Crowdfunding in a duopoly under asymmetric information

Miglo, Anton

Birmingham City University

2018

Crowdfunding in a duopoly under asymmetric information

Anton Miglo[*]

2018

Abstract

Traditionally crowdfunding has been used for funding very innovative projects. Recently, however, companies have begun using crowdfunding to finance more traditional products where they compete against other sellers of similar products. One of the major platforms Indiegogo launched several projects consistent with this trend. This paper offers a model of a duopoly where firms can use crowdfunding prior to direct sales. The model is based on asymmetric information between competitors regarding the demand for the product. It provides several implications that have not yet been tested. For example we find that high-demand firms can use crowdfunding to signal their quality.

Keywords: crowdfunding, asymmetric information, reward-based crowdfunding, duopoly, signalling

JEL Codes: D43, D82, G32, L11, L26, M13

1 Introduction

Crowdfunding is the practice of funding a start-up company or project by raising funds from a large number of people. It is usually performed online. When talking about crowdfunding the media and internet usually provide examples of firms that use it for funding extremely innovative and often very sofisticated Apple-esque[1] products.[2] Examples include 3D-printers, electric cars, smart watches etc.[3] In this case firms retain monopoly power during the stage of development and sales of the project.[4] Less attention is paid to companies that

---

[*]Birmingham City University, anton.miglo@bcu.ac.uk, Department of Finance, Accountancy and Economics, Birmingham, UK.

[1]https://artofthekickstart.com/kickstarter-vs-indiegogo-and-how-to-decide-for-your-crowdfunding-campaign/

[2]See, for example, Kumar et al (2015).

[3]https://3dprint.com/188971/cubibot-3d-printer-kickstarter/

https://www.cnbc.com/2015/03/30/pebble-watch-funding-hits-record–.html

https://www.crowdfundinsider.com/2017/02/96351-pod-point-launches-third-equity-crowdfunding-campaign-crowdcube/

[4]See, for example, Santos (2017).

use crowdfunding for financing more traditional products and services. Examples of products include handbags, perfumes, toys etc.[5] In this case the level of competition with producers of similar products increases. One of the major crowdfunding website platforms, Indiegogo, is an open platform and can be used by any company for any product.[6] It also launched several strategic projects in 2017-2018 consistent with the trend described above. For example, it introduced Indiegogo Marketplace where firms sell their products initially financed through crowdfunding and compete against other firms which may not have necessarily used crowdfunding to launch their products.[7] Australian farmers seem to have started using crowdfunding for improving traditional market structures such as duopolies (which are often the case).[8]

Literature on crowdfunding basically followed this trend and mostly assumed that crowdfunding is operated under monopoly conditions (see, for example, Belleflamme et al (2014) or Miglo et al (2018)). However, much less is known about the role of crowdfunding in explaning the behaviour of entrepreneurs operating in competitve markets including cases when entrepreneurs who use crowdfunding compete against entrepreneurs who do not.[9] In this article we shed some light on these questions. In particular, we argue that crowdfunding can be used to signal the quality of a firms in the case when competitors have private information about their product quality/demand.

We focus on reward-based crowdfunding (used by Indiegogo and Kickstarter-the leading platforms in the area). In this case, investors count on some extra-benefits from the company such as future product discounts. In our model, a firm decides whether or not to use crowdfunding for the pre-sale stage or just use spot price sales. The crowdfunding campaign has the following features: 1) no arbitrage condition: crowdfunding pre-sale price and spot price are equal; 2) the firm provides reward to funders; 3) the crowdfunding decision is publicly observable.[10]

We first demonstrate that in a monopoly setting, without making any additional assumptions such as community benefits to funders, crowdfunding is

---

[5] https://www.indiegogo.com/projects/public-goods-revolutionizing-household-products–3#/

https://www.indiegogo.com/projects/kantala-handbags-inspired-by-traditional-artisans-vegan#/

[6] https://artofthekickstart.com/kickstarter-vs-indiegogo-and-how-to-decide-for-your-crowdfunding-campaign/

[7] https://www.verdict.co.uk/indiegogo-marketplace/

https://www.recode.net/2017/10/16/16474794/indiegogo-crowdfunding-commerce-amazon

[8] https://www.linkedin.com/pulse/digital-farmers-market-aims-disrupt-duopoly-directly-supporting

[9] https://www.verdict.co.uk/indiegogo-marketplace/

[10] The fact that the crowdfunding decision is well observed publicly given the nature of crowdfunding where firms use public websites (platforms) makes crowdfunding different from other pre-sale forms like forward sales for example. Although there is literature that argues that the disclosure of these contracts would be desirable (see, among others, Hughes and Kao, 1997, Allaz, 1992), this issue remains quite ambiguous. As another example note that the development of a product within a private company that uses private financing is not as transparent as it is with crowdfunding etc.

never used and firms prefer to just use the spot market since crowdfunding involves a cost in the form of rewards. Then we consider a duopoly. When information between firms is symmetric different equilibria can emerge. A situation where both duopolists do not use crowdfunding and only use the spot market is not an equilibrium because each firm has an incentive to deviate and use the crowdfunding campaign prior to its spot sales. Early committment of this firm makes the product price lower, increases the production of this firm and forces the other firm out of its optimal quantity and decreases profits compared to the equilibrium situation. When information between firms is asymmetric, we find that the only signalling equilibrium that exists is when high-quality (high demand) firms are likely to chose reward-based crowdfunding as a signal of quality. Low-quality firms are less likely to mimick high-quality firms by chosing crowdfunding, which implies more cost related to rewards, and prefer spot sales exclusively instead. On the other hand an equilibrium where low-quality firms select crowdfunding and high-quality firms do not does not exist. If the uninformed competitor perceives the firm that uses a crowdfunding campaign as a low-demand firm, it will be pessimistic about the price and will concede the market. A high-demand firm can benefit from this situation by mimicking the strategy of low-demand firms during the crowdfunding stage.

David Mandelbrot, CEO of Indiegogo, noted the following: "The other trend we're seeing is more and more companies using Indiegogo as a way to engage with their audience early. In the last year we've had campaigns from companies like Procter and Gamble, Honeywell, and Bose. They're big, public companies....But they're using Indiegogo to validate the products coming out of their... divisions and launch those products to an audience they can engage with directly."[11] This comment illustrates that good-quality firms are interested in using crowdfunding for early engagements with customers versus just using the sport market for sales, which is consistent with the spirit of the processes described in our model.

As was mentioned previously, the number of theoretical papers on crowdfunding involving asymmetric information is relatively small. Note the following.

Belleflamme et al (2014) compare reward-based and equity-based crowdfunding. In either case, the funders enjoy community benefits that increase their utility. It is shown that the entrepreneur prefers pre-ordering if the initial capital requirement is relatively small compared to the market size and prefers profit sharing otherwise. Belleflamme et al (2014) also offer some extensions on the impact of quality uncertainty and information asymmetry but in these extensions the choice between the different forms of crowdfunding and other forms of financing is not modelled. As the authors mentioned, further research is required.

Miglo et al (2018) consider the choice between the different types of crowdfunding and traditional financing under different types of market imperfections. In contrast to most existing literature they focus on financial aspects of crowdfunding rather than on price discrimination between customers using a new

---

[11]https://venturebeat.com/2018/01/15/indiegogo-moves-beyond-crowdfunding-to-help-startups-with-manufacturing/

approach on the demand side. It was found that when asymmetric information is important, high-quality projects prefer reward-based crowdfunding. A low-quality firm may find it unprofitable to mimick this strategy as it will be taking more risk to achieve a threshold. This result is contradictory to the spirit of the results in Belleflamme et al (2014), which finds that asymmetric information favours equity-based crowdfunding. In contrast to Belleflamme et al (2014), in this model, crowdfunding does not have any ad-hoc non-monetary benefits.

Chakraborty and Swinney (2017) consider a crowdfunding model where product quality is known to the entrepreneur but not to some contributors. They find that a larger campaign target can be used by high quality firms as a signalling device. Miglo et al (2018) find that the relationship between a firm's quality and the campaign goal is non-linear. More specifically they argue that the threshold should neither be very low or very high. To some extent it is consistent with the spirit of the results in some papers in that higher targets do not necessarily signal a better quality. For example, Mollick (2015) and Cordova et al (2015) found that setting higher thresholds does not lead to higher campaign success rates.

Miglo (2018) considers a model of the choice between the different types of crowdfunding, which contains elements of the asymmetric information approach and behavioral finance (overconfident entrepreneurs). The model provides several implications, most of which have not yet been tested. The model predicts that high-quality firms may use equity-based crowdfunding in equilibrium which contrasts the traditional results (for example pecking-order theory) where equity represents an inferior security. The latter has rational managers. It also contrasts traditional behavioral finance literature (for example, Fairchild (2007)) where equity is dominated by other kinds of financing.

None of these papers analyze crowdfunding in a duopoly setting. Some common features and ideas which we share are that under perfect information and without introducing any additional assumptions in the model, the Modigliani-Miller proposition usually holds, i.e all methods of financing (including crowdfunding) bring the same result. Under asymmetric information, different equilibria may exist where crowdfunding may play a role. Miglo (2018) is probably the closest one to the spirit of our result in that in this paper equity-based crowdfunding is a longer-term phenomenon compared to reward-based crowdfunding (since under equity-based crowdfunding funders are long-term investors) and hence, the roles of information asymmetry and information revelation are different for different types of crowdfunding. It is similar to our model where crowdfunding is a longer-term process (in our case because of the earlier commitment by the firm) than just spot sales. In both papers the process of revealing information is longer and in some sense more interesting (because the results from earlier stages of the game affect the outcome in later stages) for longer-term method of financing: crowdfunding in our paper and equity-based crowdfunding in the other paper.

The rest of the paper is organized as follows. Section 2 presents the basic model and its results for the symmetric as well asymmetric information cases. Section 3 discusses the model's predictions. Section 4 discusses the model's

robustness and its potential extensions and Section 5 is a conclusion to the study.

2 The Model

We begin by considering a traditional framework where an entrepreneurial firm has monopoly power over its product or service. The production is q. The firm trades on the spot market (the price is $p = a - q$) and (prior to that) it can use a crowdfunding campaign.[12] Let c and s denote crowdfunding pre-sales and spot sales respectively: $q = c + s$. We consider a non-arbitrage situation where the pre-sale (crowdfunding) price equals p. If a firm uses crowdfunding, the funders (those who pre-order the product during the pre-sale/crowdfunding stage) expect to receive an extra-benefit (reward) β from the firm.[13] So the total cost of these benefits for the firm equals βc. We assume that β is just large enough to compensate funders for the waiting time between the pre-sale stage and the actual sale of the product so the non-arbitrage condition holds. The firm maximizes its profit $\Pi = pq - \beta c$.

When selecting s, the firm maximizes $(a - c - s)s$.

The solution is:

$$s = \frac{a-c}{2} \tag{1}$$

Also

$$p = a - c - s = \frac{a-c}{2}$$

When selecting c, the firm maximizes $p(c+s) - \beta c = \frac{a-c}{2}\frac{a+c}{2} - \beta c$. The solution is

$$c = 0 \tag{2}$$

Lemma 1. *Under monopoly situation, crowdfunding is not used.*

Exisitng literature incorporates different additonal crowdfunding features to explain their usage. Some examples include ad-hoc non-monetary benefits as in Belleflamme et al (2014), different market imperfections as in Miglo et al (2018), uncertainty about the demand function as in Strausz (2017) and Chemla et al (2017) etc. Note, however, that none of these theoretical papers have ultimate empirical support especially in terms of the assumptions made. Also all of them need to make a lot of extra assumptions to explain the non-arbitrage condition

---

[12] In Section 4 we discuss the model's robustness with regard to different assumptions including, for example, demand function.

[13] It may include discounts on the firm's products/services, early access to some of its services, exclusive access to some services etc. Also note that there exist two types of reward-based crowdfunding. The "Keep-It-All" (KIA) model involves setting a fundraising goal and keeping the entire amount raised, regardless of whether or not they meet their goal. The "All-Or-Nothing" (AON) model involves setting a fundraising goal and keeping nothing unless the goal is achieved. In this article we do not focus on the difference between AON and KIA since asymmetric information is related to the relationship between competitors and not between the firm and the funders (the latter is the focus in Miglo et al (2018) and Belleflamme et al (2014)).

between the pre-sale (crowdfunding) price and the spot price. In our case we do not have same problem, the arbitrage condition holds automatically, we do not have any supplementary questionable empirically assumptions and hence we can focus on competitve market analysis and the crowdfunding role in this market.

Now consider a standard duopoly situation: there are two firms producing and trading the same product/service. The production of Firm 1 is q_1 and that of Firm 2 is q_2. Let c_i and s_i denote crowdfunding pre-sales and spot sales respectively for Firm i, $i \in 1, 2$: $q_i = c_i + s_i$. The spot price of the good is $p = a - q_1 - q_2$. Firm 1 has an informational advantage on its rival: it has private knowledge of the demand parameter a. Firms decide whether to use crowdfunding (this strategy will be denoted CF) or not (S). This decision is publicly observable. If a firm decides to not use crowdfunding, it will only sell on the spot market. Firms maximize their profits $\Pi_i = pq_i - \beta c_i$, $i \in 1, 2$.

2.1 Symmetric information case

Suppose that both firms are equally informed, i.e. a is common knowledge. The sequence of events in the game is as follows.
1. Firms decide whether or not to use crowdfunding.
2. Firms observe each other decision.
3. Firms determine c_i. ($c_i = 0$ if the firm does not use crowdfunding).
4. Firms determine s_i.

In stage 1 the following situations can occur: both firms select S; both firms select CF; Firm 1 selects CF and Firm 2 selects S; Firm 2 selects CF and Firm 1 uses S. We use the Nash equilibrium concept. An equilibrium is defined as a situation where no firm has an incentive to deviate. If both firms select S, the equilibrium outcome is $s_1 = s_2 = a/3$ and $\Pi_1 = \Pi_2 = a^2/9$. Indeed Firm 1 chooses s_1 to maximize $s_1(a - s_1 - s_2)$, which makes:

$$s_1 = \frac{a - s_2}{2} \tag{3}$$

Similarly for Firm 2 we get

$$s_2 = \frac{a - s_1}{2} \tag{4}$$

Solving (3) and (4) produces

$$s_i = \frac{a}{3} \tag{5}$$

Also

$$p = a - s_1 - s_2 = \frac{a}{3} \tag{6}$$

$$\Pi_i = \frac{a^2}{9} \tag{7}$$

Now consider a situation where both firms select CF. We begin the solution of this case by backwards. On the spot market, Firm 1 chooses s_1 to maximize

$s_1(a - s_1 - s_2 - c_1 - c_2)$, which makes:

$$s_1 = \frac{a - s_2 - c_1 - c_2}{2} \tag{8}$$

Similarly for Firm 2 we get

$$s_2 = \frac{a - s_1 - c_1 - c_2}{2} \tag{9}$$

Solving (8) and (9) produces

$$s_i = \frac{a - c_1 - c_2}{3} \tag{10}$$

During crowdfunding Firm 1 maximizes $(s_1 + c_1)(a - s_1 - s_2 - c_1 - c_2) - \beta c_1$ subject (10). This gives us:

$$c_1 = \frac{a - c_2 - 9\beta}{4}$$

Similarly for Firm 2:

$$c_2 = \frac{a - c_1 - 9\beta}{4}$$

It implies:

$$c_i = \frac{a - 9\beta}{5} \tag{11}$$

(10) and (11) imply that the price equals

$$p = \frac{a + 6\beta}{5} \tag{12}$$

The firm's profit equals then

$$\Pi_i = \frac{2a^2 + 2a\beta - 9\beta^2}{25} \tag{13}$$

Now consider a situation where one firm (for instance, Firm 1) selects CF and the other one selects S. In this case $c_2 = 0$.

Since $c_2 = 0$, (10) implies:

$$s_1 = s_2 = p = \frac{a - c_1}{3}$$

$$\Pi_1 = (c_1 + \frac{a - c_1}{3})\frac{a - c_1}{3} - \beta c_1 = \frac{(a + 2c_1)(a - c_1)}{9} - \beta c_1 \tag{14}$$

Firm 2 profit equals

$$\Pi_2 = s_2 p = \frac{(a - c_1)^2}{9}$$

Optimal c_1 that maximizes Firm 1 expected profit (given by (14)) equals

$$c_1 = \frac{a - 9\beta}{4} \tag{15}$$

Accordingly we have $\Pi_2 = \frac{(a+3\beta)^2}{16}$ and $\Pi_1 = \frac{a^2-2a\beta+9\beta^2}{8}$.

Note that if β is sufficiently small, not using crowdfunding makes Firm 2 worse off compared to the case (S,S). Early committment of Firm 1 makes the product price lower, increases the production of Firm 1 and forces Firm 2 out of its optimal quantity.

The matrix of payoffs for the different cases is shown in Figure 1.

Firm 1/Firm 2	S	CF
S	$\frac{a^2}{9} ; \frac{a^2}{9}$	$\frac{(a+3\beta)^2}{16} ; \frac{a^2-2a\beta+9\beta^2}{8}$
CF	$\frac{a^2-2a\beta+9\beta^2}{8} ; \frac{(a+3\beta)^2}{16}$	$\frac{2a^2+2a\beta-9\beta^2}{25} ; \frac{2a^2+2a\beta-9\beta^2}{25}$

Figure 1. Matrix of payoffs.

Proposition 1. *(S,S) is not an equilibrium.*

Proof. Indeed consider the situation where both firms select S. Suppose that Firm 1 decides to use crowdfunding. We have:

$$\frac{a^2 - 2a\beta + 15\beta^2}{8} > \frac{a^2}{9}$$

So (S,S) is not an equilibrium. Firms have an incentive to use crowdfunding and force the second firm out of the market to some extent. Note that if β is small neither of the 3 possible equilibria are Pareto improving compared to (S,S). And (CF,CF) makes both firms worse off compared to (S,S). If crowdfunding destroys social surplus should the government prohibit it? The next section considers the case of asymmetric information between firms and sheds more lights on the role of crowdfunding.

2.2 Asymmetric information

Suppose that there are two types of Firm 1: $a = a_h$ for type h and $a = a_l$ for type l, where $a_h > a_l$ (further subscript h/l indicates that the firm is type h/l). Firm 1 knows the value of a while Firm 2 does not so firm 2 tries to figure it out from the actions undertaken by Firm 1.[14] Then for each type of Firm 1 we have a different payoff matrix depending on the value of a. An equilibrium is a situation where no type has an incentive to deviate. It is characterized by actions (strategies) undertaken by each type of Firm 1, the beliefs of Firm 2 about Firm 1's type after observing different actions (on equilibrium path and off-equilibrium path) and actions undertaken by Firm 2. We focus on separating equilibria which help to generate predictions about the signalling power of crowdfunding. It is an equilibrium where different types of Firm 1 select different strategies. Two possible separating equilibria may exist. One

---

[14] Asymmetric information between firms and consumers (in a monopolistic setting) is studied in Belleflamme et al (2014) and Miglo et al (2018). In a competitve setting this represents an interesting direction for future research.

where type l uses crowdfunding and type h does not and another where type h uses it and l does not.

Proposition 2. *A separating equilibrium exists where type h selects CF and type l selects S. A separating equilibrium where type l selects CF and type h selects S does not exist.*

Proof. First consider the case $\beta = 0$. The matrix of payoffs for the case of perfect information for each type of Firm 1 is as follows.

Firm 1/Firm 2	S	CF
S	$\frac{a_l^2}{9} ; \frac{a_l^2}{9}$	$\frac{a_l^2}{16} ; \frac{a_l^2}{8}$
CF	$\frac{a_l^2}{8} ; \frac{a_l^2}{16}$	$\frac{2a_l^2}{25} ; \frac{2a_l^2}{25}$

Figure 2a. Matrix of payoffs for type l when $\beta = 0$.

Firm 1/Firm 2	S	CF
S	$\frac{a_h^2}{9} ; \frac{a_h^2}{9}$	$\frac{a_h^2}{16} ; \frac{a_h^2}{8}$
CF	$\frac{a_h^2}{8} ; \frac{a_h^2}{16}$	$\frac{2a_h^2}{25} ; \frac{2a_h^2}{25}$

Figure 2b. Matrix of payoffs for type h when $\beta = 0$.

The candidate for a separating equilibrium is the case where Firm 2 selects CF and different types of Firm 1 select different strategies. The situation where Firm 2 selects S can not be an equilibrium. As follows from Figure 2, Firm 2 would deviate to CF. So we consider a situation where Firm 2 selects CF and Firm 1 selects CF if it has type l and selects S otherwise. Firm 2 believes that the type is l when observing CF and h when observing S. From Figure 2 the payoffs of each type are

$$\Pi_{1l} = \frac{2a_l^2}{25} \tag{16}$$

$$\Pi_{1h} = \frac{a_h^2}{16} \tag{17}$$

where Π_{1j} is the equilibrium profit of type j (all calculations are based on the symmetric information case for each type described in the previous section). Suppose that h mimics l and uses crowdfunding. (11) implies

$$c_2 = \frac{a_l}{5}$$

$$s_2 = \frac{a_l}{5}$$

Firm h chooses s_1 to maximize $s_1(a_h - s_1 - s_2 - c_1 - c_2)$. Solving for s_1

$$s_1 = \frac{5a_h - 3a_l}{10}$$

$$p = \frac{5a_h - 3a_l}{10}$$

9

$$\Pi_{1h} = \frac{(5a_h - a_l)(5a_h - 3a_l)}{100}$$

Comparing this with (17) we find that this is smaller if

$$a_l\left(\frac{8}{15} - \frac{2\sqrt{7}}{15}\right) < a_h < a_l\left(\frac{8}{15} + \frac{2\sqrt{7}}{15}\right) \tag{18}$$

The right side of this condition does not hold since it is smaller than a_l but $a_h \geq a_l$. So this equilibrium does not exist. If Firm 2 perceives a firm that uses a crowdfunding campaign as a low demand firm, it will be pessimistic about the price and will concede the market. Type h can benefit from this situation by mimicking the strategy of type l during the crowdfunding stage.

Now consider an equilibrium where type h uses crowdfunding and l does not. The equilibrium's payoffs are:

$$\Pi_{1h} = \frac{2a_h^2}{25} \tag{19}$$

$$\Pi_{1l} = \frac{a_l^2}{16} \tag{20}$$

Suppose that h mimics l and does not use crowdfunding. (15) implies:

$$c_2 = \frac{a_l}{4}$$

$$s_2 = \frac{a_l}{4}$$

h maximizes its profit: $(a_h - \frac{a_l}{4} - \frac{a_l}{4} - s_1)s_1$. Solving for s_1

$$s_1 = \frac{2a_h - a_l}{4}$$

$$p = \frac{2a_h - a_l}{4}$$

$$\Pi_{1h} = \frac{(2a_h - a_l)^2}{16}$$

Comparing this with (19) we find that this is smaller if

$$\frac{25 - 10\sqrt{2}}{34}a_l < a_h < \frac{25 + 10\sqrt{2}}{34}a_l \tag{21}$$

.

Suppose that l mimics h and does use crowdfunding. (11) implies

$$c_2 = \frac{a_h}{5}$$

$$s_2 = \frac{a_h}{5}$$

10

Firm l chooses s_1 to maximize $s_1(a_l - s_1 - s_2 - c_1 - c_2)$. Solving for s_1

$$s_1 = \frac{5a_l - 3a_h}{10}$$

$$p = \frac{5a_l - 3a_h}{10}$$

$$\Pi_{1l} = \frac{(5a_l - a_h)(5a_l - 3a_h)}{100}$$

Comparing this with (20) we find that this is smaller if

$$\frac{(4 - \sqrt{7})5a_l}{6} < a_h < \frac{(4 + \sqrt{7})5a_l}{6} \tag{22}$$

.

Note that the conditions (21) and (22) can hold simultaneously because $\frac{(4-\sqrt{7})5}{6} < \frac{25+10\sqrt{2}}{34}$.

Therefore an equilibrium where type h uses crowdfunding (and sells $c_{1h} = a_h/5$) and l does not (and sells $c_{1l} = 0$) may exist.

The case with $\beta > 0$ is considered in the Appendix.

The main result of Proposition 2 is that the only signalling equilibrium that can exist is when the high-demand type selects crowdfunding.

3 Implications

Our paper has several implications for an entrepreneurial firm's choice of crowdfunding.

Proposition 1 explains the value of crowdfunding for firms. Under monopoly, crowdfunding is not used. If the non-argbitrage condition holds, the firm should compensate buyers for waiting by offering rewards, which makes crowdfunding a more expensive option. However in the case of a duopoly firms may select crowdfunding in favor of just spot price sales. A situation where both firms do not use crowdfunding is never an equilibrium. Firms have an incentive to use crowdfunding that forces the second firm out of the market to some extent. Early committment from one firm by using crowdfunding makes the product price lower, increases the production of this firm and forces the other firm out of its optimal quantity.

Proposition 2 implies that high-quality firms can use crowdfunding to signal their quality. If an uninformed firm perceives a firm that uses a crowdfunding campaign as being a low-demand firm, it will be pessimistic about the price and will concede the market. A high-quality firm can benefit from this situation by mimicking the strategy of low-quality firms during the crowdfunding stage. So an equilibrium where the low-demand firm uses crowdfunding and the high-demand firm does not use it does not exist. However, as we show the opposite is true and an equilibrium where a high-demand firm uses crowdfunding can exist.

Competition is high because firm 2 perceives crowdufnding as being a high-demand product with high prices so firm 2 also increases its production, which implies that a low quality firm will not mimick this strategy. This prediction has not been directly tested but is consistent with the spirit of the results found in Ahlers, Cumming, Guenther, and Schweizer (2015), Cumming, Leboeuf and Schwienbacher (2014) and Mollick (2014) (the firm's financing choice can serve as a signal of a project's quality).[15]

4   The Model Extensions And Robustness

Different demand functions. Our focus in this article is to analyze the role of asymmetric information in crowdfunding. That is why we adopt a relatively simple demand function. In dynamic monopoly pricing literature this approach is not unusual (see, for example, Demichelis and Tarola (2006)). The intuitions behind our results (such as Propositions 1, 2) is general enough and will hold if mathematically different demand functions are used. Alternatively, a sigificantly different approach of modelling the demand side can be taken where individual customers with different demand functions are included (see, for example, Belleflamme et al (2014) and Strausz (2017)). This approach is often used in industrial organization or price discrimination literature. Our focus is on asymmetric information between competitors and the approach that uses total demand functions from investors/funders (the market) is very common. Below we analyze a setting with individual demands and show that the basic idea holds.

An entrepreneurial firm has monopoly power over its product or service. The production is q. A potential consumer's surplus from buying the product is $v-p$, where p is the price and v is the consumer's product valuation. Each consumer only needs one unit of the product/service. The valuation from consuming an extra-unit is zero. Consumers buy/order the product/service as long as they have a non-negative surplus $v-p$, where p is the price. v is uniformly distributed between 0 and a. The firm trades on the spot market and (prior to that) it can use a crowdfunding campaign. Let c and s denote crowdfunding pre-sales and spot sales respectively: $q = c + s$. We consider a non-arbitrage situation where the pre-sale (crowdfunding) price equals p. If a firm uses crowdfunding, the funders (those who pre-order the product during the pre-sale/crowdfunding stage) expect to receive an extra-benefit (reward) β from the firm, $\beta \leq a$. So the total cost of these benefits for the firm equals βc. We assume that β is just large enough to compensate the funders for the waiting time between the pre-sale stage and the actual sale of the product so the non-arbitrage condition holds. The firm maximizes its profit $\Pi = pq - \beta c$. Also we assume that if a consumer is indifferent between buying during crowdfunding and spot selling, they will split randomly between periods.

---

[15]See, for example:
 http://crowdfunding.cmf-fmc.ca/facts_and_stats/how-likely-is-your-crowdfunding-campaign-to-succeed

Suppose the price is p. All buyers with $v \geq p$ are interested in buying the product. By assumption 50% of them will be buying during crowdfunding and 50% during pre-sale. Since they are randomly split, the firm's profit equals: $p\frac{a-p}{2} - \beta\frac{a-p}{2} + p\frac{a-p}{2} = p(a-p) - \beta\frac{a-p}{2}$. The optimal price is $p = \frac{a+\beta/2}{2}$. The firm's profit is

$$\frac{a+\beta/2}{2}(a - \frac{a+\beta/2}{2}) - \beta\frac{a-\beta/2}{4} = \frac{a^2}{4} + \frac{\beta^2}{16} - \frac{a\beta}{4} \tag{23}$$

If the firm does not use crowdfunding all consumers with $v \geq p$ will buy the product on the spot market. The firm's profit equals $p(a-p)$. The optimal price is $p = \frac{a}{2}$. The firm's profit is $\frac{a}{2}(a - \frac{a}{2}) = \frac{a^2}{4}$. This is greater than (23). So the firm should not use crowdfunding which is consistent with Lemma 1.

Now consider a duopoly. We assume that if there is more than one firm offering the same price, consumers will be split randomly. Suppose that both firms do not use crowdfunding. By assumption 50% of them will be from Firm 1 and 50% from Firm 2. Since they are randomly split, each firm's profit equals $p\frac{a-p}{2}$. The optimal price is $p = \frac{a}{2}$. The firm's profit is

$$\frac{a}{2}(\frac{a - \frac{a}{2}}{2}) = \frac{a^2}{8} \tag{24}$$

Now suppose that one firm deviates and uses crowdfunding (for example, Firm 1). By assumption 50% of consumers will buy the product during crowdfunding and 50% during spot market sale. Firm 1's profit equals: $\frac{a}{2}\frac{3a}{8} - \beta\frac{a}{4} = \frac{3}{16}a^2 - \beta\frac{a}{4}$. This greater than (24). So an equilibrium where both firms do not use crowdfunding does not exist.

Now consider the case where only one firm uses crowdfunding (for example, Firm 1). By assumption 50% of consumers will be buying the product during crowdfunding and 50% during spot market sale. Firm 1's profit equals: $p\frac{3(a-p)}{4} - \beta\frac{a-p}{2}$. The optimal price is $p = \frac{\frac{3a}{4} + \frac{\beta}{2}}{\frac{3}{2}}$. The firm's profit is $\frac{a+\beta/2}{2}(a - \frac{a+\beta/2}{2}) - \beta\frac{a-\beta/2}{4}$. The other firm profit is $\frac{\frac{3a}{4}+\frac{\beta}{2}}{\frac{3}{2}}\frac{(a-p)}{4}$.

Now consider the case where both firms use crowdfunding. By assumption 50% of consumers will be buying the product during crowdfunding and 50% during spot market sale. The firm's profit equals: $p\frac{a-p}{4} - \beta\frac{a-p}{4} + p\frac{a-p}{4} = \frac{p(a-p)}{2} - \beta\frac{a-p}{4}$. The optimal price is $p = \frac{a+\beta/2}{2}$. The firm's profit is

$$\frac{a+\beta/2}{2}(\frac{a}{2} - \frac{a+\beta/2}{4}) - \beta\frac{a-\beta/2}{8} = \frac{a^2}{8} + \frac{\beta^2}{32} - \frac{a\beta}{8} \tag{25}$$

Now suppose that one firm deviates and does not use crowdfunding (for example, Firm 1). By assumption 50% of consumers will buy the product during crowdfunding and 50% during spot market sale. Firm 1's profit equals: $\frac{a+\beta/2}{2}(a - \frac{a+\beta/2}{2})/4 = \frac{a^2}{16} - \frac{\beta^2}{64}$. This is smaller than (25). So an equilibrium where both firms use crowdfunding does exist, which is consistent with Proposition 1.

Changing the value of the reward. One of the assumption of our analysis is that the reward is just high enough to comensate buyers for waiting. Different concepts can instead be used. One should note however that without any additional assumptions ours is the simplest approach such that the non-arbitrage condition holds, which is one of the crucial assumptions when modelling consumers behavior and demand. Different papers make different assumptions in order to model rewards, for example in Belleflamme et al (2014) there are ad-hoc community benefits related to crowdfunding which creates a difference between the pre-sale price and the spot price; in Chemla et al (2017) a risk exists that the firm will not make some intermediate investment required to produce the product between the crowdfunding stage and actual sales so the crowdfunding price can be lower than spot price because of moral hazard and risk problems for funders etc.

The distribution of types. In the sections that deal with asymmetric information we use two types of firms to illustrate the main ideas. This is also very typical in literature. A natural question though is whether the results stand if one considers a case with multiple types. Our analysis shows[16] that most conclusions remain the same: under asymmetric information, crowdfunding is a signal of quality compared to spot sales. In the case of multple types, however, an equilibrium may exist where only the type with the lowest demand (speaking about Proposition 2 when $\beta = 0$) will be indifferent between crowdfunding and spot sales and every other type selects crowdfunding. When $\beta > 0$, our analysis shows that the results may hold even in a multiple types environment though more research is required. The main implication of our analysis holds. In particular, our results show that there is no semi-separating equilibrium where the average quality of types that choose crowdfunding is lower than those that choose spot sales, which is consistent with our basic model.

Different types of crowdfunding. Unlike capital structure literature, where debt/equity mix is a very common strategy (as opposed to pure equity or pure debt financing), in our paper firms decide whether or not to use crowwdfunding. So mixing these two decisions makes no sense. Further extensions however are possible where firms consider different types of crowdfunding including equity-based, debt-based crowdfunding, etc.. Most resutls regarding the costs and benefits of different financing strategies found in this paper are quite general and do not depend on the introduction of more options in the model. Quantitatively though, some conditions may change. It is definitely an interesting direction for future research. Note that most existing theoretical literature on crowdfunding does often consider reward-based and equity-based crowdfunding separately from debt-based crowdfunding. One of the reasons for this seems to be that the founders' objectives are quite different in these scenarios (see, for example, Hildebrand, Puri, and Rocholl (2014)).

---

[16]Proofs are available upon demand. Note that the calculations become much longer and technically more complicated, which is very typical for multiple types games with asymmetric information.

5   Conclusions

Traditionally crowdfunding was used for funding highly innovative projects where firms retain monopoly power during the development and sales of the product. Recently, however, companies began to use crowdfunding for financing more traditional products and services where they compete against other sellers of similar products. This paper offers a model of a duopoly where firms can use crowdfunding prior to direct sales. The model is based on asymmetric information between competitors regarding the demand for the product. It provides several implications that have not yet been tested. For example we find that high-demand firms can use crowdfunding to signal their quality.

References

Ahlers, Gerrit, Cumming, Douglas, Guenther, Christina, and Denis Schweizer (2015). 'Signaling in Equity Crowdfunding'. *Entrepreneurship Theory and Practice*, 39 (4), 955-980.

Allaz, Blaise (1992). 'Oligopoly, Uncertainty and Strategic Forward Transactions'. *International Journal of Industrial Organization*, 10 (2), 297-308.

Belleflamme, Paul, Lambert, Thomas, and Armin Schwienbacher (2014). 'Crowdfunding: Tapping the Right Crowd'. *Journal of Business Venturing: entrepreneurship, entrepreneurial finance, innovation and regional development* 29 (5), 585-609.

Chakraborty, Soudipta, and Robert Swinney (2017). 'Signalling to the Crowd: Private Quality Information and Rewards-Based Crowdfunding'. SSRN Working Paper. http://dx.doi.org/10.2139/ssrn.2885457.

Chemla, Gillles, and Katrin Tinn (2017). 'Learning Through Crowdfunding'. Available at SSRN: https://ssrn.com/abstract=2796435   10.2139/ssrn.2796435

Cholakova, Magdalena, and Bart Clarysse. (2015). 'Does the Possibility to Make Equity Investments in Crowdfunding Projects Crowd Out Reward-Based Investments?' *Entrepreneurship Theory and Practice,* 39 (1), 145–172.

Cordova, Alessandro, and Johanna Dolci. (2015). The Determinants of Crowdfunding Success: Evidence from Technology Projects' *Gianfranco Gianfrate Procedia - Social and Behavioral Sciences* Volume 181 (11), 115-124.

Cumming, Douglas, Leboeuf, Gaël, and Armin Schwienbacher (2014). 'Crowdfunding Models: Keep-it-All vs. All-or-Nothing'. SSRN working paper.

Demichelis, Stefano, and Ornella Tarola (2006). 'Capacity Expansion And Dynamic Monopoly Pricing'. *Research in Economics,* 60 (4), 169-178.

Fairchild, Richard (2005). 'The Effect of Managerial Overconfidence, Asymmetric Information, And Moral Hazard On Capital Structure Decisions'. *ICFAI Journal of Behavioral Finance* 2 (4), 34-44.

Hildebrand, Thomas, Puri, Manju, and Jörg Rocholl (2014). Adverse Incentives in Crowdfunding. Available at SSRN: http://ssrn.com/abstract=1615483.

Hughes, John S., and Jennifer L. Kao (1997). 'Strategic forward contracting and observability'. *International Journal of Industrial Organization*, 16 (1), 121-133.

Kumar, Praveen, Landberg, Nisan, and David Zvilichovsky (2015).

'(Crowd)funding Innovation'. working paper.

https://www.aeaweb.org/conference/2016/retrieve.php?pdfid=661.

Miglo, Anton (2018). 'Crowdfunding Under Market Feedback, Asymmetric Information And Overconfident Entrepreneur'. working paper.

Miglo, Anton, and Victor Miglo (2018). 'Market Imperfections and Crowdfunding'. *Small Business Economics Journal*, forthcoming.

Modigliani, Franco, and Merton Miller (1958). 'The Cost of Capital, Corporation Finance and the Theory of Investment'. *American Economic Review, 48 (3)*, 261–297.

Mollick, Ethan (2014). 'The Dynamics of Crowdfunding: An Exploratory Study'. *Journal of Business Venturing, 29 (1)*, 1–16.

Mollick, Ethan (2015). 'Delivery Rates on Kickstarter'. Available at SSRN: https://ssrn.com/abstract=2699251

Santos, Vasco. (2017). 'The Economics of Crowdfunding: Surplus Appropriation, and Allocative Efficiency'. working paper

Strausz, Roland (2017). 'Crowdfunding, Demand Uncertainty, And Moral Hazard - a Mechanism Design Approach'. *American Economic Review*, 107(6), 1430-76. 10.1257/aer.20151700.

Appendix

Proof of Proposition 2 case $\beta > 0$. Consider an equilibrium where type h uses crowdfunding and l does not. The equilibrium's payoffs are:

$$\Pi_{1h} = \frac{2a_h^2 + 2a_h\beta - 9\beta^2}{25} \tag{26}$$

$$\Pi_{1l} = \frac{(a_l + 3\beta)^2}{16} \tag{27}$$

where Π_{1j} is the equilibrium profit of type j (all calculations are based on the symmetric information case for each type described in the previous section). Suppose that h mimics l and does not use crowdfunding. (11) implies

$$c_2 = \frac{a_l - 9\beta}{4}$$

$$s_2 = \frac{a_l - 9\beta}{4}$$

$(a_h - \frac{a_l - 9\beta}{4} - \frac{a_l - 9\beta}{4} - s_1)s_1$. Solving for s_1

$$s_1 = \frac{2a_h - a_l + 9\beta}{4}$$

$$p = \frac{2a_h - a_l + 9\beta}{4}$$

$$\Pi_{1h} = \frac{(2a_h - a_l + 9\beta)^2}{16}$$

Comparing this with (26) we find that this is smaller if

$$\frac{25a_l}{34} - \frac{217\beta}{34} - \frac{100}{34}\sqrt{\frac{a_l^2}{50} - \frac{a_l\beta}{25} + \frac{43417\beta^2}{10000}} < a_h < \frac{25a_l}{34} - \frac{217\beta}{34} + \frac{100}{34}\sqrt{\frac{a_l^2}{50} - \frac{a_l\beta}{25} + \frac{43417\beta^2}{10000}}$$
(28)

Suppose that l mimics h and does use crowdfunding. (11) implies

$$c_2 = \frac{a_h - 9\beta}{5}$$

$$s_2 = \frac{a_h + 6\beta}{5}$$

Since l pretends to be h, it chooses $c_1 = c_2 = \frac{a_h - 9\beta}{5}$. Also firm l chooses s_1 to maximize $s_1(a_l - s_1 - s_2 - c_1 - c_2)$. Solving for s_1

$$s_1 = \frac{5a_l - 3a_h + 12\beta}{10}$$

$$p = \frac{5a_l - 3a_h + 12\beta}{10}$$

$$\Pi_{1l} = \frac{(5a_l - a_h - 6\beta)(5a_l - 3a_h + 12\beta)}{100}$$

Comparing this with (27) we find that this is smaller if

$$\frac{10a_l}{3} - \beta - \frac{50}{3}\sqrt{\frac{7a_l^2}{400} - \frac{3a_l\beta}{200} + \frac{315}{2000}\beta^2} < a_h < \frac{10a_l}{3} - \beta + \frac{50}{3}\sqrt{\frac{7a_l^2}{400} - \frac{3a_l\beta}{200} + \frac{315}{2000}\beta^2}$$
(29)

The first part of the proposition follows from the case $\beta = 0$ and the continuity of conditions (28) and (29) with regard to β. Since an equilibrium exists when $\beta = 0$, it also exists when β is sufficiently small.

Now consider a situation where type l uses crowdfunding and h does not. The payoffs of each type

$$\Pi_{1l} = \frac{2a_l^2 + 2a_l\beta - 9\beta^2}{25} \tag{30}$$

$$\Pi_{1h} = \frac{(a_h + 3\beta)^2}{16} \tag{31}$$

where Π_{1j} is the equilibrium profit of type j (all calculations are based on the symmetric information case for each type described in the previous section). Suppose that h mimics l and does use crowdfunding. (11) implies

$$c_2 = \frac{a_l - 9\beta}{5}$$

$$s_2 = \frac{a_l + 6\beta}{5}$$

17

Since h pretends to be l, it chooses $c_1 = c_2 = \frac{a_l - 9\beta}{5}$. Also firm h chooses s_1 to maximize $s_1(a_h - s_1 - s_2 - c_1 - c_2)$. Solving for s_1

$$s_1 = \frac{5a_h - 3a_l + 12\beta}{10}$$

$$p = \frac{5a_h - 3a_l + 12\beta}{10}$$

$$\Pi_{1h} = \frac{(5a_h - a_l - 6\beta)(5a_h - 3a_l + 12\beta)}{100}$$

Comparing this with (31) we find that this is smaller if

$$\frac{8a_l}{15} + \frac{\beta}{5} - \frac{8}{3}\sqrt{\frac{7a_l^2}{400} - \frac{3a_l\beta}{200} + \frac{1548}{1600}\beta^2} < a_h < \frac{8a_l}{15} + \frac{\beta}{5} + \frac{8}{3}\sqrt{\frac{7a_l^2}{400} - \frac{3a_l\beta}{200} + \frac{1548}{1600}\beta^2} \tag{32}$$

If β is sufficiently small, the right side of this inequality does not hold. Suppose that l mimics h and does not use crowdfunding. (11) implies

$$c_2 = \frac{a_h - 9\beta}{4}$$

$$s_2 = \frac{a_h - 9\beta}{4}$$

When chosing s_1, Firm 1 maximizes $(a_l - \frac{a_h - 9\beta}{4} - \frac{a_h - 9\beta}{4} - s_1)s_1$. Solving for s_1

$$s_1 = \frac{2a_l - a_h + 9\beta}{4}$$

$$p = \frac{2a_l - a_h + 9\beta}{4}$$

$$\Pi_{1l} = \frac{(2a_l - a_h + 9\beta)^2}{16}$$

Comparing this with (30) we find that this is smaller if

$$2a_l + 9\beta - 8\sqrt{\frac{a_l^2}{50} + \frac{a_l\beta}{50} - \frac{9\beta^2}{100}} < a_h < 2a_l + 9\beta + 8\sqrt{\frac{a_l^2}{50} + \frac{a_l\beta}{50} - \frac{9\beta^2}{100}} \tag{33}$$

The second part of the proposition follows from the case $\beta = 0$ and the numerical analysis of conditions (32) and (33). The following pictures present a graphical illustration of the above conditions for different values of β (horizontal axes is a_l, vertical axes is a_h).
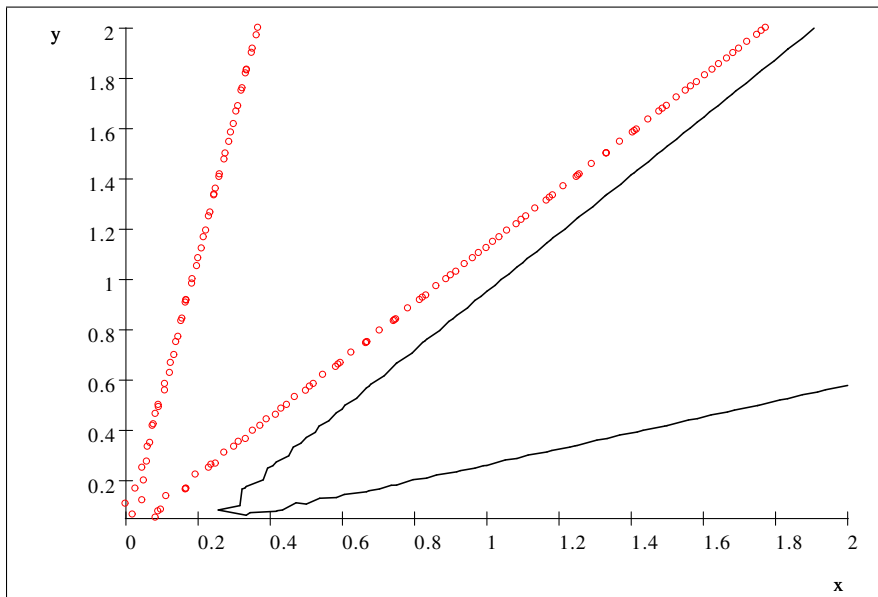
18
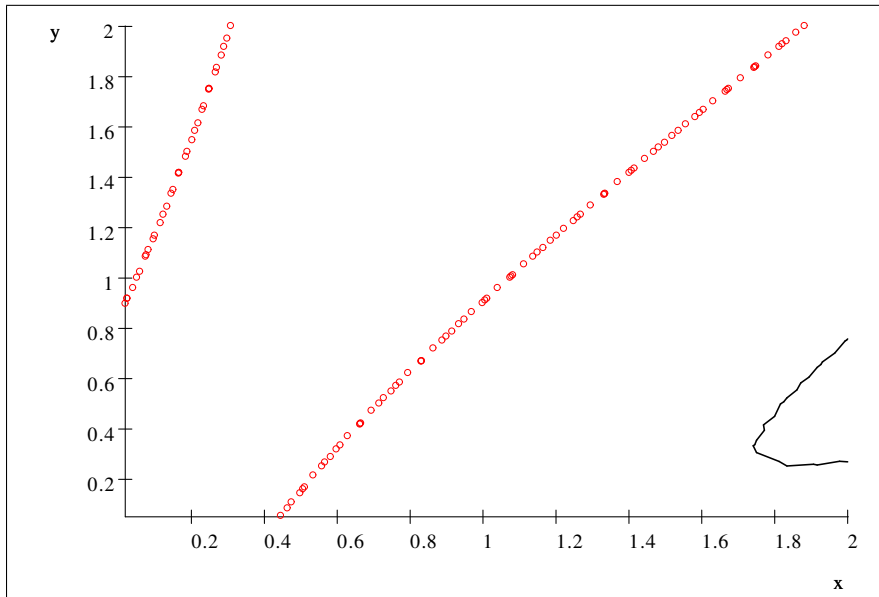
$\beta = 0.15$. **Area between circled lines: non-mimicking condition for** h**.**
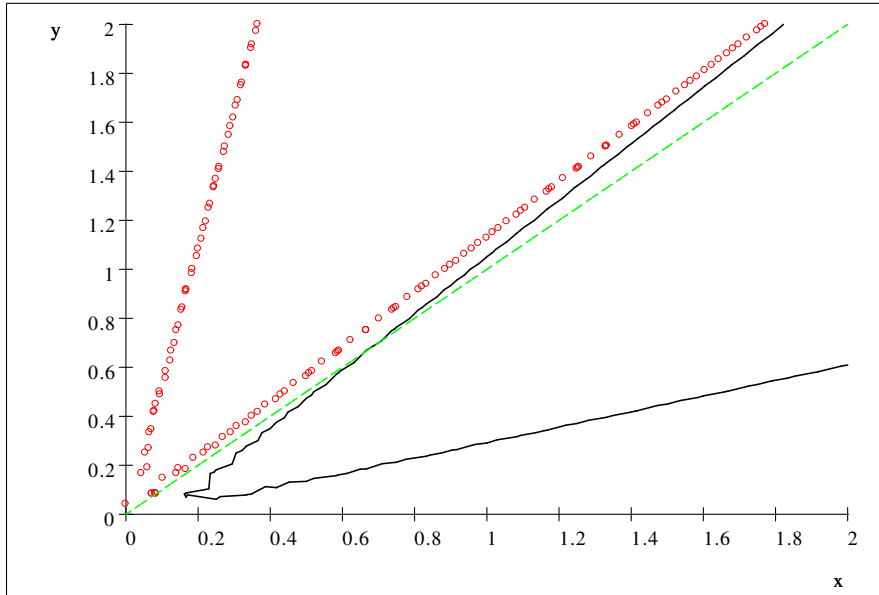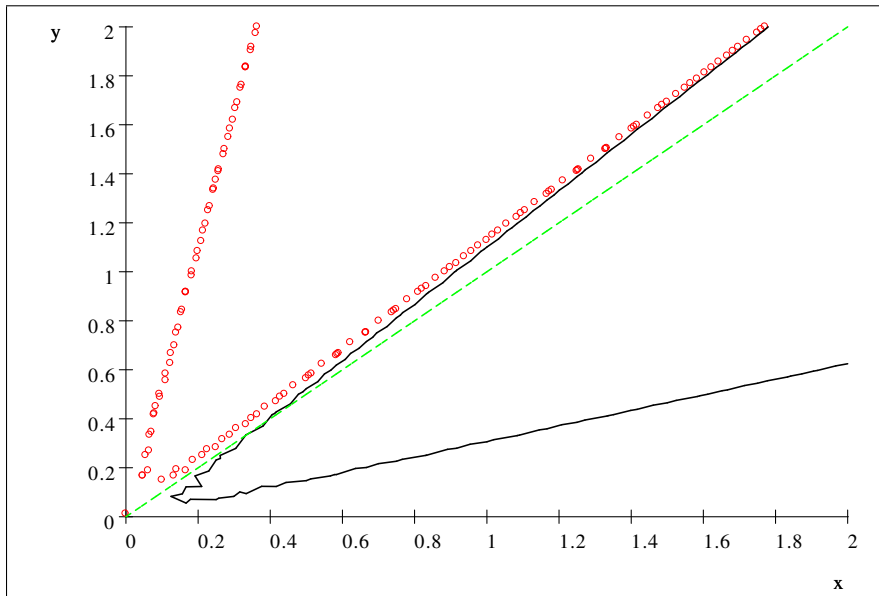**Area between bold lines: non-mimicking condition for** l**.**
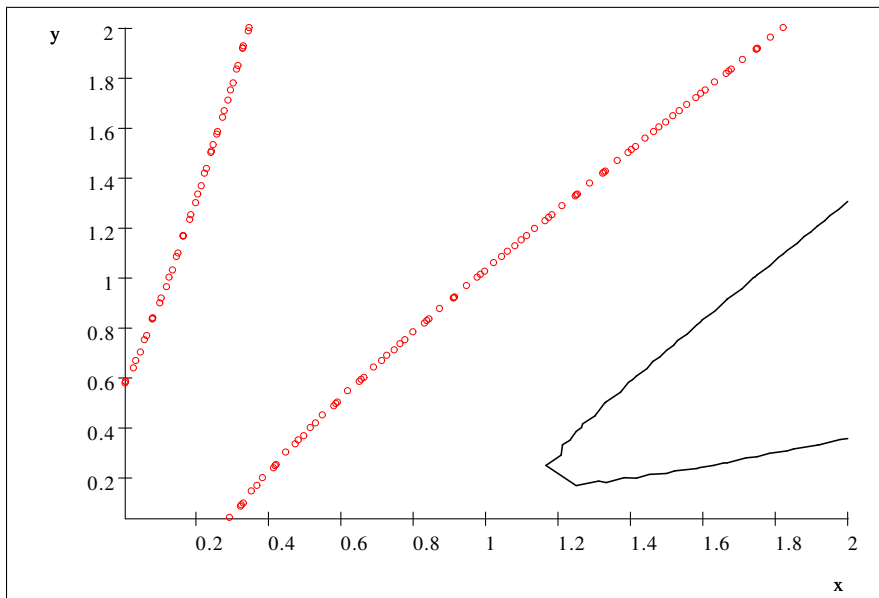
$\beta = 0.1$. **Area between circled lines: non-mimicking condition for** h**.**
Area between bold lines: non-mimicking condition for l**.**
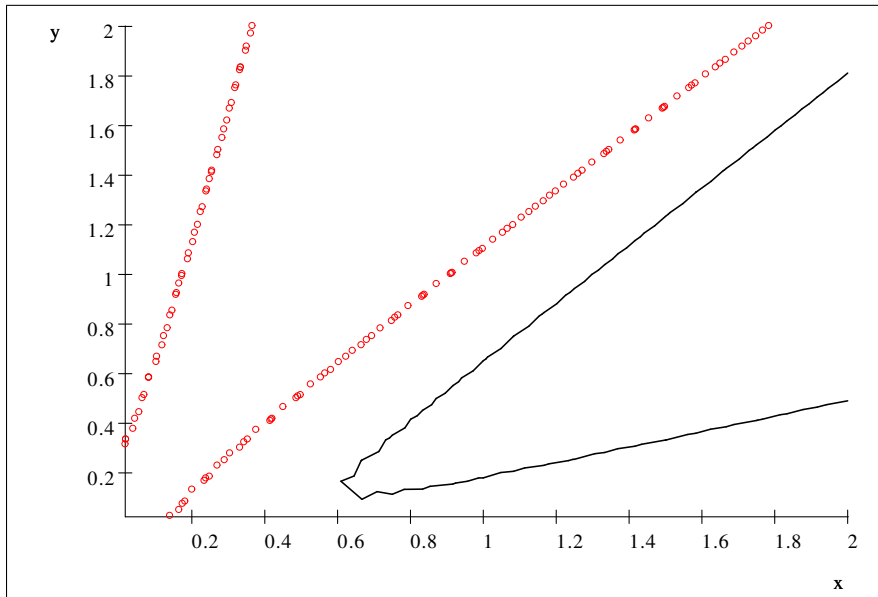
$\beta = 0.05$. **Area between circled lines: non-mimicking condition for** h**.**
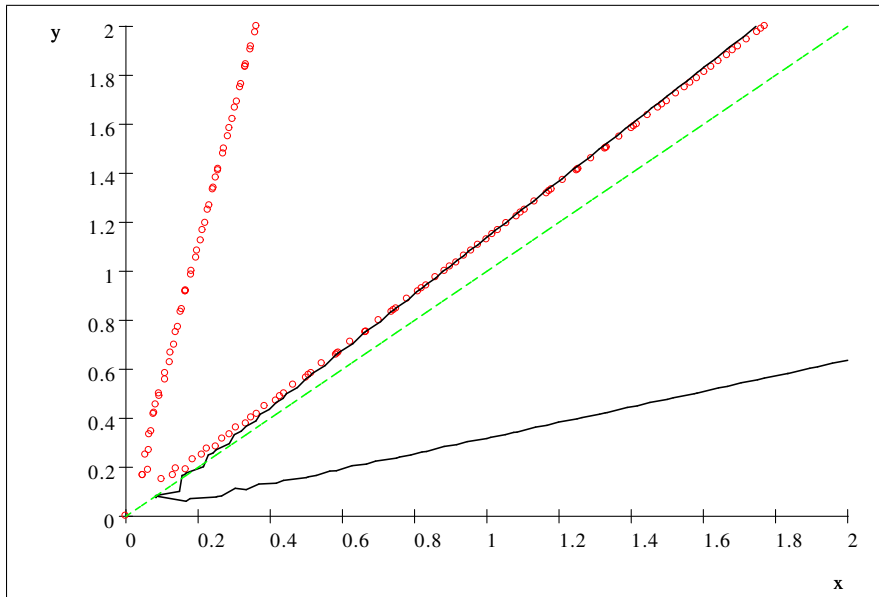**Area between bold lines: non-mimicking condition for** l**.**

$\beta = 0.02$. **Area between circled lines: non-mimicking condition for** h**.**
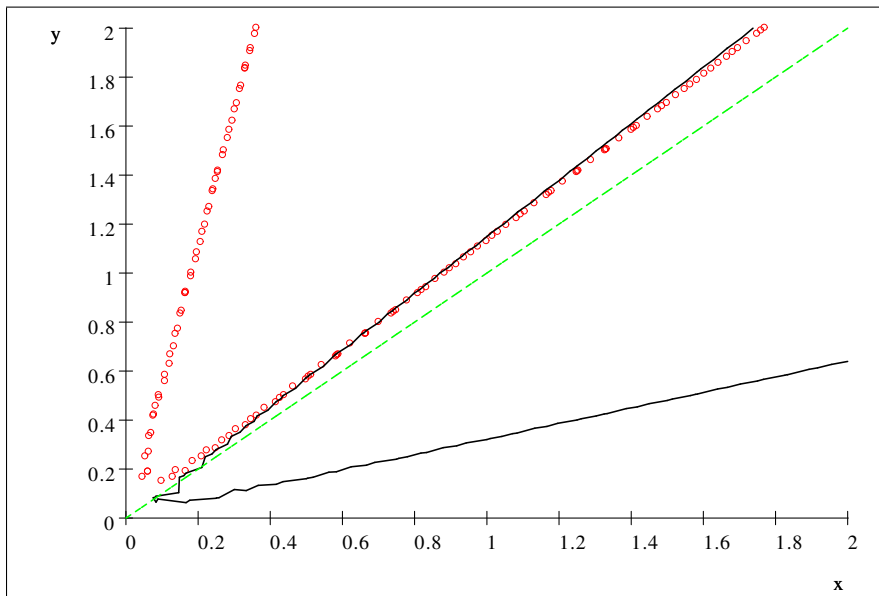**Area between bold lines: non-mimicking condition for** l**.**

$\beta = 0.01$. **Area between circled lines: non-mimicking condition for** h.
Area between bold lines: non-mimicking condition for l**. Dot-dash
line:** $a_h = a_l$.

$\beta = 0.005$. **Area between circled lines: non-mimicking condition for** h.
Area between bold lines: non-mimicking condition for l**. Dot-dash
line:** $a_h = a_l$.

$\beta = 0.001$. **Area between circled lines: non-mimicking condition for** h**.**
Area between bold lines: non-mimicking condition for l**. Dot-dash**
line: $a_h = a_l$**.**

$\beta = 0$. **Area between circled lines: non-mimicking condition for** h**.**
Area between bold lines: non-mimicking condition for l**. Dot-dash**
line: $a_h = a_l$**.**

We see that the zone where both non-mimicking conditions intersect does not exist for cases $\beta = 0.01$, $\beta = 0.02$, $\beta = 0.05$, $\beta = 0.1$ and $\beta = 0.15$ so they cannot hold simultaneously. Furthermore, with a higher β these areas become farther away. For cases $\beta = 0$, $\beta = 0.001$ and $\beta = 0.005$ these areas do intersect (or can intersect) however it happens in the non-feasible area where a_h (vertical axis) is less than a_l (horizontal axis). The latter is consistent with the case $\beta = 0$ described in the main text.