Screening workers for ability and motivation

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Abstract

We study the screening problem of a firm that hires workers not knowing their ability and their intrinsic motivation. We completely characterise the set of optimal contracts (consisting in observable effort levels and non-linear salaries) that depend on how the heterogeneity in motivation relates to the heterogeneity in ability. Accordingly, optimal contracts differ as to whether ability or motivation prevails in determining workers' performance. We show that full separation and full participation of workers' types is always implemented, when feasible, because it is preferred by the firm to either pooling or exclusion of some workers. Moreover, when ability prevails, there exist full screening contracts such that motivated workers are asked to provide the efficient level of effort and such that the firm pays low information rents to its workers. Despite this fact, the firm makes higher profits when motivation rather than ability prevails, because of labour donation by motivated workers.

Jel classification: D82, D86, J31, M55.

1 Introduction

A recent literature addresses the issue of the selection of applicants in labour markets where potential workers can be intrinsically motivated for the job, as in the market for civil servants, health professionals and teachers (see Handy and Katz 1998, Delfgaauw and Dur 2007, 2010, Francois 2000, Heyes 2005). A shared view from this literature is that low monetary rewards select highly motivated workers, who have lower reservation wages but who might not necessarily be talented or skilled for the job. Conversely, high wages are necessary to attract applicants with high skills, but this might come at the cost of employing workers who are less motivated for the task to be performed. These observations seem to suggest that, in a world where workers' attributes are not observable, there exists an underlying trade-off that makes it difficult, if not impossible, for firms to screen workers according to both dimensions, ability and motivation. Since workers' overall performance depends on the interplay of both characteristics, it

is important to investigate how a firm can address the problem of adverse selection on both ability and motivation.

To tackle this issue, we consider a principal-agent relationship where agents' skills (or productive ability) and intrinsic motivation are independently and discretely distributed, and take two possible values each. Moreover, we fix the higher level of ability and the lower level of motivation (in particular, workers can either be motivated or not) and let both the difference in ability and the difference in motivation vary.

Productive ability lowers the worker's cost of accomplishing her task, whereas motivation is interpreted as the worker's enjoyment of her personal contribution to the firm's mission or goal, or as a non-monetary benefit accruing to the worker when performing a given task. Since workers' characteristics cannot be observed by the employer, they cannot be contracted upon. Instead, the firm can observe and verify the task (for example the hours worked) that different types of workers are asked to perform. Consistently with the existing literature on workers' intrinsic motivation, we call such contractible task the effort level exerted by a worker. Thus, the employer offers a menu of contracts consisting of different combinations of effort provision and non-linear wage rate (which depends on effort levels).

Take the market for registered nurses, where hospitals typically offer contracts characterised by a different number of working hours: in the U.S., part-time contracts require about 24 hours each week, full-time nurses work on average 43 hours a week; moreover, nurses can choose paid voluntary overtime up to 60 hours a week.[1] As for nurses' monetary compensation, the total salary they receive is generally represented by an hourly wage that depends on the number of hours worked per day: it encompasses part-time penalties and/or overtime premia. We show that such simple contracts (defined only by the number of hours worked per week and by the total salary) are likely to enable the hospital to identify applicants with respect to their unobservable ability and motivation. In particular, our model predicts that high-ability motivated applicants choose the contract with the largest paid overtime and low-ability non-motivated nurses are targeted to part-time contracts.

Workers' career concerns can be used as a screening device too. Typically, workers self-select into different career paths: some of them accept tasks involving strong performance evaluation in exchange for more likely and faster promotions; some others prefer a slower progress up the job ladder together with lower pay and almost no performance evaluation. In the academia, for instance, junior professors can either choose tenure-track positions, which require them to demonstrate, within a short time span, a strong record of published research, grant funding, teaching and administrative service, or positions off

[1] Bae (2012) presents a quantitative survey data collected from registered nurses who worked in hospitals as staff nurses in North Carolina and West Virginia in 2010-2011. Concerning overtime, 33.2% of nurses working overtime are choosing to perform voluntary paid overtime; among them, 42% are working overtime more than 12 hours a week. Interestingly, the reasons reported by nearly half nurses as to why they worked overtime is that they "like to work overtime".

the tenure track (such as lecturer or adjunct professor), which require full- or part-time teaching but few or no research responsibilities. In this context, an optimal contract consists of the career path and the overall compensation. Intuitively, tenure-track positions are targeted to attract the best researchers.

Our goal is to describe the set of optimal screening contracts and, in particular, to analyse to what extent separation of workers is possible, which types of workers are hired, which are the optimal task levels that they are required to accomplish, and, finally, which are the optimal compensation practices that the firm adopts. The complete characterization of optimal contracts delivers some novel and interesting insights.

We show that four different and mutually exclusive solutions involving full separation and full participation of types might exist, which are always implemented (when they exist), because they yield the highest payoffs to the firm. When full screening is impossible, the firm is bound to offer contracts with pooling or exclusion (i.e. contracts such that some workers' types are offered the same contract or some workers' types remain unemployed, respectively). Therefore, our model shows that, despite using only one instrument (the task level), the firm might be able to fully screen applicants for both ability and motivation. In this case, the firm designs four different individually rational and incentive compatible contracts, one for each type of worker, and each type, choosing her preferred contract, reveals her private information to the firm.

As for the optimal effort levels with full screening, we find that the ordering of effort levels required from the different types is the same as under full information, i.e. is the efficient one. In particular, there are two alternative rankings of effort levels exerted by the different types of workers which, in turn, reflect the firm's different preference orderings on worker's types. A crucial role is played by the relative importance of workers' heterogeneity in ability *vis à vis* workers' heterogeneity in motivation. If the difference in motivation is more significant than the difference in ability, then motivation has a larger impact than ability on workers' performance (and on the firm's output), in which case motivated workers are asked to provide higher effort than non-motivated types. Conversely, if the difference in ability prevails over the difference in motivation, then ability is the main determinant of workers' performance and high-skilled workers are induced to supply higher effort than low-skilled types.

More concretely, when the difference in motivation prevails, then some workers are very motivated and, on average, employees's skills are high. This could be the case of health professionals and researchers, who are highly educated and trained. When, instead, the difference in ability prevails, then some employees have low skills and average motivation is either intermediate or low. This might be the case, respectively, of high-school teachers and lecturers or civil servants and bureaucrats; the latter might have a reputation for being lazy and not so much dedicated, as Delfgaauw and Dur (2008) point out.

Within full screening contracts, we find that the firm is better-off when the difference in motivation prevails. Hence, a monopsonist needing to select good researchers or good health professionals makes

higher payoffs than an organisation confronted with the selection of high-school teachers and lecturers. However, full screening contracts in the latter case are surprisingly close to efficiency, given that there is no distortion in the tasks accomplished by motivated workers, and low information rents can be paid. Our results thus predict that, when the employer selects high-school teachers or lecturers he faces lower costs (but earns lower revenues) than when hiring health professionals and researchers.

When neither heterogeneity in ability nor heterogeneity in motivation prevails, then a pooling contract must be offered to low-skilled motivated workers and to high-skilled non-motivated workers, who cannot be separated. In other words, in the case of tasks where ability and motivation have a comparable impact on workers' performance, employers can only coarsely identify the different types of workers and at most three different contracts are offered. This implies that the returns to either ability or motivation are lower than under full screening. Consider, for instance, primary school teachers: one frequently observes less engaged workers that are just assigned the basic teaching charge, or teachers who accept some additional administrative duties, or teachers who take high responsibilities in exchange for a relatively small increase in salary (i.e. school principals). Our model suggests that a limited differentiation of duties and wages in such professions could depend not only on the stringent administrative constraints existing in many countries, but also on incentives. To this respect, the previous literature has explained low-powered incentives on the basis of moral hazard issues, either modeling a multitasking environment (Holmstrom and Milgrom 1991) or studying assortative matching between employers and employees (Besley and Ghatak 2005). Our model offers an alternative explanation based on bidimensional screening.

Finally, considering optimal wage schemes, we find a sharp difference between full and asymmetric information. At the first-best, non-motivated workers with high ability are always paid the highest wage, while motivated employees with low ability receive the lowest salary. This is consistent with the so-called "donative labour hypothesis" whereby workers endowed with intrinsic motivation and sharing the mission of their organisation donate part of their labour by accepting lower wages. Under asymmetric information, however, there is a reversal in the ranking of rewards: high-skilled motivated workers receive the highest transfer, while low-skilled non-motivated workers obtain the lowest reward. This is because motivated workers are able to mimic non-motivated ones and thus need to be given information rents for truthful revelation, which increase their compensation. Indeed, when motivation prevails and full screening contracts are offered, low-skilled motivated workers might even become 'paid volunteers' and earn a strictly positive salary even if they would be ready to work for free.

The rest of the paper is organized as follows. In the following Subsection we describe the related literature. In Section 2, we set up the model. Section 3 describes the benchmark cases: the first-best (Section 3.1), asymmetric information about one characteristic only, be it ability (Section 3.2) or intrinsic motivation (Section 3.3). In Section 4, we consider the interaction between the two sources of asymmetric information. We distinguish between the two scenarios in which motivation or ability prevail

and we describe the set of optimal contracts. Section 5 considers more in detail optimal contracts with full separation and full participation and offers some interesting comparisons among them. The concluding Section 6 adds some comments on workers' exclusion and sorting.

1.1 Related literature

Our work contributes to two different strands of literature: from an economic point of view, it adds to the recent literature on the selection of workers with intrinsic motivation; from a technical viewpoint, it explicitly solves the principal-agent problem in a labour market where workers are characterised by two dimensions of private information.

Heyes (2005) and Delfgaauw and Dur (2007) address the issue of the selection of workers who are privately informed about their motivation only. They show that workers' motivation negatively affects reservation wages. Therefore, as the wage offered by a firm increases, the average motivation of workers willing to accept the job deteriorates. Delfgaauw and Dur (2007) show that optimal wage schemes entail a trade-off among the probability of filling a vacancy, the rents left to the workers and the expected motivation of job applicants. Our analysis departs from this work because it includes a second source of asymmetric information (ability) and, most importantly, because it resorts to a direct revelation mechanism.

Our paper is also related to Handy and Katz (1998) and Delfgaauw and Dur (2008), where asymmetric information on both workers' ability and motivation is introduced. The first article suggests that non-profits attract motivated managers by offering them lower money wages and higher institution-specific fringe benefits than for-profits do. Results are driven by an exogenously given ranking of reservation wages for the different types of managers. Delfgaauw and Dur (2008) characterize the optimal incentive schemes offered by a public agency when workers differ in laziness and public service motivation. They show that the government attracts motivated and productive workers as well as the laziest workers, while the remaining types of workers are hired by the private, perfectly competitive sector. We depart from the last paper in two main ways: we consider one sector in isolation and we do not constrain the principal to hire at most two types of agents.

Other papers deal with sorting of motivated workers into different sectors of the labour market, but do not solve a screening problem. Delfgaauw and Dur (2010) focus on the issue of managerial self-selection into public vs private sectors in a perfectly competitive framework where workers' ability and motivation are fully observable. They argue that the return to managerial ability is lower in the public than in the private sector. Thus, attracting more able managers to the public sector by increasing their remuneration up to the private sector levels is not efficient. Barigozzi *et al.* (2013) and Barigozzi and Turati (2012) consider labour supply in a market where workers have private information about ability and motivation

and where firms offer a flat salary. They show that an increase in the market wage can determine a simultaneous decrease of applicants' average vocation and average productivity.

Finally, some papers in health economics analyse optimal screening mechanisms based on physicians' altruism (i.e. concern for patients' health). In Jack (2005), the physician is characterised by private information about his level of altruism, while in Choné and Ma (2011) the physician also has private information about his patients' health. Conversely, the design of screening contracts when health providers are privately informed about their ability while their altruism is common knowledge is the subject of Makris (2009) and Makris and Siciliani (2013).

The literature on the analysis of optimal screening of agents with unknown characteristics has mainly been examined under the assumption of unidimensional asymmetric information. The interesting and possibly more realistic cases where agents have several unobservable characteristics have been studied by a few important exceptions.

Armstrong and Rochet (1999) provide a complete characterization of optimal contracts when the dimensionality of actions is the same as the dimensionality of private information and the type space is discrete. In our model, there is only one screening instrument (the contractible effort level) and hence we cannot apply their results. When the dimensionality of actions is smaller than the dimensionality of private information and the type space is continuous, Armstrong (1996), Rochet and Choné (1998) and Basov (2005) show that most of the qualitative results and regularity conditions relative to the unidimensional environment do not carry over to a multidimensional framework. In particular, exclusion is pervasive and full separation of types is impossible.

Our analysis owes much to Armstrong (1999), who considers optimal price regulation of a monopoly that is privately informed about its cost and demand. Two classes of problems are distinguished: if cost uncertainty is relatively more important than demand uncertainty, then optimal prices are weakly above marginal costs; if the opposite holds, then pricing below marginal cost could be optimal. In both classes of solutions, some pooling of types exists. This result stands in contrast with our finding that full separation is always preferred by the principal. The main reason for this difference is that, in Armstrong (1999), pooling already emerges at the first-best.

Moreover, some papers analyse the issue of multidimensional screening in insurance markets. Crocker and Snow (2011) consider competitive screening with consumers possessing hidden knowledge of their probability of incurring different losses associated with different perils. The problem reduces to one-dimensional screening because of an efficient bundling of coverage. Olivella and Schroyen (2014) describe a monopolistic insurer facing customers who differ in their risks and risk aversion. Two classes of solutions arise depending on how the difference in expected losses compares with the difference in the degree of absolute risk aversion. Optimal contracts are such that full separation never occurs and exclusion of some high-risk individuals might be optimal.

Finally, von Siemens (2011) analyses incentive contracts when workers have private information about their ability and their propensity for social comparisons. It is shown that the firm cannot separate workers according to their social preferences, whereby bidimensional screening cannot be implemented.

2 The model

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

The production function is such that the only input is labour supplied by the agent. We call e the observable and measurable effort (task) level that the worker is asked to provide.[2] The production function displays constant returns to effort in such a way that $q(e) = e$ and so the firm's payoff function is

$$\pi = e - w,$$

where the price of output is assumed to be exogenous and normalized to 1, and w is the total salary paid to the hired worker.

Suppose that the worker differs in two characteristics, productive ability and intrinsic motivation, which are independently distributed and can take two values each.[3] In order to make notation less cumbersome, we use upper-case letters to denote high values of a worker's characteristic and lower-case letters to denote low values of the characteristic. A worker characterised by high ability incurs in a low cost of providing a given effort level. Ability is denoted by $\theta_i \in \{\theta_A, \theta_a\}$ where $\theta_a > \theta_A > 0$. Thus, employees have high ability θ_A (i.e. a low cost of effort), with probability ν, or they have low ability θ_a (i.e. a high cost of effort), with probability $1 - \nu$. As for intrinsic motivation, we assume that workers, to a certain extent, derive utility from exerting effort. Since there exists a one-to-one relationship between effort exerted and output produced by the firm, this interpretation is equivalent to considering intrinsic motivation as the enjoyment of one's personal contribution to the firm's goals.[4] We denote workers' motivation as $\gamma_j \in \{\gamma_m, \gamma_M\}$ with $\gamma_M > \gamma_m \geq 0$. Workers either have high motivation γ_M, with probability μ, or low motivation γ_m, with probability $1 - \mu$.

For simplicity, we fix the lower bounds of the support of the distribution for both attributes, setting $\theta_A = 1$ and $\theta_a = \theta$ and also $\gamma_m = 0$ and $\gamma_M = \gamma$. We will thus denote by $\Delta\theta = \theta_a - \theta_A = \theta - 1$ the

[2] The variable e can be interpreted as a job-specific requirement like the amount of hours of labour devoted to production.

[3] Allowing for more general distribution functions that admit correlation between ability and motivation does not alter our results qualitatively, since all possible classes of solutions that we find are still relevant.

[4] Intrinsic motivation can also arise because "the firm has some unique trait that is valued differently by different workers, giving the firm monopsony power" (Delfgaauw and Dur 2007, page 607). In turn, the link between workers' motivation and market power justifies our hypothesis concerning profit maximization and wage setting on the part of the principal.

heterogeneity in ability, and by $\Delta\gamma = \gamma_M - \gamma_m = \gamma$ the heterogeneity in motivation. Given that $\Delta\gamma = \gamma$, we will talk about the heterogeneity or the level of motivation interchangeably.

Worker's types will be generically denoted as ij where the first index represents ability and the second index stands for motivation. So the four possible types of worker are indexed as $ij = \{AM, Am, aM, am\}$.

The agent's reservation utility is normalized to zero for all possible worker's types.[5]

Workers' utility is quasi-linear in income and takes the form

$$u_{ij} = w_{ij} - \frac{1}{2}\theta_i e_{ij}^2 + \gamma_j e_{ij},$$

where both ability θ_i and motivation γ_j enter linearly and are related to effort exertion.[6]

The marginal rate of substitution between effort and wage is given by

$$MRS_{e,w} = -\frac{\partial u_{ij}/\partial e_{ij}}{\partial u_{ij}/\partial w_{ij}} = \theta_i e_{ij} - \gamma_j,$$

which is always positive for non-motivated workers with $\gamma_j = 0$. When effort required by the firm is sufficiently low, i.e. $e_{ij} < \frac{\gamma_j}{\theta_i}$ with $j = M$, motivated workers' indifference curves have a negative slope in the space (e, w) and effort is a 'good'. Moreover, providing effort represents a net benefit to the worker when

$$-\frac{1}{2}\theta_i e_{ij}^2 + \gamma_j e_{ij} > 0.$$

Thus, if the effort required by the firm is sufficiently low that $e_{ij} < \frac{2\gamma_j}{\theta_i}$, then motivated workers obtain a net positive utility from effort exertion and are in principle willing to receive a non-positive reward. However, there is no need to impose a limited liability constraint on the part of motivated workers and require $w_{ij} \geq 0$: such condition is always verified when both ability and motivation are private information (see Section 4).[7]

Finally, workers' utility function satisfies the single-crossing property only with respect to each parameter of private information at a time. In fact, $MRS_{e,w}$ is increasing in θ (holding motivation constant) and decreasing in γ (given ability). This means that the indifference curves of workers with the same motivation but different ability, or with the same ability but different motivation, intersect only once at $e = 0$. Nonetheless, the single-crossing property does not hold when both ability and motivation change simultaneously.

[5] In the concluding section, we consider type-dependent outside options and discuss results from this extension.

[6] Our results are robust to alternative, more general specifications of the utility function. The necessary ingredients are: (*i*) utility is linear and separable in the parameters of asymmetric information, (*ii*) such parameters are both related to effort; (*iii*) the cost of effort is convex while the benefit from exerting effort, due to intrinsic motivation, is concave.

[7] In our model, effort provision generates a non-monetary cost. Conversely, when costs paid by the worker are mainly monetary (as when a physician provides health care to a patient), then limited liability requires transfers to be above monetary costs.

Remark 1 *The indifference curves of intermediate types Am and aM cross twice, at* $e = 0$ *and also at* $e = \frac{2\gamma_M}{\theta_a - \theta_A} = \frac{2\gamma}{\theta - 1}$.

In Section 4, we assume that the firm offers the agent a menu of second-best contracts of the form $\{e, w(e)\}$. Applying the Revelation Principle, we focus on four contracts such that a worker of type ij exerts effort e_{ij} and receives a wage $w(e_{ij}) = w_{ij}$. Before turning to the second-best, let us examine the benchmark cases in which either there is no private information at all or there is only one characteristic that is the worker's private information.

3 Benchmark cases

3.1 Full information

At the first-best, both ability and motivation are observable. For $i = A, a$ and $j = M, m$, the firm solves the problem

$$\max_{(e_{ij}, w_{ij})} \pi = e_{ij} - w_{ij} \qquad (FB)$$
$$\text{s.t. } u_{ij} \geq 0$$

which yields effort levels

$$e_{ij}^{FB} = \frac{1 + \gamma_j}{\theta_i} \qquad (1)$$

that are increasing in motivation γ_j and decreasing in the cost of providing effort θ_i. Indeed, both higher motivation and lower effort cost improve workers' performance and, in turn, lead to higher output produced by the firm.

Wages are set in such a way that each worker receives her zero reservation utility and are equal to

$$w_{ij}^{FB} = \frac{\left(1 + \gamma_j\right)\left(1 - \gamma_j\right)}{2\theta_i}.$$

Importantly, all wages are non-negative at the first-best if $\gamma_j \leq 1$.

Assumption 1 *Let* $0 < \gamma \leq 1$. *Then, motivated workers always receive a non-negative salary at the first-best.*

At the second-best, Assumption 1 is no longer sufficient to ensure that low-ability motivated workers aM receive a positive monetary transfer from the firm, because incentives might force the firm to distort effort levels downwards. This implies that it is necessary to check whether $e_{aM} \gtreqless \frac{2\gamma}{\theta}$ at the second-best. Type aM can indeed experience a net utility from effort provision, nonetheless, her salary w_{aM} is always strictly positive.

Let us examine effort levels and their ranking under full information. Considering equation (1), it is clear that the best type is worker AM (with high ability and high motivation) who exerts the highest effort, whereas the worst worker is am (with low ability and no motivation) who provides the lowest effort. Worker types Am and aM are in-between and their effort levels cannot be ordered unambiguously.[8] For intermediate types, either

$$e_{aM}^{FB} > e_{Am}^{FB} \text{ if and only if } \gamma > \theta - 1 \equiv \Delta\theta, \tag{2}$$

or

$$e_{Am}^{FB} > e_{aM}^{FB} \text{ if and only if } \gamma < \theta - 1 \equiv \Delta\theta, \tag{3}$$

whereas $e_{Am}^{FB} = e_{aM}^{FB}$ whenever $\gamma = \Delta\theta$. Hence, $\gamma = \Delta\theta$ is the value of motivation such that the types' space corresponds to a square and workers Am and aM become equivalent in terms of effort provision.

Given Assumption 1, a necessary condition for (2) is that $\Delta\theta \leq 1$ or else that $\theta \leq 2$.

Remark 2 *At the first-best, the ordering of effort levels is as follows:*

1. *If $\theta \leq 2$ and $\gamma > \Delta\theta$ both hold, then $e_{AM}^{FB} > e_{aM}^{FB} > e_{Am}^{FB} > e_{am}^{FB}$.*
2. *If $\gamma < \Delta\theta$, then $e_{AM}^{FB} > e_{Am}^{FB} > e_{aM}^{FB} > e_{am}^{FB}$.*

Intuitively, when $\gamma > \Delta\theta$, the difference in motivation $\Delta\gamma = \gamma$ is higher than the difference in ability $\Delta\theta$, in which case the effort provided by worker aM is higher than that of worker Am, and the first ranking in Remark 2 is relevant. Conversely, when $\gamma < \Delta\theta$, the difference in ability is more important than the difference in motivation, and the second ranking is relevant. Since both instances are economically relevant, we impose that $\Delta\theta \leq 1$ which is equivalent to $\theta \leq 2$.

Assumption 2 *Let $1 < \theta \leq 2$. Then $0 < \Delta\theta \leq 1$ holds and all orderings $e_{aM}^{FB} \gtreqless e_{Am}^{FB}$ are possible.*

Finally, let us consider the ranking of wages with perfect information.

Remark 3 *At the first-best, the ordering of wage levels is as follows:*

$$w_{Am}^{FB} > \max\left\{w_{AM}^{FB}, w_{am}^{FB}\right\} \geq \min\left\{w_{AM}^{FB}, w_{am}^{FB}\right\} > w_{aM}^{FB} \geq 0$$

For fixed ability, motivated workers always obtain lower rewards than non-motivated ones. In addition, when $w_{am}^{FB} > w_{AM}^{FB}$, motivated workers earn less than non-motivated workers independently of their ability.

[8] The existence of two possible orderings of effort levels is a consequence of the bidimensionality of our problem and of the failure of the single-crossing condition. It could not be generated in a unidimensional set-up with different types of employees characterized by a single summary statistic, like the overall cost of providing effort.

3.2 Private information about ability

Suppose that workers' motivation γ_j is observable to the firm but ability θ_i is not. We call this benchmark case unidimensional screening about ability, and denote it with $U\mathcal{A}$. For fixed $j = M, m$ the firm solves

$$\max_{(e_{Aj},w_{Aj});(e_{aj},w_{aj})} E(\pi) = \nu(e_{Aj} - w_{Aj}) + (1-\nu)(e_{aj} - w_{aj}) \qquad (U\mathcal{A})$$

subject to the binding participation constraint of the low-ability worker and to the binding incentive compatibility constraint of the high-ability worker not being tempted to choose the contract designed for the low-ability worker. Solving the binding constraints for wages, substituting into the firm's program $U\mathcal{A}$ and maximising with respect to effort levels, we obtain

$$e_{Aj}^{U\mathcal{A}} = 1 + \gamma_j = e_{Aj}^{FB}$$

and

$$e_{aj}^{U\mathcal{A}} = \frac{(1+\gamma_j)(1-\nu)}{(\theta-\nu)},$$

where the results of no-distortion-at-the-top and downward distortion in the effort exerted by the low-ability worker both hold. Full participation is always optimal and it is never in the firm's interest to exclude low-ability workers (types aj).

As for optimal wages (not displayed here for the sake of brevity), we find that, given motivation, the wage rate is increasing in workers' ability, i.e. $w_{Aj}^{U\mathcal{A}} > w_{aj}^{U\mathcal{A}}$. Considering motivated types of agents, notice that $w_{AM}^{U\mathcal{A}} > 0$ always holds while $w_{aM}^{U\mathcal{A}} > 0$ if and only if

$$\gamma < \frac{\theta(1-\nu)}{(\theta-\nu)+\nu\Delta\theta} \equiv \gamma^{U\mathcal{A}} < 1,$$

meaning that, if motivation is high enough, worker aM can accept $w_{aM}^{U\mathcal{A}} \leq 0$ because she enjoys providing effort.

Finally, payoffs to the firm are always increasing in motivation, implying that it is always preferable to employ motivated workers.[9]

3.3 Private information about motivation

Suppose now that workers' ability θ_i is observable to the firm but motivation γ_j is not.[10] We call this benchmark case unidimensional screening about motivation, or benchmark $U\mathcal{M}$. For fixed $i = A, a$ the firm solves

$$\max_{(e_{iM},w_{iM});(e_{im},w_{im})} E(\pi) = \mu(e_{iM} - w_{iM}) + (1-\mu)(e_{im} - w_{im}) \qquad (U\mathcal{M})$$

[9] Our result stands in contrast to Makris and Siciliani (2013), who find that the principal prefers agents with moderate rather than high altruism. This difference depends on the limited liability constraint that they impose.

[10] Jack (2005) analyzes optimal non-linear, cost-sharing mechanisms when physicians, who are privately informed about their degree of altruism, choose both effort and quality of service.

subject to the binding participation constraint of the non-motivated worker and to the binding incentive compatibility constraint of the motivated worker not being attracted by the non-motivated type's contract. Optimal effort levels are

$$e_{iM}^{U\mathcal{M}} = \frac{1+\gamma}{\theta_i} = e_{iM}^{FB}$$

and

$$e_{im}^{U\mathcal{M}} = \frac{(1-\mu)-\mu\gamma}{(1-\mu)\,\theta_i},$$

where the results of no-distortion-at-the-top and downward distortion in the effort exerted by the non-motivated worker both hold. Also, $e_{im}^{U\mathcal{M}} > 0$ for

$$\gamma < \frac{1-\mu}{\mu} \equiv \gamma^{U\mathcal{M}}$$

where $\gamma < \gamma^{U\mathcal{M}}$ always holds if $\mu < \frac{1}{2}$. Moreover, $e_{im}^{U\mathcal{M}} > 0$ is both necessary and sufficient for full participation. Conversely, when γ is sufficiently high, the information rent that the firm must pay to motivated types is so costly that he prefers to exclude non-motivated workers.

As for optimal wages, they are always increasing in motivation and $w_{iM}^{U\mathcal{M}} > w_{im}^{U\mathcal{M}}$. Hence, when ability is observable and motivation is the worker's private information, the ranking of salaries for workers who are equally skilled but have different motivation is reversed with respect to the first-best. This is because of the information rents that motivated workers have to be given for truthful revelation.

4 Screening according to both ability and motivation

The benchmark cases with unidimensional hidden information provide the following predictions: (i) When the firm cannot observe workers' skills, but is perfectly informed about their motivation, it might take advantage of motivated workers and make them work for free: this will not occur at the second-best. (ii) When the employer cannot observe workers' motivation, but is perfectly informed about their skills, he might find in his interest not to hire non-motivated employees: exclusion will always be dominated at the second-best; furthermore, given ability, the firm always offers to motivated employees higher salaries than to non-motivated ones: this result stands in contrast with the first-best but will be confirmed at the second-best.

Suppose now that both ability θ_i and motivation γ_j are the workers' private information. For $i = A, a$ and $j = M, m$, the firm's program is

$$\begin{aligned}\max_{(e_{ij},w_{ij})} E(\pi) = \quad & \nu\mu\,(e_{AM} - w_{AM}) + \nu\,(1-\mu)\,(e_{Am} - w_{Am}) + \\ & (1-\nu)\,\mu\,(e_{aM} - w_{aM}) + (1-\nu)\,(1-\mu)\,(e_{am} - w_{am})\end{aligned} \tag{SB}$$

subject to four participation constraints

$$w_{ij} - \frac{1}{2}\theta_i e_{ij}^2 + \gamma_j e_{ij} \geq 0, \tag{PC_{ij}}$$

requiring that each worker be offered at least her reservation utility, and subject to twelve incentive compatibility constraints whose generic form is

$$w_{ij} - \frac{1}{2}\theta_i e_{ij}^2 + \gamma_j e_{ij} \geq w_{i'j'} - \frac{1}{2}\theta_i e_{i'j'}^2 + \gamma_j e_{i'j'}, \qquad (IC_{ij/i'j'})$$

with ij different from $i'j'$. Such incentive constraint requires that type ij prefers her own contract to the one designed for type $i'j'$.

All constraints are listed in Appendix A, where we show that they satisfy some regularity conditions. In particular, if the participation constraint of the worst worker am holds, then all other PCs are also satisfied. Then, only PC_{am} is relevant. As for incentive constraints, some manipulations yield the following monotonicity (or implementability) condition

$$e_{AM} \geq \max\{e_{Am}; e_{aM}\} \geq \min\{e_{Am}; e_{aM}\} \geq e_{am}. \qquad (4)$$

Concerning intermediate types, one can add the incentive compatibility constraints that type aM is not tempted to choose type Am's contract, $IC_{aM/Am}$, and the incentive constraint that type Am is not attracted by type aM's contract, $IC_{Am/aM}$, and find that

$$\frac{1}{2}\Delta\theta\,(e_{Am} - e_{aM})\,(e_{Am} + e_{aM}) - \gamma\,(e_{Am} - e_{aM}) \geq 0.$$

This inequality is satisfied when either

$$e_{aM} > e_{Am} \quad \text{and} \quad e_{Am} + e_{aM} \leq \frac{2\gamma}{\Delta\theta}, \qquad (5)$$

or

$$e_{Am} > e_{aM} \quad \text{and} \quad e_{Am} + e_{aM} \geq \frac{2\gamma}{\Delta\theta} \qquad (6)$$

holds. Otherwise $e_{aM} = e_{Am}$ and bunching between intermediate types necessarily occurs because it is impossible to separate workers aM and Am, who are asked to provide the same effort and are paid the same salary.

In line with the first-best, condition (5) holds when the quantity $\frac{\gamma}{\Delta\theta}$ is high, or else when the heterogeneity in motivation $\Delta\gamma = \gamma$ is important relative to the heterogeneity in ability $\Delta\theta$. In other words, there are some very motivated workers and there is little variation in workers' skills. This latter feature, given that the lower bound of the support for ability is fixed, means that workers' average ability is high, irrespective of how skills are distributed. This might describe health professionals and researchers. It is now optimal for the firm to ask motivated workers to work harder than non-motivated ones. On the contrary, condition (6) holds when the quantity $\frac{\gamma}{\Delta\theta}$ is low, namely when the heterogeneity in ability is more important than the heterogeneity in motivation. In this case, regardless of the distribution of motivation, workers' average motivation is low (because γ is close to zero) and there are some poorly

skilled workers, as for civil servants and bureaucrats. So, it is optimal for the firm to make more able workers work harder.[11]

To sum up, monotonicity condition (4) can be specified in two different ways: when either condition (5) is satisfied or $e_{aM} = e_{Am}$, we consider solutions to program SB such that the ranking of effort levels is $e_{AM} \geq e_{aM} \geq e_{Am} \geq e_{am}$ and we say that *motivation prevails* or that Case $\mathcal{M}$ holds. Conversely, when either condition (6) is verified or $e_{aM} = e_{Am}$, we search for solutions to program SB with $e_{AM} \geq e_{Am} \geq e_{aM} \geq e_{am}$ and we say that *ability prevails*, or that Case $\mathcal{A}$ holds.

We start considering solutions with full separation and full participation of worker's types, namely full screening solutions, which are characterised by the fact that all participation and incentive constraints are satisfied. Nonetheless, it might well be that some incentive constraints fail to hold and that the solution calls for pooling of some workers' types, or that some participation constraints fail to hold and that the solution requires exclusion of some workers, or both.

In what follows, we first present the different full screening solutions, dividing them according to whether condition (5) or condition (6) holds. We explain which incentive constraints are relevant in the two alternative situations and we provide a general overview of the results. We also briefly discuss the solutions entailing bunching or exclusion, but their formal analysis is contained in the Appendix.

The full screening solution when motivation prevails (Case $\mathcal{M}$) When condition (5) holds, motivation has a higher impact on effort provision than ability and a solution to program SB with full screening of workers' types, such that $e_{AM} > e_{aM} > e_{Am} > e_{am}$, might be attained. From the firm's viewpoint, workers can be ordered as $AM \succ aM \succ Am \succ am$. The worst worker am is left with her reservation utility and she is indifferent between accepting her contract or remaining unemployed. The other types are made indifferent between their contract and the contract designed for the next-worse type (with respect to the firm's preference ordering).

The full screening solutions when ability prevails (Case $\mathcal{A}$) When condition (6) holds, ability has a higher impact on effort provision than motivation and a solution to program SB with full screening of workers' types, such that $e_{AM} > e_{Am} > e_{aM} > e_{am}$, might be attained. Now, from the firm's viewpoint, workers can be ordered as $AM \succ Am \succ aM \succ am$. Again, type am's participation constraint is binding, but the solution with full screening under Case $\mathcal{A}$ is no longer unique. There are different possible relevant incentive constraints that have to be considered in turn.

Case $\mathcal{A}$.1 It is symmetric with respect to Case $\mathcal{M}$, because it requires that all types (except am) are just indifferent between their contract and the contract designed for the next-worse type.

[11] Note that conditions (5) and (6) are *per se* less restrictive than the corresponding first-best conditions (2) and (3), respectively. This might leave room for some misalignment between first- and second-best effort levels as for intermediate types.

In particular, worker Am is more attracted by worker aM than by worker am's contract, and this is equivalent to condition $e_{aM} + e_{am} \geq \frac{2\gamma}{\Delta\theta}$.

Case $\mathcal{A}.2$ Worker Am no longer finds worker aM's contract attractive and rather prefers to mimic type am directly. This corresponds to condition $e_{aM} + e_{am} \leq \frac{2\gamma}{\Delta\theta}$. Moreover, the motivated low-skilled worker aM still finds the contract designed for type am more attractive than the contract designed for worker Am: this is equivalent to condition $e_{Am} + e_{am} \geq \frac{2\gamma}{\Delta\theta}$.

Case $\mathcal{A}.3$ Not only is worker Am willing to mimic worker am rather than aM (as in Case $\mathcal{A}.2$) but also worker aM prefers to mimic Am rather than am. Then condition $e_{Am} + e_{am} \leq \frac{2\gamma}{\Delta\theta}$ holds.

Figure 1 illustrates the necessary conditions for the existence of the different full screening solutions just presented.

Figure 1

Within the same regions described in Figure 1 it might well be that: (i) other possible solutions (with pooling and/or exclusion) coexist with full screening solutions, or that (ii) full screening solutions (which are the most demanding in terms of constraints to be satisfied) do not exist and that only solutions involving pooling or exclusion remain.

Solutions such that the same contract is offered to more than one type are pervasive, and this is a common feature of multidimensional screening models. In our discrete setup, the most common form of pooling is the one concerning intermediate types Am and aM.

Solutions with pooling of intermediate types When neither condition (5) nor condition (6) is satisfied, two solutions with bunching of intermediate workers Am and aM exist. They differ according to whether worker Am or worker aM is attracted by the contract offered to type am.

Finally, exclusion occurs when the null contract (characterised by zero effort and zero wage) is offered to some worker's type. This happens when the costs, represented by the cumulative effect of information rents that the firm must pay when hiring a given type, more than outweigh the benefits, due to the contribution of that type to the firm's output.

Solutions with exclusion The firm might find in its interest to exclude the worst worker am and, eventually, worker Am when motivation prevails and condition (5) holds, or worker aM when ability prevails and condition (6) holds.

In order to determine the menu of optimal contracts that the firm offers its potential applicants, it is then necessary to compare the different solutions that might coexist under a given parameter configuration. The solution providing the highest payoffs to the principal is singled out as the optimum.

Interestingly, the solutions to program SB characterised by full screening of workers' types always yield the highest payoffs to the principal. The firm will then always resort to full screening contracts, whenever they exist.

Proposition 1 *Independently of whether motivation or ability prevails, the firm's payoff is maximal at the solutions with full participation and full separation of workers' types.*

Proof. The proof for the situation in which motivation prevails is provided in Appendix B.3. The procedure for the case in which ability prevails is equivalent and then omitted. ■

Figure 2 fully describes the menu of optimal contracts, displayed according to the magnitude of intrinsic motivation γ, which in turn depends on the difference in ability $\Delta\theta$.

Figure 2

Since the four full screening contracts will be described in more detail in the next Section, here we add some comments about contracts with pooling and/or exclusion that emerge when full screening is not feasible.

As for optimal contracts with pooling, note that, when motivation takes the lowest possible values (that is to the left of $\underline{\gamma}^{\mathcal{A}1}$), then low-ability types aM and am are given the same contract. At the other extreme, for the highest possible values of motivation (that is to the right of $\overline{\gamma}^{\mathcal{M}}$), non-motivated types am and Am are given the same contract. As mentioned before, there is a wide range of situations in which optimal contracts entail bunching of intermediate types aM and Am (see Appendix D). In particular, pooling of intermediate types with type Am being indifferent between her contract and type am's contract is optimal when γ is close to $\Delta\theta$.

As for exclusion, Figure 2 shows that the occurrence of optimal contracts with exclusion is really limited and essentially relegated to small regions lying in-between full screening optimal contracts in Cases $\mathcal{A}.1$ and $\mathcal{A}.2$ and in-between full screening optimal contracts in Cases $\mathcal{A}.2$ and $\mathcal{A}.3$.

As mentioned, Figure 2 does not explicitly consider the difference in ability and is thus a one-dimensional representation of the model's optimal contracts (a further limitation of Figure 2 is that the length of the different intervals is arbitrary).

To illustrate optimal contracts as a function of both γ and $\Delta\theta$, we further consider the case in which both ability and motivation are uniformly distributed, with each worker's type having probability 1/4 (see Appendix E).

Figure 3

Under a uniform distribution, the full screening solution for Case $\mathcal{A}.2$ does not exist. When $\gamma > 1/2$, all optimal contracts involve pooling (either between intermediate types or between non-motivated types). When $\gamma < 1/2$, full screening optimal contracts for Case $\mathcal{A}.1$, Case $\mathcal{A}.3$ and Case $\mathcal{M}$ exist. Notice that

full screening in Case $\mathcal{M}$ realizes for $\gamma > \Delta\theta$, whereas full screening in Cases $\mathcal{A}.1$ and $\mathcal{A}.3$ occurs when $\gamma < \Delta\theta$ implying that first- and second-best effort levels are aligned.

Alternatively, consider the particular case in which the distribution of types is general but the type space is the unit square, with $\gamma = 1$ and $\theta = 2$. Now, the unique solution is such that there is pooling between intermediate types Am and aM with incentive constraint $IC_{Am/am}$ that binds. When the probabilities of able and motivated types, i.e. ν and μ respectively, are sufficiently high, then the optimal contract calls for the exclusion of the worst worker am.

To conclude this general overview of our results, let us emphasize that, despite having only one instrument (the observable effort level) at his disposal, the employer always prefers to offer contracts that entail full separation and full participation of workers' types (whenever they exist), which dominate menus with pooling or exclusion. From this viewpoint, our results stand in contrast with the existing literature on multidimensional screening, which predicts that bunching and/or exclusion are inevitable, both in the continuous and in the discrete setup. A discrete framework intuitively offers more opportunities for separating solutions with respect to the continuous one. Nonetheless, in the two existing applications with a discrete setup (namely Armstrong 1999 and Olivella and Schroyen 2014) full separation is never optimal: this result is a consequence of the features of their models, where pooling already occurs at the first-best.

5 Optimal contracts with full screening

In this Section, we focus on the qualitative features of contracts with full screening of worker's types (quantitative results and existence conditions are given in the online Appendix). We solve a relaxed program in which only PC_{am} and some incentive constraints are binding; we then check ex-post that the omitted constraints are verified as well.

All full screening contracts share the following characteristics: (i) for all parameter configurations, the ranking of effort levels required from the different workers is the same as at the first-best; (ii) the properties of no-distortion-at-the-top (i.e. $e_{AM} = e_{AM}^{FB}$) and zero-rents-at-the-bottom (i.e. $u_{am} = 0$) hold.

5.1 Full screening when motivation prevails (Case $\mathcal{M}$)

Suppose that motivation has a higher impact than ability on effort and output provision (i.e. condition 5 holds). In this case, the bidimensional screening problem embeds the two problems (the one for motivated and the other for non-motivated workers) with adverse selection about workers' ability only (Benchmark $U\mathcal{A}$ in Subsection 3.2). The two problems $U\mathcal{A}$ are now linked by incentive constraint $IC_{aM/Am}$. Figure

4 describes this case.[12] Ability θ is displayed on the horizontal axis, while motivation γ is represented on the vertical axis. Types are located at the corners of a rectangle whose width is the difference in ability $\Delta\theta$, and whose height is the difference in motivation $\Delta\gamma = \gamma$. An arrow from one worker type to another means that the incentive constraint that the former type is not attracted by the contract designed for the latter is binding.

Figure 4

Intuitively, when motivation prevails, the rectangle on which worker types are located has height greater than width. Then, the incentive constraints that bind first are those of the closest pairs of workers, i.e. $IC_{AM/aM}$ and $IC_{Am/am}$. The remaining binding constraint is $IC_{aM/Am}$, which connects intermediate types. Technically, all local downward incentive compatibility constraints are binding.[13]

Proposition 2 *When motivation prevails (Case $\mathcal{M}$), the full screening solution is such that the binding constraints are $IC_{AM/aM}$, $IC_{aM/Am}$ and $IC_{Am/am}$ together with PC_{am}; effort levels are such that*

$$e_{AM}^{SB\mathcal{M}} = e_{AM}^{FB} > e_{aM}^{SB\mathcal{M}} = e_{aM}^{U\mathcal{A}} > e_{Am}^{SB\mathcal{M}} > e_{am}^{SB\mathcal{M}} > 0,$$

wages are such that

$$w_{AM}^{SB\mathcal{M}} > \max\left\{w_{aM}^{SB\mathcal{M}}, w_{Am}^{SB\mathcal{M}}\right\} \geq \min\left\{w_{aM}^{SB\mathcal{M}}, w_{Am}^{SB\mathcal{M}}\right\} > w_{am}^{SB\mathcal{M}} > 0$$

and information rents (indirect utilities) are such that

$$u_{AM}^{SB\mathcal{M}} > u_{aM}^{SB\mathcal{M}} > u_{Am}^{SB\mathcal{M}} > u_{am}^{SB\mathcal{M}} = 0.$$

All workers except am receive an information rent, and information rents cumulate when moving from the worst type am to the best type AM. Since information rents are increasing in the effort exerted by the types that can be mimicked, the principal distorts downward the effort levels of all workers other than AM. Indeed, worker AM is given the first-best allocation, whereas type aM is given the same allocation as in Benchmark $U\mathcal{A}$. However, effort levels required from worse workers Am and am are more downward distorted than in program $U\mathcal{A}$, because of the cumulative effect of information rents.

Information rents are monotonic in effort levels, meaning that types are ordered in the same way according to their efforts and their information rents. Conversely, wages need not be monotonic in effort. When $w_{aM}^{SB\mathcal{M}} > w_{Am}^{SB\mathcal{M}}$, monotonicity is satisfied and motivated workers earn more than non-motivated

[12] For simplicity, Figures from 4 to 5c are all drawn letting the difference in motivation vary while keeping the difference in ability constant.

[13] The adjectives 'local' and 'downward' both refer to the relevant preference ordering of workers types. In particular, for every pair of types $ij \neq i'j'$, the incentive constraint of type ij trying to mimic type $i'j'$, denoted by $IC_{ij/i'j'}$, is called 'downward' constraint if $ij \succ i'j'$, while it is called 'upward' constraint if $i'j' \succ ij$. Finally, the incentive constraint $IC_{ij/i'j'}$ is called 'local' when types ij and $i'j'$are adjacent or 'global' when types are distant.

employees irrespective of their ability. When instead $w_{aM}^{SB\mathcal{M}} < w_{Am}^{SB\mathcal{M}}$, there is a reversal in the ranking of salaries for intermediate types: the firm offers the low-ability motivated worker aM a contract in which remuneration is lower than in the contract proposed to worker Am, despite effort provision being higher, i.e. $e_{aM}^{SB\mathcal{M}} > e_{Am}^{SB\mathcal{M}}$. Nonetheless, worker aM always reaches a higher utility than type Am, because of her high motivation. This fact depends on the peculiarity of motivated workers' utility function. Indeed, if $w_{aM}^{SB\mathcal{M}} < w_{Am}^{SB\mathcal{M}}$, then also $e_{aM}^{SB\mathcal{M}} < \frac{2\gamma}{\theta}$, and motivation is sufficiently high that worker aM enjoys a net positive utility from the effort required and is ready to work for free. Nonetheless, the contracted salary $w_{aM}^{SB\mathcal{M}}$ is strictly positive because type aM is able to mimic both types Am and am and needs to receive high information rents for truthful revelation. Thus:

Corollary 1 *When the full screening solution with motivation prevailing (Case $\mathcal{M}$) is such that $e_{aM}^{SB\mathcal{M}} > e_{Am}^{SB\mathcal{M}}$ and $w_{aM}^{SB\mathcal{M}} < w_{Am}^{SB\mathcal{M}}$, the low-ability motivated worker aM becomes a 'paid volunteer': she is offered a positive wage although she enjoys a positive utility from effort exertion.*

This could be the case of researchers and health professionals: some very motivated but less-skilled workers contribute a high amount of effort, which is only partially rewarded by the employer, because the rest is donated to the organisation. Non-motivated and more able colleagues might be separated from the former using higher wages per unit of effort. Indeed, when motivation is sufficiently high, worker aM enjoys providing effort and she is thus indifferent between her contract and worker Am's contract that consists in a lower effort combined with a higher wage.

More surprisingly, when motivation is even higher so that $e_{aM}^{SB\mathcal{M}} < \frac{\gamma}{\theta}$, effort required from worker aM falls in the range in which her utility increases in effort and her indifference curve is downward sloping in the space (e, w). In practice, given the contracted wage, the employee would be better-off if she could work more. Then, it would be necessary to forbid worker aM from exerting more effort than her optimal contract specifies, i.e. from engaging in voluntary unpaid overtime or from undertaking more demanding tasks.

5.2 Full screening when ability prevails (Case $\mathcal{A}$)

Suppose now that ability has a higher impact than motivation on effort provision (i.e. condition 6 holds).

A plurality of situations arise because the employer faces a trade-off between the need to satisfy condition $e_{Am} > e_{aM}$ and the incentive to increase e_{aM} while decreasing w_{aM}, taking advantage of workers' motivation.

5.2.1 Case $\mathcal{A}$.1

Case $\mathcal{A}$.1 is similar to Case $\mathcal{M}$ because it represents the most intuitive scenario where all downward local ICs are binding. It requires to solve a bidimensional screening problem that consists of the two

programs of Benchmark $U\mathcal{M}$ in Subsection 3.3, related by incentive constraint $IC_{Am/aM}$ connecting intermediate types (see Figure 5a). Now, the rectangle on which types are located has height smaller than width, whereby the incentive constraints that bind first are those of the closest pairs, i.e. $IC_{AM/Am}$ and $IC_{aM/am}$.

Figure 5a

In this case, motivation must be sufficiently low with respect to $\Delta\theta$, so that worker aM receives a relatively high salary in exchange for a relatively low effort, and such a contract is attracting for type Am.

Proposition 3 *When ability prevails, at the full screening solution with binding constraints $IC_{AM/Am}$, $IC_{Am/aM}$ and $IC_{aM/am}$ together with PC_{am} (Case $\mathcal{A}$.1), effort levels are such that*

$$e_{AM}^{SB\mathcal{A}1} = e_{AM}^{FB} > e_{Am}^{SB\mathcal{A}1} = e_{Am}^{U\mathcal{M}} > e_{aM}^{SB\mathcal{A}1} > e_{am}^{SB\mathcal{A}1} > 0,$$

wages are such that

$$w_{AM}^{SB\mathcal{A}1} > w_{Am}^{SB\mathcal{A}1} > w_{aM}^{SB\mathcal{A}1} > w_{am}^{SB\mathcal{A}1} > 0$$

and information rents are such that

$$u_{AM}^{SB\mathcal{A}1} > u_{Am}^{SB\mathcal{A}1} > u_{aM}^{SB\mathcal{A}1} > u_{am}^{SB\mathcal{A}1} = 0.$$

Paralleling Case $\mathcal{M}$, effort $e_{AM}^{SB\mathcal{A}1}$ is set at the first-best and effort $e_{Am}^{SB\mathcal{A}1}$ is equal to the one obtained in Benchmark $U\mathcal{M}$, while effort levels required from less efficient workers (types aM and am) are characterised by a larger downward distortion than in program $U\mathcal{M}$.

Case $\mathcal{A}$.1 represents the unique instance in which wages and information rents have the same ordering as effort levels. Hence, it features a situation in which the bidimensional screening problem is equivalent to the unidimensional one with four types, the parameter of private information being the workers' overall cost of effort exertion. Intuitively, when the role played by motivation is limited, as for some civil servants and bureaucrats, ability represents the driving force shaping the design of optimal contracts.

Between Case $\mathcal{M}$ and Case $\mathcal{A}$.1, that is when ability still prevails but motivation becomes more relevant, effort increases and salary decreases in the contract offered to type aM; thus type Am prefers to mimic type am rather than aM. This is what happens in the two peculiar Cases $\mathcal{A}$.2 and $\mathcal{A}$.3 that follow.

5.2.2 Case $\mathcal{A}$.2

Case $\mathcal{A}$.2 consists of the two programs of in Benchmark $U\mathcal{M}$, connected by the global incentive constraint $IC_{Am/am}$ (see Figure 5b).

Figure 5b

Worker Am is not willing to mimic worker aM because the former would enjoy a higher information rent when mimicking am. Indeed, motivation γ is high enough so that worker aM is asked to make a relatively high effort in exchange for a relatively low wage and her contract is not appealing to type Am. As a consequence, no type is willing to mimic worker aM and it is useless for the principal to distort her effort. On the other hand, type aM is attracted by the contract offered to type am, as in Case $\mathcal{A}.1$. Then, intermediate types Am and aM both have incentive to mimic the worst type am.

These features are shared with Case $\mathcal{A}.3$ that follows. Instead, the peculiarity of Case $\mathcal{A}.2$ is that there is no envy between intermediate workers Am and aM, since worker Am is not attracted by the contract offered to worker aM and vice-versa.

Proposition 4 *When ability prevails, at the full screening solution with binding constraints $IC_{AM/Am}$, $IC_{Am/am}$ and $IC_{aM/am}$ together with PC_{am} (Case $\mathcal{A}.2$), effort levels are such that*

$$e_{AM}^{SB\mathcal{A}2} = e_{AM}^{FB} > e_{Am}^{SB\mathcal{A}2} = e_{Am}^{SB\mathcal{A}1} = e_{Am}^{U\mathcal{M}} > e_{aM}^{SB\mathcal{A}2} = e_{aM}^{FB} > e_{am}^{SB\mathcal{A}2} > 0,$$

wages are such that

$$w_{AM}^{SB\mathcal{A}2} > w_{Am}^{SB\mathcal{A}2} > w_{aM}^{SB\mathcal{A}2} > w_{am}^{SB\mathcal{A}2} > 0 \tag{7}$$

and information rents are such that

$$u_{AM}^{SB\mathcal{A}2} > u_{aM}^{SB\mathcal{A}2} > u_{Am}^{SB\mathcal{A}2} > u_{am}^{SB\mathcal{A}2} = 0. \tag{8}$$

Note that $e_{Am}^{SB\mathcal{A}2}$ has the same expression as $e_{Am}^{SB\mathcal{A}1}$ and as $e_{Am}^{U\mathcal{M}}$. Moreover, both $e_{AM}^{SB\mathcal{A}2}$ and $e_{aM}^{SB\mathcal{A}2}$ are equal to their first-best levels, whereas e_{Am}^{SBA2} and e_{am}^{SBA2} are distorted downwards, with e_{am}^{SBA2} being more distorted than in program $U\mathcal{M}$. Indeed, effort of type am needs to be very downward distorted in order to prevent mimicking from both intermediate types aM and Am and to keep their information rents low.

In Case $\mathcal{A}.2$ (and Case $\mathcal{A}.3$ too), while total salaries are monotonic in effort levels, information rents are not, since there is a reversal between intermediate types. In particular, the effort that the motivated unskilled worker aM is asked to provide is lower than the effort required from the non-motivated skilled worker Am, even though the former gains higher information rents than the latter. The switch depends both on the fact that worker Am is not willing to mimic type aM (so that Am does not receive any rent depending on the effort exerted by aM) and on the fact that γ is sufficiently high so as to substantially reduce the disutility of effort provision for worker aM.

Importantly, a full screening solution in Case $\mathcal{A}.2$ only exists if $\mu < \frac{1}{2}$, that is if the probability of motivated workers is sufficiently low.[14] The difference in motivation is higher in Case $\mathcal{A}.2$ than in Case $\mathcal{A}.1$; nonetheless, the requirement $\mu < \frac{1}{2}$ makes average motivation in the two regimes not so different.

[14] See the example with the uniform distribution at page 16, where $\mu = \frac{1}{2}$ and full screening under Case $\mathcal{A}.2$ does not exists.

5.2.3 Case $\mathcal{A}.3$

In Case $\mathcal{A}.3$, not only is worker Am willing to mimic worker am rather than aM, but also worker aM prefers to mimic Am rather than am and the *upward* incentive constraint $IC_{aM/Am}$ is binding. This occurs because the motivated unskilled worker aM values a relatively high wage associated with a high effort (that she would obtain by mimicking Am) more than the combination of low wage and low effort (that she would get by mimicking am). This provides a counterweight for the standard incentive to downward distort the effort level for the high-ability non-motivated type Am that stems from the incentive constraint of the best type AM trying to mimic Am. Figure 5c illustrates all binding constraints.

Figure 5c

Proposition 5 *When ability prevails, at the full screening solution with binding constraints $IC_{AM/Am}$, $IC_{Am/am}$ and $IC_{aM/Am}$ together with PC_{am} (Case $\mathcal{A}.3$), effort levels are such that*

$$e_{AM}^{SB\mathcal{A}3} = e_{AM}^{FB} > e_{Am}^{SB\mathcal{A}3} > e_{aM}^{SB\mathcal{A}3} = e_{aM}^{FB} > e_{am}^{SB\mathcal{A}3} = e_{am}^{SB\mathcal{M}} > 0$$

and the orderings of wages and information rents are the same as in Case $\mathcal{A}.2$.

Both $e_{AM}^{SB\mathcal{A}3}$ and $e_{aM}^{SB\mathcal{A}3}$ are equal to their first-best levels and $e_{am}^{SB\mathcal{A}3}$ has the same expression as $e_{am}^{SB\mathcal{M}}$. Moreover, the usual downward distortion holds for the effort provided by types Am and am, the former despite the upward incentive constraint $IC_{aM/Am}$ being binding.

Nonetheless, when the optimal contract calls for exclusion of type am (occurring for motivation levels that are below the range in which full screening is guaranteed, namely in-between Cases $\mathcal{A}.2$ and $\mathcal{A}.3$ with full screening), then it might be that effort $e_{Am}^{SB\mathcal{A}3}$ is distorted upward with respect to its first-best level. The existence of an upward distortion in second-best effort levels parallels the result of sub-marginal cost pricing in Armstrong (1999).

Before concluding, let us point out that it is extremely difficult to make comparisons among the four classes of full screening solutions, because they exist for different and mutually exclusive parameter ranges. Nonetheless, the following results can be singled out.

The optimal allocations in Cases $\mathcal{A}.2$ and $\mathcal{A}.3$ are close to the efficient ones, because not only is the no-distortion-at-the-top property satisfied, but also type aM's effort is not distorted.

Remark 4 *At the full screening solutions in Case $\mathcal{A}.2$ and Case $\mathcal{A}.3$, the effort of motivated workers is not distorted and is set at the efficient level.*

In the real-world, Cases $\mathcal{A}.2$ and $\mathcal{A}.3$ could correspond to high-school teachers and lecturers characterised by high heterogeneity in ability (there are some low-skilled workers) and non-negligible motivation.

For these professions, not only is full screening possible, but it can also be performed with few departures from efficiency.

Moreover, let us consider the solutions characterized by the highest possible levels of motivation, namely Cases $\mathcal{A}.3$ and $\mathcal{M}$.

Remark 5 *Fix θ in such a way that both full screening solutions in Case $\mathcal{M}$ and Case $\mathcal{A}.3$ exist, although for different values of γ. Then, the firm pays lower information rents in Case $\mathcal{A}.3$ than in Case $\mathcal{M}$.*

Proof. See Appendix C.4. ■

The facts highlighted in Remarks 4 and 5 suggest that the rent extraction-efficiency trade-off faced by the uninformed employer is less demanding in Case $\mathcal{A}.3$ than in Case $\mathcal{M}$. In other words, screening workers in Case $\mathcal{A}.3$ implies no distortions for motivated types and lower information rents than in Case $\mathcal{M}$. Ceteris paribus, the lower the effort distortions, the higher the firm's revenues, and the lower the information rents that the firm must leave to its employees, the lower the salaries that it must pay. Therefore, one could expect payoffs to the firm to be higher in Case $\mathcal{A}.3$ than in Case $\mathcal{M}$. However, for a given θ, Case $\mathcal{A}.3$ exists for lower levels of motivation than Case $\mathcal{M}$; and one can show that, under a mild condition, the firms' payoffs are lower in Case $\mathcal{A}.3$ than in Case $\mathcal{M}$.

Proposition 6 *Fix θ in such a way that both full screening solutions in Case $\mathcal{M}$ and Case $\mathcal{A}.3$ exist, although for different values of γ. Provided that the given cost of effort θ is sufficiently low, the firm's payoffs are higher in Case $\mathcal{M}$ than in Case $\mathcal{A}.3$.*

Proof. See Appendix C.5. ■

The comparison between Case $\mathcal{A}.3$ and Case $\mathcal{M}$ requires considering the effect of changes in motivation on the firm's payoffs. This effect is mediated through effort levels and wages. Eliminating wages from expected profit by substituting them for the binding constraints, we obtain expressions for payoffs that depend on γ both directly and indirectly via optimal effort levels. We then resort to the envelope theorem to focus only on the direct effect of γ on the firm's expected payoffs. This allows us to find that payoffs are strictly increasing in γ for Case $\mathcal{M}$ and that payoffs in Case $\mathcal{A}.3$ are increasing in γ provided that θ be sufficiently low. Having proved that profits are monotonically increasing in γ, it is sufficient to show that payoffs at the highest level of γ for which full screening is possible under Case $\mathcal{A}.3$ are lower than the firm's payoffs at the lowest level of γ for which full screening is possible under Case $\mathcal{M}$.[15]

In a nutshell, a higher motivation has a positive effect on the firm's payoffs because it induces an overall increase in total effort provision, and thus in total output, which more than compensates the rise in wages due to an overall increase in information rents.

[15] It is worth mentioning that, because of the simplification $\gamma_L = 0$, we are not able to say whether this results depends on the level of motivation or on the amount of heterogeneity in motivation.

Proposition 6 states that it is preferable for the firm to be confronted with an applicant's pool where motivation prevails and heterogeneity in ability is low; i.e. average ability is high. This generates the largest profits for the firm. We can conclude that a monopsonistic employer is better-off when screening for ability and motivation physicians or researchers rather than high-school teachers and lecturers.

6 Conclusion

We consider the screening problem of a firm willing to hire workers endowed with different unobservable ability and motivation. We find that the firm prefers full separation and full participation to bunching and/or exclusion of some workers. Concerning full screening contracts, our main findings are the following: (i) when the difference in motivation is much more important (or much less important) than the difference in ability, fairly intuitive optimal contracts emerge where information rents and effort distortions cumulate according to the firm's preference ordering over workers; (ii) when the difference in ability prevails but motivation is however sufficiently high, non-standard contracts emerge with no effort distortions for motivated workers and possibly lower information rents.

Our results provide interesting insights about the selection of workers in a specific sector. Indeed, should the employer's output not exceed some threshold, then he would be forced to exclude some types. This is the framework analysed in Delfgaauw and Dur (2008), where the public sector optimally hires dedicated workers together with lazy workers. In our model, if at most two types of workers could be employed, the worse workers would be excluded, namely non-motivated workers when motivation prevails, or low-ability workers when ability prevails.

Our paper has interesting policy implications. As mentioned in the Introduction, it suggests a new rationale for the poor screening observed in real-world vocational markets, i.e. in professions where workers differ in unobservable ability and motivation. In particular, for primary school teachers (such that the heterogeneity in the two characteristics is similar and motivation is relatively important), we show that the employer is constrained to offer pooling contracts. Conversely, for other teacher's categories as high-school teachers and lectures (such that ability prevails but motivation is still important) the analysis hints that full screening is not only feasible, but also optimal for the employer. In the ongoing policy debate about the advisability of paying teachers according to their productivity, our work suggests that, when the task is unidimensional and observable, screening high-school teachers for both ability and motivation is possible and desirable, provided that a broad choice among different tasks, together with wages depending non-linearly on the task level, is available to the employer.

Finally, our setup can be generalized introducing competition between our firm and another employer for whom workers' motivation might not be relevant. The screening problem's complexity increases because applicants' reservation utilities might depend on both ability and motivation. Our monopson-

ist might then employ motivated workers while non-motivated employees might prefer to work for the competitor. This would imply that sorting is ability-neutral and that (maintaining the assumption of independent distribution of workers' characteristics) workers' average ability is the same across employers. This could be the case of a labour market that is fully segmented between a corporate socially responsible firm, which attracts workers who share their employer's social mission, and a firm without a mission, hiring non-motivated workers.

Supplementary material

Supplementary material (the Appendix) is available online at the OUP website.

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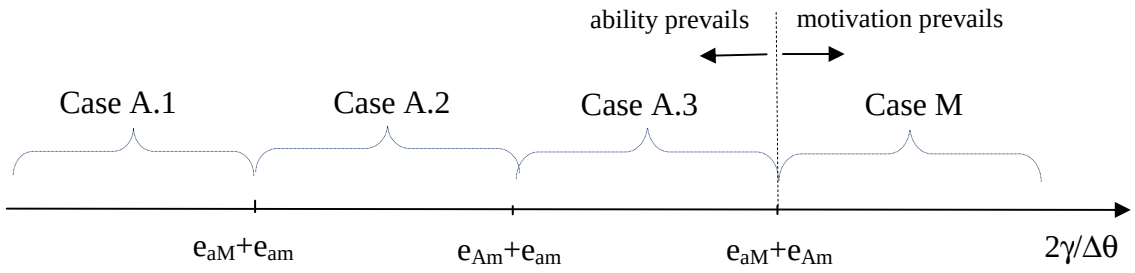


Figure 1. Possible classes of full screening solutions as a function of $2\gamma/\Delta\theta$.

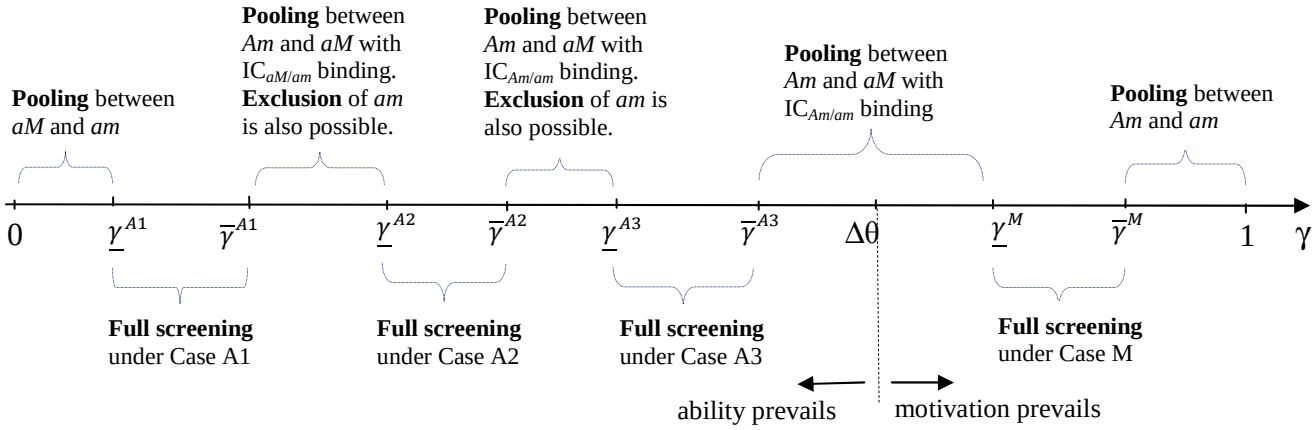
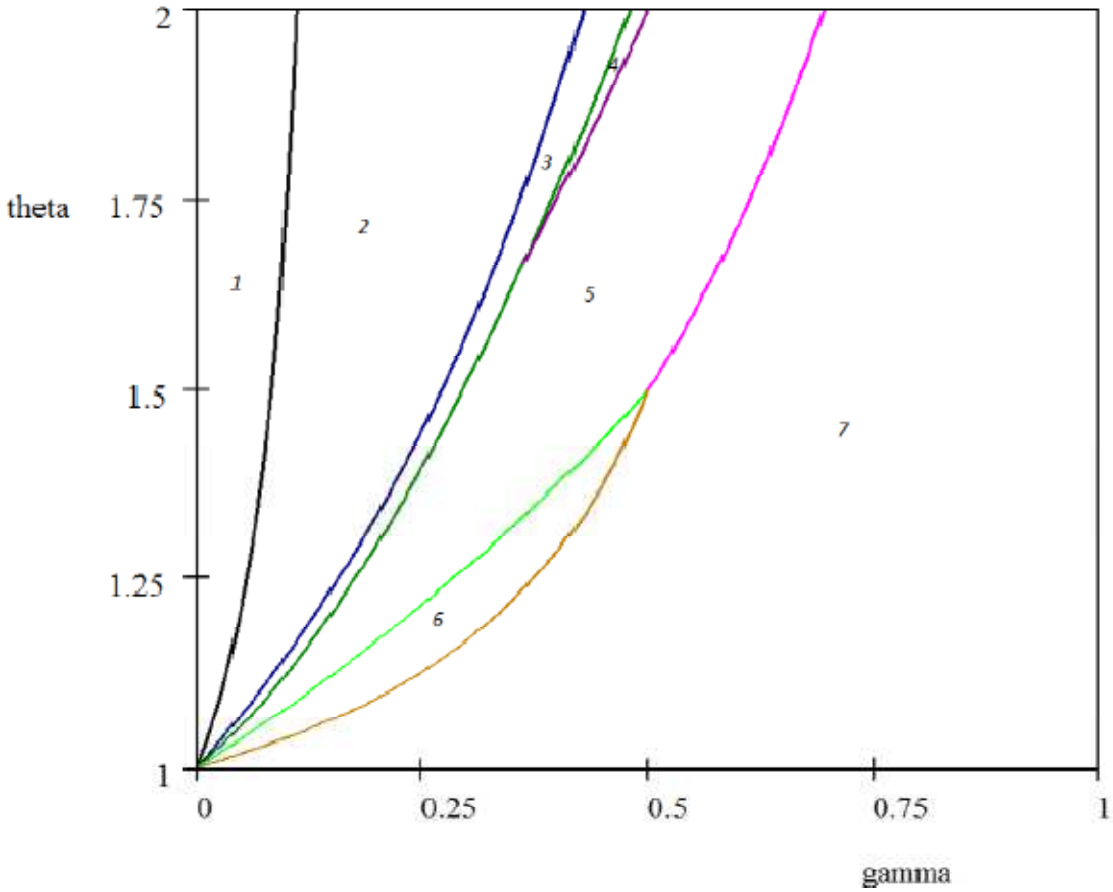


Figure 2. Optimal contracts as a function of γ.



Region 1: pooling of low-skilled workers
Region 2: Case *A.1* with full screening
Region 3: pooling of intermediate types with exclusion of worker *am*
Region 4: Case *A.3* with full screening
Region 5: pooling of intermediate types with full participation
Region 6: Case *M* with full screening
Region 7: pooling of non-motivated workers

Figure 3. Optimal contracts with uniform distribution of workers' types.

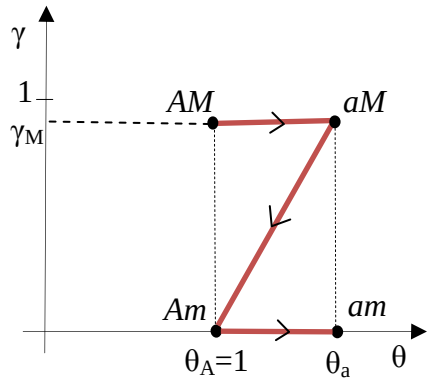


Figure 4. CaseM

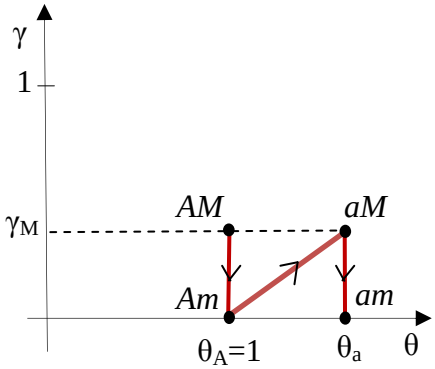


Figure 5a. Case A.1

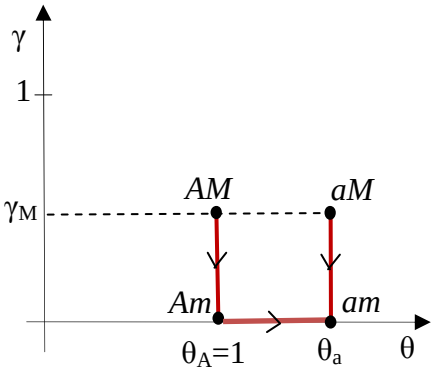


Figure 5b. Case A.2

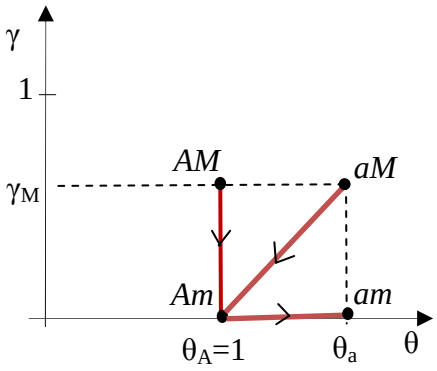


Figure 5c. Case A.3