Economics Letters 231 (2023) 111265

Contents lists available at ScienceDirect

Economics Letters

journal homepage: www.elsevier.com/locate/ecolet

Refund bonuses and revenue equivalence

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A R T I C L E I N F O

Article history:
Received 29 June 2023
Received in revised form 21 July 2023
Accepted 22 July 2023
Available online 26 July 2023

JEL classification:
C72
D82
H41

Keywords:
Assurance contract
Refund bonus
Crowdfunding
Public good
Revenue equivalence

A B S T R A C T

Refund bonuses are a practical solution to the implementation problem of crowdfunding. This paper shows in a framework with imperfect information that refund bonuses have no implications for the project developer's expected revenue, thus, underscoring the practicality of this solution.

1. Introduction

The all-or-nothing mechanism is the most commonly used funding method in crowdfunding. Under this mechanism, contributions are solicited toward a project and if the contribution target is reached, the project developer collects the contributions, which are otherwise refunded to their contributors. This mechanism is also known as the assurance contract, the provision-point mechanism, or the threshold implementation mechanism and is a subject of extensive study across different disciplines. In the context of crowdfunding for public goods, which is also the context of the present paper, the application of the all-or-nothing mechanism is a showcase of its weak implementation properties. Due to multiple equilibria and free riding, most fundraising campaigns are not successful and the most frequent outcome is when none or very few contributions are raised.[1]

In the refund bonus extension of the all-or-nothing mechanism or, henceforth, the assurance contract, proposed by Tabarrok (1998) and further developed by Zubrickas (2014), if the contribution target is missed contributors are not only refunded but also receive a refund bonus. With refund bonuses the zero-contribution outcome cannot be an equilibrium, and in the absence of uncertainty about the aggregate value of the public good project, the contribution target is reached in equilibrium and, thus, refund bonuses are not paid. Intuitively, the prospect of receiving a refund bonus or having the public good provided encourages contributions up to the provision point. This prediction finds experimental support in Cason and Zubrickas (2017, 2019), Cason et al. (2021), and Li et al. (2023). For more discussion and application of refund bonuses, see Chandra et al. (2016) and Li et al. (2021).

Previous studies, however, do not address the question of the source of refund bonuses. If it is the project developer who is to pay refund bonuses (rather than the crowdfunding platform), then the risk of their payout may discourage project developers from their application. This risk comes to the fore if the value of the public good is uncertain because refund bonus payout then occurs with a positive probability in Bayesian Nash equilibrium. In this paper, we demonstrate in a framework with imperfect information that when offering refund bonuses the project developer obtains the same expected revenue as in the efficient equilibrium of the standard assurance contract. Hence, refund bonuses improve the implementation properties of the assurance contract without financial implications for project developers or their supporting entrepreneurs. This result can be related to

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1 Kickstarter, a popular crowdfunding platform, reports a success rate of 40% with nearly 50% of all campaigns having raised less than 20% of their target (see https://www.kickstarter.com/help/stats as retrieved on 23 June 2023). According to an industry report by Fundly.com, the global average success rate for crowdfunding campaigns is 22.4%, see https://blog.fundly.com/crowdfunding-statistics/ (as retrieved on 23 June 2023).

https://doi.org/10.1016/j.econlet.2023.111265

the Revenue Equivalence Theorem (Myerson, 1981) applied to crowdfunding.

2. Assurance contract

There is a public good project that a group of N agents, indexed by i, can benefit from. Agent i has a private valuation for the public good, which is given by v_i. It is commonly known that individual valuations are independently distributed over $[0, \overline{v}]$ according to distribution $F(.)$. There is an entrepreneur who can implement the project. The entrepreneur wishes to maximize the revenue from the agents but cannot charge them individually or deny them the public good once it is created.

The entrepreneur offers the agents a contract that specifies threshold $T \geq 2$, which is a minimum number of contributing agents needed to implement the project, and contribution $c > 0$ to be paid by each contributing agent. The contract also specifies refund bonus $b \geq 0$ to be paid by the entrepreneur to the contributing agents if fewer than T agents pay the contribution. All in all, if T or more agents pay contribution c, then the entrepreneur implements the project and receives c per contributor in revenue. If fewer than T agents pay the contribution, then those agents are refunded and receive refund bonus b. We refer to a contract with zero refund bonuses, $b = 0$, as a standard assurance contract. Following Tabarrok (1998), we refer to a contract with positive refund bonuses, $b > 0$, as a dominant assurance contract. The entrepreneur is free to choose contract parameters T, c, and b.

Assurance contract (T, c, b) creates a Bayesian game for the agents. In this game, a strategy of agent i is given by $s_i(v_i)$, which is a mapping from individual valuation v_i into the decision of paying or not paying contribution c, $s_i : [0, \overline{v}] \to \{0, c\}$. Given the strategy profile of other agents, $\{s_j(v_j)\}_{j\neq i}$, we denote the probability of fundraising success, as observed by agent i, by $\overline{p}$ if he pays the contribution ($s_i = c$) and by $\underline{p}$ if he does not pay ($s_i = 0$). Agent i's expected payoff is $\overline{p}(v_i - c) + (1 - \overline{p})b$ if he pays the contribution and $\underline{p}v_i$ if not. In our equilibrium analysis, we restrict attention to symmetric strategies $s(v_i)$, which implies that probabilities $\overline{p}$ and $\underline{p}$ are the same for all agents.

It is straightforward to establish that in a symmetric Bayesian Nash equilibrium, agents play cut-off strategies:

$$s(v) = \begin{cases} c & \text{if } v \geq v^*, \\ 0 & \text{otherwise,} \end{cases}$$

where the cut-off valuation v^* is determined by equilibrium payoff condition $\overline{p}(v^* - c) + (1 - \overline{p})b = \underline{p}v^*$, at which the payoffs from paying and not paying the contribution are equal. This condition can be expressed as

$$(\overline{p} - \underline{p})v^* = \overline{p}(b + c) - b. \tag{1}$$

Tabarrok (1998) shows that the cut-off valuation v^* always exists and that the symmetric Bayesian Nash equilibrium is unique for a strictly positive refund bonus $b > 0$. Besides an efficient equilibrium the standard assurance contract also has an inefficient, zero-contribution equilibrium $s(v) = 0$ for any v, which is eliminated by the offer of refund bonuses under the dominant assurance contract.

We define θ as the equilibrium probability that an agent drawn at random pays the contribution. This probability is equal to the probability that the valuation of a randomly drawn agent is at least v^*,

$$\theta = 1 - F(v^*). \tag{2}$$

Using the Binomial distribution, we can write down the equilibrium probabilities of success, $\underline{p}$ and $\overline{p}$, calculated from the point of view of an agent, as

$$\underline{p} = \sum_{r=T}^{N-1} \binom{N-1}{r} \theta^r (1-\theta)^{N-1-r}, \tag{3}$$

$$\overline{p} = \sum_{r=T-1}^{N-1} \binom{N-1}{r} \theta^r (1-\theta)^{N-1-r}. \tag{4}$$

This implies

$$\overline{p} - \underline{p} = \binom{N-1}{T-1} \theta^{T-1} (1-\theta)^{N-T}. \tag{5}$$

Given assurance contract (T, c, b), Eqs. (1)–(4) determine its symmetric Bayesian Nash equilibrium.

We can now determine the expected equilibrium revenue, denoted by Π, that the entrepreneur obtains from offering assurance contract (T, c, b). If at least T agents contribute, then the revenue per agent is c, otherwise it is $-b$, so the expected revenue is

$$\Pi = \sum_{r=0}^{N} \binom{N}{r} \theta^r (1-\theta)^{N-r}\, r\, (c\mathbf{1}_{r\geq T} - b\mathbf{1}_{r<T}),$$

where $\mathbf{1}_{condition}$ is an index function that takes the value of 1 if *condition* holds and 0 otherwise. We use Eq. (4) and the following identity of the Binomial distribution

$$\sum_{r=0}^{N} \binom{N}{r} p^r (1-p)^{N-r}\, rf(r) = Np \sum_{r=0}^{N-1} \binom{N-1}{r} p^r (1-p)^{N-1-r} f(r+1),$$

where $f(.)$ is any function, to express the expected revenue as

$$\Pi = N\theta(\overline{p}(b + c) - b).$$

Applying equilibrium condition (1) to the last expression, we obtain

$$\Pi = N\theta v^*(\overline{p} - \underline{p}) \tag{6}$$

or, using (5),

$$\Pi = Tv^* \binom{N}{T} \theta^T (1-\theta)^{N-T}. \tag{7}$$

We observe that the entrepreneur's expected revenue does not depend directly on contribution c and refund bonus b except through their impact on cut-off valuation v^*. Hence, if two assurance contracts with the same threshold T result in the same equilibrium cut-off valuation v^*, then the entrepreneur's expected revenue from each contract is the same. This observation will be important for proving our main result.

3. Revenue equivalence

The standard assurance contract has weak implementation properties and, specifically, the inefficient zero-contribution equilibrium. While the introduction of refund bonuses mitigates the implementation problem of the assurance contract, the question arises whether it comes at a revenue loss for the entrepreneur. In the next proposition, we show that there is no loss for the entrepreneur from extending the assurance contract with refund bonuses.

Proposition 1. *For any standard assurance contract there is a dominant assurance contract that generates the same expected revenue.*

Proof. Consider a standard assurance contract $\{T, c, b = 0\}$ and its efficient equilibrium with a positive probability of success. This equilibrium satisfies condition (1) or

$$(\overline{p} - \underline{p})v^* = \overline{p}c. \tag{8}$$

Now consider a dominant assurance contract with the same threshold T but contribution c' and refund bonus b' chosen to satisfy $\overline{p}(b' + c') - b' = \overline{p}c$. Then, using (8) we obtain

$$(\overline{p} - \underline{p})v^* = \overline{p}(b' + c') - b',$$

which is the equilibrium condition for contract (T, c', b'). This implies that contracts $\{T, c, b = 0\}$ and $\{T, c', b'\}$ have the same cut-off valuation v^* and, hence, the same probability θ from (2). Since by design both contracts have the same threshold T, the expected revenue for the entrepreneur given by (7) is the same from each contract. ■

We note that Proposition 1 can be viewed as a special case of the Revenue Equivalence Theorem (Myerson, 1981) applied to crowdfunding. Namely, we show in the proof that the standard assurance contract and its dominant counterpart result in the same project implementation outcome (due to the same threshold and cut-off valuation) and that agents have the same expected payoffs, which according to the Revenue Equivalence Theorem implies the same expected payoff for the entrepreneur. Revenue equivalence also has another implication for our study that refund bonuses *per se* cannot increase the entrepreneur's revenue.

Proposition 2. *The introduction of refund bonuses does not increase the expected revenue unless the standard assurance contract results in the zero-contribution outcome.*

Proof. The proof is identical to the proof of Proposition 1 with the roles of the standard and dominant assurance contracts swapped. ■

4. Conclusion

The offer of refund bonuses is a practical solution to the implementation problem of the all-or-nothing crowdfunding method. In this paper, we show in a framework with imperfect information that this solution can be self-funded for entrepreneurs are not expected to lose in their revenue when offering refund bonuses.

Data availability

No data was used for the research described in the article.

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