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Original article

The patent paradox in crowdfunding: an empirical analysis of Kickstarter data

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Abstract

Building on signaling theory, this paper analyzes whether projects signaling patented technologies have a higher probability of funding success on a reward-based crowdfunding platform as compared with a control group of similar projects. Our analysis of a set of Kickstarter projects suggests the existence of an apparent paradox concerning the role of patents in this funding context. Despite solid evidence in entrepreneurial finance literature on the positive role of patents for accessing financing from professional investors such as venture capitals and business angels, our results from the reward-based crowdfunding context point out a negative signaling role of patents. We provide explanations to reconcile such evidence with previous relevant literature and highlight promising avenues for future research in this area.

JEL classification: O31, O34, O35, G29

1. Introduction

Raising money is one of the most pressing issues for early-stage startups, especially in recent years following the financial crisis. New ventures are typically not yet profitable, lack tangible assets, and face high levels of risk, particularly in high-technology sectors (Denis, 2004). Further complicating the relationship between aspiring entrepreneurs and potential investors is the existence of asymmetric information (Hall and Lerner, 2010; Conti *et al.*, 2013b). Given these challenges, new ventures encounter significant constraints in accessing traditional funding channels such as debt and equity. In order to overcome these problems and resolve the funding gap, entrepreneurs increasingly resort to alternative ways to obtain funding. One such alternative is crowdfunding, the financing of a project or venture by a large group of individuals through an *ad hoc* Internet platform instead of professional parties.

Given the newness of the phenomenon, scholars still know little about the dynamics of crowdfunding, as well as the general distribution and use of crowdfunding mechanisms (Schwienbacher and Lambert, 2010; Belleflamme *et al.*, 2014; Mollick, 2014; Colombo *et al.*, 2015b). One underexplored issue in this emerging literature is represented by the role patents play as instruments facilitating (or hindering) access to financing through crowdfunding. This lack of interest is surprising, given the existence of a large body of literature that shows, in general, the effectiveness of patents as quality signals that help new ventures access external equity financing in traditional contexts and

thus, to some degree resolve information asymmetry. For instance, recent studies highlight that possessing a large and strong patent portfolio is associated with a higher likelihood of receiving venture capital (VC), business angel, (Long, 2002; Mann and Sager, 2007; Conti *et al.*, 2013b; Hsu and Ziedonis, 2013) or a higher amount of VC funding (Munari and Toschi, 2015). Further, research on Initial Public Offers (IPOs) suggests that patents can help reduce the level of information asymmetries with external investors for firms going public (Heeley *et al.*, 2007; Morricone *et al.*, 2017).

This article provides theoretical explanations and presents empirical evidence of the signaling role of patents in reward-based crowdfunding. In particular, the aim of this study is to gain insight into whether projects signaling patented technologies have a higher or lower probability of funding success on a reward-based crowdfunding platform as compared with a control group of similar projects (with no mention of patents). Our study suggests that in reward-based crowdfunding, funders receive and interpret patent signals in a very different way than traditional investors in entrepreneurial finance. We use the central elements of signaling theory (Spence, 1973; Connelly *et al.*, 2011; Hsu and Ziedonis, 2013) to discuss how the specificities of the reward-based crowdfunding context affect the signaling role of patents.

Empirically, we leverage data extracted from Kickstarter, the largest and most dominant reward-based crowdfunding website in the world. We first identify a sample of 834 projects signaling the presence of a patent and match them to a control group of similar projects (with no underlying patents) using propensity score matching (PSM). We then compare the two groups in terms of funding success, measured as the likelihood of obtaining funding.

Our analyses unveil an apparent patent paradox in reward-based crowdfunding, in line with our theoretical arguments. Despite solid evidence in entrepreneurial finance literature on the positive role of patents for accessing capital from professional investors, our results suggest that patents send a negative signal in the reward-based crowdfunding context. On the one hand, projects that declare the presence of an underlying patent represent a minority of the crowdfunding projects in Kickstarter. On the other hand, a reference to patents in a Kickstarter project pitch is associated with a lower likelihood of obtaining funding in the campaign. We provide explanations—confirmed by our analyses—for this counterintuitive result, with reference to the higher degree of innovativeness and risk, higher level of technical complexity, and lower integration with the crowd community.

Although exploratory in nature, our study provides unique contributions to existing literature. First, we add new knowledge to the literature on crowdfunding (Mollick, 2014; Ahlers *et al.*, 2015; Colombo *et al.*, 2015b; Short *et al.*, 2017; Piva and Rossi-Lamastra, 2018). We provide evidence on the signals derived from patents, which has been neglected so far by existing studies, and we illustrate the mechanisms underlying this process. Second, we contribute to signaling theory, showing how signals can be interpreted differently when used in distinct contexts (Lester *et al.*, 2006; Connelly *et al.*, 2011). Finally, we provide practical implications for entrepreneurs planning to use crowdfunding to finance innovative products or ventures.

The remainder of this article is organized as follows. Section 2 presents the theoretical background of our paper, summarizing the existing literature on the role of patents as signals to attract external financing. In Section 3, we describe the data, in Section 4, the matching methodology, and Section 5 discusses the main results. Then in Section 6, we discuss the implications of our findings. Section 7 presents the limitations and directions for future work, and finally Section 8 shows the conclusions.

2. Theoretical background

2.1 Information asymmetry and signaling theory

New ventures face several problems attracting external financing because it is difficult to measure, evaluate, and manage investments in R&D and new technologies (Litan and Wallison, 2003). One major problem is the presence of information asymmetries between insiders and external parties (Murray and Lott, 1995; Berger and Udell, 1998; Hall, 2005). The asymmetric information problem refers to the information differences and conflicting interests between the potential entrepreneur and the investors. On the one hand, investors typically lack the distinctive competencies necessary to evaluate the new ideas and technologies developed by the entrepreneurial venture; on the other hand, entrepreneurs tend to be reluctant to reveal all of the information about their technologies and their market potential. As a result, investors face severe problems finding the information they need in order to evaluate the quality

of the firms and disentangle good investments from bad ones (Akerlof, 1970; Pyle and Leland, 1977; Winborg and Landstrom, 2001).

Signaling theory is essentially concerned with reducing information asymmetry between two parties. When information asymmetry is high, investors can rely on signals to make decisions concerning economic exchanges because signals convey critical information to potential investors affecting the probability to attract financial resources (Spence, 1973; Spence, 2002; Connelly *et al.*, 2011). The signaling process is characterized by the signal itself, the signaling environment, and the presence of two main actors, the signaler and the receiver (Connelly *et al.*, 2011).

The signaler is an insider who has information about an individual (Spence, 1973), a product (Kirmani and Rao, 2000), or an organization (Ross, 1973) that is not available to outsiders. The signal could be either a positive or negative piece of information held by the insiders of the organization (Connelly *et al.*, 2011). The receivers are outsiders and observers of the organization who look for information about the organization. The characteristics of the receivers influence the effectiveness of the signaling process due to their interpretation of the signal (Gulati and Higgins, 2003). Finally, the signaling environment is the institutional or the industrial environment in which the signaling process occurs, which can make signals either more or less observable. For example, as the environment in which the signaling process occurs becomes noisier, the effectiveness of the signal diminishes (Zahra and Filatotchev, 2004; Jiang *et al.*, 2007).

2.2 Patents as a quality signal for entrepreneurial finance

Entrepreneurship scholars have identified several effective signals of quality that can be used to reduce information asymmetry with external investors. Signals related to human, social, and intellectual capital, are highly efficacious in different financial settings (Zucker *et al.*, 1998; Burton and Beckman, 2002; Baum and Silverman, 2004). In particular, these studies unpack the ways in which patents owned by technology startups can act as a credible signal of the underlying quality of the firm toward external investors (e.g. Hsu and Ziedonis, 2013).

First, patents represent a tangible signal regarding the firm's ability to transform research investments into new and potentially valuable knowledge (Levitas and McFadyen, 2009). Patents decrease the information gap between investors and firms seeking external financing as they represent tangible outputs of the firm's invention process, and thus, provide robust signals of the effectiveness of a firm's ability to recombine different types of knowledge and develop novel, useful, valuable, and industrially applicable technologies (Griliches, 1990). Second, patents are strategic tools used by firms to protect their technologies and increase returns from its R&D activities by ensuring restricted but enforceable monopoly rights, that is, the right to exclude competitors from the protected technology (Granstrand, 1999). Third, patents can be directly exploited as sources of additional revenue/finance for the firm, through licensing agreements or sale transactions to third parties (Arora *et al.*, 2001; Gans *et al.* 2002; Lin and Kulatilaka, 2006; Morricone *et al.*, 2017). As such, patents display significant potential as a means to improve the competitive position of firms and as sources of additional revenue streams (Gans *et al.* 2002; Lin and Kulatilaka, 2006).

A relevant stream of research has assessed the impact of patenting on a new venture's ability to attract external financing, with reference to VC funding rounds (e.g., Bertoni *et al.*, 2010; Hsu and Ziedonis, 2013; Haeussler *et al.*, 2014; Hoenig and Henkel, 2015; Munari and Toschi, 2015), business angel investments (Conti *et al.*, 2013a), initial public offerings, and public financial markets (e.g., Heeley *et al.* 2007). These studies show that sophisticated investors tend to place more value on patents (i.e., specialized VCs vs. generalist VCs; VCs vs. business angels), suggesting differing interpretations of the same signal (Conti *et al.*, 2013b). Further, the efficacy of the process is also likely to depend on the characteristics of the sender: patents have proved to be less effective signals in cases where the sender can exploit other tangible and intangible signals to communicate the quality of its business to external actors (Hsu and Ziedonis, 2013). Finally, the signaling environment can influence the efficacy of signaling a patent. The study of Heeley *et al.* (2007) on IPOs shows that the possession of patents by companies going public does not significantly reduce IPO underpricing in sectors characterized by a weak association between intellectual property rights (IPR) protection and value creation.

This literature presents robust evidence of a positive, significant association between high-tech new ventures' patent activity and their ability to attract external financing from VCs, business angels, and stock markets, and suggests that the effectiveness of patents as quality signals is likely to depend on the characteristics of the signaling context. Table 1 summarizes the main findings of such studies.

Table 1. The role of patents in financing innovative firms: selected studies

	Study	Sample (type)	Dep. variable	Explanatory variables	Key findings
Patents and venture capitalist	Bertoni *et al.* (2010)	351 NTBF (tech industry)	– Presence of Patent (t) – Number of Patents (t)	VC investment (t−1)	VC investments positively affect subsequent patenting activity.
	Haeussler *et al.*, (2014)	346 German and 343 British companies (biotech industry)	The first time of first VC investment	Number of patents	Information generated in the patenting process facilitates access to external finance.
	Munari and Toschi (2015)	332 companies financed by VC (biotech industry)	VC investment amount	Number of core technology patents	The type of patents, owned by the startup, rather than their quantity, affects the VC financing decision.
	Hoenig and Henkel (2015)	187 individual VCs	VC investment choice	Presence of patents	There is no evidence of the role of patent as signals of unobserved technological quality. VCs rely on alliances and in part on team as signals of technological quality.
	Hsu and Ziedonis (2013)	370 startups (semiconductor industry)	VC investment and IPO	Number of patents	– Patents are more influential in the first rounding of financing by VC firms, rather than in later rounds. – Patents fill the information gap in the process of IPO
	Mann and Sager (2007)	1089 startups (software industry)	VC investment, rounds, and longevity	– Presence of patents – Number of patents	There is a significant and positive robust correlation between patent and the VC investment, amount of capital, exit status, receipt of late stage financing, and longevity
	Hoenen *et al.* (2014)	580 startups (biotech industry)	VC investment amount	Number of patents	Patents positively affect the first round of financing, but the signaling value of patent diminishes and then does not affect other rounds of financing
	Kolympiris *et al.* (2018)	586 U.S.-based emerging biotechnology firms	VC investment amount	– Patent application – Granted patents	Firm patent activity is a strong signal for long-distance transactions
Patents and business angels	Conti *et al.* (2013b)	117 startups (tech industry)	VC investment and Business Angel investment	Number of patents	Patents are used by startups to attract VC investments but not BA financing
	Conti *et al.* (2013a)	787 Israeli startups	VC investment and Business Angel investment	Number of patents	Patents are used to attract VC but not private investors, as Business Angels
	Vo (2018)	468 early-stages Canadian ventures	VC investment and Business Angel investment	Patents applications	Patents may not help in obtaining investments, but ventures with patents match with early-stage investors, who support their patent protection strategies
Patents and IPO	Useche (2014)	476 IPO deals (software industry)	IPO	Patents	There is a significant and positive robust correlation between patent applications and IPO performance. The signaling power of patent change between USA and European companies
	Heeley *et al.* (2007)	1413 firms (manufacturing industry)	IPO	Number of patents	Patents reduce information asymmetry and associated underpricing
	Morricone *et al.* (2017)	130 IPO deals (semiconductors)	IPO	Number of patents	The stock of patents reduces information asymmetries (and associated underpricing) for companies pursuing licensing-based strategies

2.3 Information asymmetry in crowdfunding

Crowdfunding is an increasingly valuable source of seed capital for small enterprises. During the early stages of development of new innovative businesses, crowdfunding can help fill important funding gaps (Schwienbacher and Larralde, 2010; Agrawal *et al.*, 2014; Lee *et al.*, 2015; Greenberg and Mollick, 2017). However, crowdfunding is characterized by unique information challenges (Mollick, 2014; Ahlers *et al.*, 2015). The funding campaign takes place online and in a short-time window, and the majority of the projects are in the very early stages with high uncertainty about the feasibility of the project (Belleflamme *et al.*, 2014). Therefore, the information asymmetry issue is critical because backers may be informationally disadvantaged with regard to the credibility of the project that they are willing to fund (Mollick, 2014; Ahlers *et al.*, 2015; Courtney *et al.*, 2017). The quality of the project depends in most cases on the perceived feasibility of the product or the service and, as such, is not observable until the campaign is completed and the backers receive the project's product or service (Courtney *et al.*, 2017). Nevertheless, the potential entrepreneurs who start a crowdfunding campaign might reflect the quality of their projects by highlighting different attributes and in doing so, send quality signals that may help overcome uncertainty and information asymmetry and provide credibility to the project.

The literature on crowdfunding has identified a set of effective signals that might enhance the credibility of the founder and the project itself. In particular, the intensity of communication with backers (Mollick, 2014), the size of the entrepreneur's social network and their active involvement with backers in the community (Colombo *et al.*, 2015b), the effect of localized social capital (Giudici *et al.*, 2017) and human capital signals (Piva and Rossi-Lamastra, 2018) are relevant characteristics that affect a project's success on the crowdfunding platform. However, literature has devoted very limited attention to the role of patents in the context of reward-based crowdfunding.

The research on patenting and external financing suggests that patents may serve as quality signals to convince external investors of the novelty and originality of the idea, of the possibility for the inventor to exploit it exclusively, and of the feasibility and market viability of the product or service (Hsu and Ziedonis, 2013; Conti *et al.*, 2013b; Hoenig and Henkel, 2015). However, a deeper consideration of the conceptual foundations of signaling theory caution against a simple and automatic extension of the previous results found in traditional forms of startup equity financing in the context of reward-based crowdfunding. Indeed, the characteristics of signals may take on different meanings and outcomes when used in different signaling contexts and interpreted by different receivers (Lester *et al.*, 2006).

To date, few studies have explored the role of patents as an effective signal in the crowdfunding setting. The study by Erickson *et al.* (2015) looking at the effect of the IP (intellectual property) status (public domain works vs. copyrighted works) on a reward-based platform found only moderate support for the role of IP status in supporting projects' funding levels, with counterintuitive results (public domain projects raising more funds than licensed third-party work) (Erickson *et al.*, 2015). This study, however, does not directly tackle the signaling role of patents, as it focuses on media projects. In the context of equity-based crowdfunding, Ahlers *et al.* (2015) conducted an empirical examination of the effectiveness of several types of signals in the context of equity crowdfunding. They show that possessing a granted patent by the new venture is not significantly associated at conventional statistical levels with funding success (Ahlers *et al.*, 2015). Vismara (2016) shows that intellectual capital plays an important role for sophisticated investors that fund companies in the very early stages on equity crowdfunding platforms, but the patent itself does not seem to be a significant predictor of a campaign's success.

2.4 The signaling role of patents in reward-based crowdfunding

In the context of reward-based crowdfunding, the characteristics of the receivers (the crowd) who interpret the signals sent by the entrepreneur, and the signal itself (the patent), may influence the effectiveness of signaling a patent (Connelly *et al.*, 2011). Crowdfunders are not professional equity investors; they often lack financial, technical, or industry expertise, and they do not seek significant returns from their contributions, but are instead motivated by other goals and values (Bretschneider *et al.*, 2014). As such, we can expect a different impact of patents as quality signals in the reward-based crowdfunding context, and also a negative one.

First, signaling a patent can be associated with a higher degree of radical innovativeness of the campaign, whereas previous literature has shown that crowdfunders are likely to prefer incrementally innovative campaign outcomes (Chan and Parhankangas, 2017). Studies in entrepreneurial finance show that equity investors prefer highly innovative ventures (Kortum and Lerner, 2000; Metrick and Yasuda, 2010); however, they are strictly driven by a financial

logic centered on the generation of a return (Manigart *et al.*, 2002). On the contrary, reward-based crowdfunders do not receive equity positions, but rather they expect a reward through the delivery of a product or a different form of intangible benefit, such as the preordering of new products or helping entrepreneurs commercialize their ideas (Ordanini *et al.*, 2011; Gerber *et al.*, 2012; Cholakova and Clarysse, 2015). Funders, in the context of reward-based crowdfunding, act mainly as consumers and are concerned about the quality of the product/service and with the likelihood that it will be delivered. In this sense, radically innovative campaigns might be perceived as highly risky, very challenging, and difficult to complete. Therefore, these campaigns might be less likely to be supported because the potential benefits face feasibility challenges (Chan and Parhankangas, 2017). By definition, patented inventions should possess an inventive step, thus signaling elements of technical novelty and originality to external observers. Moreover, there is evidence that innovators with relevant, new-to-the-market, innovations are significantly more likely to exploit patents to protect their ideas (Schneider and Veugelers, 2010). Thus, in the context of reward-based crowdfunding, signaling a patent might be associated with a radical innovation and a risky campaign.

Second, patents can be related to higher levels of technical complexity, thus making the campaign more difficult to understand for potential backers (Colombo *et al.*, 2015a). Reiterating above, crowd investors are typically not professional investors, and thus, they lack the technical and managerial sophistication and expertise of professional investors, who generally pass through a very careful and lengthy process in order to screen and evaluate the target companies before completing the investment process (MacMillan *et al.*, 1985; Munari and Toschi, 2015). Further, since crowds are pledging small amounts of money per project, they have fewer incentives to gather detailed information on the project itself. Indeed, the cost to engage in extensive due-diligence processes in order to assess the technological merit and the intellectual property strengths of a prospective investment is likely to be extremely high for crowdfunders in relation to the amount of money to be invested, whereas it is relatively limited for venture capitalists or business angels. As a consequence, technology-intensive campaigns are unlikely to attract the general crowd, as they often lack the specialized knowledge needed to understand the underlying products and technologies. For such reasons, previous research has raised doubts of the suitability of reward-based crowdfunding as a means of funding basic research or technology-intensive projects (Colombo *et al.*, 2015a). Mentioning a patent in a crowdfunding project might potentially signal the technical complexity of the project, leading to a distortion of the piece of information related to the patent. The perception of high complexity and low familiarity can be seen as a negative signal for the receivers, which can have a negative effect on the ultimate success of the project.

Third, the exclusivity rights associated with patents can contrast with the values of openness, reciprocity, and altruism infusing the crowdfunding community (Bretschneider *et al.*, 2014), thus generating a clash. Initial research on the motivations of the crowd to support reward-based crowdfunding campaigns has pointed to a diverse set of reasons, going well beyond the goal of achieving a reward or a financial return (Ordanini *et al.*, 2011; Gerber *et al.*, 2012). In particular, values as the desire to help others, being part of a community and supporting a cause, are frequently cited by supporters of crowdfunding campaigns (Gerber *et al.*, 2012; Bretschneider *et al.*, 2014). Moreover, backers are often motivated to improve the product they are eventually going to receive by providing feedback and suggestions that might help the entrepreneurs in the development process (Stanko and Henard, 2017). The presence of a patent might hinder this process of co-creation, disengaging the potential interested backers in the funding process. Moreover, such values centered on openness, altruism, co-creation, and reciprocity are typical of online communities, and they might clash with the notions of exclusivity and appropriability associated with patent rights.

In sum, the specificities of the reward-based crowdfunding model and the degree to which it differs from traditional funding sources for startups, suggest that patents could have a negative signaling value (or might have no value at all) in the context of reward-based crowdfunding. We empirically address this issue in the following sections of the article, where we explore whether and how patent signals affect the success of crowdfunding campaigns in the Kickstarter platform. More specifically, we analyze whether Kickstarter projects signaling patented technologies have a higher (or lower) likelihood to be funded as compared with a control group of similar projects (with no mention to patents).

3. Data

In order to address our research question regarding the relationship between patent signals and campaign success in reward-based crowdfunding, we collected data from Kickstarter, which is the largest reward-based crowdfunding platform and has been extensively used in prior crowdfunding research (e.g., Mollick, 2014). We utilized web

harvesting techniques to obtain a large and unobtrusive sample of records from the website (Landers *et al.*, 2016) for projects signaling patents and those that do not. We collected a total of 87,706 projects with dates ranging from 2011 to 2016 and we performed the following procedures to build the sample.

First, we removed projects that were suspended by Kickstarter as these projects were found to be in violation of Kickstarter's terms of service and thus, unable to complete their campaigns. Second, following previous empirical research in crowdfunding (Cumming *et al.*, 2014; Mollick, 2014), we excluded projects with a fundraising goal of less than $5000 USD and more than $500,000 USD. Those projects with a low fundraising goal generally rely on money from family and friends, and as such, they should not be compared with projects that rely primarily on outside backers. We then excluded those projects with a goal over $500,000 USD, corresponding to the 99th percentile of our distribution. These projects are outliers and they differ from the traditional projects on the platform. Finally, we isolated projects signaling patent language in their text or title description, which included words or phrases such as, "patent," "patented," and "patent pending." This resulted in 834 projects with 19,756 projects remaining to serve as a comparison group.

4. Matching methodology

4.1 Matching analysis strategy

The first challenge with analyzing a treatment-based outcome—in our case, the use of a patent signal in a crowdfunding campaign—is how to build the counterfactual case for comparison (Elert *et al.*, 2015). The second challenge is the issue of self-selection bias, where participation in a certain group is not randomly assigned. Indeed, our data—historical Kickstarter projects where the decision to signal a patent has already been made—is observational rather than experimental, and thus could suffer from selection bias (Li, 2013). As we are interested in the effect that signaling a patent has on the project's outcome (i.e., the treatment effect on the treated), these challenges require careful consideration.

To do so, we leverage PSM (Rosenbaum and Rubin, 1983). PSM is a popular approach to build counterfactual cases as it reduces bias in covariates due to distribution differences among treated and untreated subjects (Ming and Rosenbaum, 2000). For instance, given the costs associated with obtaining a patent, it would be reasonable to assume that a covariate such as the funding goal is systematically different for projects that offer a patent signal. PSM ultimately reduces our many covariates down to one dimension (Li, 2013) and assigns a propensity score to each observation, which is the basis for the treated subject to be matched with the untreated. The propensity score is defined as the probability that the subject in the sample would receive the treatment based on observed characteristics. This reduces the differences between the two groups and more closely isolates the effect that the treatment has on the outcome (Kautonen *et al.*, 2017).

An important note about the propensity score is that it is derived via the set of observed variables within the model. Thus, the strength of the propensity score relies on the set of theoretically relevant variables observed. However, despite our best efforts, unobserved heterogeneity may influence the following results, which we expand on in our discussion.

4.2 Dependent variable: success

As in previous studies in the field of crowdfunding (Mollick, 2014; Ahlers *et al.*, 2015; Colombo *et al.*, 2015a; Courtney *et al.*, 2017), the key dependent variable of interest in our analyses is *D_Success*, which measures the success of the project in obtaining funds on the platform. It is constructed as a dummy variable taking the value 1 in case the project reaches the funding goal and is therefore funded, and 0 otherwise.

4.3 Treatment: patent signal

The key explanatory variable of interest is *Patent_Signal*, a dummy variable that takes the value 1 for projects signaling a patent in their descriptions (as previously identified), and 0 for projects from the control group. This variable includes any usage of patent language throughout the text of the project, which we then manually verified.

In addition, we categorize the status of the patent (*Patent_Status*) based on the patent description within the project's text description. Such variables take the following categories: "patent held" that indicates the possession of a patent (granted patent); "patent pending," which indicates the pending status of a patent (patent applied for, but not

yet granted); and "patent mentioned" that indicates a patent with no clear specification about the status. The absence of a patent ("no patent") is used for the control group.

4.4 Variables used in the matching process

The quality of the PSM model is dependent on accurate and theoretically relevant observed variables that may guide the decision to elect treatment (Elert *et al.*, 2015). We leverage both variables from recent advances in crowdfunding research (e.g. Mollick, 2014; Colombo *et al.*, 2015a; Courtney *et al.*, 2017) as well as variables that might have practical relevance when a project's proponent considers leveraging a patent signal.

First, we include a high-level proxy for similarity, the category of the project (*Primary_Category*) as identified in Kickstarter. We consider the following categories: design, fashion, film and video, food, game, music, photography, publishing, technology, and theater. Each category was assigned a dummy variable. For example, the dummy *design* takes the value "1" if the project belongs to the design category and "0" otherwise. Next, we match the year the project was posted (*Year_Created*). While our window of projects is relatively short, spanning roughly 5 years, both technology and the usage of Kickstarter continuously evolve. Therefore, we leverage the year the project was posted to Kickstarter as another mechanism to assist with project similarity.

Next, we include three variables where signaling patent language might serve as a competitive advantage as well as strengthen the criteria for project similarity. First, we include the project's funding goal (*Project_Goal*). The funding goal allows us to match projects that are similar in scope. In addition, the project's scope may influence whether a proponent decides to signal a patent as the costs associated with filing and maintaining patents can be substantial. Thus, the larger the financial scope of the project, the more likely a proponent would elect to protect it via patent. We then follow with the duration of fundraising, counted in days (*Days_of_Funding*). In this case, a patent might mitigate the risk of an imitative product being introduced to the market should the proponent choose a longer fundraising period. Last, we add a measure of the complexity of the project (*Complexity_Index*). This variable is measured via the "Flesch–Kincaid Grade Level Formula" (Bansal and Aggrarwal, 2015), which generates a score indicating number of years of education generally required to understand the text. Project complexity positively influences funding success in certain cases (Calic and Mosakowski, 2016), but it can also be an impediment to success (Chan and Parhankangas, 2017).

We then turn our attention to measures regarding the quality of the project's presentation by assessing the description of the project, which can impact funding outcomes. Previous research highlights a strong relationship between the manner in which potential backers understand the project and the subsequent success of the project (e.g. Li *et al.*, 2017). One important issue is the length of the description offered by the project. Projects that use a patent may require longer descriptions due to the complexity of the project and as such, we measured the total word count (*Text_Length*). As a complement to the word count, we also count the total number of images provided in the project description (*Image_Count*). Images can be used to alleviate a backer's information asymmetry due to the complexity or innovativeness of the project, and also to help the backer assess the overall quality of the project (Mollick, 2014).

Last, we add factors related to the project proponent. Both human and social capital play important roles in how crowdfunding projects unfold. First, we accounted for the proponents' previous experience on the Kickstarter platform with a count variable of the total number of projects they have launched (*Project_Experience*). Previous experience has been noted to influence crowdfunding performance (e.g. Allison *et al.*, 2017), and this effect might be amplified by the scope of the project. Next, we looked at the proponent's internal social capital. Colombo *et al.* (2015a) suggested that project success is influenced by the social capital the proponent has accumulated from within the crowdfunding community. We follow the measure offered by Colombo *et al.* (2015a) and create a variable capturing the total number of projects the proponent had previously supported (*Internal_Social_Capital*). Crowdfunding literature also highlights that social media activity plays a role in a potential backer's decision to support a project (Bi *et al.*, 2017). As such, we assess external social capital by counting the proponent's number of Facebook friends (*External_Social_Capital*). Finally, we code the country in which the proponent was located (*Country*). The institutional environment of the proponent may result in significant differences as to whether they would choose to signal a patent or not. Specifically, countries vary in regard to intellectual property protection efficacy and further, the costs associated with assuring that protection (Zhao, 2006). Table 2 displays the name and a brief description of the variables used in the matching procedure.

Table 2. Variables descriptions

Variable name	Variable description
Patent_Signal	Dummy = 1 if the project utilizes patent language; 0 otherwise.
Patent_Status	Categorical variable identifying the status of the patent as described in the text description of project. Categories include, 'patent held', 'patent pending', 'patent mentiond' and 'no patent'.
D_Success	Dummy = 1 if the project has reached the funding goal or more; 0 otherwise
Project_Goal (Log)	The projected goal settled by the project's proponents
External_Social_Captial	Number of the proponent's Facebook contacts
Internal_Social_Capital	Number of projects that the proponent had backed at the time of the campaign launch
Project_Experience	Number of projects that the proponent had backed at the time of the campaign launch
Days_Of_Funding	Number of days
Text_Length	Number of words contained in the project's description on the platform
Complexity_ Index	Number of years of education generally required to understand the text, derived by Flesh-Kincaid grade level formula
Image_Count	Number of images used in the project's description on the platform

4.5 Descriptive statistics

Table 3 summarizes the mean and standard deviation for the sample of projects signaling a patent ($n = 834$) and for those that do not signal a patent in their description ($n = 19{,}762$). Table 4 presents the correlation matrix and highlights that signaling a patent is negatively and significantly correlated with the probability of being successful on the platform. Moreover, we can see from the descriptive statistics that there are systematic differences between those projects signaling a patent in their project presentations and those that do not.

We also assess the statistical significance of these differences with a set of *t*-tests, which are elaborated in our PSM diagnostics (Table 5). The tests indicate that projects signaling a patent on average, ask for more money, are longer, are more complex, and the proponents seem to be less socially connected on the platform. Such results are consistent with our theoretical arguments reported in Section 2.4, highlighting that patents could signal projects characterized by higher levels of innovativeness and risk, higher degree of technical complexity, and lower coherence with the values of the crowd community. In the next section, we describe the efforts to reduce the influence of these differences on the estimation of the treatment effect via the matching procedure.

4.6 Matching procedure

Our implementation of the PSM technique follows the recommendations of Caliendo and Kopeinig (2008) and Austin (2011) and was conducted via the MatchIt (Ho *et al.*, 2011) R package. Our primary interest is to understand how signaling a patent may influence the result of a campaign. Our first step was to choose a model to estimate our propensity scores. Caliendo and Kopeinig (2008) highlight that probit and logit models for binary outcomes will yield similar results; we utilize probit models throughout our process. We next determined which of our variables should be included in the matching process. This issue has differing views; some suggest matching models should be parsimonious (Augurzky and Schmidt, 2001), while others suggest complexity (Rubin and Thomas, 1996). As highlighted above, our model includes variables of both theoretical and practical significance.

Next, we set "nearest neighbor" as our matching algorithm, and a caliper distance of 0.2 of the pooled standard deviation, following the suggestion of Austin (2011). The aim of the nearest neighbor algorithm is to find propensity score matches as close as possible to the treated (projects signaling patent) and untreated (projects that do not signal patent) groups, and the caliper setting defines a maximum distance between these scores. Nearest neighbor matching generally handles issues of common support well (Caliendo and Kopeinig, 2008). However, we also visually inspected the distribution, shown in Figure 1, of our propensity scores for each group to determine if trimming was necessary. The visual inspection indicated that common support was not an issue. The nearest neighbor algorithm found matches for 711 of the 834 projects signaling a patent, creating a matched data set of 1422 projects. To ensure robustness, we also utilized several other matching algorithms, discussed in Section 5.1.

We then conduct a set of diagnostics on our matched and unmatched samples to determine the quality of the matching process. We first compare the distribution of variables between the treatment and control groups in the

Table 3. Summary statistics

	Total		No patent signaling		Patent signaling	
	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation
Patent_Signal	0.04	0.19	0	0	1	0
D_Success	0.29	0.46	0.30	0.46	0.15	0.35
Project_Goal (Log)	9.88	0.91	9.86	0.90	10.30	0.95
External_Social_Capital	156	257	156	257	149	244
Internal_Social_Capital	5.84	22.30	5.94	22.64	3.68	11.66
Project_Experience	0.82	2.84	0.82	2.88	0.66	1.51
Days_Of_Funding	34.28	10.74	34.22	10.71	35.78	11.42
Text_Length (Log)	7.24	0.74	7.24	0.74	7.16	0.72
Complexity_ Index	7.25	1.52	7.22	1.51	7.81	1.79
Image_Count	9.64	13.22	9.63	13.26	9.90	12.05
Total n	20,596		19,762		834	

Table 4. Correlation matrix

	1	2	3	4	5	6	7	8	9
1. *D_Success*									
2. *Patent_Signal*	−0.07***								
3. *Project_Goal (Log)*	−0.19***	0.09***							
4. *External_Social_Capital*	0.04***	−0.01	−0.04***						
5. *Internal_Social_Capital*	0.23***	−0.02**	−0.04***	0.04***					
6. *Project_Experience*	0.15***	−0.01	−0.05***	−0.02*	0.35***				
7. *Days_Of_Funding*	−0.07***	0.03***	0.12***	−0.03***	−0.06***	−0.06***			
8. *Text_Length (Log)*	0.52***	−0.02***	0.05***	0.06***	0.25***	0.18***	−0.04***		
9. *Complexity_ Index*	−0.06***	0.08***	0.12***	−0.03***	−0.05***	−0.05***	0.01	0.16***	
10. *Image_Count*	0.33***	0.00	0.06***	0.04***	0.21***	0.17***	−0.04***	0.58***	0.02**

Notes: Pooled data ($n = 20{,}596$).
*$P < 0.1$;
**$P < 0.05$;
***$P < 0.01$.

matched and unmatched samples. The more similar the distributions of the treatment groups are, the better the matching quality. Full balance diagnostics can be found in Table 5, which includes tests of significance for each covariate, and then a calculation of the standardized difference between the treatment and control group for the matched sample. A score of 20% has been used as a guideline in previous research utilizing PSM (e.g. Rahko, 2016), and all of our variables are below this threshold.

As a last step, in order to view the fit of the propensity score estimation model between the matched and unmatched sample, we use a probit model (Table 6). In our matched sample, significance dropped across our set of covariates, indicating again that the matching procedure was successful by reducing the influence of the covariates on the treatment.

5. Results

We estimate the average treatment effect on the treated (ATT) with the probability of a successful campaign as the outcome variable. The purpose of the ATT is to show the difference of the dependent variable between the two groups within the matched sample, and as highlighted by Kautonen *et al.* (2017), the interpretation of the ATT is similar to the effect size of treatment. Projects within our treated sample had a lower rate of funding success (16%)

Table 5. Balance diagnostics for matching estimates

Variable	Sample	Means treated	Means control	$P>t$	Standard diff.
Project_Goal (Log)	Unmatched	10.30	9.86	0.001	
	Matched	10.25	10.26	0.951	−0.01
External_Social_Capital	Unmatched	149	156	0.344	
	Matched	156	150	0.646	0.02
Internal_Social_Capital	Unmatched	3.68	5.94	0.001	
	Matched	3.94	4.62	0.40	−0.02
Projects_Experience	Unmatched	0.66	0.82	0.003	
	Matched	0.68	0.77	0.521	−0.05
Days_Of_Funding	Unmatched	35.78	34.28	0.001	
	Matched	35.77	36.30	0.440	−0.02
Text_Length (Log)	Unmatched	7.16	7.24	0.001	
	Matched	7.15	7.14	0.785	0.01
Complexity_ Index	Unmatched	7.81	7.22	0.001	
	Matched	7.67	7.66	0.927	0.01
Image_Count	Unmatched	9.90	9.63	0.534	
	Matched	9.98	9.61	0.566	0.03
Primary category (%)					
Crafts	Unmatched	0.087	0.054	0.001	
	Matched	0.098	0.099	0.929	0.09
Design	Unmatched	0.470	0.129	0.001	
	Matched	0.437	0.418	0.453	0.04
Fashion	Unmatched	0.078	0.082	0.831	
	Matched	0.077	0.052	0.052	0.09
Film and Video	Unmatched	0.008	0.090	0.001	
	Matched	0.008	0.013	0.437	−0.04
Food	Unmatched	0.036	0.139	0.001	
	Matched	0.041	0.052	0.314	−0.06
Games	Unmatched	0.036	0.152	0.001	
	Matched	0.038	0.048	0.360	−0.05
Music	Unmatched	0.007	0.076	0.001	
	Matched	0.008	0.017	0.155	−0.10
Photography	Unmatched	0.001	0.002	0.562	
	Matched	0.001	0.001	1.00	0.00
Publishing	Unmatched	0.011	0.010	0.001	
	Matched	0.013	0.020	0.294	−0.06
Technology	Unmatched	0.267	0.177	0.001	
	Matched	0.276	0.280	0.859	−0.01
Year created (%)					
2011	Unmatched	0.020	0.040	0.001	
	Matched	0.024	0.018	0.461	0.04
2012	Unmatched	0.025	0.019	0.188	
	Matched	0.027	0.028	0.871	−0.01
2013	Unmatched	0.079	0.001	0.001	
	Matched	0.011	0.015	0.489	−0.02
2014	Unmatched	0.291	0.520	0.001	
	Matched	0.342	0.347	0.405	−0.01
2015	Unmatched	0.241	0.022	0.001	
	Matched	0.197	0.194	0.864	0.02
2016	Unmatched	0.340	0.388	0.001	
	Matched	0.399	0.381	0.480	0.01

(continued)

Table 5. Continued

Variable	Sample	Means treated	Means control	$P > t$	Standard diff.
Country (%)					
Austria	Unmatched	0.002	0.054	0.895	
	Matched	0.002	0.002	0.654	0.00
Canada	Unmatched	0.042	0.054	0.060	
	Matched	0.044	0.048	0.456	−0.02
Germany	Unmatched	0.012	0.015	0.340	
	Matched	0.014	0.030	0.826	0.01
Hong Kong	Unmatched	0.006	0.002	0.168	
	Matched	0.007	0.006	0.762	0.02
Ireland	Unmatched	0.005	0.003	0.481	
	Matched	0.008	0.010	0.179	−0.02
Italy	Unmatched	0.007	0.012	0.117	
	Matched	0.008	0.010	0.591	−0.02
Netherlands	Unmatched	0.001	0.017	0.001	
	Matched	0.001	0.003	0.318	−0.04
Spain	Unmatched	0.005	0.009	0.054	
	Matched	0.006	0.003	0.414	0.04
Sweden	Unmatched	0.012	0.005	0.052	
	Matched	0.013	0.011	1.00	0.01
UK	Unmatched	0.038	0.073	0.001	
	Matched	0.037	0.044	0.099	−0.04
United States	Unmatched	0.870	0.804	0.001	
	Matched	0.862	0.834	0.182	0.03

Notes: Unmatched $N = 20{,}596$; Matched $N = 1422$.

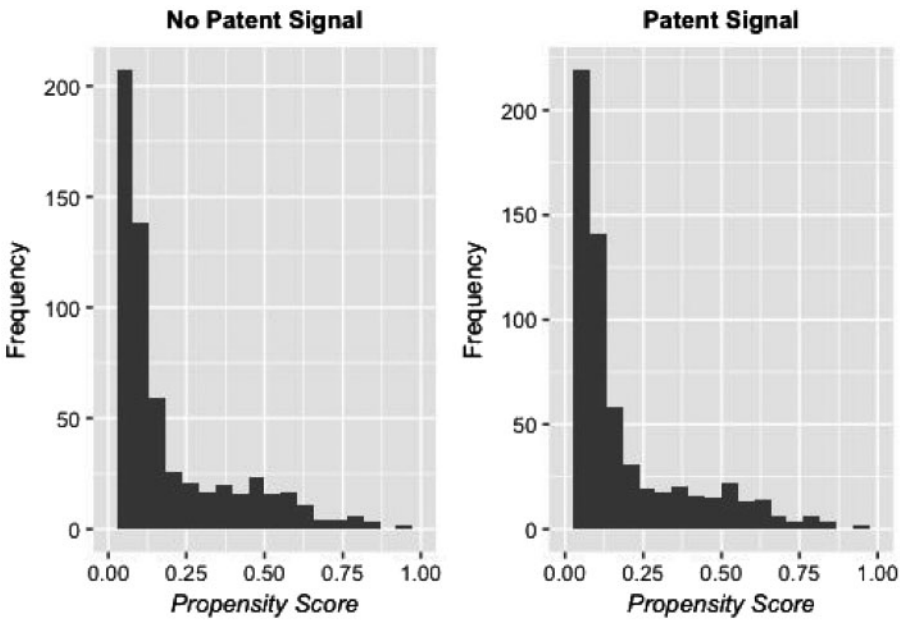

Figure 1. Distribution of propensity score.

Table 6. Probit model—probability of patent signal usage

Dependent variable:		
	Patent signal	
	Unmatched	Matched
Constant	−3.123***	−0.089
	(0.308)	(0.522)
Project_Goal (Log)	0.169***	−0.010
	(0.021)	(0.036)
External_Social_Capital	0.0001	0.0001
	(0.0001)	(0.0001)
Internal_Social_Capital	−0.001	−0.002
	(0.001)	(0.003)
Projects_Experience	0.011	−0.002
	(0.009)	(0.016)
Days_Of_Funding	0.002	0.002
	(0.002)	(0.003)
Text_Length (Log)	−0.099***	0.012
	(0.033)	(0.052)
Complexity_ Index	0.112***	0.003
	(0.012)	(0.020)
Image_Count	−0.004**	0.001
	(0.002)	(0.003)
Primary category[a]		
Crafts	−0.369***	−0.036
	(0.071)	(0.119)
Fashion	−0.667***	0.225
	(0.072)	(0.144)
Film and Video	−1.919***	−0.355
	(0.166)	(0.341)
Food	−1.283***	−0.184
	(0.085)	(0.166)
Games	−1.207***	−0.118
	(0.087)	(0.177)
Music	−1.665***	−0.495
	(0.159)	(0.315)
Photography	−0.935*	−0.022
	(0.517)	(0.891)
Publishing	−1.658***	−0.245
	(0.141)	(0.277)
Technology	−0.586***	−0.035
	(0.051)	(0.088)
Year created[b]		
2011	0.506***	0.252
	(0.130)	(0.248)
2012	0.903***	−0.035
	(0.133)	(0.215)
2013	2.807***	−0.142
	(0.174)	(0.305)
2015	1.458***	0.025
	(0.065)	(0.096)
2016	0.143***	0.061
	(0.043)	(0.080)

(continued)

Table 6. Continued

Dependent variable:		
	Patent signal	
	Unmatched	Matched
Country[c]		
Austria	−0.126	−0.333
	(0.363)	(0.572)
Canada	−0.201**	−0.144
	(0.092)	(0.158)
Germany	−0.329**	−0.123
	(0.158)	(0.279)
Hong Kong	0.489*	−0.166
	(0.255)	(0.387)
Ireland	0.040	0.815
	(0.297)	(0.643)
Italy	−0.675***	−0.280
	(0.209)	(0.343)
Netherlands	−1.387***	4.666
	(0.454)	(92.126)
Spain	−0.541**	0.383
	(0.242)	(0.539)
Sweden	0.415**	−0.031
	(0.206)	(0.300)
UK	−0.445***	−0.262
	(0.092)	(0.164)
Observations	20,596	1422
Log likelihood	−2451.225	−974.297

*$P < 0.1$;
**$P < 0.05$;
***$P < 0.01$.
[a]Compared against omitted category Design.
[b]Compared against omitted year 2014.
[c]Compared against omitted country United States.

compared with those in the untreated group (23%). Pan and Bai (2015) highlight that the mean difference between the treated and untreated groups is generally sufficient to estimate the ATT. However, they note that PSM does not produce a perfectly matched data set and therefore suggest utilizing regressions to generate more accurate estimates. We derive our ATT estimate using the Zelig R package (Imai *et al.*, 2009) model with funding success (*D_Success*) as the dependent variable and utilized variables previously discussed as controls. Next, we test our more detailed categorical variable, *Patent_Status*, using the same model specification. Results are summarized in Table 7.

The estimated treatment effect of the presence of patent language on the probability of success was negative and statistically significant (ATT = −0.076, $P < 0.001$). That is, signaling a patent is negatively associated with the success of a crowdfunding campaign, where the rate is around 30% lower. We then replace the patent language dummy variable with patent status, our more detailed categorical patent variable. Here, our coefficients are expressed as odds ratios accompanied by confidence intervals at the 95% level. An odds ratio of less than 1 implies that influence of the variable is negative and above 1, a positive influence. We find the strongest relationship when the patent was described as pending (*Patent_Pending*), where the odds were <1 and $P < 0.001$. The relationship was weaker ($P < 0.05$), yet still negative (odds < 1) if the project possessed the patent (*Patent_Held*) or just merely referenced a patent with no clear indication of the status (*Patent_Mentioned)*.

We implement several additional tests in order to gain a deeper understanding of the underlying reasons for the observed negative effect of signaling patents in crowdfunding campaigns. In our theoretical reasoning, we first posit

Table 7. Estimated treatment effect on the treated—probability of success ($N = 1422$)

	ATT	$P > \lvert z \rvert$		Odds ratios	$P > \lvert z \rvert$
Patent signal	−0.076 [−0.115, −0.042]	>0.001			
			Patent held	0.774 [0.603, 0.988]	0.042
			Patent pending	0.742 [0.574, 0.908]	0.001
			Patent mentioned	0.735 [0.582, 0.924]	0.014

Table 8. Radical innovativeness and social orientation: difference-in-means

Variable	Mean			
	Patent signal	No patent signal	*t*-test ($P > t$)	Effect size[a]
Social value orientation	1.52	1.61	−2.21 (0.028)	−0.11
Radical innovation	0.59	0.55	2.35 (0.02)	0.12

[a]Cohen's effect size.

that projects mentioning a patent could be characterized by higher levels of radical innovativeness of the campaign outcomes. This could have negative implications in terms of campaign success, due to higher levels of perceived risk. In this respect, we ran an additional test, reported in Table 8, to empirically assess the presence (or not) of differences in terms of degree of radical innovativeness (Chan and Parhankangas, 2017) between projects mentioning patents and control projects. Following previous research (Michalisin, 2001; Parhankangas and Renko, 2017), we leverage text-based analysis in order to assess the degree of innovativeness of projects.[1] We then conduct a simple *t*-test to investigate whether some differences exist in this respect between projects signaling patents and those that do not (Table 8). Results indicate that projects signaling a patent tend to use more intensive language related to radical innovation. The difference is positive and statistically significant (2.35, $P < 0.05$), in line with our theoretical reasoning.

In a similar way, we also test our additional potential explanation, referring to differences in the degree of openness and altruism of projects based on patents, as compared with other projects (Moss *et al.*, 2018). In order to do this, we measure the expressions of social value through the campaign narratives, following previous examples in the literature (Moss *et al.*, 2018).[2] Results from the *t*-tests reported in Table 8 indicate that projects mentioning patent less frequently use language related to social orientation as compared with control projects. The difference is negative and statistically significant (−2.21, $P < 0.05$). Such exploratory analyses thus provide support for our set of arguments related to the lower alignment of patent-based projects with the values of openness and altruism infusing the crowdfunding community.[3]

As a further robustness test, we vary our matching specification, as the algorithm plays an important role in how matches are generated (Caliendo and Kopeinig, 2008). First, we modify our nearest neighbor parameters to utilize replacement and added assigned weights to the model, with results that were nearly identical for the patent signal variable and deviated slightly for patent status.[4] Next, we use a two-to-one match nearest neighbor match, where we observe slightly stronger results.[5] We then alter the matching algorithm, leveraging genetic and coarsened exact matching,[6] both of which provide results consistent with our previous matched sets.

We then turn our attention to variables[7] that might significantly moderate the relationship between the usage of patent language and subsequent campaign success. First, we examine to what extent the funding goal moderates the relationship between patent language and success, finding no significant interaction. We repeat the same to gauge the influence of project complexity. While complexity is not a significant predictor of success per se, it does significantly interact with the patent signal, where higher complexity further reduces the probability of campaign success. Last,

we find no significant interactions between the patent signal and the project's category (e.g., technology, design, etc.—results are available upon request).

6. Discussion

Given the rise of crowdfunding as a promising financial alternative in the startup phase of a new venture, the question of how patents affect the process of obtaining financing is of particular relevance. Reward-based crowdfunding operates differently compared with other forms of entrepreneurial finance and signaling a patent also differs in this context. Through a comparison of a set of projects from the Kickstarter platform mentioning the use of patented ideas and a control group of similar projects (with no reference to patents), we were able to shed light on an underaddressed issue in the emerging literature on crowdfunding, namely the signaling impact of IPR in this innovative funding vehicle. Different from the general findings of the literature on the relationship between patenting activity and access to external finance, our findings highlight a very limited number of projects declaring the underlying possession of a patent in their pitch. Our evidence shows that projects based on patents have higher capital needs, tend to be riskier, are more complex, more sophisticated in technical terms, and are less socially integrated in the crowd community. Moreover, the results show that projects signaling a patent have no advantage over similar projects that do not. Further, the association between a patent signal and funding success in the crowdfunding context is generally negative, and projects utilizing patent language were 20% less likely to have a positive funding outcome in our matched sample. Drilling further, we found that the pending status of the patent has the strongest negative effect on the probability of success. However, even when the patent was held by the project owner, the patent still offered no competitive advantage in terms of funding outcome.

This study, although exploratory in its aims, makes several contributions to existing literature. We first contribute to the crowdfunding literature adding new arguments and evidence of the differences between the crowdfunding context and the traditional forms of equity finance for startups. Specifically, we add new knowledge about the evaluation of projects' characteristics and consequent funding outcomes (Mollick and Nanda, 2015). Our analyses suggest that, in the case of reward-based crowdfunding, the crowd is generally unswayed by the possession or pursuit of a patent. This result is counterintuitive, given that according to previous literature patents are generally considered to be an important asset in driving the investment decisions of more professionalized investors, such as venture capitalists and business angels. However, the crowdfunding context differs from traditional new venture investment contexts. First, funders in reward-based crowdfunding do not behave as professional investors, but more as final consumers (Chan and Parhankangas, 2017). They are more willing to invest in projects providing consumer benefits instead of potential returns. In this setting, patents could be associated with higher technical complexity, so that individuals may perceive patent-based projects as more risky and unfamiliar for their purpose of use. Moreover, projects signaling patents tend to have higher degrees of innovation and thus, might be perceived as very far from the market and less usable to the general crowd. Finally, we provide initial evidence that projects signaling patents are less committed to social causes and, as such, less aligned with the values of openness, reciprocity, and altruism characterizing the reward-based crowdfunding community.

Second, our paper contributes to the literature of signaling theory in new venture financing. In the specific case of patents, our findings show that the nature of how entrepreneurs signal quality presents specific differences in the virtual world of crowdfunding as compared with traditional new venture settings. Our study thus confirms the underlying view of signaling theory that the relevance of signals and the effect size of signals have a dependency on the characteristic of the context. With respect to patent-based projects, the specific characteristics of the recipients (the crowd) and of the signaling environment (the reward-based crowdfunding platform) lead to a divergence of the criteria of assessment as compared with predictions of the literature on professional equity investors.

Finally, our study provides useful implications for entrepreneurs planning to utilize crowdfunding to finance innovative products and new ventures. In order to achieve optimal results via crowdfunding, entrepreneurs must pay careful attention to how they highlight innovative and technical aspects of their projects, including the presence of a patent.

7. Limitations and future research directions

The results outlined above should be interpreted carefully with the following limitations in mind. First, the PSM technique has several strengths but also important limitations referenced earlier, which are worth reiterating. PSM does

not account for unobserved heterogeneity, therefore some level of bias caused by unobservable differences between the projects may linger. For instance, proponents may have differences in social competence (Baron and Markman, 2003) despite similarities in network size, for which our observed count measures may not fully proxy.

Next, we were unable to account for the quality of the patent. It is well-known in the literature that there is a significant heterogeneity in the value of patents (Gambardella *et al.*, 2008), and such differences are likely to be reflected in the decisions made by experienced investors (Munari and Toschi, 2015). Given that specific information on the underlying patent is reported in only a minority of cases in crowdfunding pitches, we were able to consider only the legal status of the patent in our analyses (differentiating the cases declaring pending patents from the others). However, we were not able to construct more sophisticated measures such as citations, family size, or scope, to take into consideration patent quality.

Third, we only identify projects that explicitly mentioned a patent in their campaign narrative. This is a clear limitation of our analyses, driven by the research design based on secondary data available on the Kickstarter platform. As to this point, however, our frequency data of patent-based projects are very close to those presented in the survey-based study by Mollick (2016), showing that crowdfunding projects based on patents represent a small minority (around 4%) of the population of projects on Kickstarter. The similarity in such figures suggests that the use of patent language in pitches reflects the underlying possession of patents. Future studies, however, should address such issues in a more direct and detailed way, conducting dedicated surveys with campaign creators. Understanding the actual motivations of entrepreneurs to use (or not use) patents or other types of IPRs in order to protect their ideas, and then to signal them in crowdfunding campaigns, represents an interesting research question for future studies in order to address the perceived importance of IPR in this innovative financial setting. On the other hand, more studies should provide evidence about the mechanism underlying the negative effect of signaling patents, by the application, for example, of laboratory experiments.

Finally, we based our analyses on a single platform adopting a reward-based model. It is possible to argue that the relevance of patent protection might differ between types of platforms, depending on the specific objectives, focus, and types of crowdfunders. In particular, it would be interesting to address such topics in more detail (ideally using a comparative approach) also in the equity crowdfunding context, due to the higher sophistication of the investment process and the different expectations of investors. It is possible to argue, for instance, that appropriability concerns could play a more pronounced role in the equity crowdfunding context as compared with reward-based crowdfunding.

8. Conclusions

This work offers a first effort to understand how patents can affect the success of a reward-based crowdfunding campaign. Our empirical analyses based on Kickstarter data show that those projects that use patent language are less likely to be financed by the crowd. The signaling role of patents appears to work in a very different way in this context as compared with more traditional settings of entrepreneurial finance, such as professional equity investors. This work highlights the need to build additional insights into the specificities of crowdfunding and the limits of directly extending some theories and lessons of the entrepreneurial finance literature in this innovative setting. The article also suggests that technology-intensive projects leveraging patented inventions may not be ideal targets for reward-based crowdfunding campaigns.

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