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Receiving external equity following successfully crowdfunded technological projects: an informational mechanism

Massimo G. Colombo · Kourosh Shafi

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Abstract Reward-based crowdfunding not only provides finance to entrepreneurs but also generates valuable information on their products' potential demand, their feasibility, and customers' satisfaction. This study investigates how information from the campaigns, relating to the funding amount raised in excess of target capital, delays (if any) in product delivery, and crowd sentiment, influences the chances that a venture receives equity capital from professional investors in the aftermath of a campaign. To build a sample of ventures at risk of obtaining equity capital from professional investors, we focus on 300 successful hardware campaigns that have raised $100,000 or more on Kickstarter and Indiegogo. Our results indicate that the information provided by crowdfunding campaigns influences the odds of receiving external equity in the aftermath of the campaign; however, this relationship depends on whether the ventures have already backing from professional investors or not. Our study offers insights into what information professional investors use to assess crowdfunded ventures.

M. G. Colombo
Department of Management, Economics, and Industrial Engineering, Politecnico di Milano, Piazza Leonardo da Vinci, 32, 20133 Milan, Italy
e-mail: massimo.colombo@polimi.it

K. Shafi (✉)
Department of Management, College of Business and Economics, California State University East Bay, Hayward, CA, USA
e-mail: kourosh.shafi@csueastbay.edu

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1 Introduction

Reward-based crowdfunding (hereafter, CF) is an open call on the Internet whereby entrepreneurs solicit the interest of individual backers in a project, product, or service; in exchange for their financial contributions, the backers receive products or services, symbolic rewards, or both. CF is rapidly gaining momentum as an "alternative" financial source for entrepreneurs: from its inception in 2009 up to October 29, 2018, Kickstarter, the largest CF platform by size, hosted over 400,000 campaigns that raised about $4 billion from approximately 15 million backers (see https://www.kickstarter.com/help/stats). Most of the previous studies on CF have investigated the determinants of the success of CF campaigns (Mollick 2014). A smaller stream of literature has considered post-campaign outcomes such as firm growth or access to additional resources (Mollick and Kuppuswamy 2014).

Among the post-campaign outcomes of particular interest to researchers is access to *external equity provided by professional investors* such as venture capitalists and business angels (hereafter, despite differences between these two types of investor, we follow the previous studies on this topic in referring to both types of investors as VCs). The few studies that have

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addressed this topic offer preliminary evidence in support of the view that CF is *complementary* to VC (Drover et al. 2017; Kaminski et al. 2019; Kuppuswammy and Roth 2016; Sorenson et al. 2016) and highlight the "boundary conditions" under which this complementarity materializes (Roma et al. 2017; Ryu et al. 2018).[1] Nevertheless, there are important gaps in this literature.

The present study intends to fill two gaps. First, as indicated by a stream of recent theoretical studies (Chemla & Tinn, 2019; Strausz, 2017), CF is an *informational mechanism* that provides valuable information on ventures' projects relating to aspects such as the technical feasibility of the focal venture's products, their liking by customers, and the size of the potential market for these products. Da & Jordana (2018) shows that entrepreneurs who run an unsuccessful CF campaign, and so do not raise money from the crowd, use this information to refine their subsequent product-market strategies. It remains an open question whether and how VCs use this information to revise their expectations about the attractiveness of CF ventures as an investment target.

Second, the CF literature fails to recognize that some ventures with VC-backing later use CF. Distinguishing CF ventures based on whether they have already received equity finance from VCs before the CF campaign is noteworthy for both practical and theoretical reasons. In fact, the locus of control of VC-backed ventures and the information available to both existing and prospective VCs on these ventures' projects differ from those of non-VC-backed CF ventures. As a corollary, one would expect that the information from a CF campaign differently influences the odds of subsequently receiving VC for VC-backed and non-VC-backed CF ventures.

To address these gaps in the literature, we rely on the "pecking order" (or "financing hierarchy") theory (Myers 1984; Myers and Majluf 1984). This theory claims that because of imperfections in capital markets, "… external capital is *not* a perfect substitute for internal funds" (Fazzari, Hubbard & Petersen, 1988, p. 142, italics added). We also consider insights from the evaluation criteria employed by VCs in their investment decisions (Kaplan and Strömberg 2004; MacMillan et al. 1986; Petty and Gruber 2011; Tyebjee and Bruno 1984). In assessing the probability of obtaining VC in the aftermath of a CF campaign (i.e., the first VC round for non-VC-backed ventures and an additional VC round for VC-backed ones), we formulate a series of hypotheses around the following constructs: (i) the capital raised by CF ventures in excess of the target capital of the campaign (thereafter, the excess capital), (ii) the delays (if any) in product delivery to the backers of the campaign, and (iii) the positive or negative sentiment expressed by the crowds towards ventures' products.

We claim that information from a successful CF campaign differently influences the odds that VC-backed and non-VC-backed ventures will obtain VC in the aftermath of the campaign. This is so because in the case of VC-backed ventures, VCs are insiders like entrepreneurs and face limited (or even no) information asymmetries on ventures' internal operations. While in the case of VC-backed ventures, VCs may only use the information provided by the CF campaign as a testbed of the potential market size for their products; in the case of non-VC-backed ventures, prospective investors additionally use such information to assess ventures' ability to meet customers' needs, with good (bad) news making these ventures more (less) attractive to them. Lastly, there is an additional important distinction between VC-backed and non-VC-backed CF ventures. With all else equal, entrepreneurs of non-VC-backed ventures may be less inclined to seek VC with greater excess capital provided by backers in the campaign. In fact, this excess capital, as any advance payment from customers, increases the amount of cash entrepreneurs can use to finance their ventures' operations (i.e., it is an innovative form of bootstrapping, e.g., Winborg and Landström 2001). Hence, it reduces ventures' demand for capital and makes it more likely that internal funds (i.e., the funds provided by entrepreneurs, their family members and friends) suffice to match this demand. Under these conditions, entrepreneurs will abstain from resorting to VC. This effect is less important for VC-backed CF ventures. As we will document later, the demand for capital of these ventures typically is greater than that of their non-VC-backed counterparts, and so the excess capital raised through the CF campaign is less

[1] We will survey this literature in Sect. 2.1. A parallel literature has focused on the post-campaign outcome of *equity crowdfunding* (Coakley et al. 2018; Walthoff-Borm, Vanacker, & Collewaert, 2018), with special interest in the relationship between equity crowdfunding and VC (D. Cumming et al. 2019; Hornuf et al. 2018; Signori and Vismara 2018). As the institutional characteristics and operating mechanisms of equity crowdfunding are different from those of reward-based crowdfunding, it remains an open question whether the results of these studies are generalizable to the context under consideration in the present study.

likely to reduce the propensity of these ventures to look for additional external equity.

To empirically test our predictions, we consider the population of all successful CF campaigns with the following characteristics: (a) they have an electronic hardware component (such as 3D printers or smartwatches), (b) they were posted on the Kickstarter and Indiegogo platforms from the beginning of the operations of these platforms up to the end of 2013, and (c) they raised $100,000 or more. We focus on ventures running this type of campaigns because they generally have relatively capital-intensive projects, and thus are more likely to be seeking external equity and to be a potential target for VC investment than other CF ventures. Moreover, we focus on successful campaigns to be able to consider information generated after the end of the campaign (e.g., related to delays in product delivery). We follow this sample of ventures up to the end of 2014 to check whether the hazard rate of obtaining finance from VCs in the aftermath of the campaign depends on the excess capital raised through the campaign and its informational characteristics. We estimate Cox proportional hazards models with time-varying covariates. As a robustness check, we also control for sample selection issues generated by our focus on large and successful CF campaigns. The results of the estimates offer support to some, but not all, our predictions.

Our study contributes to the literature on CF that has investigated how this new source of finance influences ventures' outcomes after crowdfunding campaigns, especially access to equity from VCs (Drover et al. 2017; Kaminski et al. 2019; Kuppuswammy and Roth 2016; Mödl 2018; Roma et al. 2017; Ryu et al. 2018; Sorenson et al. 2016). We contribute to this discourse by distinctively focusing on the informational attributes of the CF campaigns that differently influence the post-CF funding outcomes, depending on ventures' VC-backed or non-VC-backed status. Our study also contributes to the work that has reinterpreted the "pecking order" theory in the light of the recent availability of alternative financing channels (Walthoff-Borm et al. 2018a). We highlight that CF campaigns modify not only the demand for capital of CF ventures but also the cost for them of obtaining VC, because of the valuable, yet noisy, information they convey to external investors.

2 Literature review, conceptual background, and hypotheses

2.1 Related literature

Crowdfunding scholars are increasingly interested in exploring post-campaign outcomes, and particularly obtaining VC for ventures having secured crowdfunding money. In the context of equity crowdfunding, Hornhuf et al. (2018) and Signori and Vismara (2018) find that 18% and 10% of the ventures in their sample having gone successfully through a crowdfunding campaign obtained an injection of external equity from VCs in the aftermath of the campaign. However, these studies do not highlight any systematic relationship between the characteristics of the campaigns and the probability of receiving follow-on VC — with the exception of the presence and number of initial VC investors, which have sizable positive effects.

This study focuses on the relationship between CF and VC. A few recent studies have investigated this issue, suggesting that these two financing channels may be complementary. Sorenson et al. (2016) find that CF has been funding new ventures in locations that have been typically excluded from VC and that VC is attracted by locations (i.e., counties in the USA) that exhibit intense CF activity. Kaminski et al. (2019) show that the number of successful Kickstarter campaigns (in aggregate and by product categories) leads the volume of VC activity, while this is not true in the opposite direction. However, these studies are at an aggregate level, with limited implications for our understanding of venture- or campaign-level factors of direct interest to this study.

Evaluating whether conducting a successful CF campaign helps new ventures attract finance from VCs, scholars have focused on two important specific aspects of CF campaigns: the total amount of capital raised from the campaign and the number of backers. Drover et al.'s (2017) conjoint analysis reveals that VCs are more willing to conduct formal due diligence if CF ventures receive finance from a larger number of backers. Mödl (2018) uses a similar methodology and finds that high sums of CF rapidly collected by firms with B2C business models have a positive effect on VC managers' investment decisions. Kuppuswammy and Roth (2016) use survey data on both successful and non-successful CF campaigns posted on Kickstarter in the technology, design, and game product categories to assess the relationship between the total amount raised during the campaigns and a variable capturing the subjective judgment expressed by entrepreneurs

about how useful the campaign was in finding external finance. The authors find a non-linear relationship: the positive marginal effect of the total amount raised vanishes after reaching a threshold equal to approximately $250,000. Roma et al. (2017) consider medium-to-large high-tech projects posted on Kickstarter and show that the probability of obtaining VC increases with the money pledged by the crowd, but only if ventures have been granted one or more patents and entrepreneurs have a large network of social contacts. Thies et al. (2018) also analyze campaigns posted on Kickstarter in the "technology," "design," and "game" categories and find that CF campaigns that successfully reach the target capital and staff pick campaigns are more likely to attract VC in the aftermath of the campaign than other campaigns. Moreover, there is an inverse U-shaped relation between the ratio of the funding received to the target capital and the likelihood of obtaining VC.[2]

Despite the research efforts just mentioned, our understanding of the conditions under which running a successful CF campaign accelerates (or hinders) receipt of VC remains limited. A small but growing stream of theoretical literature regards CF as an informational mechanism that allows entrepreneurs to update their expectations about the size of the demand for their ventures' products (Ellman & Hurkens, 2016; Strausz, 2017). In accordance with this view, Da & Jordana (2018) shows that entrepreneurs who have run an unsuccessful CF campaign—and thus have *not* raised capital—are more inclined to release their products to the market if the results from the campaign suggest a positive evaluation from the crowd. This evaluation is reflected in the total number of backers, the average pledge, the total amount collected from the campaign, and the amount collected in relation to the target capital. These studies suggest that entrepreneurs can use a CF campaign as a market validation test. Taking inspiration from these studies, in this work, we argue that VCs can use the information provided by a CF campaign to revise their expectations about the risk and returns of investing in the focal venture. For non-VC-backed CF ventures, good news from a CF campaign lowers the information asymmetries between VCs and entrepreneurs, making the focal venture a more attractive investment target. Bad news from the campaign has the opposite effects of deterring VC investments.

CF is becoming increasingly popular among ventures that have already obtained one or more rounds of VC. For these ventures, obtaining finance through product prepayment likely is *not* the predominant reason for resorting to CF, as their demand for capital is typically larger than the one of non-VC-backed ventures and largely exceeds the amount of capital that is usually provided by the crowd in a CF campaign.[3] Moreover, VCs are insiders in these ventures and have access to the same information set as entrepreneurs. Therefore, the information conveyed by the CF campaign is likely to be used differently by these ventures and their VCs in comparison to non-VC-backed ventures.

2.2 Conceptual background

We employ the pecking order theory (Myers 1984; Myers and Majluf 1984; see also Fazzari et al., 1988) as a theoretical foundation. This theory argues that if managers have inside information that external investors do not have, there are cases in which "management, if it acts in the interest of the *old* stakeholders, will refuse to issue shares even if it means passing up a good investment opportunity. That is, the cost to old shareholders of issuing shares at a bargain price may outweigh the project's NPV" (Myers and Majluf 1984, p. 188). A somehow similar reasoning applies to non-default-risk-free external debt. It follows that under conditions of asymmetric information, firms will use internal capital first. If internal capital is exhausted, they will prefer debt to equity. The two key assumptions of the pecking order theory (e.g., Carpenter and Petersen 2002; Cassar 2004) are as follows: the presence of information asymmetries and the fact that (owner-)managers make financing and investment decisions that are aligned with the interests of old stakeholders (which coincide with their own interests). These assumptions apply to entrepreneurial ventures in seed and early stages. We therefore use these theoretical lens to investigate how CF modifies the supply and demand of capital of entrepreneurial ventures.

We follow previous studies (see in particular Table 4 in Robb and Robinson 2014, p. 163) and define

[2] Ryu et al. (2018) compare the effect of the receipt of crowdfunding and angel investing on subsequent financing by VCs, after controlling for selection into the type of financing. They show that ventures that have gone through a successful CF campaign are more likely than angel-backed ventures to obtain finance from corporate VC investors; however, they are less likely to be financed by independent VC investors.

[3] For instance, according to data from Pitchbook, in the USA in 2013, the average amount of capital raised in series A VC rounds is two times as large as in seed rounds. In series B VC rounds, it is more than five times as large.

external capital as capital provided by outsiders, as opposed to firm's owners and other insiders (e.g., family members), in the form of *external debt* and *external equity capital*. External debt is provided by banks (in the form of loans to the firm or to owners, or in any other forms) and other financial intermediaries. External equity capital is provided by equity investors, like venture capitalists and business angels (i.e., VCs). We define internal capital as capital provided by entrepreneurs and other insiders regardless of the form. It includes the equity owned by entrepreneurs and other insiders and owner and insider debt (i.e., personal loans provided to the focal venture by entrepreneurs and their relatives).

This study focuses on technology-based early-stage ventures that have gone through a CF campaign (hereafter, CF ventures). For these ventures, bank debt is not a suitable financing channel.[4] Moreover, the wedge between the cost external equity capital and internal capital generally is extremely high (Carpenter and Petersen 2002; Hall 2002; Sanders and Boivie 2004). CF ventures have limited or no track record and are informationally opaque. Information asymmetries between entrepreneurs and potential investors are even more pronounced if entrepreneurs fear appropriability concerns about their innovations and abstain from disclosing sensitive information to third parties (Himmelberg and Petersen 1994). Therefore, when raising new equity from VCs, entrepreneurs will forgo a substantial fraction of future profits as their ownership stakes are diluted (Kaplan and Strömberg 2004). The greater the information asymmetries, the higher the dilution costs because VCs will ask for a larger "lemon" premium (Akerlof, 1970) to compensate for the higher risk associated with investments in these ventures. In addition, VC investments may lead to a loss of entrepreneurs' control over their ventures (Wasserman 2003). VC contracts often involve the transfer of substantial control rights to VCs, thus allowing VCs to take charge of the venture if things take a turn for the worse.[5] Retention of control is an important consideration for many entrepreneurs (Brav 2009; Manigart and Struyf 1997; Sapienza et al. 2003), who exhibit strong psychological attachment and identification with the venture they founded (Dobrev and Barnett 2005). The anticipation of losing control over their ventures further increases the (personal) cost entrepreneurs would incur in obtaining external equity from VCs.

Considering the wedge between the costs of external and internal capital described above, internal capital will be the preferred financing channel for CF ventures and they will only seek VC if capital needs exceed the amount of internal capital available to them. Bootstrapping will help them rely on internal capital only (Bhide 1992; Ebben and Johnson 2006; Winborg and Landström 2001). Bootstrapping is defined as a range of "highly creative ways of acquiring the use of resources without borrowing money or raising equity financing from traditional sources" (Freear et al. 2002, p. 276). Among other techniques (for a list, see Winborg and Landström 2001), bootstrapping involves the use of advance payments by customers to finance firm's operations, which reduces its demand for capital.

We argue that CF can be regarded as an innovative bootstrapping technique. In CF, the funding comes from listing a prototype/product on an online platform, soliciting pre-orders, and receiving payment from the crowd in advance of shipping the product. The crowd provides funding to entrepreneurs without asking for equity in exchange; that is, there is neither dilution of entrepreneurs' ownership nor contractual provisions that limit the control

[4] While previous work shows that banks are an important source of finance for new ventures (Cassar 2004; Cosh et al. 2009; Robb and Robinson 2014), for technology-based ventures in the early stages of their life, bank debt is not a suitable financing instrument because these ventures are the most informationally opaque, have highly intangible and firm-specific assets with little collateral value, and have a high risk of failure, which bank loans could magnify (Carpenter and Petersen 2002).Therefore, we do not discuss bank financing here and only focus on external equity capital provided by VCs. See M. Colombo and Grilli (2007) for an analysis of the (limited) use of debt by high-tech ventures during founding.

[5] Given the high level of uncertainty involved in investing in early-stage ventures, VCs frequently ask for control rights such as the right to replace founder executives with seasoned professional managers. As was noted by a VC, "our default assumption when we first look at a company is that the founder-CEO cannot lead this company going forward" (cited in Wasserman 2003, p. 154–155). Even if the entrepreneurs are not replaced, VCs usually structure investments with contractual provisions including board rights, voting rights, and other control rights, which allow them active involvement in their portfolio firm's management (Fried et al. 1998). These provisions could allow VCs to gain full control if the venture performs poorly or fails to meet specific milestones (Kaplan & Strömberg, 2004). VC contracts also frequently include non-compete clauses, which prevent entrepreneurs from starting another venture in the same industry (Barney et al. 1994; Hoffman and Blakely 1987) and vesting clauses, which allow VCs to repurchase departing entrepreneurs' shares at a low price (Sahlman 1990). Viewed from the entrepreneurs' perspective, these contractual provisions may be perceived as non-friendly and clearly limit entrepreneurs' decision autonomy.

rights of entrepreneurs over the direction of the venture. The money pledged by the crowd, as any other advance payments from customers, reduces a CF venture's demand for capital, making it more likely that internal capital suffices to finance venture's operations.

This situation is illustrated in Fig. 1, which depicts a modified "financing hierarchy" (see Fig. 1 in Fazzari et al., 1988, p. 156 for the original). C_{INT} and C_{VC} are respectively the opportunity cost to entrepreneurs of using internal capital to finance their ventures' operations and the cost they incur by using VC, with $C_{VC} >> C_{INT}$. Let us first consider venture A. D_A is the demand for capital of venture A in absence of CF. K_1 is the maximum amount of internal capital available to entrepreneurs. In absence of CF, venture's A entrepreneurs would be forced to rely on (costly) VC to finance their venture's operations. A successful CF campaign would make recourse to VC unnecessary if it allowed the venture to raise an amount of excess capital equal to K_{CF}, which could be used to finance venture's operations. Indeed, the amount of capital raised through a successful CF campaign reduces accordingly venture's demand for capital from D_A to D_A^{CF}. To the extent that internal capital suffices to match the reduced demand for capital, it makes it unnecessary to look for the (expensive) external equity provided by VCs.

Alternatively, entrepreneurs' projects are sometimes too ambitious and capital-intensive, and the demand for capital of their ventures is too large to be financed only through internal finance—even if a successful CF campaign allows entrepreneurs to raise K_{CF} from the crowd. This situation is illustrated by venture B. Venture's B demand for capital in absence of CF, indicated by D_B, is very large. Even if venture's demand for capital is reduced from D_B to D_B^{CF}, after raising K_{CF} through a CF campaign, entrepreneurs do not have any other option in the aftermath of the CF campaign but to look for VC.[6]

In addition to providing entrepreneurs with an innovative bootstrapping mechanism, a CF campaign modifies the information set of both entrepreneurs and VCs. Previous studies show that through a CF campaign, entrepreneurs obtain valuable information about the demand for their products as reflected in the quantity pre-ordered (Ellman & Hurkens, 2016; Strausz, 2017; Da & Jordana, 2018). Likewise, VCs can use the information generated by the CF campaign to adjust their opinion about the risks and returns involved in investing in the focal CF venture. Figure 2 illustrates the effect of the information conveyed by a CF campaign on the likelihood of obtaining VC.[7] It advances the idea that the cost of obtaining equity from VCs, and by implication, the probability of obtaining VC in the aftermath of a CF campaign, do depend on the information that the CF campaign conveys to VCs. Indeed, this information can help resolve (some of) the information asymmetries between entrepreneurs and VCs, thereby reducing the "lemon premium" asked by VCs.

Since the seminal study by Tyebjee and Bruno (1984), a large body of work has examined the criteria used by VCs to select investment targets (Petty and Gruber 2011, p. 174–175). These studies suggest that VCs are looking for high return (and high risk) projects for which there is a large and rapidly growing (potential) market. Moreover, they indicate that the characteristics of ventures' products and their linking by customers are major drivers of VCs' decisions. Accordingly, the good news from a successful CF campaign about such aspects as customers' appreciation of the focal venture's products, the size of the potential market for these products, and the ability of entrepreneurs to overcome technical challenges and timely deliver the pre-ordered products to customers will positively influence VCs' judgment on the venture's attractiveness as an investment target, thereby reducing (from C_{VC} to $C_{VC/CF}$ in the figure) the cost of the external equity provided by VCs. In turn, this cost reduction makes entrepreneurs more inclined to look for VC and also to obtain VC finance more likely. Following a similar logic, bad news from the campaign will make VC finance more costly and will reduce the likelihood of post-campaign VC finance.

While the above reasoning applies to non-VC-backed CF ventures, we assert that the above

[6] Attracting external resources of high quality (notably, highly skilled personnel) in adequate amounts and managing these resources effectively play a crucial role in the commercial success of these large-scale projects. In this situation, the coaching provided by VCs to entrepreneurs (Gorman and Sahlman 1989) and the quality signal associated with affiliation with VC investors (Vanacker and Forbes 2016) are extremely valuable to entrepreneurs, thus making VC a relatively more attractive source of finance when ventures have large-scale projects.

[7] For the sake of clarity, in Fig. 2, we neglect the advance payments provided by backers and the consequent reduction of the demand for capital of the focal venture. That is, we assume $K_{CF} = 0$. In other words, we do not consider the campaign as a bootstrapping mechanism, but only as an informational mechanism.

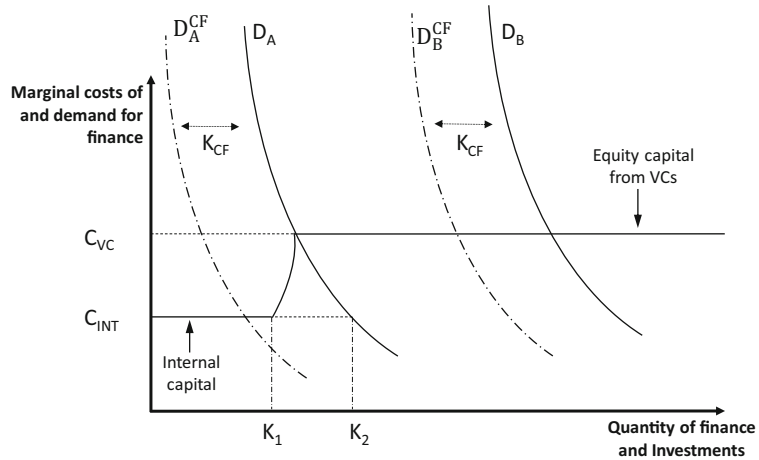

Fig. 1 A modified financing hierarchy: Supply and demand of capital with venture capital and reward-based crowdfunding. C_{INT} is the opportunity cost of internal capital; C_{VC} is the cost of venture capital; K_1 is the maximum available amount of internal capital; K_{CF} is the amount of capital raised through a reward-based crowdfunding campaign; D_A and D_B are the demand for capital of ventures A and B in absence of crowdfunding; D_A^{CF} and D_B^{CF} are the demand for capital of ventures A and B after raising K_{CF} from backers of their reward-based crowdfunding campaigns

considerations are not pertinent for these ventures. CF campaigns are increasingly launched by VC-backed ventures, that is, ventures that have already received one or more VC rounds at the time of the launch of the CF campaign. First, the demand for capital of VC-backed ventures typically is larger than that of their non-VC-backed counterparts. This is indirectly documented by the fact that the typical amount of capital raised in a follow-on VC round is considerably larger than the typical amount of capital raised in the first VC round (see again footnote 3). In comparison to the amount of capital raised in a typical follow-on VC round, the typical amount of capital raised through a CF campaign is rather small. Consequently, the reduction of the demand for capital of the focal VC-backed venture generated by the CF campaign is likely not to be large enough to make the infusion of equity capital by VCs unnecessary. Therefore, the probability that the venture obtains a follow-on VC round is likely not to be significantly affected by the capital raised through the CF campaign, a situation illustrated by venture B in Fig. 1. Second, VCs are hands-on investors, typically sit on the board of portfolio ventures, and play an active role in management decisions (e.g., Gorman and Sahlman 1989). In other words, in VC-backed ventures, VCs are insiders who have the same set of information that entrepreneurs have. Therefore, a CF campaign does not help reduce the information asymmetries between entrepreneurs and VCs, which are limited or even non-existent. However, a CF campaign can still generate

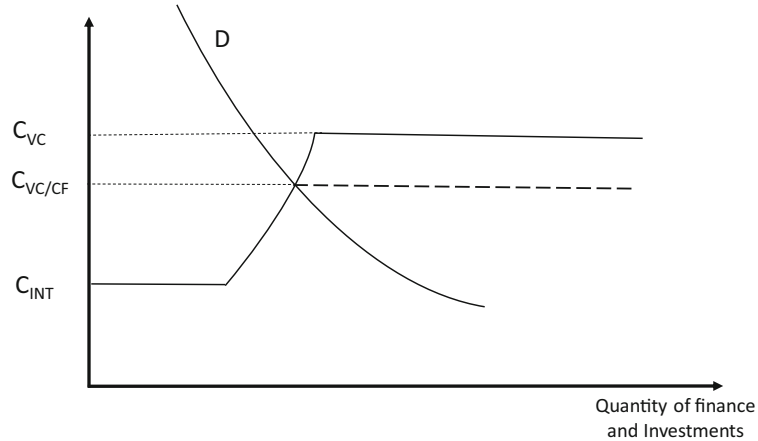

Fig. 2 A modified financing hierarchy: reward-based crowdfunding as an informational mechanism. C_{INT} is the opportunity cost of internal capital; C_{VC} is the cost of venture capital; $C_{VC/CF}$ is the cost of venture capital, with VCs having received "good news" from a reward-based crowdfunding campaign; and D is the demand for capital of the focal venture

useful information to both VCs and entrepreneurs, as it can be used as a testbed of the size of the potential market for venture's products.

2.3 Hypotheses

Money pledged by backers in excess of target capital On one hand, for non-VC-backed ventures, the larger the amount of excess capital raised through the CF campaign, the smaller the residual demand for capital of their ventures. In accordance with the arguments inspired by the pecking order theory, we argue that the larger the excess capital, the more likely it is that entrepreneurs will be able to opt out of the VC market. Therefore, there will be a lower probability that they will seek and eventually receive VC.

On the other hand, the amount of excess capital raised by a venture through a successful CF campaign also influences the perceptions of VCs towards the non-VC-backed ventures. A successful CF campaign raising a considerable amount of excess capital indicates the presence of a large potential market for the venture's products (e.g., Da & Jordana, 2018). Viewed from the potential investors' perspective, the larger the demand for the focal venture's products from backers of the campaign, the more attractive as investment target the venture will be. Indeed, studies that have examined the criteria used by VCs to select investment targets emphasize that the anticipated size and growth of the market for a venture's products is a fundamental driver of VCs' screening decisions. For example, this criterion is explicitly mentioned in 68.7% of the investment memoranda examined by Kaplan and Strömberg (2004). Therefore, after accounting for the money pledged by the crowd, if internal capital is not enough for a venture to proceed with the development of its project and entrepreneurs seek VC in the aftermath of a successful CF campaign, the probability that the focal venture will obtain VC will be greater the larger the amount of excess capital.[8]

[8] In accordance with this view, Danae Ringelmann, co-founder of Indiegogo, observes that "We do not see crowdfunding and venture capital as mutually exclusive. We're seeing Indiegogo become an incubation platform for traditional financiers to come in and discover new ideas … A successful crowdfunding campaign helps prove to venture capitalists, angel investors, and banks that there is a demand for a product in a marketplace, removing some of the risk from the equation" (http://www.techrepublic.com/article/funding-your-startup-crowdfunding-vs-angel-investment-vs-vc/).

In sum, two opposed forces are at work. When the amount of excess capital is very large, entrepreneurs are likely to abstain from seeking VC, as VC is an expensive source of capital and internal capital may suffice to match the (reduced) demand for capital of their ventures. When the amount of excess capital is very low, meaning that the money pledged by backers is just enough to reach the target capital, VCs are likely to consider the focal venture an unattractive investment target. In both situations, the probability of the focal venture obtaining VC is likely to be low. Hence, we propose the following hypothesis.

> Hypothesis 1a. *For non-VC-backed ventures, there is an inverse U-shaped relationship between the amount of excess capital raised through a crowdfunding campaign and the probability of obtaining VC in the aftermath of the campaign.*

The previous studies linking crowdfunding outcomes with subsequent VC financing have neglected the possibility that some ventures turning to CF are already VC-backed. These ventures face different opportunities and constraints in raising additional VC finance with respect to their non-VC-backed counterparts. In VC-backed ventures, VCs own shares of their equity capital, often sit on their boards, and play an active role in their management (e.g., Gorman and Sahlman 1989). Being insiders, VCs have access to the same set of first-hand information as entrepreneurs. In absence of sizable information asymmetries between entrepreneurs and VCs, the pecking order theory does not apply to subsequent VC rounds.

For VC-backed ventures, the CF campaign can be considered a component of VCs' staging strategy (Tian 2011; Wang and Zhou 2004). Staging consists in the stepwise provision of several rounds of VC instead of an upfront infusion of all the required capital to develop and scale-up an entrepreneurial project. Staging creates efficient incentives for entrepreneurs, as VCs may stop financing the venture at each financing round if agreed-upon milestones are not met. Even more importantly, staging allows VCs to learn about the venture's operations over time and use the information acquired between each round to make better investment decisions.

For VC-backed ventures, we argue that the probability of obtaining an additional round of VC is *positively* related to the amount of excess capital raised through the CF campaign. The large excess capital obtained from

pre-selling products to backers indicates that the focal venture has validated customers' needs for the product and identified a promising business opportunity with a large potential market. Accordingly, the larger the amount of excess capital, the lower the investment risk perceived by VCs in providing the venture with additional capital. Indeed, it is typical for VCs that resort to staging to provide additional financing to the ventures they back when they achieve pre-set milestones (often referred to as "equity milestones" in US-style VC contracts, see Kaplan et al. 2007: p. 291), with the aim of reducing investment risk and alleviating moral hazard problems. For VC-backed ventures, the market validation associated with the amount of excess capital raised through the CF campaign can be considered to be the achievement of an important milestone, which then triggers an additional VC round. Hypothesis H1b follows.

> Hypothesis 1b. *For VC-backed ventures, the probability of obtaining an additional round of VC in the aftermath of a successful* CF *campaign increases with the amount of excess capital raised through the campaign.*

Additional product-market information generated by the CF campaign The previous studies that have examined the criteria used by VCs to screen investment proposals indicate that, in addition to the size and growth of the potential market for ventures' products, VCs devote specific attention to the technical quality of the products and their linking by customers. For example, Tyebjee and Bruno (1984) show that VCs' expected returns are mainly determined by factors associated with the market attractiveness and differentiation (e.g., innovativeness, non-imitability) of ventures' products. Ventures' products and/or technologies were mentioned in 40.3% of the VC reports examined by Kaplan and Strömberg (2004) as a reason for investing and in 31.3% as a source of investment risk. The likelihood of customers' adoption was mentioned in 29.9% and 22.4% of the cases, respectively. However, when investing at the seed stage, uncertainty about the quality of ventures' products and their ability to meet customers' needs is very high, and it is difficult for VCs to form a reliable opinion about these aspects.

We argue that under conditions of information scarcity and uncertainty, a CF campaign may offer valuable insights to VCs, allowing them to revise their expectations about ventures' products and make better investment decisions. We consider two aspects of a (successful) CF campaign that potentially convey valuable information to VCs: the delay in shipping products to customers beyond the announced delivery date and the sentiment of the feedback expressed by the crowd towards the focal project during and in the aftermath of the campaign.[9]

First, at the beginning of a CF campaign, entrepreneurs must set a date for the expected delivery of the products to backers of the campaign. This is an important decision for entrepreneurs. Failure to timely ship products to customers who have prepurchased them may induce backers to cancel their pre-orders. These cancelations decrease the amount of free cash flow that entrepreneurs can use in the further development of their projects and can be a source of serious financial troubles. Delays in product delivery may indicate that entrepreneurs were too optimistic in their estimations of the time required for new product development due to the presence of unanticipated technical challenges that were difficult to overcome.[10] They may also indicate difficulties in scaling-up production. Delays in product delivery may thus be interpreted by VCs as a signal of the poor technical quality of a focal venture's products, and it may induce VCs to consider the venture to be an unattractive investment target.

Second, an important characteristic of CF is that the platform provides a communication channel through which backers and entrepreneurs can exchange messages. Backers use the platform to communicate feedback to entrepreneurs relating to their projects. In particular, backers can express their appreciation of the focal venture's products and give entrepreneurs advice on how to make the products more aligned with their needs and tastes. They can also express negative

[9] The following quotation from Mr. Casey Hopkins, the creator of the crowdfunded iPhone holder Elevation Dock, documents the significance of these two measures: "I had this vision: If we ship late or people do not like it, the entire Internet will be outside my house with pitchforks and torches. I cannot even articulate the pressure. It's not for the faint of heart." (see http://money.cnn.com/2012/12/18/technology/innovation/kickstarter-ship-delay/).

[10] Mollick (2014) analyzes 381 projects in the design and technology category. Only less than 5% of these projects failed to deliver products to backers. However, only 24.5% delivered in time. Excluding the projects that at the date of the study had yet to deliver (33% of the total number of projects), the average delay in delivery was 2.4 months.

opinions about products or their dissatisfaction arising from the failure of the delivered products to meet their expectations.

We argue that the positive or negative sentiment expressed by the crowd during and in the aftermath of a CF campaign provides VCs with indications relating to customers' appreciation of ventures' products. In absence of more precise and reliable information, VCs can use the sentiment of the crowd to revise their judgments about the attractiveness of the focal venture as an investment target.

Lastly, the information conveyed by a CF campaign about the delivery of ventures' products and the sentiment of the crowd ultimately relates to the ability of ventures' products to properly satisfy customers' needs. This information is admittedly noisy. Therefore, we expect that VCs will rely more on these pieces of information in their screening decisions if they are concomitant and reinforce each other (e.g., there are substantial delays in product delivery *and* the sentiment of the crowd is negative). Conversely, if these pieces of information are discordant (e.g., in spite of the substantial delays in product delivery, the sentiment of the crowd remains positive), they are likely to have limited effect on VCs' investment decisions. We then derive the following hypotheses for the non-VC-backed ventures.

> Hypothesis 2. *For non-VC-backed ventures, there is a negative relationship between the delays in delivering products to customers with respect to the schedule announced at the beginning of the* CF *campaign and the probability of obtaining VC in the aftermath of the campaign.*
>
> Hypothesis 3. *For non-VC-backed ventures, there is a positive (negative) relationship between the positive (negative) sentiment of the crowd and the probability of obtaining VC in the aftermath of the campaign.*
>
> Hypothesis 4. *For non-VC-backed ventures, the negative relationship between the delays in delivering products to customers with respect to the schedule announced at the beginning of a* CF *campaign and the probability of obtaining VC in the aftermath of the campaign is stronger (weaker) the more negative (positive) the sentiment of the crowd.*

For VC-backed ventures, we expect that the information conveyed by delays in product delivery and the sentiment of the crowd towards ventures' products will play a minor role in influencing the provision of an additional round of finance. We mentioned earlier that in VC-backed ventures, VCs are insiders and have access to first-hand information that is normally out of reach for outsiders. Hence, it is unlikely that the admittedly noisy information about ventures' products and customers' satisfaction conveyed by delays in product delivery and the sentiment of backers of CF campaigns will influence VCs' expectations relating to the returns they can make by providing additional finance to portfolio ventures.

3 Data and methods

3.1 Sample

We collected data from the Indiegogo and Kickstarter platforms by searching the keyword "hardware" in the description of projects. Most of these projects are listed in the following categories "Hardware," "Technology," "Wearables," "Gadgets," "Robots," "3D Printing," "DIY Electronics"; some of these projects are in the "Design" and "Product Design" categories. We also apply two additional filters. First, the campaigns were launched in the period from the beginning of the operations of these platforms until December 31, 2013. Second, the projects have successfully raised at least $100,000. There are 300 projects that comply with those conditions.[11]

We explain the logic behind our choices. First, Indiegogo and Kickstarter are currently the largest US CF platforms and have large communities, which are attractive for hardware entrepreneurs. For instance, one hardware entrepreneur noted that "we talked to both [Indiegogo and Kickstarter], and I would say both are helpful and we could not have gone wrong either way".[12] Second, developing hardware products is a capital-

[11] In the period considered in this study, 3279 hardware-related campaigns were launched on Kickstarter. Out of these, 1282 campaigns (39.66%) were successful (i.e., they reached the target fundraising amount), raising a total of $143 million. Two hundred fifty-two of these campaigns raised $100,000 or more. We do not have the corresponding data from Indiegogo since we do not have a database of all Indiegogo projects.

[12] https://www.youtube.com/watch?v=zDlavV9-La0?t=51m. Indiegogo even has created a hardware handbook for entrepreneurs (http://landing.indiegogo.com/hardwarehandbook/). It is also noteworthy to mention that in 2012, Kickstarter tightened its requirements due to delays in product delivery and rejected an increasing number of projects, especially hardware projects (Hurst, 2012) (http://www.wired.com/2012/12/kickstarter-rejects/). Hardware entrepreneurs have recently turned to Indiegogo as their favorite platform.

intensive activity, which makes entrepreneurs more inclined to seek external financing in comparison to entrepreneurs that operate in other industries.[13] Third, we applied a threshold of $100,000, with the aim of excluding from the analysis ventures that have smaller-scale projects and are thus unlikely to become the target of VC investments, independently of the information provided by their CF campaigns. The inclusion of these campaigns would make it more difficult to identify the link (if there is any) between the informational characteristics of CF projects and the likelihood of obtaining VC in the aftermath of the campaign. The interviews we conducted with industry experts and venture capitalists indicated that campaigns raising less than this amount are very unlikely to be considered to be potentially attractive investment opportunities by professional investors.[14] This qualitative evidence is corroborated by observation of the amounts of capital typically invested by VCs at the seed stage. For example, the Angel Capital Association reports that the average investment per deal for angel investors in 2015 in the USA was $347,000. In the same year, the median seed-stage investment for venture capital deals was approximately $1 million.[15] The focus on campaigns that raised $100,000 or more may create a sample selection issue. Indeed, the unobserved factors that determine the success of a venture's CF campaign may also drive the receipt of VC in the aftermath of the campaign (or vice versa), thus leading to biased estimates. As explained below in greater detail, we address this issue in a robustness check by resorting to Heckman two-stage estimations, as suggested by Signori and Vismara (2018), among others.

We collected data on the external equity capital received by sample ventures from venture capitalists and business angels prior to the end of 2014. We used various data sources: the Crunchbase database, the AngelList online dataset (accessible at https://angel.co), and the Thomson One (previously known as VentureXpert) database. In addition to these datasets, we performed manual searches for all the ventures, collecting news from ventures' websites, investors' blog-posts, and other Internet sources. As a final step in this process, we contacted a few project creators on the CF platforms whose ventures had confusing information about the financing status of their ventures.

We collected additional information on the ventures, their founders, and top management team members. These individuals are identified on the campaign webpage, ventures' websites, or LinkedIn accounts of the venture as members of the C-suite (i.e., their titles begin with "chief") or founders. The quality of the top management in terms of human capital is viewed as important to investors (Beckman et al. 2007; M. Colombo and Grilli 2010; Franke et al. 2008; Kaplan et al. 2009; Kirsch et al. 2009). More specifically, we collected data on the educational background of 578 individuals. Information on ventures include their location (i.e., whether in the top 20 VC hubs), age, and patenting activity.

3.2 Variables

Dependent variable The dependent variable in our estimates is the ventures' "hazard rate" of receiving external equity capital at time t (i.e., the probability of receiving external equity capital at time t, conditional on not having received it before time t). The time variable t measures the time in days from the end of a focal venture's CF campaign until the date of receipt of the initial or follow-on round of VC financing. Ventures that did not receive external equity capital by the end of December 2014 were at "risk" for subsequent financing and were right censored. Ventures that ceased operations, were acquired, or underwent an IPO were excluded from the analysis at that time and were no longer considered to be at risk of receiving VC.

[13] Beyond the capital intensity of hardware, as the quote goes, "there is a reason they call it hardware—it is hard" (https://blogs.wsj.com/tech-europe/2013/06/17/hardware-is-hard-thats-why-they-call-it-hardware/). Hardware companies (compared to software ones) face the following challenges: (1) hardware products take a longer development time due to the need to assemble a larger team of specialists with diverse backgrounds, such as mechanical and electrical engineers and industrial designers; (2) the iteration of product designs is difficult, and mistakes and changes are more costly after the initiation of manufacturing; (3) tools are more expensive, and figuring out (4) distribution channels and (5) the number of units to make can be difficult; and, finally, (6) software is needed to make the hardware work. All these factors combine to make hardware "hard."

[14] Specifically, we interviewed one venture capitalist who is active in investing in hardware companies in the USA with several crowdfunded portfolio companies and the founder-CEO of a VC-backed hardware venture who had gone through crowdfunding.

[15] See page 9 (http://angelcapitalassociation.org/data/Documents/ACAatAEBAN09-26-16.pdf) and page 7 (https://nvca.org/research/venture-monitor/). Note also that 29% of the ventures in our sample obtained VC in the observation period. Thies et al. (2018) consider all CF campaign posted in Kickstarter between 2010 and 2015 (261,255 campaigns) and find that only 610 campaigns received VC up to 2016 (610 campaigns). Seventy-one percent of these latter campaigns are in the "technology" and "design" categories.

Independent variables Excess capital is the amount in US dollars pledged by backers of a campaign in excess of the target capital. We claim that this is a better proxy for the amount of money that ventures can use to further develop their projects, thus resulting in reduced demand for capital, than the total amount raised through the campaign. We assume that ventures use the target capital raised mainly to cover development costs and the production costs of the target units of their products, leaving entrepreneurs with little additional finance. The excess capital will mostly go towards producing further units and generating free cash flow.[16] This variable is log-transformed (after increasing it by one) and then mean-centered. *Days of delay in delivery* is a time-varying variable measuring the number of days that entrepreneurs have delayed shipping their products as measured from the earliest date of estimated delivery, the so-called early-bird product offering, noting that the different delivery dates announced are most often very close to each other. *Days of delay in delivery* is equal to zero prior to the announced delivery date (i.e., if the product is delivered on time or in advance of the schedule). Otherwise, it is equal to the difference (in days) between the current time passed (*t*) and the announced delivery date. After shipping occurs, the value of this variable remains unchanged until the end of the observation period and is set to the latest delay observed. This variable is log-transformed after increasing it by one and then mean-centered.

To capture the sentiment of the crowd, we created two variables. *Positive review* (*negative review*) is a time-varying variable that represents the extent to which projects receive positive (negative) comments out of all the comments received on the campaign page up to time t-1 (i.e., the two variables are lagged by 1 day). To create these variables, we followed several steps. First, we collected all the comments for each project, with each project having 1,187 comments on average. Second, we analyzed the content of each comment after excluding the project creators' responses (130 responses on average) in the comments. For this purpose, we used the Sentiment Analysis API service provided by Indico (https://indico.io). The values of this analysis range from zero, corresponding to the most negative comment, to 1, corresponding to the most positive comment, with 0.5 being a neutral comment (i.e., a more positive comment receives a higher score). Third, we counted a comment as positive (negative) if the sentiment score is above one standard deviation above (below) the average score of all the comments received by all projects.[17] Lastly, we divided the number of positive (negative) comments over all comments received by the focal project up to t-1 to obtain *positive review* (*negative review*).

Control variables We insert several controls into the model specification. *Target capital* is the amount of the target fundraising in US dollars requested in the CF campaign. This variable is log-transformed to alleviate skewness concerns and then mean-centered. *Target capital* may be considered to be a proxy for the total financing needs of the focal project. The previous studies show that there is an inverse relationship between the target capital and the likelihood of success of reward-based CF campaigns that operate in all-or-nothing modes (M. Colombo et al. 2015; Mollick 2014). Hence, project creators are reluctant to set an arbitrarily high target capital, as this choice increases the risk of not reaching the target. However, if the target is set too low, project creators are likely to face financial challenges in delivering the product. Therefore, our intuition is that when the target fundraising goal is higher, the financing needs of the project are also larger. *Age* is the log of 1 plus the number of years from the foundation of the venture until the end of the CF campaign. *Patents* is the number of granted patents dated at the time of the application, as is common in innovation studies; patent data are collected using the Thomson Innovation database. This variable is log-transformed after increasing it by one. Patents reflect the technical capabilities of research personnel and signal the quality of ventures' technological resources (Häussler et al. 2012; Hsu and Ziedonis 2013). *Top 20 VC hubs* is a dummy variable indicating whether the venture is in a city included in the top 20 cities in the USA in terms of venture capital investments. The list of these cities is obtained from the National Venture Capital Association (NVCA). We control for whether the campaign was on Indiegogo or Kickstarter by the dummy variable *Indiegogo*, which equals one for projects listed on Indiegogo. We also control for the size of ventures' top management team (*TMT size*) and the university education of entrepreneurs

[16] Industry experts suggest that, for a product aiming for US$100,000, a rough breakdown is as follows: US$30,000 for purchasing materials and US$20,000 for tooling, on average, leaving US$50,000 for salary expenses (http://techcrunch.com/2014/10/11/8-things-about-hardware-crowdfunding-we-learned-from-20-campaigns/).

[17] Results are robust if we set the threshold for positive (negative) comments at the 75th (25th) or 90th (10th) percentile of the distribution of the comments.

and other top managers. *Top 20 universities* is a dummy variable equal to one if one or more members of the top management team obtained their last degree from one of the top 20 universities (from the 2016 list of US news rankings of engineering schools).

3.3 Descriptive statistics

Tables 1 and 2 present the distribution of our sample on several dimensions. The number of hardware campaigns grows rapidly over time, with most campaigns in the sample having been launched in 2013. A total of 84% (16%) of the campaigns are funded on Kickstarter (Indiegogo). Moreover, 88% of the campaigns use an all-or-nothing model (i.e., fixed funding), and 77% are launched by ventures located in the USA. In terms of exits, by the end of the observation period, one venture went public, 12 were acquired, 8 ceased operations, and the rest were operating as independent private entities.

Table 2 provides additional information on the sampled ventures. We distinguish ventures based on their external financing status at the time of the crowdfunding campaign: 247 (82%) ventures did not have any prior external equity capital when they closed their CF campaign, while 53 ventures (18%) were backed by one or more professional investors (there are five campaigns that received external equity capital while the campaign was ongoing; we obtain similar results when excluding these campaigns from the sample of VC-backed ventures). We also show univariate statistics to compare the two samples of ventures. We perform *t* tests for the continuous variables and Pearson's chi-squared tests for the binary variables. In total, 55 of the ventures without any prior external equity financing (22%) obtained an initial external equity round during the observation period. Out of the ventures with prior external equity, 32 (60%) obtained an additional external equity round after the end of campaign, with the difference being significant at the 1% level. Additionally, those ventures with prior external equity capital have a greater number of patents, raise greater sums of capital and excess capital from backers, have more backers and have a longer pre-announced delivery date than ventures without any prior external equity financing.

Table 4 shows the correlation of the variables used in the multivariate analysis. To flag issues related to multicollinearity, we mean-centered the variables *Target capital*, *Excess Capital*, and *Days of delay in delivery*. Furthermore, we computed uncentered variance inflation factors and found that none of these values were close to the cutoff of 10, which is associated with multicollinearity (Neter et al. 1985).

Table 1 Characteristics of crowdfunding projects

Presentation year	Frequency
2011	17
2012	82
2013	201
Crowdfunding platform	
Indiegogo	47
Kickstarter	253
Funding type	
Fixed funding (all-or-nothing)	266
Flexible funding (keep-it-all)	34
Location of campaign	
USA located	231
Non-USA located	69
Exit status	
IPO	1
M&A	12
Out of business	8
Operating	279

4 Results

To estimate the hazard rate of receiving a round of external equity finance after the end of the CF campaign, we perform an event-history analysis using Cox models, which do not require the distribution of the time dependence of the hazard to be specified.[18] The data were organized so that each day is one spell. A spell is treated as censored if it does not result in an external financing event. Multiple observations for the same venture may create correlations between the error structure and the independent variables, leading to underestimation of the standard errors. We thus estimated all models with the Huber-White sandwich estimator of variance to yield robust standard errors clustered on the ventures.

[18] We checked the Schoenfeld residuals and do not find violations of the proportional hazards assumption. Specifically, none of the non-time-varying variables violated the proportional hazards assumption. Time-varying variables violate this assumption; however, this does not cause concern because these variables are non-proportional; see Allison (1984).

Table 2 Characteristics of crowdfunding projects based on their external financing status at the time of the crowdfunding campaign

	All		With prior external equity finance		Without prior external equity finance		Difference
	Mean	SD	Mean	SD	Mean	SD	
Financing							
Post-campaign VC financing	0.29	0.45	0.60	0.49	0.22	0.42	−0.38***
Time to receive VC (days)[a]	288.72	172.97	268.83	173.05	300.30	173.45	31.46
Firm characteristics							
Age of firm (years)	3.02	8.31	2.42	2.51	3.15	9.09	0.73
No. of patents	0.52	1.70	1.08	2.21	0.40	1.55	−0.67*
Campaign							
Raised capital ($)	408,602.80	835,724.26	690,539.13	1,468,734.58	348,106.34	610,017.35	−342,432.79***
Target capital ($)	848,39.92	879,29.89	100,754.70	103,665.33	81,425.00	84,021.04	−19,329.70
Excess capital ($)	323,837.09	802,134.13	589,784.43	1,469,064.18	266,771.47	554,382.46	−323,012.96***
No. of total backers	2750.63	5921.85	4264.47	9966.50	2425.80	4585.54	−1838.67**
Product timeline							
Days before shipping	274.71	212.78	268.31	176.93	276.08	220.00	7.77
Estimated delivery time pre-announced (days)	111.92	79.51	128.75	69.66	108.31	81.15	−20.44*
On-time delivery	0.13	0.34	0.13	0.34	0.13	0.34	−0.00
Shipped or not	0.83	0.37	0.89	0.32	0.82	0.38	−0.06
Observations	300		53		247		300

The last column presents the mean differences between the sample with and without prior external equity finance; however, statistical significance is reported based on *t* test of difference in means for continuous variables, and Pearson's chi square test of proportion difference for binary variables

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

[a] Only for the subsample that receive financing in the aftermath of the campaign

We split the sample based on the external equity financing status of ventures. Table 3 presents the results of the estimates. While models 1-to-5 show the estimates for the sample of non-VC-backed ventures, models 6 and 7 show these estimates for the sample of VC-backed ventures.

Let us first consider the estimates relating to non-VC-backed ventures. Model 1 of Table 3 includes only control variables. All controls are statistically significant at conventional levels except for *Target capital*. Based on the estimates of model 1, a 1-S.D. increase in the log of age (in years) decreases the hazard of receiving an initial round of external financing by 40%, and a 1-S.D. increase in log of patents increases it by 24%. The hazard increases by 78% when the focal venture is located in one of the top 20 VC hubs. Having at least one member of the top management team with a degree obtained in one of the top 20 universities increases the hazard by 97%. Furthermore, an increase in *TMT size* by 1 S.D. increases the hazard by 47%.

In model 2, we add *Excess capital* and its squared terms to test hypothesis 1a. Our estimates indicate that the amount of capital raised during the campaign in excess of the target capital is not significantly associated with the hazard rate of obtaining an initial round of external equity capital. The null hypotheses that the coefficients of *Excess capital* and its squared term are jointly equal to zero cannot be rejected by a Wald test ($\chi^2(2) = 1.18$; $p = 0.55$). Thus, Hypothesis 1a is not confirmed.

To test hypotheses 2 and 3, model 3 includes additional explanatory variables: *Days of delay in delivery, Positive Review*, and *Negative Review*.[19] *Days of delay in delivery* and *Positive review* are not significant; however,

[19] Given the correlation between *Positive review* and *Negative review*, there might be concerns of multi-collinearity; we also insert these variables separately in regressions and obtain similar results (they are available from the authors upon request).

Table 3 Cox regression results predicting the hazard of obtaining external equity financing[a]

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Without prior external equity finance					With prior external equity finance	
Indiegogo platform	0.787**	0.770**	0.798**	0.779**	0.722*	0.729**	0.735**
	(0.375)	(0.376)	(0.389)	(0.391)	(0.406)	(0.346)	(0.331)
Age	− 0.629***	− 0.629***	− 0.643***	− 0.631***	− 0.610***	− 0.306	− 0.231
	(0.224)	(0.223)	(0.230)	(0.225)	(0.226)	(0.321)	(0.327)
Top 20 VC hubs	0.574**	0.587**	0.674**	0.696**	0.732**	0.084	0.173
	(0.275)	(0.278)	(0.284)	(0.288)	(0.293)	(0.412)	(0.409)
Patents	0.486*	0.464*	0.512*	0.565**	0.556*	0.082	0.003
	(0.261)	(0.268)	(0.278)	(0.287)	(0.292)	(0.279)	(0.280)
Top 20 universities	0.679**	0.681**	0.575*	0.565*	0.573*	0.143	0.102
	(0.283)	(0.286)	(0.295)	(0.295)	(0.299)	(0.351)	(0.342)
TMT size	0.419***	0.411***	0.421***	0.462***	0.453***	− 0.024	− 0.015
	(0.146)	(0.149)	(0.140)	(0.148)	(0.141)	(0.145)	(0.148)
Target capital	0.155	0.186	0.197	0.182	0.180	0.404**	0.496***
	(0.174)	(0.182)	(0.186)	(0.187)	(0.189)	(0.190)	(0.192)
Excess capital		0.049	0.016	0.019	− 0.004		0.161*
		(0.099)	(0.103)	(0.101)	(0.101)		(0.090)
Excess capital × excess capital		− 0.015	− 0.018	− 0.019	− 0.029		
		(0.025)	(0.025)	(0.027)	(0.037)		
Negative review			− 7.375**	− 6.523**	− 7.417**		
			(3.293)	(3.041)	(3.242)		
Positive review			− 3.021	− 2.721	− 3.286		
			(2.232)	(2.216)	(2.188)		
Days of delay in delivery			− 0.053	0.119	− 0.421**		
			(0.083)	(0.139)	(0.190)		
Negative review × days of delay in delivery				− 1.954			
				(1.340)			
Positive review × days of delay in delivery					1.826**		
					(0.818)		
N	132,692	132,692	132,692	132,692	132,692	19,572	19,572
No. of ventures	247	247	247	247	247	53	53
No. of ventures subsequently VC funded	55	55	55	55	55	32	32
Log likelihood	− 267.005	− 266.595	− 263.453	− 262.237	− 261.389	− 107.857	− 106.755
Chi squared	42.027	41.989	44.176	43.513	44.405	9.016	15.302

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

[a] Robust standard errors appear in parentheses clustered around ventures

Negative review has a negative and significant coefficient ($p < 0.05$) in line with the prediction of hypothesis 3. In terms of economic magnitude, with all variables at the mean value, a 1-S.D. increase in *Negative review* decreases the hazard by 45%.

In models 4 and 5, we test hypothesis 4, which investigates whether the predicted negative relationship between *Days of delay in delivery* and the hazard of receiving an initial round of external equity capital is stronger (weaker) when there is more negative (positive) feedback from the crowd. For this purpose, we include the interaction term between *Days of delay in delivery* and *Negative review* in model 4 and the interaction between *Days of delay in delivery* and *Positive review* in model 5.

In model 4, the interactive term is not significant at conventional levels, even if the sign is negative as expected, while in model (5), the interactive term is positive and significant ($p < 0.05$). The estimate of this model indicates that when there is little positive feedback from the crowd (i.e., *Positive review* is at 1 S.D. below the mean), the magnitude of the decrease in the hazard rate triggered by a 1-S.D. increase in *Days of delay in delivery* is equal to 37%. However, this negative association becomes progressively weaker the more positive the feedback from the crowd. When *Positive review* is at the mean value, the decrease in the hazard rate induced by a 1-S.D. increase in *Days of delay in delivery* is only 13%. In sum, our results relating to hypotheses 2–4 suggest that both *Negative review* and *Days of delay in delivery* negatively influence the hazard of obtaining VC. This latter negative association vanishes if *Positive review* obtains sufficiently large values, reflecting positive feedback from the crowd, in spite of the fact that this positive feedback does not have any direct positive effect on the odds of obtaining VC.

We then consider the sample of VC-backed ventures (models 6 and 7). Model 6 includes only the control variables. Notably in model 6, *Target capital* has a positive coefficient significant at 5%. A 1 SD increase in this variable is associated with a 45% increase in the hazard of follow-on VC financing ($p < 0.05$). In model 7, we include *Excess capital*. In line with hypothesis 1b, the coefficient of *Excess capital* is positive and weakly significant ($p < 0.10$). A 1-S.D. increase in *Excess capital* increases the hazard by 26%.[20]

Robustness tests Because our analyses consider ventures that have successfully raised $100,000 or more, there are sample selection concerns. Unobservable factors that determine the successful CF fundraising may also be correlated with the likelihood of receiving VC in the aftermath of the campaign, biasing the estimates from the Cox models. To alleviate some of this concern, we employ the two-step Heckman procedure. In the first step, we calculate the probability that a hardware campaign will successfully raise more than $100,000 by estimating a probit model among all hardware campaigns on Kickstarter. Because we do not have data on the population of Indiegogo campaigns, we could not use Indiegogo campaigns in the Heckman first-stage regressions. Therefore, we use the first-stage estimates based on data on Kickstarter campaigns to impute the values of the Inverse Mills Ratio for the 48 Indiegogo campaigns that are included in the second-stage estimates.[21] The following variables are used in this estimation: *Target capital*, *Video*, indicating the presence of video in the campaign webpage, category and year fixed effects, and *Competing offers*, defined as the log of one plus the number of offerings active and available on Kickstarter at the launch date of the focal campaign. Like Signori and Vismara (2018), we identify *Competing offers* as an instrumental variable because it negatively correlates with the selection likelihood. However, it is presumably uncorrelated with a venture's likelihood of receiving VC financing in the aftermath of the campaign. The results from the first stage are reported in Table 6. *Competing offers* shows a statistically negative coefficient in the probit model. From this first step, we calculate the Inverse Mills Ratio and include it in the second step that uses Cox hazard models. We present the results of the second-stage regression in Table 5, and these results support prior conclusions. The Heckman specification assumes that the error terms in the first stage and second stage are jointly normal. However, this assumption is strong. Lee (1983) proposes a generalization of the two-step selection bias correction method introduced by Heckman (1979) that allows for any parameterized error distribution. Using this approach, we again obtain similar results (regressions are available from the authors upon request). While we recognize the possibility that misspecification might impact our results, it appears that our results are robust given these commonly used alternative specifications.

We also perform a series of additional robustness tests. For the sake of synthesis, the results of these robustness checks are not reported in the text (they are available from the authors upon request). First, we include a dummy variable that is equal to one if the venture is located in the USA. This is so because entrepreneurs benefit from the active and well-developed VC market in the USA compared with other countries (M. G. Colombo and Shafi 2016). The results remain similar with the addition of this variable. Second, we replaced

[20] We also added to the model specification *Negative review*, *Positive review*, and *Days of delay in delivery*. As expected, these variables are not significant at conventional confidence levels. The results are available from the authors upon request.

[21] As a further robustness check, we rerun all estimates on the Kickstarter campaigns only (i.e., after excluding the Indiegogo campaigns from the sample). The results (available from the authors upon request) are qualitatively similar.

the *Indiegogo* dummy variable with a variable that considers whether the campaign follows all-or-nothing model or keep-it-all (flexible funding) model. The type of funding model chosen by entrepreneurs reflects whether crowds or entrepreneurs bear the risk and reap the returns, influencing campaign characteristics such as target capital (D. J. Cumming et al. 2015). Results remain similar, except that the *Excess capital* variable loses statistical significance at the conventional levels in the estimates relating to VC-backed ventures. Third, we replaced the amount raised by ventures from backers in excess of the target capital with the total amount raised. This new variable and its squared term were again not significant at conventional confidence levels. Fourth, to relax the assumption behind the proportional hazard model that the effect of the covariates influences the hazard by a proportionate amount at all durations, we employ parametric survival models with both log-normal and log-logistic survival distributions. We obtain similar results. Finally, we perform shared-frailty Cox survival models to check for the presence of unobserved heterogeneity (Gutierrez 2002). Shared-frailty survival models are analogous to regression models with random effects. They assume that unobserved heterogeneity occurs because some observations are more failure-prone than others. An additional random parameter is inserted in the model to account for this heterogeneity. We use gamma frailty models, which are typically the recommended choice for the distribution of latent random effects (Hougaard 2000). We do not find any significant frailty effect, and the results of the shared-frailty estimates are again similar to those reported in Table 3.

5 Discussion, limitations, and implications

This paper examines the characteristics of successful CF campaigns that accelerate (or hinder) the receipt of external equity finance from VCs in the aftermath of the campaign. In doing so, we distinguish campaigns launched by VC-backed and non-VC-backed ventures.

For non-VC-backed ventures, our findings suggest that VCs are influenced by the "wisdom of the crowd" over and above the amount of pledged money. When a CF campaign conveys bad news relating to the negative sentiment of the crowd on the projects, obtaining an initial round of VC is unlikely. We also find a similarly negative association with the length of the delay in the product delivery to backers of the campaign, unless there is a sufficiently strong positive sentiment of the crowd towards the focal project. Our results do not support the hypothesis that there is an inverse U-shaped relationship between the excess capital raised during a successful and large campaign and the probability of receiving an initial round of VC. The relationship between the cash flow available to ventures that have run a successful CF campaign raising a large amount of capital in excess of the target capital and the likelihood of receiving an initial round of VC may admittedly be more complex. The success of the campaign may lower the cost incurred by entrepreneurs in obtaining VC, as entrepreneurs plausibly have higher bargaining power to negotiate better terms with VCs, and they can obtain a larger amount of finance at a competitive price from higher-quality VCs. Therefore, these ventures have more freedom in choosing their financing sources.[22]

For VC-backed ventures, we find that the excess capital raised during the campaign has a positive but only weakly significant association with the probability of obtaining an additional round of VC. Thus, this study's evidence is admittedly weak regarding our hypothesis that VC-backed ventures use CF as a testbed of the market potential of their products. Additionally, length of the delay in the product delivery and crowd sentiment is inconsequential for VC-backed ventures.

Our study provides a new contribution to the literature that has examined the relationship between CF and VC. A few recent studies have appraised the idea that CF campaigns are a valuable source of information for entrepreneurs in that they reduce the uncertainty about the interest of potential customers in their ventures' products (Ellman & Hurkens, 2016; Strausz, 2017), and they have provided initial evidence supporting this argument (Da & Jordana, 2018). We take inspiration from this work and argue that this information is also valuable to VCs as it allows them to develop a more

[22] The exceptional case of Pebble Watch offers an illustrative case. Pebble Watch raised approximately $10 million in its first CF campaign after being rejected by VC investors. Subsequently, having demonstrated the large customer demand for its watch, Pebble Watch raised a $15 million series A round of VC from a syndicate led by Charles River Ventures, a prominent early-stage VC investor, and then raised another $20 million in a follow-on CF campaign. For more details, see http://www.forbes.com/sites/anthonykosner/2012/04/19/who-needs-venture-capital-pebble-smart-watch-raises-over-5-million-on-kickstarter/ and http://techcrunch.com/2015/03/29/pebble-times-20m-kickstarter-campaign-by-the-numbers/.

accurate judgment about the attractiveness of the focal venture as an investment target. The previous studies on the relationship between CF and VC have focused on the total amount of money pledged by backers. We argue that a CF campaign provides a richer set of information on a venture's products and their liking by customers, two aspects that figure prominently in VCs' investment decisions (Tyebjee and Bruno 1984; Kaplan and Strömberg 2004; Petty and Gruber 2011). Delays in product delivery can signal the underlying technical challenges that are difficult to overcome, while the sentiment of the crowd towards a venture's project reflects backers' appreciation of such products. This information is noisy and in fact is discarded by VCs if more reliable information is available. This situation applies to ventures that obtain the first round of VC before the CF campaign, as VCs are insiders in these ventures and have access to first-hand information. Nonetheless, our findings suggest that in the absence of more accurate information, VCs use the bad news from the CF campaigns of non-VC-backed ventures to screen out investment candidates, especially when different informational channels provide consistently negative information.

Our study also contributes to the literature interested in establishing a link between the pecking order theory and crowdfunding, a phenomenon that did not exist when the theory was originally developed. Walthoff-Borm et al. (2018a) have investigated whether and how equity crowdfunding modifies the pecking order hypothesis. They suggest that equity crowdfunding, as any other type of external equity capital (e.g., VC or capital raised through an IPO), is used by entrepreneurs as a last resort source of finance, when internal capital is exhausted and the level of debt is high. We add to the pecking order hypothesis by considering reward-based crowdfunding. Our findings are consistent with the view that CF campaigns convey valuable, yet noisy, information to VCs, thus modifying the cost entrepreneurs incur to obtain VC finance. In turn, the lower (or higher) cost of VC finance makes it more (or less) likely that entrepreneurs resort to it to finance their operations. Conversely, we do not find any evidence supporting the view that a successful CF campaign that allows entrepreneurs to raise a large amount of capital in excess of the target capital decreases the residual demand for external capital of their ventures, possibly making use of external equity capital less likely.

Limitations Our work has some limitations that offer avenues for future research. First, we have collected data on the population of large and successful hardware CF campaigns posted on the two largest crowdfunding platforms (Kickstarter and Indiegogo) since platforms' inception up to the end of 2013. Moreover, we have hand-collected longitudinal data on the receipt of VC funding for all these ventures. Unfortunately, the size of this population of ventures is small, especially when considering ventures that were VC-backed.

The small number of observations limits the precision of our estimates. This limitation also makes it difficult to further differentiate ventures into sub-categories. For example, we consider the external equity capital provided by venture capitalists and business angels without distinguishing between these two types of investors. Venture capitalists and business angels differ in terms of investment size, preferred stage of investment, and value-adding capabilities (Kerr et al. 2014). It would be interesting to assess whether the information generated by a CF campaign is processed differently by these two types of investors, leading to different investment behaviors.

The limited number of firms also limits exploring how the resource endowment of ventures and other firm-level characteristics influence the association between campaign-generated information and the likelihood of obtaining VC. For example, one may presume that the CF campaigns of younger ventures and those of ventures that lack quality signals (e.g., from endorsement by reputable third parties) are more informative to investors.

Lastly, we have focused on one milestone in the development of new ventures, i.e., VC funding. However, we encourage further investigation of other positive outcomes, such as the attraction of talented employees or managers (Vanacker and Forbes 2016), the establishment of business partnerships (Stuart et al. 1999), or exit through an IPO or acquisition. One final limitation of our approach is that we have assumed that debt financing by banks is not the most suitable option for the high-tech and risky ventures in our sample. However, a general consideration of bank financing as an alternative option may enrich our understanding.

Managerial implications Our study has important practical implications for both professional investors and entrepreneurs. VCs should be aware that a CF campaign

conveys information not only on the size of the demand for a venture's products but also on the technical quality of the products and their appeal to potential customers, as reflected in entrepreneurs' ability to timely deliver products to customers and the sentiment expressed by the crowd during the campaign. Even if this information is noisy, it can be valuable to VCs if they lack more accurate first-hand information. In particular, VCs can use it as a low-cost initial screening device. Our findings are also useful for entrepreneurs involved in CF. The provision of information that reduces the information asymmetries between them and potential investors may be an important corollary benefit of their CF campaigns, over and above the money raised by backers.

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Appendix

Table 4 Correlation matrix and descriptive statistics ($N = 152{,}264$)

Variables	Mean	Std. Dev.	Min	Max	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1) Excess capital	− 0.04	1.42	− 11.83	4.31	1.000									
(2) Negative review	.1	.08	0	1	− 0.066	1.000								
(3) Positive review	0.2	0.08	0	0.8	− 0.094	− 0.537	1.000							
(4) Days of delay in delivery	0	2.19	− 2.86	4.14	− 0.005	0.255	− 0.224	1.000						
(5) Indiegogo platform	0.13	0.34	0	1	0.003	0.132	− 0.153	− 0.001	1.000					
(6) Age	1.23	0.8	0	4.62	− 0.002	0.131	− 0.074	0.173	0.022	1.000				
(7) Top 20 VC hubs	0.35	0.48	0	1	− 0.002	0.103	− 0.080	0.065	− 0.059	0.020	1.000			
(8) Patents	0.23	0.48	0	2.94	0.074	− 0.034	0.058	− 0.019	− 0.030	0.219	0.092	1.000		
(9) Top 20 universities	0.25	0.43	0	1	0.043	− 0.077	0.046	− 0.086	− 0.088	− 0.028	0.115	0.229	1.000	
(10) TMT size	1.85	.99	1	6	− 0.057	− 0.115	0.120	0.011	− 0.147	− 0.199	0.077	− 0.036	0.101	1.000
(11) Target capital	0	0.92	− 3.36	2.87	− 0.164	0.050	− 0.091	0.095	0.080	0.075	0.065	0.144	0.050	0.173

Table 5 Cox regression results predicting the hazard of obtaining external equity financing: correction for sample selection [a]

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Without prior external equity finance					With prior external equity finance	
Indiegogo platform	0.800**	0.777**	0.808**	0.775*	0.717*	0.341	0.362
	(0.375)	(0.375)	(0.397)	(0.397)	(0.413)	(0.494)	(0.462)
Age	− 0.627***	− 0.627***	− 0.641***	− 0.631***	− 0.610***	−0.374	− 0.309
	(0.228)	(0.229)	(0.235)	(0.230)	(0.230)	(0.315)	(0.323)
Top 20 VC hubs	0.576**	0.588**	0.675**	0.696**	0.734**	0.173	0.268
	(0.275)	(0.277)	(0.283)	(0.287)	(0.292)	(0.409)	(0.410)
Patents	0.483*	0.462*	0.505*	0.564*	0.555*	−0.027	−0.085
	(0.264)	(0.274)	(0.283)	(0.293)	(0.298)	(0.311)	(0.302)
Top 20 universities	0.681**	0.682**	0.578*	0.566*	0.571*	0.091	0.033
	(0.287)	(0.291)	(0.300)	(0.301)	(0.304)	(0.361)	(0.361)
TMT size	0.421***	0.412***	0.422***	0.463***	0.454***	−0.103	−0.083
	(0.147)	(0.150)	(0.141)	(0.149)	(0.142)	(0.151)	(0.150)
Target capital	0.166	0.192	0.204	0.179	0.174	0.212	0.312
	(0.209)	(0.211)	(0.212)	(0.212)	(0.214)	(0.245)	(0.244)
Excess capital		0.049	0.020	0.023	− 0.002		0.158*
		(0.100)	(0.104)	(0.102)	(0.102)		(0.092)
Excess capital × excess capital		− 0.015	− 0.018	−0.019	− 0.029		
		(0.025)	(0.026)	(0.028)	(0.037)		
Negative review			− 8.223**	− 7.263**	− 8.281**		
			(3.561)	(3.364)	(3.507)		
Positive review			− 3.630	− 3.292	− 3.971		
			(2.772)	(2.766)	(2.684)		
Days of delay in delivery			− 0.052	0.131	− 0.458**		
			(0.084)	(0.143)	(0.208)		
Negative review × days of delay in delivery				− 2.208			
				(1.471)			
Positive review × days of delay in delivery					2.230**		
					(1.002)		
Inverse Mills ratio	0.040	0.022	0.029	− 0.006	− 0.016	− 0.708	− 0.683
	(0.390)	(0.406)	(0.380)	(0.384)	(0.389)	(0.522)	(0.491)
N	132,692	132,692	132,692	132,692	132,692	19,572	19,572
No. of ventures	247	247	247	247	247	53	53
No. of ventures subsequently VC funded	55	55	55	55	55	32	32
Log likelihood	− 267.000	− 266.593	− 263.473	− 262.192	− 261.369	− 107.05	− 105.99
Chi squared	42.045	41.996	44.433	43.712	44.771	13.886	19.302

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

[a] Robust standard errors appear in parentheses clustered around ventures

Table 6 First-stage Heckman probit model predicting the likelihood of selection

	(1)
Competing offers	− 0.596***
	(0.167)
Target capital (log)	0.421***
	(0.031)
Video	0.684***
	(0.046)
Category fixed effects	Yes
Year fixed effects	Yes
Constant	− 2.313**
	(0.943)
N	3154
R squared	0.293
Log likelihood	−700.443
Chi squared	581.215

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