No Mission? No Motivation.
On the Determinants of Firms' Organizational Form

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Preliminary and incomplete

Abstract

A firm hires its prospective workers without observing their heterogeneous skills and their motivation to work. The firm's optimal screening contracts, which are contingent on workers' ability and which satisfy workers' limited liability are studied and related to the optimal choice of the mission-orientation on the part of the firm. Indeed, the firm's mission also has an impact on the level of workers' motivation. When the firm sacrifices a significant fraction of its revenues for socially worthwhile projects, it increases the pro-social motivation of workers and induces them to donate their labor Then volunteerism emerges as the contractual outcome for low-skilled employees. The relationship introduced between the firm's mission choice and the endogenous motivation of workers allows to provide an explanation for the emergence of different organizational forms, such as non-profits, non-governmental organizations and socially responsible corporations, which complement public agencies in the provision of collective goods and services.

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1 Introduction

In recent years and all over the world, the delivery of many goods and services, which have a collective or public nature, has no longer been the prerogative of governments. Indeed, in

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health care, education and research, just to mention the most relevant sectors, increasing importance have acquired "private social-sector organizations such as non-profits, non-governmental organizations (NGOs), and social enterprises" (see Besley and Gathak, 2018, page 412).

The non-profit sector, for instance, accounts for a substantial amount of economic activity in the United States. According to Salamon (2012) and to the 2018 report by the Center for Civil Society Studies at Johns Hopkins University, there are approximately 2 million non-profits in the U.S. that together account for approximately $2 trillion in revenue. The non-profit workforce is the third largest of all U.S. industries behind retail trade and manufacturing, with total (paid) employees numbering 13.5 million. In particular, Lakdawalla and Philipson (2006) document that: "Health care production dominates the non-profit sector in the U.S. and accounts for half of its total employment. [..] Education and research make up the second largest component of non-profit employment with about 20%, followed by social services, such as child care and job training, with about 15%". Moreover, when the estimated 4.5 million volunteer workers are added to the 13.5 million paid workers, the nonprofit sector has the largest workforce in the U.S. economy.[1]

Despite the growing importance of these private social-sector organizations, little research has been done to explain why different organizational forms have emerged for the provision of collective goods and how these organizations operate in the relevant markets (in particular in the marker for labor). Besides being involved in the production of goods and services that have significant social returns, over and above their private returns, there are other characteristic features of these enterprises, that represent the building blocks of the present analysis. First, such organizations experience a trade-off between profit and purpose (see Besley and Gathak, 2017), meaning that they do not strictly pursue the objective of profit maximization, they rather sacrifice part of their profits to engage in socially worthwhile projects; in a nutshell, they are mission-oriented firms that are free to choose their level of commitment to a social cause. Second, social enterprises are staffed with motivated workers, i.e. with employees who are not

[1] There are approximately 1.5 million NGOs that operate in the United States. Many of them operate as non-profit organizations and are devoted exclusively to activities such as education, health care, poverty relief and other charitable purposes. This makes them eligible for tax-exempt status. As for development aid, Aldashev *et al.* (2018) point out that, in developing countries, NGOs involved in international aid programs rose from less than 5,000 in the Seventies to more than 28,000 in 2013.

only moved by pecuniary incentives but who enjoy their personal contribution to the mission and goals of their organization. The interpretation of pro-social motivation that is used in this paper parallels the concept of warm-glow giving in Andreoni (2006), where individuals care about their own donation over and above the public goods that it funds. Similarly, pro-social motivation underpins a workers' involvement in a prosocial activity over and above the output that is produced.

The human resource management literature has recently started to acknowledge that motivation is a desirable workers' characteristic,[2] because of the "donative-labor hypothesis" (Preston, 1989). Indeed, motivated workers, relative to selfish workers who have standard pecuniary incentives, are willing to accept lower salaries in exchange for a given level of effort provision or are willing to exert more effort in exchange for a given level of compensation. To their full extent, labor donations give rise to volunteer work. The literature has usually treated prosocial motivation as an exogenously given workers' characteristic, even when allowing it to be heterogeneous across workers.[3] Indeed, motivation is often called *intrinsic*. At most, workers' motivation has been interpreted as a dichotomous attribute, with the same worker being motivated when employed in a social enterprise, or not motivated at all when employed by a strict profit-seeking firm.[4]

In this paper, I depart from this view and acknowledge that workers' motivation depends on the type of job that workers are asked to accomplish and on the organizational culture that the employer adopts. In particular, I admit that non-monetary incentives and non-pecuniary aspects of a worker's job are influenced by the mission of the employing organization. This is in line with Cassar and Meier (2018), who state that individuals are in search for meaning from their work, beyond monetary compensations and that "an organization or a job with a social mission will be more likely to fulfill workers' drive for sense-making" (see page 218). For instance, both the pro-social mission set by non-profit organizations and the investments in corporate social responsibility undertaken by for-profit firms might serve as a tool to motivate employees and to enhance their work effort. This is also in line with the insights provided by Besley and Ghatak (2018) who argue not only that prosocial motivation can be related to the

[2] See Burbano (2016) and Cassar and Meier (2018) among others.

[3] A notable exception is Besley and Gathak (2015) in Section C.

[4] See Delfgaauw and Dur (2008 and 2010) and Barigozzi and Burani (2016a,b and 2019).

sociological concept of identity, but that identity formation can be a strategic practice. Indeed, they suggest considering a firm that invests in motivational capital at a pecuniary cost that affects motivation; such pecuniary cost, for instance, "could reflect the amount of resources that go into teaching medical ethics to doctors" (see their Section 4.3).

This paper studies the endogenous mission choice of an employer, and its effects on workers' intrinsic motivation, extending the analysis carried out in Burani and Palestini (2016). In that work, we consider the screening problem of a firm willing to hire potential applicants, who have heterogeneous and unobservable skills, but the same observable level of intrinsic motivation. Optimal contracts consist in different pairs of (observable) effort and non-linear compensation offered by the firm. Each worker selects the preferred pair thus allowing the firm to infer the employee's private information about her skills. When workers' motivation is sufficiently high, limited liability protects prospective employees and prevents them from accepting negative salaries. Moreover, the most able workers are fully separated whereas volunteerism is the contractual outcome for low-ability workers, who are asked to provide the same effort level independently of their skills (i.e. pooling emerges) in exchange for a null reward. When, instead, motivation is low, limited liability has no bite and the optimal contracts is fully separating, with different effort-salary pairs being offered contingent to each possible level of worker's ability. In this latter case, volunteerism does not emerge.

This paper takes the optimal screening contracts satisfying workers' limited liability as a starting point, and analyzes the firm's strategic choice of its mission. For simplicity, the firm's mission is conceived as a one-dimensional attribute whose level can be set by the firm within a specific interval. Moreover, the relationship between the firm's investment in its mission and the employees' pro-social motivation is assumed to be deterministic, in such a way that the firm can exactly induce the desired level of motivation in its prospective employees. Thus, by selecting the level of its mission, the firm systematically affects the degree of motivation of its prospective employees. In particular, in the present context, selecting a mission means that the firms optimally decides how much to sacrifice of its profits (or revenues) in the social interest. The firm's degree of engagement in socially worthwhile activities in turn determines the level of workers' pro-social motivation (which is taken as given in Burani and Palestini, 2016). Indeed, the higher the fraction of revenues that the firm sacrifices to pursue its mission, the higher workers' motivation. Moreover, highly motivated workers are ready to work harder for their employer while accepting lower wages (this reflects the above-mentioned "donative-labour hypothesis"). So the firm optimally trades off the costs of investing in a highly demanding mission (i.e. sacrificing a high fraction of its revenues) with the benefits from hiring a highly motivated workforce. And it is shown that, in some circumstances, profit maximization might be aligned with the attainment of pro-social goals.

In order to describe how the firm's choice of a mission drives workers' motivation, I consider an extremely general family of functions, borrowed from the fields of statistics and probability theory. Going into details, I exploit the similarities between the characteristic features of the relationship between mission and motivation and the survival function, namely the function giving the probability that a randon variable takes values above a certain level. I use the Kumaraswamy distribution to generate the desired family of functions. I then find the possible solutions to the problem of optimally setting the mission for the firm, given the optimal contract that screens workers for their heterogeneous ability and given the mission-motivation relationship. In particular, I derive the conditions under which a sufficiently high motivation is generated so as to induce the least able workers to become volunteers.

1.1 Related literature

In spirit, the most closely related paper is Besley and Ghatak (2017) because it considers a firm's trade-off between profit and purpose and how selection on motivation operates for resolving this conflict of interests. Nonetheless, the setup of the two models is completely different. Besley and Ghatak (2017) consider the action relating to balancing profit considerations with the social objective as a binary decision which can be taken either by the manager (i.e. the worker) in a social enterprise or by the founder (i.e. the firm) in a for-profit or in a non-profit organization. In the present context, instead, this same action is more flexible because it can take any continuous value in the interval $[0, 1]$ but it is always taken by the firm, with no delegation to the manager/worker. In some sense, this model is closer to the literature on corporate social responsibility showing that the pursuit of pro-social goals might enhance firms' payoffs.[5] Moreover, in Besley and Ghatak (2017), organizations vary in the degree to which the manager/worker is financially incentivized, with the manager being either the full residual

[5] See Bénabou and Tirole (2010) and Besley and Gathak (2007), among aothers.

claimant or having a flat payoff. In this paper, the worker always receives a non-linear wage, except in the case in which she works for free.

This paper is related to the strand of literature which examines incentives and motivation (see Arce, 2013, Barigozzi and Burani, 2016a and Delfgaauw and Dur, 2007 and 2008). Besley and Gathak (2005) study the provision of incentives in a moral hazard framework where mission-oriented organizations compete to attract motivated agents. They underline the importance of matching the mission preference of firms and workers in order to save on high-powered incentives. The self-selection of workers, that are heterogeneous in both their talent and their motivation, has been analyzed by Delfgaauw and Dur (2010) in a perfectly competitive framework with full information, in which a governmental agency competes against the private sector in hiring labor. It has also been analyzed by Barigozzi and Burani (2016b and 2019) in a more complex setup featuring a non-profit firm competing against a for-profit for skilled and motivated workers under incomplete information about the workers' traits. I depart from this literature in two main respects. First, workers are heterogeneous in (and privately informed about) their ability but not in their pro-social motivation, which can vary but is assumed to be the same across all prospective employees. Second, I do not consider here the issue of workers sorting across different organizations and therefore I only focus on a single firm setting both its optimal contracts and its mission-orientation.

Optimal contracting with endogenous project mission has already been analyzed by Cassar and Armouti-Hansen (2016), who consider neither workers' heterogeneity in skills nor firm's organizational forms nor volunteerism. Their results are thus not directly comparable to mine.

In addition, this paper draws from the strand of literature related to non-profit organizations (see Glaeser and Shleifer, 2001, and Gathak and Mueller, 2011). These articles introduce a non-distribution constraint whereby the manager of a non-profit organization can appropriate, in the form of perquisites, only a given fraction of profits. This share is the counterpart to the degree of engagement in pro-social goals in the present context.

Finally, given that the results speak to the emergence of heterogeneous corporate cultures, the present paper is complementary to Van den Steen (2010) and Kostfeld and von Siemens (2009, 2011). In the latter, conditionally cooperative or selfish workers self-select into different firms for team production.

2 The basic model

The basic model is borrowed from Burani and Palestini (2016) but it is slightly modified in order to take explicitly into account the impact of the employer's mission on the screening contracts.

Consider a principal-agent model with adverse selection. The principal is a firm willing to hire a worker (she) to perform a given task. Both the firm and the agent are risk neutral.

The firm produces output according to a linear technology with labour as the only input. Its production function is $q(e) = e$, where e is the observable (and contractible) effort that the worker is asked to exert. Effort e can be interpreted as the task level that the worker is asked to perform or as the number of working hours. The firm's payoff, per-worker, conditional on the worker being hired, is given by

$$\pi(e, w(e)) = \alpha q(e) - w(e) = \alpha e - w(e), \tag{1}$$

where the (exogenous) price of output is set equal to 1, $w(e)$ is the total (non-linear) compensation or salary paid to the worker who exerts effort level e, and $\alpha \in [0, 1]$ captures the firm's mission. More precisely, when $\alpha = 1$, the firm is purely profit-oriented whereas, when $0 < \alpha < 1$, the employer is a mission-oriented organization that does not strictly maximize profits, but rather sacrifices a fraction $(1 - \alpha)$ of its revenues (or, more generally, some of its profits) for the social interest. For example, consider a non-profit hospital whose status can be acquired only if it engages in the provision of treatment to uninsured patients, on top of insured ones; in other words, the hospital's mission consists in engaging in both compensated and non-compensated (i.e. charity) care. The hospital earns positive revenues only for the fraction α of insured patients, whereas it receives a null compensation, i.e. a null revenue, for the fraction $(1 - \alpha)$ of charity care provided. Notwithstanding, the hospital bears the same costs of labor irrespective of whether the patients treated are insured or not. Or else, consider a non-profit university that offers special tuition wavers to entering students that come from disadvantaged backgrounds. The university makes positive revenues only from the students paying their tuition fees, while it bears the full costs, related to its teachers' compensation, irrespective of which students take which courses.[6] For the time being, let's take the firm's mission, as represented by the level of α, as given; it will be endogenized in what follows (see Section 3).[7]

[6] See also Barigozzi and Burani (2016b) and (2019).

[7] The present definition of mission is perfectly consistent with the social objective having a "redistributive

Workers differ in productive ability, which lowers their cost of effort provision θ. High realizations of θ represent workers with a high cost of effort provision and thus low ability, whereas low realizations of θ correspond to a low cost of providing effort and thus to high-skills. A worker's ability cannot be observed by the firm, which only knows the probability distribution function of skills across the whole population of workers. For simplicity, assume that ability is uniformly distributed in the unit interval, so that $\theta \sim U\,[0,1]$. Workers are also characterized by their intrinsic motivation, $\gamma \in [0,1]$, representing the enjoyment of one's personal contribution to the firm's mission or to its output. Motivation γ is assumed to be homogeneous across all workers.[8] For the time being, let motivation γ be observable to the firm. In the sequel (see Section 3), I'll assume that motivation is not observable to the firm; nonetheless, workers' motivation will be exactly inferred by the employer, because it is driven by the firm's choice of the mission.

For each possible worker with ability type θ, the worker's utility is quasi-linear in income $w\,(e)$ and takes the form

$$u\,(e, w\,(e)\,, \theta) = w\,(e) - \frac{1}{2}\,(\theta + 1)\,e^2 + \gamma e, \tag{2}$$

where the worker's type θ enters utility linearly and is inversely related to effort exertion. Indeed, $\frac{\partial^2 u}{\partial e \partial \theta} < 0$ always holds and this amounts to the well-known single-crossing condition being satisfied. In other words, the indifference curves of different θ-type workers cross only once in the space (e, w).

If workers are not hired by the firm, they receive zero utility.

Workers do not own any asset when they start their relationship with the firm, and so they must be protected by limited liability, meaning that $w\,(e) \geq 0$. As shown in Burani and Palestini (2016), if this were not the case, the firm would exploit highly motivated workers, who would be willing to accept negative transfers from their employer in exchange for a strictly positive level of effort provision.

The firm aims at maximizing expected profits. Applying the Revelation Principle, one can focus on type-contingent contracts of the form $\{e\,(\theta)\,, w\,(\theta)\}$, assuming, without loss of generality,

motive" in Besley and Gathak (2017).

[8] This assumption is shared by Makris (2009) and Makris and Siciliani (2013) who argue that a uniform motivation can be justified in sectors, such as the health care sector, characterized by strong norms.

that the firm chooses effort levels $e(\theta)$ and salaries $w(\theta) \equiv w(e(\theta))$ based on the worker's truthful report of θ. Moreover, denote the indirect utility, or information rent, of a worker of type θ, accepting to exert effort $e(\theta)$ when faced with compensation $w(\theta)$, by

$$U(\theta) = w(\theta) - \frac{1}{2}(\theta + 1)\, e(\theta)^2 + \gamma e(\theta). \tag{3}$$

Solving (3) for $w(\theta)$ and taking limited liability into account, one has

$$w(\theta) = \max\left\{0, U(\theta) + \frac{1}{2}(\theta + 1)\, e(\theta)^2 - \gamma e(\theta)\right\}. \tag{4}$$

Notice that, when both $e(\theta) < \frac{2\gamma}{\theta+1}$ and $U(\theta) < \gamma e(\theta) - \frac{1}{2}(\theta + 1)\, e(\theta)^2$ hold, the liability constraint is binding and $w(\theta) = 0$.

The firm's problem can be written as

$$\max_{e,w} E[\pi(e, w)] = \max_{e(\theta),w(\theta)} \int_0^1 [\alpha e(\theta) - w(\theta)]\, d\theta. \tag{$P1$}$$

subject to $w(\theta)$ satisfying (4) and

$$\frac{\partial e(\theta)}{\partial \theta} \leq 0, \tag{$C.1$}$$

$$\frac{\partial U(\theta)}{\partial \theta} = -\frac{1}{2} e(\theta)^2, \tag{$C.2$}$$

$$U(\theta) \geq 0 \text{ for all } \theta \in [0, 1]. \tag{$C.3$}$$

Condition $(C.1)$ is the monotonicity condition, requiring that the schedule of effort be decreasing in the type of worker (namely, more skilled workers should be asked to provide more effort). Condition $(C.2)$ is the envelope condition, stating that the information rents left to the workers be decreasing in the type of worker (namely, more skilled workers should receive higher information rents). This comes from the fact that it is always in the interest of a given type of worker to underreport her ability and try to mimic a worker with lower skills, i.e. higher θ. Together, conditions $(C.1)$ and $(C.2)$ characterize incentive compatibility. Finally, Condition $(C.3)$ is the participation constraint, requiring that all worker types be left with an indirect utility that exceeds their outside option.

The above program is solved using the Hamiltonian technique, with $e(\theta)$ being the control and $U(\theta)$ being the state variable (see Appendix A.1 for more details). The solution yields the following optimal incentive scheme.

Proposition 1 ***The optimal contract under limited liability.*** *When workers' ability θ is not observable to the firm, the optimal contract is such that the firm asks workers to provide effort*

$$e^*(\theta) = \begin{cases} \frac{\alpha+\gamma}{2\theta+1} & \textit{for } 0 \leq \theta \leq \overline{\theta} = \frac{\alpha}{2\gamma} \\ \gamma & \textit{for } \overline{\theta} = \frac{\alpha}{2\gamma} \leq \theta \leq 1 \end{cases}$$

and offers the wage schedule

$$w^*(\theta) = \begin{cases} \frac{(3\alpha+4\theta\alpha-2\theta\gamma)(\alpha-2\theta\gamma)}{4(2\theta+1)^2} & \textit{for } 0 \leq \theta \leq \frac{\alpha}{2\gamma} \\ 0 & \textit{for } \frac{\alpha}{2\gamma} \leq \theta \leq 1 \end{cases},$$

with information rents being equal to

$$U^*(\theta) = \begin{cases} \frac{(\alpha+\gamma)^2}{4(2\theta+1)} - \frac{1}{4}\gamma(2\alpha-\gamma) & \textit{for } 0 \leq \theta \leq \frac{\alpha}{2\gamma} \\ \frac{(1-\theta)\gamma^2}{2} & \textit{for } \frac{\alpha}{2\gamma} \leq \theta \leq 1 \end{cases}.$$

Proof. See Appendix A.1 ■

Optimal contracts satisfy two standard properties in incentive theory. The first one is no-distortion-at-the-top: the effort level required from the most able type of worker $\theta = 0$ is not distorted with respect to the first-best solution, namely $e^*(0) = e^{FB}(0) = \alpha + \gamma$, whereas the optimal effort levels set for workers with lower skills are distorted downwards with respect to the full information solution. Secondly, optimal contracts satisfy the property of zero-rents-at-the-bottom: the least able type $\theta = 1$ is left with an utility that equals her outside option, namely $U^*(1) = 0$, whereas all workers with higher skills receive positive information rents which prevent them from underreporting their ability type.

Nonetheless, optimal contracts have a novel feature which originates from the interplay between incentive compatibility, which prescribes a downward distortion in effort schedules, and limited liability, which prescribes an increase in effort provision as a response to the mandatory lower bound in compensation. Indeed, there exists a threshold level of ability $\overline{\theta}$ which triggers a change in the nature of the optimal contract. Workers whose skills are higher (or else whose effort cost is lower) than the threshold, i.e. workers whose type is such that $0 \leq \theta \leq \overline{\theta}$, are offered a fully separating contract characterized by an effort schedule $e(\theta)$ which is downward distorted with the respect to the first-best and strictly decreasing in θ, and by a transfer scheme $w(\theta)$ which is strictly positive and strictly decreasing in θ. Conversely, workers whose skills fall below (or whose effort cost exceeds) the threshold, i.e. types such that $\overline{\theta} \leq \theta \leq 1$, are offered a pooling contract characterized by a strictly positive and constant level of effort (equal to their homogeneous motivation) and by a null compensation. These latter workers are thus volunteers to the firm.[9] Figure 1 represents the optimal contract (effort-compensation schedules).

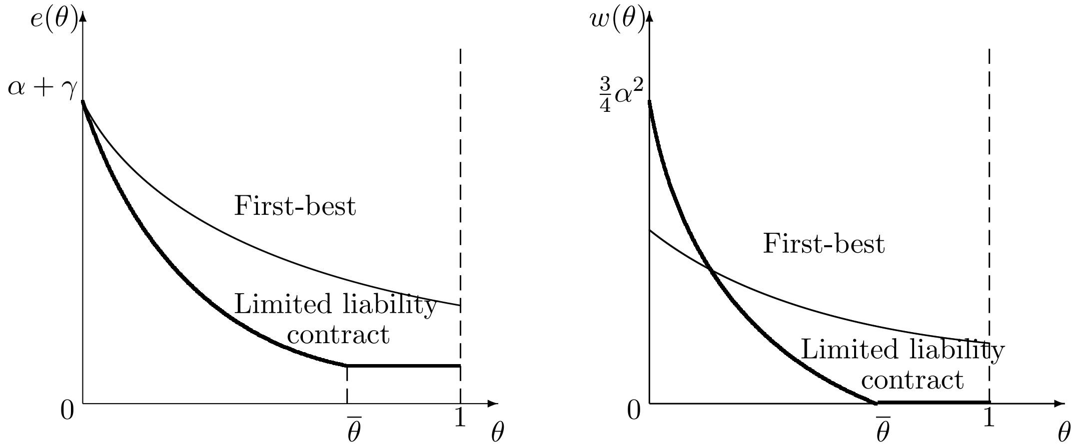

Figure 0: Optimal contracts. Effort (left) and wage (right) schedules

Notice that the ability threshold $\overline{\theta} = \frac{\alpha}{2\gamma}$ is decreasing both in workers' motivation γ and in the social mission of the firm, meaning that the lower workers' motivation γ and/or the higher the fraction of revenues that the firm retains α (i.e. the lower the mission $1 - \alpha$), the higher $\overline{\theta}$. Thus, it is possible that the threshold exceeds the support of the distribution of ability types, i.e. that $\overline{\theta} > 1$, in which case the optimal contract becomes fully separating. In particular, full separation of types occurs when workers' motivation is sufficiently low, given the fraction of revenues retained, i.e. when $\gamma < \frac{\alpha}{2}$, or when the fraction of revenues retained by the firm is sufficiently high, given the level of workers' motivation, i.e. when $\alpha > 2\gamma$. When the threshold is such that $\overline{\theta} > 1$ the optimal effort and wage schedules $\{e^*(\theta), w^*(\theta)\}$ are strictly decreasing in the workers' types θ for all $\theta \in [0, 1]$ and limited liability has no bite. In this latter case, all workers receive a strictly positive reward and volunteerism does not emerge within the firm's workforce.

[9] For a complete description of the features of the optimal contract and for the intuition behind these results, the reader is referred to Burani and Palestini (2016).

3 The optimal mission choice

Given the optimal contract, and given that the constraint imposed by limited liability is binding when workers' motivation is sufficiently high, let me take a step back and let me assume that there exists a deterministic relationship between the firm's level of investment in its mission and the employees' pro-social motivation. In particular, the firm knows that it is able to induce the desired motivation level (which the firm cannot observe directly) in its prospective employees' by appropriately setting the fraction of its revenues devoted to socially worthwhile projects. Thus, one can address another firm's problem, consisting in the choice of its mission, i.e. the value of α. For instance, a non-profit hospital is concerned with setting its optimal level of non-compensated care, over and above the mandatory charity care standard, whenever it exists. Similarly, a non-profit university can freely determine the fraction of incoming students to be subsidized because of their low-income economic background.

Indeed, suppose that workers' motivation behaves according to the continuous and differentiable function $\gamma(\alpha)$ which satisfies the following minimal requirements: (i) $\gamma(\alpha) : [0,1] \to [0,1]$; (ii) $\gamma'(\alpha) < 0$ for all $\alpha \in (0,1)$; and (iii) $\lim_{\alpha \to 0} \gamma(\alpha) = 1$ and $\lim_{\alpha \to 1} \gamma(\alpha) = 0$. Condition (i) requires that motivation be bounded above so that labor donations are not excessive. This is consistent with the basic model outlined in the previous Section 2. Conditions (ii) and (iii) guarantee that the lower the firm's commitment to the social interest, i.e. the higher α, the lower workers' motivation γ.[10]

Substituting the optimal contract $(e^*(\theta), w^*(\theta))$ into the firm's program $(P1)$ and taking into account that workers' motivation depends on α according to the mission-motivation function $\gamma(\alpha)$, the problem of the firm reduces to the uconstrained choice of the optimal level of its mission, and it can be written as

$$\max_{\alpha} E[\pi(\alpha)] = \begin{cases} \int_0^{\frac{\alpha}{2\gamma(\alpha)}} \left(\frac{(\alpha+\gamma(\alpha))^2(4\theta+1)}{4(2\theta+1)^2} + \frac{1}{4}\gamma(\alpha)(2\alpha - \gamma(\alpha)) \right) d\theta + \frac{\alpha}{2}(2\gamma(\alpha) - \alpha) & \text{if } 0 \le \alpha \le 2\gamma(\alpha) \\ \int_0^1 \left(\frac{(\alpha+\gamma(\alpha))^2(4\theta+1)}{4(2\theta+1)^2} + \frac{1}{4}\gamma(\alpha)(2\alpha - \gamma(\alpha)) \right) d\theta & \text{if } 2\gamma(\alpha) \le \alpha \le 1 \end{cases} . \quad (P2)$$

Notice that the condition $\alpha \le 2\gamma(\alpha)$ in the firm's program $(P2)$ corresponds to the condition $\overline{\theta} = \frac{\alpha}{2\gamma} \le 1$ in the optimal contract $\{e^*(\theta), w^*(\theta)\}$ (see Proposition 1). Therefore, when the

[10] These requirements allow me to establish a link with the fields of statistics and probability theory, as will be done in Section 3.1.

fraction of revenues retained by the firm is such that $0 \leq \alpha \leq 2\gamma(\alpha)$, the firm anticipates that it will be able to separate high-skilled workers with types $\theta \in [0, \overline{\theta}]$ and that it will pool low ability types $\theta \in [\overline{\theta}, 1]$, who become volunteers to the firm. Conversely, when the fraction of revenues retained by the firm increases and is such that $2\gamma(\alpha) \leq \alpha \leq 1$, the firm anticipates that $\overline{\theta} \geq 1$ and that limited liability will not play any role. So, the firm can offer a fully separating contract to all its prospective workers, despite being able to resort to volunteer work.

The first-order conditions associated to program $(P2)$ are as follows

$$\begin{aligned} &\int_0^{\frac{\alpha}{2\gamma(\alpha)}} \left(\frac{(\alpha+\gamma(\alpha))(1+\gamma'(\alpha))(4\theta+1)}{2(2\theta+1)^2} + \frac{\gamma'(\alpha)(2\alpha-\gamma(\alpha))}{4} + \frac{\gamma(\alpha)(2-\gamma'(\alpha))}{4} \right) d\theta \\ &\quad + \frac{\alpha(\gamma(\alpha)-\alpha\gamma'(\alpha))}{2\gamma(\alpha)} + (\gamma(\alpha) + \alpha(\gamma'(\alpha) - 1)) = 0 \qquad \text{if } 0 \leq \alpha \leq 2\gamma(\alpha) \end{aligned} \tag{5}$$

$$\int_0^1 \left(\frac{(\alpha+\gamma(\alpha))(1+\gamma'(\alpha))(4\theta+1)}{2(2\theta+1)^2} + \frac{\gamma'(\alpha)(2\alpha-\gamma(\alpha))}{4} + \frac{\gamma(\alpha)(2-\gamma'(\alpha))}{4} \right) d\theta = 0 \quad \text{if } 2\gamma(\alpha) \leq \alpha \leq 1 \tag{6}$$

There are several effects at work that first-order conditions impose to balance.

First of all, an increase in α yields higher profits to the firm directly in the form of higher revenues. Nonetheless, an increase in α triggers a decrease in motivation which influences negatively the effort level provided by workers and their labor donations. In turn, a decrease in labor donations means that the optimal salary has to increase, for each possible level of effort provided. A decrease in effort provision and an increase in compensation (for each possible effort level) have a detrimental effect on profits.

Moreover, considering (5), an increase in α determines an increase in the upper bound of integration, which is beneficial for profits because the mass of workers who are offered the separating contract increases. And the firm always prefers separating to pooling contracts whenever the former are feasible. On the other hand, an increase in α decreases profits because it decreases the mass of volunteer workers who are offered the pooling contract, and also because it reduces the fixed effort provided by these volunteers.

Alternatively, one can simplify program $(P2)$ performing the integration with respect to θ at the outset. This yields

$$\max_{\alpha} E[\pi(\alpha)] = \begin{cases} \frac{(\alpha+\gamma(\alpha))^2}{4} \left(\frac{\gamma(\alpha)}{2(\alpha+\gamma(\alpha))} + \ln\left(\frac{\alpha+\gamma(\alpha)}{2\gamma(\alpha)}\right) - \left(\frac{1}{2} + \ln\left(\frac{1}{2}\right)\right) \right) + \frac{\alpha(7\gamma(\alpha)-2\alpha)}{8} & \text{if } 0 \leq \alpha \leq 2\gamma(\alpha) \\ \frac{1}{12}\left((3\ln 3 - 1)(\alpha + \gamma(\alpha))^2 + 3\gamma(\alpha)(2\alpha - \gamma(\alpha)) \right) & \text{if } 2\gamma(\alpha) \leq \alpha \leq 1 \end{cases} \tag{P2bis}$$

The associated first-order conditions are

$$
\begin{aligned}
&\tfrac{(\alpha+\gamma(\alpha))(1+\gamma'(\alpha))}{2}\left(\ln 2-\tfrac{1}{2}+\tfrac{\gamma(\alpha)}{2(\alpha+\gamma(\alpha))}+\ln\left(\tfrac{(\alpha+\gamma(\alpha))}{2\gamma(\alpha)}\right)\right)\\
&\qquad+\tfrac{\left(3\alpha\gamma(\alpha)\gamma'(\alpha)-\alpha\gamma(\alpha)+4\gamma(\alpha)^2-\alpha^2\gamma'(\alpha)\right)}{4\gamma(\alpha)}=0 \qquad \text{if } 0\leq\alpha\leq 2\gamma(\alpha) \qquad (7)\\
&\tfrac{(\alpha+\gamma(\alpha))(1+\gamma'(\alpha))}{2}\left(\ln 3-\tfrac{1}{3}\right)+\tfrac{1}{2}\left(\gamma(\alpha)+\alpha\gamma'(\alpha)-\gamma(\alpha)\gamma'(\alpha)\right)=0 \quad \text{if } 2\gamma(\alpha)\leq\alpha\leq 1 \qquad (8)
\end{aligned}
$$

These conditions are equivalent to (5) and (6), respectively, the difference being, again, that now integration with respect to θ has already been performed.

In general, there is no guarantee that problem ($P2bis$) is well-behaved so that the profit function is strictly concave in its domain and that first-order conditions (7) and (8) have a unique and interior solution. Hence, a solution to the above problem can only be found once a specific mission-motivation function $\gamma(\alpha)$ is provided. In what follows, I'll focus attention on a very broad family of functions $\gamma(\alpha)$ and compute the optimal α^* and the associated level of motivation $\gamma(\alpha^*)$.

3.1 The Kumaraswamy distribution and its survival function

Observe that the characteristic features of the mission-motivation function $\gamma(\alpha)$ are that it is defined on the interval $[0,1]$, being α a *fraction* of revenues and, most importantly, that it is continuous and monotonically decreasing from $\gamma(0)=1$ to $\gamma(1)=0$.

These features also belong to a well-known function in probability theory and statistics which is the survival function or the complementary cumulative distribution function. Imagine that A be a continuous random variable defined on the interval $[0,1]$ with cumulative distribution function

$$F(\alpha)=\Pr(A\leq\alpha)=\int_0^{\alpha} f(a)\,da,$$

which provides the probability that A assumes a value less than or equal to α with f being the probability density function. The survival function gives, instead, the probability that the random variable A will take values (i.e. will survive) beyond a given specified level α, namely

$$S(\alpha)=\Pr(A>\alpha)=\int_{\alpha}^{1} f(a)\,da=1-F(\alpha).$$

Then, the mission-motivation function $\gamma(\alpha)$, which relates the fraction of revenues retained by the firm (or else the fraction of revenues invested in socially worthwhile projects) to workers' motivation can be conceived, and treated mathematically, as a survival function, with $S(\alpha) = \gamma(\alpha)$.

In statistics, there exist many probability density functions (with their corresponding cumulative distribution and survival functions), each having some desirable properties and each being suited to describe a given phenomenon. In particular, "it remains fair to say that the Beta distribution provides the premier family of continuous distributions on bounded support" (see Jones, 2009, page 70). Nonetheless, the Beta distribution is fairly intractable because it does not have a closed form neither in its probability density function, nor in the cumulative distribution function nor, consequently, in the survival function. Therefore, I consider an alternative two-parameter distribution defined on the interval $[0, 1]$, called the Kumaraswamy distribution, which is far more tractable and which satisfies many of the same properties as the Beta distribution. Moreover, both the Beta and the Kumaraswamy distributions can assume a strikingly large variety of shapes and both share other simpler distributions (like the power function or the uniform) as special cases. The interested reader is referred to Appendix A.2, where the characteristics of the Kumaraswamy distribution are presented for different parameter values, and where its behavior is studied at the boundaries of its support.

For the purposes of the present analysis, it suffices to consider the survival function of the Kumaraswamy distribution, which has the following, extremely simple form

$$S(\alpha) = \gamma(\alpha) = (1 - \alpha^x)^y \text{ for } 0 \leq \alpha \leq 1, \tag{9}$$

where x and y are the two positive parameters that determine the shape of the function. It can easily be shown that, by varying the values taken by the two parameters x and y, the above specification of $\gamma(\alpha)$ spans the entire square $[0, 1] \times [0, 1]$. In particular, $\gamma(\alpha)$ can be strictly concave, if $x > 1$ and $y < 1$, or strictly convex, if $x < 1$ and $y > 1$, or turn from convex to concave, if $x < 1$ and $y < 1$, and vice-versa (see, again, Appendix A.2).

Inserting (9) into program $(P2bis)$ one gets an alternative program which is

$$\max_{\alpha} \begin{cases} \frac{(\alpha+(1-\alpha^x)^y)^2}{4}\left(\frac{(1-\alpha^x)^y}{2(\alpha+(1-\alpha^x)^y)} + \ln\left(\frac{\alpha+(1-\alpha^x)^y}{2(1-\alpha^x)^y}\right) - \left(\frac{1}{2} + \ln\frac{1}{2}\right)\right) + \frac{\alpha(7(1-\alpha^x)^y - 2\alpha)}{8} & \text{if } 0 \leq \alpha \leq \overline{\alpha} \\ \frac{1}{12}\left((3\ln 3 - 1)(\alpha + (1-\alpha^x)^y)^2 + 3(1-\alpha^x)^y(2\alpha - (1-\alpha^x)^y)\right) & \text{if } \overline{\alpha} \leq \alpha \leq 1 \end{cases}, \tag{P2ter}$$

where

$$\overline{\alpha} \equiv \text{ solution to } (1 - \alpha^x)^y = \frac{\alpha}{2}. \tag{10}$$

Graphically, the cutoff $\overline{\alpha}$ can be found at the intersection between the straight line having equation $\gamma(\alpha) = \frac{\alpha}{2}$ and the actual plot of the survival function $S(\alpha) = (1-\alpha^x)^y$, once specific values are assigned to the parameters x and y.

Observe that the first row in program ($P2ter$) corresponds to the case in which the optimal contract is first separating then pooling, i.e. to the case in which $0 < \overline{\theta} < 1$, whereas the second row corresponds to the case in which the optimal contract is only separating and $\overline{\theta} \geq 1$.

Analogously, the first-order conditions (7) and (8) become

$$\begin{aligned}&(\alpha + (1-\alpha^x)^y)\left(1 - xy\alpha^{x-1}(1-\alpha^x)^{y-1}\right)\left(\ln 2 - \frac{1}{2} + \frac{(1-\alpha^x)^y}{2(\alpha+(1-\alpha^x)^y)} + \ln\left(\frac{(\alpha+(1-\alpha^x)^y)}{2(1-\alpha^x)^y}\right)\right) + \\ &\frac{\left(\alpha^2 xy\alpha^{x-1}(1-\alpha^x)^{y-1} - 3\alpha(1-\alpha^x)^y xy\alpha^{x-1}(1-\alpha^x)^{y-1} - \alpha(1-\alpha^x)^y + 4(1-\alpha^x)^{2y}\right)}{2(1-\alpha^x)^y} = 0 \qquad \text{if } 0 \leq \alpha \leq \overline{\alpha}\end{aligned} \tag{11}$$

and

$$\begin{aligned}&(\alpha + (1-\alpha^x)^y)\left(1 + \left(-xy\alpha^{x-1}(1-\alpha^x)^{y-1}\right)\right)\left(\ln 3 - \frac{1}{3}\right) + \\ &\left((1-\alpha^x)^y + \alpha\left(-xy\alpha^{x-1}(1-\alpha^x)^{y-1}\right) - (1-\alpha^x)^y\left(-xy\alpha^{x-1}(1-\alpha^x)^{y-1}\right)\right) = 0 \quad \text{if } \overline{\alpha} \leq \alpha \leq 1.\end{aligned} \tag{12}$$

Unfortunately, the functional form envisaged for the mission-motivation function $\gamma(\alpha)$ is still too general to provide a simple solution to the optimal mission choice problem: the objective function is not strictly concave and the first-order conditions can deliver minima rather maxima.

Before turning to the main results, let me present some examples that provide the flavour of the analysis performed.[11]

3.1.1 Examples

As a first example, set $x = y = 1$ and consider

$$\gamma(\alpha) = 1 - \alpha.$$

What is peculiar to this specification is that, when α is sufficiently high that $2\gamma(\alpha) \leq \alpha \leq 1$ holds,[12] then limited liability does not bind and full separation of workers according to their ability is possible. In this case, profits are strictly decreasing in α because optimal effort does not depend on α, neither directly not indirectly through motivation, whereas optimal salaries

[11] The examples that follow are examined in more detail in Appendix A.3.1.

[12] It is immediate to check that the condition $2\gamma(\alpha) \leq \alpha \leq 1$ simplifies as $\frac{2}{3} \leq \alpha \leq 1$ under the present specification.

are increasing in α. When, instead, α is sufficiently low that $0 \leq \alpha \leq 2\gamma(\alpha)$ holds,[13] then limited liability binds and a pooling contract is proposed to low-ability workers. In this case, profits are increasing in α because the optimal effort decreases in α, while the wage is set equal to zero irrespective of α. Both first-order conditions (7) and (8) solve for $\alpha^* = \frac{2}{3}$, which is the point at which $\pi(\alpha)$ has a kink and reaches a global maximum. The induced level of motivation is $\gamma(\alpha^*) = \frac{1}{3}$. The optimal contract is fully separating because the threshold $\overline{\theta}$ is precisely equal to one and there are no volunteers, except for the least-able type, $\theta = 1$, who earns $w^*(1) = 0$ while providing a strictly positive effort $e^*(1) = \frac{1}{3}$.

As a second example, set $x = 1$ and $y = \frac{1}{2}$ and consider the function

$$\gamma(\alpha) = (1-\alpha)^{\frac{1}{2}}.$$

Condition (7) is the relevant one and it can be solved numerically for $\alpha^* = 0.7867$. Motivation is equal to $\gamma(\alpha^*) = 0.46184$. Furthermore, the threshold value $\overline{\theta}$ is given by $\frac{\alpha}{2\gamma} = 0.8517$ so types with high skills $\theta \in [0, 0.8517]$ are separated whereas types with low skills $\theta \in [0.8517, 1]$ are offered a pooling contract and are volunteers.

Similar results are obtained when one sets $x = 2$ and $y = 1$, so

$$\gamma(\alpha) = 1 - \alpha^2.$$

In this case, again, (7) is the relevant first-order condition and its numerical solution is $\alpha^* = 0.62416$, leading to $\gamma(\alpha^*) = 0.61043$. Workers with high skills, i.e. whose effort cost is $\theta \in [0, 0.51125]$, are offered a fully separating contract, whereas workers with lower skills, i.e. such that $\theta \in [0.51125, 1]$, become volunteers.

The proposition that follows generalizes the results obtained so far, providing sufficient conditions under which the firm sacrifices a positive fraction of its revenues to pursue its mission and, moreover, has incentive to hire volunteer workers.

Proposition 2 ***Sufficient conditions for volunteerism.*** *Consider the function* $\gamma(\alpha) = (1-\alpha^x)^y$. *When* $x = 1$ *and* $y \leq 1$ *or when* $x \geq 1$ *and* $y = 1$*: (i) the optimal choice of the firm's mission is such that* $\alpha^* < 1$*; (ii) the optimal contract is separating for workers with high ability, i.e. such that* $0 \leq \theta \leq \frac{\alpha^*}{2\gamma(\alpha^*)}$*, and pooling for workers with lower ability, i.e. such that* $\frac{\alpha^*}{2\gamma(\alpha^*)} \leq \theta \leq 1$*, who become volunteers.*

[13] Again, condition $2\gamma(\alpha) \leq \alpha \leq 1$ specifies as $0 \leq \alpha \leq \frac{2}{3}$ in the example at hand.

Proof. See Appendix A.3.1. ■

When $\gamma(\alpha)$ satisfies the above requirements, it is always in the interest of the firm to sacrifice a sufficiently high fraction of its revenues in the social interest, so as to induce a high motivation in its workforce. In turn, the high willingness to donate labor on the part of prospective employees, makes liability limitations relevant and calls for optimal contracts being such that: (i) high-skilled applicants are separated and asked to exert effort levels which are increasing in ability (i.e. decreasing in θ) and distorted downward (with respect to the efficient level), except for the most able worker; and (ii) low-skilled applicants are pooled and asked to provide a fixed level of effort in exchange for a null salary.

The main driver of this result is the concavity of $\gamma(\alpha)$. Indeed, when α is already high, a further increase in the fraction of revenues retained by the employer generates a sharp drop in workers' motivation; this is harmful for the firm because it causes a sizeable decrease in workers' willingness to work and a corresponding increase in salary, leading to lower profits.

As a counterpart to the result stated above, consider the case in which $\gamma(\alpha)$ is still decreasing, but convex in α. In particular, suppose that $x = \frac{1}{2}$ and $y = 1$ so that

$$\gamma(\alpha) = 1 - \alpha^{\frac{1}{2}}.$$

Profits attain a maximum for $\alpha^* = 0.82949$, inducing motivation $\gamma(\alpha^*) = 0.089237$. Condition (8) is now the relevant one and limited liability has no bite. Intrinsic motivation is so low that all workers' types are offered a different contract and receive a strictly positive wage in exchange for their labor services. In this case, the firm still invests a strictly positive share of revenues in its mission but it knows that the induced labor donations are low and that it can not count on volunteers.

3.2 Results

The parallel established between the mission-motivation function $\gamma(\alpha)$ and the survival function of the Kumaraswamy distribution, allows to predict, for each possible behavior of the mission-motivation function: (i) the optimal level of the mission, if any, to be set by the firm; (ii) the induced level of motivation of the potential workforce; and, finally, (iii) the optimal contract offered by the firm.

Let me start considering the behaviour of the cutoff value $\overline{\alpha}$. Notice that the equation

$2(1-\alpha^x)^y = \alpha$ might not have an interior solution within the desired interval $[0,1]$. In particular, when y tends to zero, one gets $\overline{\alpha} = 2$, meaning that, for sufficiently low y, workers' motivation is sufficiently high that limited liability is binding and pooling contracts with volunteer work emerge. Consequently, one can disregard the second row in program $(P2ter)$ and concentrate on the first row only, or else on first-order condition (11). Alternatively, when x tends to zero, one gets $\overline{\alpha} = 0$, meaning that, when x is sufficiently low, workers' motivation is always sufficiently low that full separation is possible and limited liability never binds. Therefore, one can disregard the first row in program $(P2ter)$, and concentrate on the second row only, or else on first-order condition (12).

There are different scenarios that emerge.

First of all, when the mission-motivation function is sufficiently convex, for the firm it is not worth the while to invest in a social mission. Then prospective employees will not be motivated at all and we are then confronted with a standard profit-maximizing firm hiring regular workers who do not donate their labor but who are fully screened for their heterogeneous ability.

Secondly, when the mission-motivation function is neither too convex nor too concave, the firm will invest in a socially worthwhile project in order to motivate its employees and benefit from their labor donations. Moreover, workers with different ability types will be fully separated by the screening contracts which are such that limited liability does nor bite.

Finally, when the mission-motivation function is sufficiently concave, then it pays the firm to sacrifice even a small fraction of its revenues in pursuing a social mission because this generated a strong motivation in its prospective employees. Labor donations will then be sizeable and the workers' limited liability constraints will bind. This prevents the firm from fully eliciting the workers' private information about their skills and forces the firm to offer a pooling contract to the least able workers. In this latter case, the firm only separates the most productive workers, paying them a strictly positive salary, which is increasing in the workers' skills; conversely, it offers the same contract to the least able workers, who are paid a null salary in exchange for a fixed positive level effort and who become volunteers.

In order to summarize the results obtained, I propose a table which has the same structure as the figures presented in the Appendix relative to the Kumaraswamy distribution (see Figures 2 and 3), and which describes the qualitative features of the mission choice operated by the firm and of its optimal screening contract.

	$y < 1$	$y = 1$	$y > 1$
$x < 1$	$\alpha^* < 1$ Pooling and volunteerism for low values of y relative to x Full separation for high values of y relative to x	Full separation $\alpha^* = 1$ for $0 < x \leq \widetilde{x}$ $\alpha^* < 1$ for $\widetilde{x} < x < 1$	$\alpha^* = 1$ Full separation and no mission
$x = 1$	$\alpha^* < 1$ Pooling and volunteerism	$\alpha^* < 1$ Full separation One volunteer, $\theta = 1$	Full separation $\alpha^* < 1$ for $1 < y < \widetilde{y}$ $\alpha^* = 1$ for $y \geq \widetilde{y}$
$x > 1$	$\alpha^* < 1$ Pooling and volunteerism	$\alpha^* < 1$ Pooling and volunteerism	$\alpha^* < 1$ with pooling and volunteerism for high values of x relative to y $\alpha^* = 1$ with full separation and no mission for low values of x relative to y

Figure 1: Optimal mission choice and organizational form for different parameter values

Proposition 3 ***Optimal mission choice.*** *Consider the mission-motivation function* $\gamma(\alpha) = (1-\alpha^x)^y$ *and let* $\widetilde{x} = \frac{\frac{1}{2}\ln 3 - \frac{1}{6}}{\frac{1}{2}\ln 3 + \frac{1}{3}} = 0.43352$ *and* $\widetilde{y} = 1.57414$*. Then, Figure 1 describes the optimal choice of the firm's mission and the optimal screening contract that it offers its prospective workers.*

Proof. See Appendix. ■

4 Conclusion

I analyze the screening problem of a firm that hires motivated workers who have private information about their ability, taking into account workers' liability limitations. Given the optimal contract, it becomes natural for the firm to choose its mission-orientation in such a way as to the drive the desired level of motivation for its pool of applicants. It is shown that, for a whole family of functions representing workers' mission-induced motivation, the firm sets its mission so as to generate a high motivation in its workforce and to induce the least able workers to become volunteers.

Thus, different organizations, faced with prospective employees having mission-driven motivations, optimally develop heterogeneous corporate cultures. So this paper provides the rationale for the emergence of different organizational forms (pure for-profits, private non-profits, non-governmental organizations relying on volunteer workforce) that produce goods or services having a social component. Such organizations stand as an alternative to government provision, and have recently received attention by the literature.

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A Appendix

A.1 Optimal contracts

The derivation of the optimal contracts, with α and γ taken as exogenous, follows Burani and Palestini (2016).

Suppose first that limited liability has no bite and that

$$w(\theta) = U(\theta) + \frac{1}{2}(\theta + 1)\, e(\theta)^2 - \gamma e(\theta) > 0. \tag{13}$$

The firm's problem is thus

$$\max_{e(\theta)} \int_0^1 \left[(\alpha + \gamma)\, e(\theta) - U(\theta) - \frac{1}{2}(\theta + 1)\, e(\theta)^2 \right] d\theta, \tag{14}$$

subject to $(C.1)-(C.3)$, for all $\theta \in [0, 1]$. Condition $(C.3)$ is the individual rationality constraint, whereas the monotonicity condition $(C.1)$ and the envelope condition $(C.2)$ characterize incentive compatibility. Given the envelope condition, incentive compatibility implies that only the participation constraint of the least able type be binding, whereby the participation constraint $(C.3)$ reduces to the boundary condition $U(1) = 0$.

This is an optimal control problem, where e is the control variable and U is the state variable. In order to solve this problem, build the Hamiltonian

$$H = (\alpha + \gamma) e(\theta) - U(\theta) - \frac{1}{2}(\theta + 1) e(\theta)^2 + \lambda(\theta)\left(-\frac{1}{2} e(\theta)^2\right),$$

where multiplier λ is the co-state variable. The first order conditions are the following ones

$$\begin{aligned}
\frac{\partial H}{\partial e} &= (\alpha + \gamma) - (\theta + 1) e(\theta) - \lambda(\theta) e(\theta) = 0 && (a) \\
-\frac{\partial H}{\partial U} &= 1 = \lambda'(\theta) && (b) \\
\frac{\partial U(\theta)}{\partial \theta} &= -\frac{1}{2} e(\theta)^2 && (c) \\
\lambda(0) &= 0 && (d)
\end{aligned}$$

where (d) is the transversality condition, since there is no constraint on $U(0)$. Integrating (b) over θ, one gets

$$\lambda(\theta) = \theta + c$$

and, using (d) to compute the value of the constant c, one obtains $c = 0$ and $\lambda(\theta) = \theta$. Replacing the latter expression into (a) yields the optimal effort

$$(\alpha + \gamma) - (\theta + 1) e(\theta) - \theta e(\theta) = 0 \quad \Longrightarrow \quad e^*(\theta) = \frac{\alpha + \gamma}{2\theta + 1}. \tag{16}$$

The optimal wage rate is obtained by the envelope condition

$$\frac{\partial U(\theta)}{\partial \theta} = -\frac{1}{2} e(\theta)^2 = -\frac{(\alpha + \gamma)^2}{2(2\theta + 1)^2}.$$

Integrating it over θ, with the requirement that $U(1) = 0$, yields

$$U(\theta) = \frac{(\alpha + \gamma)^2}{4(2\theta + 1)} - \frac{(\alpha + \gamma)^2}{12} = \frac{(\alpha + \gamma)^2 (1 - \theta)}{6(2\theta + 1)}. \tag{17}$$

Substituting (17) and (16) into (13) one gets

$$w^*(\theta) = \frac{(\alpha + \gamma)\left((2\theta + 1)(\alpha - 2\gamma) + (1 - \theta)(1 + \theta)(\alpha + \gamma)\right)}{3(2\theta + 1)^2}.$$

Since the wage schedule is non-increasing in θ, the sufficient condition for $w(\theta) > 0$ becomes $w(1) > 0$ which amounts to $\gamma < \frac{\alpha}{2}$.

Suppose then that limited liability is binding and consider $w(\theta) = 0$. From Burani and Palestini (2016), the optimal contract is such that all types of workers are employed, even though some types (those with high effort cost, i.e. low θ) are not separated and are offered the same contract. Thus, there exists an optimal threshold $\overline{\theta}$ such that types below $\overline{\theta}$ are fully separated whereas types above $\overline{\theta}$ are pooled. By continuity of the optimal allocation, the solution is such that, for some threshold $\overline{\theta}$,

$$e(\theta) = \begin{cases} \frac{\alpha+\gamma}{2\theta+1} & \text{for } 0 \le \theta \le \overline{\theta} \\ \frac{\alpha+\gamma}{2\overline{\theta}+1} & \text{for } \overline{\theta} \le \theta \le 1 \end{cases} . \tag{18}$$

When workers' types belong to the range $\overline{\theta} \le \theta \le 1$, the schedule of information rents is given by (3) with $w = 0$ and $e = \frac{\alpha+\gamma}{2\overline{\theta}+1}$ and it is such that

$$U(\theta) = \frac{(\alpha+\gamma)\left(4\overline{\theta}\gamma - (\alpha-\gamma) - \theta(\alpha+\gamma)\right)}{2\left(2\overline{\theta}+1\right)^2}$$

Under full participation, it is optimal for the employer to leave the worst worker with zero rents, so it must be that $U(1) = 0$, which yields the optimal threshold

$$\overline{\theta} = \frac{\alpha}{2\gamma}$$

and the optimal constant level of effort, that is required for types in the range $\overline{\theta} \le \theta \le 1$,

$$e = \frac{\alpha+\gamma}{2\left(\frac{\alpha}{2\gamma}\right)+1} = \gamma.$$

Accordingly, the optimal allocation (18) can be fully specified as

$$e^*(\theta) = \begin{cases} \frac{\alpha+\gamma}{2\theta+1} & \text{for } 0 \le \theta \le \frac{\alpha}{2\gamma} \\ \gamma & \text{for } \frac{\alpha}{2\gamma} \le \theta \le 1 \end{cases} .$$

When workers' types belong to the interval $0 \le \theta \le \frac{\alpha}{2\gamma}$, the function $U(\theta)$ can be recovered from the envelope condition $(C.2)$ and it is equal to

$$U(\theta) = \frac{(\alpha+\gamma)^2}{4(2\theta+1)} + c,$$

where the constant c can be computed using the continuity of the surplus function at $\overline{\theta}$ and the fact that

$$U\left(\theta, \overline{\theta} = \frac{\alpha}{2\gamma}\right) = \frac{(1-\theta)\gamma^2}{2}.$$

This leads to

$$U^*(\theta) = \begin{cases} \frac{(\alpha+\gamma)^2}{4(2\theta+1)} - \frac{1}{4}\gamma(2\alpha-\gamma) & \text{for } 0 \leq \theta \leq \frac{\alpha}{2\gamma} \\ \frac{(1-\theta)\gamma^2}{2} & \text{for } \frac{\alpha}{2\gamma} \leq \theta \leq 1 \end{cases}$$

Finally, the wage rate as a function of θ is such that

$$w^*(\theta) = \begin{cases} \frac{(\alpha+\gamma)(4\theta(\alpha-\gamma)+3\alpha-\gamma)}{4(2\theta+1)^2} - \frac{1}{4}\gamma(2\alpha-\gamma) = \frac{(3\alpha+4\theta\alpha-2\theta\gamma)(\alpha-2\theta\gamma)}{4(2\theta+1)^2} & \text{for } 0 \leq \theta \leq \frac{\alpha}{2\gamma} \\ 0 & \text{for } \frac{\alpha}{2\gamma} \leq \theta \leq 1 \end{cases}.$$

A.2 The Kumaraswamy distribution

Following Mitnik (2011), the Kumaraswamy density function, in its standard form, is

$$f(\alpha) = xy\alpha^{x-1}(1-\alpha^x)^{y-1} \text{ for } 0 \leq \alpha \leq 1,$$

with shape parameters $x > 0$ and $y > 0$. Notice that, setting both $x = 1$ and $y = 1$, the Kumaraswamy density function simplifies as $f(\alpha) = 1$ which characterizes the uniform distribution defined on the interval $[0, 1]$. Similarly, setting $y = 1$ and letting $x \in (0, \infty)$, one obtains $f(\alpha) = x\alpha^{x-1}$ which is the power function distribution defined, again, on the unit interval. Moreover, letting $x = 1$ and $y \in (0, \infty)$ yields $f(\alpha) = y(1-\alpha)^{y-1}$ which is another kind of power function distribution.

Figure 2 (taken from Mitnik, 2011) shows the possible shapes of the Kumaraswamy distribution and its behaviour at the boundary of its support, as a function of the values of the parameters x and y.[14] Notice that the same results would hold for the Beta distribution under the same parameter configurations.

The cumulative distribution function of the Kumaraswamy distribution has a closed form expression which is

$$F(\alpha) = 1 - (1-\alpha^x)^y \text{ for } 0 \leq \alpha \leq 1,$$

and it immediately follows that the survival function simply is

$$S(\alpha) = (1-\alpha^x)^y \text{ for } 0 \leq \alpha \leq 1.$$

[14] There is no consensus among scholars as to whether the bounds of the support $\alpha = 0$ and $\alpha = 1$ should be included in the definition of the distribution. I tend to include them, expecially when the survival function is concerned.

	$y<1$	$y=1$	$y>1$
$x<1$	Distributionwith one anti-mode $\lim_{\alpha\to 0} f(\alpha)=\infty$ $\lim_{\alpha\to 1} f(\alpha)=\infty$	Monotonicallydecreasing (power function) distribution $\lim_{\alpha\to 0} f(\alpha)=\infty$ $\lim_{\alpha\to 1} f(\alpha)=x$	Monotonicallydecreasing distribution $\lim_{\alpha\to 0} f(\alpha)=\infty$ $\lim_{\alpha\to 1} f(\alpha)=0$
$x=1$	Monotonicallyincreasing distribution $\lim_{\alpha\to 0} f(\alpha)=y$ $\lim_{\alpha\to 1} f(\alpha)=\infty$	Uniform distribution $\lim_{\alpha\to 0} f(\alpha)=1$ $\lim_{\alpha\to 1} f(\alpha)=1$	Monotonicallydecreasing distribution $\lim_{\alpha\to 0} f(\alpha)=y$ $\lim_{\alpha\to 1} f(\alpha)=0$
$x>1$	Monotonicallyincreasing distribution $\lim_{\alpha\to 0} f(\alpha)=0$ $\lim_{\alpha\to 1} f(\alpha)=\infty$	Monotonicallyincreasing (power function) distribution $\lim_{\alpha\to 0} f(\alpha)=0$ $\lim_{\alpha\to 1} f(\alpha)=x$	Distributionwith one mode $\lim_{\alpha\to 0} f(\alpha)=0$ $\lim_{\alpha\to 1} f(\alpha)=0$

Figure 2: Characteristics of the Kumaraswamy distribution for different parameter values.

Given that $S'(\alpha) \equiv \frac{\partial}{\partial\alpha} S(\alpha) = -f(\alpha)$ and $S''(\alpha) \equiv \frac{\partial^2}{\partial\alpha^2} S(\alpha) = -f'(\alpha)$, it is immediate to see that the survival function, besides being strictly decreasing in α, can have different curvatures, again according to the values taken by the parameters x and y. Figure 3 summarizes the possible shapes of the survival function depending on the values taken by the parameters of the Kumaraswamy distribution.

A.3 Optimal mission choice

A.3.1 Examples

Consider the family of functions $\gamma(\alpha) = (1-\alpha^x)^y$ with attention limited to the following set of parameters: $x \geq 1$ and $y \leq 1$.

As a first example, examine the instance in which $x=1$ and $y=1$ so that $\gamma(\alpha) = 1-\alpha$. Expected profits in $(P2ter)$ specify as

$$E[\pi(\alpha)] = \begin{cases} \frac{1}{4}\ln 2 - \frac{1}{4}\alpha + \frac{3}{8}\alpha^2 + \frac{1}{4}\ln\left(\frac{1}{2} + \frac{\alpha}{2(1-\alpha)}\right) + \frac{\alpha}{2}(2-3\alpha) & \text{if} \quad 0 \leq \alpha \leq \frac{2}{3} \\ \alpha + \frac{1}{4}\ln 3 - \frac{3}{4}\alpha^2 - \frac{1}{3} & \text{if} \quad \frac{2}{3} \leq \alpha \leq 1 \end{cases}$$

and are depicted in Figure 5, where the solid curve represents profits when α is smaller than the critical value, i.e. to the left of $\alpha = \frac{2}{3}$, whereas the dashed curve corresponds to expected

	$y < 1$	$y = 1$	$y > 1$
$x < 1$	Convex for low values of α Concave for high values of α Mostly below (resp. above) the top-left to bottom-right diagonal for high (resp. low) values of y relative to x	Strictly convex	Strictly convex
$x = 1$	Strictly concave	Straight line: Top-left to bottom-right diagonal	Strictly convex
$x > 1$	Strictly concave	Strictly concave	Concave for low values of α Convex for high values of α Mostly below (resp. above) the top-left to bottom-right diagonal for low (resp. high) values of x relative to y

Figure 3: Characteristics of the survival function for different parameter values

profits when α is higher than its critical value, i.e. to the right of $\alpha = \frac{2}{3}$.

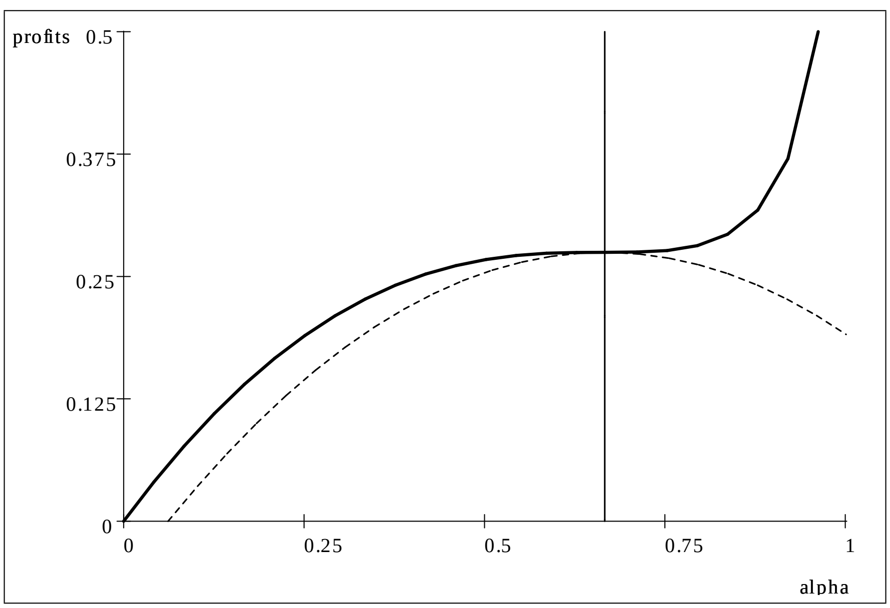

Figure 5

The first-order conditions (7) and (8) are given by

$$\begin{cases} \frac{(3\alpha-2)^2}{4(1-\alpha)} = 0 & \text{if} \quad 0 \leq \alpha \leq \frac{2}{3} \\ 1 - \frac{3}{2}\alpha = 0 & \text{if} \quad \frac{2}{3} \leq \alpha \leq 1 \end{cases},$$

respectively, and the unique solution is $\alpha^* = \frac{2}{3}$.

Consider now the second example in which $x = 2$ and $y = 1$ so that $\gamma(\alpha) = 1 - \alpha^2$. Now expected profits $E[\pi(\alpha)]$ become

$$\frac{\left(\alpha+1-\alpha^2\right)^2}{4}\left(\frac{\left(1-\alpha^2\right)}{2(\alpha+1-\alpha^2)} + \ln\left(\frac{\alpha+1-\alpha^2}{2(1-\alpha^2)}\right) - \left(\frac{1}{2} + \ln\left(\frac{1}{2}\right)\right)\right) + \quad \frac{\alpha\left(7-7\alpha^2-2\alpha\right)}{8}$$
$$\text{if } 0 \leq \alpha \leq \frac{\sqrt{17}-1}{4} = 0.78078$$

and

$$\frac{1}{12}\left((3\ln 3 - 1)\left(\alpha + 1 - \alpha^2\right)^2 + 3\left(1-\alpha^2\right)\left(2\alpha - 1 + \alpha^2\right)\right)$$
$$\text{if } \frac{\sqrt{17}-1}{4} \leq \alpha \leq 1$$

and they are represented in Figure 5 (the same rule concerning solid vs dashed curves is adopted).

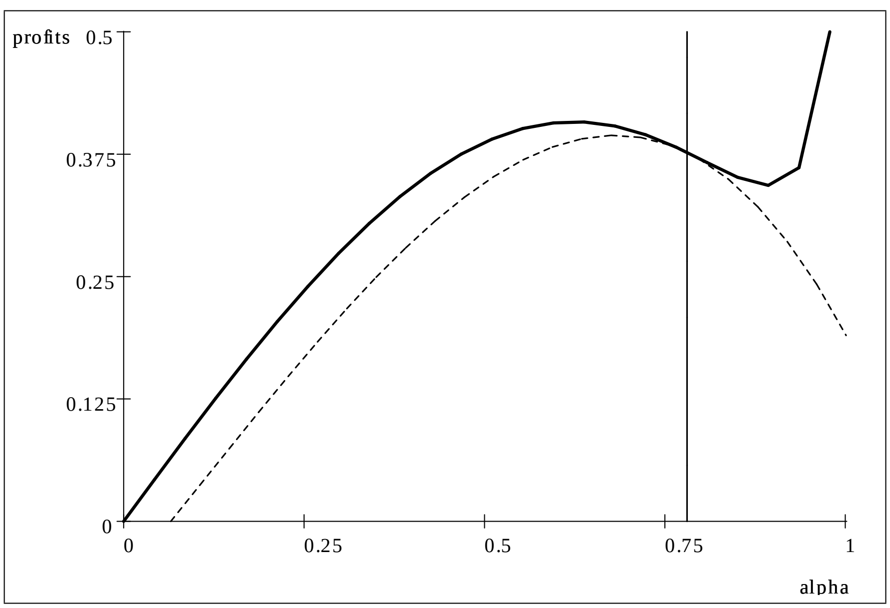

Figure 5

The first-order conditions specify as

$$\frac{\left(\alpha+1-\alpha^2\right)(1-2\alpha)}{2}\left(\frac{1-\alpha^2}{2(\alpha+1-\alpha^2)} + \ln\left(\frac{\alpha}{2(1-\alpha^2)} + \frac{1}{2}\right) + \ln 2 - \frac{1}{2}\right) + \frac{\left(3\alpha^3-14\alpha^2-\alpha+10\alpha^4+4\right)}{4(1-\alpha^2)} \quad = 0$$
$$\text{if } 0 \leq \alpha \leq \frac{\sqrt{17}-1}{4} \tag{19}$$

and

$$
\begin{aligned}
&2\left(3\ln 3-1\right)\left(1-\alpha-3\alpha^{2}+2\alpha^{3}\right)+6\left(1-3\alpha^{2}+2\alpha-2\alpha^{3}\right) &= 0\\
&\text{if } \tfrac{\sqrt{17}-1}{4}\leq\alpha\leq 1.
\end{aligned}
\tag{20}
$$

Condition (20) has solution $\alpha = 0.68128$, which does not belong to the relevant range, so condition (20) can be discarded. Condition (19), instead, solves for $\alpha^{*} = 0.62416$ which is the global maximum and yields $\gamma\left(\alpha^{*}\right) = 1-(0.62416)^{2} = 0.61043$.

One can generalize this example considering $x > 1$ and $y = 1$, so that $\gamma\left(\alpha\right) = 1-\alpha^{x}$. First-order conditions are then given by

$$
\begin{aligned}
&\left(\alpha+1-\alpha^{x}\right)\left(1-x\alpha^{x-1}\right)\left(\tfrac{(1-\alpha^{x})}{4(\alpha+1-\alpha^{x})}+\tfrac{1}{2}\ln\left(\tfrac{\alpha}{2(1-\alpha^{x})}+\tfrac{1}{2}\right)+\tfrac{1}{2}\ln 2-\tfrac{1}{4}\right)+\tfrac{4(1-\alpha^{x})^{2}-3(1-\alpha^{x})x\alpha^{x}-\alpha(1-\alpha^{x})+x\alpha^{x+1}}{4(1-\alpha^{x})} =\\
&\text{if } 2-\alpha-2\alpha^{x}\geq 0
\end{aligned}
\tag{21}
$$

and

$$
\begin{aligned}
&2\left(3\ln 3-1\right)\left(\alpha+1-\alpha^{x}-x\alpha^{x}-x\alpha^{x-1}\left(1-\alpha^{x}\right)\right)+6\left(1-\alpha^{x}-x\alpha^{x}+x\alpha^{x-1}\left(1-\alpha^{x}\right)\right) &= 0\\
&\text{if } 2-\alpha-2\alpha^{x}\leq 0.
\end{aligned}
\tag{22}
$$

In Figure 6, the dotted curve is the locus of points (x,α) such that condition (21) holds whereas the solid curve is the locus of points satisfying condition (22). At the same time, Figure 6 depicts as a thick curve the locus of points (x,α) such that $2-\alpha-2\alpha^{x} = 0$, i.e. such that the contract switches from separating to pooling. In particular, above the thick curve condition (22) is relevant whereas below the thick curve condition (21) matters. This picture shows that (22) can be discarded because it can only be satisfied when it is not relevant; condition (21) instead admits a solution in the relevant range.

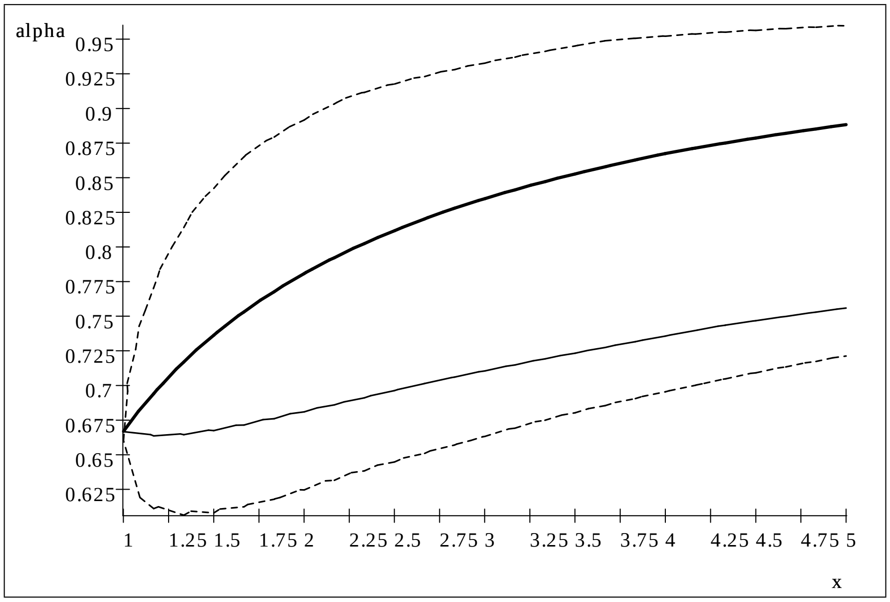

Figure 6

In the third example, one has $x = 1$ and $y = \frac{1}{2}$ so that $\gamma(\alpha) = (1-\alpha)^{\frac{1}{2}}$. Profits to the firm $E[\pi(\alpha)]$ are equal to

$$\frac{\left(\alpha+(1-\alpha)^{\frac{1}{2}}\right)^2}{4}\left(\frac{(1-\alpha)^{\frac{1}{2}}}{2\left(\alpha+(1-\alpha)^{\frac{1}{2}}\right)}+\ln\left(\frac{\alpha+(1-\alpha)^{\frac{1}{2}}}{2(1-\alpha)^{\frac{1}{2}}}\right)-\left(\frac{1}{2}+\ln\left(\frac{1}{2}\right)\right)\right)+\frac{\alpha\left(7(1-\alpha)^{\frac{1}{2}}-2\alpha\right)}{8}$$

if $0 \leq \alpha \leq 2\left(\sqrt{2}-1\right) = 0.828\,43$

and

$$\frac{1}{12}\left((3\ln 3-1)\left(\alpha+(1-\alpha)^{\frac{1}{2}}\right)^2+3(1-\alpha)^{\frac{1}{2}}\left(2\alpha-(1-\alpha)^{\frac{1}{2}}\right)\right)$$

if $2\left(\sqrt{2}-1\right) \leq \alpha \leq 1$

and they are represented in Figure 7.

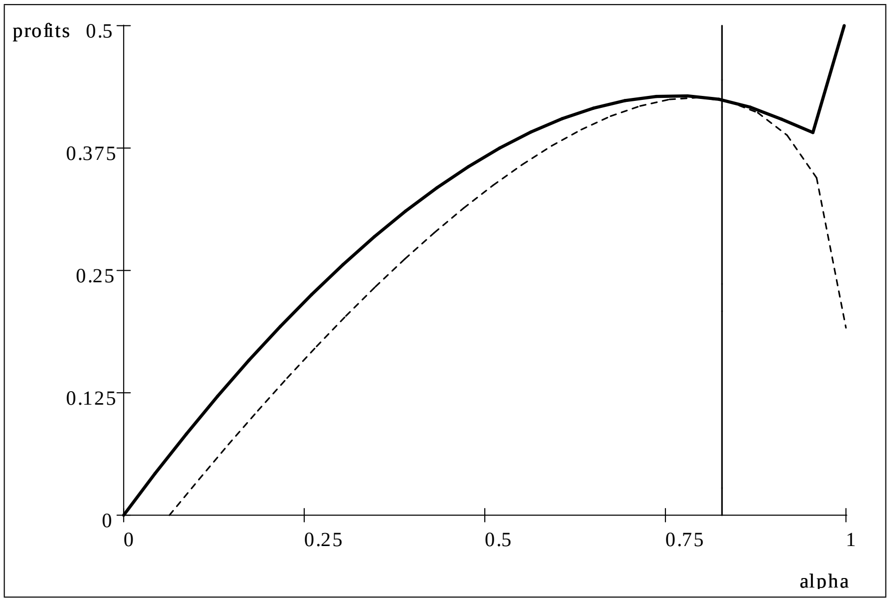

Figure 7

The first-order conditions specify as

$$\frac{\left(\alpha+(1-\alpha)^{\frac{1}{2}}\right)\left(1-\frac{1}{2}(1-\alpha)^{-\frac{1}{2}}\right)}{2}\left(\ln 2-\frac{1}{2}+\frac{(1-\alpha)^{\frac{1}{2}}}{2\left(\alpha+(1-\alpha)^{\frac{1}{2}}\right)}+\ln\left(\frac{\left(\alpha+(1-\alpha)^{\frac{1}{2}}\right)}{2(1-\alpha)^{\frac{1}{2}}}\right)\right)+\frac{\left(4(1-\alpha)-\frac{3}{2}\alpha-\alpha(1-\alpha)^{\frac{1}{2}}+\frac{\alpha^2}{2}(1-\alpha)^{-\frac{1}{2}}\right)}{4(1-\alpha)^{\frac{1}{2}}}=0$$
$$\text{if } 0\leq\alpha\leq 2\left(\sqrt{2}-1\right)=0.828\,43 \tag{23}$$

and

$$\begin{aligned}&(2\,(3\ln 3-1)+6)\left((1-\alpha)^{\frac{1}{2}}-\frac{\alpha}{2(1-\alpha)^{\frac{1}{2}}}\right)+3+(2\alpha-1)\,(3\ln 3-1)=0\\&\text{if } 2\left(\sqrt{2}-1\right)\leq\alpha\leq 1,\end{aligned} \tag{24}$$

where condition (24) solves for $\alpha = 0.79138$ which does not belong to the relevant range, so condition (24) can be discarded; condition (23), instead, has solution $\alpha^* = 0.76527$, so that $\gamma(\alpha^*) = 0.48449$.

This example can be generalized considering $x = 1$ and $y < 1$, so that $\gamma(\alpha) = (1-\alpha)^y$. The associated first-order conditions are

$$\frac{(\alpha+(1-\alpha)^y)\left(1-y(1-\alpha)^{y-1}\right)}{2}\left(\ln 2-\frac{1}{2}+\frac{(1-\alpha)^y}{2(\alpha+(1-\alpha)^y)}+\ln\left(\frac{(\alpha+(1-\alpha)^y)}{2(1-\alpha)^y}\right)\right)+\frac{\left(4(1-\alpha)^y-3\alpha y(1-\alpha)^{y-1}-\alpha+\alpha^2 y(1-\alpha)^{-1}\right)}{4}=0$$
$$\text{if } 2\,(1-\alpha)^y-\alpha\geq 0 \tag{25}$$

and

$$\begin{aligned}(2(3\ln 3-1)+6)\left((1-\alpha)^{y}-\alpha y(1-\alpha)^{y-1}\right)+(6-2(3\ln 3-1))\,y(1-\alpha)^{2y-1}+2(3\ln 3-1)\,\alpha &= 0\\ \text{if } 2(1-\alpha)^{y}-\alpha\leq 0.\end{aligned} \tag{26}$$

In Figure 8, the dotted curve represents the locus of points (α, y) such that condition (25) holds whereas the solid curve is the locus of points satisfying condition (26). The thick curve is the locus of points (α, y) such that $2(1-\alpha)^{y}-\alpha=0$, i.e. such that the contract switches from separating to pooling. In particular, above the thick curve condition (26) is relevant, whereas below the thick curve condition (25) matters. As before, this picture shows that (26) can be discarded because it can only be satisfied when it is not relevant; condition (25) instead admits a solution in the relevant range.

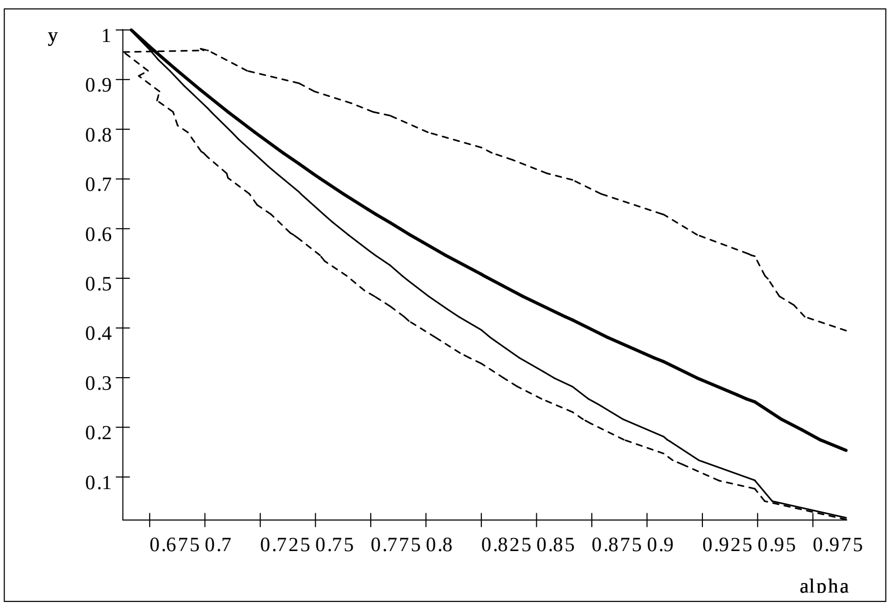

Figure 8

Finally, consider the case in which $\gamma(\alpha)$ is convex and examine $\gamma(\alpha)=1-\alpha^{\frac{1}{2}}$. Expected profits to the firm are still concave and are depicted in Figure 9. It is clear that a maximum is attained to the right of the critical α corresponding to $\overline{\theta}>1$ and full separation, or else no volunteerism, is the outcome.

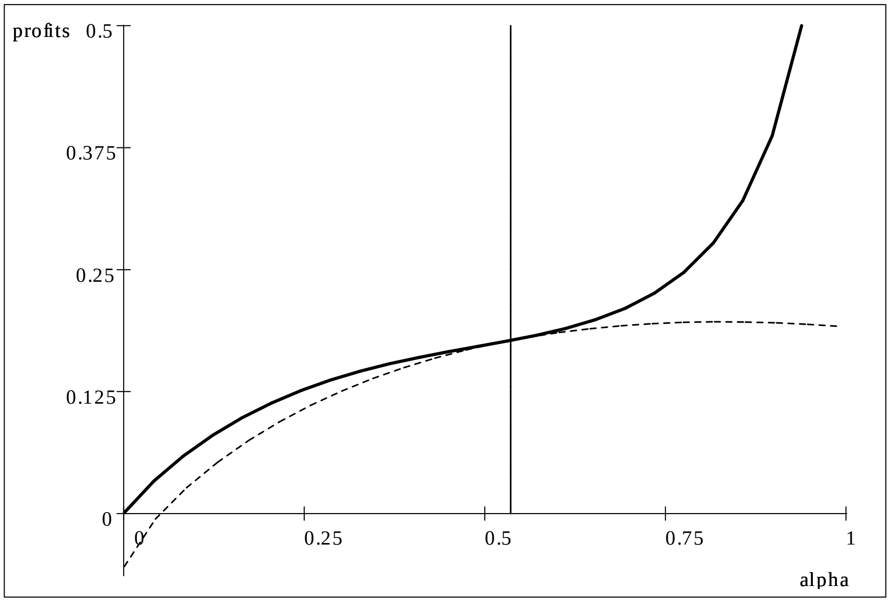

Figure 9