Optimal Screening in Mission-Oriented Organizations: A Conceptual Framework And Practical Implications For Recruitment

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Abstract

This paper presents a conceptual framework to analyze personnel policies used for the screening and selection of workers. Our framework, while general, focuses on organizations that value a worker's general quality-which affects his expected market opportunities-, but also his mission-alignment ("intrinsic motivation")-which is more dependent on a match with the organization. A key feature of the analysis is a fundamental asymmetry in the applicant pool when quality carries a market wage premium: quality will tend to be scarce in the applicant pool relative to motivation. When the organization can screen on a single attribute, that asymmetry will lead to a preference for screening on quality, and bias hiring towards overly qualified, but under-motivated applicants. We also analyze conditions under which wage increases will help employers in screening and selection and identify situations where screening may improve by paying lower wages. Finally, we apply our framework to data from an actual recruitment drive conducted by the Federal Government in Mexico in 2011 where both measures of quality and motivation of applicants where available. Our findings suggest that if forced to screen on a single dimension, for most relative valuations for quality vs motivation the government would have gained by screening applicants based on their quality.

Keywords: public service motivation, public sector personnel, quality of bureaucracy, personality traits, personnel psychology, state-building, state capacity.

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1 Introduction

It seems obvious that every organization should strive to select personnel with those traits that most contribute to its goals. In the world of for-profit organizations, those traits are commonly thought to be related to general intelligence and personality traits such as conscientiousness and emotional stability. These traits can be expected, and are empirically seen to, carry a premium in the form of on-the-job performance and higher wages.[1] Firms can either screen individuals directly on those traits, or also indirectly infer them from the past earnings of individuals.

The desire to select high quality personnel is not limited to for-profit organizations. Public bureaucracies and private nonprofit organizations also care about quality, but may in addition need a workforce that is aligned with the mission of the organization. Mission-alignment may be valuable when there are constraints to writing complete enforceable contracts, and can help by motivating agents to perform even when extrinsic incentives would not compel them to [2] This motivation to perform stemming from mission-alignment is usually termed "intrinsic motivation"Ṡuch intrinsic motivation may not always be easy to ascertain, and thus difficult to screen on. The implications of this for personnel policy can be quite significant. For instance, organizations that raise wages in hopes of attracting applicants with higher quality, may do so at the cost of attracting individuals who are greedy or do not particularly care about the organization's goals.[3]

In this paper we derive implications for personnel policy when organizations care about workers who differ on multiple dimensions, such as raw quality but also motivation. In particular, we focus mainly on one type of personnel policy, namely the screening of job candidates, and examine two problems. First, we study how best to screen when observing all relevant dimensions is difficult, and how screening will shape the selected workforce. Second, we elucidate how the best compensation policy will depend on the chosen screening policy. This will answer the question of when will the employer want to raise wages to attract more and better workers.

In the first part of the analysis we take compensation policy as given and focus on screening and selection from a given applicant pool. We later consider when changes in compensation may yield benefits from the point of view of allowing for better personnel selection. The first part of the analysis hinges strongly on a fundamental asymmetry between

[1]See for instance Schmidt and Hunter (1998).

[2]For example, motivated agents are of interest in the model by Besley and Ghatak (2005) because effort is non-contractible and there are limited liability constraints.

[3]For theoretical arguments, see for instance Delfgaauw and Dur (2007), Francois (2000), and Prendergast (2007). For empirical work, see for example Karl and Sutton (1998) and Bright (2005).

general quality (such as smarts, good personality, general human capital, "quality" for short) and mission-alignment. Quality is likely to command a market premium, so at a given wage offered by the employer the set of workers that self-select into the applicant pool are not a scale-replica of the full set of workers initially available. The highest quality workers, expecting better wage opportunities, may pass on applying. But high motivation workers will apply. Thus, the resulting applicant pool will typically be biased towards those with less quality and more specific motivation to work for the particular employer announcing vacancies. As a result, while the best motivated workers are always available, the highest quality ones are not necessarily so.

The employer can then screen among self-selected applicants. In a world where both quality and vocational profile can be observed, the employer will select the candidate with the highest level of both traits subject to his valuation of these traits. In practice, however, employers are often constrained in the number of dimensions that they can screen on, due either to legal constraints, or measurability reasons. Given the basic asymmetry introduced by worker self-selection, partial screening regimes introduce a bias in the balance of traits that is selected by the employer. The end result of this, as we will show, is that employers will tend to hire what they can measure. That is, if an organization screens on quality, it will tend to hire workers with higher quality and lower motivation relative to a situation where it can screen on both attributes (the converse statement holds for organizations that screen on motivation). This implies two things: first, the choice of what attribute to screen on is not a neutral one, and it may trigger organizational politics when people disagree on what traits are most valuable. Second, since quality is of value to all employers, we may expect the market for screening methods to further develop approaches to screen on quality.[4] Thus, organizations may find that it is easier to screen on quality than on motivation. Because organizations "hire what they can measure," hiring will tilt towards quality, and this can be expected to create a wage premium on quality that is entirely attributable to screening practices.

Based on our framework, we can also examine when will higher wages be of value from the selection and screening perspectives. If an organization values quality relatively more, then raising wages is best. But if the organization values motivation relatively more, then raising wages may yield no, or even *negative* value, even if one abstracts from the direct cost of wages.

Naturally, many of these implications will depend on the actual context, and the question

[4]Tests of cognitive ability are broadly available, while specific tests of motivation are not. For example, there are relatively few inventories for Public Service Motivation, with the best known being the one due to (Perry 1996).

is whether real life recruitment looks anything like our framework. We will contrast our conceptual framework with data stemming from an actual governmental recruitment drive performed by the Mexican Federal Government in 2011. Our empirical illustration with the Mexican government data shows that the theoretical graphs can be virtually overlaid on real life data, and one can work out the optimal hire once the relative values of the different traits for the employer are known. In addition, it is also possible to determine when it is more valuable to screen on one dimension versus the other, and what the value is to being able to screen on both simultaneously.

While our focus is squarely on the public sector and non-profit organizations, our findings are pertinent to private firms where motivation and alignment with organizational goals are deemed to be important. Our focus on public sector and non-profit operations reflects the consensus that motivational factors are likely relatively, though not absolutely, more important in those sectors.

The structure of the paper is as follows. The following section presents our conceptual framework. Section 3 derives the bulk of the practical implications that stem from the framework. Section 4 presents the empirical illustration and Section 5 concludes.

2 Conceptual framework

In this section we present a formal model that helps think about various aspects of personnel policy. We present some technical results as propositions. These results are necessary as groundwork for the more applied implications that are our focus here. We emphasize intuition throughout by deriving our statements from geometrical arguments that are represented in Figures.

2.1 Preliminaries

In this paper, we focus on organizations, such as public bureaucracies and non-profit organizations, that value and recruit employees both based on their quality, as it relates to marketable skills such as intelligence, as well as their commitment to missions and goals of the organization. Whereas the first worker trait is correlated with the opportunities a worker expects to receive in the labor market, the second trait can be, and often is, unrelated to the type of compensation a worker may expect from the market. In the case of public sector organizations, such a trait is public service motivation (henceforth, PSM).

Our model begins by considering an organization (henceforth the "organization") that hires from a residual labor supply made up of a large population that we approximate through a continuum of agents. Each agent is characterized by quality q and a level of PSM p. Both traits have a minimum value of 0 and maximum values $\hat{q}$ and $\hat{p}$, respectively. The organization hires under a given announced wage w. The full support of human traits is the convex set U (where U stands for the universe of agents). This set contains all the points under and including the frontier $p(q)$ giving the highest value of PSM conditional on each value of quality. We will assume the frontier $p\,(q)$ to be weakly decreasing, as represented in Figure 1. There is a joint distribution of quality and PSM, $H\,(q,p)$ over U, with associated density $h\,(q,p)$. For simplicity, except when noted, we will assume H to be a Uniform distribution.

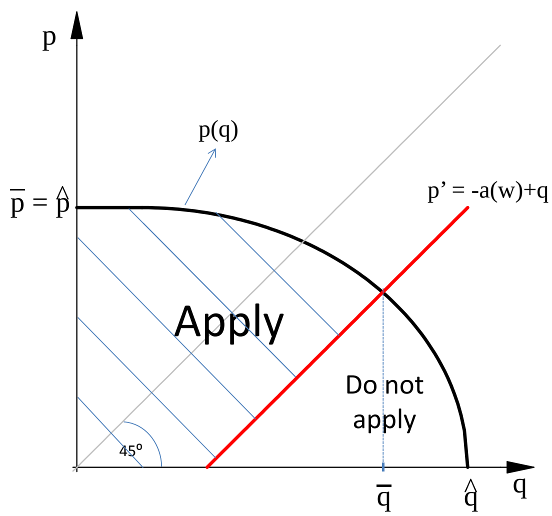

Figure 1: Set of worker types and self-selection into the applicant pool

There are two periods and no discounting. In period 1, the organization announces a wage w. Individuals then must decide whether to apply for jobs. In the second period, every individual will receive an outside market opportunity of value q.[5] In other words, an individual's reservation wage is given by his quality. An individual who applies to the organization incurs a cost $c > 0$, due perhaps to the time and effort involved in showing up for a job interview. Should the worker decide to apply, the individual may receive an offer

[5]This is a simplification of the framework we introduced in (Dal Bó, Finan, and Rossi 2013). In that model we allowed for outside market opportunities to be realized with noise after the time of application, so applicants would have an insurance motive to apply and would reject the job offer made by our employer with positive probability. Moreover, that probability would depend on the quality of the applicant. The model we examine here yields the same implications for screening policy while saving on notational burden. An expanded version of the model is available upon request.

in period 2 from the organization. Upon receiving both the market opportunity and, in the case of selected applicants, the offer from the organization, individuals take their preferred offers. Then payoffs are collected.

To keep things simple, we will assume throughout that workers apply under a diffuse prior about screening, so workers anticipate the same probability of receiving an offer conditional on having applied, regardless of their own attributes. To avoid carrying notation we will normalize that probability to one. This is innocuous to our predictions of equilibrium recruitment: if a worker would be willing to apply in the diffuse prior situation, she will want to apply when certain of an appointment. The assumption is not innocuous however when it comes to predicting the entire set of applicants: if a screening policy is such that only the smartest applicant will be hired, all others should abstain from applying. Our analysis, predicated on the diffuse prior, helps pinpoint the optimal hire under each screening policy, and that optimal hire will always be available. In situations where diffuse priors are plausible (say, when the organization is new and screening policies unknown, which matches our empirical application), one can expect the applicant set to include the optimal hire but be much larger, and to resemble the theoretically-predicted set under diffuse priors. In situations where screening policies are institutionalized and well-known, one can expect the applicant pool to be trimmed in the direction of types who stand a better chance of being selected. We return to this issue when developing our empirical application.

2.2 Solving the model

We now study the different decisions facing a worker in each period and solve the model by working backwards. If offered a job in period 2, a candidate with outside opportunity q will accept the job whenever $q < w + p$. However, applying for the job posted by the organization costs c. Therefore, in order to be interested in applying, an individual must have a type (q, p) satisfying $q < w - c + p$. This readily implies,

Proposition 1 *: Suppose all agents in the set U learn about the wage w. Then the set of agents U is split into two parts: the types that apply for the job and the types that prefer to stay out. More technically,*

(i) There exists a function $p'(q) = q - (w - c)$ (with inverse $q'(p) = w - c + p$) describing the locus of all types (q, p) in the set U who are indifferent between entering the applicant pool and staying out.

(ii) Given q, those with $p > p'(q)$ ($< p'(q)$) strictly want to enter (stay out); given p, those with $q < q'(p)$ ($> q'(p)$) strictly want to enter (stay out).

This proposition basically says that given a wage, the set of potential applicants is split into two groups: those with relatively high PSM and low quality who apply, and those with relatively high quality and low PSM, who do not. This is shown in Figure 1. A key assumption underlying this result is that quality affects expected outside opportunities in the labor market and PSM does not. We denote the set of applicants with A.

We denote with $\bar{q}$ and $\bar{p}$ respectively the highest quality and highest PSM levels available in the applicant pool A. Note that given $p'(q) = q - (w - c)$ holds, the following practical implication follows once we take into account that the frontier $p(q)$ is weakly decreasing:

Practical Implication 1 *For any nonnegative wage net of application costs, the highest PSM person will always apply and be available in the pool (i.e., $\bar{p} = \hat{p}$). However, this is not true for the highest quality individual.*

Given the basic self-selection pattern laid out in this section, we now explore how different screening and recruitment policies might affect the type of applicants that an organization might be willing and able to hire.

3 Implications for personnel policy

When considering personnel policies, it is important to distinguish between policies that affect recruitment given an existing applicant pool (e.g., screening) and those that can shape the applicant pool while holding constant the screening policy (e.g., compensation).

We begin by studying screening and later in this section we consider policies affecting the applicant pool. We will close the section detailing informally some broader implications.

3.1 Screening policies

Let us assume that the organization is primarily concerned with attracting individuals of high quality and high PSM, and that it values these two dimensions of a worker according to the function $\alpha q + \beta p$, where $\alpha, \beta \geq 0$ are scalars. In order to make the problem interesting, let us further assume that the organization can only screen on one attribute, which may reflect the fact that one dimension might not be measureable due to informational or legal constraints, or because the cost of screening on an additional dimension might be too high.[6] We assume, however, that the screening test will perfectly reveal the level of the examined attribute in the worker.

[6] As long as screening is restricted to a subset of desirable attributes, then the same set of issues that we highlight will arise.

Given this setup, we are interested in two questions: (i) if the organization were constrained to screen on only one dimension given prevailing wages, which dimension would the organization prefer to screen on? And (ii) is it ever the case that even if one cares significantly about PSM one may still want to screen on quality and hire the top scoring candidate in that dimension? These questions are of practical concern because it is often assumed that screening on quality may hinder the vocational profile of the selected candidates.

If the organization is constrained to screen on one dimension, in order to decide which dimension to screen on it must compare two payoffs. If an organization screens on q then it will be able to observe the quality of any worker it selects. If the organization makes an offer to the highest quality type $\bar{q}$, then the PSM of the person is known to be $p(\bar{q})$ as given by the intersection of the function $p'(q)$ and the frontier of the applicant pool, as we saw in Figure 1. Now suppose instead the employer wished to make an offer to someone with a lower quality q^o. In this case, the employer can choose from several candidates. And given that screening on q will not reveal their PSM levels, these remain unknown to the employer. If the employer picks a person of quality q^o at random, the expected PSM of that candidate would be the mathematical expectation of PSM given the selected quality: $E(p|q^o)$. The calculus that emerges when screening on PSM is similar. When screening on PSM, the organization can select a person in the applicant pool with the desired level of PSM, but must then take a gamble on the quality of the person. Given this discussion, when respectively screening on q and p the employer gets payoffs that can be expressed mathematically as follows,

$$\begin{aligned}\max_q \alpha q + \beta E(p|q) &= \alpha q^* + \beta E(p|q^*) \\ \max_p \alpha E(q|p) + \beta p &= \alpha E(q|p^*) + \beta p^*,\end{aligned}$$

where the asterisks denote the optimal level of the trait conditional on the recruiter screening on that trait. The relative value of screening on q is the difference between these payoffs,

$$\alpha\left(q^* - E(q|p^*)\right) - \beta\left(p^* - E(p|q^*)\right). \tag{1}$$

It then follows that the organization, when constrained to screen on only one dimension and considering equal costs, will screen on quality whenever the term (1) is positive, and it will screen on PSM otherwise. This term says that the value of screening on q grows when there is a large distance between the quality q^* that would be chosen optimally when being able to screen on quality and the expected quality $E(q|p^*)$ that would be received when screening on, and optimally selecting, PSM. Conversely, this term will be negative, favoring screening on PSM, when there is a large distance between the optimal PSM p^* that can be selected when screening on this attribute and the level $E(p|q^*)$ that can be expected when screening on quality.

To gain a better understanding of the forces involved, let us first consider the most symmetric situation possible: suppose the set U is symmetric and that $\alpha = \beta$. Since valuations are equal and the applicant pool is fixed given the wage, we can abstract from costs. Given the prevailing wage, the applicant pool is the set A which results from subtracting from U all the types below the function $p'(q)$ that choose not to apply. The fact that the organization's objective is to maximize $\alpha q + \beta p$ implies that the organization desires to select the outermost point in A that is tangent to a level curve with slope -1. Given the symmetry of U and the fact that from proposition (1) the function $p'(q)$ has a negative intercept, the optimal type (q^0, p^0) in the eyes of the organization is always in the applicant pool and it's the type on the intersection of the 45 degree line and the frontier $p(q)$, as depicted in Figure 2. If the organization could screen on both dimensions, it would recruit that type, which perfectly balances the two desired attributes. We saw from Proposition 1 that for any nonnegative wage the selection condition $p'(q)$ will lie below the 45 degree line. That means that all symmetric types for whom $p = q$ apply to the job. Thus, the second of the practical implications is,

Practical Implication 2 *The ideal candidate profile for an employer with symmetric valuations facing a symmetric workers' type space is the applicant with the highest identical level of both traits in the workers' space U (i.e., the type having $p^o = q^o$ in Figure 2). Moreover, this type always applies.*

This message stems from Figure 2 and the strong symmetry conditions we have imposed on valuations ($\alpha = \beta$) and on the set of worker types U. Now we will trace implications of the strong asymmetry introduced by the self-selection of workers. This asymmetry becomes relevant when considering organizations that are constrained to screen on a single attribute. In this situation, the employer cannot reach a specific point in the applicant pool with certainty. When screening on quality q the employer can choose an applicant with any level q between zero and the highest quality available $\bar{q}$. For any q that is selected, the employer expects PSM to be given by the mathematical expectation of p conditional on the selected q: $E(p|q)$. Thus, when screening on q the employer is constrained to solve,

Problem 1 *q: Selects q to maximize the expression $\alpha q + \beta E(p|q)$.*

Conversely, when screening on PSM the employer solves,

Problem 2 *p: Selects p to maximize $\alpha E(q|p) + \beta p$.*

Figure 2 plots the two conditional expectations $E(p|q)$ and $E(q|p)$ assuming a Uniform distribution of traits. Note that the conditional expectations at different levels of q and p are shaped by the presence of the self-selection function $p'(q)$. As said earlier, when $\alpha = \beta$, the level curves corresponding to the objective function have slope -1. Thus, the illustrated solution for problems (1) and (2) is where each curve representing a conditional expectation touches the outermost level curve with slope -1.

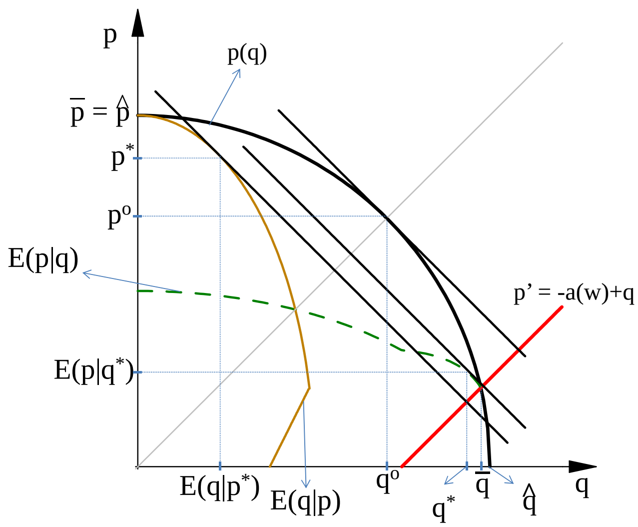

Figure 2: Optimal candidate profile under alternative screening policies

The asymmetry introduced by applicant self-selection is that the relatively high-q, low-p types are the ones to stay out of the applicant pool. Note that this causes the expected level of one trait conditional on the other to be asymmetric, too. In particular, if one is to screen on PSM and hire the highest PSM type in the pool, with a strictly decreasing frontier $p(q)$, that highest PSM type can be expected to have the lowest quality. The converse is not true: screening on q and selecting the highest scoring person in fact guarantees a hire with positive PSM. Now of course an employer who values both traits and faces a strict tradeoff as depicted in the function $p(q)$ will not hire the top scoring person in one dimension.

If we keep all else symmetric, the fundamental asymmetry introduced by self-selection creates a bias towards making screening in q more desirable. In Figure 2 this is reflected in the fact that the solution to problem (1) lies on a higher level curve, and hence yields more value to the employer, than the solution to (2). This yields,

Practical Implication 3 *All else equal, the self-selection of individuals into the applicant* *pool tends to reduce the range over PSM at high quality levels, and this makes screening on quality more desirable than screening on PSM.*

Another implication is that availability of partial screening distorts the profile of hires relative to what would be ideal for the organization. Note that in the solution to problem (2) the organization hires a person with PSM level higher than the ideal p^o, and in the solution to problem (1) the organization hires a person with quality higher than the ideal q^o. We then obtain,

Practical Implication 4 *Under partial screening the profile of selected applicants is biased in favor of the dimension on which screening takes place.*

This implication, while non-obvious and driven by the geometry of screening, is intuitive: when it comes to personnel profiles, organizations tend to hire what they can measure.

Introducing asymmetries We have derived a number of practical implications while maintaining strong symmetry conditions. At this point in our analysis it is valuable to relax this assumption. The organization may value one trait more than the other, and the set of types U may not be symmetric. To isolate the effect of each asymmetry, we introduce them in turn in Figures 3a and 3b.

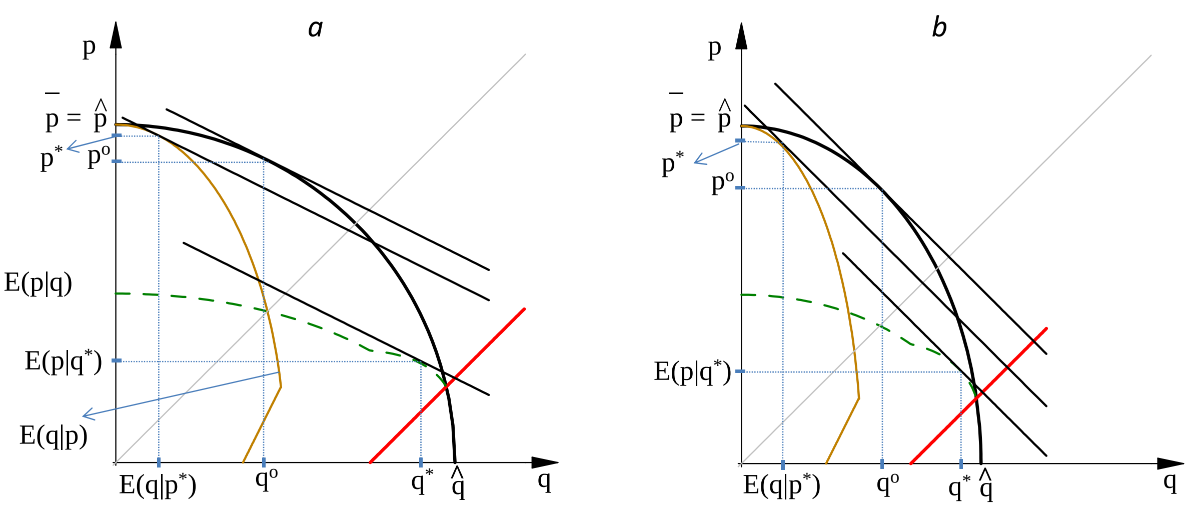

Figure 3: Pro-PSM bias under asymmetric conditions

In Figure 3a we show that if the organization values PSM sufficiently more (the α/β ratio is low), the solution to problem (2) lies on a higher level curve than the solution to problem (1), meaning the organization will prefer to screen on PSM. In Figure 3b we show a situation where the range of PSM values is much higher, and again the solution to problem (2) lies on a higher level curve than the solution to problem (1). This yields,

Practical Implication 5 *All else equal, the organization is more likely to prefer screening on PSM if a) this trait is more valuable than quality (i.e., α/β is relatively low), and b) the range of PSM values is sufficiently larger than that of quality values.*

The intuition for the first part of this implication is simple: even if the asymmetry of the applicant pool creates a bias towards wanting to screen on quality, if PSM is much more valuable, then the employer will want to make sure it is getting the right level of PSM, which can only be done by screening on PSM. The intuition for the second part of the implication is slightly more involved. As reflected in expression (1), what makes screening on, say, quality, a desirable approach is that it guarantees the optimal level of the trait instead of getting the expected quality conditional on the selected PSM (which is what would obtain under PSM screening). The symmetric opposite argument works for screening on PSM: one can guarantee the optimal level on PSM instead of a conditional expectation. When the range of possible PSM values is very high, the conditionally expected PSM is vastly different from the optimal level, at least relative to the analogous gap on quality. In other words, PSM is the dimension most vulnerable to bad luck. Consider the second question posed at the beginning of this section, namely whether an organization that cares about PSM may ever want to screen on quality and appoint the top candidate along that dimension. The answer is yes, and to see this, consider the situation in Figure 4.

The applicant pool is such that the relevant portion of the frontier $p(q)$ is flat. This is more likely to arise when wages are relatively low, or where the population has a relatively narrow range of PSM relative to quality. In this situation there is effectively no tradeoff between the traits. If the organization screens on q it is optimal to pick the highest quality person $\bar{q}$. Doing this not only entails gains in the quality dimension but entails no losses in the PSM dimension relative to a completely random hire or even a hire based on PSM screening. Note that if one were to hire under PSM screening, the optimal choice would be to select someone with the highest PSM $\hat{p}$, but screening on PSM would force the employer to take a gamble on quality. Moreover, it is unnecessary to screen on PSM to be able to get the highest PSM candidate. Given the self-selection pattern, the highest quality type is also necessarily the highest PSM type, so screening on q is the best option. (Mathematically, in this situation $\bar{q} - E(q|p^*) > 0$ while $p^* - E(p|\bar{q}) = 0$ so given equal costs the expression in (1) must be positive). This discussion yields the following,

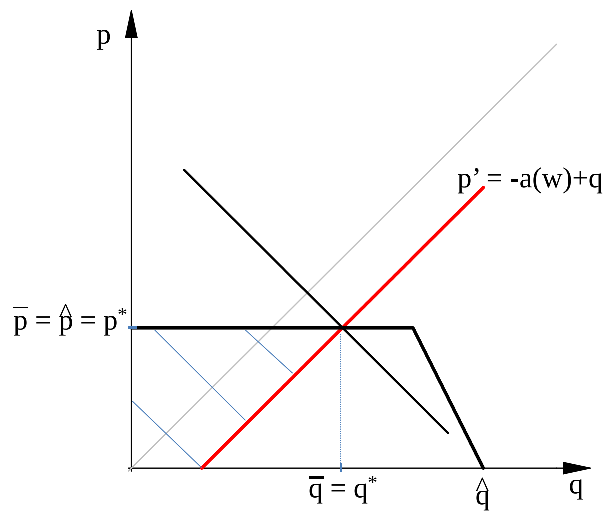

Figure 4: Selecting the highest quality while getting the highest PSM

Practical Implication 6 *In the absence of a tradeoff between quality and PSM as shown in Figure 4, screening on quality is sufficient to select not only the highest quality but also the highest PSM candidate, and is therefore preferred regardless of the valuations α and β.*

3.2 Policies that shape the applicant pool conditional on screening

At least two main policies can directly affect the applicant pool, conditional on the screening scheme in place. Recall our exposition assumes applicants to make decisions under a diffuse prior on selection chances. Obviously, if workers anticipate exactly what screening will be like, screening itself can affect the applicant pool in equilibrium. What we are interested in here is on policies that can affect applications conditional on the prevailing screening policy, and in doing so it will again be convenient to stick with the diffuse prior assumption. One policy that can affect the applicant pool is a targeting policy, which relates to how the organization's job vacancies are advertised to different segments of the population, or whether the position requires minimum qualifications, such as a high school diploma. The other main policy is the compensation, or wage policy. We will focus on the compensation policy, and take the issues involving targeting as given.

Proposition (1) tells us that if all agents learn about the wage then those with relatively low quality and high PSM will want to apply. How do wages affect the applicant pool? Note that increases in wages move the function $p'(q) = q - (w - c)$ downward, expanding the set of types who want to apply.

Proposition 2 *If at the initial wage there were individuals outside the applicant pool and given the joint Uniform distribution assumption, an increase in wages raises the average and maxium quality applicant and reduces the PSM of the average applicant.*

The effect of a wage increase is depicted in Figure 5.

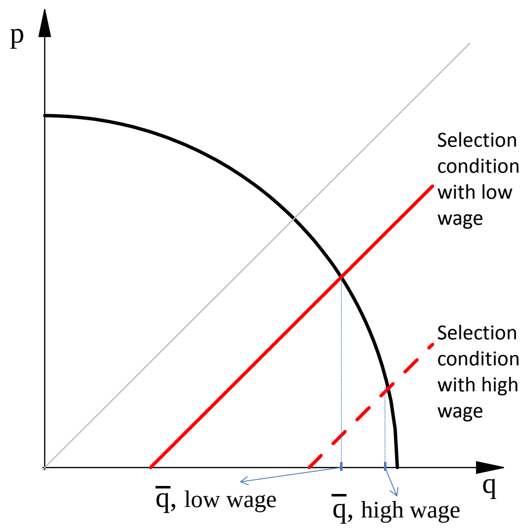

Figure 5: Expansion of the applicant pool with a wage increase

Higher wages not only increase the size of the applicant pool, but also improve the average and maximum quality under the stated assumptions.[7] But whether this improvement is valuable to the recruiter depends on the valuation of the two traits and on the screening technology. To see this, consider again a situation with Uniform distribution of types, symmetry in terms of valuations ($\alpha = \beta$) and of the set U, and a strictly decreasing and concave frontier $p(q)$. Figures 6a, 6b, and 6c show situations where the increase in wages is not valuable in the respective cases where there is screening on both traits, on q, and on p. In Figure 6 we represent the highest payoff that the employer can obtain before wages go up with a solid, black indifference line, and the selection condition with a solid, red line, as before. After wages go up, the selection condition moves out to the dashed red line, and if the employer finds it advantageous to change the hiring profile (in case b), the new payoff that the employer can attain is given by the dashed black indifference line.

In Figure 6a we show that if able to screen on both traits, the employer gets the type (q^o, p^o), which, as stated in Practical Implication 2, is always in the feasible set under sym-

[7]As shown in Dal Bó, Finan, and Rossi (2013), under forms of positive correlation between p and q it is possible for wage increases to raise the average PSM. This case is analyzed below.

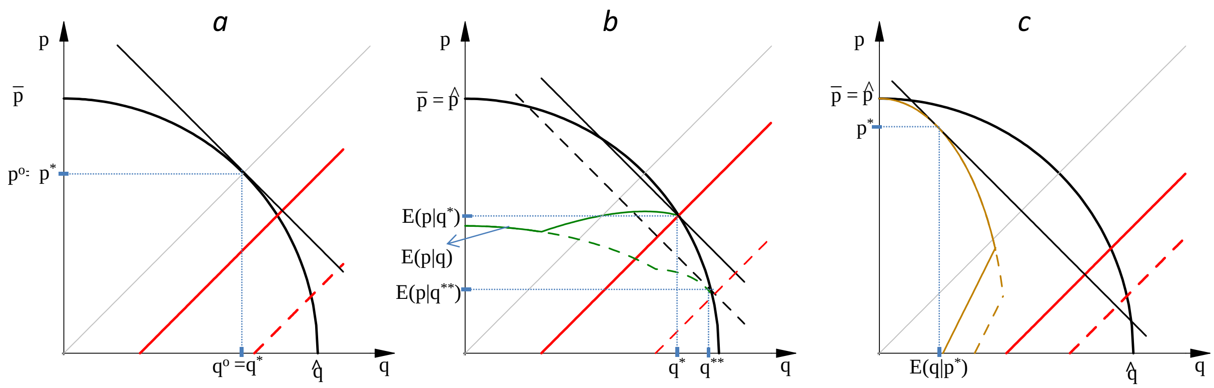

Figure 6: Situations where a wage increase is of negative or no value to the employer

metry. In that situation, all the increase in wages does is to expand the applicant pool in a direction of higher q and lower p that is of no interest to the employer. The employer continues to select the type (q^o, p^o) but will find itself paying a higher wage for no selection advantage.

In Figure 6*b* we show the case where again under symmetry the employer can only screen on q. In this situation the employer already selects a quite high quality q^* before the wage increases. This solution, as seen in the figure, lies on the triple intersection between the continuous indifference curve, the frontier $p(q)$ and the function $E(p|q)$ represented by the continuous green curve. When the wage goes up, the curve $E(p|q)$ in between the points $E(p'(q=a)|q=a)$ and $\hat{q}$ must necessarily shift down. Note the new function $E(p|q)$ is now given by the green dashed curve, and it is strictly lower than before. The best the employer can do is to select quality q^{**}. But because the function $E(p|q)$ as given by the green dashed curve is lower than before, this causes its point of contact with the highest possible level curve (now the dashed straight line in black) to be lower also, worsening the payoff to the employer. The intuition is that in this case the employer is screening on q and hence is already biasing selection towards quality. An increase in wages raises quality in the pool, but worsens average PSM, the dimension that is relatively "scarce" and unmeasurable, which hurts the employer. In this situation the employer would prefer to actually *reduce wages to improve the outcome of the selection/screening process*, and bring the point $(q^*, E(p|q^*))$ closer to (q^o, p^o).

In Figure 6*c*, we depict the situation under symmetry where the employer can only screen on p. Symmetry implies that $p^* \geq p^o$ and from proposition 1 the function $p'(q)$ intersects the frontier $p(q)$ below the 45 degree line, meaning that $p(\bar{q}) < p^o$. This means the increase in wages only affects the term $E(q|p)$ below p^o and therefore below p^*. This, together with the fact that the frontier is concave, guarantees that the expansion of the applicant pool is irrelevant to the employer's choice. The level curve yielding the original value $\alpha p^* + \beta E(q|p^*)$ cannot be achieved by selecting any other p after the change in wages. This yields the following,

Practical Implication 7 *Under the assumptions underlying Figures* $6a, 6b$, *and* $6c$, *increases in wages do not change, or even reduce, the employer's payoff under all types of screening. The reason is that higher wages expand the applicant pool in a region that is either irrelevant for the employer's optimal selection, or that worsens the expectation on the trait that cannot be screened.*

This does not mean, however, that raising wages never makes sense from a selection standpoint (and of course there are also benefits from the standpoint of getting the applicant to accept the position (see Dal Bó, Finan, and Rossi (2013))). In Figures $7a, 7b$, and $7c$ we present situations where the employer will prefer to raise wages. Again we represent the highest payoff that the employer can obtain before wages go up with a solid, black indifference line, and the selection condition with a solid, red line. After wages go up, the selection condition moves down and out to the dashed red line, and the new payoff that the employer can attain is given by the dashed black indifference line. The key difference relative to Figure 6 is that the employer can now reach a higher payoff, as evidenced by the indifference lines lying further out after the wage increases.

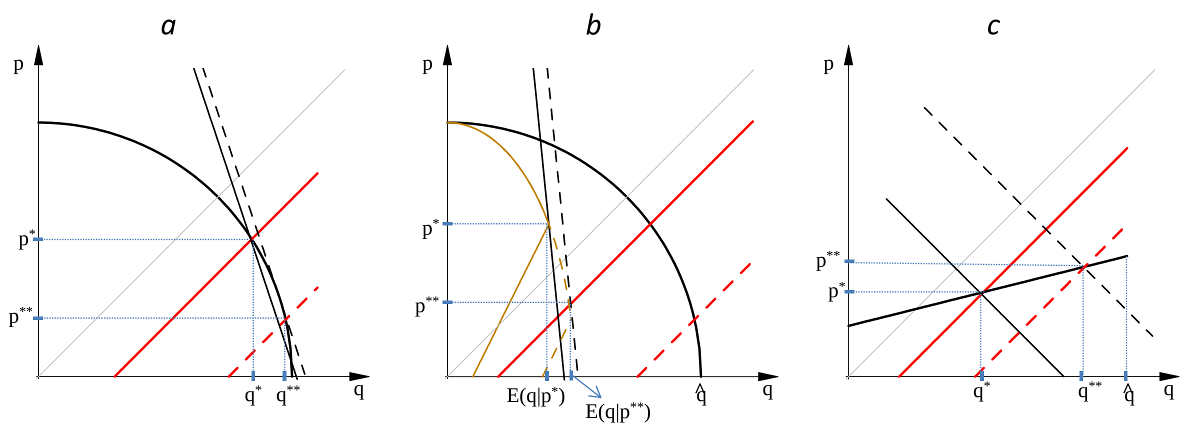

Figure 7: Situations where a wage increase is of value to the employer

In Figure $7a$, we show a situation where the employer screens on, and cares very strongly about, quality. By "very strongly" we mean that under the initial wage, the ideal hire that the employer would make if able to screen on both traits (the point of tangency between level curves and frontier), is not in the applicant pool, and that the highest attainable level curve corresponding to the employer's objective $\alpha q + \beta p$ cuts the frontier $p(q)$ from above at the point $(\bar{q}, p(\bar{q}))$. In other words, the employer is "quality constrained" in that his ideal hire features higher quality and lower PSM than under the actual hire $(q^*, p(q^*))$. In this situation, a marginal increase in wages raises the level of the highest quality applicant, and allows the employer to make hires closer to his ideal, thus reaching a higher level curve and higher payoff.

In Figure 7*b*, we show a similar case when the employer also cares strongly about q but is constrained to screening on p. Because the employer cares so strongly about quality, he chooses a fairly low p^* in order to increase the expected quality $E(q|p^*)$ he can get. In fact, strict concavity of $p(q)$ and the Uniform distribution imply that p^* must be lower than $p(\bar{q})$. This means that the wage increase adds higher quality individuals to the pool and increases the expected quality that can be obtained by selecting candidates with PSM equal to p^* and lower. This implies again that the employer can increase her payoff by selecting a more quality-oriented hire, this time in the form of a lower p candidate whose expected quality is higher.

Finally, in Figure 7*c* we consider a very different case. Our previous research (Dal Bó, Finan, and Rossi (2013)) indicated that an increase in wages led to an increase in the average quality of the applicant pool without a decrease in average PSM. If anything, average PSM went slightly up. One way to explain this is if there is a positive correlation between quality and PSM in the population U. A simple way to examine that case is by assuming that all the population U lives in the graph of the function $p(q)$ in Figure 7*c* (notice that now the $p(q)$ function has an upward slope). In that situation, the highest quality applicant is also the one with the highest PSM, and would be the preferred hire regardless of the relative valuations α and β (provided the valuations are nonnegative and at least one is positive). In this situation, an increase in wages increases the quality and PSM of the top applicant, which naturally increases the employer's payoff. Summarizing,

Practical Implication 8 *Under any screening policy, wage increases can yield selection benefits when the employer cares strongly about quality or when there is a positive correlation between quality and PSM.*

Since under symmetry the ideal hire (q^o, p^o) is in the applicant pool even under a wage of zero, one might think that symmetry in terms of valuations and shape of the set U is unlikely to characterize the real world. Many employers are much more likely to care about quality than about vocational profile. But the contrast between the last two practical implications suggests that a zero wage policy, or, in other words, relying on volunteers, may yield the most selection value when the employer cares less about quality and more about the vocational profile of the hire. Our framework would then predict that activities that rely on highly non-contractible tasks that require a lot of identification with the cause will go together with low wages as a way to help hit the right combination of traits in the workforce.

3.3 Implications for organizational politics

The practical implication that organizations hire what they can measure means that screening policy may be a boon of contention in the organization. So far we have considered the organization to be a monolithic actor with valuations α and β. But consider the case where different actors within the organization care differently about quality vis-a-vis PSM. Those with high α to β ratios, if able to screen on both dimensions, would want to make hires that have a higher quality to PSM composition. Those with low α to β ratios will desire the opposite. In a situation where the organization can screen on only one attribute, the first group will vie to have the organization screen on quality, and the latter will hold that the organization should screen on on PSM. This would make sense from each of their perspectives since they know that when screening on quality the optimal hire will be biased towards quality and against PSM, and the opposite will hold when screening on PSM. We then get,

Practical Implication 9 *If different actors within the organization have different valuations of α and β (meaning different valuations for quality vis-a-vis PSM), those with higher α relative to β are more likely to advocate for screening on quality than those with the opposite preference, since screening on quality leads to hires of higher quality. The converse statement holds for those with higher valuation for PSM relative to quality.*

3.4 Implications for dynamics and prices

The Practical Implication 4 tells us that there will be a bias in the hiring profile towards what can be measured. In a world where employers can screen, say, on quality but not on PSM, hiring will tilt towards candidates with higher quality than employers would prefer if they could observe all aspects of applicants. In our model quality stands more generally for any trait that correlates with expected outside opportunities in the labor market, while PSM stands as example of more narrow vocational inclinations that may not correlate as much with expected earnings. Note that in a world where talent measurement organizations prefer to develop products with wider market application, scales are more likely to be developed on general human capital traits such as IQ, rather than to measure traits that may be of idiosyncratic value to a few employers. In addition, educational qualifications or past experience may often serve as a better predictor of those general traits than as a predictor of fit with a specific type of organization. Thus, we may expect a hiring bias towards generic measurable traits, such as IQ, conscientiousness, tenacity, which can be measured through specific scales (commercial or academic in origin), or gleaned from past educational achievements.

If screening difficulties lead to a pro-quality bias, we may expect the labor market to reflect this extra demand for quality in the form of a quality premium. In other words, we may expect quality to be overpriced relative to the situation where all traits can be observed equally.

To be sure, the price of talent does not get set for good at the time of hiring. An organization facing the screening problems investigated here may get eventually to observe the worker's PSM p once the person is on the job. Thus, an organization may hire with a pro-quality bias (as in the solution $(q^*, E(p|q^*))$ in Figure 2, but retain and promote according to a more balanced set of traits. Retention and promotion policies may try and steer the workforce toward the bundle (q^o, p^o) that the organization would have liked to hit at first, had it been able to screen on both dimensions. Thus, the pro-quality premium is likely to be present for the newer, younger elements of the workforce and be progressively eliminated at higher echelons of the organization, and for older, more experienced workers.

4 Illustration: the Regional Development Program in Mexico

We have derived several practical implications for personnel policy from our framework. But the usefulness of these policy prescriptions will ultimately depend on the shape of the applicant pool. This of course begs the central empirical question of what does the shape of applicant pool actually look like in practice. Unfortunately, few datasets allow for such analysis. Rarely does a single dataset contain both information about the individual's cognitive skills and his vocational profile. And even in the rare occasion in which this information does exist, the interviewees will not be from a single applicant pool. In our empirical application, we are able to overcome these limitations, and provide one of the few empirical examples of the tradeoffs an employer of a mission-driven organization might face.

Our empirical example is based on a dataset that was collected during a recent recruitment drive in Mexico. In 2011 the Mexican government began a program – the Regional Development Program (henceforth, RDP) – designed to increase the presence of the State in

167 of its most marginalized and conflict-ridden municipalities.[8] To achieve this objective, the program sought to create a large network of public agents – 350 community development agents and the 50 coordinators who supervise them – whose primary responsibilities are to identify the needs of the community and to report them directly to the federal government, who will then seek to channel resources to meet these demands. By establishing a direct link to its citizens, the federal government hopes to establish a presence in several of the areas where the local government has proven to be ineffective.

Recruitment took place during the months of June to August of 2011. The recruitment sites were located mostly within the ten target regions in localities with a small community college – in hopes of attracting a younger and more educated applicant pool. Job postings were then sent out to 113 schools in 106 localities throughout the regions.

The job advertisements provided a general description of the job, along with a toll-free number and an email address for interested applicants. Telephone operators would then register the applicants by recording, in addition to their contact information, answers to some questions regarding the applicant's education level and employment background. After registering the applicant and depending on the locality in which the person had seen the advertisement, the operator would communicate the salary attached to the job (the wage was not announced within the job ad to avoid sorting effects), as well as the date and place for the candidate to show up and participate in the screening session. At the screening session applicants were administered a three-hour exam designed to measure three broad categories of personal characteristics: aptitude, personality, and motivations (especially inclination towards public sector employment).

What is the shape of the applicant pool? Before we examine the shape of the applicant pool, we have to take a stance on how to best measure quality and public sector motivation. To measure an applicant's public service motivation we used Perry's 1996 scale of Public Service Motivation (Perry 1996). This index has become the gold standard in the literature on public service motivation, and is constructed based on a questionnaire in which the subject must express agreement or disagreement with each of thirty-two statements. The questionnaire elicits opinions on the attractiveness of politics, public service, and prosocial activities.

To measure a person's quality is a bit trickier, and here we use two approaches. Our first approach relies on a person's IQ, which has been shown extensively to be a strong predictor

[8] The program was implemented across ten regions and in 167 municipalities containing thousands of localities. The ten regions are Sierra Cora-Huichol, Costa Infiernillo, Huasteca Veracruzana, Montaña de Guerrero, Sierra Guerrero, Selva Lacandona, Sierra Tarahumara, Tierra Caliente-Oriente, Triqui-Mixteca, and Zapoteca Chontal.

of earnings and job performance. To measure a person's IQ, we used the *Raven's Progressive Matrices* Set I published by Pearson. The Raven's test, which is one of the most widely used tests for abstract mental aptitudes, measures a person's capacity to think logically and solve abstract problems, independent of context or acquired knowledge. The test comprises a series of matrices, and for each matrix the test taker observes a visual pattern of abstract figures and must identify the missing piece from a set of available options. This requires the ability to perceive the logic of a whole by drawing out the relationships among the parts (a process labeled "eduction"). The Raven's test has the advantage of hinging far less than other tests on verbal and other skills acquired through a formal education, and it is also relatively quick and easy to administer. It is important to note that due to logistical constraints and the need to screen for various attributes, we administered the Set I exam, which only contains 12 matrices. Consequently, this shorter version of the test cannot usually discriminate within the top 5% of the distribution.

In Figure 8, we present a scatter plot between an applicant's PSM and their score on the Raven exam. In this graph, we also distinguish between individuals who scored in the normal to above normal range and those who scored below normal. Out of 2252 individuals who took the exam, 379 scored below normal range, and one might question their ability to answer the rest of the exam. For those applicants who had a normal or above normal IQ, we find an applicant pool that appears similar to those depicted by our conceptual framework. Individuals with low levels of PSM and high levels of IQ have selected out of the applicant, and the frontier does appear to be weakly decreasing at higher levels of PSM and IQ. The sharp edge at the upper IQ score reflects the fact that the IQ test cannot discern among the highest IQ individuals.

A person's intelligence is only one factor that determines a person's labor market opportunities, which is our definition of quality. Consequently, our second and main approach uses a much broader measure of quality, namely the person's current and/or previous wage. As part of the screening exam, and as is common on most job applications, candidates were asked to provide information about their last three places of employment. This information included length of employment, employer's contact information (which signaled that information was potentially verifiable) as well as previous wages. This measure has the advantage of capturing other elements of skill or productivity that are valued by the market but not reflected in our measure of IQ. Also, the outside opportunity is more directly linked to a person's decision to self-select into a job. A disadvantage of this measure is that realized past or current earnings may contain random shocks.

Now, we map the theoretical findings to the Mexican data using our second (and preferred) measure of quality, the applicant's previous wage. We first construct a frontier in the

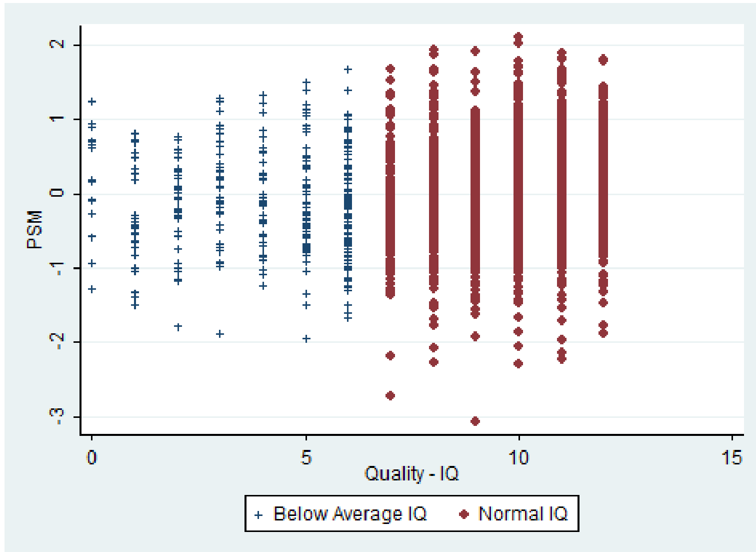

Figure 8: The applicant pool and the trade-off between quality and PSM

public sector motivation-quality dimensions in order to compare it to the theoretical frontier in Figure 1. To build the frontier we use a modification of the standard Data Envelopment Analysis (DEA) model called Free Disposal Hull (FDH) analysis, first introduced by Deprins and Tulken (1984) and further developed by Tulken (1993). Given that quality and public sector motivation are both desirable attributes for an individual, the frontier is defined by those individuals that do not have another observed individual with more of the two attributes (we called them "efficient" individuals, using the terminology in frontier analysis). The frontier constructed in this way is a step function.

Formally, in our framework there are two attributes, public sector motivation (p) and quality (q). Now consider a p-q combination (q^1, p^1). The set of p-q bundles dominated by (q^1, p^1) is $FDH\,(q^1, p^1) = \{(p; q) : p < p^1; q < q^1\}$.

Compared to (q^1, p^1), every bundle in FDH involves less public sector motivation and quality and, therefore, it is dominated by (q^1, p^1). The advantage of this approach compared to a standard DEA analysis is that the concept of dominance can be used without the additional convexity assumption usually required to define the individuals on the frontier.

As observed in Figure 9, the estimated frontier has a remarkably similar shape compared to the theoretical frontier. As in Figure 1, the relationship between PSM and quality is decreasing along the frontier. Also, the self-selection into the job (as seen by the missing bottom-right triangle in Figure 9) is much more pronounced using this measure of quality, which is expected given its more direct link to outside opportunity.

In the spirit of our framework, in Figure 10 we have also superimposed the conditional

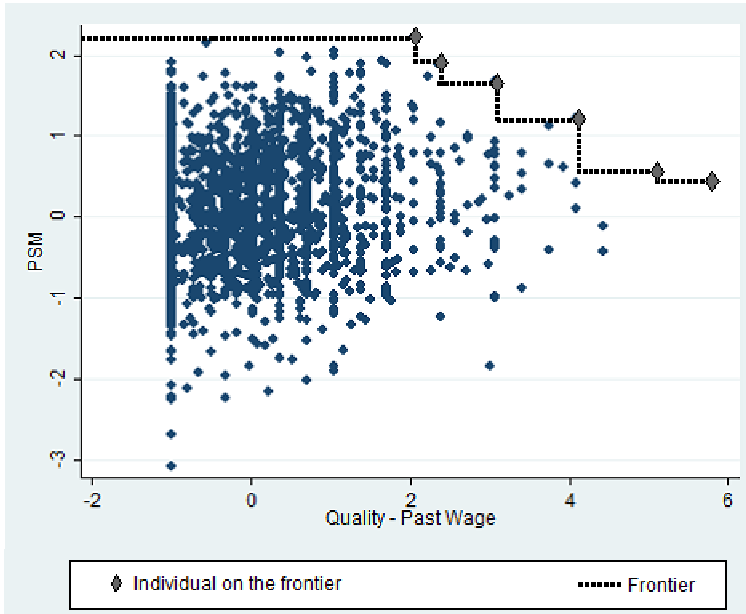

Figure 9: The frontier

expectations, as it is the tangency on these curves that determine which attribute one should screen on. In fact, if the Mexican government valued quality and PSM equally, then given these candidates, the expected attributes of the candidate when screening on PSM is depicted by the plus sign and expected attributes of the candidate when screening on quality is depicted by the diamond symbol. Given equal valuation, it is optimal to screen on quality. In fact, a back-of-the-envelop geometrical analysis shows that one would have to value PSM seven times as much as quality, in order for it to be optimal to screen on PSM for this given applicant pool.

5 Conclusion

How to screen and select a workforce are central issues facing every organization. In this paper, we present a simple framework and derive some practical implications for the screening and selection of personnel when the organization values both the quality and intrinsic motivation of its workforce. This analysis, although simple, yields several lessons. First, given the asymmetric pattern of worker self-selection, motivation tends to be abundant in the applicant pool relative to quality. If both attributes are valued equally, then employers are more likely to benefit from being able to screen on quality. Second, because employers are not always able to screen on all dimensions of interest, a bias will emerge toward hiring

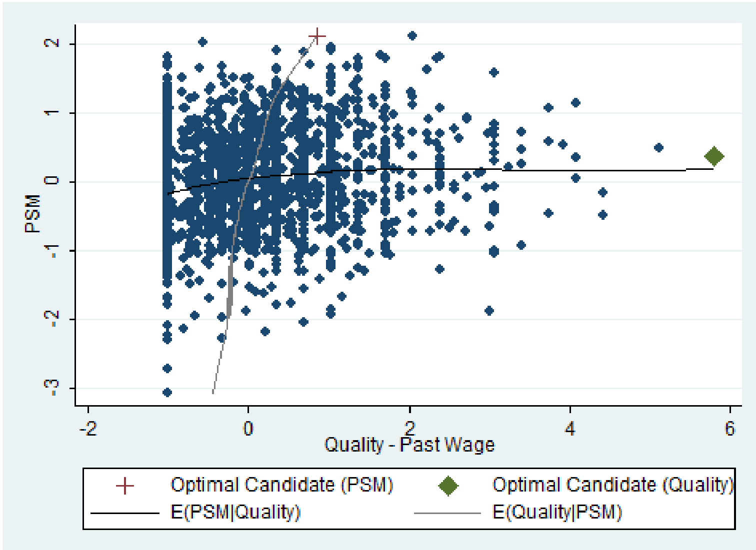

Figure 10: The applicant pool and optimal hiring under partial screening regimes

candidates who excel in the dimensions that can be screened on, making the choice of screening policy consequential for the profile of workers that will eventually be hired. A logical implication is that this bias, if generalized, may in turn create distortions in the market wage premia of the various attributes of workers.

We also derive implications for when higher wages become a useful tool for screening and selection. If the organization cares strongly about quality or if there is a positive correlation between quality and motivation, then increasing wages can yield positive selection benefits.

We apply our framework to a recent recruitment drive conducted by the Federal Government of Mexico in 2011 to hire community development agents to assist households in marginalized communities of Mexico. Based on this applicant pool, our framework recommends screening on IQ for equal valuation of IQ and motivation.

6 Appendix

Proof of Proposition 1:

i) Note that the option to stay out yields expected payoff $q + E(\varepsilon) = q$. The option to enter yields an expected payoff equal to,

$$-c + G(w+p-q)(w+p) + [1 - G(w+p-q)][q + E(\varepsilon|\varepsilon > w+p-q)].$$

Therefore, the infinite pairs (q, p) who are indifferent between entering and staying out perceive equivalent expected returns to staying out and opting in:

$$q = -c + G\left(w+p-q\right)\left(w+p\right) + \left[1 - G\left(w+p-q\right)\right]\left[q + E\left(\varepsilon|\varepsilon > w+p-q\right)\right]. \tag{2}$$

The implicit function theorem guarantees that a continuous function $\bar{q}\left(p\right)$ exists, mapping the PSM parameter to the quality type $\bar{q}$ that will be indifferent between entering the applicant pool and staying out. Rewrite (2) and we have,

$$-c + G(w+p-q)(w+p-q) + \int_{w+p-q}^{\infty} \varepsilon g(\varepsilon)\, d\varepsilon = 0$$

Letting $t \equiv w+p-q$, the equation becomes,

$$h(t) \equiv -c + G(t)t + \int_{t}^{\infty} \varepsilon g(\varepsilon)\, d\varepsilon = 0 \tag{3}$$

Notice that $h'(t) = G(t) > 0$, so $h(t)$ is continuous and strictly increasing. We now show that a unique solution of $h(t) = 0$ exists.

First, let $p = q = 0$, so that $t = w$. Then,

$$\begin{aligned}
h(w) =& - c + G(w)w + \int_{w}^{\infty} \varepsilon g(\varepsilon)\, d\varepsilon \\
=& - c + G(w)w + [1 - G(w)]E(\varepsilon|\varepsilon > w) \\
>& - c + G(w)w + [1 - G(w)]w = w - c > 0 \quad \text{(because of the assumption that } w > c).
\end{aligned}$$

Second, as $t \to -\infty$ (which we can allow if we consider $\bar{Q}$ arbitrarily large), $G(t)t \leq 0$, $\int_t^{\infty} \varepsilon g(\varepsilon)\, d\varepsilon \to 0$, so $h(t) < 0$. Therefore, as t increases $h\left(t\right)$ goes from negative to positive and given it is continuous and increasing there exists a unique value k such that $h(k) = 0$. Therefore, a type (q, p) is indifferent iff $w+p-q = k$, which means $\overline{q}(p) = p+(w-k) = p+a$. In addition, $h(k) = h(w-a) = 0$, and $h(w) > 0$, so $w - a < w$ leaving $a > 0$.

The lowest level of t is at $w = p = 0\,, q = \bar{q}$. We need

$$-c - G\left(\bar{q}\right)\bar{q} + \int_{-\bar{q}}^{\infty} \varepsilon g(\varepsilon)\, d\varepsilon < 0,$$

which means a highest quality guy with the lowest PSM would not apply for a public sector job paying zero.

(ii). If $p' > \overline{p}(q)$ or $q' < \overline{q}(p)$, then $t > k$ and $h(t) > h(k) = 0$, so

$$-c + G(w+p-q)(w+p) + [1 - G(w+p-q)][q + E(\varepsilon|\varepsilon > w+p-q)] > q,$$

indicating that there are candidates who strictly want to enter. The proof is similar when $p' < \overline{p}(q)$ or $q' > \overline{q}(p)$.■

From the last proposition, the applicant pool is the set $A = \{(q, p) \in S | q < a + p\}$, where a is a parameter that depends on wages. If $\bar{P} \leq \bar{Q} - a$, the applicant pool is a trapezoid with upper side $\bar{P}$, and right side $p = q - a$. If $\bar{P} > \bar{Q} - a$, the right side is $q = p + a$ for $p < \bar{Q} - a$, and it is $\bar{Q}$ for $p \geq \bar{Q} - a$.

Proof of Proposition 2:

Let (Q_1, P_1) be the intersection of the frontier of the workers' pool $q(p)$ and the indifference line $q = a + p$.

Define

$$q(a,p) = \begin{cases} a + p & if \quad p \leq P_1 \\ q(p) & if \quad p > P_1 \end{cases}$$

And

$$q_a(a,p) = \begin{cases} 1 & if \quad p \leq P_1 \\ 0 & if \quad p > P_1 \end{cases}$$

According to definition, the average quality of applicants pool is

$$\begin{aligned} E[Q|Q \leq a + p] =& \frac{\int_0^{\overline{P}} \mathrm{d}p \int_0^{q(a,p)} q \, \mathrm{d}q}{\int_0^{\overline{P}} \mathrm{d}p \int_0^{q(a,p)} \mathrm{d}q} \\ =& \frac{1}{2} \frac{\int_0^{\overline{P}} q^2(a,p) \, \mathrm{d}p}{\int_0^{\overline{P}} q(a,p) \, \mathrm{d}p} \end{aligned}$$

In the following part we will show that this function is increasing in a.

$$
\begin{aligned}
\left(\frac{\int_0^{\overline{P}} q^2(a,p)\,\mathrm{d}p}{\int_0^{\overline{P}} q(a,p)\,\mathrm{d}p}\right)' &= \frac{2[\int_0^{\overline{P}} q(a,p)q_a(a,p)\,\mathrm{d}p][\int_0^{\overline{P}} q(a,p)\,\mathrm{d}p] - [\int_0^{\overline{P}} q^2(a,p)\,\mathrm{d}p][\int_0^{\overline{P}} q_a(a,p)\,\mathrm{d}p]}{\left(\int_0^{\overline{P}} q(a,p)\,\mathrm{d}p\right)^2} \\
&= \frac{2[\int_0^{P_1} q(a,p)\,\mathrm{d}p]\left[\begin{array}{c} [\int_0^{P_1} q(a,p)\,\mathrm{d}p \\ +\int_{P_1}^{\overline{P}} q(a,p)\,\mathrm{d}p \end{array}\right] - \left[\begin{array}{c} \int_0^{P_1} q^2(a,p)\,\mathrm{d}p \\ +\int_{P_1}^{\overline{P}} q^2(a,p)\,\mathrm{d}p \end{array}\right]\int_0^{P_1}\,\mathrm{d}p}{\left(\int_0^{\overline{P}} q(a,p)\,\mathrm{d}p\right)^2} \\
&= \frac{[P_1^2+2aP_1]\left[\begin{array}{c} \frac{1}{2}(P_1^2+2aP_1) \\ +\int_{P_1}^{\overline{P}} q(a,p)\,\mathrm{d}p \end{array}\right] - \left[\frac{1}{3}(3a^2P_1+3aP_1^2+P_1^3)+\int_{P_1}^{\overline{P}} q^2(a,p)\,\mathrm{d}p\right]P_1}{\left(\int_0^{\overline{P}} f(a,p)\,\mathrm{d}p\right)^2} \\
&= \frac{\left\{\begin{array}{c} \frac{1}{2}\left(P_1^4+4aP_1^3+4a^2P_1^2\right) - P_1\frac{1}{3}(3a^2P_1+3aP_1^2+P_1^3) \\ +[P_1^2+2aP_1]\int_{P_1}^{\overline{P}} q(a,p)\,\mathrm{d}p - \int_{P_1}^{\overline{P}} q^2(a,p)\,\mathrm{d}pP_1 \end{array}\right\}}{\left(\int_0^{\overline{P}} f(a,p)\,\mathrm{d}p\right)^2} \\
&= \frac{\frac{1}{6}P_1^4 + a^2P_1^2 + aP_1^3 + [P_1^2+2aP_1]\int_{P_1}^{\overline{P}} q(a,p)\,\mathrm{d}p - \int_{P_1}^{\overline{P}} q^2(a,p)\,\mathrm{d}pP_1}{\left(\int_0^{\overline{P}} f(a,p)\,\mathrm{d}p\right)^2} \\
&= \frac{P_1^2(a^2+aP_1+\frac{1}{6}P_1^2) + P_1\int_{P_1}^{\overline{P}}(P_1+2a-q(a,p))q(a,p)\,\mathrm{d}p]P_1}{\left(\int_0^{\overline{P}} f(a,p)\,\mathrm{d}p\right)^2}
\end{aligned}
$$

When $p \in [P_1, \overline{P}]$, $q(a,p)$ is decreasing in p, so $q(a,p) \leq a + P_1$ and we have

$$\frac{\partial E[Q|Q \leq a+P]}{\partial a} > 0$$

Which means that the average quality in the applicant pool is increasing in a.

Now we will use the similar strategy to prove the second part of the proposition. Same with previous settings, we have

$$
\begin{aligned}
E[P|Q \leq a+P] =& \frac{\int_0^{\overline{P}} \mathrm{d}p \int_0^{q(a,p)} p \,\mathrm{d}q}{\int_0^{\overline{P}} \mathrm{d}p \int_0^{q(a,p)} \mathrm{d}q} \\
=& \frac{\int_0^{\overline{P}} pq(a,p)\,\mathrm{d}p}{\int_0^{\overline{P}} q(a,p)\,\mathrm{d}p}
\end{aligned}
$$

$$
\begin{aligned}
\left(\frac{\int_0^{\overline{P}} pq(a,p)\,\mathrm{d}p}{\int_0^{\overline{P}} q(a,p)\,\mathrm{d}p}\right)' =& \frac{[\int_0^{\overline{P}} pq_a(a,p)\,\mathrm{d}p][\int_0^{\overline{P}} q(a,p)\,\mathrm{d}p] - [\int_0^{\overline{P}} pq(a,p)\,\mathrm{d}p][\int_0^{\overline{P}} q_a(a,p)\,\mathrm{d}p]}{\left(\int_0^{\overline{P}} q(a,p)\,\mathrm{d}p\right)^2} \\
=& \frac{[\int_0^{P_1} p\,\mathrm{d}p][\int_0^{P_1} q(a,p)\,\mathrm{d}p + \int_{P_1}^{\overline{P}} q(a,p)\,\mathrm{d}p] - [\int_0^{P_1} pq(a,p)\,\mathrm{d}p + \int_{P_1}^{\overline{P}} pq(a,p)\,\mathrm{d}p][\int_0^{P_1} \mathrm{d}p]}{\left(\int_0^{\overline{P}} q(a,p)\,\mathrm{d}p\right)^2} \\
=& \frac{\frac{1}{2}P_1^2[\frac{1}{2}(P_1^2 + 2aP_1) + \int_{P_1}^{\overline{P}} q(a,p)\,\mathrm{d}p] - (\frac{1}{2}aP_1^2 + \frac{1}{3}P_1^3 + \int_{P_1}^{\overline{P}} pq(a,p)\,\mathrm{d}p)P_1}{\left(\int_0^{\overline{P}} q(a,p)\,\mathrm{d}p\right)^2} \\
=& \frac{-\frac{1}{12}P_1^4 + \frac{1}{2}P_1^2 \int_{P_1}^{\overline{P}} q(a,p)\,\mathrm{d}p - \int_{P_1}^{\overline{P}} pq(a,p)\,\mathrm{d}pP_1}{\left(\int_0^{\overline{P}} q(a,p)\,\mathrm{d}p\right)^2} \\
=& \frac{-\frac{1}{12}P_1^4 + P_1 \int_{P_1}^{\overline{P}} (\frac{P_1}{2} - p)q(a,p)\,\mathrm{d}p}{\left(\int_0^{\overline{P}} f(a,p)\,\mathrm{d}p\right)^2} < 0
\end{aligned}
$$

The first term is strictly negative and the second term is less or equal to zero, so we have

$$
\frac{\partial E[P|Q \leq a+p]}{\partial a} < 0
$$

Which means the average PSM in the applicant pool is decreasing in a.

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