ALL-OR-NOTHING VS KEEP-IT-ALL: COMPARING CAMPAIGN DESIGNS IN REWARDS-BASED CROWDFUNDING PLATFORMS

Abstract. We compare the two most popular campaign designs employed by rewards-based crowdfunding platforms: AoN, in which the entrepreneur collects the money pledged by backers only if the project can raise the funding goal, and KiA, in which the entrepreneur collects the money pledged by backers even when the project is partially financed. KiA reduces backers' willingness to pay relative to AoN, as the risk that the project may never see the light of day due to a lack of funds increases. However, achieving partial financing of the project under KiA provides cash, which the entrepreneur may choose to keep for herself, as well as a tangible proof of demand for the product, which may in turn unlock additional financing, allowing the project to move forward. We find that (i) a KiA campaign always raises less money relative to an AoN campaign; (ii) despite this, KiA leads to higher profits for projects with low ex-ante financing probability and high retail potential; and (iii) the advantage of KiA stems not from the extra revenues obtained by appropriating backers' funds, but from increasing the odds to ultimately carry through with the project. KiA further improves when backers can withdraw their pledges before the campaign ends. A new design employed at Seed&Spark, where the campaign succeeds if a minimum fraction of the goal is raised, can dominate both AoN and KiA even when constrained to set the same minimum goal completion for all campaigns, provided that said campaigns share the same retail potential.

Key words: Crowdfunding, New Business Models, Entrepreneurship, Online Platforms.

1. Introduction

Crowdfunding is a growing phenomenon. The global crowdfunding market in 2019 was valued at \$12.3B,[1] and by some estimates it is expected to reach \$25.8B by 2026, with a 11.2% CAGR (**?**). Rewards-based crowdfunding, which is the most popular form of crowdfunding and is the focus of our study, accounted for 74% of total revenues in 2019 (**?**).

In rewards-based crowdfunding, an entrepreneur (she) creates a web page on a crowdfunding platform describing the product she is working on, in an attempt to induce users of the platform to become *backers* and financially support the project. Importantly, at this stage the product is still under development: while a functioning prototype of the product typically exists already, more

[1]This number includes rewards-based, equity-based, and donation-based crowdfunding.

funds are needed to finalize development (e.g., quality testing, design for manufacturing, etc.), manufacture, and deliver the products — hence the need to launch a crowdfunding campaign. Most projects are creative endeavors of different kinds: at Kickstarter, the largest rewards-based crowdfunding platform, a large majority of the funds are raised by projects that aim to develop technology gadgets, products with innovative designs, or games, but campaigns for music albums, documentaries, and fashion items are also not uncommon. In exchange for their money, the entrepreneur promises backers a reward, typically in the form of a unit of the final product, as soon as development has been finalized and the actual product is available, usually several months after the crowdfunding campaign ends. Besides the product description and the pledge amount that backers must contribute in order to receive a unit of the final product, each crowdfunding campaign also features a funding goal, which represents the money a creator needs to complete her project (**?**).

Different crowdfunding campaigns may work according to different rules depending on which crowdfunding *campaign design* is employed. In particular, two campaign designs remain popular to this day: the All-or-Nothing design (henceforth AoN) also known as Fixed Funding, and the Keep-it-All design (henceforth KiA) also known as Flexible Funding. The largest rewards-based crowdfunding platform, Kickstarter, has employed the AoN design for all of its campaigns since its inception in 2009, while the second-largest platform, Indiegogo, has let entrepreneurs choose between the AoN and KiA designs since 2011 — and a vast majority of entrepreneurs have since chosen and still choose KiA over AoN. These two designs work the same way except for one crucial difference. Specifically, in the AoN design, the funding goal acts as a provision point, meaning that the entrepreneur collects all funds pledged by backers only if by the time the campaign ends — typically after a month — these funds are equal or higher than the campaign's funding goal. In this case, the campaign is considered successful, and the entrepreneur can move forward with the project. If the sum of all the pledges is instead less than the funding goal, the campaign is considered failed: pledges are refunded in full to backers and the entrepreneur gets nothing. By contrast, in the KiA design, the entrepreneur collects all the money pledged by backers at the end of the campaign even if these are less than the funding goal.

Given the existence of two alternative, popular crowdfunding campaign designs, it is of interest to understand what their respective advantages are. Theoretical results on this topic are very recent (**?**, **?**) and portray a somewhat controversial picture: It is found that the AoN design always leads to higher profit than the KiA design (a discussion on these papers and their assumptions is done in Section 2). This conclusion is controversial because it contrasts with what can be observed in the crowdfunding industry, where both the AoN and KiA designs have been employed successfully for well over a decade.[2] Our work aims to revisit this conclusion.

Specifically, we model an entrepreneur who needs funds to finalize development of a new product, and to this end, decides to launch a crowdfunding campaign, choosing either an AoN or a KiA campaign design. Once developed, the product can be sold to the retail market. Consistent with practice, we assume that the entrepreneur may take advantage of crowdfunding's uncertain regulatory framework by misappropriating backers' money at no cost and at any point in time (in Sections 3.3.2 and 4.4, we take more moderate stances on moral hazard). Our model identifies two potential drawbacks and two potential advantages of KiA, relative to AoN. On the negative side, KiA reduces backers' willingness to pay relative to the AoN design, and therefore, also the chance of meeting the goal. This is because of the risk that backers may lose their money without receiving any product is higher under KiA, given that the entrepreneur always keeps backers' money, even when the money raised is not enough to finance development. We also show the risk born by bakers can be too much and render crowdfunding simply infeasible, and while this holds in general for both designs (Corollary 1), we show that in certain settings KiA suffers from this problem to a larger extent than AoN does (Section 4.4).

On the positive side, KiA provides an extra source of revenues for the entrepreneur, backers' pledges, which are always collected – even if development is not attempted. Moreover, the funds collected from backers reduce the financial needs of the project and constitute tangible proof of existing demand for the product, which may help unlock financing from a third party (e.g., a bank), allowing the entrepreneur to move forward with the project.

After evaluating all the pros and cons, our analysis shows that KiA can indeed outperform AoN. This happens for campaigns with a high enough retail potential — that is, campaigns to develop products whose retail market is larger than the crowdfunding market — and with low odds of success — campaigns that are difficult to finance with crowdfunding alone, due for example to a combination of low expected crowdfunding demand, less attractive product features, and higher development costs. However, in some cases, choosing the KiA design for low-odds campaigns can turn a difficult campaign into a hopeless one, due to excessive risk born by backers under the KiA design (Theorem 6).

[2]The use of the KiA design can, to some extent, be explained by its suitability for projects with a flexible budget, e.g., community projects, where any dollar raised can be put to good use. While the extent of a project's financial flexibility is likely to play a role in the choice of the campaign design, this is at best a partial explanation. This can be seen by noting that, on the Indiegogo platform, in the Innovation category — which hosts projects whose budget is typically inflexible — 9 projects out of 10 choose KiA over AoN.

We also identify that the key driver of KiA's advantage is its ability to increase the carry-through probability of a project (the probability of financing, developing, and delivering the product to backers). We do so by first showing that this ability is necessary for KiA to outperform AoN (Proposition 3) and then showing that the other potential advantage—funds misappropriation—is not an advantage at all (Theorem 2).

We complete our analysis by extending our base model in multiple directions. We consider AoN's access to external funding (Section 4.1), endogenous goal setting (Section 4.2), pledge withdrawals (Section 4.3), and a different take on moral hazard, more aligned with anecdotal behavior of entrepreneurs (i.e., development is preferred to misappropriation, Section 4.4). We conclude by studying a relatively recent design employed at Seed&Spark, where funds are collected only when 80% of the goal has been met, and compare it with KiA and AoN.

To summarize, the contribution of our work is to develop a stylized model that, in contrast to existing models, can (i) identify and explain the relative advantages of the two most popular crowdfunding campaign designs employed in practice, (ii) provide guidelines to help entrepreneurs in the choice between existing crowdfunding designs, based on project characteristics, (iii) inform entrepreneurs as well as crowdfunding platforms on the implications of pledge withdrawal policies at the platform level, and (iv) advise platforms and entrepreneurs on the benefits of a new design, which has been employed by Seed&Spark with great effectiveness.

2. Literature Review

The papers most closely related to ours are **?** and **?**. Like ours, these papers use game-theoretic models to compare AoN with KiA. Both papers show that AoN always leads to a higher profit than KiA. Our paper is different from these papers on a number of dimensions — we focus on two in particular. The first difference is that in both papers, the *only* implication of setting the funding goal under the AoN design is to set the provision point of the campaign, that is, determine whether the campaign is successful (pledged funds are equal to or more than the goal, funds are collected) or not (pledged funds are less than the goal, backers get refunded). While focusing only on this implication is a fine choice in models that consider only the AoN design, it is not without consequences when comparing AoN with KiA. An implicit shortcoming of such assumption is that an AoN campaign with a funding goal set to $0 is equivalent to a KiA campaign, in that the entrepreneur always collects any amount pledged by backers. This perspective relegates KiA to be a special case of AoN, and thus be dominated by it — a conclusion that appears to contrast with practice, where both designs have been employed for over a decade, and that we aim to reevaluate with this paper.

In a nutshell, our paper argues that AoN is at a disadvantage compared to KiA when it comes to raising funds from a third party to compensate for the fact that crowdfunding funds do not fully cover development needs. While KiA keeps all the money raised via crowdfunding, and can use them as proof of a tangible interest from backers, AoN can either use the crowdfunding signal as a proxy for interest, which is arguably less credible, or can lie and lower the campaign goal below the amount needed, which can undermine the credibility of the project. We cover these extensions in Sections 4.1 and 4.2.

A second difference with the existing literature is that our paper accounts for a potential advantage of the KiA design that stems from its distinguishing characteristic and has not been considered so far. As mentioned in the introduction, collecting backers' pledges even when these are less than the funding goal, as allowed under KiA, reduces the financial needs of the project and provides tangible proof of existing demand for the product, which may help unlock financing from a third party (e.g., a bank), allowing the project to be fully funded. Once these differences are accounted for, we show that KiA can outperform AoN for projects with certain characteristics.

Our paper belongs to the recent and growing theoretical literature on crowdfunding, which has so far focused almost exclusively on the AoN design, and which we succinctly mention hereafter. **?** compare rewards-based crowdfunding with equity-based crowdfunding. **?** investigate the interaction between product line decisions, customers' valuation heterogeneity, and the campaign settings of a crowdfunding campaign. They find that product lines are less heterogeneous in quality when offered via crowdfunding compared to more traditional strategies. **?** use a dynamic model to study the implications of backers' pledging behavior over time, and understand how the informational cascades that ensue can affect the probability of success of a project. **?** consider a setting in which product quality is private knowledge of the entrepreneur and show that an entrepreneur can signal higher product quality by setting a goal that is larger than the funds needed. **?** consider a signaling model where quality is endogenous and the entrepreneur has either high or low competence, and show that the entrepreneur can signal high competence by price discriminating customers. **?** study how crowdfunding affects competing VC firms' investment decisions. **?** study the use of contingent stimuli as a way to help campaigns reach their goal. **?** develop a revenue management model of crowdfunding to obtain insights on how to maximize revenues. **?** studies the value of crowdfunding in the presence of bank and VC financing. **?** develop a model to study backers' strategic waiting: They show that it can explain the notorious last-minute surge of pledges, it hurts profit, and it can be profitably deterred by employing early bird discounts. **?** use a game theoretic model to study the effect of reciprocity and social ties in crowdfunding investment decisions. None of these papers compare the AoN and KiA designs.

The empirical literature on crowdfunding is also rapidly growing, and we do not attempt to provide an overview here. A worthy mention is **?**, who analyze a data set of projects launched on the Indiegogo platform, where entrepreneurs can choose between AoN and KiA. Our results in Corollary 1 and Theorem 1 are consistent with their finding that AoN campaigns meet their goal more often relative to KiA campaigns. Our model offers a different — though potentially complementary — explanation for this finding. **?** hypothesize that the choice of AoN increases the odds of meeting the campaign goal by acting as a quality signal. In our model, we find that campaigns with higher *ex-ante* odds of meeting the goal choose AoN over KiA to begin with. For a review of crowdfunding papers, we refer the reader to **?**.

Our work is broadly related to the literature on crowdsourcing platforms, where users are asked to participate in a project with ideas, rather than money. Among the earlier works, **?** find that the level and structure of prizes in tournaments have a significant impact on participants' performance, while **?** provide recommendations on the rules to be employed in a contest depending on the type of problem at hand. Recent works include **?**, which develops a game-theoretic model to guide platforms in designing problem specifications, and **?**, which studies how a crowdsourcing platform can design welfare-improving interventions when multiple contests compete for solvers' participation. See **?** for a review.

3. Model

3.1. **Model Setup.** An entrepreneur with a functioning prototype of a new product needs capital in the amount of C to finalize its development (e.g., further testing, design for manufacturing, quality control, etc.).[3] To this end, she decides to launch a crowdfunding campaign. This setting could capture the situation of an entrepreneur who is unable to raise capital from traditional financing channels, such as a bank or a VC, due for example to a lack of reputation, connections, or solid market prospects. The timeline of the model is organized around four sequential periods (see Figure 3.1).

Time zero: The market. The size of the consumer market for the product is the sum of the *crowdfunding* market X, which is comprised of consumers who regularly browse crowdfunding projects and can therefore decide to contribute funds to the campaign, and the *retail* market Y, which comprises of all other consumers who are interested in purchasing the product when it will be made available

[3]At Kickstarter, projects in the technology category are required to have a functioning prototype of their product before they can launch a campaign.

in the retail market, with X and Y being positively-correlated continuous random variables. Let the unconditional density of X be $g_X(x)$, with support over $\mathbb{R}^+$ and a finite mean, and let $G_X(x)$ be its cdf. Consumers are assumed to be atomistic, hence the use of continuous random variables. The sizes of the crowdfunding and retail markets are bound by the relation $\mathbb{E}[Y|X=x] = \gamma x$, where x is the realization of the crowdfunding market. In other words, the size of the retail market is, in expectation, γ times the realized size of the crowdfunding market, with $\gamma > 0$. The use of a linear relation keeps the analysis simple and has no qualitative bearing on our results. The positive correlation between X and Y captures the intuitive idea that, everything else being equal, a campaign raising more capital via crowdfunding is expected to do better also in the retail market. We refer to γ as the *retail potential*. A campaign with a $\gamma < 1$ is one for which crowdfunding backers are expected to account for a majority of sales, while a $\gamma > 1$ indicates a campaign that expects to sell a majority of units in the retail market, once the product has been finalized. Customer's valuation for the product is equal to v.

Time 1: The crowdfunding stage. This is the time window between the launch of the crowdfunding campaign and its end, typically after about a month from its launch. Below is the sequence of events within this time window.

(a) *Launch.* Upon launching the campaign, the entrepreneur chooses the campaign design d, which can be either All-or-Nothing or Keep-it-All, henceforth referred to as AoN and KiA respectively — these designs will be described in detail later. She also chooses a pledge price, p_d, where $d \in \{A, K\}$ identifies the design chosen, either <u>A</u>oN or <u>K</u>iA. The goal of the campaign is set equal to the funds needed, C.[4]

(b) *Pledges.* Once the campaign has been launched, crowdfunding consumers observe the campaign parameters and independently and simultaneously decide whether to pledge p_d (they become *backers*) or not. At this time, pledges in the amount of $z = \psi x p_d$ are accrued by the platform, where x is the realized mass of the crowdfunding market and ψ is the fraction of crowdfunding users who decide to pledge.

Time 2: The post-crowdfunding stage.

(a) *The goal is met.* If at the end of the campaign the sum of all the pledges, z, is equal to or higher than the funding goal, i.e., $z \geq C$, the platform releases all such funds to the entrepreneur. At this point, the entrepreneur can choose to use these funds to attempt development, as promised to backers. However, she can also decide to terminate the project if she so prefers. When this happens, we henceforth assume that the entrepreneur keeps all backers' money in her possession

[4]Section 4.2 covers the case of endogenous goal setting.

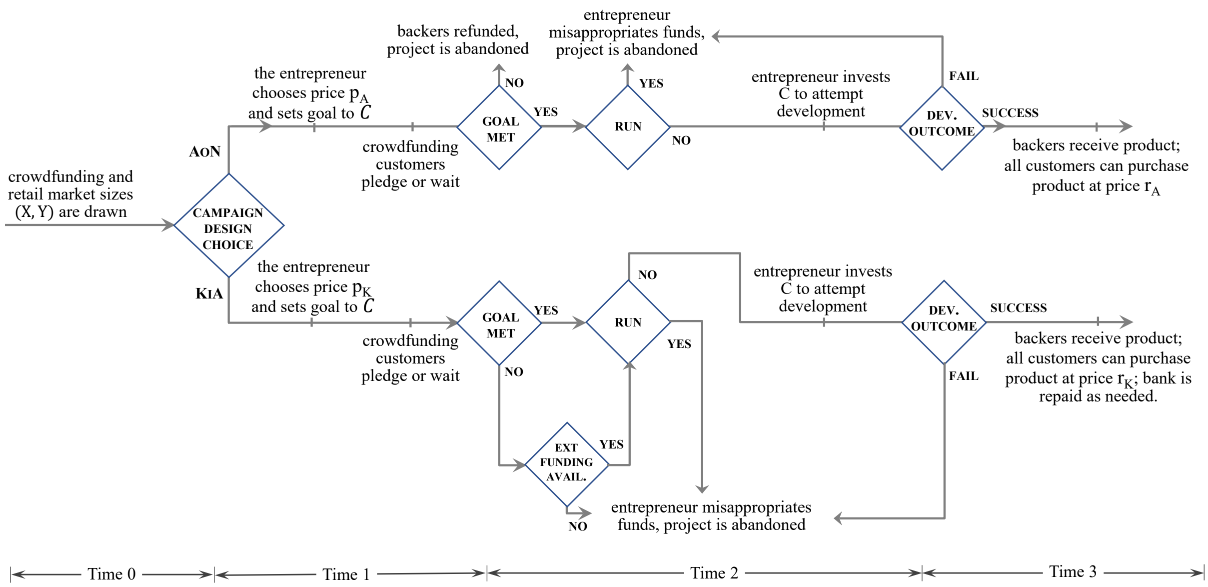

Figure 3.1: Timeline of the model

without incurring any negative consequence, which is unfortunately consistent with practice (**?**, **?**, **?**).[5]

(b) *The goal is not met.* Conversely, if the sum of all the pledges is strictly less than the funding goal, $z < C$, things work out differently depending on the design d chosen by the entrepreneur, that is, either AoN or KiA. Specifically, in this contingency:

- *AoN.* Under the AoN design the platform refunds all backers — the campaign "fails", and the project is terminated.
- *KiA.* Under the KiA design, instead, the platform releases all funds raised to the entrepreneur — that is, even if these are less than the funding goal. Raising money from backers provides tangible evidence that demand for the product exists — and this may, in turn, unlock financing from a third party, like a bank. Specifically, upon raising z from backers, with probability $\xi(z)$, the entrepreneur can borrow the missing funds, $C - z$, from a bank, at an interest i. We assume that $\xi : [0, C] \to [0, 1]$ is (weakly) increasing in the amount of funds raised, z. The entrepreneur can decide to terminate the project (and keep backer's money) or, if financing is available, may choose to borrow $C - z$ from the bank and attempt development.

[5]We relax this assumption in Section 3.3.2 by making misappropriation probabilistic, thereby making refunds possible, and in Section 4.4, by making misappropriation an option only when development is not possible.

Time 3: Development. If the entrepreneur has managed to raise (at least) the capital needed, C, either from backers or with the help of the bank, at this time she uses it to finalize development of the product. The outcome is uncertain. With probability δ, development succeeds: the entrepreneur delivers the product to all crowdfunding customers who pledged p_d during the campaign, and offers the product to all other customers (all retail market customers, plus the crowdfunding customers who did not pledge during the campaign) at a retail price r_d of her choosing. We assume that the marginal cost of production is zero — this assumption is common in the crowdfunding literature (**??**) and has no qualitative bearings on our results. If the entrepreneur borrowed money from the bank, she uses the profit earned to pay back the bank, in the amount of $(C - z)(1 + i)$, with the interest i being exogenous — we will relax this assumption later. With probability $1-\delta$, development instead fails (e.g., the product turns out to be infeasible), all invested funds are lost, and the project is terminated.

All game parameters are common knowledge, including the joint distribution of X and Y (but not their realizations), and all players are risk neutral.

Brief discussion. The model presented in this section is parsimonious, and includes simplifying assumptions. For example, the entrepreneur always misappropriates backers' money instead of refunding backers when development is not pursued; after a failed AoN campaign, the entrepreneur cannot gain access to the lending market; the funding goal of an AoN campaign is exogenously set equal to the funds needed; once made, pledges cannot be withdrawn; and, the entrepreneur shuns development if misappropriation is more profitable. . These assumptions were made to keep the model tractable, and the effects easier to interpret. After solving the base model in Section 3.2, we will relax these simplifying assumptions (see Sections 3.3.2, 4.1, 4.2, 4.3, and 4.4). All results and intuition from the base model are qualitatively confirmed in these extensions, which also allow us to obtain additional insights (for example to identify the drivers behind our results).

3.2. **Equilibrium outcome.**

3.2.1. *Equilibrium outcome for the All-or-Nothing design (AoN).* We now solve for the subgame perfect Nash Equilibrium of the game that starts at time 1, for the subgame in which the entrepreneur chooses to employ the AoN design for her crowdfunding campaign. The equilibrium analysis for the choice of the KiA design is covered next in Section 3.2.2. Henceforth we use subscript A to refer to actions taken under the AoN design, and further use superscript * to indicate equilibrium strategies.

Using backward induction, it is easy to see that the profit-maximizing price that the entrepreneur charges to customers who purchase the product at the end of time 3, after it has been developed, is $r^*_{\mathrm{A}} = v$.

At the beginning of time 2, if the goal is not met, the platform refunds all backers, as dictated by platform's rules, and the project is terminated. If the goal is met, on the other hand, the entrepreneur will terminate the project and take backers' pledges $p^*_A x$ if doing so is more profitable to her than investing in development and selling the product to the retail market, which yields an expected profit of $p^*_A x - C + \delta v x \gamma$. This means she will terminate the project if and only if, after observing the crowdfunding market size x, she expects the retail market size not to be large enough, or

$$x < \frac{C}{\delta v \gamma}, \tag{3.1}$$

and she will attempt development otherwise.

We now distinguish between two cases. Fist, we are going to assume that the entrepreneur sets a price such that she is always better off choosing development over termination. This means that, at time 1(b), backers will pledge on the campaign if and only if [6]

$$\int_{C/p_{\mathrm{A}}}^{+\infty} (-p_{\mathrm{A}} + \delta v)\, g_X(x)\, \mathrm{d}x \geq \int_{C/p_{\mathrm{A}}}^{+\infty} \delta \underbrace{(v - r^*_{\mathrm{A}})}_{=0}\, g_X(x)\, \mathrm{d}x, \tag{3.2}$$

that is, if the expected surplus of a backer from pledging during the campaign (if the goal is met, pay the pledge price and get the product if development succeeds, left hand side) is higher than the surplus from buying the product in the retail market (which is zero),[7] and where x is the realized crowdfunding market size. Simplifying, we obtain $p_A \leq \delta v$, hence the highest price backers are willing to pay is

$$p^*_{A1} = \delta v. \tag{3.3}$$

Note that when $\gamma \geq 1$, equation 3.3 implies condition 3.1. This means that when the retail potential is higher than or equal to 1, and the entrepreneur sets the pledge price according to 3.3, then indeed she prefers to attempt development rather than terminating the project, making 3.3

[6] Equation 3.2 is conditional on all other consumers pledging. As typical in coordination games, there also exists a Nash Equilibrium in which no consumer pledges because no one does, but it is easy to show that such equilibrium is Pareto dominated by the equilibrium in which customers pledge, which is why we henceforth focus our analysis on this equilibrium.

[7] We normalize backers' outside option to zero without loss of generality.

the equilibrium price. We henceforth assume that $C \leq 2\delta v\mu$, to rule out the uninteresting case in which *AoN* cannot reach the goal even in the highest market state.

We now consider the remaining cases, those in which it could happen that, upon meeting the goal, the entrepreneur, rather than attempting development, finds it optimal to terminate the project (and keep backers' pledges). In particular, this happens if the observed crowdfunding market size x is large enough to meet the goal (i.e., larger than C/p_A) but not large enough to justify development (i.e., lower than $C/(\delta v\gamma)$). In short, this will happen with some positive probability if and only if

$$p_{_A} > \delta v\gamma. \tag{3.4}$$

In this case, the pledge price $p_{_A}$ must solve

$$\int_{C/p_{\mathrm{A}}}^{C/(\delta v\gamma)} (-p_{\mathrm{A}})\, g_X(x)\,\mathrm{d}x + \int_{C/(\delta v\gamma)}^{+\infty} (-p_{\mathrm{A}} + \delta v)\, g_X(x)\,\mathrm{d}x \geq \int_{C/p_{\mathrm{A}}}^{+\infty} \delta(\underbrace{v - r^*_{\mathrm{A}}}_{=0})\, g_X(x)\,\mathrm{d}x,$$

which simplifies into

$$p_{_A} \leq v\delta \frac{\bar{G}_X\left(C/\left(\delta v\gamma\right)\right)}{\bar{G}_X\left(C/p_{_A}\right)}.$$

In order to find a tractable expression for $p_{_A}$, we henceforth assume that the crowdfunding market size is uniformly distributed between 0 and 2μ. Hence, we obtain

$$p^*_{_{A2}} = \delta v - C\frac{1-\gamma}{2\gamma\mu}; \tag{3.5}$$

moreover, substituting p^*_{A2} into condition 3.4 yields $\gamma < 1$, meaning that prices $p^*_{_{A1}}$ and $p^*_{_{A2}}$, together, cover the full parameter space of the model.

Before we can present the equilibrium outcome of AoN, it is convenient to introduce the following definition.

Definition 1. Define the *crowdfunding hazard index* of a campaign as $\mathcal{H} \triangleq \frac{C}{\mu\delta v}$.

The crowdfunding hazard index $\mathcal{H}$ compares the capital needed for the project, C, with the expected value of the crowdfunding market, measured as the expected size of the crowdfunding market, μ, times the willingness to pay of a consumer before development uncertainty is realized, δv. The numerator is higher when the sum needed for the project is bigger. The denominator is higher when the expected amount of money raised via crowdfunding is larger. Thus, a higher $\mathcal{H}$ is associated with projects that are less likely to raise the capital needed via crowdfunding — hence the name. The next proposition summarizes the equilibrium price and profit under AoN.

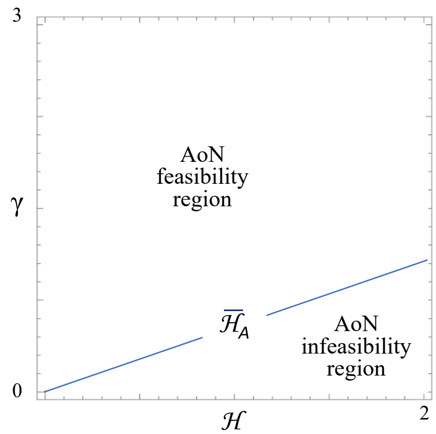

Figure 3.2: AoN infeasibility space, as a function of crowdfunding hazard rate $\mathcal{H}$ and retail potential γ.

Proposition 1. AoN Equilibrium

- *If $\mathcal{H} \leq \bar{\mathcal{H}}_A$, then:*

  the pledge price under AoN is given by

$$p_A^* = v\delta\left(1 - \mathcal{H}\left(\frac{1-\gamma}{2\gamma}\right)^+\right), \tag{3.6}$$

  and the profit under AoN is given by

$$\Pi_A^* = \begin{cases} \delta v\mu\left[1+\gamma-\mathcal{H}-\frac{\mathcal{H}^2}{4}(\gamma-1)\right] & if\ \gamma \geq 1 \\ \delta v\mu\left[1+\gamma-\mathcal{H}\frac{1-\gamma^2}{2\gamma}+\frac{\mathcal{H}^2}{4}\frac{(1-\gamma)}{\gamma}\right]\frac{2\gamma-\mathcal{H}}{2\gamma-\mathcal{H}(1-\gamma)} & if\ \gamma < 1 \end{cases}; \tag{3.7}$$

- *if $\mathcal{H} > \bar{\mathcal{H}}_A$, the AoN design is infeasible; that is, consumers do not pledge, and the profit is zero,*

where $\bar{\mathcal{H}}_A \triangleq 2\gamma$.

The first point in Proposition 1 gives closed-form solutions to the equilibrium price and profit of the AoN design. In particular, equation 3.6 highlights that pledging on a crowdfunding campaign is not like buying products from an established vendor, like Amazon or Walmart. By pledging on an AoN campaign, customers incur additional risk, due for example to the possibility that development goes wrong and no product is developed, which lowers willingness to pay down to $v\delta$, but also that, in some cases (i.e., when $\gamma < 1$), the entrepreneur may terminate the project without refunding backers, a risk captured by the term $1 - \mathcal{H}\left(\frac{1-\gamma}{\gamma}\right)$. In order to induce customers to pledge, the entrepreneur must offer them a low-enough pledge amount, one that compensates them for the additional risk they incur by pledging during the campaign instead of waiting.

The second point in Proposition 1 states that for some projects, AoN is infeasible, that is, the entrepreneur cannot raise any funds under AoN when the crowdfunding hazard index $\mathcal{H}$ is larger than the threshold $\bar{\mathcal{H}}_A$, no matter how low a pledge price she sets. We have plotted the threshold $\bar{\mathcal{H}}_A$ in Figure 3.2 — the crowdfunding hazard index is naturally bound to be between 0 and 2 in our setting. The reason for this *infeasibility* result is best explained by looking again at the pricing condition 3.6. When meeting the goal is not very likely (high $\mathcal{H}$), the odds that backers will pledge on the campaign and get nothing in return are higher, forcing the entrepreneur to offer a discount to compensate backers for such contingency, so to induce them to pledge. However, while a lower price can be a good strategy in a normal retail setting if one wanted to increase sales, in crowdfunding campaigns a lower pledge price means that less money will be collected in the first place, making development even less likely. When $\mathcal{H} \geq \bar{\mathcal{H}}_A$, there exists no price, no matter how low, that would convince backers to pledge on the campaign (i.e., condition 3.6 yields a negative price).

3.2.2. *Equilibrium outcome for the Keep-it-All design (KiA).* We now solve for the subgame perfect Nash Equilibrium of the game that starts at time 1, for the subgame in which the entrepreneur chooses to employ the KiA design.

As for the case of AoN, backward induction reveals that the entrepreneur extracts all consumer surplus in the retail market, $r_{\mathrm{K}}^* = v$.

At time 2, if the goal is met, the entrepreneur is faced with the same choice as under AoN. This means she will terminate the project if and only if condition 3.1 holds, and she will attempt development otherwise. If instead the goal is not met, but financing is not available, she will terminate the project.

Finally, if the goal is not met and financing is available, she must decide between attempting development and terminating the project. Let $\sigma(z) : \mathbb{R}^+ \to \{0,1\}$ be the development decision of the entrepreneur after raising $z = p_K x < C$ when she can borrow from the bank, where $\sigma = 1$ if she borrows, and $\sigma = 0$ if she terminates the project. Then we have

$$\sigma^*(xp_K) = \begin{cases} 1 & if\, \mathbb{E}_{Y|x}\left[(\delta v Y - (C - xp_K)\, i)^+\right] > xp_K \\ 0 & otherwise \end{cases}, \tag{3.8}$$

that is, the entrepreneur develops if and only if the expected profit from borrowing and developing — computed as the expectation over the retail market size Y, given x, of the positive value of the revenues earned in the retail market, vY, multiplied by the development risk, δ, minus the interest paid to the bank, $(C - xp_K)\, i$ — is higher than the funds she raised from backers, xp_K, else she terminates the project.

At time 1b, backers will pledge on the campaign if and only if their expected payoff from doing so is higher than waiting and buying in the retail market,

$$-p_K + \Phi_K(p_K)\, v \geq \Phi_K(p_K)\,(\underbrace{v - r^*_{\mathrm{K}}}_{=0}), \tag{3.9}$$

where

$$\Phi_K(p_K) = \delta \frac{2\mu - \max\left(\frac{C}{p_K}, \frac{C}{\delta v \gamma}\right)}{2\mu} + \int_0^{\max\left(\frac{C}{p_K}, \frac{C}{\delta v\gamma}\right)} \delta\, \xi(x p_K)\, \sigma^*(x p_K) \frac{1}{2\mu} \mathrm{d}x \tag{3.10}$$

is KiA's *carry-through probability*, i.e., the probability that the entrepreneur will carry the project through and ultimately finance, develop, and deliver the product to backers, either by raising all money from backers (the goal was met, she invests, first term), or by borrowing the missing funds from the bank (second term), and where $\sigma^*(z) \in \{0,1\}$ is given by equation 3.8. Clearly, $\Phi_K < 1$. Rearranging the terms in condition 3.9 and knowing that $r^*_{\mathrm{K}} = v$, we obtain

$$p_K \leq v\, \Phi_K(p_K)\,. \tag{3.11}$$

The equilibrium price under the KiA design, p_K, is the highest price that satisfies condition 3.11. Henceforth, we use Φ^*_K to indicate the carry-through probability under the equilibrium price, $\Phi_K(p^*_K)$.

The profit under the KiA design can be written as

$$\begin{aligned}\Pi^*_{\mathrm{K}} = & \int_{\max\left(\frac{C}{v\,\Phi^*_K}, \frac{C}{\delta v\gamma}\right)}^{2\mu} \left[-C + \Phi^*_K x + \delta v x \gamma\right] \frac{1}{2\mu} \mathrm{d}x + \int_{\frac{C}{v\Phi^*_K}}^{\max\left(\frac{C}{v\Phi^*_K}, \frac{C}{\delta v\gamma}\right)} \left[v \Phi^*_K x\right] \frac{1}{2\mu} \mathrm{d}x \\ & + \int_0^{C/\left(v\Phi^*_{\mathrm{K}}\right)} \left\{\xi\left(v\Phi^*_K x\right) \sigma^*\left(v\Phi^*_K x\right) \mathbb{E}_{Y|x}\left[\left(\delta v Y - (C - x p_K)\, i\right)^+\right] + \left[1 - \xi\left(v\Phi^*_K x\right)\right] v\Phi^*_K x\right\} \frac{1}{2\mu} \mathrm{d}x,\end{aligned} \tag{3.12}$$

where the three terms consider the market states in which the goal is met and development is attempted, is met and development is not attempted, and is not met, respectively, and where the last term further distinguishes between the case in which additional funding is or is not raised by the bank.

Before we proceed further, we add some structure to our model, with a twofold objective. First of all, we need to simplify some equilibrium conditions — for example the implicit inequality in condition 3.11 and the profit expression 3.12 — in order to obtain expressions that are analytically tractable. Furthermore, it is desirable that the external financing probability ξ be derived endogenously from the model. This would have the advantage of reducing the degrees of freedom of the game by rejecting functional forms for ξ that would be inconsistent with the behavior of a rational third party lender — in other words, the willingness of the bank to finance the project should not be independent from the characteristics of the project, rather, it should be higher for projects with a larger expected market, a lower risk of development, and so on. To this aim, we henceforth assume that the crowdfunding market state X is distributed uniformly over the interval $[0, 2\mu]$, and that the bank acts as a rational lender operating in a competitive lending market (**??**). This means that the bank will lend money to the entrepreneur if and only if doing so earns a non-negative expected profit, and that the interest it charges is only as high as needed to break-even in expectation.

We can now characterize the external financing probability $\xi(\cdot)$, which is given in the next lemma.

Lemma 1. External Financing Probability in a Competitive Lending Market

Suppose the bank acts as a rational lender operating in a competitive lending market; then, the external financing probability function takes the following form:

$$\xi(z) = \begin{cases} 1 & if\; z \geq \hat{z} \\ 0 & otherwise, \end{cases} \qquad with\ \hat{z} = \frac{p_K C}{p_K + \delta v \gamma}; \tag{3.13}$$

that is, conditional on the campaign raising z, the bank offers to lend $C - z$ to the entrepreneur if and only if the funds raised via crowdfunding, z, exceed a threshold amount $\hat{z}$.

The bank will lend the missing funds if and only if the campaign raises enough. The threshold strategy arises because raising more funds has two implications: the prospects of the project in the retail market look better, and less capital will be needed from the bank, both of which increase the attractiveness of the project for the lender.

Leveraging the above assumptions, we can also express the entrepreneur's borrowing strategy σ^*, characterized in (3.8), in a much simpler form.

Lemma 2. *Under* KiA*, upon failing to raise the goal, the entrepreneur will seek financing if and only if*

$$x > \frac{C}{\delta v \gamma} \triangleq \hat{x}_{\mathrm{K}}, \tag{3.14}$$

and she will misappropriate backers' money otherwise.

The above condition is quite useful. Upon closer inspection, it can be seen that condition 3.14 is always tighter than the condition for financing to become available in (3.13) — when the profit-to-go is positive but small, the bank is willing to lend the money, but the entrepreneur prefers diverting backers' funds instead. This means that financing is always governed by condition 3.14, and this is good news, because this condition, unlike condition 3.8, is *not* a function of the price charged to backers, p_K. It may not be readily obvious why the money on hand, $p_K x$, does not actually matter for the decision of whether to misappropriate said money or seek financing. The intuition is as follows. Backers' pledges, if not diverted by the entrepreneur, will be used as down payment to the bank, who will then reduce the interest charged to the entrepreneur, to account for the lower risk it bears. This means the use of such funds carries the same expected payoff to the entrepreneur no matter what she chooses to do with them, making such funds inconsequential for her choice.

Thanks to these observations, we can use condition 3.14 to compute the carry-through probability Φ_K^* and obtain a tractable closed form, which we can use to compute both the pledge price and the profit under KiA.

We now present the equilibrium strategies and profit under the KiA design.

Proposition 2. KiA Equilibrium Pricing and Profit

- If $\mathcal{H} < \bar{\mathcal{H}}_K$, the entrepreneur sets the pledge price $p_K^* = \delta v \left(1 - \frac{\mathcal{H}}{2\gamma}\right)$ and the profit is

$$\Pi_{\mathrm{K}}^* = \delta v \mu \left[1 + \gamma - \mathcal{H} - \frac{1}{\gamma}\left(\frac{\mathcal{H}}{2} - \frac{\mathcal{H}^2}{4}\right)\right]; \tag{3.15}$$

  - if $\mathcal{H} \geq \bar{\mathcal{H}}_K$, the KiA design is infeasible, that is, there exists no price that consumers are willing to pledge; consequently, the campaign raises no funds and the profit is equal to zero,

  where $\bar{\mathcal{H}}_K \triangleq 2\gamma$.

Corollary 1. Equilibrium outcome comparison between AoN and KiA

- *The infeasibility region is the same under KiA and AoN, that is,* $\bar{\mathcal{H}} \triangleq \bar{\mathcal{H}}_K = \bar{\mathcal{H}}_A = 2\gamma$.
- *When* $\mathcal{H} < 2\gamma$ *(crowdfunding is feasible):*
  - *the pledge price is lower under KiA than it is under AoN, that is,* $p_A^* > p_K^* > 0$;
  - *the probability of meeting the goal is lower under KiA than it is under AoN.*

Proposition 2 describes the equilibrium pledge price and profit for the KiA design, using closed-form expressions. Together with Corollary 1, it also remarks that KiA, relative to AoN, charges a lower pledge price, due to the higher risk born by backers, and as a consequence, has lower odds of meeting the goal. Despite the higher risk born by backers under the KiA design, its infeasibility region is the same as AoN's. The reason is that, while backers' willingness to pay is, ceteris paribus, higher under AoN than that under KiA (hence the higher pledge price), backers' willingness to pay becomes equal to zero in the same conditions under both designs. Formally, as $\mathcal{H} \to 2\gamma^-$, $p^*_A \to 0^+$, and since $p^*_A > p^*_K > 0$, we also have that $p^*_A \to p^*_K$. In Section 4.4, we will revisit this result by studying a model in which the entrepreneur chooses to appropriate backers' funds only if development is not possible, and we will see that, in that case, feasibility is actually different across the two designs.

3.3. **Comparison between AoN and KiA.** Comparing expressions 3.15 and 3.7 we obtain the next useful result.

Lemma 3. *When $\mathcal{H} \geq \bar{\mathcal{H}}$ (i.e., both designs are feasible), the ratio Π^*_K/Π^*_A can be expressed as a function of only two parameters, $\mathcal{H}$ and γ. It follows that the choice of the best performing design depends on no parameters other than $\mathcal{H}$ and γ. Here, $\bar{\mathcal{H}}$ is defined in Corollary 1.*

The above lemma, together with the fact that the feasibility threshold $\bar{\mathcal{H}}_K$ is a function of γ alone, implies that the relative profitability of AoN and KiA is only a function of two parameters, the crowdfunding hazard index $\mathcal{H}$ and the retail potential γ.[8] For this reason, we structure the presentation of our results and the ensuing discussion solely around $\mathcal{H}$ and γ, since all other project characteristics — C, δ, μ, and v — only affect the comparison through $\mathcal{H}$.

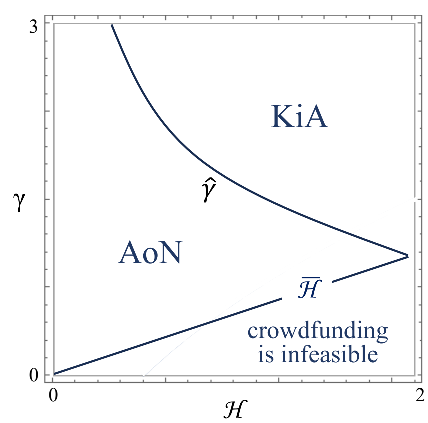

Figure 3.3: Design-equivalence threshold $\hat{\gamma}$, feasibility threshold $\bar{\mathcal{H}}$, and dominance regions for different crowdfunding designs, as a function of a project's hazard index $\mathcal{H}$ and retail potential γ.

Theorem 1. Profit Comparison of Crowdfunding Designs

[8]We do not claim this property to be general, and it may be a function of the assumptions made in the model, e.g., uniform demand. It does, however, help a lot to condense the exposition and provide intuition for our results.

Suppose crowdfunding is feasible, i.e., $\mathcal{H} < 2\gamma$. Then, KiA outperforms AoN if and only if the retail potential, γ, is large enough. Formally, $\Pi_K^* > \Pi_A^*$ if and only if $\gamma > \hat{\gamma}(\mathcal{H})$, where the threshold $\hat{\gamma}(\mathcal{H})$ is decreasing in $\mathcal{H}$, and is given by

$$\hat{\gamma}(\mathcal{H}) = \frac{1}{2} + \sqrt{\frac{2}{\mathcal{H}} - \frac{3}{4}}.$$

The result of Theorem 1 is depicted in Figure 3.3, which shows the dominance regions of the AoN and KiA designs as a function of the crowdfunding hazard index $\mathcal{H}$ and retail potential γ (thanks to Lemma 3, no arbitrary choice of parameter values was made to plot this figure). The blue line on the top, $\hat{\gamma}$, contains the points in which KiA and AoN are equally profitable, and also demarcates the two regions in which KiA earns a higher profit than AoN and vice versa. The blue line at the bottom, $\bar{\mathcal{H}}$, is the feasibility threshold discussed in Corollary 1, below which neither design is feasible.

The first important message from Theorem 1 is also a simple one: KiA *can* outperform AoN. This is an important message because, as discussed in the introduction, the existing theoretical literature has so far argued that the AoN design is always more profitable than the KiA design, a result that is difficult to reconcile with the popularity of the KiA design over the last decade.

The second important message from Theorem 1 pertains to *when* KiA outperforms AoN. The two designs are equally profitable along $\hat{\gamma}$ — see Figure 3.3 — and KiA is the most profitable design anywhere above this curve (i.e., for a higher γ). In short, we can say that KiA is more profitable than AoN when the retail potential γ and the crowdfunding hazard index $\mathcal{H}$ are high enough (the "top-right" area of the graph). This finding implies that projects that are better off choosing the KiA design are also, on average, projects with lower odds of reaching the goal, which is consistent with empirical findings that AoN campaigns are, on average, more successful (i.e., meet the goal more often) compared to KiA campaigns (**?**).

The fact that KiA outperforms AoN when $\mathcal{H}$ is large means this design is quite useful for platforms' bottom line. The reason is that crowdfunding platforms typically earn a commission if the entrepreneur collects the money pledge by backers, and earn no commission otherwise. When $\mathcal{H}$ is large, a platform rarely earn any commission under the AoN design, while it always earns a commission under the KiA design. Although the pledges made by backers tend to be higher under AoN (remember the price ranking from Corollary 1), the balance quickly tilts in favor of KiA once $\mathcal{H}$ grows high enough.

What Theorem 1 does not say is *why* KiA can outperform AoN. To understand this, it is useful to remember that so far, we have uncovered one drawback of the KiA design relative to the AoN design, namely the lower pledge price (and consequently lower chance to meet the goal, Corollary 1), and two *potential* advantages, namely, that when the campaign raises less than the goal, the entrepreneur may leverage the funds raised from backers to raise money from the bank, and the fact that under KiA, the entrepreneur always keeps all the money pledged on the campaign (that is, even if the goal is not met and/or development is not attempted, while under AoN the entrepreneur raises nothing when the goal is not met). The next two subsections investigate the role played by these two potential advantages, to better understand the reason why KiA can, in some cases, outperform AoN.

3.3.1. *On the role of carry-through probability.* In this section, we aim to understand the role played by one of the two potential advantages of KiA—a potentially higher carry-through probability, that is, its ability to ultimately deliver the product to backers, thanks to the possibility to use the funds raised to unlock additional financing. In Section 3.2.2, we have defined Φ_{K}^* as the carry-through probability under KiA, in equilibrium. Let Φ_{A}^* represent the same measure for the AoN design, that is, the probability that under AoN the entrepreneur raises enough funds, invests, develops, and delivers the product to its bakers — again in equilibrium. We have the following result.

Proposition 3. On the role of carry-through probability

- $\Phi_{\mathrm{K}}^* - \Phi_{\mathrm{A}}^*$ increases in γ; $\Phi_{\mathrm{K}}^* > \Phi_{\mathrm{A}}^*$ if and only if $\gamma > 1$;
- $\Pi_{\mathrm{K}}^* > \Pi_{\mathrm{A}}^*$ only if $\Phi_{\mathrm{K}}^* > \Phi_{\mathrm{A}}^*$;
- When $\mathcal{H} \to 0^+$, $\Phi_{\mathrm{K}}^* \to 1$ and $\Phi_{\mathrm{A}}^* \to 1$.

The first point of Proposition 3 reveals that, despite the lower pledge price, the KiA design *can* lead to a higher carry-through, and this happens when the retail marker is large enough, and in particular, larger than the crowdfunding market. Here is why. When the retail potential is larger, raising money from the bank is easier, as every dollar invested in the project can potentially yield more once the product hits the retail market, making the investment more attractive. This, in turn, is beneficial for KiA in two ways. First, because its ability to unlock extra financing is more effective (the amount of funds needed to unlock bank financing, $\hat{z}$, decreases in γ). And second, because this in turn makes backers more hopeful to receive a product: This means the entrepreneur can charge a higher pledge price to backers (remember condition 3.11) thereby increasing the money raised via crowdfunding.

The second point of Proposition 2 identifies the higher carry-through probability that the KiA design can grant to the entrepreneur (relative to AoN) as a *necessary* requirement for KiA to outperform AoN. In other words, this point establishes that *granting a higher carry-through probability is a crucial advantage of KiA*, as without it, KiA cannot outperform AoN.

Lastly, we note that when $\mathcal{H} \to 0$ (third point), that is, when the cost of the project is negligible compared to its market value, the funds can be raised almost surely under both designs. In such case, we have $\Phi^*_{\mathrm{K}} - \Phi^*_{\mathrm{A}} \to 0$ and $\Phi^*_{\mathrm{K}} \to 1$ and $p^*_{K} \to p^*_{A}$. That is, KiA$'s$ advantages and drawbacks disappear. This means that projects with extremely favorable odds fare well no matter what crowdfunding design is chosen.

We are now in a position to reflect on the result in Theorem 1, that is, why KiA is more profitable than AoN when the retail potential γ is high enough and the crowdfunding hazard index $\mathcal{H}$ is high enough. A high-enough retail potential is crucial, as without it, KiA loses its higher carry-through probability, a key element to outperform AoN. We also understand the apparently ambivalent role of the crowdfunding hazard index $\mathcal{H}$. A project with high $\mathcal{H}$ is difficult to finance via crowdfunding alone. For this type of projects, the ability of KiA to unlock extra financing when the goal is not met can be very valuable — when the upside potential is high, because it increases the odds of financing the project — *but* can also lead to failure — when the upside potential is low, since backers will refuse to pledge on the project because it's too risky.

3.3.2. *On the role of funds misappropriation.* A second, potential advantage of KiA over AoN consists in its ability to retain backers money not only when the goal is met, as AoN does, but also when the goal is not met. To investigate the role played by this extra form of revenue, and to what extent this is driving KiA's superiority, we extend the base model described in Section 3.1. In this extension, when the entrepreneur does not deliver the product to backers, she misappropriates backers' funds with probability $\eta \in [0, 1]$, rather than doing so with certainty as in the base model, and refunds them otherwise. This uncertainty could capture the degree of media exposure the campaign gets, or how vocal bakers are on social media, in short, situations in which misappropriating backers' money may come at a substantial cost, thus making refunds the better option. By varying the value of η, we can thus study how funds misappropriation affects KiA's performance relative to AoN. We also assume that development always works, $\delta = 1$, to obtain tractability.[9] The equilibrium analysis can be found in the Appendix Section A.

Theorem 2. Probabilistic refunds and the role of misappropriation

(1) When refunds are possible but not guaranteed, $(0 < \eta < 1)$:

  (a) KiA outperforms AoN if and only if the retail market potential is large enough, i.e., $\Pi^{\eta*}_{K} > \Pi^{\eta*}_{A}$ if and only if $\gamma > \hat{\gamma}_{\eta}$, where $\hat{\gamma}_{\eta} \geq 1$.

[9]Since both designs are subject to development risk, this assumption does not provide unfair advantage to any one of them. When development can fail ($\delta < 1$), in order to derive the equilibrium pledge price, one needs to compute the refund that each backers will receive in expectation. This is a function of the capital raised, hence of price itself, and it also depends on how much leftover capital is divided over a varying number of backers, thus rendering the equilibrium price expression intractable.

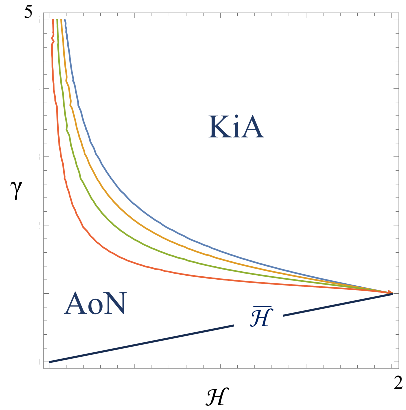

Figure 3.4: Profit-maximizing design choice (and feasibility threshold) for different values of the misappropriation probability η. The value of η for the four different curves, from left to right: $\eta = 0.25, 0.5, 0.75, 1$, where $\eta = 1$ corresponds to the base model.

(b) KiA's relative advantage over AoN decreases in η, that is, $\frac{d}{d\eta}\left(\Pi_K^{\eta*}/\Pi_A^{\eta*}\right) < 0$.

(2) When refunds are guaranteed, $\eta = 0$, KiA weakly outperforms AoN, i.e., $\Pi_K^{\eta*} \geq \Pi_A^{\eta*}$.

Theorem 2, point 1(a), shows that even when considering funds misappropriation to be not as prevalent as in the base model, our main finding that KiA outperforms AoN when the retail potential is large enough continues to hold. Perhaps more surprisingly, point 1(b) in the theorem reveals that KiA's ability to always keep backers' money, even when the goal is not met, does not constitute an advantage of KiA, and in fact, it actually hurts KiA's performance. The extra revenues collected by the entrepreneur when she does not deliver anything to backers do not come as a free lunch, rather, they translate into higher risk for backers — risk of getting nothing in exchange for their pledges. Backers account for it when they decide whether to pledge, and this, in turn, reduces the pledge price they are willing to pay. Our result shows that the lower pledge price outweighs the higher odds of keeping the pledges. This finding allows us to *clearly identify* the higher carry-through probability not only as a necessary advantage of KiA, as done in Proposition 3, but also as a sufficient, and ultimately unique, advantage of KiA relative to AoN.

Point 2 in Theorem 2 shows that, in the extreme case of $\eta = 0$, which means the entrepreneur always refunds backers when she cannot deliver the product, KiA (weakly) outperforms AoN in the entire parameter space. While this is, unfortunately, an overly-optimistic case, it is useful because it shows that the one thing holding KiA back is the possibility of entrepreneurs' misconduct, and the consequent lack of trust backers have in them. Unfortunately, this is a tough problem to solve, since it is intertwined with the still largely immature regulatory framework that surrounds crowdfunding, and with the hands-off stance taken by all major platforms. Nevertheless, identifying the root cause of KiA's under-performance is a first, important step on the path to further improving the KiA design.

4. Additional Extensions

4.1. **Raising funds after a failed AoN campaign.** In the base model we have assumed that, when an AoN campaign fails to meet the goal, the entrepreneur will terminate the project. In this extension, we relax this assumption, and allow the entrepreneur to attempt to raise funds from the bank when the campaign "fails" and the goal is not met. In this scenario, as done per KiA, a lender observes the funds that were pledged at the end of the campaign, $p_A^* x$, infers the size of the crowdfunding market, x, extrapolates the expected size of the retail market, γx, and decides whether to lend the missing money or not. However, there are two important considerations to be made on the difference between AoN and KiA when the goal is not met.

The first consideration is that a lender may be wary of trusting the pledge level of an AoN campaign as a truthful signal of the underlying market. Remember that under AoN, unlike KiA, pledges are refunded to backers when the campaign fails, therefore money does not change hands — the pledge level $p_A^* x$ is not a transaction, but rather a declaration of intent, and this weakens the credibility of the signal (there is extensive research on the intention-behavior gap). It is possible, for example, that some backers decided to pledge on the campaign close to the end date, when it was already clear it would not meet the goal, only to inflate the market signal — it would be costless for them to do so, since their pledges will be refunded. By contrast, in a KiA campaign, backers literally "put their money where their mouth is" because every pledge is a transaction. To account for this difference, we assume that a lender will trust the signal of a failed AoN campaign only with probability β, and will refuse to lend otherwise. We refer to β as signal credibility, and we use superscript β to identify equilibrium actions and profits for this extension.

The second consideration is that, after a failed AoN campaign, refunded backers may not show up in the retail market — they could find a better alternative, run into financial hardship, or simply lose interest, since it may take more than a year before the product is actually developed. Thus, we assume that only a fraction ζ of backers will show up in the retail market. We refer to ζ as backers' retention, and we use superscript ζ to identify equilibrium actions and profits for this extension.

Theorem 3. Profit comparison when AoN can raise funds after a failed campaign

(1) *Partial retention: Suppose $\zeta < 1$ and $\beta = 1$. Then, KiA outperforms AoN if and only if retail potential is large enough. Formally, $Formally, \Pi_K^* > \Pi_A^{\zeta *}$ if and only if $\gamma > \hat{\gamma}^{\zeta}(\mathcal{H})$, where $\hat{\gamma}^{\zeta}(\mathcal{H})$ is decreasing in $\mathcal{H}$, increasing in ζ, and always larger than 1.*

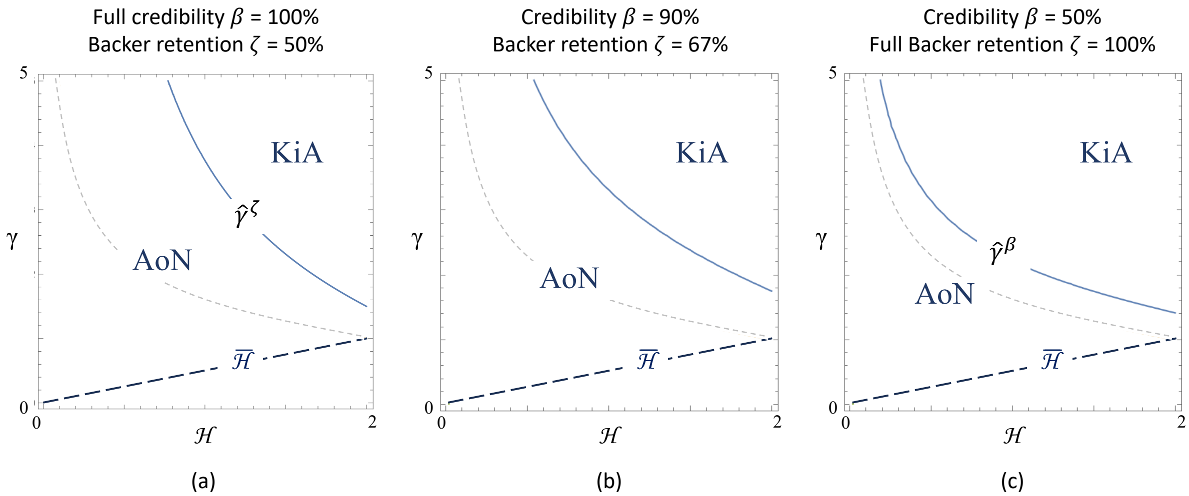

Figure 4.1: Profit-maximizing design choice (and feasibility threshold) for different values of the signal credibility β and backers' retention ζ. *The dashed curve is $\hat{\gamma}$ from Theorem 1 and Figure 3.3, and is plotted to better appreciate the change from the base model.*

(2) *Weak signal credibility: Suppose $\beta < 1$ and $\zeta = 1$. Then, KiA outperforms AoN if and only if retail potential is large enough. Formally, $Formally, \Pi_K^* > \Pi_A^{\beta *}$ if and only if $\gamma > \hat{\gamma}^\beta(\mathcal{H})$, where $\hat{\gamma}^\beta(\mathcal{H})$ is decreasing in $\mathcal{H}$, increasing in β, and always larger than 1.*

Theorem 3 considers two models, one for each of the drawbacks AoN suffers from (relative to KiA) when attempting to raise funds and develop the product after a failed campaign. When some backers do not show up in the retail market, a large enough retail potential makes KiA better than AoN even if one assumes the market signal of a failed AoN campaign is as credible as under KiA (see Figure 4.1, panel a). Similarly, when the market signal of a failed AoN campaign is not as credible as the one of a KiA campaign, a large enough retail potential makes KiA better than AoN even if one assumes that all backers show up in the retail market (see Figure 4.1, panel c). The advantage of KiA is intuitively higher when such drawbacks are stronger, i.e., lower ζ or β. Figure 4.1, panel (b), shows a case where both drawbacks are at work, but are milder. In addition, Theorem 3 states that under both models, a higher crowdfunding hazard rate makes KiA perform better relative to AoN.

Overall, Theorem 3 shows that even when AoN can attempt to raise funds after a failed campaign, our main results continue to hold.

4.2. **Endogenous goal setting.** In the base model, we assumed that the goal of a crowdfunding campaign is set equal to the funds needed, as recommended by all major platforms. In this extension, we let the entrepreneur set a goal in the range $[0, C]$. This helps the AoN design, because it can set a goal lower than what needed, keep the funds, and then attempt to borrow from the bank.

As discussed in Section 2, if launching an AoN campaign with a goal lower than the real funds needed could be done without suffering any adverse consequence, the AoN design would be trivially superior to KiA, because it would be a more general design — one could "obtain" KiA by setting the goal of an AoN campaign equal to zero. However, setting a lower, untruthful goal comes with a host of negative consequences. We will mention two here for brevity, the interested reader will find a more extensive discussion in the Appendix Section B. One is credibility: The goal is defined as the amount needed to complete the project, hence it must be realistic given what the entrepreneur set off to achieve. Nobody would pledge on a campaign to send a rocket to Mars if the goal was just \$1000. Another one is goal-pursuit: Crowdfunding users not only are more likely to fund projects, but also contribute greater amounts of money prior to goal attainment compared to after the goal is reached (?). In short, setting a lower goal hinders fundraising. In the model, we account for this by modifying the amount pledged by backers to be $wp_d^* x$ when the goal is set to wC, with $w \in [0, 1]$, thus recovering the base model when $w = 1$ and the goal is set truthfully to C.[10] We assume that the goal set during the campaign does not affect the dynamics in the retail market.

We use superscript w to identify equilibrium actions and profits for this extension where the goal can be set lower than the funds needed. The next lemma provides the optimal goal for each design.

Lemma 4. Endogenous Goal

- *Under KiA, the optimal goal adjustment is 1, that is,* $w_K^* = 1$.
- *Under AoN, the optimal goal adjustment is* $w_A^* = 1$ *when* $\gamma < 1$*, and* $w_A^* = \max[1/\gamma, \min[1, \hat{w}]]$ *otherwise, where* $\hat{w}$ *is given by*

$$\hat{w} = -\frac{\gamma}{3} + \frac{1}{3}\sqrt{\frac{12}{\mathcal{H}^2} + 6 + \gamma^2}.$$

The KiA design always chooses a true goal, since it gains nothing by choosing a lower one. For the AoN design, when $\gamma < 1$, setting a goal equal to C is optimal, because when the goal is not met, the market state is not promising enough to secure financing from the bank, making a lower goal suboptimal. When $\gamma \geq 1$, by contrast, the entrepreneur may be better off setting a goal lower than the amount needed, to expand the states of the world in which she is allowed to keep the pledges in order to pursue development. Figure 4.2, panel (a), shows the equilibrium goal strategy for the

[10] One could wonder whether AoN might benefit from increasing the goal beyond the amount needed, and why we do not model this. Any benefit of a higher-than-needed goal can be mimicked by KiA without problems by setting the same goal. But a higher-than-needed goal would reduce probability of funding for AoN. And it would not help with moral hazard when KiA beats AoN, that is, when $\gamma > 1$, because AoN does not suffer from moral hazard when $\gamma > 1$. So, increasing the goal of AoN beyond C would be pointless, which is why we only consider lowering the goal.

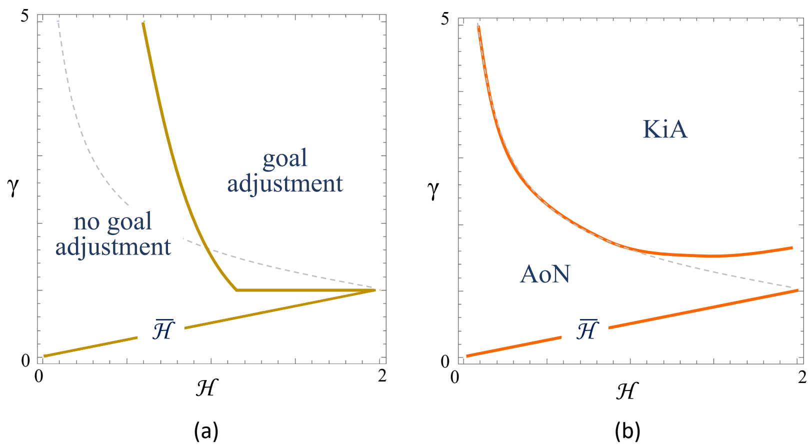

FIGURE 4.2: Optimal goal strategy for the AoN design (panel a) and optimal design choice (and feasibility threshold) when the campaign goal is endogenized (panel b). *The dashed curve in both panels is $\hat{\gamma}$ from Theorem 1 and Figure 3.3, and is plotted to better appreciate the change from the base model.*

AoN design. As it can be garnered from the figure, AoN is better off lowering the goal below C when the goal is hard to reach (high $\mathcal{H}$) and the retail potential is not too low.

The profit of AoN is given by

$$\Pi_A^{w*} = \delta v \mu \left[w_A^* + \gamma - \mathcal{H} - (\gamma + w_A^*) \left(\frac{\mathcal{H}^2 {w_A^*}^2}{4} \right) + \frac{\mathcal{H}^2 w_A^*}{2} \right],$$

where w_A^* is given in Lemma 4. The next theorem shows the optimal design choice, which can once again be plotted solely as a function of $\mathcal{H}$ and γ — see Figure 4.2, panel (b).

Theorem 4. PROFIT COMPARISON WITH ENDOGENOUS GOAL

- *KiA outperforms AoN if and only if the retail potential is large enough. Formally,* $\Pi_K^* > \Pi_A^w$ *if and only if* $\gamma > \hat{\gamma}^w(\mathcal{H})$*, where* $\hat{\gamma}^w(\mathcal{H}) > 1$.
- *When the crowdfunding hazard risk is low enough, the AoN design performs as in the base model. Formally, if* $\mathcal{H} \leq \mathcal{H}^w$*, then* $\Pi_A^w = \Pi_A^*$*, where*

$$\mathcal{H}^w = \frac{2}{\sqrt{1+2\gamma}}.$$

Theorem 4 confirms our main findings from the base model: KiA outperforms AoN when the retail potential is large enough. Figure 4.2, panel (b), illustrates the choice regions as a function of $\mathcal{H}$ and γ, and also depicts with a gray dashed line the border $\hat{\gamma}(\mathcal{H})$ identified in the base model. It can be seen that the comparison is remarkably similar to what seen in the base model, with KiA dominating AoN in the top-right area of the $\mathcal{H} - \gamma$ space. It can also be seen that, as presented in the theorem, the border on which the two designs perform equally well is the same as under the base model, $\hat{\gamma}(\mathcal{H})$, as long as the crowdfunding hazard index is low enough — in this case, the funds needed will be raised most of the times even when the goal is set truthfully, so setting a lower goal is not worth it. Overall, our main findings from the base model are qualitatively confirmed under this extension.

4.3. **Pledge withdrawals.** In the base model from Section 3, backers' decisions about whether to pledge on the campaign or not are final. In practice, many platforms (including Kickstarter and Indiegogo) allow backers to change their mind and withdraw their pledge, provided this is done before the campaign ends. In this section, we relax the base model by allowing backers to check the status of the campaign right before it ends, and to withdraw their pledge if they so wish (the platform refunds their pledge). Specifically, after all pledges have been made, but before the campaign ends, a fraction $1-\phi$ of backers observe the total funds raised by the campaign and independently and simultaneously decide whether to withdraw their own pledge, while the remaining fraction ϕ of backers forget — or is otherwise unable — to do so. The parameter ϕ affects the extent to which backers may decide to withdraw their pledge, and thus subsumes backers' behavior as well as a platform's decisions, for example regarding its withdrawal policy. At one extreme, the case $\phi = 1$ describes a setting in which no withdrawals are allowed and all pledges are considered finals, as in the base model, while at the other extreme, the case $\phi = 0$ describes a setting in which not only the platform allows pledges to be withdrawn before a campaign ends, but all backers punctually verify the status of the campaign shortly before it expires, without exceptions, possibly also thanks to reminders issued by the platform — in short, a frictionless withdrawal process. We call ϕ *withdrawals' friction*. Understanding the role played by ϕ is important, and will allow us to answer two questions: How does the possibility of withdrawals change backers' behavior in the two designs under study? Under what conditions are withdrawals beneficial/harmful for entrepreneurs and for platforms?

We use superscript ϕ to identify equilibrium actions and profits for this extension. The equilibrium solution and discussion can be found in the Appendix Section A. Here, we want to briefly note that the withdrawal option is used by bakers under the KiA design when the funds pledged are low enough, since this makes misappropriation more likely; by contrast, when the retail potential is low enough, no backers withdraw their pledge under the AoN design, because when the goal is not met, refunds are automatic, and when the goal is met, backers prefer to stick with their decision to pledge. In other words, when the retail potential is low enough, the withdrawal decision backers make under the AoN design is contingent on the outcome of the campaign in a way that is perfectly aligned with backers' interest.[11]

Next, we investigate the role played by withdrawal's friction ϕ.

Theorem 5. Impact of Withdrawals' Friction ϕ

As ϕ gets smaller:

- *The price p_A weakly increases, the price p_K strictly increases, and the price ratio p_K/p_A strictly increases.*
- *KiA's relative advantage over AoN increases, that is, $\frac{d}{d\phi}\left(\Pi_K^{\phi*}/\Pi_A^{\phi*}\right) < 0$.*

The first point of Theorem 5 highlights that both designs can charge backers a higher price when withdrawals' friction ϕ is lower. This is because, thanks to withdrawals, backers may take their money back when the funding is low and they expect their money to be misappropriated, and this increases their willingness to pay. This is particularly true for the KiA design, because it always collects all the pledges, and this makes misappropriation more likely. As a consequence, a lower withdrawal friction increases the price under KiA to a larger extent than it does under AoN (Figure 4.3, panels a and b).

The second point of Theorem 5 states that a lower ϕ also makes KiA more profitable relative to AoN. This is the result of two conflicting effects. On the one hand, a lower ϕ means that more customers will withdraw their pledge, and the entrepreneur will collect — hence misappropriate — less money. On the other hand, for the very same reason, backers are willing to pledge more money, as stated in point 1. The net result of these two effects is always an increase in the expected profit for the entrepreneur. The reason is that the entrepreneur would rather get more of backers' money when the crowdfunding market is large enough and the project can be financed, as it happens by allowing withdrawals (remember point 1), as opposed to when the crowdfunding market is too small and the project cannot move forward, as it happens when withdrawals are not allowed, because in the former case the extra money may enable development and allow her to get access to the retail market, while in the latter case it does not. In other words, withdrawals (i.e., a lower ϕ) increase profit of the entrepreneur on average, but decrease it conditional on not attempting development, leading to a higher alignment between the entrepreneur's and backers' payoff as a function of the underlying market state X. This effect is, once again, stronger under KiA, because of the larger role misappropriation has under this design. It is worth noting that such improved alignment is likely beneficial beyond what already observed in our model; for example, in the presence of information

[11]Withdrawals could play a role for other reasons, for example, if users were prone to changing their minds after pledging, but this is outside the scope of our model.

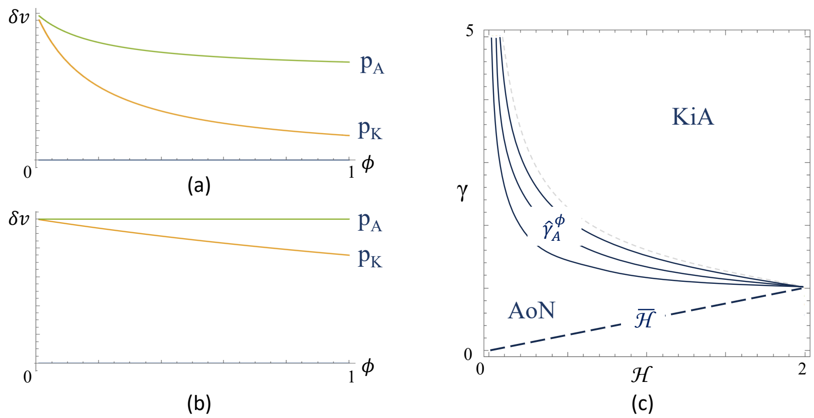

FIGURE 4.3: Pledge prices as a function of withdrawals' friction ϕ, when $\gamma < 1$ (a) and $\gamma \geq 1$ (b), and optimal design choice and feasibility threshold, for different values of withdrawals' friction: From right to left, $\phi = 0.75,\ 0.5,\ 0.25$. *For panel (a) we used $\mathcal{H} = 1$ and $\gamma = 0.6$, for panel (b) we used $\mathcal{H} = 1$ and $\gamma = 2$. In panel (c), the dashed curve in light gray is threshold $\hat{\gamma}$ from Theorem 1, and is plotted to better appreciate the change from the base model.*

asymmetries, the entrepreneur and the backers are more likely to coordinate on an equilibrium that benefits all of them. The effects described in Theorem 5 can be appreciated in Figure 4.3, where, as ϕ decreases (moving from panel a to panel b) the infeasibility area of KiA shrinks and the area in which KiA outperforms AoN grows larger.

The results in Theorem 5 point to the fact that enabling withdrawals and making them as seamless as possible (low ϕ) is clearly advantageous for the entrepreneur. Moreover, it can be shown that it also leads to more funds raised on average and to a higher probability of meeting the funding goal, meaning that a lower ϕ is also in the interest of the platform since this will earn higher profit (platform fees are typically a percentage of the funds collected) and attract more entrepreneurs (a higher success rate of projects hosted on the platform can help attract entrepreneurs and backers alike). Since backers in our model earn zero surplus in equilibrium, this means that a lower ϕ also improves total welfare.

Practical implications for platforms. Our findings are consistent with the rules in place at Indiegogo (and most other platforms), where pledge withdrawals are allowed. However, based on our findings, we can recommend some changes to how withdrawals are currently handled. As of today, a new user who decided to skip the "How It Works" portion of the website, would only learn about the possibility of withdrawals *after* deciding to pledge on a project. Since the main advantage of withdrawals is to encourage users to pledge, not knowing about the possibility of withdrawals until after the decision to pledge has already been made takes away this advantage, and does in fact reduce profit for the entrepreneur. This means the mere existence of a withdrawal option can work in the opposite way than intended. To avoid this, such option should be well advertised, possibly even on the campaign page itself. Moreover, while a user can pledge without verifying her email, he cannot withdraw his pledge, nor contact support, until her email has been verified, something that, as we have experienced ourselves, can take several days. This should also be remedied, as withdrawals should work seamlessly. Finally, backers on the Indiegogo platform are not reminded that a campaign they pledged on is about to end. Our findings suggest that Indiegogo, and crowdfunding platforms in general, should take a more active role in reminding backers that the end of a KiA campaign is approaching. Sending an email 48 hours before the campaign ends would be a simple and cost-effective way, but the platform could go as far as making automated voice phone calls to all backers 24 hours before a campaign ends, much alike many service businesses do these days to remind customers of an upcoming reservation: This would make it safer for backers to pledge, to the benefit of everyone.

4.4. **Development is preferred to misappropriation.** In the base model, we have assumed that the entrepreneur appropriates pledges whenever doing so maximizes her own profit, and in particular, never refunds backers. In Section 3.3.2, we tempered this assumption by making misappropriation probabilistic, thereby allowing refunds. Here, we temper misappropriation in a different way: The entrepreneur attempts development whenever possible, and only misappropriates funds if development is not possible, that is, either because she does not have enough funds, she cannot borrow, or development failed. This preference structure captures anecdotal behavior of entrepreneurs who are obsessed with their product idea to the extent that they intend to pursue it even when, on average, it may not be worth it — possibly due to risk-seeking behavior, or because they derive private benefit from attempting development either by developing a network of contacts, improving their CV, or simply by gaining personal satisfaction. As we are going to discuss, such a small change in the entrepreneur's preferences (for most market realizations, the entrepreneur behaves as in the base model, since development is either not an option, or it is more profitable than pledge misappropriation) has quite a significant impact on the relative feasibility of the two designs under study.

We use superscript D to identify equilibrium actions and profits for this extension where development is preferred to misappropriation. The equilibrium analysis can be found in the Appendix Section A. Here, in the interest of brevity, we present directly the dominance and feasibility results.

Theorem 6. Profit comparison when development is preferred to misappropriation

(1) *The AoN design is feasible in the entire parameter space. The KiA design is feasible if and only if* $\mathcal{H} < \bar{\mathcal{H}}^D$, *where* $\bar{\mathcal{H}}^D$ *is given by*

$$\bar{\mathcal{H}}^D = \frac{\gamma^2 + 2\gamma + 1}{2},$$

and it is always higher (i.e., looser) than $\bar{\mathcal{H}}$ *from Corollary 1.*

(2) *The KiA design outperforms the AoN design if and only if the retail potential is large enough. Formally,* $\Pi_K^D > \Pi_A^D$ *if and only if* $\gamma > \hat{\gamma}^D$.

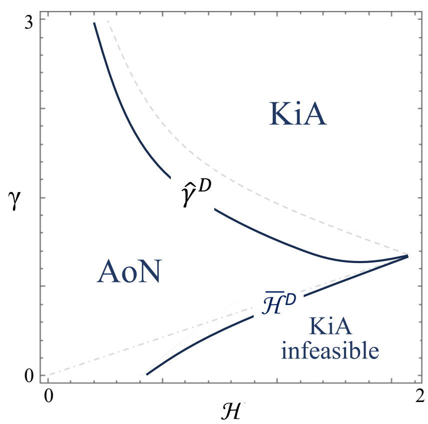

Figure 4.4: Optimal design choice and KiA feasibility threshold when the entrepreneur prefers attempting development to misappropriating pledges. *The dashed curves in light grey are* $\hat{\gamma}$ *from Theorem 1 and* $\bar{\mathcal{H}}$ *from Corollary 1, and are plotted to better appreciate the change from the base model.*

Theorem 6 states that the AoN design is *always* feasible, while the KiA design *is not*. This is quite a strong departure from the base model from Section 3, in which both designs were infeasible under the same conditions. When development is preferred to misappropriation, the AoN design is a much safer bet for backers, as in this case, they either enable the entrepreneur to attempt development (the goal is met) or get their money back (the goal is not met). By contrast, the KiA design still suffers from an infeasibility problem. The reason is that, by construction, the KiA design enables the entrepreneur to keep any money pledged on the campaign, and this may not be enough to finance development, or even enable bank financing. The entrepreneur may attempt to sweeten the deal by lowering the pledge price, but doing so can be a double-edged sword. On the one hand, backers are more willing to pledge because less money is demanded from them. On the other hand, if each backer is pledging less money, less funds will be raised in total, thus reducing the probability that the project is ultimately financed, making it more likely that backers will lose their money and receive nothing. The result of these effects is a downward pressure on the pledge price, which must be lowered to entice backers into pledging because, due to price reductions, the risk that the project will not be financed has increased. In short, somewhat paradoxically, one could say that the pledge price must be lowered because it's too low. When $\mathcal{H}$ is too high, this dynamic leads to a self-reinforcing downward spiral on the pledge price, and as a result, there exists no price, no matter how low, that makes backers willing to pledge under the KiA design.

To summarize, on the one hand, this extension allows us to uncover an important difference between the two designs in terms of feasibility — KiA is more prone to infeasibility than AoN — while on the other hand, it confirms once again that the KiA design outperforms AoN when retail potential is large enough, especially when the crowdfunding hazard rate is large.

4.5. **Beyond AoN and KiA: Seed&Spark.** In recent years, we have begun to see new ideas and design changes being implemented by crowdfunding platforms, with the objective to deter entrepreneurial misconduct (**?**) but also improve crowdfunding outcomes. So, while our paper focuses on the comparison between the two most popular designs, AoN and KiA, we want to say a few words about a design that has been developed in relatively recent times.

Specifically, the platform Seed&Spark has been employing a campaign design in which the campaign is successful — the entrepreneur can collect backers' pledges — even when the goal is not met, as long as at least 80% of the goal has been raised. This design is interesting for two reasons. First, the very existence of such a campaign design, where the provision point is decoupled from (and set lower than) the goal of the campaign, speaks to the fact that the goal of the campaign is more than just a provision point, and setting it too low comes with negative implications, as already discussed in Section 4.2 (if it wasn't so, the design employed at Seed&Spark would have no reason to exist, as lowering the goal of an AoN design would achieve the same thing). Second, this design seemingly attempts to strike a middle ground between AoN and KiA: on the one hand, it allows partially financed projects to move forward, as KiA does, on the other hand, it offers some protection for backers by requiring a minimum threshold of funding below which pledges are refunded, as AoN does. A few years ago, the Seed&Spark crowdfunding platform reportedly achieved some of the highest funding rates (percentage of campaigns that are successful) ever registered by a crowdfunding platform: a noteworthy 75%, compared to Kickstarter's rate for film projects of around 43% (**?**). We will refer to the design employed at Seed&Spark as the SS design. In such a design, the entrepreneur will collect backers' pledges as long as at least yC is raised on the campaign, where $y \in (0, 1)$ is the *minimum goal completion* set by the platform. Since this is the same for all campaigns (at Seed&Spark, this is $y = 0.8$), we will consider y exogenous for the purpose of studying SS's performance on a single campaign, though we'll also discuss what the optimal y would be for a given campaign. The next theorem compares the dominance region of the SS design when compared to the AoN design and to the KiA design. We break ties by letting AoN and KiA be preferred to SS due to their design simplicity.

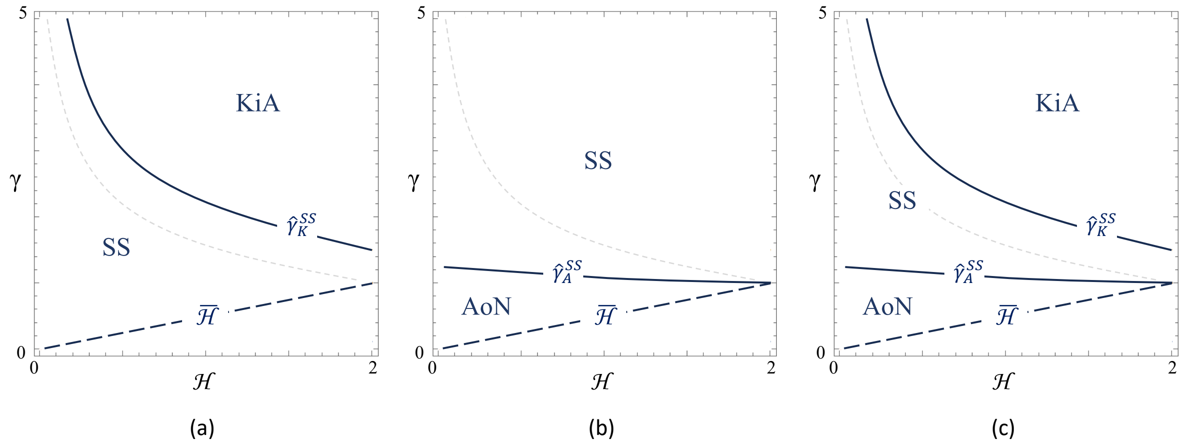

FIGURE 4.5: Optimal design choice between SS and KiA (panel a), between SS and AoN (panel b), and three-way comparison of SS, AoN, and KiA. *For the SS design, the value of the goal completion level, y, has been set to 80%.*

Theorem 7. SS DESIGN: PROFIT COMPARISON AND OPTIMAL GOAL COMPLETION

- *The set of parameters in which SS outperforms KiA is larger than the set in which AoN outperforms KiA, for any* $y \in (0, 1)$.
- *The set of parameters in which SS outperforms AoN is larger than the set in which KiA outperforms AoN, for any* $y \in (0, 1)$.
- *In a three-way comparison among SS, AoN, and KiA, for any* $y \in (0, 1)$, *there exist two thresholds,* $\hat{\gamma}_A^{SS}(y)$ *and* $\hat{\gamma}_K^{SS}(y)$, *such that the optimal design choice is AoN when* $\gamma \leq \hat{\gamma}_A^{SS}(y)$; *it is SS when* $\hat{\gamma}_A^{SS}(y) < \gamma < \hat{\gamma}_K^{SS}(y)$; *and it is KiA when* $\gamma \geq \hat{\gamma}_K^{SS}(y)$.
- *For any given campaign with* $\gamma > 1$, *the optimal goal completion level for the SS design is equal to* $y^* = 1/\gamma$. *At the optimal goal completion level, the SS design strictly dominates both AoN and KiA.*

Theorem 7 is best discussed with the help of Figure 4.5. The first two points in the theorem are illustrated in panels (a) and (b) respectively: There, we can appreciate how swapping the SS design with either of the two basic designs, AoN or KiA, *always* reduces the dominance region of the design it is compared with, for any value of $y \in (0, 1)$. This means the SS design is a solid competitive choice for a platform that aims to attract entrepreneurs, if that platform intends to focus on a single design, as most crowdfunding platforms choose to do. This is a rather strong result, and it is best explained by noting that the SS design shares some of the characteristics of AoN (it cannot always collect the funds pledged) but also some of KiA (it can collect the pledges even when the goal is not met), and this gives it a competitive advantage on a 1-to-1 comparison. This is best explained with an analogy, in which crowdfunding designs are political parties, with the right wing and left wing party being AoN and KiA, and where entrepreneurs are voters. If either party (AoN or KiA) were to be replaced by SS, which would be a center-left or center-right party, then SS would get more votes than the party it replaced, because being a moderate party, it would be politically closer to the party it competes with, and is thus in a better position to attract voters from either of them.

The third point shows that in a three-way comparison, the SS design outperforms both AoN and KiA for projects with an intermediate retail potential. This can be seen in Figure 4.5, panel (c), where SS is the optimal choice for an intermediate range of retail potential, which is very wide when the crowdfunding hazard rate is small.[12] This is consistent with the fact that Seed&Spark is a platform with a high project success rate, which corresponds to a low crowdfunding hazard index $\mathcal{H}$.

The fourth point of Theorem 7 states that for any given campaign with retail potential higher than 1, if the goal completion level y is set optimally at $1/\gamma$, SS strictly dominates both AoN and KiA. The reason is that in this case, SS can raise funds in all states in which development is worth attempting, and refunds backers in all states in which misappropriation would happen. A clear limitation of SS, as employed at Seed&Spark, is that the platform sets the same goal completion level for all campaigns. A possible explanation is that having a different goal completion level for each campaign could be quite confusing for the average backer. Given this, it is quite interesting to observe that the optimal goal completion level is simply the inverse of retail potential; and even more interesting to observe that the optimal goal completion level does not depend on any other project characteristic, such as project budget, development probability, product valuation, or expected crowdfunding market size. This means that setting the optimal goal completion level for SS does not need any complex formula, and it can work near-optimally for a lot of different campaigns even if set to be the same for all of them, as long as they share a similar retail potential — and this might just be what Seed&Spark is doing.[13] Overall, the study of the SS design shows that this is quite a promising design, especially for platforms focusing on a single design, or that host campaigns with similar retail potentials.

[12]Figure 4.5 plots SS for a completion rate of 80%, the one used at Seed&Spark, but this observation holds true in general.

[13]Of course, there could be other reasons for why goal completion has been set at that level that go beyond our model. For example, it is conceivable that allowing entrepreneurs to collect pledges when a low fraction of the goal has been raised could fuel fears in backers that their money will be wasted in a project that will never be financed, and this would quickly become a self-fulfilling prophecy. Ours is just a first step on a longer journey to understand all the implications and limitations of the optimal use of the SS design.

5. Concluding Remarks

When it comes to comparing existing crowdfunding campaign designs, there currently is a gap between academic theory and real-world practices, with the former praising AoN as the superior designs, and the latter having witnessed both KiA and AoN being employed for well over a decade. Our work aims to fill this gap and help entrepreneurs navigate the current choices in the crowdfunding world. On the one hand, our results caution entrepreneurs on the use of the KiA design, which can allocate excessive risk on backers, and in so doing, cripple fundraising, or even doom a campaign to failure. On the other hand, our results clearly identify an unexplored advantage of the KiA design — the possibility to increase financing and carry-through probability by unlocking third–party financing — which leads to a higher expected profit than that of the AoN design, for campaigns with a large retail potential that are unlikely to raise all the funds they need via crowdfunding alone. We also identify that what holds KiA back in terms of performance is entrepreneurs' misconduct: Without it, KiA would always outperform AoN. Our many extensions confirm the robustness of our results, the importance of allowing pledge withdrawals to further boost the performance of KiA, and the surprising effectiveness of the relatively recent design employed at Seed&Spark, even when it cannot be optimized on a per-campaign basis.

Our analysis is based on a parsimonious model and, as such, rests on simplifying assumptions that have been made to preserve tractability and ease the exposition — we discuss some of them below.

We assume that the only cost of accessing bank financing is the interest charged by the bank, but there could be other costs, including red tape, which may be country-specific. Predictably, the advantage of the KiA design would be diminished if bank financing was more costly or less accessible than what assumed in our model.

In our model, consumers and the entrepreneur have the same information on the crowdfunding market size distribution. An alternative approach would be one in which both have the same prior information, and consumers form a posterior belief conditional on their own existence in the market (**?**). This latter approach would result in the entrepreneur being more pessimistic on the odds of their project being financed compared to consumers, which may not be too realistic, the entrepreneur being often the most optimistic person about the success of her own project. One way to reconcile the latter approach with the one used in the paper is to note that crowdfunding entrepreneurs are often times consumers of their own product, and for this reason may share the same expectation on the market size distribution.

Our model abstracts away from platform fees, since these are relatively small (typically 5% of the funds raised plus processing fees) and unlikely to change our results as long as their magnitude is similar across the two designs studied.

There are many questions around crowdfunding design that still remain unanswered and are worth pursuing. For example, in our model consumers' valuation of the product is known to them, however, it is possible that consumers may face uncertainty with respect to their valuation for a product, if such product is of a kind never seen before; moreover, backers in our model pledge simultaneously, but in reality, backers pledge sequentially, and it is possible that different designs may be affected differently by these characteristics which are currently not present in our model. It is also possible that different designs may induce different effort on the part of the entrepreneur or backers to advertise the campaign. We leave these as promising directions of investigation for future research.

We conclude with two observations. Our analysis reveals that KiA is not inferior to AoN, and in fact can outperform AoN in some cases. While the KiA design is employed by some of the largest rewards-based crowdfunding platforms in the world (e.g., Indiegogo and GoFundMe) its adoption is not as common as that of the AoN design. In light of our findings, one possible explanation could be the fact that crowdfunding platforms are often compared to one another based on the average success rate of the campaigns they host, that is, on the percentage of campaigns that reach their goal. Our results show that everything else being equal, a KiA campaign meets its goal with a lower probability compared to an AoN campaign (Corollary 1) and moreover, that KiA outperforms AoN for those campaigns that have a low likelihood of meeting the goal to begin with (i.e., high $\mathcal{H}$, see Figure 4.3). Thus, it is possible that the adoption of KiA in the crowdfunding world may have been hindered by the bad publicity (in terms of lower % of campaigns that reach their goal) that it might bring to a platform that decided to employ it.

Our work is just a first step towards a better understanding of crowdfunding designs. We hope our results will rekindle the discussion on the relative merits of existing designs, which we believe has been prematurely called off, and inspire others to devise new campaign designs, like the one employed by the Seed&Spark platform, to harness the full power of this innovative business model.

References

Appendix A. Proofs

Proof of Proposition 1

It is shown in the body of the paper. Profit expressions are obtained using $\mathcal{H} = C(\delta v\mu)^{-1}$ with simple algebraic manipulations.

Proof of Lemma 1

When the crowdfunding market is x, the bank would need to lend $C - xp_K$, which decreases in x, and may receive in expectation up to $\delta\gamma xv$ (i.e., it can be paid back at most the profit accrued at time 2), which increases in x. This means that, upon lending, the bank can break even in expectation if and only if $x \geq \hat{x}_K$, where the state $\hat{x}_K$ solves $C - \hat{x}_K p_K = \delta\gamma\hat{x}_K v$. Therefore, the financing decision of the bank follows a threshold strategy, where the bank lends $C - xp_K$ if and only if backers pledge at least $\hat{z}$, where $\hat{z} = \hat{x}_K p_K = Cp_K(p_K + \delta v\gamma)^{-1}$.

Proof of Lemma 2

Upon raising $p_K x$ and therefore observing x, the entrepreneur has a choice. If she does not invest, she gets $p_K x$. If she invests, the entrepreneur gets $\delta vx\gamma$ in expectation, which is the value generated by attempting development (since the bank breaks even by the competitive lending market assumption) minus the money borrowed from the bank, which is $C - p_K x$. In short, the choice is between $p_K x$ on one hand, and $\delta vx\gamma - (C - p_K x)$ on the other. So the net benefit of investing, rather than misappropriating the funds, is $\delta vx\gamma - C$. Hence, borrowing and attempting development is undertaken when $x > C(\delta v\gamma)^{-1} \triangleq \hat{x}_K$.

Proof of Proposition 2

The price under KiA is the highest one that satisfies $p_K \leq \delta\, v\Phi_{\text{KiA}}$, meaning $p_K^* = \delta v\frac{2\mu - \hat{x}_{\text{KiA}}}{2\mu} = \delta v - C(2\mu\gamma)^{-1}$. It follows that $p_K^* \leq 0$ (KiA unfeasible) whenever $2\delta v\mu\gamma < C$, or equivalently $\mathcal{H} > 2\gamma$. The profit expression is obtained from $\Pi_{\text{K}}^* = \int_0^{\hat{x}_{\text{KiA}}} \left[p_K^* x\right](2\mu)^{-1} dx + \int_{\hat{x}_{\text{KiA}}}^{2\mu} \left[-C + p_K^* x + \delta vx\gamma\right](2\mu)^{-1} dx$ substituting $\mathcal{H} = C(\delta v\mu)^{-1}$.

***Proof of Corollary* 1**

It follows directly from Propositions 1 and 2, from (3.11), and the fact that $\Phi_K^* \leq 1$.

Proof of Lemma 3

Π_{A}^* can be written as $\delta v\mu\left[1 + \gamma - \mathcal{H} - \frac{\mathcal{H}^2}{4}(\gamma - 1)\right]$. Since $\Pi_{\text{K}}^* = \delta v\mu\left[1 + \gamma - \mathcal{H} - \frac{1}{\gamma}\left(\frac{\mathcal{H}}{2} - \frac{\mathcal{H}^2}{4}\right)\right]$, their ratio is only a function of $\mathcal{H}$ and γ.

Proof of Theorem 1

The profit of the two designs are best rewritten as

$$\Pi_{\text{A}}^* = \delta v\mu\left[1 + \gamma - \mathcal{H}\right] - \Delta_{AoN}\delta v\mu\frac{\mathcal{H}^2}{4}(\gamma - 1)$$

$$\Pi^*_{\mathrm{K}} = \delta v\mu\left[1+\gamma-\mathcal{H}\right] - \Delta_{KiA}\delta v\mu\frac{1}{\gamma}\left(\frac{\mathcal{H}}{2}-\frac{\mathcal{H}^2}{4}\right)$$

where $\Delta_{AoN} = \delta v\mu\frac{\mathcal{H}^2}{4}(\gamma-1)$ and $\Delta_{KiA} = \delta v\mu\frac{1}{\gamma}\left(\frac{\mathcal{H}}{2}-\frac{\mathcal{H}^2}{4}\right)$. Clearly, KiA outperforms AoN if and only if the ratio between Δ_{KiA} and Δ_{AoN} is less than 1. Note also that when $\gamma < 1$we have $\Delta_{KiA} > 0 > \Delta_{AoN}$, so clearly KiA can outperform AoN only if $\gamma > 1$, which we hereafter assume. So,

$$\begin{aligned}
\frac{\frac{1}{\gamma}\left(\frac{\mathcal{H}}{2}-\frac{\mathcal{H}^2}{4}\right)}{\frac{\mathcal{H}^2}{4}(\gamma-1)} &< 1\\
\frac{1}{\gamma}\left(\frac{\mathcal{H}}{2}-\frac{\mathcal{H}^2}{4}\right) &< \frac{\mathcal{H}^2}{4}(\gamma-1)\\
\frac{1}{2}-\frac{\mathcal{H}}{4} &< \frac{\mathcal{H}}{4}\gamma(\gamma-1)\\
\frac{1}{2}-\frac{\mathcal{H}}{4} &< \frac{\mathcal{H}}{4}\gamma^2-\frac{\mathcal{H}}{4}\gamma\\
0 &< \frac{\mathcal{H}}{4}\gamma^2-\frac{\mathcal{H}}{4}\gamma+\frac{\mathcal{H}}{4}-\frac{1}{2}\\
0 &< \mathcal{H}\gamma^2-\mathcal{H}\gamma+\mathcal{H}-2
\end{aligned}$$

Whose solution is $\gamma > \frac{1}{2}+\sqrt{\frac{2}{\mathcal{H}}-\frac{3}{4}}$, the other root being negative. It is easy to verify that when this holds, KIA is feasible.

Proof of Proposition 3

For the first point, we know that $\hat{x}_{AoN} = \mu\mathcal{H}$ and that $\hat{x}_{KiA} = \frac{\mu\mathcal{H}}{\gamma}$, so we can derive the financing probability of both designs as $\Phi^*_A = \frac{2\mu-\hat{x}_{AoN}}{2\mu} = \frac{2\mu-\mu\mathcal{H}}{2\mu} = 1-\frac{\mathcal{H}}{2}$ and $\Phi^*_K = \frac{2\mu-\hat{x}_{KiA}}{2\mu} = \frac{2\mu-\frac{\mu\mathcal{H}}{\gamma}}{2\mu} = 1-\frac{\mathcal{H}}{2\gamma}$. Hence $\Phi^*_K > \Phi^*_{\mathrm{A}}$ if and only if $\gamma > 1$.

The second point also follows from Φ^*_K being increasing in γ, while Φ^*_A is not a function of γ.

The third point follows from Theorem 1, the first point of this proposition, and by noting that $\frac{1}{2}+\sqrt{\frac{2}{\mathcal{H}}-\frac{3}{4}} > 1$ when $0 < \mathcal{H} < 2$.

The fourth point is obtained by taking the limit of Φ^*_K and Φ^*_A.

Proof of Theorem 2

Equilibrium outcome for the All-or-Nothing design (AoN). Here, we solve for the subgame perfect Nash Equilibrium of the game that starts at time 1, for the subgame in which the entrepreneur chooses to employ the AoN design for her crowdfunding campaign.

Similar to the base model, we now distinguish between two cases: (i) $\gamma > 1$ and (ii) $\gamma \leq 1$.

(i) When $\gamma > 1$, in the base model, development is always worth doing and there is no stealing. Therefore, even if we introduce η, which makes stealing probabilistic, there will be still no stealing. So, this case in unchanged, and the profit remains the same:

$$\Pi^\eta_A|_{\gamma>1} = \int_{H\mu}^{2\mu}\left(-Hv\mu+\mu v(1+\gamma)x\right)\frac{1}{2\mu}dx.$$

Integrating out and simplifying the expression delivers:

$$\Pi_A^\eta|_{\gamma>1} = -\frac{1}{4}(H-2)\mu v(\gamma(H+2)-H+2).$$

(ii) When $\gamma < 1$, the case is more nuanced.

Let us suppose that the state needed to reach the goal is lower than the state needed to make development worth it, i.e. $p_A^\eta > v\gamma$. So that it can happen that we meet the goal but we don't have the market that is large enough to make development worth it, so that stealing can happen. Consumers pledge if the expected surplus is non-negative, and the entrepreneur extracts all the surplus from the consumers, which translates into the following equation for the consumer surplus equal to zero:

$$\int\limits_{C/p_A^\eta}^{C/(\gamma v)} -p_A^\eta \frac{1}{2\mu} x + \int\limits_{C/(\gamma v)}^{2\mu} (-p_{\text{A}}^\eta + v)\frac{1}{2\mu}(x)\,\mathrm{d}x = 0$$

which delivers the optimal pledge price $p_A^\eta = \frac{v(\gamma C\delta\eta - C + 2\gamma\delta\mu v)}{C\eta - C + 2\gamma\delta\mu v}$. Using the expression for C via H ($C = Hv\mu$) , we obtain the alternative expression for the optimal pledge price: $p_A^\eta = \frac{v(2\gamma+\gamma\eta H-H)}{2\gamma+\eta H-H}$. The feasibility condition $H < 2\gamma$ again ensures that $p_A^\eta > 0$, so there is no change in feasibility condition under this extension as compared to the base model.

Let us write down the expected profit of the entrepreneur:

$$\Pi_A^\eta|_{\gamma\le 1} = \int_{Hv\mu/p_A^\eta}^{H\mu/\gamma} \frac{x(v(2\gamma+\gamma\eta H-H))}{2\gamma+\eta H-H}\eta\frac{1}{2\mu}dx + \int_{H\mu/\gamma}^{2\mu}\left(x\cdot\frac{v(2\gamma+\gamma\eta H-H)}{2\gamma+\eta H-H} - Hv\mu + vx\gamma\right)\frac{1}{2\mu}dx.$$

Integrating the above delivers the final expression for the expected profit of the entrepreneur:

$$\Pi_A^\eta|_{\gamma\le 1} = \frac{\mu v(H-2\gamma)\left(-8\gamma^3(\gamma+1)+(\gamma-1)(\eta-1)H^3(2\gamma\eta-1)-2\gamma H^2(\gamma(2\eta-3)(\gamma\eta-1)+\eta-1)-4\gamma^2 H((\gamma+3)\gamma\eta-3\gamma-1)\right)}{4\gamma^2(2\gamma+(\eta-1)H)(2\gamma+H(\gamma\eta-1))}.$$

Equilibrium outcome for the Keep-it-All design (KiA). Here, we solve for the subgame perfect Nash Equilibrium of the game that starts at time 1, for the subgame in which the entrepreneur chooses to employ the KiA design for her crowdfunding campaign.

Let $\hat{x}$ be the market size needed for development to be worth doing. We assume that $\hat{x}$ is no larger than the highest possible state 2μ (so, $\frac{C}{\nu\mu} < 2\mu$ or $H < 2\gamma$, where $H \triangleq \frac{C}{\mu v}$.), otherwise crowdfunding will never result in development of the project.

Consumers pledge only if their expected surplus is non-negative, and the price that the entrepreneur sets is such that it squeezes all the surplus from the consumers. If the market realization

$x$is such that it is lower than $\hat{x}$, then consumer gets $\eta(0-p_K^\eta)+(1-\eta)\cdot 0=-\eta p_K^\eta$; if the market realization $x$is larger or equal than $\hat{x}$, then the consumer's surplus is $v-p_K^\eta$. Therefore the expected consumer surplus is given by LHS of the below:

$$\int_0^{C/(\gamma v)} -\eta p_K^\eta \frac{1}{2\mu}\mathrm{d}x + \int_{C/(\gamma v)}^{2\mu} \left(v-p_K^\eta\right)\frac{1}{2\mu}\mathrm{d}x = \int_0^{H\mu/\gamma} -\eta p_K^\eta \frac{1}{2\mu}\mathrm{d}x + \int_{H\mu/\gamma}^{2\mu} \left(v-p_K^\eta\right)\frac{1}{2\mu}\mathrm{d}x = 0. \tag{A.1}$$

Solving the above delivers $p_K^\eta = \frac{v(2\gamma-H)}{2\gamma+\eta H-H}$.

The expression for the optimal price confirms that the feasibility condition remains unchanged under this extension as compared to the base model. In particular, as long as $H<2\gamma$, KiA is feasible.

The expected profit is given by the following expression:

$$\Pi_K^\eta = \int_0^{H\mu/\gamma} \left(\eta\cdot p_K^\eta + (1-\eta)\cdot 0\right)\frac{1}{2\mu}\mathrm{d}x + \int_{H\mu/\gamma}^{2\mu} \left(-H\mu v + p_K^\eta\cdot x + \gamma v\cdot x\right)\frac{1}{2\mu}\mathrm{d}x \tag{A.2}$$

We plug in the expression for the optimal price into the above and obtain:

$$\Pi_K^{\eta^*} = \int_0^{H\mu/\gamma} \left(\eta\cdot\frac{v(2\gamma-H)}{2\gamma+\eta H-H}\right)\frac{1}{2\mu}\mathrm{d}x + \int_{H\mu/\gamma}^{2\mu} \left(-H\mu v + \frac{v(2\gamma-H)}{2\gamma+\eta H-H}\cdot x + \gamma v\cdot x\right)\frac{1}{2\mu}\mathrm{d}x$$

Straightforward integration and algebraic manipulations deliver the final expression for the optimal profit under KiA:

$$\Pi_K^{\eta^*} = \frac{\mu v(H-2\gamma)\left(-4\gamma^2(\gamma+1)+(\gamma-1)(\eta-1)H^2-2\gamma^2(\eta-2)H\right)}{4\gamma^2(2\gamma+(\eta-1)H)}.$$

Profit comparison for $\eta=0$. We split the analyses into two cases.

(i) If $\gamma>1$, then the below confirms that under $\eta=0$ KiA is strictly dominated by AoN.

The profit ratio of KiA to AoN in this case is given by

$g(\gamma)=\frac{(-1)(2\gamma-H)\left(-4\gamma^2(\gamma+1)+(\gamma-1)(\eta-1)H^2-2\gamma^2(\eta-2)H\right)}{\gamma^2(2\gamma+(\eta-1)H)(-1)(H-2)(\gamma(H+2)-H+2)}$

which for $\eta=0$ reduces to

$g(\gamma)=\frac{(2\gamma-H)(-1)\left(-4\gamma^2(\gamma+1)-(\gamma-1)H^2+4\gamma^2H\right)}{\gamma^2(2\gamma-H)(-1)(H-2)(\gamma(H+2)-H+2)}$

Simplifying

$g(\gamma)=\frac{-4\gamma^2(\gamma+1)-(\gamma-1)H^2+4\gamma^2H}{\gamma^2(H-2)(\gamma(H+2)-H+2)}=\frac{4\gamma^3-4\gamma^2H+4\gamma^2-(1-\gamma)H^2}{4\gamma^3-4\gamma^2H+4\gamma^2-\gamma^2(\gamma-1)H^2}=\frac{4\gamma^3-4\gamma^2H+4\gamma^2+(\gamma-1)H^2}{4\gamma^3-4\gamma^2H+4\gamma^2+\gamma^2(1-\gamma)H^2}$

Let $\Delta(\gamma) = 4\gamma^3 - 4\gamma^2 H + 4\gamma^2$. Here, $\Delta(\gamma) = 4\gamma^3 - 4\gamma^2 H + 4\gamma^2 = 4\gamma^2(\gamma + 1 - H) > 0\ \forall\gamma > 1$ and $H < 2$.

Then $g(\gamma) = \frac{\Delta(\gamma)+(\gamma-1)H^2}{\Delta(\gamma)+\gamma^2(1-\gamma)H^2}$.

Since $(\gamma-1)H^2 > 0$ and $\gamma^2(1-\gamma)H^2 < 0$, for $\forall\gamma > 1$, therefore, $g(\gamma) = \frac{\Delta(\gamma)+(\gamma-1)H^2}{\Delta(\gamma)+\gamma^2(1-\gamma)H^2} > 1$ $\forall\gamma > 1$.

(ii) If $\gamma \leq 1$, then the below confirms that under $\eta = 0$ KiA delivers the same profit as AoN.

The profit ratio of KiA to AoN in this case is given by

$g(\gamma) = \frac{\left(-4\gamma^2(\gamma+1)+(\gamma-1)(\eta-1)H^2-2\gamma^2(\eta-2)H\right)(2\gamma+H(\gamma\eta-1))}{(-8\gamma^3(\gamma+1)+(\gamma-1)(\eta-1)H^3(2\gamma\eta-1)-2\gamma H^2(\gamma(2\eta-3)(\gamma\eta-1)+\eta-1)-4\gamma^2 H((\gamma+3)\gamma\eta-3\gamma-1))}$

which for $\eta = 0$ reduces to

$g(\gamma) = \frac{\left(-4\gamma^2(\gamma+1)+(\gamma-1)(-1)H^2-2\gamma^2(-2)H\right)(2\gamma-H)}{(-8\gamma^3(\gamma+1)+(\gamma-1)H^3-2\gamma H^2(3\gamma-1)+4\gamma^2 H(3\gamma+1))}$.

Expand the numerator of $g(\gamma)$ as follows:

$\left(-4\gamma^2(\gamma+1) + (\gamma-1)(-1)H^2 - 2\gamma^2(-2)H\right)(2\gamma - H) =$

$-8\gamma^4 + 12\gamma^3 H - 8\gamma^3 - 6\gamma^2 H^2 + 4\gamma^2 H + \gamma H^3 + 2\gamma H^2 - H^3$

Expand the denominator of $g(\gamma)$ as follows:

$-8\gamma^3(\gamma+1) + (\gamma-1)H^3 - 2\gamma H^2(3\gamma-1) + 4\gamma^2 H(3\gamma+1) =$

$-8\gamma^4 + 12\gamma^3 H - 8\gamma^3 - 6\gamma^2 H^2 + 4\gamma^2 H + \gamma H^3 + 2\gamma H^2 - H^3$

Hence $g(\gamma) = 1$.

Profit comparison for $\eta > 0$. In what follows we show that profit ratio of KiA to AoN decreases in η.

We split the analyses into two cases.

(i) If $\gamma > 1$, then the profit ratio of KiA to AoN is given by

$g(\eta) = \frac{(-1)(2\gamma-H)\left(-4\gamma^2(\gamma+1)+(\gamma-1)(\eta-1)H^2-2\gamma^2(\eta-2)H\right)}{\gamma^2(2\gamma+(\eta-1)H)(-1)(H-2)(\gamma(H+2)-H+2)}$

and $g'_\eta(\eta) = \frac{2H(H-2\gamma)^2}{\gamma(H-2)(2(\gamma+1)+(\gamma-1)H)(2\gamma+(\eta-1)H)^2} < 0$ because the numerator is positive $(2H(H-2\gamma)^2 > 0)$ and the denominator is negative $((2\gamma+(\eta-1)H)^2 > 0, (H-2) < 0\ \forall H < 2$ and $(2(\gamma+1)+(\gamma-1)H) > 0\ \forall\gamma > 1$ and $H > 0)$. Therefore, the profit ratio $g(\eta)$ decreases in η $\forall\gamma > 1$.

(ii) If $\gamma < 1$, then the profit ratio of KiA to AoN is given by

$g(\eta) = \frac{(H-2\gamma)\left(-4\gamma^2(\gamma+1)+(\gamma-1)(\eta-1)H^2-2\gamma^2(\eta-2)H\right)}{(-8\gamma^3(\gamma+1)+(\gamma-1)(\eta-1)H^3(2\gamma\eta-1)-2\gamma H^2(\gamma(2\eta-3)(\gamma\eta-1)+\eta-1)-4\gamma^2 H((\gamma+3)\gamma\eta-3\gamma-1))}$.

Take the derivative of this expression with respect to η. The denominator is always non-negative. The numerator is a quadratic function of η: $\alpha\eta^2 + \beta\eta + \zeta$. We will consider α, β, ζ separately and will show that they are all non-positive.

Consider $\alpha = \gamma H^3(H-2\gamma)\left(4(\gamma+1)\gamma^4 + (\gamma-1)^2 H^2 - 2\left(\gamma^2+\gamma-2\right)\gamma^2 H\right)$. The expression in the brackets is a quadratic function of H. Given $\gamma \in (0,1)$, it is always non-negative. Hence, given $H < 2\gamma$, we have $\alpha \leq 0$.

Consider now $\beta = -2\gamma H^2(H-2\gamma)^2\left((\gamma-1)H-2\gamma^2\right)((\gamma-1)H-2\gamma(\gamma+1))$. Clearly, it is non-positive.

Finally, consider $\zeta = \gamma H(H-2\gamma)^3((\gamma-1)H-2\gamma)((\gamma-1)H-2\gamma(\gamma+1))$. It is also non-positive given that $\gamma < 1$ and $H < 2\gamma$.

Comparing the performance of KiA and AoN for $\gamma < 1$. Let us now show that, if $\gamma < 1$, then AoN beats Kia all the time. That is: $\frac{\Pi_K^\eta}{\Pi_A^\eta|_{\gamma<1}} < 1 \ \forall \gamma < 1$.

Denote the profit ratio $\frac{\Pi_K^\eta}{\Pi_A^\eta|_{\gamma<1}}$ by $g(\gamma)$. Substituting the expressions for the profits into the ratio delivers:

$$g(\gamma) = \frac{\frac{\mu v(H-2\gamma)\left(-4\gamma^2(\gamma+1)+(\gamma-1)(\eta-1)H^2-2\gamma^2(\eta-2)H\right)}{4\gamma^2(2\gamma+(\eta-1)H)}}{\frac{\mu v(H-2\gamma)\left(-8\gamma^3(\gamma+1)+(\gamma-1)(\eta-1)H^3(2\gamma\eta-1)-2\gamma H^2(\gamma(2\eta-3)(\gamma\eta-1)+\eta-1)-4\gamma^2 H((\gamma+3)\gamma\eta-3\gamma-1)\right)}{4\gamma^2(2\gamma+(\eta-1)H)(2\gamma+H(\gamma\eta-1))}}.$$

Note, that as long as $0 < H < 2$, $0 \leq \eta \leq 1$, $0 < \gamma < 1$, $H < 2\gamma$, then $2\gamma + (\eta-1)H > 0$.

Simplifying the above, we obtain:

$$g(\gamma) = \frac{\left(-4\gamma^2(\gamma+1)+(\gamma-1)(\eta-1)H^2-2\gamma^2(\eta-2)H\right)(2\gamma+H(\gamma\eta-1))}{\left(-8\gamma^3(\gamma+1)+(\gamma-1)(\eta-1)H^3(2\gamma\eta-1)-2\gamma H^2(\gamma(2\eta-3)(\gamma\eta-1)+\eta-1)-4\gamma^2 H((\gamma+3)\gamma\eta-3\gamma-1)\right)}$$

In what follows we show that the above expression is always < 1.

When $\eta \to 0$ it is equal to 1. When $\eta \to 1$ it is equal to $1 - \frac{2\gamma H}{H^2(1-\gamma)-2H(1-\gamma^2)+4\gamma(1+\gamma)}$ which is smaller than 1 because $H^2(1-\gamma) - 2H(1-\gamma^2) + 4\gamma(1+\gamma)$ is positive on $H < 2\gamma$ (evaluate this expression at $H = 2\gamma$ to obtain $8\gamma^2 > 0$ and also find its minimum $H = 1+\gamma > 2\gamma$ since $\gamma < 1$). We now know that the original expression is decreasing in η. Also there are no points where this function is discontinuous – the denominator of the function is always strictly negative under our range of parameters. To see that, notice that the denominator is a quadratic function of η with coefficients: $-2\gamma H^2\left((1-\gamma)H + 2\gamma^2\right) < 0$ (in front of η^2); $-H(2\gamma - H)\left(2(\gamma+3)\gamma^2 + \left(1+\gamma-2\gamma^2\right)H\right) < 0$ (in front of η); and $-(H-2\gamma)^2((1-\gamma)H + 2\gamma(\gamma+1)) < 0$.

Comparing the performance of KiA and AoN for $\gamma > 1$. Let us now show that, if $\gamma > 1$, then for a large enough γ, KiA beats AoN and otherwise AoN betas Kia. That is: $\exists \bar{\gamma} > 1 : \frac{\Pi_K^\eta}{\Pi_A^\eta|_{\gamma>1}} > 1$ $\forall \gamma > \bar{\gamma}$, and otherwise $\frac{\Pi_K^\eta}{\Pi_A^\eta|_{\gamma>1}} < 1$.

Denote the profit ratio $\frac{\Pi_K^\eta}{\Pi_A^\eta|_{\gamma>1}}$ by $g(\gamma)$. Substituting the expressions for the profits into the ratio delivers:

$$g(\gamma) = \frac{\mu v(H-2\gamma)\left(-4\gamma^2(\gamma+1)+(\gamma-1)(\eta-1)H^2-2\gamma^2(\eta-2)H\right)}{4\gamma^2(2\gamma+(\eta-1)H)} / (-\tfrac{1}{4})(H-2)\mu v(\gamma(H+2)-H+2)$$

Simplifying the above, we obtain:

$$g(\gamma) = \frac{(H-2\gamma)\left(-4\gamma^2(\gamma+1)+(\gamma-1)(\eta-1)H^2-2\gamma^2(\eta-2)H\right)}{\gamma^2(2\gamma+(\eta-1)H)(-1)(H-2)(\gamma(H+2)-H+2)}.$$

In what follows we show that $\exists \bar{\gamma} > 1$ such that $\forall \gamma > \bar{\gamma}$ we have $g(\gamma) > 1$, and otherwise $g(\gamma) < 1$.

First, evaluate profit ratio at $\gamma = 1$ which yields $\frac{2(2-H)+H\eta}{2(2-H)+2H\eta} < 1$ (given that $0 < H < 2$ and $0 < \eta < 1$). Taking the limit of the profit ratio at $\gamma \to \infty$ yields $\frac{4}{4-H^2} > 1$. Now compare profit ratio to 1. After algebraic simplification this is equivalent to comparing $4\gamma^2\eta - (\gamma-1)\left(\gamma^2+1\right)(\eta-$

$1)H^2 - 2\gamma H\left(\gamma^3 - \gamma^2 + \gamma + \eta - 1\right)$ with 0. We will show that there is only one root such that $\gamma > 1$. Substitute $\gamma = t + 1$. Obtain:

$$-2Ht^4 + t^3\left((1-\eta)H^2 - 6H\right) + t^2\left(4\eta - 2(\eta-1)H^2 - 8H\right) + t\left(8\eta - 2(\eta-1)H^2 - 2H(\eta+2)\right) + 2\eta(2-H).$$

Then we need to show that there is only one root such that $t > 0$. We will use Descartes' rule of sign to determine the number of real zeros of this polynomial of t. The sign of the coefficients in front of t^4 and t^3 is negative. Also, $2\eta(2-H) > 0$. We will show that it is never possible that the sign in front of t^2 is positive while the sign in front of t is negative. From that it will follow that there is only one change of signs of the coefficients and thus there exists only one such root that $t > 0$, which is equivalent to showing that there is only one root such that $\gamma > 1$ – profit ratio intersects 1 only once. To show the above rewrite the coefficient in front of t^2 as $\alpha = 2H^2(1-\eta) - 8H + 4\eta$. Similarly rewrite the coefficient in front of t as $\beta = 2H^2(1-\eta) - 2H(\eta+2) + 8\eta$. Then $\beta - \alpha = 2H(2-\eta) + 4\eta > 0$. Hence, $\beta > \alpha$. Then if $\alpha > 0$ it must be that $\beta > 0$ and hence it is not possible that simultaneously $\alpha > 0$ and $\beta < 0$. This completes the proof.

Proof of Theorem 3

We develop this model with two possible sources of cost. Since having both makes the model intractable, in the end we have to isolate either cost to hope to get some analytical result. We assume that (i) some backers are lost in the retail market. After a failed campaign, only a fraction ζ of backers will buy the product in the retail market. And that (ii) AoN signal is less credible. After a failed campaign, with a probability of $1-\beta$, the bank will choose not to finance the project regardless of the signal observed in the failed campaign.

When AoN fails the goal, the entrepreneur can decide to raise money from the bank to sell the product to the retail market plus the fraction ζ of backers. After observing a market signal x, the expected profit from investing C into the project is then $-C + \delta(vx\gamma + \zeta vx)$. So the bank will finance the project (and the entrepreneur will borrow) if and only if the retail market will at least repay the loan. The lowest state in which the bank is willing to finance the project x_b is one for which the retail market will barely repay the loan: $\delta v x_b(\zeta + \gamma) = H\delta v\mu$, so $x_b = \frac{H\mu}{\gamma+\zeta}$. Here, x_b is always lower than the market size needed to make development worth when backers have already pledged: $x_b < \hat{x} = \frac{H\mu}{\gamma}$.

The market size needed to hit the goal is same as in the base model, $H\mu$. We now distinguish between two cases: (i) $\gamma \leq 1$ and (ii) $\gamma > 1$.

Case (i): $\gamma \leq 1$. In this case, the goal is not enough to justify investment, we need a higher x than that. Yet, after failing the goal, it may be worth investing since now some backers will also buy. This happens if the goal is enough to justify investment when selling to some backers and retail, or (assume funding is available): $-C + \delta v x|_{=\frac{C}{p_A}}(\gamma + \zeta) > 0$. Paradoxically, feasibility might be higher than in the base model. When β is high and ζ is also high, failing to meet the goal might make it worth developing because now both backers and retailers will buy.

The pledge price in this case is the same as in the base model, since when goal is not met, backers are refunded, so for them the game is not different (the only equilibrium in pure strategies is, once again, all backers pledging, as long as waiting does not yield a higher surplus, which is impossible since surplus in retail market is zero).

So the profit is, meet the goal and raise enough to get NPV> 0 and develop, or, fail to meet the goal, but raise enough to make it worth develop when some backers also will buy the product, and if the bank lends, borrow and develop. In math, this is:

$$\Pi_A^* = \int_{\frac{H\mu}{\gamma}}^{2\mu} (x(\delta v) - H\delta v\mu + \delta x\gamma v)\frac{1}{2\mu}dx + \beta\int_{\frac{H\mu}{\gamma+\zeta}}^{H\mu} (-H\delta v\mu + \delta v x(\zeta+\gamma)\frac{1}{2\mu}dx$$

Which is equivalent to:

$$\Pi_A^* = \frac{1}{4}\delta\mu v\left(4(\gamma+1) + \frac{H^2(\gamma(\gamma+\zeta-1)(\beta\gamma(\gamma+\zeta-1)+1)-\zeta)}{\gamma^2(\gamma+\zeta)} - 4H\right).$$

Now, let us show that KiA can not beat AoN when $\gamma \leq 1$.

The profit gap between Kia and Aon is given by
$g(\gamma) = (\delta v\mu)\left[(\gamma + \frac{H^2}{4\gamma} - \frac{H}{2\gamma} - H + 1) - \frac{1}{4}\left(4(\gamma+1) + \frac{H^2(\gamma(\gamma+\zeta-1)(\beta\gamma(\gamma+\zeta-1)+1)-\zeta)}{\gamma^2(\gamma+\zeta)} - 4H\right)\right] = (\delta v\mu)f(\gamma)$,
where $\delta v\mu > 0$ and let
$f(\gamma) = (\gamma + \frac{H^2}{4\gamma} - \frac{H}{2\gamma} - H + 1) - \frac{1}{4}\left(4(\gamma+1) + \frac{H^2(\gamma(\gamma+\zeta-1)(\beta\gamma(\gamma+\zeta-1)+1)-\zeta)}{\gamma^2(\gamma+\zeta)} - 4H\right)$.
Simplify $f(\gamma)$ as follows:
$f(\gamma) = -\frac{H\left(2\gamma(\gamma+\zeta)+\gamma H\left(\beta\gamma(\gamma+\zeta-1)^2-1\right)+\zeta(-H)\right)}{4\gamma^2(\gamma+\zeta)}$.

We need to show that $g(\gamma) < 0$ if $0 < H < 2$, $0 < \gamma \leq 1$, $H < 2\gamma$, $0 < \zeta < 1$, and $0 < \beta < 1$. To show this, in what follows we will prove that $f(\gamma) < 0$ on $0 < \gamma \leq 1$.

(a) To show that $f(\gamma) = -\frac{H\left(2\gamma(\gamma+\zeta)+\gamma H\left(\beta\gamma(\gamma+\zeta-1)^2-1\right)+\zeta(-H)\right)}{4\gamma^2(\gamma+\zeta)}$ is negative, it is enough to show that the numerator of this expression $H\left(2\gamma(\gamma+\zeta)+\gamma H\left(\beta\gamma(\gamma+\zeta-1)^2-1\right)+\zeta(-H)\right)$ is negative. We take out $H > 0$ and work with the remaining expression denoted by $r(\gamma,\eta,\beta,H)$ and given by $r(\gamma,\eta,\beta,H) = 2\gamma(\gamma+\zeta)+\gamma H\left(\beta\gamma(\gamma+\zeta-1)^2-1\right)+\zeta(-H)$. We isolate two special cases ($\eta = 1$ and $\beta = 1$) and show for each that $r(\gamma,\eta,\beta,H) < 0$.

Consider the first special case. Simplify $r(\gamma,\eta,\beta,H)$ and evaluate at $\eta = 1$ to get:

$r(\gamma, 1, \beta, H) = \gamma(H - 2\gamma) + (H - 2\gamma) + (-1)\beta H\gamma^4$.

Recall that $H < 2\gamma$ for feasibility. Hence, the expression $r(\gamma, 1, \beta, H)$ is always negative. Which means that, in the first special case, the profit gap is always less than 0 when $\gamma \leq 1$.

Consider the second special case. Simplify $r(\gamma, \eta, \beta, H)$ and evaluate at $\beta = 1$ to get:

$r(\gamma, \eta, 1, H) = -2\gamma^2 - 2\gamma\zeta + \gamma^4(-H) - 2\gamma^3\zeta H + 2\gamma^3 H - \gamma^2\zeta^2 H + 2\gamma^2\zeta H - \gamma^2 H + \gamma H + \zeta H$.

This expression increases in H because $r'_H(\gamma, \eta, 1, H) = -\gamma^4 + 2\gamma^3(1-\zeta) + \gamma^2\left(-\zeta^2 + 2\zeta - 1\right) + \gamma + \zeta > 0$ on $0 < \gamma \leq 1$, $0 < \zeta < 1$. (This is because is a concave quadratic function of ζ which is positive and has a positive derivative at $\zeta = 0$, furthermore, at $\zeta = 1$ it becomes $1 + \gamma - \gamma^4 > 0$). Now, evaluate this expression at $H = 2\gamma$. $r(\gamma, \eta, 1, 2\gamma) = -\frac{\gamma^2(\gamma+\zeta-1)^2}{H}$ which is clearly negative. Hence, $r(\gamma, \eta, 1, H)$ is negative on $H \in (0, 2\gamma), 0 < \gamma \leq 1$, $0 < \zeta < 1$. Which means that, in the second special case, the profit gap is always less than 0 when $\gamma \leq 1$.

This completes the proof of the fact that KiA can not beat AoN when $\gamma \leq 1$.

Case (ii): $\gamma > 1$.

When $\gamma > 1$, as in the base model, if we conjecture that meeting the goal means development is worth it, i.e., $\frac{C}{p_A} > \frac{C}{\delta v\gamma}$, we find that the pledge price is equal to δv, and under this pledge price, the conjecture holds iff $\gamma > 1$, because the conjecture translates into $\frac{C}{\delta v} > \frac{C}{\delta v\gamma}$. Thus, price is $v\delta$, hence the goal is $\frac{H}{\mu}$. When the campaign is unsuccessful, $x < \frac{H}{\mu}$, so the expected profit for this range of market size is $\beta\int_{\frac{H\mu}{\gamma+\zeta}}^{H\mu}(-H\delta v\mu + \delta v x(\zeta+\gamma))\frac{1}{2\mu}dx$, which can be simplified to $\frac{\beta\delta H^2\mu v(\gamma+\zeta-1)^2}{4(\gamma+\zeta)}$. We now group $\delta\mu v$ out to obtain $\delta\mu v\frac{\beta\left(H^2(\gamma+\zeta-1)^2\right)}{4(\gamma+\zeta)}$, which is always positive because the bank will surely not finance when the signal is less than $\frac{H\mu}{\gamma+\zeta}$. We put together all states and obtain the AoN profit when $\gamma > 1$: $\Pi^*_A(\gamma) = \int_{H\mu}^{2\mu}(x(\delta v) - H\delta v\mu + \delta x\gamma v)\frac{1}{2\mu}dx + \frac{\beta\delta\mu v\left(H^2(\gamma+\zeta-1)^2\right)}{4(\gamma+\zeta)}$. Integrating out leads to $\Pi^*_A(\gamma) = \frac{\left(2\mu^2 - \frac{H^2\mu^2}{2}\right)(\gamma\delta v + \delta v) - \delta H\mu v(2\mu - H\mu)}{2\mu} + \delta\mu v\frac{\beta\left(H^2(\gamma+\zeta-1)^2\right)}{4(\gamma+\zeta)}$ Now, group $\delta\mu v$ out to obtain: $g(\gamma) \equiv \frac{\Pi^*_A(\gamma)}{\delta\mu v} = \frac{\beta H^2(\gamma+\zeta-1)^2}{4(\gamma+\zeta)} + \frac{1}{2}\left((\gamma+1)\left(2 - \frac{H^2}{2}\right) - H(2-H)\right)$.

Let us show that when $\gamma \geq 1$, KiA beats AoN when γ is large enough. The profit ratio of KiA to AoN is given by $g(\gamma) = \frac{(\gamma+\zeta)(H-2\gamma)(H-2(\gamma+1))}{\gamma(4(\gamma+1)(\gamma+\zeta)+H^2(\beta(\gamma+\zeta-1)^2-\gamma(\gamma+\zeta)+\gamma+\zeta)-4H(\gamma+\zeta))}$. We start from the general model but then zoom in on the two special cases: $\zeta = 1$ and $\beta = 1$. The denominator of this expression is positive. Therefore showing that $g(\eta) > 1$ for large enough γ is equivalent to showing that the numerator minus denominator of $g(\gamma)$ is bigger than zero for large enough γ. Numerator minus denominator is simplified to the following function: $s(\gamma, H, \beta, \zeta) = H\left(H\left(\zeta - \gamma\left(\beta(\gamma+\zeta-1)^2 - \gamma(\gamma+\zeta) + \gamma + \zeta - 1\right)\right) - 2(\gamma+\zeta)\right)$. This function is in the form $-aH + bH^2$, where $a < 0$. So the function is zero when $H = 0$, then decreases, and either keeps decreasing or goes up and eventually goes into positive. Therefore, KiA beats AoN if and only if H is large enough. Now, evaluate $s(\gamma, H, \beta, \zeta)$ at $\gamma = 1$: $s(1, H) = H\left((-1)\beta\zeta^2 H + \zeta(H-2) + (H-2)\right)$, which is always negative. This proves that profit ratio is less than 1 when $\gamma = 1$.

Now consider two special cases mentioned above. Then, we equate $s(\gamma, H, \beta, \zeta)$ to zero, so that profit ratio is equal to 1. We do this for each special case, starting with $\beta = 1$. $s(\gamma, H, 1, \zeta) = \gamma^2\left(H^2 - \zeta H^2\right) + \gamma\left(-\zeta^2 H^2 + \zeta H^2 - 2H\right) + \zeta H^2 - 2\zeta H$, this is a quadratic function of γ; it is convex and since at $\gamma = 0$ it's value is negative ($\zeta H^2 - 2\zeta H = H\zeta(H-2) < 0$), it has one positive and one negative root. Also, $s(1, H, 1, \zeta) = H\left(\zeta^2(-H) + \zeta(H-2) + H - 2\right) < 0$. So, clearly, on $\gamma > 1$, $s(\gamma, H, 1, \zeta)$ crosses zero only once when γ is large enough, and such γ is larger than 1.

Consider the second special case: $\zeta = 1$. $s(\gamma, H, \beta, 1) = \gamma^3 H^2(1-\beta) - \gamma(2H) + H(H-2)$. This is a 3rd degree expression with no second degree term. When $\gamma = 0$, it is clearly negative. The derivative at $\gamma = 0$ is negative. As γ increases, eventually the third degree term, which is the only positive term, becomes prevalent and the function shoots up. Also $s(1, H, \beta, 1) = -H(\beta H - 2H + 4) < 0$. So, clearly, this crosses zero only once when γ is large enough, and such γ is larger than 1.

We have proven that KiA beats AoN when γ is large enough in either model. Such threshold γ is larger than 1.

Proof of Lemma 4 and Theorem 4

One could argue that AoN might benefit from increasing the goal. Any benefit of higher goal can be mimicked by KiA without problems. A higher goal would reduce probability of funding for AoN. And would not help with moral hazard when KiA beats AoN, that is, when $\gamma > 1$, because AoN does not suffer from moral hazard when $\gamma > 1$. So, it would be pointless. Therefore, we only consider lowering the goal.

In this extension, when setting the goal to wC, pledges are reduced from $p_A x$ down to $wp_A x$, on account of all the goal-related effects discussed in the paper.

Under the new base model, when AoN lowers the goal, it can increase the probability that funds are stolen. Specifically, when the true-goal stat, $\frac{C}{p_A}$, is lower than development state, $\frac{C}{\delta v \gamma}$, lowering the goal to less than C does no good to AoN, since it adds stealing probability, which in the best case is neutral, and reduces pledges due to goal-related effects. Thus, when $\gamma < 1$, optimal goal is the true funds needed C since a higher goal would only increase stealing, hence (weakly) reduce profit.

So, our analysis from the base model should change only when $\gamma > 1$, which is the relevant part. Here, it could make sense for the entrepreneur to lower the goal, but never so low to collect funds in states lower than $\frac{C}{\delta v \gamma}$ (this would add stealing without increasing carry-through probability, hence would be bad). This means when $\gamma > 1$, there is no stealing. Let $wC \in [0, C]$ be the goal chosen by the entrepreneur, with $w \in [0,1]$. If $\frac{wC}{\delta v}$, which is the lowest funding state (state in which funds are collected), can never be less than $\frac{C}{\delta v \gamma}$, which is the lowest investing state (because again, this would induce stealing), this means that w must be no less than $\frac{1}{\gamma}$. Ok, so we know that $\frac{1}{\gamma} \leq w^* \leq 1$ *(condition 1).*

Assume $\gamma > 1$ since this is the only relevant case. Goal met, hence develop, so there is no stealing, hence pledge price is δv. The AoN profit is given by $\Pi_A^* = \int_{w(\frac{H\delta v \mu}{\delta v})}^{2\mu} (x(\delta v)w - H\delta v\mu + \delta x \gamma v)\frac{1}{2\mu}dx$, which can be further simplified to $\Pi_A^* = \frac{\left(2\mu^2 - \frac{1}{2}H^2\mu^2 w^2\right)(\gamma\delta v + \delta v w) - \delta H\mu v(2\mu - H\mu w)}{2\mu}$.

We must find optimal goal w^*. First, notice that AoN profit is concave in w because second derivative of the profit with respect to w is given by $\frac{-H^2\mu^2(\gamma\delta v + \delta v w) - 2\delta H^2\mu^2 v w}{2\mu}$ which can be further simplified to $\frac{\delta\left(-H^2\right)\mu^2 v(\gamma + 3w)}{2\mu}$ which is clearly negative. Therefore, we will use first order conditions to find a potential optimal w. The derivative of the AoN profit with respect to w is given by $\frac{1}{4}\delta\mu v\left(H^2\left(-2\gamma w - 3w^2 + 2\right) + 4\right)$. This is a quadratic concave function of w, which at $w = 0$ is positive, therefore, it has two roots: one negative and one positive. The positive root is equal to $\frac{\sqrt{\gamma^2 H^4 + 6H^4 + 12H^2} - \gamma H^2}{3H^2}$ and is the potential optimal w. It is indeed optimal if it lies within the boundaries provided by *condition 1* from above: $\frac{1}{\gamma} \leq w^* \leq 1$. Which means $w^*(H,\gamma) = \max\{\frac{1}{\gamma}, \min\{1, w(H,\gamma)\}\}$, where $w(H,\gamma) = \frac{\sqrt{\gamma^2 H^4 + 6H^4 + 12H^2} - \gamma H^2}{3H^2} \equiv -\frac{\gamma}{3} + \frac{1}{3}\sqrt{\frac{12}{H^2} + 6 + \gamma^2}$. (In the main body of the paper we denote this value by $\hat{w}$.)

Explore the properties of $w(H,\gamma)$. (1) Take a derivative of $w(H,\gamma)$ with respect to γ and simplify to obtain the expression: $\frac{1}{3}\left(\frac{\gamma H^2}{\sqrt{(\gamma^2+6)H^4 + 12H^2}} - 1\right)$. Factor out $\frac{1}{3}$ to obtain $\frac{\gamma H^2}{\sqrt{(\gamma^2+6)H^4+12H^2}} - 1$. Given $0 < H < 2$ and $\gamma > 0$, this expression is negative, because $\frac{\gamma H^2}{\sqrt{(\gamma^2+6)H^4+12H^2}} - 1 < 0$ iff $\gamma H^2 < \sqrt{\left(\gamma^2+6\right)H^4 + 12H^2}$ iff $\gamma^2 H^4 < \left(\gamma^2+6\right)H^4 + 12H^2$ iff $0 < 6H^4 + 12H^2$, which holds true for $H > 0$. Thus, $w(H,\gamma)$ degreases in γ on $0 < H < 2$ and $\gamma > 0$. (2) Take a derivative of $w(H,\gamma)$ with respect to H and simplify to obtain the expression: $-\frac{4}{H\sqrt{H^2((\gamma^2+6)H^2+12)}}$, which is is clearly negative on $0 < H < 2$ and $\gamma > 0$. Thus, $w(H,\gamma)$ degreases in H on $0 < H < 2$ and $\gamma > 0$. (3) Recall that $w^*(H,\gamma) = \max\{\frac{1}{\gamma}, \min\{1, w(H,\gamma)\}\}$, where $w(H,\gamma) = \frac{\sqrt{\gamma^2 H^4 + 6H^4 + 12H^2} - \gamma H^2}{3H^2}$. Since $w(H,\gamma)$ degreases in H (shown in point 2), there exist two threshold values on H: $H_1(\gamma)$ and $H_2(\gamma)$; where $H_2(\gamma)$ is such that $\forall H < H_2(\gamma)$: $w^*(H,\gamma) = 1$ and $H_1(\gamma)$ is such that $\forall H > H_1(\gamma)$: $w^*(H,\gamma) = \frac{1}{\gamma}$. Let us find the exact values of these thresholds. $H_1(\gamma)$ solves $w(H,\gamma) = 1$. Substitute for w to obtain: $\frac{\sqrt{\gamma^2 H^4 + 6H^4 + 12H^2} - \gamma H^2}{3H^2} = 1$ which is equivalent to $\sqrt{H^2\left(\left(\gamma^2+6\right)H^2 + 12\right)} - (\gamma+3)H^2 = 0$ since $H > 0$. Let $t = H^2 > 0$ to obtain $\sqrt{t\left(\left(\gamma^2+6\right)t + 12\right)} - (\gamma+3)t = 0$, solving for t and getting back to H yields $H = \frac{1}{\sqrt{2\gamma+1}} \equiv H_1(\gamma)$. Note that $H_1(\gamma)$ decreases in γ. $H_2(\gamma)$ solves $w(H,\gamma) = \frac{1}{\gamma}$. Substitute for w to obtain: $\frac{\sqrt{\gamma^2 H^4 + 6H^4 + 12H^2} - \gamma H^2}{3H^2} = \frac{1}{\gamma}$ which is equivalent to $-\gamma^2 H^2 + \gamma\sqrt{H^2\left(\gamma^2 H^2 + 6H^2 + 12\right)} - 3H^2 = 0$. Let $t = H^2 > 0$ to obtain $\gamma\sqrt{t\left(\gamma^2 t + 6t + 12\right)} = t(3 + \gamma^2)$, solving for t and getting back to H yields $H = \frac{2\gamma}{\sqrt{3}} \equiv H_2(\gamma)$. Note that $H_2(\gamma)$ increases in γ. Further, $H_1(\gamma) = H_2(\gamma) = \frac{2}{\sqrt{3}}$ if $\gamma = 1$.

Given point (3) from above, we now can slice up the (H, γ) space (for $\gamma \geq 1$) into three regions. A "left" region where $w^* = 1$ (here, $H < H_1(\gamma)$), a middle region where $w^* = w(H, \gamma) = \frac{\sqrt{\gamma^2 H^4 + 6H^4 + 12H^2} - \gamma H^2}{3H^2} \in (\frac{1}{\gamma}, 1)$ (here, $H_1(\gamma) < H < H_2(\gamma)$), and a "right" region, where $w^* = \frac{1}{\gamma}$ (here, $H > H_2(\gamma)$). The profit gap between KiA and AoN is given by (where we factored out $\mu v \delta$ as this multiplicative term does not impact the ensuing analyses): $r(H, \gamma) = \frac{(H-2\gamma)(H-2(\gamma+1))}{4\gamma} - \frac{1}{2}\left((\gamma + w^*)\left(2 - \frac{H^2 (w^*)^2}{2}\right) - H(2 - Hw^*)\right)$, where $w^* = w^*(H, \gamma)$. In what follows, we analyze region by region and show that, for each region KiA beats AoN iff $\forall \gamma > \bar{\gamma} > 1$, where the value for $\bar{\gamma}$ is specific to each region.

Since the left region is the same as the base model, we know that KiA beats AoN iff γ is large enough and such a threshold $\bar{\gamma}$ is strictly larger than 1. Now, let us show that this also holds true for the right region. In the right region, the profit gap between KiA and AoN is given by $r(H, \gamma) = \frac{(H-2\gamma)(H-2(\gamma+1))}{4\gamma} - \frac{1}{2}\left(\left(\gamma + \frac{1}{\gamma}\right)\left(2 - \frac{H^2}{2\gamma^2}\right) - H\left(2 - \frac{H}{\gamma}\right)\right)$ which can be simplified as $\frac{4(\gamma-1)\gamma^2 + H^2 - 2\gamma^2 H}{4\gamma^3}$. This is a quadratic function of H, it is convex in H and is equal to $\frac{4(\gamma-1)}{\gamma} > 0$ (for $\gamma > 1$) when evaluated at $H = 0$. It has two positive roots: one equal to 2γ and the other equal to $2\gamma(\gamma - 1)$. The function turns positive and stays positive indefinitely for any γ that is larger than the largest of the two roots. Hence $\exists \bar{\gamma} \equiv \max\{2\gamma, 2\gamma(\gamma-1)\} > 1$ (because $\gamma > 1$), such that $\forall \gamma > \bar{\gamma}$ profit difference between KiA and AoN is positive. Finally, since with these analyses we focus on the case of $\gamma > 1$, and $r(H, 1) = \frac{1}{4}(H-2)H < 0$ (because $H < 2$), then for $\forall \gamma < \bar{\gamma}$ profit difference between KiA and AoN is negative.

Last, consider the middle region and consider the difference between the KiA and AoN profits:

$$\frac{(H-2\gamma)(H-2(\gamma+1))}{4\gamma} - \frac{1}{2}\left((w(H,\gamma) + \gamma)\left(2 - \frac{1}{2}H^2 w(H,\gamma)^2\right) - H(2 - Hw(H,\gamma))\right),$$

where $w(H, \gamma) = \frac{\sqrt{\gamma^2 H^4 + 6H^4 + 12H^2} - \gamma H^2}{3H^2}$. This difference is negative at $\gamma = 1$ and is positive when $\gamma \to \infty$. The derivative with respect to γ has the following form after algebraic simplification: $\frac{-2\gamma^2\left(\gamma\sqrt{H^2((\gamma^2+6)H^2+12)} - 6\right) + \left(2\gamma^4 + 6\gamma^2 - 9\right)H^2 + 18H}{36\gamma^2}$. We will show that the profit difference increases with γ for all $\gamma > 1$. Thus, we need to show that $-2\gamma^2\left(\gamma\sqrt{H^2\left(\left(\gamma^2+6\right)H^2+12\right)} - 6\right) + \left(2\gamma^4 + 6\gamma^2 - 9\right)H^2 + 18H > 0$ for $\gamma > 1$. Rewrite this inequality as follows:

$$12\gamma^2 + 2\gamma^4 H^2 + 6\gamma^2 H^2 - 9H^2 + 18H > 2\gamma^3\sqrt{H^2\left(\left(\gamma^2+6\right)H^2+12\right)}$$

Notice that the left-hand-side is positive since $18H > 9H^2$ for $H \in (0, 2)$. Then square the left- and right-hand side and simplify the inequality as follows:

$$8\gamma^4\left((H+2)H^2+2\right)+12\gamma^2(2-H)H\left(H^2+2\right)+9(2-H)^2H^2>0.$$

Notice that all the coefficients in this polynomial are positive. Hence, trivially, this inequality is true. Thus, we showed that the profit difference increases in γ for $\gamma > 1$; and since the profit difference is negative at $\gamma = 1$ and positive at $\gamma \to +\infty$; then there $\exists\bar{\gamma} > 1$ such that KiA beats AoN iff $\gamma > \bar{\gamma}$. This finishes the proof.

Proof of Theorem 5

Consider AON, $\gamma \geq 1$. When the goal is met, development is worth it. So, if the goal is met, entrepreneur develops, which is what backers want. No reason to withdraw then (if the goal is met). If goal is not met, backers are refunded, so withdrawal option cannot change the outcome. So, in this case nothing changes compared to the base model. The AoN profit is given by $\Pi_A^* = \int_{H\mu}^{2\mu}(x(\delta v) - H\delta v\mu + \delta x\gamma v)\frac{1}{2\mu}dx = -\frac{1}{4}\delta(H-2)\mu v(\gamma(H+2) - H + 2)$.

Consider AON, $\gamma < 1$. If the goal is not met, backers are refunded, so withdrawal option cannot change the outcome. If the goal is met, entrepreneur may steal or may develop. If pledge level is not large enough to warrant development, backers are better off withdrawing their pledge if they do not forget to do so. So the expected surplus of a backer is the sum of: (i) if $x < \frac{C}{p_A}$, then 0 (refund), (ii) if $\frac{C}{p_A} < x < \frac{C}{\delta v\gamma}$, then $-p_A\phi$ (refund if you remember, else you lose your pledge), (iii) if $x > \frac{C}{\delta v\gamma}$, then $\delta\cdot(v - p_A)$ (get the product if development works out), and (iv) if $x > \frac{C}{\delta v\gamma}$, then $(1-\delta)\cdot(-p_A)$ (lose money if development fails). We replace C with $H\delta v\mu$, integrate over each state, and sum those up to obtain the following: $-\frac{\mathrm{pA}\phi\left(\frac{\delta H\mu v}{\gamma\delta v}-\frac{\delta H\mu v}{\mathrm{pA}}\right)}{2\mu}-\frac{(1-\delta)\mathrm{pA}\left(2\mu-\frac{\delta H\mu v}{\gamma\delta v}\right)}{2\mu}+\frac{\delta(v-\mathrm{pA})\left(2\mu-\frac{\delta H\mu v}{\gamma\delta v}\right)}{2\mu}=0$. By solving for p_A we obtain the optimal pledge price: $p_A = \frac{\delta v(2\gamma+\gamma H\phi-H)}{2\gamma+H\phi-H}$. This implies that, for $\gamma < 1$ as long as $H < 2\gamma$, AoN is always feasible. The AoN profit is given by the sum of (i) if $x < \frac{C}{p_A}$, then 0 (get nothing), (ii) if $\frac{C}{p_A} < x < \frac{C}{\delta v\gamma}$, then $p_A x\phi$ (get money of those who forget to withdraw), (iii) if $x > \frac{C}{\delta v\gamma}$, then $\delta\cdot(p_A x - C + v\gamma x)$ (get pledges, invest, get retail profit), and (iv) if $x > \frac{C}{\delta v\gamma}$, then $(1-\delta)\cdot(p_A x - C)$ (get pledges, invest, fail, keep the money). We replace C with $H\delta v\mu$, and pledge price with the optimal pledge price, integrate over each state, and sum those up to obtain the following: $\Pi_A^* = \int_{\frac{\delta H\mu v}{\frac{\delta v(2\gamma+\gamma H\phi-H)}{2\gamma+H\phi-H}}}^{\frac{H\mu}{\gamma}}\left(\frac{x\phi(\delta v(2\gamma+\gamma H\phi-H))}{2\gamma+H\phi-H}\right)\frac{1}{2\mu}dx + \int_{\frac{H\mu}{\gamma}}^{2\mu}\left(x\frac{\delta v(2\gamma+\gamma H\phi-H)}{2\gamma+H\phi-H} - H\delta v\mu + \gamma\delta vx\right)\frac{1}{2\mu}dx$.

Which can be simplified to $\Pi_A^* = \frac{\delta\mu v(H-2\gamma)\left(-4\gamma^2-\frac{2(\gamma-1)\gamma(H-2\gamma)}{2\gamma+H(\phi-1)}+\frac{(\gamma-1)H(H-2\gamma)}{2\gamma+H(\gamma\phi-1)}+2(\gamma-1)H\right)}{4\gamma^2}$.

Consider KiA. The pricing condition changes in the following way: $\Phi_{\text{KiA}}(\delta v - p_K) + (1 - \Phi_{\text{KiA}})(-p_K) = 0$. Φ_{KiA} does not change: borrow iff retail market covers costs. So, we can find

Φ_{KiA} as $\frac{2\mu-\frac{C}{\delta v\gamma}}{2\mu}$ and p_K solves (replacing C with $H\delta v\mu$): $\frac{2\mu-\frac{\delta H\mu v}{\gamma\delta v}}{2\mu}(\delta v - p_K) + (\frac{\frac{\delta H\mu v}{\gamma\delta v}}{2\mu})(-p_K) = 0$, which simplifies to $p_K = -\frac{\delta v(H-2\gamma)}{2\gamma+H(\phi-1)}$. Hence, feasibility is the same as in the base model. The KiA profit is given by $\Pi_K^* = \int_0^{\frac{H\mu}{\gamma}} (\phi x \frac{\delta v(H-2\gamma)}{2\gamma+H(1-\phi)})\frac{1}{2\mu}dx + \int_{\frac{H\mu}{\gamma}}^{2\mu}(x\frac{\delta v(H-2\gamma)}{2\gamma+H(1-\phi)} - H\delta v\mu + \delta v\gamma x)\frac{1}{2\mu}dx$ which simplifies to $\Pi_K^* = \frac{\delta\mu v(H-2\gamma)\left(-4\gamma^2(\gamma+1)+(\gamma-1)H^2(\phi-1)-2\gamma^2H(\phi-2)\right)}{4\gamma^2(2\gamma+H(\phi-1))}$.

Proof that price ratio $\frac{p_K}{p_A}$ decreases in ϕ for $\gamma \geq 1$.

The price ratio $\frac{p_K}{p_A}$ is given by $-\frac{\delta v(H-2\gamma)}{2\gamma+H(\phi-1)}/(\delta v \cdot 1)$. Take a derivative of $\frac{p_K}{p_A}$ with respect to ϕ and simplify to obtain $\frac{H(H-2\gamma)}{(2\gamma+H(\phi-1))^2}$, which is clearly negative because $H < 2$ and $\gamma \geq 1$.

Proof that price ratio $\frac{p_K}{p_A}$ decreases in ϕ for $\gamma < 1$.

The price ratio $\frac{p_K}{p_A}$ is given by $-\frac{\delta v(H-2\gamma)}{(2\gamma+H(\phi-1))}/\frac{\delta v(2\gamma+\gamma H\phi-H)}{(2\gamma+H(\phi-1))}$. Take a derivative of $\frac{p_K}{p_A}$ with respect to ϕ and simplify to obtain $\frac{\gamma H(H-2\gamma)}{(2\gamma+H(\gamma\phi-1))^2}$, which is clearly negative because $H < 2\gamma$.

Proof that AoN always beats KiA when $\gamma < 1$.

Consider the difference between the profit of KiA and AoN. After algebraic simplification it can be rewritten as: $(\delta v\mu)\frac{H\phi(2\gamma-H)\left(-4\gamma^2+(\gamma-1)H^2(\phi-1)-2\gamma^2H(\phi-1)\right)}{4\gamma(2\gamma+H(\phi-1))(2\gamma+H(\gamma\phi-1))}$. In what follows, we take out the positive multiplicative term $(\delta v\mu)$ and conduct the analysis of this ratio without it. In the region under consideration, the sign of this expression is defined by the sign of $\frac{2\gamma}{-2\gamma+H(1-\phi)} - \frac{(1-\gamma)H}{2\gamma-H(1-\gamma\phi)}$. The first term is negative since $H < 2\gamma$. The second term is positive: $2\gamma - H(1-\gamma\phi) > 2\gamma - 2\gamma(1-\gamma\phi) = 2\gamma^2\phi > 0$. Hence, the difference between the profit of KiA and that of AoN is negative.

Proof that profit ratio of KiA to AoN decreases in ϕ when $\gamma < 1$.

The profit ratio of KiA to AoN can be simplified as:

$$\frac{-4\gamma^2(\gamma+1)+(\gamma-1)H^2(\phi-1)-2\gamma^2H(\phi-2)}{(2\gamma+H(\phi-1))\left(-4\gamma^2 - \frac{2(\gamma-1)\gamma(H-2\gamma)}{2\gamma+H(\phi-1)} + \frac{(\gamma-1)H(H-2\gamma)}{2\gamma+H(\gamma\phi-1)} + 2(\gamma-1)H\right)}.$$

By taking the derivative with respect to ϕ and simplifying we obtain a quadratic function of ϕ: $\alpha\phi^2 + \beta\phi + \zeta$, where $\alpha = H^2\left(4(\gamma+1)\gamma^4 + (\gamma-1)^2H^2 - 2\left(\gamma^2+\gamma-2\right)\gamma^2H\right)$, $\beta = 2H(2\gamma - H)\left((1-\gamma)H + 2\gamma^2\right)((1-\gamma)H+2\gamma(\gamma+1)) > 0$, and $\zeta = (H-2\gamma)^2((1-\gamma)H+2\gamma)((1-\gamma)H+2\gamma(\gamma+1)) > 0$. Hence, the function $\alpha\phi^2+\beta\phi+\zeta$ is first positive and then is negative when ϕ increases. Thus, to show that this function is positive on $\phi \in (0,1)$ it is sufficient to show that $\alpha\phi^2+\beta\phi+\zeta > 0$ when evaluated at $\phi = 1$. Simplify $\alpha+\beta+\zeta$ as $2\gamma^2\left(H^2(1-\gamma)^2(2\gamma-H) + 8\gamma^2(\gamma+1) - 4H(1-\gamma)\gamma^2\right)$. The first expression in the brackets is positive due to $H < 2\gamma$. For the other two expressions notice that $8\gamma^2(\gamma+1) - 4H(1-\gamma)\gamma^2 > 8\gamma^2(1+\gamma) - 8\gamma^3(1-\gamma) > 0$, where the inequality follows from $H < 2\gamma$. Hence, we showed that the derivative of the profit ratio in our range of parameters is positive.

Proof that profit ratio of KiA to AoN decreases in ϕ when $\gamma > 1$.

The profit ratio of KiA to AoN is given by $\frac{(H-2\gamma)\left(-4\gamma^2(\gamma+1)+(\gamma-1)H^2(\phi-1)-2\gamma^2H(\phi-2)\right)}{4\gamma^2(2\gamma+H(\phi-1))}/(-\frac{1}{4}(H-2)(\gamma(H+2)-H+2))$. Take a derivative of this expression with respect to ϕ and simplify to obtain $\frac{2H(H-2\gamma)^2}{\gamma(H-2)(\gamma(H+2)+(2-H))(2\gamma+H(\phi-1))^2}$, where the numerator is clearly positive and denominator is negative since $H-2<0$ (because $H<2$) and $\gamma(H+2)+(2-H)>0$ (because $H<2$). So, the derivative of the profit ratio with respect to ϕ is negative, which concludes the proof.

Proof that there exists $\bar{\gamma}>1$ such that KiA beats AoN for $\gamma>\bar{\gamma}$ and AoN beats KiA for $1<\gamma<\bar{\gamma}$.

Consider the difference between the profit of KiA and that of AoN. After algebraic simplification it takes the following form: $(\delta v\mu)\frac{H\left(-4\gamma^2\phi+(\gamma-1)\left(\gamma^2+1\right)H^2(\phi-1)+2\gamma H\left(\gamma^3-\gamma^2+\gamma+\phi-1\right)\right)}{4\gamma^2(2\gamma+H(\phi-1))}$. In what follows, we take out the positive multiplicative term $(\delta v\mu)$ and conduct the analysis of this ratio without it. It is easy to show that the limit of the above difference at $\gamma\to 1$ is negative while it is ∞ at $\gamma\to\infty$. We will show that the difference intersects zero only once. First, notice that the roots of the denominator are all lower than 1. Then, we need to show that the numerator crosses zero only once for $\gamma>1$. Substitute $\gamma=t+1$. Obtain $2Ht^4+t^3\left(H^2(\phi-1)+6H\right)+t^2\left(2H^2(\phi-1)+8H-4\phi\right)+t\left(2H^2(\phi-1)+2H\phi+4H-8\phi\right)-2\phi(2-H)$. We will use Descartes' rule of sign to show that there is only one positive real root. Coefficients in front of t^4 and t^3 are positive. While the last term is negative. We will show that it is never the case that *simultaneously* $\alpha=2H^2(\phi-1)+8H-4\phi<0$ and $\beta=2H^2(\phi-1)+2H\phi+4H-8\phi>0$. This is because $\alpha>\beta$. Then for all other combinations of signs of α and β, we have only one change of sign of coefficients of the above polynomial. Hence, there is only one positive root for t. This is equivalent to having only one root such that $\gamma>1$.

Proof of Theorem 6

To prove the first point in the theorem, note that under AoN no misappropriation ever happens, since whenever the goal is met, development can be financed and it will be attempted. Hence, AoN is always feasible.

For KiA, the price is the highest one that satisfies $p_{\mathrm{K}}\leq\delta v\hat{\Phi}_{\mathrm{K}}(p_{\mathrm{K}})$, where $\hat{\Phi}_{\mathrm{K}}$ is the probability of financing development and is given by $\frac{2\mu-\hat{x}}{2\mu}$, where $\hat{x}$ is the lowest state in which financing is possible and solves $C-\hat{x}p_{\mathrm{K}}^D=\delta\gamma\hat{x}v$, hence is equal to $C\left(p_{\mathrm{K}}^D+\delta v\gamma\right)^{-1}$. This means $p_{\mathrm{K}}^D=\delta v\frac{2\mu-\hat{x}}{2\mu}$. Solving for p_{K}^D, we obtain

$$\begin{aligned}
p_{\mathrm{K}}^{D} - \delta v \tfrac{2\mu - \hat{x}}{2\mu} &= 0 \\
p_{\mathrm{K}}^{D} - \delta v + \delta v \tfrac{C}{2\mu\left(p_{\mathrm{K}}^{D} + \delta v \gamma\right)} &= 0 \\
p_{\mathrm{K}}^{D^2} 2\mu + p_{\mathrm{K}}^{D}\left[2\mu\delta v\gamma - 2\mu\delta v\right] - 2\mu\delta^2 v^2 \gamma + \delta v C &= 0 \\
p_{\mathrm{K}}^{D^2} 2\mu + p_{\mathrm{K}}^{D} 2\mu\delta v\left[\gamma - 1\right] - 2\mu\delta^2 v^2 \gamma + \delta v C &= 0 \\
p_{\mathrm{K}}^{D} &= \tfrac{2\mu\delta v(1-\gamma) + \sqrt{4\mu^2\delta^2 v^2 (1-\gamma)^2 - 8\mu\delta v(C - 2\mu\delta v\gamma)}}{4\mu} \\
&= \delta v \tfrac{(1-\gamma) + \sqrt{(1-\gamma)^2 - 2\left(\frac{C}{\delta v \mu} - 2\gamma\right)}}{2} \\
&= \delta v \tfrac{(1-\gamma) + \sqrt{(1+\gamma)^2 - 2\mathcal{H}}}{2}
\end{aligned}$$

To obtain profit, we start from expression

$$\Pi_{\mathrm{K}}^{D} = \int_{0}^{C\left(p_{K}^{D} + \delta v \gamma\right)^{-1}} p_{K}^{D} x \frac{1}{2\mu} \mathrm{d}x + \int_{C\left(p_{K}^{D} + \delta v\gamma\right)^{-1}}^{2\mu} \left[p_{K}^{D} x - C + \delta v x \gamma\right] \frac{1}{2\mu} \mathrm{d}x,$$

which follows from Lemma 1, which now governs the decision of whether to attempt development or misappropriate pledges, since development is pursued whenever possible, which means whenever borrowing is possible.. Let $p_{\mathrm{K}}^{D} = \delta v \left(1 - \rho_{\mathrm{K}}\right)$. We have that

$$\begin{aligned}
\Pi_{\mathrm{K}}^{D} &= \int_0^{\frac{C}{\delta v\left(1-\rho_{\mathrm{K}}+\gamma\right)}} \left[x\delta v\left(1-\rho_{\mathrm{K}}\right)\right] \tfrac{1}{2\mu} dx + \int_{\frac{C}{\delta v\left(1-\rho_{\mathrm{K}}+\gamma\right)}}^{2\mu} \left[x\delta v\left(1-\rho_{\mathrm{K}}\right) - C + \delta v x \gamma\right] \tfrac{1}{2\mu} dx \\
&= \tfrac{\delta v\left(1-\rho_{\mathrm{K}}\right)\frac{1}{2\mu}C^2}{2\delta^2 v^2\left(1-\rho_{\mathrm{K}}+\gamma\right)^2} + \delta v\left(1-\rho_{\mathrm{K}}+\gamma\right)\tfrac{1}{2\mu}\cdot\left[\frac{4\mu^2}{2} - \tfrac{C^2}{2\delta^2 v^2\left(1-\rho_{\mathrm{K}}+\gamma\right)^2}\right] - C\left(2\mu - \tfrac{C}{\delta v\left(1-\rho_{\mathrm{K}}+\gamma\right)}\right) \\
&= \delta v\gamma\tfrac{1}{2\mu}\cdot\left[-\tfrac{C^2}{2\delta^2 v^2\left(1-\rho_{\mathrm{K}}+\gamma\right)^2}\right] + \delta v\left(1-\rho_{\mathrm{K}}+\gamma\right)\tfrac{1}{2\mu}\cdot\left[\frac{4\mu^2}{2}\right] - C\left(2\mu - \tfrac{C}{\delta v\left(1-\rho_{\mathrm{K}}+\gamma\right)}\right)\tfrac{1}{2\mu} \\
&= -\delta v\mu\gamma\tfrac{C^2}{\delta^2 v^2}\tfrac{1}{2\mu^2}\cdot\left[\tfrac{1}{2\left(1-\rho_{\mathrm{K}}+\gamma\right)^2}\right] + \delta v\mu\left(1-\rho_{\mathrm{K}}+\gamma\right) - \tfrac{C}{\delta v\mu}\delta v\mu\left(2\mu - \tfrac{C}{\delta v\left(1-\rho_{\mathrm{K}}+\gamma\right)}\right)\tfrac{1}{2\mu}
\end{aligned}$$

$$\begin{aligned}
&= -\delta v\mu\gamma\tfrac{\mathcal{H}^2}{2}\cdot\left[\tfrac{1}{2\left(1-\rho_{\mathrm{K}}+\gamma\right)^2}\right] + \delta v\mu\left(1-\rho_{\mathrm{K}}+\gamma\right) - \mathcal{H}\delta v\left(\mu - \mu\tfrac{C}{2\delta v\mu\left(1-\rho_{\mathrm{K}}+\gamma\right)}\right) \\
&= \delta v\mu\left[-\tfrac{\mathcal{H}^2\gamma}{4\left(1-\rho_{\mathrm{K}}+\gamma\right)^2} + \left(1-\rho_{\mathrm{K}}+\gamma\right) - \mathcal{H}\left(1 - \tfrac{\mathcal{H}}{2\left(1-\rho_{\mathrm{K}}+\gamma\right)}\right)\right] \\
&= \delta v\mu\left[1-\rho_{\mathrm{K}}+\gamma-\mathcal{H}+\tfrac{\mathcal{H}^2}{2}\left(\tfrac{1}{1-\rho_{\mathrm{K}}+\gamma} - \tfrac{\gamma}{2\left(1-\rho_{\mathrm{K}}+\gamma\right)^2}\right)\right] \\
&= \delta v\mu\left[1-\rho_{\mathrm{K}}+\gamma-\mathcal{H}+\tfrac{\mathcal{H}^2}{4}\tfrac{2-2\rho_{\mathrm{K}}+\gamma}{\left(1-\rho_{\mathrm{K}}+\gamma\right)^2}\right]
\end{aligned}$$

When the radical in the ρ_{K}expression, $\sqrt{(1+\gamma)^2 - 2\mathcal{H}}$, has no real solution, the KiA design is infeasible. This means $(1+\gamma)^2 - 2\mathcal{H} < 0$, or equivalently, $\mathcal{H} > \frac{1+2\gamma+\gamma^2}{2}$.

To prove the second point in the theorem, we show that $\Pi_{\mathrm{K}}^{D} - \Pi_{\mathrm{A}}^{D} > 0$ holds if and only if γ is large enough.

$$
\begin{aligned}
\Pi_{\mathrm{K}}^{D}-\Pi_{\mathrm{A}}^{D} &> 0\\
\tfrac{1-\gamma+\sqrt{(1+\gamma)^2-2\mathcal{H}}}{2}+\gamma-\mathcal{H}+\tfrac{\mathcal{H}^2}{4}\,\frac{2\left(\frac{1-\gamma+\sqrt{(1+\gamma)^2-2\mathcal{H}}}{2}\right)+\gamma}{\left(\frac{1-\gamma+\sqrt{(1+\gamma)^2-2\mathcal{H}}}{2}+\gamma\right)^2}-\left[1+\gamma-\mathcal{H}+\tfrac{\mathcal{H}^2}{4}(1-\gamma)\right] &> 0\\
\tfrac{-1-\gamma+\sqrt{(1+\gamma)^2-2\mathcal{H}}}{2}+\tfrac{\mathcal{H}^2}{4}\,\frac{2\left(\frac{1-\gamma+\sqrt{(1+\gamma)^2-2\mathcal{H}}}{2}\right)+\gamma}{\left(\frac{1-\gamma+\sqrt{(1+\gamma)^2-2\mathcal{H}}}{2}+\gamma\right)^2}-\tfrac{\mathcal{H}^2}{4}(1-\gamma) &> 0\\
\tfrac{-1-\gamma+\sqrt{(1+\gamma)^2-2\mathcal{H}}}{2}\left(\tfrac{1-\gamma+\sqrt{(1+\gamma)^2-2\mathcal{H}}}{2}+\gamma\right)^2+ &\\
+\tfrac{\mathcal{H}^2}{4}\left[2\left(\tfrac{1-\gamma+\sqrt{(1+\gamma)^2-2\mathcal{H}}}{2}\right)+\gamma-(1-\gamma)\left(\tfrac{1-\gamma+\sqrt{(1+\gamma)^2-2\mathcal{H}}}{2}+\gamma\right)^2\right] &> 0\\
\mathcal{H}\tfrac{\sqrt{(1+\gamma)^2-2\mathcal{H}}}{2}\left(\mathcal{H}+\mathcal{H}\gamma^2-2\right)-\mathcal{H}\left[1+\gamma-\tfrac{\mathcal{H}}{2}+\tfrac{\mathcal{H}}{2}\gamma-\tfrac{\mathcal{H}}{2}\gamma^2-\tfrac{\mathcal{H}\gamma^3}{2}-\tfrac{\mathcal{H}^2}{2}+\tfrac{\mathcal{H}^2}{2}\gamma\right] &> 0\\
2+2\gamma-\mathcal{H}+\mathcal{H}\gamma-\mathcal{H}\gamma^2-\mathcal{H}\gamma^3-\mathcal{H}^2+\mathcal{H}^2\gamma &< \left(\mathcal{H}+\mathcal{H}\gamma^2-2\right)\sqrt{(1+\gamma)^2-2\mathcal{H}};
\end{aligned}
$$

that is, $\Pi_{\mathrm{K}}^{D}-\Pi_{\mathrm{A}}^{D}>0$ if and only if the following holds

$$
\left(\mathcal{H}+\mathcal{H}\gamma^2-2\right)\sqrt{(1+\gamma)^2-2\mathcal{H}}>2+2\gamma-\mathcal{H}+\mathcal{H}\gamma-\mathcal{H}\gamma^2-\mathcal{H}\gamma^3-\mathcal{H}^2+\mathcal{H}^2\gamma. \tag{A.3}
$$

We have two cases to discuss (the case $\mathcal{H}+\mathcal{H}\gamma^2-2=0$ then follows by standard continuity arguments):

(1) When $\mathcal{H}+\mathcal{H}\gamma^2-2<0$, that is, $\mathcal{H}<\frac{2}{1+\gamma^2}$, the above condition becomes

$$
\sqrt{(1+\gamma)^2-2\mathcal{H}} \quad < \quad \frac{2+2\gamma-\mathcal{H}+\mathcal{H}\gamma-\mathcal{H}\gamma^2-\mathcal{H}\gamma^3-\mathcal{H}^2+\mathcal{H}^2\gamma}{\mathcal{H}+\mathcal{H}\gamma^2-2},
$$

which never holds because the RHS is negative due to the numerator, call it $n(\gamma,\mathcal{H})$, being positive as long as K is feasible (i.e., $\mathcal{H}<\bar{\mathcal{H}}$). Specifically, this can be shown by noting that (i) $n(\gamma,\mathcal{H})$ is positive for all γ's when $\mathcal{H}=0$, and it is equal to zero when either $\mathcal{H}=\mathcal{H}_1=\frac{1-\gamma+\gamma^2+\gamma^3+\sqrt{9-2\gamma-5\gamma^2-\gamma^4+2\gamma^5+\gamma^6}}{2(\gamma-1)}$ or $\mathcal{H}=\mathcal{H}_2=\frac{1-\gamma+\gamma^2+\gamma^3-\sqrt{9-2\gamma-5\gamma^2-\gamma^4+2\gamma^5+\gamma^6}}{2(\gamma-1)}$; (ii) $\mathcal{H}_1\notin\left[0,\frac{2}{1+\gamma^2}\right]$, and (iii) $\mathcal{H}_2\notin\left[0,\max\left(\frac{2}{1+\gamma^2},\bar{\mathcal{H}}\right)\right]$.

(2) When $\mathcal{H}+\mathcal{H}\gamma^2-2>0$, that is, $\mathcal{H}>\frac{2}{1+\gamma^2}$, the above condition becomes

$$
\sqrt{(1+\gamma)^2-2\mathcal{H}} \quad > \quad \frac{2+2\gamma-\mathcal{H}+\mathcal{H}\gamma-\mathcal{H}\gamma^2-\mathcal{H}\gamma^3-\mathcal{H}^2+\mathcal{H}^2\gamma}{\mathcal{H}+\mathcal{H}\gamma^2-2}.
$$

When $\gamma<-1+\sqrt{2\mathcal{H}}$ the RHS is not defined because KiA is not feasible, so we are interested in the other cases, that is, when $\gamma\geq-1+\sqrt{2\mathcal{H}}$. In those cases, the LHS is non negative for all γ's and is strictly increasing in γ, while the RHS decreases strictly in γ. Moreover, as $\gamma\to+\infty$, the RHS tends to $+\infty$ and the LHS tends to $-\infty$. It follows that for every $\mathcal{H}$ there exists a $\hat{\gamma}(\mathcal{H})$ such that $\Pi_{\mathrm{K}}^{D}-\Pi_{\mathrm{A}}^{D}>0$ if and only if $\gamma>\hat{\gamma}(\mathcal{H})$.

Proof of Theorem 7

We begin by proving points 3, since points 1 and 2 readily follow.

(a) Profit comparison AoN v.s. SS ($\gamma y > 1$)

Suppose $\frac{C}{\delta v \gamma} < y\frac{C}{p_S}$, then there is no stealing by construction. This implies $p_S = \delta v$, hence this condition implies $\frac{C}{\delta v \gamma} < y\frac{C}{\delta v}$, or, $\gamma y > 1$. This means, if $\gamma = 2$, y can be as low as 50% and there would be no stealing. In other words, the profit difference between SS and AoN is equal to pledges + development profit, when pledges are less than goal $H\mu$ but more than y goal: $g(H, \gamma, y) = \int_{H\mu y}^{H\mu}(-\delta H\mu v + \gamma\delta v x + \delta v x)\frac{1}{2\mu}\,dx$, which can be further simplified to $g(H, \gamma, y) = \frac{\delta v H^2\mu^2}{2\mu}(\frac{1}{2}\left(1 - y^2\right)(\gamma + 1) - (1 - y))$, which is always positive. Hence SS beats AoN when $\gamma y > 1$.

(b) Profit comparison AoN v.s. SS ($\gamma y < 1$)

Profit difference between SS and AoN is given by $r(H, \gamma, y) = \frac{(H-2\gamma)\left(-4\gamma(\gamma+1)+H^2(\gamma y-1)+H(4\gamma-2(\gamma+2)\gamma y+2)\right)}{4\gamma(2\gamma+H(\gamma y-1))} - (-\frac{1}{4}(H - 2)(\gamma(H + 2) - H + 2))$, where we took out a constant $\delta v\mu$ since it does not vary with γ or y. Take a derivative of $r(H, \gamma, y)$ with respect to γ and simplify to obtain $r'(H, \gamma, y) = \frac{1}{4}H\left(\frac{2H^2y^2}{(2\gamma+H(\gamma y-1))^2} + \frac{2-H}{\gamma^2} + H\right) > 0$. Hence profit difference increases in γ when $\gamma y < 1$. Recall that SS beats AoN when $y\gamma > 1$ (see previous point in the proof). And the SS profit is continuous as γ moves through $\frac{1}{y}$. So we are done. It is anyway easy to check that at $\gamma = \frac{1}{y}$, the gap is already positive: $\lim_{\gamma \to \frac{1}{y}} r(H, \gamma, y) = \frac{H^2(1-y)\left(y^2+1\right)}{4y} > 0$. Done.

(c) Profit comparison KiA vs SS ($\gamma y < 1$)

Profit difference between SS and KiA is given by $r(H, \gamma, y) = \frac{(H-2\gamma)\left(-4\gamma(\gamma+1)+H^2(\gamma y-1)+H(4\gamma-2(\gamma+2)\gamma y+2)\right)}{4\gamma(2\gamma+H(\gamma y-1))} - \frac{(H-2\gamma)(H-2(\gamma+1))}{4\gamma}$, where we took out a constant $\delta v\mu$ since it does not vary with γ or y. Take a derivative of $r(H, \gamma, y)$ with respect to γ and simplify to obtain $r'(H, \gamma, y) = \frac{H^3y^2}{2(2\gamma+H(\gamma y-1))^2} > 0$. Hence profit difference increases in γ when $\gamma y < 1$. Now compute $\lim_{\gamma \to \frac{H}{2}} r(H, \gamma, y) = 0$ and $\lim_{\gamma \to \frac{1}{y}} r(H, \gamma, y) = \frac{1}{4}Hy(2 - Hy) > 0$. So, the two designs are the same when γ is so low that they are not even feasible. As soon as γ increases and designs are feasible (pledge price above zero), SS gains advantage over KiA, until $\gamma = \frac{1}{y}$. So, our profit gap increases in γ and is positive when $\gamma = \frac{1}{y}$ (which is equivalent to $\gamma y = 1$).

(d) Profit comparison KiA vs SS ($\gamma y > 1$)

Profit difference between SS and KiA is given by $r(H, \gamma, y) = \frac{1}{2}\left((\gamma + 1)\left(2 - \frac{H^2y^2}{2}\right) - H(2 - Hy)\right) - \frac{(H-2\gamma)(H-2(\gamma+1))}{4\gamma}$, where we took out a constant $\delta v\mu$ since it does not vary with γ or y. Take a derivative of $r(H, \gamma, y)$ with respect to γ and simplify to obtain $r'(H, \gamma, y) = \frac{H\left((H-2)-H\gamma^2y^2\right)}{4\gamma^2} < 0$, i.e. higher gamma shrinks the profit gap when $\gamma y > 1$. And as γ goes to infinity, the gap becomes negative: $\lim_{\gamma \to +\infty} r(H, \gamma, y) = -\infty$.

(e) Summary.

All in all, we showed that KiA outperforms SS if and only if γ is large enough. We also showed that such gamma is higher than $\frac{1}{y}$, which, in turn, is higher than the gamma that makes AoN and

SS the same. So, we have also proven the relative position of these two threshold gammas: the AoN's threshold gamma is lower than the KiA's threshold gamma.

For point 4, it suffices to note that $\Pi_{SS} \to \Pi_A^*$ when y=1 and $\Pi_{SS} \to \Pi_K^*$ when y=0, and the derivative of Π_{SS} wrt y is positive when $y\gamma < 1$, and negative when $y\gamma > 1$, making $y = 1/\gamma$ the optimal value of y.

Appendix B. Goal-related Effects

In this section we provide context to explain why setting too low a goal under AoN comes with a host of negative consequences, as briefly discussed in Sections 2 and 4.2. To this end, we discuss a number of goal-related effects that arise in crowdfunding, together with their implications.

(1) A known effect of choosing the funding goal in an AoN campaign is to set the provision point for the campaign — the minimum amount of funds that the entrepreneur must raise to be allowed to actually collect such funds. This effect may provide an incentive for the entrepreneur to set a goal lower than the true amount needed, in order to increase the odds that some funds are indeed collected. Such *provision point* effect (which is absent in the KiA design) is routinely present in game-theoretic crowdfunding models, including **?** and **?**.

(2) There is ample and growing evidence that the presence of a funding goal generates *goal-pursuit* effects in crowdfunding, that is, backers' pledging behavior is different before and after the goal is reached. We know from the extensive literature on goal seeking (**??**, etc.) that people exert more effort to reach unmet goals and relax effort after achieving goals, and a similar phenomenon has been empirically documented in the context of crowdfunding campaigns. In their paper, **?** find that backers are much less likely to pledge once a project reaches its goal. **?** find that consumers not only are more likely to fund projects, but also contribute greater amounts of money prior to goal attainment compared to after the goal is reached. The effect is strong and robust: on average, the fundraising rate of a crowdfunding campaign slows down by almost 60% after the goal is met, and in some cases stops altogether. Other researchers have found evidence that points to similar dynamics (**?**, **?**). Setting a low goal therefore comes at the cost of raising less funds due to weaker goal-pursuit dynamics.

(3) A third effect of setting the funding goal hinges on what it represents, and its potential role in fostering (mis)trust. At Kickstarter, the funding goal is defined as "the amount of money that a creator needs to complete their project" (**?**) and all major platforms have similar definitions. Consistently with this definition, crowdfunding platforms recommend that the goal of a campaign be set equal to the money needed to complete the project (**?**,**?**).

Increasingly, they are also recommending entrepreneurs to explain where the goal of their campaign comes from and how the money raised from backers will be used. For example, Kickstarter has recently developed and made available for campaign creators a web tool to let them share the breakdown of the costs of the campaign on their campaign page (**?**). Being transparent may indeed be a winning strategy: preliminary empirical evidence suggests that entrepreneurs who explain where the funding goal of their campaign comes from by breaking it down into its components raise on average more funds (**?**). Setting realistic crowdfunding goals with a breakdown of costs that correspond to the amount needed is also a common recommendation in business articles and blogs (**???**). These facts point to the existence of a *trust-building* effect, which incentivizes the entrepreneur to truthfully set the funding goal equal to the funds needed and explain its constituents to backers, as failing to do so would hinder fundraising.

(4) A fourth effect, which also incentivizes entrepreneurs to truthfully set their goal, stems out of moral concerns and the desire not to lie to one's backers. This *honesty* effect has been documented in several other contexts (see for example **?**, who find that participants prefer truth-telling to lying even when the former is costly and the latter is non-detectable, and references therein).

When only the provision-point effect (1) is taken into account, there is no downside to set a goal lower than the amount needed. In such context, endogenizing the choice of the campaign goal leads to the dominance result: AoN can set a zero goal and be like KiA, or set any other goal, hence it dominates KiA. This finding is difficult to reconcile with the wide use of both designs in practice over the last decade. Thus, while focusing on the provision-point effect (1) alone is a very fine choice in models that consider only the AoN design, doing so when comparing AoN with KiA has rather undesirable effects on the comparison.

Since pairing all the above effects with an endogenous goal would render the model intractable, we chose to exogenously set the campaign goal equal to C in our model. This simplification is beneficial in a number of ways, since it (i) helps keep the analysis tractable and results easier to interpret; (ii) is consistent with recommendations by crowdfunding platforms and experts; and (iii) rules out KiA as a special case of AoN, opening the door for the possibility that KiA may outperform AoN.

Lastly, it should be noted that our model assumes that both designs set the same goal, C. One way to interpret this is that (i) C is the profit-maximizing goal under AoN once all goal-related effects are taken into account, and (ii) we constrain the KiA design to set the same (and potentially suboptimal) goal as AoN. Setting a potentially suboptimal goal for KiA is conservative with respect to showing that KiA can outperform AoN, which is one of the main objectives of the paper.