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An Assessment of the Operational Effect of Non-Financial Information Exchange on Equity Crowdfunding Project Success

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Abstract

Equity crowdfunding has supported numerous entrepreneurial projects and businesses lacking internal funding to commercialize their innovative products and grow them into businesses. Despite the above benefit, existing research has established challenges confronting the crowdfunding models. From the equity crowdfunding market perspective, information asymmetry leads to high product quality uncertainty and weakening potential investors' willingness to invest. To solve the above challenges, many platforms have improved their operational designs and policies to enhance information exchange and accessibility by investors. Despite the improvements made by various platforms, limited knowledge exists on the effect of investor and sponsor participation, subsequent project updates, and the informative content of the updates on projects' outcomes. In contributing to the above research gap, this paper uses data from Seedr's equity crowdfunding platform to test hypotheses. The empirical research section used two sets of models: the first set involved cross-sectional data instrumental variables, and the second set utilized panel data to explore the longitudinal nature of the sample, providing additional support for the results of the cross-sectional data models. In the analysis of the topics of project updates, natural language processing techniques from machine learning were employed to extract content from unstructured data. The LDA (Latent Dirichlet Allocation) model was used as a topic modeling approach to identify the themes in the updated contents. The quantified results of the extracted topics were then incorporated into the empirical models. The results show that higher comments and update frequency will attract more subsequent potential investors to invest. If the project sponsor makes project modifications according to the wishes of the comments, the success rate of the projects will increase. Different update themes also have different impacts on pro-

ject success. The findings are significant for entrepreneurs and investors involved in equity crowdfunding, providing valuable insights and empowering them to make informed decisions.

Keywords

Equity Crowdfunding, Information Reviews, Online Updates, Text Analysis

1. Introduction

The phenomenal growth rate of the phenomenal growth rate of crowdfunding has attracted much attention from the academic world. Experts and academics seem to agree that crowdfunding will become a popular way of financing in the future. [1] states global crowdfunding is expected to reach $96 billion by 2025.

The four types of crowdfunding are donation-based, loan-based model, rewards-based, and equity-based [2]. Much research still focuses on rewards-based crowdfunding and its influencing factors [2]-[4]. Equity crowdfunding was first proposed in the early 2000s in the United States. Also, the implementation and development of equity crowdfunding have been arduous, which has led to few academic discussions and studies on it.

Equity crowdfunding investors are usually motivated by the expected return on their investment. These investors face more information asymmetry [5]. The equity stake of investors makes it different from other crowdfunding models. Hence, research findings on the success factors of other models do not necessarily provide a helpful perspective on equity crowdfunding.

The current equity crowdfunding market and its operational process on the platforms have contributed to much information asymmetry [5] [6] and high uncertainty regarding project quality [5]. This uncertainty adversely affects potential investors' willingness to pledge [7]. Platforms are improving information disclosure through website policies and designs. Continuous project updates by sponsors on the platform and investors leaving comments for responses later have improved information exchanges.

The above information exchange during funding is believed to improve transparency, increase disclosure, project initiator's perceived effort, and investors' trust [8]. However, the effect of the exchange of knowledge in the investor commenting process on funding success has received little attention in the existing crowdfunding literature [9]-[11], which has explored the role of project updates in filling the above research gap. [10] used linear regression to demonstrate the correlation between project updates and investor contributions. In a predictive analysis, [11] established a link between updated information and project fundraising success. Nevertheless, both studies treated project updates as exogenous variables, possibly leading to biased estimates. Hence, the following research question remains unanswered: Do investor and sponsor participation, subsequent pro-

ject updates, and the informative content of the updates affect projects' outcomes?

To answer the above research questions and contribute to knowledge, we investigate investors' broader role in equity crowdfunding from the perspective of non-financial exchange mechanisms. We further construct a principal-agent relationship between the investors and the project sponsors, showing they can benefit from investors' participation. Then, an initial set of cross-sectional instrumental variables approach is used to correct for the frequency and content of exchanged information endogenously. Also, we use panel data to mine the longitudinal nature of the sample, thus providing additional support to the results of the cross-sectional data models and enhancing the robustness of the final results.

The rest of the paper is organized as follows: Section 2 presents the literature review and the formulation of the hypotheses. Sections 3 and 4 describe the data source and models, respectively. Section 5 presents the result analysis, and Section 6 discusses the results, concludes the paper, and proposes future research.

2. Literature Review and Hypotheses Development

The text is based on the growing literature on crowdfunding in operations management. Early empirical work addressed project and sponsor characteristics associated with crowdfunding success [3] [12]. More recently, researchers in the operations management field have conducted theoretical analyses to address the best strategies to increase project success and revenue [13] [14] and the design of crowdfunding platforms' mechanisms [15] [16]. However, few empirical papers have examined the impact of the communication features designed by equity crowdfunding platforms on investors' pledging behaviors.

In the operations management literature on crowdfunding, most empirical studies focus on project success through cross-sectional data and ignore crowdfunding's dynamic characteristics. To our knowledge, only two papers focus on crowdfunding dynamics. [16] studied the dynamics of backer behavior during fundraising and revealed that backers contribute more in the first and last weeks, whereas [17] found that investors with a public profile attract early and late investors to the project.

Unlike other research, this paper focuses on communication tools designed by equity crowdfunding platforms and used by project sponsors and investors. Thus, it investigates the impact of project updates and their informative content on project success.

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3.1. Hypotheses Development

This Section develops hypotheses regarding investor and sponsor participation, subsequent project updates, and the informative content of the updates on project success based on a closely related literature review.

3.1.1. Investor Participation and Project Success

Agency theory is one of the most essential theories in corporate operation, based on the game theory of asymmetric information. Its core task is to study how the principal can design the optimal contract to incentivize the agent under conflicting interests and asymmetric information [18] [19]. It further holds that due to the conflicting interests between the agent and principal, it is likely that the agent may pose an opportunistic behavior.

Similarly, in equity crowdfunding, investors provide funds to the project initiator with the expectation that the initiator will use the funds to develop a project that maximizes the investor's utility. Subsequently, a principal-agent relationship is created between the two parties [20]. Also, information asymmetry between project initiators and investors would result in agency risks and opportunism. Their study [2] highlights that equity crowdfunding platforms amplify information asymmetry compared to other financing options for early-stage ventures where investors know much about the venture prospects. Investors on crowdfunding platforms, in turn, face two agency problems [19]. First, information asymmetry exists where investors rely on information provided by the sponsor to assess the project quality and the ability to achieve the expected performance. Second, the project description is not fixed until the crowdfunding project is closed. Hence, difficulty exists for an investor to monitor the project progress to ensure the project sponsor does not deviate from the investment interest.

The agency problem allows investors to participate in the project through information exchange to safeguard their investment interests [21] and influence the project description to suit their needs [22]. The agency issue is often raised in investment areas [21]. Unlike traditional investors, who mitigate agency risk through

close monitoring of startups, equity crowdfunding investors battle risk due to a lack of information to assess project viability. The online information exchange during the project funding stage seeks to mitigate agency risk for equity crowdfunding investors.

A growing body of literature on crowdfunding focuses on the exchange of resources between backers and project sponsors [23], examining the contribution patterns of backers [3] [24] and the plausibility of group investment [25]. Still, exchanging non-financial resources to promote knowledge during investment has received little attention in the existing equity crowdfunding literature [9] [23]. This study constructs a principal-agent relationship between the investor and the project sponsor. The crowd investor is the principal, while the project sponsor becomes the agent. The principal entrusts their financial resource to the agent to work with for expected return. It shows that project sponsors can benefit from investors' participation as their involvement in crowdfunding projects extends beyond the provision of financial resources. The non-financial resources come in the form of information to improve the project's quality. The above position is based on customers' involvement in product development and evaluation from their point of view, which increases the quality [26]. However, in equity crowdfunding, the role of investors in project development is unknown. This research argues that equity crowdfunding investors take on some value-added activities just like institutional investors do. The value-added role of equity crowdfunding investors is to help subsequent institutional investors alleviate the agency problem by providing information about the project's quality [27].

Further, potential equity investors will refer to the information provided by pioneer investors and the level of participation to address the uncertainty of the project quality and bring a balanced investor voice into the project development [28]. The above process would constitute knowledge sourcing from the perspective of the project sponsor [29], where community members fund and influence the project's development. This paper argues that project sponsors can improve disclosure and increase investor communication by posting updates, responses, and investor comments [30]. If the cumulative number of communication messages increases over time, potential investors receive more information about the project, reducing their uncertainty about its quality. The high frequency of these messages leads to greater transparency about the project and positively impacts potential investors' willingness to invest.

As mentioned above, investor investment in equity crowdfunding projects creates a principal-agent relationship between the investor and the project sponsor. As the subject of such a relationship differs from existing literature, the investor relies on the project sponsor for non-financial resources to develop the project to maximize its effectiveness [31]. As a result, investors are incentivized to monitor the project's progress, influence its development, and drive it in an optimal direction [2]. It further argues that projects with high investor engagement will receive more financing from equity crowdfunding than projects with low customer en-

gagement. Based on the above position of the paper, the following hypothesis is put forth.

Hypothesis 1 (H1): Equity crowdfunding projects with higher investor participation attract more subsequent investors, increasing the funding success rate.

3.1.2. Project Modification and Project Success

Part of the argument for Hypothesis 1 is that investor engagement can increase financing because it allows investors to influence the project description, and investors will consider the potential future market for the project because it will affect their future financial returns. Research on product development suggests that consumers are experts in product application and value creation [32], improving product development performance and better service [33]. However, the subjective role of consumers may also hinder product and service development since potential application information from consumers to producers is sticky and costly. The above situation is evident in equity crowdfunding, where investors share sticky information because their investment in the project motivates them to influence its development (Hypothesis 1). By sharing project features, investors can reduce agency risk by directing the project development toward future customer needs.

When product developers are faced with many consumers acting only in their interests, it is difficult for them to know which ideas are likely to increase the success of their product and or result in high-cost niche products [34]. Following an idea that doesn't make sense or is trying to address all consumer suggestions can result in a product that is not viable, too costly, or unattractive to consumers in a financial market. There is ample evidence that consumers' unspecialized technical knowledge can lead products to adopt unpopular technologies. Similarly, under equity crowdfunding, the project sponsor faces a similar situation, in addition to the moral hazard of investors and the risk of group irrationality from those with solid influence [35]. However, due to future financial returns of interest, investors balance it against the project cost for market acceptance and economic gains, reducing the sponsor's moral hazard and eventually achieving a better alignment of interest.

There are no sources in the current document.

In referring to the role of consumers in product development against the more rational investors in equity crowdfunding, this paper argues that the value of a project due to investor participation is realized when project sponsors modify their project description based on the information they receive from investors. Thus, investor engagement's effect on crowdfunding success depends on whether or not the project sponsor modifies the project following the comments. Based on the paper's position above, the second hypothesis follows.

Hypothesis 2 (H2): In equity crowdfunding, investor engagement's effect on project success depends on whether the project sponsor modifies the project based on comments.

3.1.3. Frequency of Update and Project Success

The project initiator on the equity crowdfunding platform can disclose additional project-related information by releasing some communicative information during the project fundraising process. The project update section of the webpage serves as a communication tool on the crowdfunding platform, where the sponsor shares the latest project updates with expected feedback from investors. From the point of view of information disclosure, more updates can convey more current and project-related information to potential investors. The increase in information sharing perceived by potential investors will reduce information asymmetry, thus increasing investors' willingness to invest [36].

Regarding project sponsors' motivation, potential investors may perceive more significant effort and trust when a sponsor manages communication channels more effectively [10], subsequently attracting more investors. More updates may generate more project attention, transparency, and excitement, ultimately leading to better financing performance [31]. At the same time, more frequent updates can create a stronger connection between investors and the project, leading to more investment in the project [37]. [10] [11] also used project updates as an exogenous variable in their previous studies to discuss the link and correlation between it and fundraising success. However, using exogenous variables leads to estimation bias, which prevents us from determining whether the frequency of update releases positively affects the investors' decision to pledge. In contrast, this paper uses instrumental variables to correct for endogeneity and determine the positive impact of project updates. The next hypothesis is formulated as follows.

Hypothesis 3 (H3): In equity crowdfunding, a higher frequency of project updates will attract more subsequent investors, which increases the success rate of crowdfunding projects.

3.1.4. Informative Update and Project Success

Research on information content analysis suggests that different types of content can impact users' behavior differently due to the other values contained in their information. For example, [37] analyzed users' posts on the Facebook business community and found that posts in different content categories affect consumer engagement differently. Marketing research has also demonstrated that communicating information affects consumers' consumption decisions [38]. In the literature related to crowdfunding, some studies have shown that the content of communication between project promoters and investors affects crowdfunding outcomes [39]. However, there is a lack of qualitative measurements of the content of updates in equity crowdfunding projects to know how specific update topics affect investors' investment decisions. Specifically, this paper argues that including updated information topics related to the project and those closely related to the project sponsor are more likely to mitigate information asymmetry. Also, increased information transparency that may enhance disclosure will encourage potential investors to decide to invest.

Alternatively, non-informative updates released solely to attract attention will

likely be perceived as "distress signals" or objectionable to investors. This negative impact will discourage potential investors from investing, so updates that lack useful information will either be ineffective or discourage support from potential investors [40]. The effect of updates on investor behavior is content-driven. From the preceding discussion, the last hypothesis is formulated as follows.

Hypothesis 4 (H4): In equity crowdfunding, posting informative updates on different topics attracts more subsequent investors, increasing crowdfunding projects' success rate.

Figure 1 below displays the four hypotheses and predicts investor participation, project modification, update frequency, and information content will increase project success.

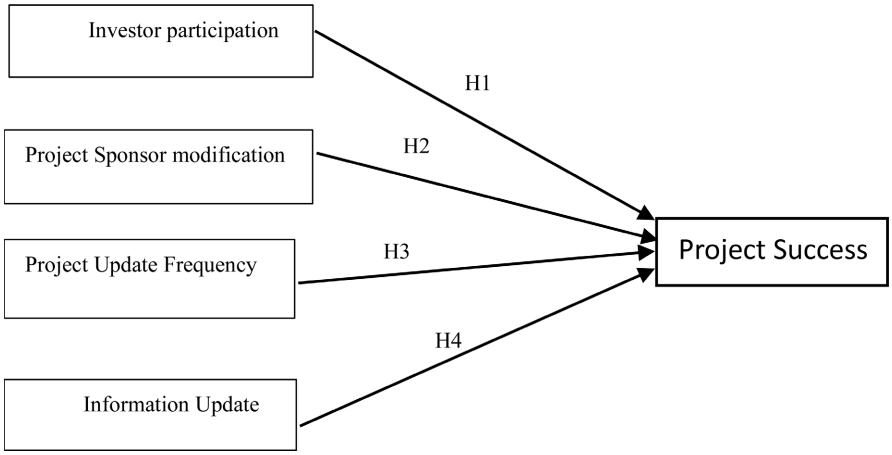

Figure 1. Hypothesis structure.

3. Variable Setting and Data

This study tests the hypotheses using data from Seedrs.com, a UK equity crowdfunding website. This paper uses a panel data modeling framework to analyze how dynamically published communication information during the project financing process moderates investor pledging behavior and affects the success of equity crowdfunding projects. This paper uses snowball sampling to collect 2534 projects funded on the Seedrs platform between May 12, 2022, and May 12, 2023. For each project, this paper observes its project attributes and all funding transaction details and tracks comments and updates during the fundraising period of each project. The data includes successful and failed projects.

3.1. Data

The sample contains daily observation data for 2,534 Seedrs.com projects that started between May 12, 2022, and May 12, 2023. Projects with the following features were excluded from the sample. First, 16 projects that lasted less than a month after the start of the data collection or started less than a month before the end of the data collection were excluded because these projects have too short a duration, which may introduce errors in the result. Second, 8 projects were sus-

pended due to lawsuits, and 11 failed projects that could not observe the complete funding phase were removed. Third, 19 projects that lasted less than a week and made capturing meaningful operational effects from investor comments or project sponsor updates challenging were excluded. Also, 48 projects with more than 2 days of missing observations were removed. The final sample contained 2432 projects with an average of six equity crowdfunding projects per day; the average duration of equity crowdfunding was 32.60 days, with a median of 30 days.

Equity crowdfunding projects on Seedrs fall into 13 categories, such as art, fashion, gaming, and technology, allowing this research to look at investor behavior in various contexts to remove industry or market bias.

There are three key advantages of using data from Seedrs.com. First, projects on Seedrs vary by product, entrepreneur, and industry, allowing data to be collected on both successful and failed projects. Second, the content of individual investor reviews can be collected on the Seedrs website, which permits this paper to use investor reviews as a metric. Third, variations in project descriptions can be captured by manipulating the webpage's backend, which often causes investors to ignore this information.

This project proposes to use two sets of models to validate the impact of investor participation in reviews on crowdfunding success. The first is a set of cross-sectional data models, while the second is the panel data model. The choice of the dataset is based on the premise that crowdfunding success is a dichotomous variable. Hence, the logit model is preferred to the linear probability model. Also, using cross-sectional data would help tap into the longitudinal nature of the sample, thus providing additional support for the results.

Further, this paper uses the control function method to control for endogeneity, which is preferred in logit models. To rule out reverse causality, the fixed effects model allows for the temporal separation of investor comments and subsequent investments. Moreover, to enhance the robustness of the final results, the fixed effects would allow for the removal of all constant influences from the estimation and the explicit control of social learning (e.g., herding effects). The remainder of this Section introduces the variables in more detail.

3.2. Dependent Variable

This paper uses the same explanatory variables in the instrumental variable (IV) and the panel models. The panel model uses all time-series observations. In contrast, the IV model uses the cumulative amount of equity crowdfunding projects during their success or failure.

Investor comments. To measure investor comments, this research counts the comments left by investors in the "Discussions" section of a project webpage, where investors can only comment on the projects they have invested in. For project i, $C_{i,t}$ is the cumulative number of investors' comments up to the period t. In the panel model, we use this variable directly, while the cross-section IV model uses the cumulative number of investors' comments up to the time when the pro-

ject reaches its funding goal, defined as C_{i,t^F}, t^F.

Project updates. To determine the number of updates posted by a project sponsor, this paper counts the number of updates displayed in the "Updates" section of the project webpage, where a sponsor can post updates for any information about the project. For project U_{i,t^F}. is the cumulative number of updates posted by the initiator up to period t; we use this variable directly in the panel model. In the cross-sectional data IV model, this paper uses the cumulative number of investor comments until the project reaches its funding goal, which is defined as U_{i,t^F}.

Project modifications. To test whether a project sponsor's response to investor comments moderates the impact of comments on the success of a project, it counts the number of changes made to the project description by the sponsor. It identifies such changes by looking at the timestamps of updates in the HTML code of the project's webpage. Each time the timestamp of an update moves forward, it represents a change in the project description. Notably, the timestamps are not visible to investors. This paper uses R_{i,t^F} defined as the cumulative number of revisions up to the period t^F in the IV model, and the difference in the number of revisions $\nabla R_{i,t}$ from the previous period in the panel model.

Update content topics. To study the impact of updated content presented in H4, we will extract content from unstructured data using machine learning techniques. We use the LDA model, a popular method for extracting the topics designed in each update. The LDA model treats updated text documents as a mixture of several latent topics, each modeled as a distribution of high-frequency keywords extracted from all the textual documents [41] [42]. As a probabilistic generative model, LDA has received increasing attention from economics and business researchers in dealing with non-institutionalized text data [43] [44].

Following the standard steps of the LDA method, topic extraction is performed on the preprocessed comment text. Based on a set of keywords associated with each topic, we can derive the main content of all the topics. For the update, we obtained three extracted topics: the project success announcement, the details related to the project cooperation, and the project launch announcement. The keywords associated with each theme are provided in Table 1.

Table 1. Keywords corresponding to the topics.

Topic	Keywords
Success announcement	remarkable, outstanding, achieve, excellence, testament, commitment, team, completion, successful, property
Details related to cooperation	Game, energy, industry, player, share, delight, collaboration, financial, please
Launch announcement	leisure, sport, industry, embark, ready, journey, solution, experience, travel, exceptional

The LDA model in this paper generates probability distributions of each ex-

tracted topic in a given document, which are crucial pieces of information. Some quantifiable metrics are needed to validate the extracted content information, which can be used in subsequent analysis. Therefore, for the updated content, this paper constructs cumulative update topics ($CummulativeUpdateTopic_j$, where $j = 1, 2, 3$) by aggregating the specific topic probabilities of all updates related to the same project.

4. Instrumental Variable and Panel Models

In the first set of models, this paper uses an instrumental variable to control for the promoter's personal competence and the project's quality. It further tests the effect of investor comments on a project's likelihood of success. The IV model is described in this Section.

4.1. Instrumental Variable Model

4.1.1. Selection of Instrumental Variable

This paper uses the mobile application published by Seedrs as a tool. The application facilitates investment and improves the interaction between the sponsor and the investors. The mobile app works independently; therefore, the change in the likelihood of success of a project caused by increased investor comments via the mobile app is exogenous. What is certain is that this kind of change in likelihood is not a derivative of unobservable project promoter competence or project quality. This paper uses a two-stage estimation to achieve this process [45]. The first stage uses the estimated exogenous growth of investor comments to estimate its impact on the success of a project. In the second stage, the results are independent of the project promoter's ability and quality. The following paragraphs describe and evaluate the instrumental variable in detail.

This paper evaluates the quality of this instrumental variable in an uncontrolled model, and the results show that the introduction of the mobile app had a significant positive impact on investor comments ($\beta_1 = 0.55$, $p < 0.01$). The first stage of F value is 24.86, much higher than the common threshold value of 10, indicating that the mobile app should be an effective instrumental variable. According to the control function approach, the second stage incorporates the residual values estimated in the first stage $\left(\hat{u}_i\right)$, to control for unobservable confounders. The paper finds significant residual values in the second stage, which suggests that there is indeed an endogeneity problem and, therefore, justifies the use of this instrumental variable ($\gamma_u = -0.03$, $p < 0.01$) [45]. Despite using the mobile app on Seedrs, there is no evidence of violating the exclusivity restrictions that govern the selection of instrumental variables.

4.1.2. Description of Control Variables

This paper includes several control variables in the model to account for potential confounders, particularly project sponsor competence, project quality, and complexity.

The paper controls the following variables. First, video production is costly and influences an investor's pledge decision [46]. Therefore, the number of videos in a project description allows us to control the project sponsor's ability and the project's attractiveness [47]. Second, we control whether a project has a separate website. Creating and maintaining a separate website requires resources and signifies a high-quality project. Third, the paper controls the length of the project description based on the number of words and the number of images uploaded.

The description communicates the project idea and provides "first-hand information to the public" [48]. These variables are controlled because investors rely on the description and the images to assess the project quality [49]. Uploading product prototypes augments the textual information [50], proves initiator credibility, and enhances investment decisions. Also, whether or not a project sponsor launches a pitch is a variable that must be controlled. A pitch helps potential investors understand the project and evaluate it comprehensively. A project initiated by a team is also a control variable. A team is more resourced due to the diverse resources needed to begin a quality project than an individual [51]. Reward is also one of the control variables since it can influence investment decisions and as a symbol of project quality [52]. Therefore, we expect that the reward setting will positively impact the attraction of investors.

Moreover, the natural logarithm of the project crowdfunding target amount (in pounds) is controlled. The project goal is the sponsor's actual expectation of the minimum feasible project budget, which allows us to control the size and complexity of the project [53]. Additionally, the length of time is a common measure of project complexity [53]; hence, it is also controlled.

We control whether projects have partnerships with other organizations and are backed by venture capital, which is a good control indicator of project resources, development experience, and financing networks of sponsors. The existence of venture capital is bound to be followed by lead and follow-on investments. Each investment round would attract many venture capitalists and potential investors to invest in projects. Furthermore, we control for project categories. Project frequency, funding deal volume, and investor investment amount vary by category. Lastly, the paper controls whether a project involves e-commerce or not. In an era of e-commerce development, people tend to expect more from the e-commerce economy, and the difference between the e-commerce and brick-and-mortar economy is a factor that influences the decisions of potential investors.

4.1.3. Model Description

Equity crowdfunding project success is a dichotomous variable; therefore, the logit model is preferred to the linear probability model [54]. To control for endogeneity, we use the control function method in two-stage regressions [46], the preferred method for dealing with endogeneity problems in logit models. In the first stage, we regress the number of investor reviews on exogenous and instrumental variables (Z_i) in an ordinary least squares model, followed by the residuals from the first-stage estimation $(\hat{u}_i)$ in the second stage, logit regression.

The second-stage estimates are consistent estimators. In the case of logit models, the obtained estimates will be smaller than the actual effect size. Since the obtained standard errors may not be strictly valid, we use a nonparametric bootstrap in the second stage to obtain corrected standard errors [54]. We obtained H1 first and second-stage regressions (IV model 1):

$$C_{i,t^F} = \beta_0 + \beta_1 Z_i + \beta_X X_i + u_i$$

$$S_i = \gamma_0 + \gamma_1 C_{i,t^F} + \gamma_u \hat{u}_i + \gamma_X X_i + v_i,$$

Positioning Figures and Tables: Figures/tables where C_{i,t^F} is the number of investor comments, Z_i is an instrumental variable, and X_i is a vector of a set of control variables. Next, we describe how to test whether project sponsors making project changes based on the content of comments moderates the effect on project success (H2) in a cross-sectional IV model. In the initial model (IV Model 1), where project success is the dependent variable, and the number of investor comments is the independent variable, we are interested in $R_{i,t^F} = \delta C_{i,t^F}$ and $S_i = \gamma_R R_{i,t^F}$. We are still using the cell phone application as an instrumental variable, but this time, it serves as the mediating variable R_{i,t^F}. Because project sponsors cannot use the mobile app to modify their project descriptions, there is no direct causal relationship between the introduction of the mobile app and project content modification. Therefore, project content modification is irrelevant to the instrumental variable and will only be affected by increased investor comments ∂. Any moderating effect of project content modification on success is denoted as γ_R, which is a consequence of ∂. Thus, we can obtain a model for H2 in the first and second stages (IV Model 2):

$$R_{i,t^F} = \beta_0 + \beta_1 Z_i + \beta_X X_i + u_i$$

$$S_i = \gamma_0 + \gamma_1 R_{i,t^F} + \gamma_U \hat{u}_i + \gamma_X X_i + v_i$$

For testing H3, we use the same idea as for testing H1, and we can get the model of H3 in the first and second stages (IV model 3):

$$U_{i,t^F} = \beta_0 + \beta_1 Z_i + \beta_X X_i + u_i$$

$$S_i = \gamma_0 + \gamma_1 U_{i,t^F} + \gamma_U \hat{u}_i + \gamma_X X_i + v_i$$

To investigate the content effect of updated information, this paper directly observes the significant relationship between the final success of a project and a specific topic by adding the variable $CummulativeUpdateTopic_j$, (where $j = 1,2,3$) to the model (IV model 4):

$$S_i = \beta_0 + \beta_{1:3}\left(CummulativeUpdateTopic1_i : CummulativeUpdateTopic3_i\right) + \beta_X X_i$$

The parameter we are interested in testing H4 is β will be supported when estimating β changes concerning sign and significance level.

4.2. Panel Model

A panel model will be used to explore the longitudinal nature of the sample to

provide additional support for the initial results of the IV model. It would further help to dynamically analyze the impact of investor comments and sponsors' updates on project success. The panel model enhances the robustness of the results in three ways. First, the temporal separation of investor comments and subsequent investments allows us to rule out reverse causality. Second, the project fixed effects eliminate all constant influences present in the estimation, allowing us to control for project quality and project sponsor competence differently than instrumental variables. Third, it will enable us to control social learning effectively. The panel data contains unbalanced data at 24-hour observation intervals from when the project is posted on Seedrs to when it ends. Since some variables require two lags, the first two observations for each project are removed, and the dependent variable in all panel models is the amount of new financing received since the previous period ($\nabla F_{i,t}$).

Model Description

The fixed effects models for H1 and H3 are as follows:

$$\nabla F_{i,t} = \beta_1 C_{i,t-1} + \beta_2 U_{i,t-1} + \beta_X X_{i,t-1} + \beta_{T1} TIME_{i,t} + \beta_{T2} TIME_{i,t}^2 + a_i + u_{i,t}$$

where $C_{i,t-1}$ is the one-period lag of the cumulative amount of investor comments and $U_{i,t-1}$ is the one-period lag of the cumulative amount of project sponsor updates. $X_{i,t-1}$ is the control variable for all one-period lags, and the fixed effect is a_i. We can test H1 and H3 by estimating β_1 and β_2. To test H2, we apply a two-step approach to analyze the interaction between investor comments and project modifications. First, we decompose $C_{i,t-1}$ into its two-period lag and its difference with the two-period lagged variable:

$$C_{i,t-1} = \nabla C_{i,t-1} + C_{i,t-2}$$

We then interact with program content modifications ($\nabla R_{i,t-1}$) with a two-period lag of the number of investor comments, $C_{i,t-2}$, which effectively replaces $C_{i,t-1}$ as the primary explanatory variable:

$$\begin{aligned}\nabla F_{i,t} = {} & \beta_1 \nabla C_{i,t-1} + \beta_2 C_{i,t-2} + \beta_3 \nabla R_{i,t-1} + \beta_4 C_{i,t-2} \times \nabla R_{i,t-1} + \beta_X X_{i,t-1} \\ & + \beta_{T1} TIME_{i,t} + \beta_{T2} TIME_{i,t}^2 + a_i + u_{i,t}\end{aligned}$$

The logic is that investor comments are needed to affect financing through project content changes, so we test the effect of lagged two-period volumes on financing now by lagging one-period project content changes (β_4); cumulative investor comments ($t-2$) → the number of project content changes ($t-1$) → the volume of financing (t), and also due to the separation in time, the number of project content changes in period $t-1$ does not affect the number of investor comments in period $t-2$. To investigate the content effect of update topics, this paper again expands Model 1 by including the variable $CummulativeUpdateTopic_j$ (where $j = 1,2,3$):

$$\begin{aligned}\nabla F_{i,t} = {} & \beta_{1:3} \left(CummulativeUpdateTopic1_{i,t} : CummulativeUpdateTopic3_{i,t} \right) \\ & + \beta_X X_{i,t-1} + \beta_{T1} TIME_{i,t} + \beta_{T2} TIME_{i,t}^2 + a_i + u_{i,t}\end{aligned}$$

Similarly, the parameter we are concerned with for testing H4 is $\beta_{1:3}$, which will be supported when the value of $\beta_{1:3}$ is significant.

5. Result Analysis

5.1. Instrumental Variable Model Result Analysis

Table 2 demonstrates the statistical description of the IV model, and Table 3 shows its correlation matrix, which, according to the report, shows no multicollinearity problems.

Table 2. Descriptive statistics of the IV model.

Variables	Average	Standard error	Minimum	Maximum
Project success	0.875	0.331	0.000	1.000
Mobile app	0.395	0.489	0.000	1.000
Investor participation	35.559	36.355	0.000	220.000
Sponsor updates	124.439	111.806	0.000	1291.000
Project modifications	124.801	107.970	0.000	883.000
Target amount (ln)	44.132	26.875	11.290	265.429
Project duration	32.60	91.783	22.000	1092.000
Text length	2046.748	1296.667	341.000	13,028.000
Number of pictures	14.014	13.125	0.000	147.000
Rewards	0.441	0.497	0.000	1.000
Team	0.658	0.475	0.000	1.000
Venture capital	0.329	0.470	0.000	1.000
Partnership	0.362	0.481	0.000	1.000
Pitch	0.441	0.497	0.000	1.000
e-commerce	0.803	0.398	0.000	1.000
Video	5.298	6.167	0.000	67.000
Separate website	0.586	0.493	0.000	1.000
Follow-on	0.599	0.490	0.000	1.000

IV Model 1 in Table 4 shows the results related to H1, where we find that the number of investor comments (*i.e.*, participation) has a significant positive effect on project success (H1) after controlling unobservable confounders in the second stage ($\gamma_1 = 0.260$, $p < 0.01$). Each additional comment before the project's success increases the likelihood of its eventual success by 26%.

To test whether project sponsors made project changes based on the content of the (H2), we regressed project content modification on the instrumental variable. First, we assessed the quality of the instrumental variable without control variables and found a significant positive effect on modification ($\beta_1 = 0.64$, $p < 0.01$) and

Table 3. Correlation matrix of the IV model.

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
(1) project success	1																
(2) comments	0.33***	1															
(3) updates	0.38***	0.12***	1														
(4) modifications	0.39***	0.12***	0.61***	1													
(5) target (ln)	0.02***	0.04*	0.31***	0.34***	1												
(6) duration	0.04***	−0.02	0.38***	0.43***	0.36***	1											
(7) text length	0.09***	0.09***	0.36***	0.39***	0.43***	0.37***	1										
(8) picture number	0.05***	0.01	0.22***	0.30***	0.48***	0.24***	0.31***	1									
(9) rewards	0.06***	0.07***	0.06***	0.13**	0.05**	0.08***	0.09***	0.21***	1								
(10) team	−0.02	0.10***	−0.025	0.006	−0.02	0.003	0.06***	0.002	−0.06***	1							
(11) venture capital	−0.03	0.04**	−0.05**	0.037*	0.05**	0.04*	−0.06***	0.04*	0.08***	−0.12***	1						
(12) partnership	0.08***	−0.11***	0.023	0.08***	−0.02	0.05**	0.024	−0.03	−0.01	−0.06***	0.14***	1					
(13) pitch	0.14***	0.15***	0.006	0.09***	0.03	0.05**	−0.05**	0.01	0.01	−0.03	−0.03	0.1***	1				
(14) e-commerce	−0.09***	−0.27***	−0.04**	−0.05**	−0.01	−0.02	−0.04**	−0.03	−0.03	−0.01	0.14***	−0.11***	−0.16***	1			
(15) video	0.25***	0.63***	0.23***	0.23***	0.18***	0.12***	0.22***	0.13***	0.06***	−0.02	0.05**	−0.1***	0.09***	−0.12***	1		
(16) website	0.33***	0.58***	0.16***	0.12***	0.06***	−0.07***	0.13***	−0.02	−0.06***	−0.02	−0.01	−0.09***	0.08***	−0.22***	0.44***	1	
(17) follow-on	0.26***	0.51***	0.12***	0.12***	−0.01	0.10***	0.12***	−0.004	0.13***	0.09***	0.06***	0.002	0.13***	−0.14***	0.43***	0.54***	1

$p < 0.10$; **$p < 0.05$; ***$p < 0.01$.

Table 4. H1 and H2-Stage 1 and Stage 2 regressions of IV model.

Variables	IV Model 1		IV Model 2	
	Stage 1 (investor comments)	Stage 2 (project success)	Stage 1 (project modification)	Stage 2 (project success)
Mobile app	33.418*** (28.509)		0.64*** (0.04)	
Investor comments		0.260*** (10.050)		
Project modification				0.330*** (4.076)
Target amount (ln)	−0.040* (−1.834)	−0.014** (−2.256)	0.267** (2.272)	−0.051*** (−2.370)
Project duration	−0.023*** (−4.827)	−0.000 (−0.189)	0.353*** (10.996)	−0.086*** (−3.025)
Text length	−0.000*** (−0.774)	−0.000 (−0.782)	0.015*** (5.373)	0.003** (−2.241)
Number of pictures	0.004 (0.103)	0.019** (2.246)	0.917*** (4.943)	−0.226*** (−3.010)
Rewards	0.098 (0.101)	0.358 (1.268)	15.056*** (3.709)	−3.997*** (−3.443)
Team	5.923*** (6.983)	0.828*** (3.144)	4.098 (0.992)	−0.191 (−0.528)
Venture capital	1.451 (1.444)	−0.233 (−0.930)	3.341 (0.778)	−0.891** (−2.318)
Partnership	−2.856*** (−3.534)	−0.194 (−0.708)	17.011*** (4.059)	−0.954 (−0.639)
Pitch	4.069*** (5.218)	0.991*** (3.698)	14.145*** (3.693)	−1.967* (−1.905)
e-commerce	−11.864*** (−7.372)	−2.486*** (−3.057)	5.379 (1.009)	0.273 (0.371)
Video	2.161*** (10.373)	0.880*** (7.224)	1.830*** (3.963)	−0.181 (−1.151)
Separate website	5.791*** (6.528)	−1.006*** (−2.865)	27.261*** (4.572)	−3.572* (−1.835)
Follow-on	0.030 (0.038)	−0.999*** (−2.920)	−8.283 (−1.507)	1.659** (2.208)
Residual		0.161*** (5.216)		−0.185** (−2.348)
Intercept	17.193*** (9.239)	0.572 (0.604)	−19.692** (−2.312)	0.211 (0.113)
F-statistic	276.61	6026.15	38.94	3042.30
R^2	0.600	0.615	0.910	0.851
Statistic	2432	2432	2432	2432

$p < 0.10$; **$p < 0.05$; ***$p < 0.01$.

an F-statistic of 38.94 in the first stage, which is well above the common threshold of 10, suggesting that it is a valid instrumental variable. We found significant residuals in the second stage $\gamma_U = -0.185$, $p < 0.05$), which suggests that there is indeed an endogeneity problem, thus justifying the use of an instrumental variable. In the IV model 2, with the inclusion of control variables, the effect of project modifications on project success is positive and significant ($\gamma_1 = 0.330$, $p < 0.01$). This means that when unobservable confounders are controlled for validating H2, project initiators who make project changes based on the comments' content increase the likelihood of project success by 33%.

Table 5 reports the analysis results of the impact of specific informative update themes on project success. For the project sponsor's informative, updated theme variables, the estimates for *CumulativeUpdateTopic1* (*i.e.*, project success an-

nouncement), *CumulativeUpdateTopic2* (*i.e.*, detailed information related to the project's collaboration), and *CumulativeUpdateTopic3* (*i.e.*, project launch announcement) are positive and significant ($p < 0.01$).

Table 5. H4-Thematic effects of update.

Dependent variable = project success	Topic label	Estimated value	Standard error
Update topic 1	Project success announcement	235.538***	6.553
Update topic 2	Project cooperation information	175.205***	5.811
Update topic 3	Project launch announcement	100.343***	8.414
Target amount (ln)		0.074**	2.290
Project duration		−0.021*	−1.910
Text length		0.000	0.883
Number of pictures		−0.016	−0.400
Rewards		−29.263***	−6.910
Team		−12.253***	−6.599
Venture capital		−0.392	−0.286
Partnership		25.918***	6.746
Pitch		−0.272	−0.347
e-commerce		−4.879***	−3.040
Video		−0.162	−1.278
Team		−12.253***	−6.599
Venture capital		−0.392	−0.286
Partnership		25.918***	6.746
Pitch		−0.272	−0.347
e-commerce		−4.879***	−3.040
Video		−0.162	−1.278
Separate website		20.749***	7.565
Follow-on		9.122***	2.605
Residual		−51.560***	−6.611
Intercept		38.26	
R^2		0.929	
Statistic		2432	

$p < 0.10$; **$p < 0.05$; ***$p < 0.01$.

5.2. Panel Model Result Analysis

Table 6 presents the descriptive statistics of the panel model and reports that there

are no multicollinearity problems. The dependent variable is the amount of new funds received since the previous period ($\nabla F_{i,t}$), and Table 7 demonstrates the main estimation results. All standard errors are clustered at the project level and robust to heteroskedasticity and autocorrelation.

Table 6. Descriptive statistics for panel data.

Variables	Average	Standard error	Minimum	Maximum
Cumulative investor comments	14.534	24.957	0	220
Cumulative sponsor updates	0.286	0.902	0	20
New project modifications	0.91	3.31	0	41
Cumulative investors	145.196	294.456	0	2990
New investors	9.827	60.534	−25	2116
Cumulative financing	27,368.305	350,131.704	−100,000	16,564,190
New financing	146.55	1801.56	−83,913	923,169
Average financing	87,729.866	486,863.224	0	16,564,190
Cumulative Facebook sharing	78.56	504.54	0	522

To test H1, this paper regresses the amount of new funding received since the previous period on the number of investor comments in the lagged period. The value of the β_1 coefficient in Model 1 is 0.115, which is significant ($p < 0.01$) supports H1. One investor comment immediately generates £0.115 of funding for a project, and this cumulative effect increases every 24 hours for a project duration of 32 days on average. One comment posted by an investor halfway through generates £1.84 of additional funding, while an investor comment posted at the start of the same project generates £3.68. For the most extended duration (60 - 61 days), the cumulative effect increases to £6.9 (0.115 * 60). These are averages, so some reviews may result in more or less investment. Also, to test H3, the amount of new funds received since the previous period is regressed on the amount of project promoter updates lagged by one period in Model 1. The value of the coefficient of β_2 in Model 1 is 0.434, which is positive and significant $p < 0.01$, and supports H3. Similarly, a single update from a promoter immediately generates £0.434, with a cumulative effect, and increases every 24 hours within an average project duration of 32 days. While £13.888 is generated at the start of a project, additional funding of £6.944 is generated halfway when a promoter posts one update. For the longest (60 - 61 days) project duration, the cumulative effect increases to £26.04 (0.434 * 60).

To test the mediating effect of the number of changes in program content (H2), the one-period lagged cumulative number of investor comments is split into the two-period lagged and compared with the previous results (Model 2A). The effect of the two-period lagged cumulative number of investor comments is slightly weaker than that of the one-period lagged cumulative number ($\beta_2 = 0.045$, $p <$

0.01). We then incorporate the interaction between the number of program content revisions and the number of cumulative investor comments with a two-period lag in the faceted model 2B. Now, the effect of a two-period lagged cumulative number of investor comments is not significant, and the interaction between investor comments and project content revisions is highly significant and very similar to the estimated effect of a two-period lagged number of investor comments in Model 2A $\beta_4 = 0.043$, $p < 0.01$. Thus, the direct effect of the two-period lagged cumulative number of investor comments is fully absorbed by its interaction with the number of program content revisions supporting H2. Table 7 presents the main result.

Table 7. Results of the panel data model.

Variables	Model 1	Model 2A	Model 2B
Investor comments ($t-1$)	0.115*** (8.169)		
Sponsor updates ($t-1$)	0.434*** (6.276)		
New investor comments ($t-1$)		0.5235*** (7.233)	0.277*** (3.977)
Investor comments ($t-2$)		0.045*** (4.119)	0.010 (0.915)
New project modifications ($t1$)			0.128*** (8.539)
Investor comments ($t-2$) × new project modifications ($t-1$)			0.043*** (4.257)
Cumulative investors ($t-1$)	0.0355*** (19.597)	0.026*** (15.366)	0.0165*** (9.843)
New investors ($t-1$)	−0.0005*** (−6.954)	−0.000*** (−2.990)	0.000 (0.528)
Average financing ($t-1$)	0.000 (1.576)	0.0005*** (3.174)	0.0005** (2.109)
Cumulative Facebook sharing	−2.53* (1.31)	−2.53* (1.31)	−2.54* (1.32
Project duration	−0.4595*** (−7.569)	−0.1855*** (−3.279)	0.005 (0.089)
Project duration^2	0.006*** (4.180)	0.01 (0.514)	−0.0025* (−1.735)
Fixed effects	Yes	Yes	Yes
Intercept	0.6045*** (2.809)	0.3295* (1.647)	0.058 (0.315)
F-statistic	172.68	163.55	130.81
R^2	0.57	0.57	0.58
Statistic	5624	5642	5642

$p < 0.10$; **$p < 0.05$; ***$p < 0.01$.

Table 8 reports the results of the panel data analysis for specific update content and presents the same results as the cross-sectional data. Cumulative updates on topics 1, 2, and 3 are positive and significant. Consistent with the hypotheses of this paper, Cumulative update topic 2 was found to be effective in encouraging subsequent investors to invest, as were the project launch and project success announcements.

Table 9 summarizes the hypotheses' results for both the Panel model and the instrumental variable model.

Table 8. Panel data thematic effects of updates.

Dependent variable = project success	Topic label	Estimated value	Standard error
Update topic 1	Project success announcement	235.538***	6.553
Update topic 2	Project cooperation information	175.205***	5.811
Update topic 3	Project launch announcement	100.343***	8.414
Target amount (ln)		0.074**	2.290
Project duration		−0.021*	−1.910
Text length		0.000	0.883
Number of pictures		−0.016	−0.400
Rewards		−29.263***	−6.910
Team		−12.253***	−6.599
Venture capital		−0.392	−0.286
Partnership		25.918***	6.746
Pitch		−0.272	−0.347
e-commerce		−4.879***	−3.040
Video		−0.162	−1.278
Separate website		20.749***	7.565
Follow-on		9.122***	2.605
Residual		−51.560***	−6.611
Intercept		38.26	
R^2		0.929	

$p < 0.10$; **$p < 0.05$; ***$p < 0.01$.

Table 9. Results of the panel data model.

Hypothesis No.	Hypothesis	Model	Outcome
H1	Equity crowdfunding projects with higher investor participation attract more subsequent investors, increasing the funding success rate.	Panel and Instrumental Variable Models Results	HI is positive and significant
H2	In equity crowdfunding, investor engagement's effect on project success depends on whether the project sponsor modifies the project based on comments.	Panel and Instrumental Variable Models Results	H2 is positive and significant
H3	In equity crowdfunding, a higher frequency of project updates will attract more subsequent investors, which increases the success rate of crowdfunding projects.	Instrumental Variable Model Result	H3 is positive and significant
H4	In equity crowdfunding, posting informative updates on different topics attracts more subsequent investors, increasing crowdfunding projects' success rate.	Panel and Instrumental Variable Models Results	H4 is positive and significant

6. Discussions, Limitations, and Future Research Direction

6.1. Discussions

This paper investigates the impact of information exchange in equity crowdfunding. Specifically, the effects of comments and updates and their frequency and content on investment decisions by potential investors have been explored. Theoretically, this paper's findings add to the growing literature on crowdfunding information asymmetry by examining the impact of the value of information derived from investor and promoter behavior on the success of projects. The interactive nature of the funding process reduces the information asymmetry. The principal-agent relationship is affirmed by the project initiators' role in modifying contents based on investors' input. Under this model, agency problems exist between the investors and the sponsors due to dependence and conflicting goals [20]. The exchange of information provides a solution to the agency problem, which further helps investors to determine the project quality.

The results show that comments and updates influence investment decisions, confirming the informational value of investors' and sponsors' behaviors. The herding effect is evident due to the quality signals investors pick from previous ones for investment decisions. The finding further suggests that investors react negatively to project updates that ask for more investment. An adverse reaction may occur because the project's progress is displayed in real time on the funding webpage. It further proves that investors are impacted differently when updates are measured regarding contents and that the finer details from other sources signal project quality. It also suggests that obtaining ideas from investors and modifying the project could increase its chances of receiving funding. Also, investor comments' positive effect on project success aligns with previous study findings that show that customers' influence on product development impacts project success and reduces agency costs for prospective investors [55].

Moreover, this study proves that different topics that impact investors' decisions determine the degree of investor participation in the initial offering and later attract subsequent investors. The above is consistent with [56], who point out that crowdfunding is not only about funding but also the quality of the information a project owner provides on the product. In addition, this study uses a panel data model to attenuate the effect of the herd on and correct the endogenous bias of updates and comments. The platform designs the exchange of information function, which project sponsors and investors use to reduce the investment risk associated with herding.

From a managerial perspective, this study provides some practical lessons for platform managers and project initiators in the online equity crowdfunding market. For project initiators, the crowdsourcing behavior of potential investors and the behavioral mechanisms behind it are strategically vital for day-to-day project operations. Specifically, when using these communication tools designed by crowdfunding platforms, project initiators can actively post timely updates and respond to investor comments throughout the project fundraising period. Besides,

more comments and updates help attract subsequent potential investors, who view such as a positive project signal. Similarly, project sponsors can adopt meaningful suggestions in the comments to improve their project based on the comments to avoid the negative implications that the content of such an update would bring to subsequent investors. Features such as real-time chat may allow project promoters to exchange information with investors and reduce the number of negative consumer postings on the seller's page, as found in previous studies.

6.2. Conclusion, Limitations, and Future Research Direction

There are some limitations associated with this study. First, this paper analyzes examples of equity crowdfunding platforms with an "all-or-nothing (AON)" mechanism without considering the "Keep-It-All" (KIA) mechanism. Also, due to data limitations, the study only focuses on the observational learning effect from investors' sharing and searching behaviors on the Facebook platform. It also excludes the effect of project initiators attraction of potential investors through marketing campaigns on other social media platforms. The model in this paper can continue to be expanded in future research when this type of information is available. Finally, additional attitude-based information could be collected to improve understanding of investment behavior in the equity crowdfunding market. Also, future studies should consider more equity crowdfunding platforms with the "Keep-It-All" model to support the generalizability of the findings. In conclusion, how to design more efficient service operation strategies in equity crowdfunding is a direction that deserves more research.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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