scenario ($A_i \geq T-1$), the gatekeeper or threshold has been reached. The second scenario ($A_i < T-1$ *and* $k_i > \bar{k}$) presents the conditions for the UP cascade. The third is the condition for the scenario without an information cascade ($A_i < T-1$ *and* $k_i \in \{\bar{k}-1, \bar{k}\}$) and the last scenario

presents the conditions for the DOWN cascade ($k_i < \bar{k} - 1$ *and* $A_i < T - 1$). In the case of treatment NT, all observations are included in the first scenario because is equivalent to having a threshold level of 1. Our findings suggest that a higher threshold, $T8$, has increased the proportion of decisions consistent with informer SPNE, with the exception of the third scenario.

Finally, we compare in Table 4 the proportion of sequences that achieve or not the threshold distinguishing between *Good* and *Bad* projects. These results are compared with the sequences that obtained an accumulated investment for the NT treatment, $A_N \geq 6$. The first block of rows shows the proportion of correct project selection, i.e., the *Good* projects financed (over the total number of *Good* projects) and the *Bad* projects not funded (over the total number of *Bad* projects). In the opposite way, the incorrect selection of projects are in the next rows. The best results in the correct selection are presented in bold and discussed below.

Table 4: Correct and Incorrect Project Selection

Treatment	***Baseline*** $A_N \geq 6$	$T6$	$T2$	$T8$
Correct Selection	0.56	**0.71**	0.60	0.57
Good funded	0.294	0.365	0.720	0.139
Bad not funded	0.904	0.956	0.450	0.957
Incorrect Selection	0.44	**0.29**	0.40	0.43
Good not funded	0.706	0.635	0.280	0.861
Bad funded	0.096	0.044	0.550	0.043
Total Good (Bad) projects	68 (52)	52 (68)	50 (40)	43 (47)
Total projects	120	120	90	90

$T6$ has the highest proportion of correctly selected projects and NT the lowest. Fisher exact test reveals significant differences between $T6$ and NT in the correct and incorrect project selection.

$T8$ has the lowest proportion of *Good* projects financed (13.9%) and, complementarily, the highest proportion of *Good* projects not financed (86.1%). The differences with respect to $T6$ are significant (p-value<0.001), indicating that the high levels of investment requirements in $T8$ make it difficult to identify *Good* projects. We note that while $T6$ and $T8$ are equally effective in not financing *Bad* projects, $T8$ is worse at financing *Good* projects.

$T2$ increases the proportion of both *Good* and *Bad* projects financed. In particular, the proportion of *Bad* funded projects is much higher in $T2$ than $T6$ and $T8$. The differences of *Bad* or *Good* projects funded between $T2$ and $T6$ are significant (Fisher's exact test p-value < 0.001). The results indicate that $T2$ differentiates *Good* projects worse than $T6$ in order to finance them correctly, increasing significantly the proportion of *Bad* projects funded compared to $T6$.

Result 1: Compared to the non-threshold baseline, introducing a level-6 threshold improves significantly market efficiency in terms of formation of correct cascades and correct project selection. The information aggregation is higher in $T6$ compared to NT, although the differences are not significant.

Result 2: Compared to the level-6 threshold, level-8 threshold decreases the proportion of *Good* projects financed.

Result 3: Compared to the level-6, level-2 threshold worsens the information aggregation (IPQ index), correct DOWN cascades and correct project selection. In particular, more *Bad* projects are financed in $T2$ compared to $T6$.

Our findings offer a partial confirmation of hypothesis 1, as evidenced by the significant improvement in market efficiency observed with $T6$ compared to NT, particularly in terms of the formation of correct cascades and project selection. Although the differences in terms of the IPQ index are not significant, the information aggregation is higher in $T6$ compared to NT and the behavior is consistent among the turns.

Both hypotheses 2 and 3 are supported by our results. Specifically, in hypothesis 2, we observe a decrease in market efficiency in $T8$ compared to $T6$, considering the number of *Good* projects financed. Regarding hypothesis 3, market efficiency is notably lower in $T2$ compared to $T6$, demonstrated by the worsening in information aggregation, formation of correct DOWN cascades, and correct project selection.

An Individual Analysis of Investment Behavior and Belief Formation

We are interested in the study of two key variables, the *Invest Decision*, and the belief formation, through the subjective posterior belief, *SPB*.

To analyze how agents make their investment decisions, we estimate panel data models with random

effects and clustered at group level. The dependent variable is a binary variable with value 1 for investing decision, -1 otherwise. As independent variables, we include the following ones: i) the private information through the probability that the project will be *Good* based on the private signal, being q when $s_i = 1$ and $1 - q$ when $s_i = -1$, called as *Private*, ii) the public information measured in two ways: the probability that the project will be *Good* based on observed decisions, H_i, named *Public*, and beliefs elicited by subjects, called *Prior Belief*[9], and iii) the elicited forward-looking belief, called *Forward Belief*[10], iv) gender variable (1 men and 0 for women), and v) the risk variable (with a scale from 1 to 10 being 1 risk lover and 10 risk averse). The results are shown in Table 5. In the last row we include a ratio that compares the coefficient of *Private* information to *Public* information[11].

We present the results of the NT treatment, columns 1-3, in columns 4-7 for $T2$ treatment, $T6$ treatment in columns 8-11 and $T8$ in columns 12-15. Estimates that consider exclusively public and private information show a significant impact for all treatments. In particular, the coefficient of *Private* information is higher compared to the coefficient of *Public*. If players use public and private information in a Bayesian and rational way, the result of the ratio should be equal to 1, indicating that they give equal weight to both sources of information. The ratio indicates that players assign more than three times the weight to private information compared to public information, which indicate overconfidence in their investment behavior. Moreover, if we compared the ratio between the threshold treatments, as the level of the threshold increases, the ratio between private and public information decreases, reaching the lowest ratio value for $T8$.

[9]Following Dominitz and Hung (2009), when players report a 0 or 100 percent chance, we change the response to 1 or 99, respectively, to calculate the log odds ratio.

[10]The variables private, public, prior belief and forward belief are included in the estimations as the log odds ratio.

[11]The VIF results indicate values below 10, limit typically considered indicative of multicollinearity, thereby it suggests no issues of multicollinearity.

Table 5: Determinants of Individual Investment Decision

	NT			T2				T6				T8			
VARIABLES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Private	1.862***	1.845***	1.846***	1.870***	1.857***	1.787***	2.418**	1.681***	1.679***	1.652***	2.159***	1.774***	1.785***	1.711***	2.138***
	(0.193)	(0.202)	(0.153)	(0.362)	(0.341)	(0.282)	(1.170)	(0.296)	(0.307)	(0.256)	(0.415)	(0.320)	(0.324)	(0.258)	(0.479)
Public	0.479***	0.481***	-	0.474***	0.473***	-	-0.015	0.494***	0.487***	-	0.077	0.548***	0.554***	-	0.158
	(0.096)	(0.092)	-	(0.136)	(0.127)	-	(0.297)	(0.103)	(0.101)	-	(0.115)	(0.123)	(0.130)	-	(0.134)
Prior Belief	-	-	0.302**	-	-	0.256***	-	-	-	0.301**	-	-	-	0.224***	-
	-	-	(0.132)	-	-	(0.035)	-	-	-	(0.138)	-	-	-	(0.053)	-
Forward Belief	-	-	-	-	-	-	1.536	-	-	-	1.123***	-	-	-	1.405***
	-	-	-	-	-	-	(1.194)	-	-	-	(0.170)	-	-	-	(0.353)
Risk		-0.241**	-0.190*	-	-0.293***	-0.189***	-0.122	-	-0.241**	-0.195**	-0.312**	-	-0.090	-0.087*	0.017
	-	(0.105)	(0.111)	-	- (0.046)	(0.046)	(0.126)	-	(0.107)	(0.0.96)	(0.158)	-	(0.063)	(0.049)	(0.179)
Gender		-0.066	0.025	-	-0.551	-0.603*	-1.792**	-	-0.244	-0.339	-0.193	-	-0.651**	-0.500***	-0.114
	-	(0.185)	(0.183)	-	(0.463)	(0.338)	(0.741)	-	(0.419)	(0.297)	(0.628)		(0.282)	(0.175)	(0.700)
Constant	-0.888***	-0.043	-0.582*	-1.246***	-0.050	-0.815**	-3.677**	-0.837***	-0.007	-0.347	0.254	-0.956***	0.399**	-0.841***	-0.417
	(0.129)	(0.335)	(0.303)	(0.208)	(0.349)	(0.370)	(1.591)	(0.107)	(0.432)	(0.354)	(0.699)	(0.202)	(0.199)	(0.221)	(0.481)
LL	-562.134	-557.376	-582.466	-373.535	-369.664	-376.568	-89.893	-562.665	-555.177	-569.457	-238.374	-386.167	-372.350	-403.318	-139.538
McFadden's PseudoR2	0.234	0.240	0.206	0.211	0.220	0.205	0.297	0.211	0.215	0.195	0.297	0.257	0.264	0.203	0.310
Observations	1200	1200	1200	900	900	900	361	1200	1200	1200	536	900	900	900	313
Ratio $\frac{Private}{Public}$	3.887	3.836	6.113	3.945	3.926	6.980	-	3.403	3.448	5.488	-	3.237	3.222	7.638	-

The reported estimates are obtained from panel data models with random effects and clusters at group level.

*** p<0.01, ** p<0.05, * p<0.1.

However, when we include *Forward Belief* we find that the *Public* variable is not significant in the investment decision, but the forward looking belief for treatments $T6$ and $T8$. We find an effect of this belief that is due to the presence of the threshold on investment decisions. This variable is only included in the treatments with threshold and before reaching the threshold. We find that investment decisions depend significantly on their beliefs about the actions of subsequent players, with the maximum coefficient at level-8 threshold. Results suggests that $T2$ treatment presents a small threshold to make relevant the forward looking belief in investment decision-making. Moreover, we observe that the estimations improve with the incorporation of the forward looking beliefs as the log-likelihood values of the estimations increase considerably.

The result for the *Risk* shows a negative and significant effect of risk aversion on $Invest$ decisions for each treatment, except for $T8$ in which the risk variable is not significant.

We analyse the weight given to private and public information to conform the subjective posterior belief, Table 6. The dependent variable is replaced by the subjective posterior log odds on the project is *Good*. In addition, it is included the independent variables on public, private information and subjective forward looking belief as log odds indicated before. In the last row we include again a ratio comparing the coefficients for *Private* and *Public* information.

Table 6: Determinants of Subjective Posterior Belief

	NT			T2				T6				T8			
VARIABLES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Private	0.870***	0.924***	1.328***	1.414***	1.400***	1.381***	0.491***	0.781***	0.495***	0.832***	0.773***	1.305***	1.311***	1.383***	0.948*
	(0.157)	(0.201)	(0.206)	(0.283)	(0.257)	(0.281)	(0.156)	(0.154)	(0.109)	(0.137)	(0.212)	(0.497)	(0.546)	(0.195)	(0.212)
Public	0.356***	0.357***	-	0.394***	0.396***	-	0.020	0.497***	0.494***	-	0.024	0.497***	0.498***	-	-0.690
	(0.159)	(0.089)	-	(0.047)	(0.046)	-	(0.049)	(0.063)	(0.064)		(0.035)	(0.077)	(0.080)		(0.075)
Prior Belief	-	-	0.480**	-	-	0.481***	-	-		0.755***	-	-	-	0.671***	-
	-	-	(0.130)	-	-	(0.072)	-	-	-	(0.055)	-	-	-	(0.046)	-
Forward Belief	-	-	-	-	-	-	0.514**	-	-	-	0.434***	-	-	-	0.532***
	-	-	-	-	-	-	(0.202)	-	-	-	(0.062)	-	-	-	(0.120)
Risk	-	-0.121	-0.067	-	-0.182**	0.261	-0.033	-	0.004	0.0570	-0.077	-	0.015	-0.024	0.015
	-	(0.106)	(0.041)	-	(0.089)	(0.195)	(0.041)	-	(0.077)	(0.071)	(0.056)	-	(0.095)	(0.044)	(0.095)
Gender	-	-0.143	-0.261	-	0.307	0.303	0-0.145	-	0.063	-0.198	0.056	-	-0.438*	-0.309	-0.458
	-	(0.253)	(0.110)	-	(0.266)	(0.233)	(0.214)	-	(0.233)	(0.231)	(0.215)	-	(0.214)	(0.165)	(0.215)
Constant	0.323*	0.793	0.701***	0.304	1.256***	0.303	-0.010	-0.052	-0.104	0.362	0.372*	0.077	0.223	0.009	0.002
	(0.170)	(0.447)	(0.447)	(0.120)	(0.035)	(0.233)	(0.153)	(0.254)	(0.057)	(0.253)	(0.205)	(0.269)	(0.358)	(0.269)	(0.280)
R-Squared	0.098	0.105	0.386	0.116	0.131	0.256	0.163	0.126	0.124	0.551	0.197	0.130	0.135	0.488	0.156
Observations	1200	1200	1200	900	900	900	361	1200	1200	1200	536	900	900	900	313
Ratio $\frac{Private}{Public}$	2.444	2.588	2.767	3.589	3.535	2.871	-	1.571	1.002	1.102	-	2.626	2.633	2.061	-

Estimations are based on panel data models with random effects and clusters at group level.

*** p<0.01, ** p<0.05, * p<0.1

We show the results for NT in columns 1-3, for $T2$ in columns 4-7, columns 8-11 for $T6$ and for $T8$ in columns 12-15 . Again, we find that public and private information are significant for the formation of beliefs. The weight given to private information is greater than public information in the formation of the SPB. Specifically, if we consider the ratio, a greater weight of private information compared to public information is again obtained for the formation of subjective posterior beliefs, which indicate overconfidence in the formation of the subjective posterior belief. The treatment with the greatest similarity in the weight of the two sources of information is $T6$, a ratio of 1.002. The explanatory power of the regressions increases considerably when the prior belief elicited as public information is considered instead of history, H_i.

Finally, we note again that the *Forward Belief* variable is significant on the *SPB* and public information ceases to be relevant. The finding suggests that individuals' beliefs about future actions have a greater influence on their subjective posterior beliefs than their past actions. Furthermore, we notice that the R-squared values of the estimations increase when incorporating the forward looking belief, compared to those without it.

Result 4: In investment decisions and beliefs formation, the weight of private information with respect to public information is higher in all treatments. This is true with and without threshold, which is consistent with the existence of overconfidence.

Result 5: In the contexts with threshold, forward-looking beliefs appear as a main driver for investment decisions and beliefs formation, in contrast with history-based public information. Then, beliefs about future actions are more relevant than observation of previous actions to explain investment choices and beliefs.

5.5. DISCUSSION

The main objective of this study has been to examine how the threshold and the threshold level affect market efficiency. Group and individual behaviours have been analysed under a setting without threshold and under different threshold levels. Our experiment contributes to the existing literature in the following ways:

Firstly, we have confirmed the existence of a threshold effect on market efficiency in the terms of information aggregation, formation of correct cascades and project selection. The highest level of information aggregation has been obtained with level-6 threshold. This result holds when we analyse the aggregation of information by turns. While level-8 threshold allows aggregation of similar levels of information, level-2 threshold offers the worst information aggregation. The closest experiment to ours that measures information aggregation through the IPQ index is performed by Hung and Plott (2001), (see their treatment called "individualistic"). The authors obtain an $IPQ = 0.85$, above the IPQ we obtain in our closest treatment, NT ($IPQ_{NT} = 0.635$). Nevertheless, it is important to note that their experiment is conducted under non-investment conditions and with a symmetric payoff system.

Regarding the formation of correct cascades, we have observed an improvement of the formation of correct cascades with level-6 threshold. In particular the formation of correct DOWN cascades in comparison to the NT and $T2$ treatments. These aggregate results are consistent with the theoretical predictions based on Cong and Xiao (2023) that indicate a disappearance in the formation of correct DOWN cascades with the use of an *optimal* threshold.

Considering the correct project selection, $T6$ has offered the best results compared with the other treatments. $T2$ funds a higher number of *Good* and *Bad* projects, indicating that $T2$ is too small to be able to properly select projects. Whereas $T8$ finances fewer *Good* projects, but is more likely to avoid financing *Bad* projects.

The higher number of projects funded with a $T2$ confirms the previous empirical results by Mollick (2014) and Astebro et al. (2020), in the sense that smaller thresholds increase the likelihood of campaign financing. However, financing a campaign does not imply that the project is *Good*, and investors could

lose their investments. Therefore, setting a higher threshold level may allow to increase the information aggregation and the formation of correct cascades, avoiding the financing of *Bad* projects.

When we analyse individual investment behaviour and belief formation, we find an overconfident behaviour by attributing greater weight to private information than to public information. This result is consistent with previous experimental studies of information cascades. Specifically, Dominitz and Hung (2009) obtain a ratio of 2.557, Anderson and Holt (1997) get 2.333 and Hung and Plott (2001) find 2.675. Although these ratios are not directly comparable with our results, in our closest treatment, NT, we obtain a ratio of 3.836. Moreover, Dominitz and Hung (2009) analyse the formation of subjective posterior beliefs in the information cascades without threshold. In their case showing that they give equal weight to subjective prior belief and private information, result similar to ours in the $T6$ treatment, where the ratio between private information and public information is 1.102.

One interesting result is the importance of forward looking belief. Players seem to attach greater importance to what they believe will happen in the financing process in order to make their investment decision and forming their beliefs. While public information, which include past actions, is no longer relevant for their decisions, they are more likely to pay attention to what they believe about future actions.

The last implication of this paper is the contribution at a practical level for the organizations. Appropriate mechanisms could incentivize the correct project selection. Cong and Xiao (2023) theoretically demonstrates that thresholds induce better campaign selection by the crowd. We have provided experimental evidence that the threshold can improve project selection, finding different results at different threshold levels. A low-level threshold may worsen selection by funding high percentages of both *Good* and *Bad* projects. A high-level threshold reduces the proportion of *Good* projects funded. Nevertheless, high-level thresholds are interesting for attracting high levels of funding. High-level thresholds could imply a herd behavior in the investment decision to reach it, thus they are recommended for context with high levels of quality information and/or high payoff of investing if the project is good.

This study provides a possible avenues for future research that are of interest to address. Considering our results, it may be of interest to analyze the threshold effect with other information structures (for example heterogeneous private signal qualities), like the experimental study in information cascades of Sasaki (2007) or Alevy et al. (2007). It is common that not all investors have the same information, which makes it interesting to analyze the results under different private signal accuracy in the same sequence, as it could affect the information aggregation and the correct project selection.

Furthermore, our experiment assumes that reject decisions can be observed in the project. In fact, there are currently some platforms that offer information on the number of investors who have consulted the information of a project regardless of whether they have invested or not. This information could be an indication of the number of decisions to invest once they have obtained the project information and the number of non-investing decisions. However, not always investors can observe the decisions to invest. Rather, they only observe how many people support a project or the accumulated investment decisions, as consider Vulkan et al. (2016). Therefore, it would be of interest to analyze the effect of aggregated public information, only when the accumulated investment decisions could be observed.

Finally, only one possible project is considered in this study, without any knowledge of its nature. Different types of projects, whether commercial or social, could have a significant effect on investors' investment decisions, as we demonstrated in the previous chapters of this Thesis. Therefore, it would be of interest to study the effect of the threshold when projects of different nature are available to investors.

A APPENDIX

Figure A shows the results for the simulations with 1000 sequences under the investment conditions set out in the design for each threshold level. The variables of interest shown are the mean number of correct/incorrect UP/DOWN cascades. In addition, a graph is added with the result for the IPQ index for each treatment.

It is observed that IPQ index is increasing until it reaches $T6$ with a maximum of 0.9, which remains at similar values for the rest of the thresholds levels. The correct and incorrect DOWN information cascades decrease until they disappear for threshold level 6. The correct DOWN information cascades decrease but their reason is the decrease in the formation of DOWN cascades of any type since the larger threshold level is making them disappear. Finally the UP cascades allow to increase up to a maximum of 0.79 for threshold 6, which is maintained for the following threshold levels

Therefore, the simulations show how a higher threshold makes the DOWN cascades disappear and there is a shift towards the UP cascades. In particular, the ones that increase as the DOWN cascades decrease are the UP correct cascades. This transfer is shown up to level-6 threshold, after which the results are maintained.

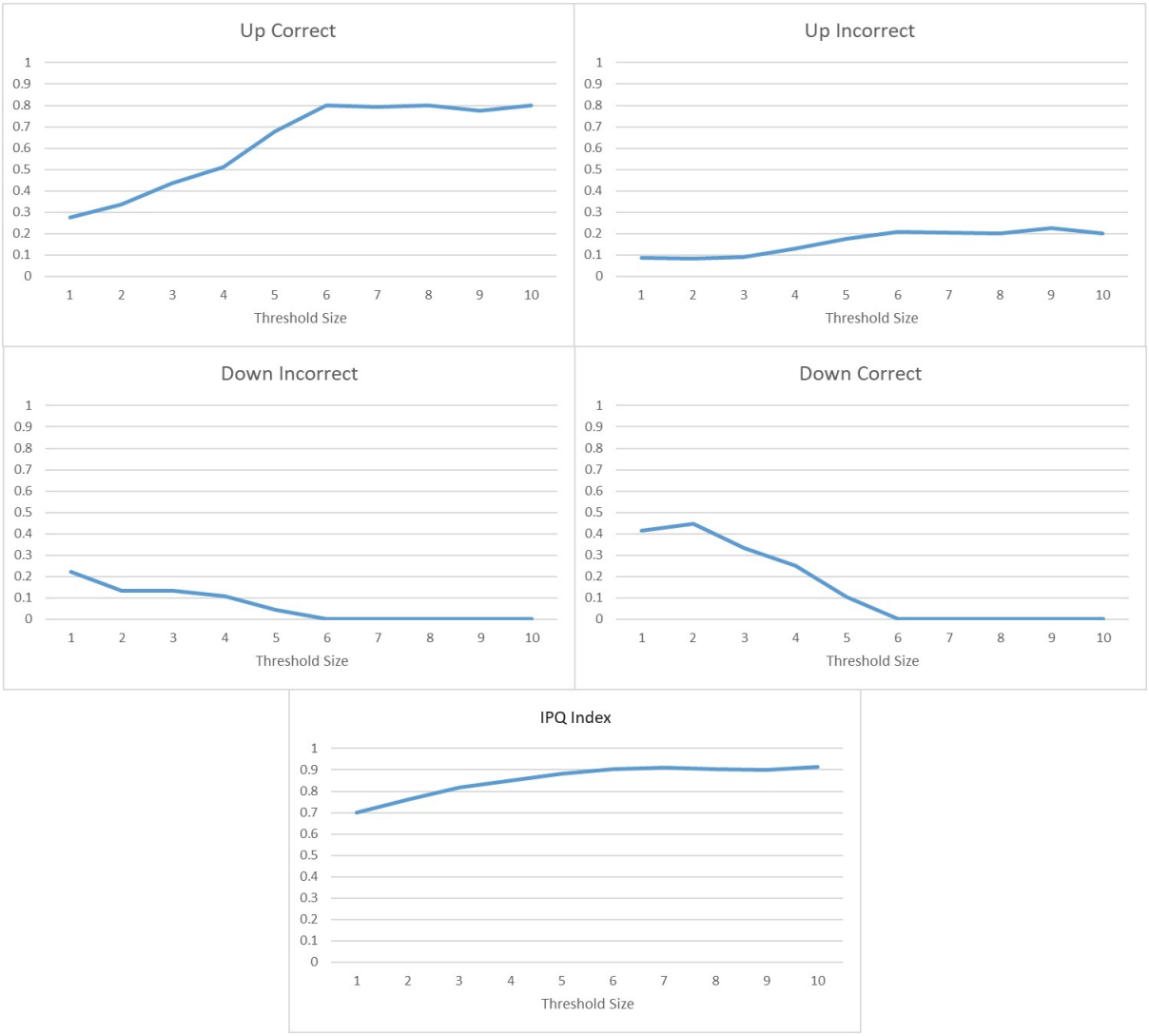

Figure 2: Results of Market Efficiency from simulations 1000 sequences

B APPENDIX

The IPQ Table 7 shows the index results for each turn aggregated for each treatment. The best results between treatments have been marked in bold. It can be seen that the values in the first turn are very similar. In most of the subsequent turns the best results are offered by the $T6$ treatment. In particular, in turn 7 the differences between the IPQ for the NT treatment and the $T6$ IPQ are significant (Mann-Whitney test p-value=0.094). The $T8$ treatment obtains the closest values to the $T6$ in almost all turns is below, except for turn 4. The differences between the $T6$ and $T8$ treatments are not significant but show a constant behavior throughout the

turns, with $T6$ being above $T8$ in the level of information aggregation. The worst results are obtained for $T2$ compared to the rest of the treatments, especially compared to $T6$. If we compare the IPQ index for turn 7 of treatment $T2$ (0.631) with the IPQ index for turn 7 of treatment $T6$ (0.711), Mann-Whitney test indicates significant differences at a p-value level=0.0645. These differences between the $T2$ and $T6$ treatment become more intense as we advance through the turns. Specifically, when we compare the IPQ for the $T2$ and $T6$ treatment at turn 8, we obtain a p-value=0.018 (Mann-Whitney). Similarly, in turn 9, the p-value obtained is 0.007 and in turn 10 we obtain p-value = 0.023, considering the IPQ index between treatments T2 and T6.

Therefore, the highest levels of information aggregation are achieved at $T6$ for most of the turns compared to the rest of the treatments. These differences become significant between treatment $T6$ and $T2$, with $T2$ being the treatment that offers the worst results in information aggregation.

Table 7: IPQ index by player turn

	1T	2T	3T	4T	5T	6T	7T	8T	9T	10T
NT	**0.919**	0.840	0.780	0.748	0.714	0.664	0.648	0.633	0.633	0.634
T2	0.893	0.823	0.763	0.722	0.682	0.660	0.631	0.596	0.582	0.588
T6	0.917	**0.865**	**0.806**	0.776	**0.754**	**0.711**	**0.713**	**0.688**	**0.677**	**0.682**
T8	0.915	0.860	0.805	**0.782**	0.736	0.709	0.700	0.685	0.654	0.644

C APPENDIX

This phase consists of **10 rounds**. At the beginning of the phase, groups of 10 people will be randomly formed. The composition of these groups will remain fixed throughout the 10 rounds, although at no time will the identity of their members be known. In each round, the members of the same group will have to make a series of decisions sequentially, one after the other.

In each round, their decision is to decide ONE of two possible options: **INVEST** or **NOT INVEST** in an investment project. The project can have two possible outcomes: "SUCCESS" or "FAILURE". If you decide INVEST you can get €10 if the result of the project is "SUCCESS" or €0 if the result of the project is "FAILURE". If you decide NOT INVEST you will get €6.

Whether the outcome of the project is "SUCCESS" or "FAILURE" is determined randomly at the beginning of the round by the computer, with a 50% probability for each of the possible outcomes. You will

not know whether the outcome of the project is "SUCCESS" or "FAILURE", but you will receive private information before making your decision. This private information is obtained in the following way:

There are two ballot boxes with virtual balls: "SUCCESS" and "FAILURE". At the beginning of each round, one of the two ballot boxes will be selected according to the "SUCCESS" or "FAILURE" result of the project. As you can see in the following figure, each virtual urn has a different composition of red and blue balls. Specifically, the "SUCCESS" urn has two blue balls and one red ball, while the "FAIL" urn has two red balls and one blue ball. Before making your INVEST/NO INVEST decision, you can privately observe the colour of a ball drawn from the urn selected at the beginning of the round. If the result of the project is "SUCCESS", the selected urn will be "SUCCESS" and you will observe a ball drawn from this urn. If, on the contrary, the result of the project is "FAIL", you will see the colour of a ball drawn from the "FAIL" urn.

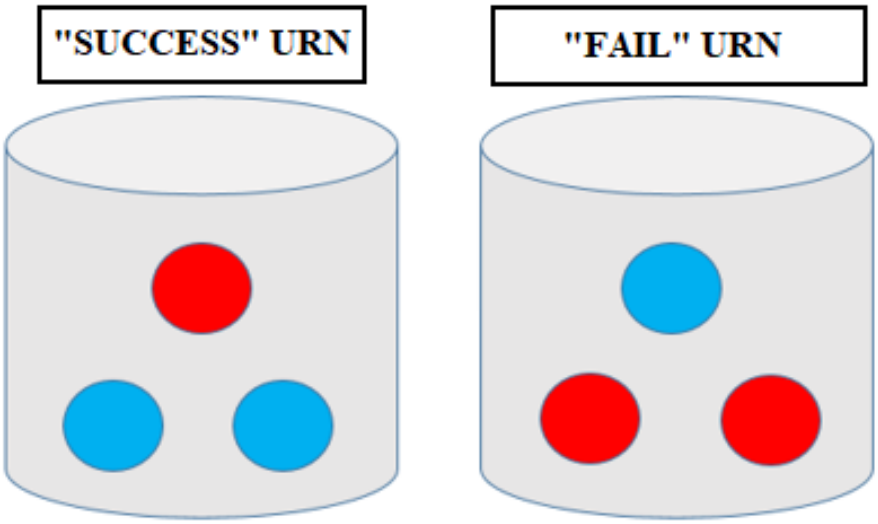

Figure 3

Therefore, if you see a blue ball it is more likely that it was drawn from the "SUCCESS" box and that the result of the project is "SUCCESS", while if the ball is red it is more likely that it was drawn from the "FAILURE" box and that the result of the project is "FAILURE". But it is important to note that at no time will you know the outcome of the project ("SUCCESS"/"FAILURE") or which type of urn ("SUCCESS"/"FAILURE") is being used for ball extraction.

You will receive the private information regarding the colour of the ball when it is your turn to decide,

and only you will know this information. Likewise, no other participant will be able to observe the colour of the balls drawn for the other members of the same group.

Procedure to be followed in each round and group

There will be 10 rounds of decisions, one for each member of the group, sequentially. Before making any decision, each participant will be able to observe the type of decision, REVERSE or NOT REVERSE, made by the preceding members belonging to the same group.

The sequence of events is as follows for each group:

First turn: the computer will randomly select who is the first person to decide. Each member of the group has the same probability (1/10) of being selected to decide first.

Before deciding whether INVEST or NOT INVEST, the person in the first turn must indicate his/her belief or degree of agreement with the following statement:

The result of the project is "SUCCESS"

To do this, you must enter a number between 0 and 100 (both included), so that the higher the number chosen, the greater your belief that the outcome of the project is "SUCCESS".

Once you have registered that decision, in the next window, the computer will draw a ball from the selected virtual urn and inform only the first person of the color of the drawn ball. After viewing this information, you must make your decision:

INVEST or NOT INVEST

Finally, you must indicate again (with a number between 0 and 100, both included) your belief or degree of agreement with the same statement above:

The result of the project is "SUCCESS"

Second turn: the computer will now randomly choose another person from the 9 remaining members of the group who have not yet decided. This second person, after having observed the first person's decision INVEST or NOT INVEST, will be asked to indicate his/her degree of agreement with the following statement:

The result of the project is "SUCCESS"

After this decision, in the next window, the computer will draw a ball from the virtual urn and inform the

second person of its colour. He/she will then have to make the decision:

INVEST or NOT INVEST

In addition, you will have to indicate again your belief about the previous statement (with a number between 0 and 100, both included):

The result of the project is "SUCCESS"

The third and subsequent shifts are developed in the same way as the previous ones.

As an EXAMPLE, in the third turn the following will occur:

1º Indicate your belief about the statement: The result of the project is "SUCCESS".

Figure 4

2º You are shown the colour of a randomly drawn ball and you must decide whether to REVERSE or NOT REVERSE and your belief again on the same statement.

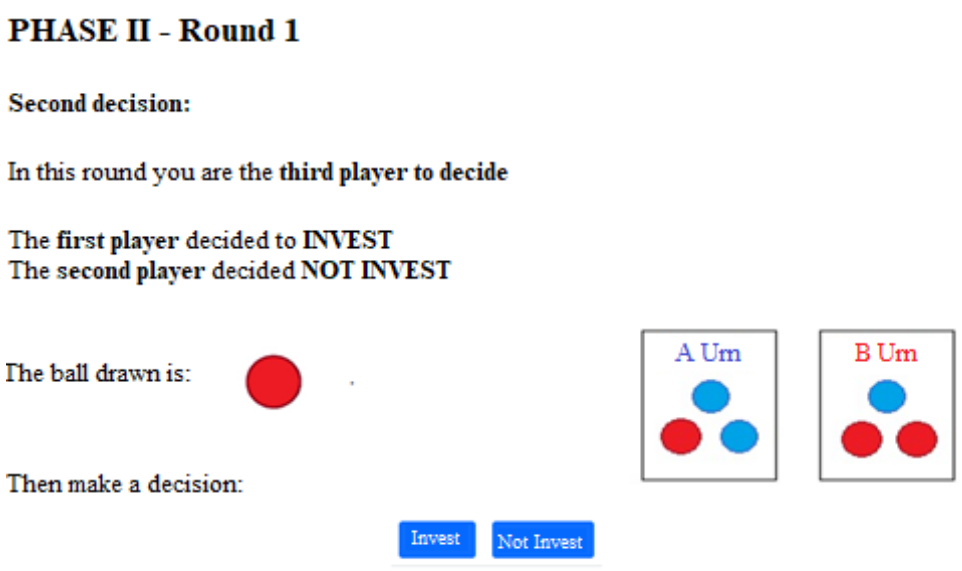

Figure 5

3º You must indicate your belief again on the affirmation: The result of the project is "SUCCESS".

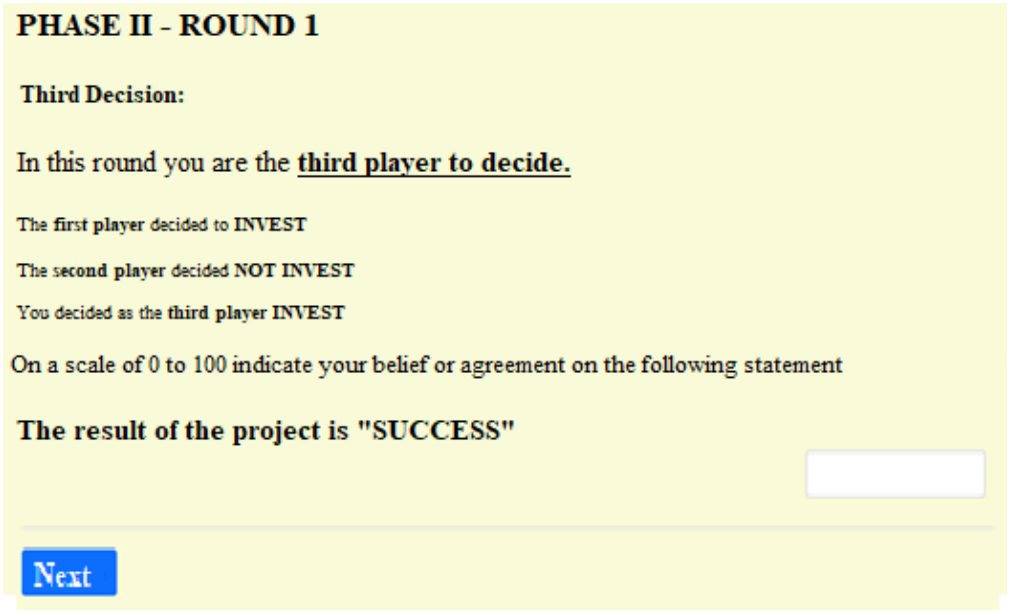

Figure 6

Payoffs

To calculate the payoffs in this second phase, one of the 10 rounds will be chosen at random. The amount

of money you win will be the sum of the following two decisions:

INVEST / NOT INVEST DECISION + YOUR BELIEF

Profits for the investment decision: in the selected round the profits obtained for your decision INVEST or NOT INVEST can be: €10 if you decided INVEST in a project whose result was "SUCCESS", €0 if you decided INVEST in a project whose result was "FAILURE" or €6 if you decided NOT INVEST.

Earnings for your belief: one of the two beliefs entered in that round about the statement: "The result of the project is "SUCCESS"" will be chosen at random (the belief indicated before seeing the colour of the ball or after seeing the colour of the ball).

The money you will receive for the chosen belief is calculated in the same way as the payoff obtained earlier in Phase I for your belief in the quiz. Below, you can see the payoff you will get according to the type of project outcome, "SUCCESS" or "FAILURE", and your belief.

If the result of the project is "SUCCESS"		If the result of the project is "FAILURE"	
Your belief	payoff you will get	Your belief	payoff you will get
100	2.00	100	0.00
90	1.98	90	0.38
80	1.92	80	0.72
70	1.82	70	1.02
60	1.68	60	1.28
50	1.50	50	1.50
40	1.28	40	1.68
30	1.02	30	1.82
20	0.72	20	1.92
10	0.38	10	1.98
0	0.00	0	2.00

Table 8

Remember that the best thing you can do to maximize your earnings is to enter your true belief. Any other prediction will decrease the amount of money you can make.

INSTRUCTIONS WITH THRESHOLD

This phase consists of **10 rounds**. At the beginning of the phase, groups of 10 people will be randomly formed. The composition of these groups will remain fixed throughout the 10 rounds, although at no time will the identity of their members be known. In each round, the members of the same group will have to make a series of decisions sequentially, one after the other.

In each round, your decision is to decide ONE of two possible options: **INVEST** or **NOT INVEST** in an investment project. The project can have two possible outcomes: "SUCCESS" or "FAILURE". **The project can be developed and, therefore, its outcome can be known IF AND ONLY IF a minimum number of 6 investors invest in it**.

If you decide INVEST and the minimum number of 6 investors is reached, you will be able to obtain **10** if the result of the project is "SUCCESS", or **€0** if the result of the project is "FAILURE". However, if you decide to INVEST but at the end of the round the minimum of 6 investors is NOT reached, then the project cannot be carried out and your payoff will be **€6**.

Finally, if you decide NOT to INVEST you will get **€6**. You can see this information in the following diagram:

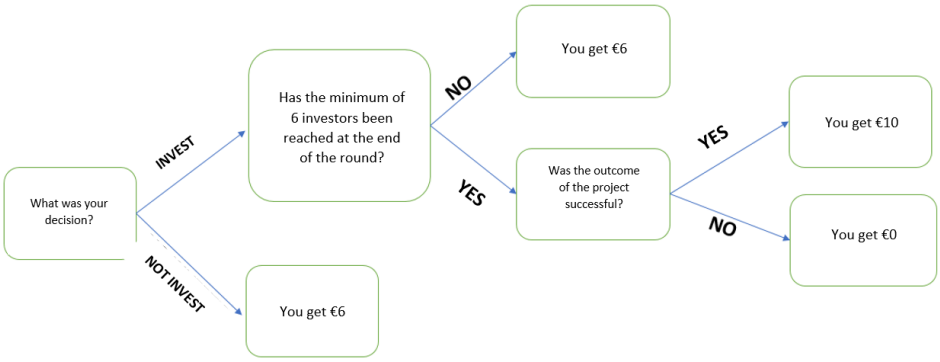

Figure 7

Whether the outcome of the project is "SUCCESS" or "FAILURE" is determined randomly at the beginning of the round by the computer, with a 50% probability for each of the possible outcomes. You will not know whether the outcome of the project is "SUCCESS" or "FAILURE", but you will receive private information before making your decision. This private information is obtained in the following way:

There are two ballot boxes with virtual balls: ballot box "SUCCESS" and ballot box "FAILURE". At the beginning of each round, one of the two ballot boxes will be selected according to the "SUCCESS" or "FAILURE" result of the project. As you can see in the following figure, each virtual ballot box has a different composition of red and blue balls. Specifically, the "SUCCESS" urn has two blue balls and one red ball, while the "FAIL" urn has two red balls and one blue ball. Before making your INVEST/NO INVEST decision, you can privately observe the colour of a ball drawn from the urn selected at the start of the round. If the outcome of the project is "SUCCESS", the selected urn will be "SUCCESS" and you will observe a ball drawn from this urn. If, on the other hand, the outcome of the project is "FAIL", you will see the colour of a ball drawn from the "FAIL" urn.

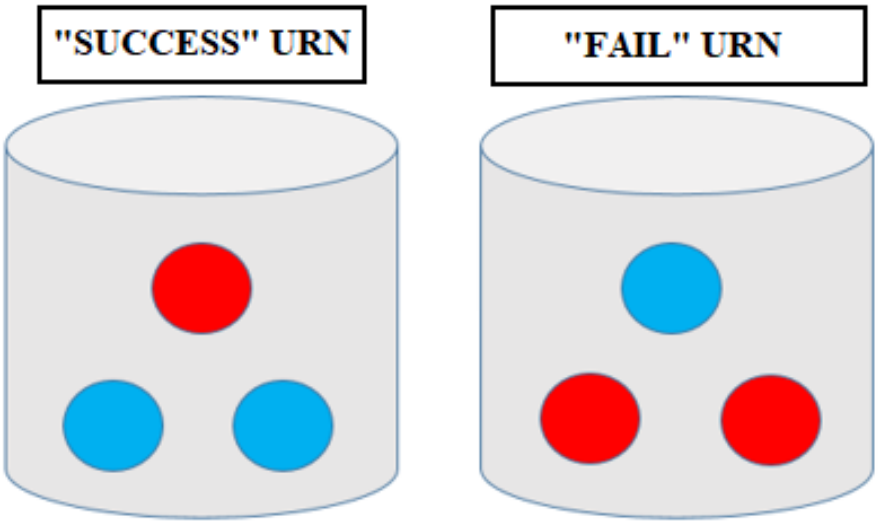

Figure 8

Therefore, if you see a blue ball it is more likely that it was drawn from the "SUCCESS" box and that the result of the project is "SUCCESS", while if the ball is red it is more likely that it was drawn from the "FAILURE" box and that the result of the project is "FAILURE". But it is important to note that at no time will you know the outcome of the project ("SUCCESS"/"FAILURE") or which type of urn ("SUCCESS"/"FAILURE") is being used for ball extraction.

You will receive the private information regarding the colour of the ball when it is your turn to decide, and only you will know this information. Likewise, no other participant will be able to observe the colour of the

balls drawn for the other members of the same group.

Procedure to be followed in each round and group

There will be 10 rounds of decisions, one for each member of the group, sequentially. Before making any decision, each participant will be able to observe the type of decision, REVERSE or NOT REVERSE, made by the preceding members belonging to the same group.

The sequence of events is as follows for each group:

First turn: the computer will randomly select who is the first person to decide. Each member of the group has the same probability (1/10) of being selected to decide first.

Before deciding whether INVEST or NOT INVEST, the person in the first turn must indicate his/her belief or degree of agreement with the following statement:

The result of the project is "SUCCESS"

To do this, you must enter a number between 0 and 100 (both included), so that the higher the number chosen, the greater your belief that the outcome of the project is "SUCCESS".

Once you have registered that decision, in the next window, the computer will draw a ball from the selected virtual urn and inform only the first person of the color of the drawn ball. After viewing this information, you must make your decision:

INVEST or NOT INVEST

Finally, you must indicate again (with a number between 0 and 100, both included) your belief or degree of agreement with the same statement above:

The result of the project is "SUCCESS"

Finally, you should indicate your belief or degree of agreement (by entering a number between 0 and 100 inclusive) with the following statement:

The minimum of 6 investors will be reached

Second turn: the computer will now randomly choose another person from the 9 remaining members of the group who have not yet decided. This second person, after having observed the first person's decision INVEST or NOT INVEST, will be asked to indicate his/her degree of agreement with the following statement:

The result of the project is "SUCCESS"

After this decision, in the next window, the computer will draw a ball from the virtual urn and inform the second person of its colour. He/she will then have to make the decision:

INVEST or NOT INVEST

Finally, you will have to indicate again your beliefs (with a number between 0 and 100 inclusive) about the statements:

The result of the project is "SUCCESS"

The minimum of 6 investors will be reached

The third and subsequent turns are carried out in the same way as the previous ones.

As an EXAMPLE, in the third turn the following will occur:

1º Indicate your belief about the statement: The result of the project is "SUCCESS".

Figure 9

2º You are shown the colour of a randomly drawn ball and you must decide whether to REVERSE or NOT REVERSE and your belief again on the same statement.

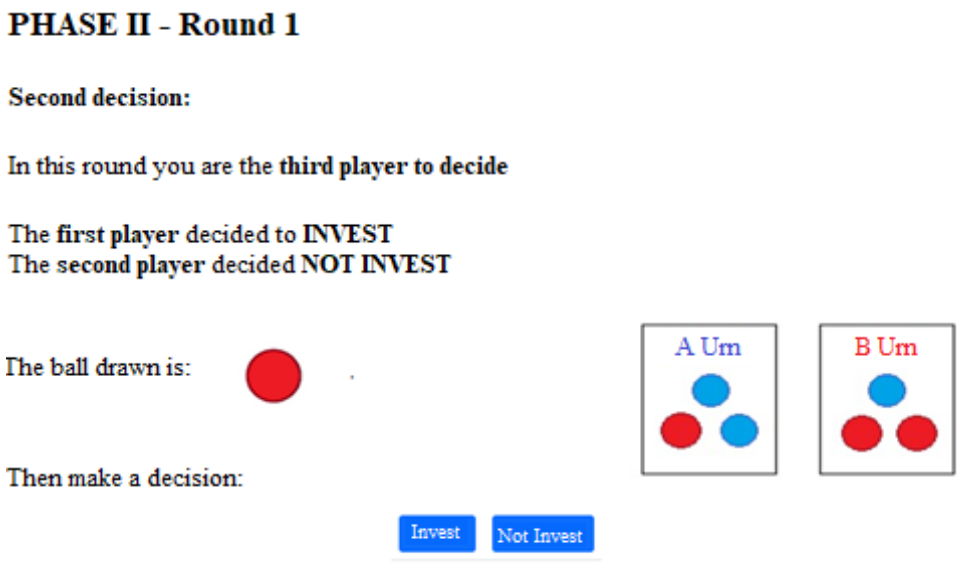

Figure 10

3º You must indicate your belief again on the affirmation: The result of the project is "SUCCESS".

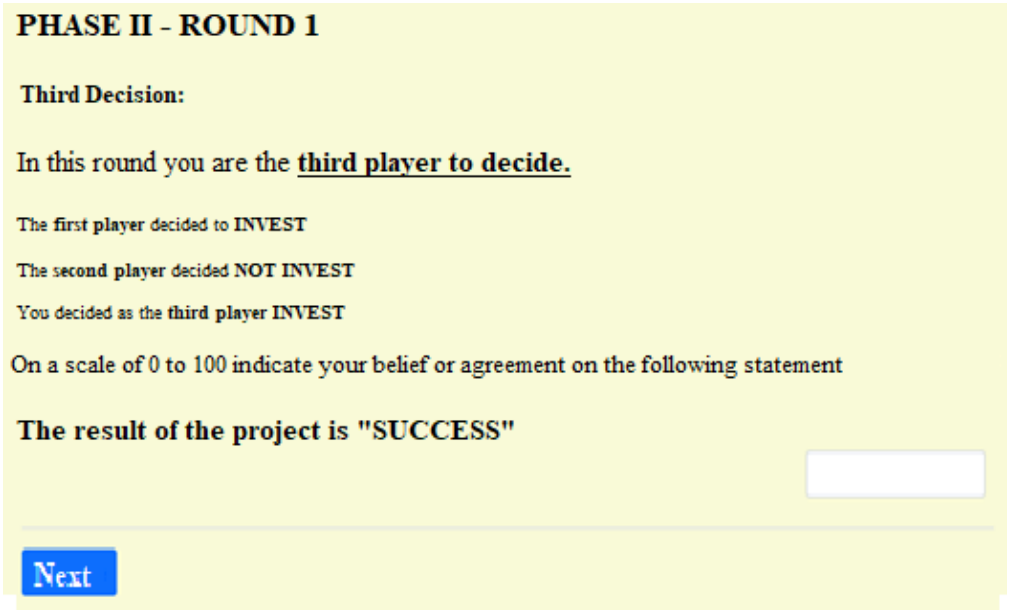

Figure 11

4º You must indicate your belief on the statement: The minimum of 6 investors will be reached.

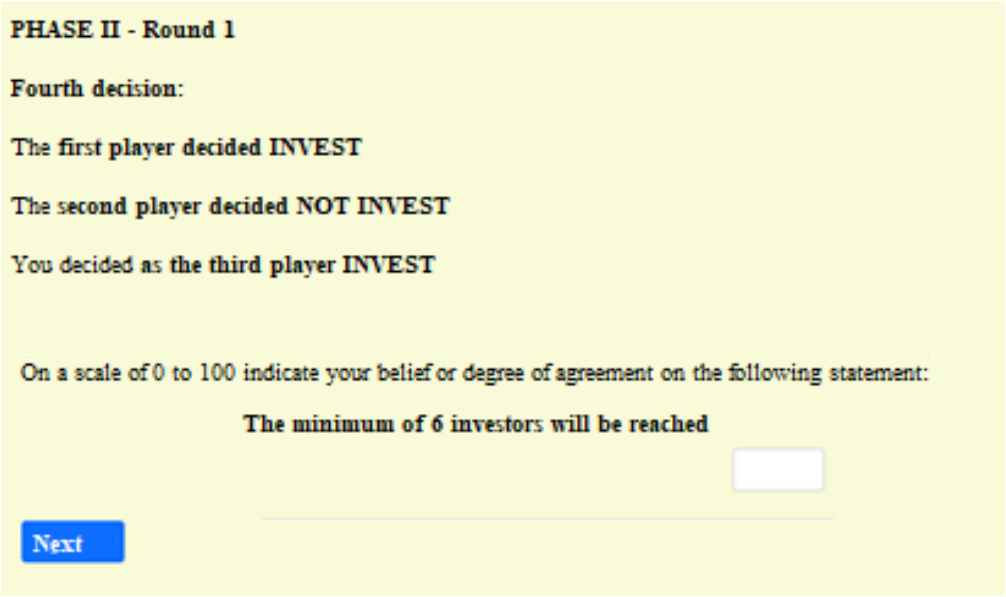

Figure 12

Payoffs

To calculate the payoffs in this second phase, one of the 10 rounds will be chosen at random. The amount of money you win will be the sum of the following two decisions:

INVEST / NOT INVEST DECISION
+ YOUR BELIEF

Payoffs for the investment decision: in the selected round the payoffs achieved for your decision to INVEST or NOT to INVEST can be:

- 10€ if you decided to INVEST in a project whose outcome was “SUCCESS” and the minimum of 6 investors was reached.
- 0€ if you decided to INVEST in a project whose result was “FAILURE” and the minimum of 6 investors was reached.
- 6€ if you decided to INVEST, but the minimum of 6 investors was not reached.
- 6€ if you decided NOT TO INVEST.

Payoffs for your belief: one of the three beliefs entered in that round will be chosen at random: "The outcome of the project is "SUCCESS"" (the belief indicated before seeing the colour of the ball or after seeing the colour of the ball) and "The minimum of 6 investments will be reached". The money you will receive

for your chosen belief is calculated in the same way as the payout previously obtained in Phase I for your belief in the quiz. Below, you can see the payout you will get depending on the type of project outcome, "SUCCESS/FRUCCESS" or if the minimum of 6 investors has been reached, and your belief.

If the result of the project is "SUCCESS" / If 6 investors are reached		If the result of the project is "FAILURE" / If 6 investors are not reached	
Your belief	payoff you will get	Your belief	payoff you will get
100	2.00	100	0.00
90	1.98	90	0.38
80	1.92	80	0.72
70	1.82	70	1.02
60	1.68	60	1.28
50	1.50	50	1.50
40	1.28	40	1.68
30	1.02	30	1.82
20	0.72	20	1.92
10	0.38	10	1.98
0	0.00	0	2.00

Table 9

Remember that the best thing you can do to maximize your earnings is to enter your true belief. Any other prediction will decrease the amount of money you can make.

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CHAPTER 6. CONCLUSIONS

6.1. MAIN CONTRIBUTIONS

The main objective of this doctoral Thesis has been to analyze empirically and experimentally the collective investment decisions. To achieve the objective of this Thesis, three research questions have been addressed: i) to analyze the determinants of overfunding in equity and rewards crowdfunding campaigns ii) to analyze quality signaling strategies, and iii) to study the effect of the threshold on sequential investment decisions.

This research has presented four studies: three empirical works and one experimental. The detailed findings are presented indicating the theoretical and practical contributions.

Chapters 2 and 3 fully address the first research question. The specific objective 1.1 has been carried out in chapter 2 through the empirical analysis of Crowdcube. The results have shown that the effect of the three campaign variables (equity, voting rights, and social capital) are more intense at the highest overfunding levels, specifically at the 75th and 90th percentiles. Hence, the determination of appropriate values by entrepreneurs is essential in order to achieve greater overfunding in platforms. Specifically, a lower percentage of offered equity can indicate higher confidence on the part of the entrepreneur in their project. Another key characteristic is the provision of voting rights, with the observation that this feature can negatively impact overfunding levels, as a greater number of non-professional investors with voting rights may enter. Conversely, the effect of social capital is positive, offering project information helps mitigate information asymmetry and encourages investment decisions.

Additionally, notable differences in overfunding between the UK and Spain have been observed with the exception of technology projects, where cultural differences may diminish. This result emphasize the significance of comprehending how cultural backgrounds shape economic decision-making processes. The study emphasizes the need for a harmonized regulatory framework for crowdfunding, especially in equity

crowdfunding, and highlights the role of platform self-regulation. These results satisfy the specific objective 1.1. of this Thesis.

Chapter 3 has answered the research question for the rewards campaigns. It has been used one of the main rewards platforms in Spain, Verkami. The reward platforms gather a substantial amount of funds in Spain; following lending and investment platforms, rewards platforms stand out. It has been found that the experience of the founders, the availability of project information or the number of rewards are determinants in the overfunding of the campaigns. Additionally, potential differences due to sectors are also considered, as previous literature and chapter 2 of this Thesis suggest possible variations in key variables. This study fulfills the specific objective 1.2. of this Thesis.

In particular, chapter 3 includes an analysis of the target effect. Previous studies yielded inconclusive results. While very high targets may pose a significant challenge and lead to failure, excessively low targets could signal lower project quality. Moreover, the target holds strategic implications in the project financing process. It enables investors to commit only if more investors decide to support it. This provides a form of assurance for the investment decision, depending on the decisions of others. Extremely low levels could result in a substantially diminished security effect of the target and high levels could make it difficult to finance them. Specifically, in this chapter 3, a negative relationship between the target and overfunding is observed.

The number of rewards and founders' experience play significant roles. Backers exhibit diverse preferences, and offering a greater variety of rewards at different price points could attract a larger number of backers with varying preferences. Additionally, the founder's experience lends credibility to the project, reducing backers' uncertainty and issues related to moral hazard. Public information from the entrepreneurs improves the overfunding levels in rewards campaigns. This variable serves to alleviate information asymmetry and mitigate uncertainty for investors. Moreover, certain sectors, such as Entertainment, Literature, and Food, stand out for having higher probabilities of achieving higher overfunding ratios in reward campaigns. On the other hand, the Art category tends to decrease the likelihood of attaining significant overfunding in terms of both ratios and funded amounts.

Chapter 4 has analyzed not only the factors that determine investment decisions, such as the target, but also their effect through mediating and moderating variables. This analysis has made possible to address the second research question of how and when the determinants of financing affect. The information provided through updates can lead to a different effect of variables on the market size. Also, the impact of these effects

is moderated by the sector in which the project is implemented, distinguishing between those of a social nature and those of a commercial nature. In this context, the market size is partly attributed to a high target, seems to be explained by the positive relationship between the target and the number of updates posted in the project profile.

However, the effect of the target is higher in the commercial projects compared with the social projects. This finding suggests that updates can help reduce backers' uncertainty about the quality of projects. Specifically, backers supporting commercial projects face the risk of not receiving the product or experiencing delays in delivery, which could explain their greater significance in commercial projects. This result has achieved the specific objective 2.1.

On the other hand, the findings have indicated a positive effect of the number of rewards on market size. Specifically, it enables attracting high-value backers with higher prices and low-value backers with lower prices. Additionally, it facilitates extracting income from backers, contributing to market growth as per theory. However, a higher willingness to pay is associated with a decrease in market size, with this effect being less pronounced in social projects. This suggests that, although the market size may be smaller in social projects compared to commercial ones, the community supporting social projects values the impact on the community more and is willing to choose higher-cost rewards. This result has satisfied the specific objective 2.2.

In summary, chapter 4 has explored how information impacts the influence of key variables on investment decisions. Beyond this finding, various sectors attract different investor profiles, distinguishing between social and commercial investors. Commercial projects need to focus on providing information and security to investors. In contrast, social projects must offer a diverse range of rewards to support investors willing to pay varying price levels, as their motivation is primarily community-driven.

Chapter 5 has addressed question on the role of threshold. Previous empirical literature does not lead to unified results. Therefore, the effect of introducing a threshold (AoN) compared to no threshold (KiA model) has been analyzed under an experimental design. Hence, the possible effect of different threshold sizes on investment decisions and their influence on market efficiency has been studied. This study has allowed us to address the third research question regarding the role of the threshold in collective projects.

Entrepreneurs have the option to choose an individual or a threshold institution. At an aggregate level, the threshold considered according with the investment conditions, has allowed to improve the formation of cascades and the project selection. These results have achieved the specific objective 3.1.

These results have been contrasted with other threshold levels to address the specific objective 3.2. When a small-level threshold is included, the formation of correct cascades, the correct selection of projects and the aggregation of information decreases significantly compared to the medium-level threshold. These results indicate that threshold sizes that are too low could be insufficient to correctly identify projects. On the other hand, a high-level threshold is more difficult to reach good projects but it allows to avoid the bad projects.

The analysis at the individual level, offers results that show a greater weight of private information compared to public information, showing overconfidence in investment decisions as previous literature indicated in the information cascades. However, an important finding is the effect of threshold compared to setting with no threshold. Public information is not relevant in collective investment decisions unlike individual decisions. However, beliefs about the future actions of upcoming investments, forward looking beliefs, are key in the investment decisions.

Finally, this study is of great practical and theoretical relevance. Project developers must consider the characteristics of their project and the strategic context to achieve the funding goal. The payoff structure and the accuracy of the information in the market will determine the value of an appropriate threshold. In addition, there is a significant effect of forward-looking beliefs in the investment decision-making.

The four chapters of this Thesis have led to conclusions derived from both empirical and experimental analyses of collective investment decisions.

In summary, the four chapters have allowed to identify the Key factors that determine the success of a campaign, such as equity level, target, number of rewards, or investment price. The project information is crucial for the decision-making and the intensity depends on the nature project. Additionally, the overconfidence behaviour has been observed when investors have both public and private information available to them in collective investment decisions.

6.2. LIMITATIONS AND DIRECTIONS FOR FUTURE RESEARCH

This doctoral Thesis presents some limitations that must be taken into account, as well as future lines of research. Firstly, the effect of key variables on investment decisions in crowdfunding platforms has been examined with two specific platforms. The results may be influenced by the platform on which the projects are developed. Although in the chapter 2, the data allow for contrasting results in different countries within the

same platform, it does not encompass other platforms or countries. On the other hand, differences attributable to the country have been observed, but specific factors that may affect depending on the country have not been considered.

Additionally, in the data used from crowdfunding platforms, the investor profile is not controlled; only different behaviors according to the project sector have been distinguished. Therefore, it would be interesting to determine the characteristics that define each investor profile as well as their motivations. Differences between genders or home bias may be of interest to address in the future.

Another limitation that we must consider is the existence of mixed projects. In the sense, if there are not only exclusive commercial or technological projects, sometimes they can show characteristics of both. In that case, it would be interesting to analyze the factors of non-pure commercial or social projects.

The experimental study have allowed for a more detailed analysis of the role of the threshold in collective investment decisions and determining the impact of its size. In addition the experiment allows to control for risk preferences or investor characteristics such as gender. However, in some contexts, such as decisions on crowdfunding platforms, the private information available to agents does not have the same quality as in our experiment. In fact, many investors are non-professionals. This context will be a future research.

Additionally, it had assumed that decisions are sequential and observable to all agents. This situation is common for some platforms in which investors can observe the number of potential investors who have visited the platform. However, this situation could be difference in other markets. Decisions could be sequential or simultaneous in the crowdfunding platforms, and sometimes only the number of supports in terms of investors or achieved funding can be observed. Therefore, it would be interesting to analyze the effect of observing only the investment decisions instead of the entire previous history when making the investment decision. A broad change opens up to investigate the effect of the threshold, different levels and analyze in detail their effect in different strategic contexts.