

RECRUITMENT AND SELECTION IN ORGANIZATIONS*

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Abstract

This paper studies employer recruitment and selection of job applicants when productivity is match-specific. Job-seekers have private, noisy assessments of their match value and the firm performs noisy interviews. Job-seekers' willingness to undergo a costly hiring process will depend both on the wage paid and on the perceived likelihood of being hired, while a noisy interview leads the firm to consider the quality of the applicant pool when setting hiring standards. I characterize job-seekers' equilibrium application decision as well as the firm's equilibrium wage and hiring rule. I show that changes in the informativeness of job-seekers assessments, or the informativeness of the firm's interview, affects the size and composition of the applicant pool, and can raise hiring costs when it dissuades applications. As a result, the firm may actually favor noisier interviews, or prefer to face applicants that are less certain of their person-job/organization fit.

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1 Introduction

Attracting and selecting the most suitable workers is arguably one of the main challenges that organizations face.¹ This challenge has become more prominent in recent times following a shift towards knowledge-intensive and team-oriented work practices that place a stronger emphasis on hiring the "right" worker *for the organization*.² The main obstacle to efficient matching derives from information costs: firms and job-seekers need to devote time and resources to identify a potential match, and evaluate its surplus, prior to reaching an employment agreement (Pissarides 2009). To improve matching, employers typically engage in a variety of recruitment and selection activities, where the former aim to create an applicant pool composed of the most promising prospects, and the latter aim to identify those applicants that are the best fit for the organization. For instance, a firm may advertise the characteristics of its work-place, showcase their particular culture, or rely on current employees to describe their work experience, in the hope of attracting workers that thrive in such environment. Concurrently, firms can improve selection techniques to provide a more precise appraisal of the candidate's performance at the firm.³ This paper is concerned with the equilibrium effects of recruitment and selection activities on matching in the presence of fit, and a firm's incentives to improving these activities.

Despite the vast literature on job-seekers' search behavior, comparatively less is known of firm-level hiring choices. While there is some discussion on how employer search differs from job-seeker search (see, e.g., Rees 1966, and Barron, Bishop and Dunkelberg 1985), by and large this literature treats the firm as a "black box", and little is understood of the main drivers of firm-level heterogeneity in hiring practices (Oyer and Schaefer 2010). There is, however, a large literature in the Social Sciences - especially, in Industrial and Personnel Psychology- documenting firm's recruiting and selection practices. This literature reports substantial heterogeneity in firm recruiting

¹While the practical importance of hiring is underscored by the amount of resources that firms allocate to it, there is some evidence of its effect on firm performance. For instance, the importance of hiring practices, among a larger set of complementary HR practices, in workplaces dominated by team structures can be traced back to Ichniowski, Shaw and Prennushi (1997). See also Bloom and Van Reenen (2010) for an analysis of HR practices in empirical studies of productivity effects of management practices.

²The importance of person-organization or person-job fit has been recently documented in the economic literature (for an overview, see Oyer and Schaefer 2010). For instance, Lazear (2003) argues that worker's human capital is general and multidimensional, but firms differ in the value they attach to each dimension, implying that firms are horizontally differentiated in their preferences over workers. Hayes, Oyer and Schaefer (2006) find strong evidence of co-worker complementarity, supporting the claim that the "right" worker for a firm may depend on the firm's current workforce. Oyer and Schaefer (2012) provide further evidence of match specific productivity derived from co-worker complementarity.

³Typical selection techniques involve direct evaluation of applicants through a series of interviews (structured or unstructured), testing (e.g. psychometric, personality, intelligence), background and resume checks, "trial" periods aimed at measuring on-the-job performance, or situational judgment tests (SJTs) that study the subjects reaction to hypothetical business situations (see e.g. Gatewood, Feild and Barrick 2010).

practices and a stark variation in their propensity to adopt new, innovative selection techniques both across firms and across jobs.⁴ What are the factors determining the propensity of firms to, for instance, adopt a specific selection process, or to actively recruit applicants by providing information of its work environment?

Consider, for example, the efforts of a firm to screen applicants by subjecting them to a battery of tests. A basic tenet in hiring is that the main factor limiting a firm's pre-employment screening are the costly resources that need to be deployed to probe each applicant. That is, the firm would surely prefer a selection process that does not require more resources and yet is more informative of the candidate's match-specific productivity. Nevertheless, the lack of adoption of "more informative" selection methods, like personality tests, has been especially noted in this literature (see, e.g., Rynes et al. 2002, 2007), where this lack of adoption cannot be explained by implementation costs (Ones et al. 2007). One leading explanation is that applicants' perceptions of the selection process dictate their willingness to be evaluated (see Breaugh and Starke 2000 and Ryan and Ployhart 2000 for a general discussion), and these new selection methods may have an adverse effect on such perceptions.⁵

The aim of this paper is to clarify how the information available to each side of the market affects firms' hiring costs, and how it determines the profitability of different recruitment or selection activities.⁶ As in the literature reviewed in Breaugh and Starke (2000) and Ryan and Ployhart (2000), the starting observation is that a job-seeker's perception of both her match value and of the hiring process dictates her willingness to apply to a firm. In this paper I develop a model of firm hiring where the intensity of firms' screening dictates each applicant's private estimate of the probability of receiving an employment offer, and thus each applicant's propensity to apply for those jobs in the first place.⁷

Applicants perception of fit naturally leads to an interdependence between recruitment and selection: how firms screen applicants affects their likelihood of being hired, and thus their willing-

⁴The main findings regarding heterogeneity in the adoption of specific selection methods come from Terpstra and Rozell (1997), Van der Zee, Bakker and Bakker (2002) and Wilk and Capelli (2003).

⁵Alternative explanations offered in the literature are: (i) poor predictive power and low validity of new screening tests, in particular, personality tests (Morgeson et al 2007), (ii) a gap between theory and practice were practitioners fail to acknowledge and exploit the evidence in favor of these new screening tests (Rynes et al 2002, 2007), and (iii) legal impediments to the deployment of personality tests as they may result in adverse impact.

⁶The terms "recruitment" and "selection" in this follow their usage in the Human Resource and Industrial Psychology literature. Following Barber (1998, pp5-6), "recruitment includes those practices and activities carried on by the organization with the primary purpose of identifying and attracting potential employees". Selection is typically defined as the practices aimed at separating from a pool of applicants those who have the appropriate knowledge, skills and abilities to perform well on the job (Gatewood et al 2010).

⁷The fact that recruitment outcomes are driven by applicants estimate of their likelihood of gaining employment can be traced back in the Psychology Literature to expectancy theory as applied to HR (see e.g. Vroom 1964, Wanous 1980 and Barber and Roehling 1993).

ness to be recruited, while the composition of a self-selected applicant pool provides a firm with additional information when making hiring choices. As a result, to evaluate improvements in one area, say selection, a firm needs to consider also their effect on other areas, in this case in its ability to recruit applicants.

I consider situations where the posted wage is a worker's sole employment benefit, so that a job-seeker's willingness to incur the costs of application and evaluation will depend on the announced wage premium. This also means that a firm's hiring costs would increase whenever it expands its applicant pool by offering a higher wage premium. In particular, changes in the information available to each side of the market that dissuades applications indirectly increase hiring costs, as the firm would need to raise the wage to attract the same applicant pool. Therefore, when evaluating improvements in recruitment and selection, a firm must weigh this indirect cost with the direct benefit of improved information. We show, for example, that firms may fail to adopt seemingly costless screening tests for fear of dissuading applicants. Also, firms may avoid advertising the characteristics of the job/firm when applicants apply to the firm but are poorly informed of match value, or when they incur low application costs. In all these cases, the analysis shows that more informative advertising, or improved screening, can have subtle equilibrium effects on the size and composition of the applicant pool. For instance, a more discriminating interview may actually encourage more applications and expand the applicant pool.

To explore this interdependence between recruitment and selection I propose a stylized model with the following ingredients: (i) Match specificity: job-seekers differ in their productivity when employed by different firms. To simplify the analysis, I assume that there is one firm for which each job-seeker's productivity is initially unknown, while all job-seekers have the same productivity when matched with a group of alternative firms.⁸ (ii) Bilateral asymmetric information: prior to applying, each job-seeker obtains a noisy, private signal of her productivity when matched with the firm (her "type"), while the firm can evaluate an applicant (by subjecting her to an "interview") and generate a noisy signal of match value. (iii) Costly Search: both applicant and firm need to devote resources during the hiring process. Applicant's costs are borne at the time of application, while the firm incurs its costs initially when it allocates resources to interview applicants. (iv) Incomplete Contracting: The firm can neither condition payments on the results of the interview nor on whether the job-seeker actually incurred the application costs, but can commit to a "posted-

⁸We do not restrict the sources of match specificity, which can arise both from the characteristics of co-workers and the attributes of the firm/job that jointly shape the productivity of the worker in *that* firm. While one could further differentiate between worker-firm productivity and worker-job productivity (Kristof-Brown et al 2005), we will not explore this distinction here.

wage" schedule that specifies payments based on whether the applicant is evaluated and whether she is ultimately hired. Finally, the firm can costlessly generate a vacancy so that it will hire any applicant whose expected productivity exceeds the posted wage.

Underlying the equilibrium is a simultaneous Bayesian inference problem that both job-seekers and the firm must solve: prior to applying, each job-seeker needs to predict her hiring probability given her type and the firm's hiring rule, while an imperfect interview leads the firm to also consider the self-selected nature of the applicant pool when estimating match value. Therefore, both application decisions and hiring rules are endogenously determined, and we show that equilibria exhibit positive assortative matching and positive selection: all job-seekers with a high estimate of match value apply to the firm and high performers are hired (Proposition 1), while reductions in the wage improves the average quality of the applicant pool (Lemma 3).⁹

Matching frictions in our setup stem from incomplete contracting. Indeed, if a job-seeker's application costs were contractible, then the effect of applicants perceptions would disappear: the firm would simply compensate the applicant for her application costs and would offer a wage that matches her outside option, and the hiring outcome would be constrained efficient (Proposition 2). Thus the need to attract applications leads the firm to consider the quality of the applicant pool when setting the wage (Proposition 3).

In the analysis, I take a reduced form approach and assume that the effect of improving the hiring process is mainly informational: improved screening leads to a more informative interview, while improving recruitment simply means that job-seekers' estimate of match value is less noisy. The fact, then, that application and hiring decisions are jointly determined leads to subtle effects of more informative signals on the composition of the applicant pool. For instance, a more discriminating interview dissuades applications when the average quality of the applicant pool is either high or low, but actually encourages more applications for a mediocre applicant pool (Proposition 4). In contrast, the effect of improved recruitment is summarized by a quality threshold level such that activities that improve the information of job-seekers dissuades applications when the quality of the applicant pool is below this threshold, but encourages applications when it exceeds the threshold (Proposition 5)

As both the informativeness of job-seekers' signal and the interview affects the equilibrium applicant pool, the firm must consider both the direct effect of better information given the application and hiring decision, but also the indirect effect of a change in the size and quality of the

⁹This follows as each worker's match-specific productivity is independent of her outside opportunities. Alonso (2014) considers a model where match value is correlated with the applicant's outside option. This can lead to both positive and adverse selection in equilibrium.

applicant pool, when evaluating improvements in recruitment and selection. For instance, while a more informative (i.e. more discriminating) interview always reduces hiring mistakes, it can also dissuade applications. This reduces the incentives to improve screening, especially when the interview is already fairly informative (Proposition 6). Moreover, better informed job-seekers also face less uncertainty over their interview score. This may prove costly for the firm, however, when application costs are low as it may reduce the applicant pool (Proposition 7). Perhaps surprisingly, we show that the firm avoid advertising when a majority of poorly informed job-seekers apply to the firm. In this case, marginally improving their information may dissuade them from applying, although the application decision is still taken with little knowledge of match value.

The rest of the paper is structured as follows. The next section describes the model in Section 2. Section 3 and 4 analyzes the equilibrium application and hiring decisions, as well as the equilibrium wage. Section 5 provides the main comparative statics on the applicant pool and Section 6 discusses the firm's incentives to improve recruitment and selection. Section ?? considers several extensions of the basic analysis, and I conclude in Section 7. All proofs are in the Appendix.

2 The Model

Players: There is a continuum of job-seekers of unit mass. Job-seekers are risk neutral, protected by limited liability, and can seek employment in firm A or in any firm of a group of alternative, identical firms. Firm A (henceforth "the firm") can create a continuum of vacancies of mass one at no cost. A job-seeker has known productivity \underline{w} when employed by an outside firm, while her productivity θ when employed at the firm is a random variable that is i.i.d. across job-seekers and normally distributed, $\theta \sim N(0, 1/h_0)$. Competition for workers implies that a job-seeker can find employment at any time in any of those firms at a wage \underline{w} .¹⁰ The sources of match-specificity can range from the existence of worker-firm production complementarities (Hayes, Oyer and Schaefer 2006), heterogeneity in firm valuations of worker attributes (Lazear 2009), or even differences in beliefs and preferences of workers (Van den Steen 2005) (see Oyer and Schaefer 2010 for a general discussion). In this paper I focus on the effect on hiring outcomes of variability in match productivity across applicants for a single firm. This assumption leads to a tractable characterization of equilibrium, and allows a clear characterization of the returns to recruitment and screening. Alternatively, each worker's set of skill, knowledge and abilities may be similarly valued by different firms. In this case, the productivity when employed by the firm and a worker's

¹⁰Also, the value of leisure is strictly lower than \underline{w} for all job-seekers so that all job-seekers strictly prefer employment. This simplification is without loss of generality as the role of the group of alternative firms is to provide a homogeneous outside option to all applicants to firm A .

outside option will be correlated, inducing the standard adverse selection effect under asymmetric information.¹¹

Hiring Process: The hiring process is divided into three stages: application, evaluation, and hiring decision. At the application stage, job-seekers decide whether to apply to the firm. Any job-seeker that applies to the firm incurs a private cost c_A . Thus, if θ were commonly observed by all market participants, $\theta - \underline{w} - c_A$ is the surplus generated by a θ -worker when employed at the firm and efficient matching would have job-seekers with $\theta \geq \underline{w} + c_A$ matching with the firm. Conversely, if parties cannot obtain any information regarding θ , then all job-seekers should match with the firm if $\underline{w} + c_A < 0 (= E[\theta])$, while all job-seekers would match with outside firms if $\underline{w} + c_A > 0$. Prior to submitting her application, a job-seeker receives a private signal s_A that is informative of θ , where s_A/θ is normally distributed, $s_A/\theta \sim N(\theta, 1/h_A)$, with h_A the precision of a job-seeker's private assessment of θ .¹²

The evaluation stage ("interview") can be thought of as a statistical experiment in which the firm obtains information about an applicant's θ through a series of tests. While, admittedly, there are other stages of the hiring process where both applicants and firms bear costs,¹³ we assume that the firms's costs of evaluation are sunk at the interview stage. In particular, if the firm decides to evaluate a measure K of applicants ("interview capacity") it incurs cost $C(K)$ ¹⁴. The timing assumption on the firm's costs matches the observation that in practice firms need to design ahead of time the tests to which applicants will be subjected, determine the number of recruiters available for interviews, etc...given their expectations of the size and quality of the applicant pool. The result of each interview is summarized in a signal s_F , which is privately observed by the firm, and is correlated with θ according to $s_F/\theta \sim N(\theta, 1/h_F)$. Thus h_F is the precision with which the firm can evaluate an applicant's match-specific productivity.

An important aspect of our model is that both applicants and the firm find it costly to generate a productive match. We follow Pissarides (2009) in arguing that these matching costs derive both from the value of the foregone opportunities and from the resources devoted to discover and bargain

¹¹The effect of correlation in the job-seekers productivity across firms is explored in Alonso (2014).

¹²In some cases, job-seekers assessment of her suitability for a job is fully embodied in certifiable credentials. In reality, however, the beliefs and views of applicants about their match productivity cannot be described in a verifiable fashion, that is, as in our case, they are "soft" information. In general, "high bandwidth" information that is difficult to describe and encode is typically privately known by applicants (Autor 2001).

¹³In particular firms must commit resources to identify job openings and requirements, as well as to advertising and screening of workers. Applicants, on the other hand, typically incur application costs, as well as evaluation costs during the interview phase, ranging from psychic costs associated with intense scrutiny, their opportunity cost of time or effort costs necessary to perform during the interview (for instance when the "interview" is a probationary period).

¹⁴Our main focus will be on $C(K) = 0$ for all K . We consider the impact of positive evaluation costs by the firm in Section 8.

over match surplus. Importantly, I argue that not only the firm devotes resources to evaluate, train or bargain with applicants, but also applicants need to invest time and resources to train for the firm's selection process, comply with the requisite credentials, cover the administrative application costs, and ultimately engage actively in the interview process. To simplify the exposition, I consider all these costs to be homogenous across job-seekers and equal to c_A .¹⁵

This model of the hiring process shares several parallels with the literature on employer search where employers have two dimensions on which to scale their search efforts (see e.g. Rees 1966 and Barron, Bishop and Dunkelberg 1985): employers can decide the number of applicants to evaluate (extensive margin) and the extent to which each applicant is evaluated (intensive margin). In this paper, the extensive margin is given by the interview capacity K while the intensive margin is given by the precision of the firm's assessment h_F . In the analysis, however, the firm is endowed with an evaluation technology characterized by $(C(K), c_A, h_F)$. Therefore only the extensive margin is determined in equilibrium, while our main results concern the firm's marginal returns to improving the intensive margin.

In the model firms screen applicants in order to avoid unsuitable matches. Typically, firms also learn progressively about match value once the worker is employed, and could limit the impact of adverse matches by terminating the employment relationship (Jovanovic 1979).¹⁶ The literature has shown that these two informational sources of match value act as substitutes (Pries and Rogerson 2005), so that firms that find it relatively easy/costless to learn about match value from on-the-job performance are less willing to invest in pre-employment screening. We could incorporate the effect of on-the-job learning about match value by reducing the adverse impact of bad matches on the firm by imposing a lower bound on the match-specific productivity. While this will affect the incentives of the firm to submit applicants to an interview, our main qualitative results regarding the marginal value of screening will also hold in this more general case.¹⁷

Informational content of private signals: It will prove convenient to normalize the signals s_A

¹⁵This assumption simplifies the inference problem of the firm and allows a simple characterization of the equilibrium simultaneous bayesian inference problem. Alonso (2014b) considers a model where applicants face different (private) application costs, but their signal s_A is embodied in her credentials and thus certifiable. Even if the firm could pay each job-seeker an "application fee", similar results would obtain in terms of the returns to improved recruitment and selection.

¹⁶Indeed, the ability of firms to learn about the worker's productivity gradually and terminate unsuitable matches provides firms with an incentive to prefer "risky workers" where the uncertainty over match value is higher (Lazear 1995).

¹⁷For instance, suppose that on-the-job learning allows the firm to terminate prior to production matches whose value θ fall below some value M , so that, effectively, on the job productivity is $\max\{\theta, M\}$. In this case, the same comparative statics of Section 6 will hold (albeit in a different parameter range).

and s_F in terms of the posterior means that they induce. Thus let v_i be

$$v_i = E[\theta|s_i] = \frac{h_i}{h_0 + h_i} s_i,$$

with ex-ante distribution $v_i \sim N(0, \sigma_{v_i}^2)$ where $\sigma_{v_i}^2 = \frac{h_i}{h_0(h_0+h_i)}$, $i \in \{A, F\}$. We will refer to v_A as the applicant's "type" and v_F as the interview "score".

This specification has two advantages. First, changes in h_i $i \in \{A, F\}$, have no effect on how a given v_i is interpreted as a predictor of θ since $E[\theta|v_i] = v_i$. If the firm had no additional information, hiring decisions based on expected productivity will depend solely on v_F , regardless of the interview's precision. Second, increases in the precisions h_i , $i \in \{A, F\}$, lead to a higher variance of the signals v_i , $i \in \{A, F\}$, which is consistent with the fact that more informative signals lead to a higher dispersion of posterior expectations.¹⁸

A key feature of our model is that the private evaluations v_A and v_F are correlated, thus allowing for both the estimation of the applicant's type from the interview score and the applicant's prediction of the interview score given her type. As the (linear) correlation coefficient ρ between v_A and v_F is

$$\rho^2 = \frac{h_F}{h_0 + h_F} \frac{h_A}{h_0 + h_A}, \quad (1)$$

we have the following mean and variance when estimating v_i from v_j , $i, j \in \{A, F\}, i \neq j$,

$$\begin{aligned} E[v_i|v_j] &= \frac{h_i}{h_0 + h_i} v_j, \\ \sigma_{v_i|v_j}^2 &\equiv \text{Var}[v_i|v_j] = (1 - \rho^2) \sigma_{v_i}^2 = \left(\frac{h_i}{h_0 + h_i} \right)^2 \left(\frac{1}{h_0 + h_j} + \frac{1}{h_i} \right). \end{aligned} \quad (2)$$

Contracts: We take an incomplete contracting view of the hiring process in that the firm can only commit to payments based on whether the applicant is hired. Implicit is the assumption that both the applicant's type and the interview score are privately observed (i.e. they are "soft" information) and contracts cannot be written directly on these values. This implies, for instance, that the firm cannot contractually commit to base hiring decisions on the interview score in arbitrary ways. Also, I assume that the firm cannot condition payments on whether the applicant has incurred the necessary application costs and is ready to be evaluated. Informally, if the firm pays each individual for simply "showing up", all individuals would apply and receive such payment, even if they prefer to afterwards be evaluated elsewhere.

As job-applicants cannot be directly compensated for their costs, the firm would need to make employment sufficiently desirable in order to attract applications. To do so, we assume that the

¹⁸For instance, Ganuza and Penalva (2010) derive a series of informational orders based on the dispersion of conditional expectations, where, for the class of decision problems considered, a more informative signal induces a higher dispersion in posterior expectations.

firm can ex-ante commit to a "posted-wage" schedule (w_E, t_E) , where w_E is the wage to be paid to a hired applicant, and t_E is a transfer paid to each applicant regardless of whether she is ultimately hired. Our limited liability assumption translates in this case to $t_E \geq 0$.

Timing and Equilibrium: The model is static and considers matching in a single period. The firm is endowed with an evaluation technology $(C(K), c_A, h_F)$ and sets the parameters of the hiring process: (i) the wage schedule (w_E, w_N, t_E) , and (ii) the interview capacity K . Job-seekers learn their type v_A and, after observing (w_E, t_E) and K , decide to apply to the firm. Given the mass of applicants, the firm decides whether to submit each applicant to an interview, and decides whether to extend an employment offer, paying $w_E + t_E$ to a hired applicant and t_E if it does not extend an employment offer. Independent of whether they are evaluated or not, applicants that do not receive an employment offer, or reject an employment offer, can costlessly find employment at any of the identical firms that pay \underline{w} . Finally, payoffs are realized and the game ends.

The notion of equilibrium is Perfect Bayesian Equilibrium. Given our assumptions on job-seekers we can directly establish that in equilibrium $t_E = 0$. Indeed, as any applicant can guarantee herself at least a payoff of $t_E + \underline{w}$ if evaluated by applying without incurring the application costs, if $t_E > 0$ all job-seekers would strictly prefer to apply to the firm, even if they believe to be a poor match. Therefore, equilibrium contracts are characterized by the posted wage w_E .

3 Equilibrium Hiring and Application Decisions

We start the analysis by characterizing the application and hiring choices in a subgame where the firm posts wage w_E and sets an interview capacity K . For simplicity, our results in Sections 4-7 are derived for the case where the firm incurs no costs of evaluating a mass K of applicants, i.e. $C(K) = 0$ for all K . We complete the analysis by considering a costly extensive margin in Section ??.

We solve for an equilibrium by backward induction. We first derive the firm's sequentially rational hiring rule after evaluating an applicant. The firm optimally sets a "hiring standard", that depends on the composition of the applicant pool, and hires any applicant whose interview score exceeds it. Anticipating the firm's hiring standard and interview decision, we then determine a job-seeker's application decision as a function of her type.

3.1 Firm's Hiring Decision

Suppose that all job-seekers with types v_A in the set A apply to the firm.^{19,20} As v_A is correlated with θ , the firm has two informative signals of match-specific productivity following an interview: the interview score v_F , and the fact that the job-seeker chose to apply to the firm, $v_A \in A$. The firm's inability to contractually condition hiring outcomes on v_F implies that under any sequentially rational hiring rule the firm rejects every applicant whose expected productivity, as given by $E[\theta|v_F, v_A \in A]$, falls short of the cost of hiring, as giving by the wage w_E , while it offers employment to every applicant whose expected productivity exceeds w_E . The following lemma shows that, regardless of the application decision, the firm always adopts a threshold hiring rule.

Lemma 1. *For each measurable set A there exists $\underline{v}_F(A)$ such that, after interviewing an applicant of type $v_A \in A$, the firm extends an employment offer if and only if $v_F \geq \underline{v}_F(A)$. The hiring standard $\underline{v}_F(A)$ satisfies*

$$E[\theta|\underline{v}_F(A), v_A \in A] = w_E. \quad (3)$$

To understand the firm's updating, and thus its hiring decision, in our setup with joint normality of match value and signals, suppose first that the applicant's type could be credibly disclosed (i.e. v_A is "hard" information). Then the firm would simply weigh each signal to obtain

$$E[\theta|v_F, v_A] = \frac{h_0 + h_F}{h_0 + h_F + h_A}v_F + \frac{h_0 + h_A}{h_0 + h_F + h_A}v_A. \quad (4)$$

When the applicant's type is "soft", however, the firm needs to solve a Bayesian filtering problem as the interview score v_F provides both a direct estimate of θ , and also an estimate of the applicant's actual type v_A given the "application signal" $\{v_A \in A\}$. Therefore, the firm's estimate becomes

$$E[\theta|v_F, v_A \in A] = \frac{h_0 + h_F}{h_0 + h_F + h_A}v_F + \frac{h_0 + h_A}{h_0 + h_F + h_A}E[v_A|v_F, v_A \in A]. \quad (5)$$

The statement in Lemma 1 that hiring decisions satisfy a cut-off rule then follows from the observation that, as v_F and v_A satisfy the MLRP with θ , they also satisfy the same property among them (Karlin and Rubin, 1956). Therefore, for any set A , the filtering term $E[v_A|v_F, v_A \in A]$ is non-decreasing in the interview score -a better score leads to a more optimistic revision of the

¹⁹As we consider a model with a continuum of job-seekers, the measurability of equilibrium strategies and computation of firm's profits may potentially be an issue. However, job-seekers' choices are finite (to apply to the firm or take her outside option). Moreover, given the structure of our game, we can construct equilibria that are well behaved such that the firm can indeed compute expectations over job-seeker's choices and types. Hence, there is no loss in assuming that A is a Borel measurable set in \mathbb{R} .

²⁰We need not worry about possible mixing by job-seekers as given our assumptions on the signal structure and optimal behavior by the firm, job-seekers have a strict preference on applications with probability 1.

applicant's type-. As a result, $E[\theta|v_F, v_A \in A]$ strictly increases in v_F both because a higher interview score implies a higher expected match value, and a higher interview score identifies a higher applicant type. Finally, the existence of a "hiring standard" $\underline{v}_F(A)$ satisfying (3) is ensured as the unbounded support of v_F implies that $E[\theta|v_F, v_A \in A]$ can take any value in \mathbb{R} .

3.2 Job-seeker's Application Decision

Given the firm's hiring standard (3), which job-seekers would be willing to apply if the firm interviews all applicants? As v_F and v_A are correlated, each job-seeker faces a prediction problem -to estimate the likelihood of meeting the firm's hiring criteria given her type-. In general, arbitrary hiring rules may deter applications from "strong" job-seekers with a high estimate of θ but attract "weak" job-seekers with lower estimates. However, as the firm's equilibrium hiring decision follows a cut-off rule, a job-seeker's application decision will also be monotone in her type.

Lemma 2. *Suppose that $w_E > \underline{w} + c_A$ and the firm only hires after evaluating the applicant. Then, for any threshold hiring standard \underline{v}_F there exists a marginal type $\underline{v}_A(\underline{v}_F)$ such that a job-seeker of type v_A applies to the firm iff $v_A \geq \underline{v}_A(\underline{v}_F)$, where $\underline{v}_A(\underline{v}_F)$ satisfies*

$$(w_E - \underline{w}) \Pr[v_F \geq \underline{v}_F | v_A(\underline{v}_F)] = c_A. \quad (6)$$

Recall that in our setup any rejected applicant can immediately secure employment elsewhere at a wage \underline{w} . The left hand side of (6) thus captures the expected incremental benefit for a type- v_A job-seeker of gaining employment at the firm. To evaluate this benefit, an applicant needs to predict the likelihood of meeting the hiring standard after being interviewed, i.e. estimate $\Pr[v_F \geq \underline{v}_F | v_A]$. As v_F and v_A satisfy the MLRP, then $\Pr[v_F \geq \underline{v}_F | v_A]$ is increasing in the applicant's type and, as all applicants incur the same application cost, the expected gain from applying to the firm also increases in v_A . Therefore, the firm's threshold hiring rule induces a monotone application rule as all types $v_A > \underline{v}_A(\underline{v}_F)$ apply to the firm, where the marginal type $\underline{v}_A(\underline{v}_F)$ obtains no expected rent from applying and satisfies (6).

3.3 Equilibrium Application and Evaluation

Contractual incompleteness of the hiring process constraints the firm's behavior in two ways. First, as explained in Lemma 1, the firm cannot commit to arbitrary hiring rules -it will only hire those whose expected productivity exceed the posted wage-. In particular, all applicants that are interviewed face a positive probability of being rejected. Second, non-contractibility of the interview itself implies that: (i) the firm cannot commit to skip the interview of applicants, and (ii) the firm

cannot pay different wages to those applicants hired without an interview. As wages don't vary with the interview and interviewing is costless for the firm, then, for any posted wage w_E , the firm will interview all applicants. There are situations, however, where the firm would certainly benefit from not interviewing applicants. For instance, if job-seekers have very precise estimates of match value (high h_A) and the firm's interview is very noisy (low h_F), the firm could post a wage $w_E = \underline{w} + c_A$ and hire all applicants without interview. As all job-seekers are then indifferent between applying to the firm or elsewhere, if the firm could avoid interviewing applicants, then an equilibrium exists in which only types $v_A \geq w_E$ apply and are hired. In Section ?? we explore this possibility by considering the case in which the interview itself is contractible.

The certainty of an interview implies that employment is not guaranteed and each applicant expects to be rejected with positive probability. Therefore Lemma 2 applies, and only those job-seekers that are sufficiently confident of meeting the firm's (endogenous) hiring standard will incur the application cost c_A .

Proposition 1 (Equilibrium Evaluation and Hiring). *For each $w_E > \underline{w} + c_A$, the unique sequentially rational continuation equilibrium is described by a type \underline{v}_A such that only types $v_A \geq \underline{v}_A$ apply to the firm. The firm evaluates all applicants and hires an applicant iff $v_F \geq \underline{v}_F$. The marginal applicant \underline{v}_A and the hiring standard \underline{v}_F are the unique solution to*

$$E[\theta | \underline{v}_F, v_A \geq \underline{v}_A] = w_E, \quad (7)$$

$$(w_E - \underline{w}) \Pr[v_F \geq \underline{v}_F | \underline{v}_A] = c_A. \quad (8)$$

In summary, for any posted wage $w_E > \underline{w} + c_A$, all job-seekers that believe to be a good match apply to the firm ($v_A \geq \underline{v}_A$) and are subject to an interview, but only the top performers are hired ($v_F \geq \underline{v}_F$), where \underline{v}_A and \underline{v}_F solve simultaneous Bayesian inference problem (7-8). We now describe in more detail this inference problem by looking separately at the firm's filtering and applicant's prediction problems. We defer the analysis of comparative statics wrt the precision of signals to Section 5.

Filtering Problem. Consider first the firm's filtering problem. In our jointly normal framework we have that $v_A | v_F \sim N\left(E[v_A | v_F], \sigma_{v_A | v_F}^2\right)$, where $E[v_A | v_F]$ and $\sigma_{v_A | v_F}^2$ are given by (2). Therefore, an applicant randomly drawn from a pool $\{v_A : v_A \geq \underline{v}_A\}$ whose test result is v_F is expected to be of type

$$E[v_A | v_F, v_A \geq \underline{v}_A] = \frac{h_A}{h_0 + h_A} v_F + \sigma_{v_A | v_F} h \left(\frac{\underline{v}_A - E[v_A | v_F]}{\sigma_{v_A | v_F}} \right),$$

where h is the hazard rate of a standard Normal.²¹ Combining this expression with (5), the firm's ex-post evaluation is

$$E[\theta|v_F, v_A \geq \underline{v}_A] = v_F + \frac{h_0 + h_A}{h_0 + h_F + h_A} \sigma_{v_A|v_F} h \left(\frac{v_A - E[v_A|v_F]}{\sigma_{v_A|v_F}} \right). \quad (9)$$

That is, the firm will correct its initial assessment of the candidate, as given by v_F , by an amount that depends on the difference between the marginal applicant and the firm's expectation of the applicant's type given v_F , $\underline{v}_A - E[v_A|v_F]$. This filtering effect disappears both when the applicant pool is non-selective and when it is very selective. First, if all applicants apply, so that \underline{v}_A tends to $-\infty$, then (9) simply becomes v_F , that is, the firm disregards the application signal when applications do not discriminate among job-seekers. Second, if the applicant pool becomes very selective, so that \underline{v}_A tends to ∞ , then (9) converges to

$$E[\theta|v_F, v_A \geq \underline{v}_A] \approx \frac{h_0 + h_F}{h_0 + h_F + h_A} v_F + \frac{h_0 + h_A}{h_0 + h_F + h_A} \underline{v}_A. \quad (10)$$

That is, when the applicant pool is very selective, the firm updates as if it faces no uncertainty about the applicant's type (and their type equals the marginal applicant).

It is also instructive to compare (9) to the case when the applicant's type is observable by the firm, as given by (4). From (4), the sensitivity of the firm's posterior expectation with respect to v_F is independent of the type of applicant. This is no longer true when v_A is unobservable as the firm tries to infer v_A from the interview score. In fact, twice differentiating (9) establishes that both pieces of information act as substitutes, in the sense that

$$\frac{\partial^2 E[\theta|v_F, v_A \geq \underline{v}_A]}{\partial v_F \partial \underline{v}_A} \leq 0.$$

Thus the firm's posterior expectation becomes less responsive to the interview score as the applicant pool becomes more selective. The intuition for this result is that a more selective applicant pool (higher \underline{v}_A) is also a "more informative" applicant pool, as the firm faces less uncertainty regarding the type of a randomly chosen applicant.²² Therefore, the firm puts more weight on the update term in (9) as \underline{v}_A increases. In summary, we can write (7) as

$$\underline{v}_F + \frac{h_0 + h_A}{h_0 + h_F + h_A} \sigma_{v_A|v_F} h \left(\frac{v_A - E[v_A|\underline{v}_F]}{\sigma_{v_A|v_F}} \right) = w_E. \quad (11)$$

²¹This expression follows from the expression for the truncated expectation of normal distribution of mean μ and variance σ $E[x|x \geq a] = \mu + \sigma h \left(\frac{a-\mu}{\sigma} \right)$.

²²This result is immediate in our case as the hazard rate of a normal distribution increases without bound, so that a randomly chosen applicant from a pool $\{v_A \geq \underline{v}_A\}$ is increasingly likely to be close to the marginal type \underline{v}_A as \underline{v}_A increases. Therefore, this result would then be true whenever the underlying distribution has an increasing and unbounded hazard rate.

Prediction Problem. We now turn to the applicant's prediction problem. The conditional distribution of v_F given v_A is $v_F|v_A \sim N\left(E[v_F|v_A], \sigma_{v_F|v_A}^2\right)$, where $E[\underline{v}_A|\underline{v}_F]$ and $\sigma_{v_A|v_F}^2$ are given by (2). Therefore condition (7) translates to

$$\underline{v}_F - E[v_F|\underline{v}_A] = -\sigma_{v_F|v_A} \Phi^{-1}\left(\frac{c_A}{w_E - \underline{w}}\right) \quad (12)$$

That is, the difference between the firm's hiring standard and the expected score of the marginal applicant is proportional to the variance the applicant faces over the interview score. This is intuitive: if $c_A/(w_E - \underline{w}) < 1/2$, so the marginal applicant is more likely to fail the interview than to pass it, a "less predictable" interview (i.e. one with a higher $\sigma_{v_F|v_A}$) increases the option value of applying and would lower \underline{v}_A , all else equal. Conversely, if $c_A/(w_E - \underline{w}) > 1/2$, so that the marginal applicant is more likely to pass the interview, higher $\sigma_{v_F|v_A}$ would, ceteris paribus, dissuade applications and increase \underline{v}_A .

Figure 1 depicts graphically the equilibrium hiring standard and application decision of Proposition 1. To understand Figure 1 define $b_A(v_A, p)$ as

$$\begin{aligned} b_A(v_A, p) &= \max\{\underline{v}_F : \Pr[v_F \geq \underline{v}_F|v_A] \geq p\} \\ &= E[v_F|v_A] + \sigma_{v_F|v_A} \Phi^{-1}(p), \end{aligned} \quad (13)$$

that is $b_A(v_A, p)$ is the maximum hiring standard that a type- v_A job-seeker would pass with probability at least p . Let also $b_F(\underline{v}_A, w)$ be the firm's optimal hiring standard (3) in response to an applicant pool $\{v_A : v_A \geq \underline{v}_A\}$ and a wage w , that is

$$E[\theta|b_F(\underline{v}_A, w), v_A \geq \underline{v}_A] = w. \quad (14)$$

Then the equilibrium (7-8) is the unique intersection of the functions $b_A(v_A, \frac{c_A}{w_E - \underline{w}})$ and $b_F(v_A, w_E)$. Figure 1 also shows the optimal hiring rule if the applicant's type is certifiable. As it is intuitive, unobservability of v_A raises the probability that lower types are hired but reduces that of higher types. Finally, uniqueness of equilibrium follows from the fact that the firm's hiring standard b_F is decreasing in the quality of the applicant pool (and hence decreasing in \underline{v}_A), while the hiring standard that an applicant is willing to beat b_A increases in her type.

XXX INSERT FIGURE 1 HERE XXX

4 The Wage as a Recruitment and Selection Tool

The firm's recruitment efforts can be based on three dimensions: (i) more intense advertising of its vacancies, (ii) more informative advertising of job/firm characteristics, and (iii) making the job

more appealing to prospective applicants. In our model, job appeal is embodied in the posted wage w_E . We now characterize the equilibrium wage w_E given the hiring and application decisions described in Proposition 1. To better understand the implications of incomplete contracting in our model, we first study a benchmark case in which job-seeker's applications costs can be contractually covered by the firm.

4.1 Benchmark: Contractible Application Costs

Suppose that the firm can condition payments on whether the applicant incurred the application costs. The firm then offers a contract (c, w_C) to each applicant, which pays c if the applicant incurred the costs c_A , and, additionally, a wage w_C if the candidate is hired. The following proposition summarizes the properties and comparative statics of equilibrium in this case.

Proposition 2 (Contractible Applicant Costs) *There exists a unique PBE of the game in which application costs are contractible: the firm offers a contract $(c, w_C) = (c_A, \underline{w})$, all job-seekers of type $v_A \geq \underline{v}_A^C$ apply to the firm and those with interview scores $v_F \geq \underline{v}_F^C$ are hired. The marginal type \underline{v}_A^C and the hiring standard \underline{v}_F^C solve*

$$E[\theta - \underline{w} | \underline{v}_A^C, v_F \geq \underline{v}_F^C] \Pr[v_F \geq \underline{v}_F^C | \underline{v}_A^C] = c_A, \quad (15)$$

$$E[\theta | \underline{v}_F^C, v_A \geq \underline{v}_A^C] = \underline{w}. \quad (16)$$

If application costs are contractible, the firm will optimally cover them and pay a wage that matches the applicant's outside option. That is, match specificity will not translate into wage dispersion if application costs can be directly covered by the firm. To see that the contract (c_A, \underline{w}) is optimal note that all applicants obtain no rents from applying to the firm. Also, there is no ex-post distortion in the hiring decision given the available information to the firm: the firm hires the applicant as long as the expected surplus from matching is positive. This follows as the hiring standard in this case satisfies (16).

The marginal applicant \underline{v}_A^C and hiring standard \underline{v}_F^C are then given by the joint solution to (15) and (16). First, (15) implies that the firm obtains a zero profit when evaluating the marginal applicant. This condition is necessary for an equilibrium - if expected profit exceeds the application costs the firm can raise the wage in order to attract more applicants, while if expected profit falls below the application costs the firm can lower its application subsidy c (and increase the wage) to dissuade applications. Second, (16) is the sequentially rational hiring standard given the marginal applicant that the firm attracts.

The solution to (15) and (16) can be compared to the equilibrium conditions that we derive below in Proposition 3. In Proposition 2 the firm still needs to infer the applicant's type from the interview score. Note, however, that all applicants are indifferent, once the application costs are covered, between being hired by the firm at wage \underline{w} or securing their outside option. One then would argue that the absence of incentive conflicts could lead to truthful disclosure of v_A . That is indeed the case: there is an equilibrium with costless communication after the application but before the hiring decision in which the applicant truthfully reports her type to the firm. In this case, there is no inefficiency in matching as hiring decisions are ex-post optimal and make use of all available information to the parties. Therefore, non-contractibility of application costs also implies that information is lost as it cannot be credibly disclosed by the applicant to the firm.

4.2 Limits to the wage as a recruitment tool.

When application costs are not contractible, the wage w_E plays a dual role as it not only motivates job-seekers to incur the costs c_A , but also induces an ex-ante sorting of applicants, as only those confident of being a good match are willing to apply in the first place.²³ The first role implies that low wages $w_E < \underline{w} + c_A$ are ineffectual in recruiting applicants. However, the firm's inability to commit to arbitrary hiring rules limits the efficacy of the wage in its second role. Indeed, Lemma 3 shows that high wages are undesirable as increasing them may actually dissuade applications.

Lemma 3. *Let $\underline{v}_A(w_E)$ be defined by (7) and let w_{\max} be the unique solution to $d\underline{v}_A/dw_E|_{w_E=w_{\max}} = 0$. Then the equilibrium posted wage w_E satisfies*

$$\underline{w} + c_A < w_E < w_{\max}.$$

Lemma 3 follows from the observation that increasing w_E has two countervailing effects on an applicant's behavior. To be sure, a higher wage makes employment more desirable. A higher wage, however, increases the hiring cost for the firm, leading to a higher hiring standard, and thus raising the probability that the marginal applicant fails the interview. The proof of Lemma 3 shows that the first effect dominates for low wages, while the second effect dominates for high wages. In other words, increasing the wage w_E above w_{\max} actually increases the marginal type \underline{v}_A , and thus reduces the number of applications. This implies that there is a lower wage that attracts the same

²³More precisely, with homogenous evaluation costs, the firm will attract applicants that believe have a high probability of exceeding the hiring standard. However, in our model with unbiased assessments by both firms and applicants, applicants with a high private estimate of match value will also believe it to be more likely to exceed any hiring threshold. This is not true, however, when we consider the role of overconfidence in Section 8.

applicant pool at a lower cost, and thus wages that dissuade applications are dominated and would never be posted in equilibrium.²⁴

4.3 Equilibrium Wage

Facing a continuum of job-seekers, the firm's expected profit is the product of the total mass of applicants and the expected match surplus of a hired applicant. If all applicants are evaluated, this is formally equivalent to

$$\begin{aligned}\Pi &= (1 - F(\underline{v}_A))E[\theta - w_E | v_F \geq \underline{v}_F, v_F \geq \underline{v}_A] = \int_{-\infty}^{\infty} \int_{\underline{v}_F}^{\infty} \int_{\underline{v}_A}^{\infty} (\theta - w_E) dF(\theta, v_A, v_F) \\ &= \int_{-\infty}^{\infty} (\theta - w_E) \Phi[z_A(\theta, \underline{v}_A)] \Phi[z_F(\theta, \underline{v}_F)] dF(\theta),\end{aligned}\quad (17)$$

with Φ the cdf of a standard normal distribution, and $z_i(\theta, \underline{v}_i) = \sqrt{h_i}[\theta - \underline{v}_i(h_i + h_0)/h_i]$, $i = A, F$. Expression (17) shows that the hiring process is, in our case, a joint detection problem: employment occurs only if a job-seeker is aware of being a sufficiently good match and applies (which occurs with probability $\Phi[z_A(\theta, \underline{v}_A)]$), and whether the interview uncovers a good fit, (which, independently of the application decision, would occur with probability $\Phi[z_F(\theta, \underline{v}_F)]$ for a randomly chosen job-seeker).

The firm behaves as a standard monopsonist when setting the wage: by raising the wage (within the limits established in Lemma 3) it attracts more applicants but increases the wage bill. The following proposition describes the properties of the optimal posted wage.

Proposition 3 (Optimal Posted Wage) *If the firm faces no direct costs of evaluating applicants, then the optimal wage w_E^* satisfies*

$$\frac{\Pr[v_F \geq \underline{v}_F, v_A \geq \underline{v}_A]}{\Pr[v_F \geq \underline{v}_F, \underline{v}_A]} = E[\theta - w_E^* | v_F \geq \underline{v}_F, \underline{v}_A] \left(-\frac{dv_A}{dw_E} \right) \Big|_{w_E=w_E^*}.\quad (18)$$

In particular,

(i) The wage w_E^* and $\Pr[v_F \geq \underline{v}_F | v_A]$ are non-decreasing in c_A .

(ii) Let \underline{v}_A^0 be such that

$$E[\theta - \underline{w} | v_F \geq \underline{v}_F, \underline{v}_A^0] = 0\quad (19)$$

$$E[\theta - \underline{w} | v_A \geq \underline{v}_A^0, \underline{v}_F] = 0\quad (20)$$

Then

$$\lim_{c_A \rightarrow 0} \underline{v}_A = \underline{v}_A^0.$$

²⁴To be precise, this is true as $\underline{v}_A(w_E)$ is continuous and unbounded as $w_E \rightarrow \underline{w}$, for any wage above $w_E > w_E^{\max}$.

The optimality condition (18) follows from applying the envelope theorem to the firm's sequentially rational hiring rule. The firm will never set a wage such that the marginal applicant, conditional on being hired, is a bad match. Indeed, from (18) it readily follows that $E[\theta - w_E^* | v_F \geq \underline{v}_F, \underline{v}_A] > 0$. Also, by comparing (18) to the case of contractible costs (15), it is clear that non-contractibility of application costs leads the firm to attract and evaluate too few applicants.

Proposition 3-i shows that as application costs increase, the firm increases the wage premium but attracts a more selective applicant pool. This last point is a consequence of the ratio $c_A/(w^* - \underline{w})$ being monotone in c_A , implying that the probability that the marginal applicant is hired increases in c_A . Thus the marginal applicant is more confident of passing the test for higher costs which necessarily requires an increase in \underline{v}_A .

Proposition 3-ii shows that vanishing evaluation costs would not lead the firm to attract and evaluate all job-seekers. In particular, the firm does not attract any job-seeker with $v_A < \underline{v}_A^0$ when $c_A > 0$. Indeed, establishing a finite marginal applicant has two effects. First, it reduces the probability that the firm benefits from a good match as it lowers the probability of hiring. Second, however, it increases the information available to the firm as the applicant pool is more selective. The conditions (19-20) jointly determine the lowest type of applicant \underline{v}_A^0 that the firm would be willing to attract. In particular, \underline{v}_A^0 is such that the firm generates no profit when hiring an applicant of type \underline{v}_A^0 after an interview and following an optimal hiring rule performed under ignorance of the applicant's type (20).²⁵

Equilibrium implications of match specificity We end this section by discussing two important properties of our model of person-to-job/organization fit: equilibrium exhibits assortative matching and positive selection.

By assortative matching I mean that better candidates (for the firm) apply and better performers are hired.²⁶ This, of course, is a consequence of the assumption that all job-seekers share the same

²⁵If applications are truly costless, i.e. $c_A = 0$, then, as in the case of contractible costs the firm could offer a wage \underline{w} and job-seekers are indifferent between applying to the firm and applying elsewhere. As employment in the firm generates no rents, there is an equilibrium in which job-seekers can truthfully communicate their private type v_A . In this equilibrium, moreover, the firm is willing to evaluate all job-seekers. However, truthful communication of v_A disappears for any $c_A > 0$ as the firm needs to pay a wage premium $w^* > \underline{w}$ to attract applicants.

²⁶Notice that we need to accommodate the notion of assortative matching to our decentralized, sequential screening process where first job-seekers decide whether to match (after observing v_A) and then the firm decides which matches to keep and which to sever (after observing v_F). In this case it is possible that applicants with expected match value $E[\theta | v_A, v_F]$ are rejected (because $v_F < \underline{v}_F$) while applicants with $E[\theta | v'_A, v'_F] < E[\theta | v_A, v_F]$ with lower match value are accepted (because $v'_F > \underline{v}_F$). Following Smith (2011), our equilibrium is assortative in the sense that if (v_A, v_F) are hired and (v'_A, v'_F) are also hired, then $(\max\{v_A, v'_A\}, \max\{v_F, v'_F\})$ must also be hired, and if (v_A, v_F) are not hired (because they don't apply or, having applied, they don't meet the hiring standard) and (v'_A, v'_F) are also not hired, then $(\min\{v_A, v'_A\}, \min\{v_F, v'_F\})$ must also be hired

does not imply that all applicants with high match value when all information available is used apply and are hired.

productivity when employed elsewhere. Trivially, a constant productivity implies that match value is independent across firms: knowing the match value θ provides no additional information about match value elsewhere.

A consequence of the independence of value across firms is that the model exhibits positive selection, in the sense that worsening the terms of trade, by reducing the wage,²⁷ can only improve the quality of the applicant pool. This of course will not be true if matches with higher synergies also have greater outside options.²⁸

5 Effect of More Informative Signals on the Applicant Pool.

One of the implications of this model of hiring is that a firm may find it profitable to target job-seekers that are less knowledgeable of their match-specific productivity, or to adopt noisier interviews. To derive this result we first analyze in this section the equilibrium effect on applications of a less noisy interview (higher h_F) or of better informed applicants (higher h_A). To simplify the exposition, we first abstract from the effect on equilibrium wages by studying the change in the application and hiring decision for a fixed wage.²⁹

5.1 Abstract Simultaneous Inference Problem

Consider the following abstract simultaneous inference problem

$$E[\theta | \underline{v}_F, v_A \geq \underline{v}_A] = w, \tag{21}$$

$$\Pr[v_F \geq \underline{v}_F | \underline{v}_A] = p, \tag{22}$$

which jointly determines the hiring standard $\underline{v}_F(w, p)$ and marginal applicant $\underline{v}_A(w, p)$ when the firm pays a wage w and the marginal applicant has probability p of being hired. By using the reaction functions $b_A(v_A, p)$ and $b_F(\underline{v}_A, w)$ defined in (13) and (14), we can alternatively represent (21-22) as

$$b_A(\underline{v}_A, p) = b_F(\underline{v}_A, w).$$

That is the maximum hiring standard that a type \underline{v}_A passes with probability at least p , which is $b_A(\underline{v}_A, p)$, is precisely equal to the actual hiring standard set by the firm when it pays w and the marginal applicant is \underline{v}_A .

Indeed an applicant with a high can nevertheless be rejected while an applicant with a lower value maybe accepted.

²⁷This is restricting attention to the range of undominated strategies given in Lemma 3.

²⁸The extent to which the presence of adverse selection affects the returns to recruiting and selection activities is explored in Alonso (2014a).

²⁹As we will see this is without loss as the envelope theorem implies that effects on applications will be driven by changing precision holding constant wages.

We can now analyze the sign of $\partial v_A / \partial h_i$, $i \in \{A, F\}$ in terms of the change in the reaction functions following a more informative signal. If

$$\frac{\partial b_A(v_A, p)}{\partial h_i} > \frac{\partial b_F(v_A, w)}{\partial h_i} \quad (23)$$

then increasing h_i lowers the equilibrium $v_A(w, p)$. This follows as the marginal applicant would be willing to beat a strictly higher standard than the new one set by the firm. Conversely if (23) does not hold then increasing h_i would lead to a higher marginal type. We next study separately the impact on b_A and b_F of changes in the precisions h_A and h_F .

Applicant's Prediction Problem As each applicant perceives v_F/v_A to be normally distributed, changes in h_i will affect the applicant's best response $b_A(v_A, p)$ only through its effect on the perceived mean $E[v_F|v_A] = v_A h_F / (h_0 + h_F)$ and variance $\sigma_{v_F|v_A}^2 = (1 - \rho^2)\sigma_{v_F}^2$ of the interview score, as given by (2). Consider first the effect of a higher h_A . The expected score is unaffected as the interview provides an unbiased signal of match value. Moreover, increasing h_A increases the correlation between v_A and θ , ultimately increasing the correlation ρ between v_A and v_F . As a result, the interview score becomes more predictable, i.e. $\partial \sigma_{v_F|v_A} / \partial h_A < 0$. Consider now the effect of a higher h_F . Increasing h_F raises the sensitivity of $E[v_F|v_A]$ to the applicant's type; good matches ($v_A > 0$) expect higher average scores while poor matches ($v_A < 0$) expect lower average scores. While a higher h_F leads to a higher correlation ρ between v_A and v_F , the unconditional variance of v_F also increases. The combined effect leads to a more predictable interview score iff both h_A and h_F are sufficiently high. More specifically we have that

$$\frac{\partial \sigma_{v_F|v_A}}{\partial h_F} < 0 \iff h_0 < \frac{h_A h_F}{h_0 + h_F + h_A}. \quad (24)$$

The combined effect on the applicant's best response b^A is summarized in the following lemma

Lemma 5. (i) *There exists $\tilde{v}_A(w, p)$ such that $\partial b^A / \partial h_F > 0$ iff $v_A > v_A^*(w, p)$. Furthermore, $\partial \tilde{v}_A / \partial p > 0$ if and only if $\partial \sigma_{v_F|v_A} / \partial h_F > 0$. (ii) *For any w , $\partial b^A / \partial h_A > 0$ if and only if $p < 1/2$.**

Lemma 5-i indicates that better screening leads to a counterclockwise rotation of b^A around an invariant type \tilde{v}_A . The intuition is as follows. On the one hand, applicants expect the interview to be more responsive to match value -good matches to induce higher average scores and bad matches to induce lower average scores-. On the other hand, applicant's payoffs follow a call-option as applicants with low interview scores are rejected. Therefore, if a more informative interview is also less predictable ($\partial \sigma_{v_F|v_A} / \partial h_F > 0$), it increases the hiring probability, and thus increases b^A , when

$p < 1/2$ (i.e. the applicant is a "long shot"), but it will reduce her hiring probability if $p > 1/2$ (i.e. when the applicant is a "shoe-in" for the job).

To understand Lemma 5-ii note that increasing h_A does not affect an applicant's expected interview score but reduces its variance. It then follows that for a "shoe in" applicant (i.e. when $p > 1/2$), higher h_A increases her chances of being hired, and thus $\partial b^A/\partial h_A > 0$, while it makes hiring less likely for a "long-shot" applicant ($p < 1/2$), in which case $\partial b^A/\partial h_A < 0$.

Firm's inference problem The following lemma describes the effect on the firm's hiring standard $b_F(\underline{v}_A, w)$ of increasing the informational content of v_A or v_F .

Lemma 6. *For any (\underline{v}_A, w) we have (i) $\partial b_F/\partial h_F > 0$, and (ii) there exists $\underline{v}_A^{**}(w)$ such that $\partial b_F/\partial h_A < 0$ if and only if $\underline{v}_A > \underline{v}_A^{**}$.*

To understand Lemma 6, recall that the firm's posterior expectation after observing v_F is

$$E[\theta|v_F, v_A \geq \underline{v}_A] = \frac{h_0 + h_F}{h_0 + h_F + h_A} v_F + \frac{h_0 + h_A}{h_0 + h_F + h_A} E[v_A|v_F, v_A \geq \underline{v}_A],$$

and a more informative interview would then lead, for the same v_F and \underline{v}_A , to revise this expectation according to

$$\frac{\partial E[\theta|v_F, v_A \geq \underline{v}_A]}{\partial h_F} = \frac{h_A v_F - (h_0 + h_A) E[v_A|v_F, v_A \geq \underline{v}_A]}{(h_0 + h_A + h_F)^2} + \frac{h_0 + h_A}{h_0 + h_F + h_A} \frac{\partial E[v_A|v_F, v_A \geq \underline{v}_A]}{\partial h_F} \quad (25)$$

This expression reflects the dual role of v_F in providing both a direct estimate of θ and also allowing to filter the applicant's type. The first term on the rhs of (25) represents the increase in the relative weight that the firm puts on the interview score compared to the "application signal" $\{v_A : v_A \geq \underline{v}_A\}$. The second term on the rhs of (25) captures the effect of a better interview on the firm's ability to "detect" which applicant is facing, that is the firm's ability to sort "the wheat from the chaff" in the applicant pool. As a better interview provides a less noisy assessment of v_A given v_F , it also leads to a reduction in the truncated expectation $E[v_A|v_F, v_A \geq \underline{v}_A]$. In other words, for the same signal realizations v_F and \underline{v}_A , the firm becomes less optimistic about the type of applicant it is evaluating. Overall, Lemma 6-i states that increasing the informativeness of the interview always makes the firm more skeptical of match value, i.e. (25) is always negative, regardless of the composition of the applicant pool, and the firm would rationally toughen the hiring standard if the interview is less noisy.

Similarly, we can study the effect of better informed applicants on the firm's posterior expecta-

tion,

$$\frac{\partial E[\theta|v_F, v_A \geq \underline{v}_A]}{\partial h_A} = \frac{h_F E[v_A|v_F, v_A \geq \underline{v}_A] - (h_0 + h_F) v_F}{(h_0 + h_A + h_F)^2} + \frac{h_0 + h_A}{h_0 + h_F + h_A} \frac{\partial E[v_A|v_F, v_A \geq \underline{v}_A]}{\partial h_A}$$

As before, the first term is the increase in the relative weight of the application signal, while the second term is the change in the firm's ability to predict the applicant's type. Lemma 6-ii states that a better informed applicant pool would lead to a lower hiring standard if and only if the firm is facing a selective pool.

5.2 Effect of improved screening on application decisions

How would applicants react to an interview process that imposes the same application costs but better identifies match value? The effect of improved screening on the applicant pool is described in the next proposition.

Proposition 4 *Consider a fixed w . Then, there exist two cut-off levels $0 < \underline{p}^F \leq \bar{p}^F < 1$ such that $\partial \underline{v}_A / \partial h_F \leq 0$ if $p \leq \underline{p}^F$ or $p \geq \bar{p}^F$ and $\partial \underline{v}_A(w, p) / \partial h_F > 0$ if $p \in (\underline{p}^F, \bar{p}^F)$.*

The proposition shows that a more informative interview can either dissuade applications or encourage applications, depending on the composition of the applicant pool. Note that Lemma 6 shows that the firm would always increase their hiring standard, for a given applicant pool, when adopting a less noisy interview. Moreover, Lemma 5 shows that, for a fixed hiring standard, a better test will encourage more applications if the marginal applicant is "strong" (i.e. high \underline{v}_A) while it would dissuades applications if the marginal applicant is "weak" (i.e. low \underline{v}_A). It readily follows that for the case of a weak marginal applicant, improving the interview will dissuade applications and lead to a more selective applicant pool. However, the effect when \underline{v}_A is high is less immediate: the firm will raise the hiring standard but the marginal applicant would also be willing to "beat" a tougher hiring standard. To gain some intuition on this case, it is instructive to analyze two extreme benchmarks : (i) the firm disregards the "application signal" when estimating match value, and (ii) the applicant's type can be credibly disclosed to the firm.

Suppose that the firm does not take into account the self-selected nature of the applicant pool when estimating match value. To hire the applicant, then, the firm only considers the interview score and sets a hiring standard $\underline{v}_F = w$. In this case, changes in h_F do not alter the hiring standard. Therefore, the marginal applicant behaves according to Lemma 5: if a marginal applicant with a hiring probability p' is still willing to apply when the precision of the test increases, this will be true for any $p > p'$. We then reach the intuitive result that a better interview encourages applications

when the marginal applicant is "strong" but discourages applications when the marginal applicant is "weak".

Now consider a setup where v_A can be credibly disclosed to the firm. The firm then weighs both pieces of information v_F and v_A and sets a hiring standard $\underline{v}_F(v_A)$ that depends on the applicant's type v_A according to

$$\frac{h_0 + h_F}{h_0 + h_F + h_A} \underline{v}_F(v_A) + \frac{h_0 + h_A}{h_0 + h_F + h_A} v_A = w. \quad (26)$$

The applicant's prediction problem is simplified in this case as the law of iterated expectations implies that her estimated interview score is independent of the precision of the signals, i.e. $E[E[\theta|v_F, v_A]|v_A] = v_A$. Moreover, the conditional variance of $E[\theta|v_F, v_A]$ given v_A is simply $\frac{h_F}{(h_0+h_A)(h_0+h_F+h_A)}$, which always increases in h_F . That is, when credentials are "hard", the only effect of a better interview is to increase the applicant's perceived variance of the firm's final assessment. This option value effect discourages applications when the marginal applicant is "strong" (i.e. when $p > 1/2$) but encourages applications when the marginal applicant a "long shot" (i.e. when $p < 1/2$).

These two benchmark cases exhibit opposing effects in the extreme situations when the marginal applicant has either a high or a low probability of being hired. Moreover, each case provides a good approximation to the equilibrium given by (21) and (22) for low and high p . On the one hand, as p tends to zero, the applicant pool becomes indistinguishable from the general population of job seekers and

$$E[\theta|v_F, v_A \geq \underline{v}_A] \approx E[\theta|v_F, v_A \in \mathbb{R}] = v_F.$$

In other words, when ex-ante sorting of applicants is muted, the firm rationally disregards the fact that an applicant is willing to be evaluated. Therefore, for low p a better interview dissuades applications.

On the other hand, when p is sufficiently large, the applicant pool is a fairly selective group from the population of job-seekers. As shown in (10) the firm's filtering problem can be approximated by

$$E[\theta|v_F, v_A \geq \underline{v}_A] \approx \frac{h_0 + h_F}{h_0 + h_F + h_A} v_F + \frac{h_0 + h_A}{h_0 + h_F + h_A} \underline{v}_A.$$

In effect, a very selective applicant pool also provides a very informative signal of the applicant's type and the firm's hiring rule approximates one in which the applicant's type is observable to the firm, and always equals \underline{v}_A . Therefore, for high p , a better interview also dissuades applications. Finally, Proposition 5 shows that for intermediate p , the encouragement effect on applications may dominate and, as a result, a better interview may actually lead to more applications.

5.3 Effect of improved recruitment on application decisions

Suppose that as a result of advertising or the choice of recruitment channel, job-seekers are better informed of match value. What effect will a higher h_A have on the firm's recruitment ability as reflected in its applicant pool? Note that increasing h_A affects both (i) the ex-ante distribution of types v_A , (ii) and the equilibrium marginal applicant (as determined by (21) and (22)). We consider here only the effect on \underline{v}_A , and analyze the combined effect in Section 6.

As the expected score $E[v_F|v_A]$ does not depend on the precision h_A , the only effect of a higher h_A is to increase the correlation between v_F and v_A , reducing the applicant's uncertainty over the interview score. Following Lemma 5, this encourages applications from "strong" marginal applicants but dissuades applications when the marginal applicant is "weak". From Lemma 6, the firm reacts to a higher h_A by putting more weight on the "application signal" thus reducing the hiring standard when the marginal applicant is "strong" but increasing it when the marginal applicant is "weak". As both effects work in the same direction, the following Proposition shows that the overall effect satisfies a single crossing in p .

Proposition 5. *Consider a fixed w . Then, there exists a cut-off p^A , $0 < p^A < 1$ such that $\partial \underline{v}_A(w, p) / \partial h_A \leq 0$ iff $p \geq p^A$.*

Improving job-seekers' information has a monotone effect on the applicant pool in the sense that if it encourages more applications when the marginal applicant is hired with probability p , it also leads to more applications for any higher probability $p' > p$. Again, we can provide some intuition by looking at the two benchmark cases where the firm disregards the application decision, and the applicant's credentials are "hard" information. As the firm's hiring rule has been described in the previous section, we concentrate on the effect on the marginal applicant.

First, when the firm disregards the composition of the applicant pool, the hiring standard does not depend on the information available to applicants. As a higher h_A reduces the perceived variance of the interview score, it dissuades applications when the hiring probability is low (so that the marginal applicant is weak) but encourages them when the hiring probability is high (so that the marginal applicant is strong). Second, when credentials are "hard" the firm sets a hiring standard according to (26). When credentials become more informative, the firm will increase their weight, reducing the hiring standard required for strong applicants but increasing it for weak applicants. It follows that when considering the precision of the applicant's private assessment of match value both benchmark cases exhibit the same comparative statics.

6 Recruitment and Selection

We now consider the incentives of the firm to engage in activities that improve the recruitment or the selection phase of the hiring process. First, the firm could improve recruitment by reducing frictions in the job-seekers' application, e.g. through activities that lower c_A . It is immediate that the firm always benefits from lower application costs as it then can attract the same applicant pool at a lower wage.³⁰ Second, the firm could face better informed job-seekers by either supplying information through informative advertising, or by using recruitment channels associated to more knowledgeable job-seekers. Third, the firm could improve their selection of applicants by adopting evaluation techniques that reduce the uncertainty surrounding the match-specific productivity. I restrict attention to the latter two cases, and adopt a reduced-form approach by positing that improved recruitment simply increases h_A , while improved selection leads to a more discriminating interview by increasing h_F .

What are the firm's incentives to improve the information on each side of the market? Abstracting from the costs of implementation, an application of the envelope theorem to the firm's equilibrium profits leads to the following decomposition of the total effect of increasing h_i , $i \in \{A, F\}$, into a direct and indirect effect,

$$\frac{d\Pi}{dh_i} = \underbrace{\frac{\partial \Pi}{\partial h_i}}_{\text{direct effect}} + \underbrace{\frac{\partial \Pi}{\partial \underline{v}_A} \frac{d\underline{v}_A}{dh_i}}_{\text{indirect effect}}. \quad (27)$$

That is, increasing h_i implies that matching would be performed with a less noisy appraisal of match value (direct effect), but will affect the recruitment costs of the firm as a result of the change in the applicant pool (indirect effect). To analyze (27), let $\mu = \Pr[v_F \geq \underline{v}_F, v_A \geq \underline{v}_A]$ be the probability that a randomly chosen job-seeker applies to the firm and is hired. Given the unit mass of job-seekers, μ also describes the equilibrium employment by the firm. Also, let $\gamma_i = E[\theta | \underline{v}_i, v_j \geq \underline{v}_j]$, $i, j \in \{A, F\}$ and $i \neq j$. In words, γ_A is the expected match productivity of the marginal applicant that passes the test, while γ_F is the expected match productivity of the marginal hire.

³⁰This argument relies on the assumption of positive selection, which is satisfied in our case. If a lower wage reduces the ex-ante quality of the applicant pool, for instance if match specific productivity is correlated with each applicant's outside option, then increasing frictions may actually improve hiring outcomes. See Horton (2013) for some experimental evidence, and Alonso (2014a) for a theoretical analysis of correlated match productivity.

Lemma 4. *The direct and indirect effect in (27) are given by*

$$\frac{\partial \Pi}{\partial h_i} = \frac{1}{2(h_0 + h_i)} \text{Var} [\theta | \underline{v}_i, v_j \geq \underline{v}_j] \left(-\frac{\partial \mu}{\partial \underline{v}_i} \right) + (\gamma_i - w_E) \frac{\partial \mu}{\partial h_i}, \quad (28)$$

$$\frac{\partial \Pi}{\partial \underline{v}_A} = (\gamma_A - w_E) \left(-\frac{\partial \mu}{\partial \underline{v}_A} \right) > 0. \quad (29)$$

for $i, j \in \{A, F\}, i \neq j$, where the change in employment following a more informative signal is

$$\frac{\partial \mu}{\partial h_i} = \frac{1}{2(h_i + h_0)} \left(\gamma_i - \frac{h_i - h_0}{h_i} \underline{v}_i \right) \left(-\frac{\partial \mu}{\partial \underline{v}_i} \right). \quad (30)$$

To understand Lemma 4, consider first the direct effect of a higher h_i given by (28). The first term in the right hand side of (28) is the *sorting effect*, and is proportional to the variance of match value at the margin of the relevant decision maker. This term captures the idea that a more precise signal better separates "the wheat from the chaff" as it would lead to a stochastically higher v_i for higher θ and, conversely, stochastically lower v_i for lower θ . The second term in the right hand side of (28) is the *dispersion effect*: a higher h_i increases the unconditional variance of v_i and thus changes the likelihood that a job-seeker gains employment at the firm (by changing the likelihood of applying, or of being hired). The effect in profits then depends on whether it leads to increased employment and on the sign of the firm's profit on the marginal decision maker ($\gamma_i - w_E$).

Turning to the indirect effect in (27), $\partial \Pi / \partial \underline{v}_A$ is always strictly negative, as the firm's monopolistic behavior implies a strictly profitable marginal applicant if hired, i.e. $\gamma_A > w_E$. Therefore, the sign of the indirect effect is given by the sign of $d\underline{v}_A / dh_i$, i.e. on whether a more precise signal dissuades or attracts applications in equilibrium. We next study the total effect separately for the case of a more discriminating interview, and the case of a more informative advertising of job/firm characteristics.

6.1 Marginal Returns to Improved Selection.

How would the firm benefit from adopting a more informative interview? It is easy to see that the direct effect of a more discriminating interview is always positive. This follows from two observations. First, sequentially rational hiring decisions require the firm to obtain a zero profit on the marginal hire - thus $\gamma_F - w_E = 0$, and the dispersion effect in (28) is zero. That is, changes in total employment, as more or less applicants pass the more discriminating interview, have no effect on firm's profits as the firm makes no profit on the marginal hire. Second, the sorting effect in (28) is always positive: for the marginal hire \underline{v}_F , a better test would increase the probability that $v_F < \underline{v}_F$ if $\theta < \underline{v}_F$, while it would increase the probability that $v_F > \underline{v}_F$ if $\theta > \underline{v}_F$. In effect, a bad match would be more likely to fail the interview, thus reducing type I errors in selection, while

a good match would be more likely to pass it, thus reducing type II errors. As this sorting effect is proportional to the variance of the marginal hire, $\partial\Pi/\partial h_F$ decreases in h_F and vanishes as the interview becomes perfectly informative.

The indirect effect (27), where $\partial\Pi/\partial \underline{v}_A$ is given by (29) and $d\underline{v}_A/dh_F$ is given in Proposition 5, captures the interdependence between recruitment and selection: a more discriminating interview affects hiring costs through its effect on applicant recruitment. This effect is negative if and only if a better test dissuades applications ($d\underline{v}_A/dh_F > 0$), as the firm would need to pay a higher wage to attract the same applicant pool.

The total effect is always positive if a better interview induces more applications. Following Proposition 5, this is the case when the marginal applicant has an intermediate chance of being hired. However, the total effect can be negative, so the firm actually benefits from a noisier interview. For instance, if the interview is very informative, the direct effect of further improvements is close to zero. Nevertheless, the value of the marginal applicant can be quite high, especially if application decisions are made with poor information (low h_A). In this case the firm would not adopt marginal improvements in selection, even if they have seemingly low cost of implementation, and, it would actually favor less informative interviews.

Proposition 6. *Given c_A and \underline{w} , there exist h_A^* and h_F^* such that $d\Pi/dh_i < 0$ for any $h_A < h_A^*$ and $h_F > h_F^*$.*

6.2 Marginal return to improved recruitment.

Is the firm better-off when recruiting among a population of better informed job-seekers? From (28), the direct effect of higher h_A is

$$\frac{\partial\Pi}{\partial h_A} = \frac{1}{2(h_0 + h_A)} \text{Var} [\theta | \underline{v}_A, v_F \geq \underline{v}_F] \left(-\frac{\partial\mu}{\partial \underline{v}_A} \right) + (\gamma_A - w_E) \frac{\partial\mu}{\partial h_A}. \quad (31)$$

The first term in (31) is the sorting effect of higher h_A and is always positive: a less noisy v_A leads to a higher correlation between match value and the application decision, ultimately improving the quality of the applicant pool for a constant marginal applicant. The second term in (31) is the dispersion effect: a higher h_A , by increasing the unconditional variance of v_A , changes the size of the applicant pool and the equilibrium level of employment. Noting that the marginal applicant that passes the interview is always a profitable match, i.e. $\gamma_A > w_E$, the dispersion effect is negative if and only if the firm's employment is reduced when job-seekers are better informed.

Can the direct effect (31) be negative? The answer is yes. To see this note that combining (30)

for $i = A$ with (31), we can conclude that

$$\text{sign} \left[\frac{\partial \Pi}{\partial h_i} \right] = \text{sign} \left[\text{Var} [\theta | \underline{v}_A, v_F \geq \underline{v}_F] + (\gamma_A - w_E) \left(\gamma_A - \frac{h_A - h_0}{h_A} \underline{v}_A \right) \right]. \quad (32)$$

If the marginal applicant is below the population average ($\underline{v}_A < E[\theta] = 0$), the second term of (32) becomes unbounded from below as h_A becomes arbitrarily small. That is, when job-seekers have very poor information concerning their person-organization fit, but nevertheless the majority of them apply for a job, then informative advertising would actually reduce firm's profits, holding constant application and hiring decisions. The intuition for this results is that more informative signals can have an adverse impact under suboptimal decision rules. To see this, consider a case in which screening is fully centralized: for each job-seeker the firm would observe v_A and then decide whether to reject the applicant or incur the evaluation cost c_A to hire her after observing v_F .³¹ Then the marginal applicant is determined by the fact that, the expected profit if the applicant is hired after a second evaluation equals the cost of this second evaluation. In other words $\gamma_A - w_E = 0$. That is, if the firm controls who they evaluate then, as in the case of better interview, the dispersion effect would be zero. In effect, the standard monopsony inefficiency can lead to a negative value of information, holding constant application decisions. A general lesson in matching markets with dispersed information is that improved information leads to better matching (Shimer and Smith 2000). In this case, however, even absent the strategic impact on application and selection, better informed applicants can be detrimental to the firm.

A direct implication of the previous discussion is that the marginal profit of informative advertising is positive if it leads to more applications, both because it increases the mass of applicants that believe are a good match but also attracts applications from lower types. Conversely, as the following proposition summarizes, if as a result of improvements in their self-assessment of fit, job-seekers are dissuaded from applying, then recruitment can have a negative effect.

Proposition 7. *If $\underline{w} < 0$ here exists a cost level \bar{c}_A , and precisions \bar{h}_A and \bar{h}_F such that whenever $c_A < \bar{c}_A$, precisions $h_A < \bar{h}_A$ and $h_F > \bar{h}_F$, the firm's equilibrium profits decrease when applicants are better informed of fit.*

When the average job-seeker is a good match for the firm (and application costs are low) but job-seekers are poorly informed of fit, firms may not want to engage in informative advertising. This is perhaps surprising as the naive view is that advertising would have the biggest effect precisely when

³¹We could entertain a more natural sequential screening by the firm: the firm first observes v_A , and decides to (i) definitely reject the job-seeker, (ii) directly hire the job-seeker, (iii) incur the cost c_A and hire the job seeker after observing v_F . Then optimal rule is... Note however that it is still true that for the marginal applicant the marginal profit if evaluated would equal the cost of evaluation.

job-seekers are poorly informed. However, if screening is sufficiently informative, then optimally the firm would prefer to rely on a more informative signal. In this case, the inefficiency stems from the fact that job-seekers that are potentially profitable matches are dissuaded based on rather poor information.

7 Conclusions

What factors determine the incentives of firms to adopt new selection methods? When is a firm willing to publicize information about its culture/job characteristics to prospective workers? When would a firm promote referrals that inform job-seekers of its work environment? This paper shows that all these questions are naturally related: to understand the gains from better screening one needs to take into account the effect on the firm's ability to recruit applicants in the first place, while recruiting activities that increase the information available to job-seekers regarding their match productivity affect the firm's selection process once it acknowledges the self-selected nature of the applicant pool.

For instance, the returns to improved screening depend in part on how they affect the likelihood that different job-seekers perceive of being hired. If better screening dissuades applications, it increases hiring costs as the firm would need to offer a higher wage premium to entice the same job-seekers to apply for a position. Alternatively, informative advertising of firm/job characteristics reduces job-seeker's uncertainty of the value of matching with the firm, and thus reduces the uncertainty over the outcome of the interview. Again, this can prove costly to the firm if it reduces the applicant pool. This would be the case, for instance, if some applicants are unlikely to land a job, but nevertheless apply based on the uncertainty surrounding their interview score. A less uncertain interview score lowers the option value of application and dissuades potentially qualified applicants.

It is often argued that firms don't engage in more detailed screening of job applicants because of the higher costs of the resources required to do so. Here I offer a different explanation for the apparent under-investment in screening applicants: a firm maybe unwilling to adopt a more discriminating selection method as it may require a higher wage to attract the same applicant pool and, ultimately lead to a higher wage bill. Moreover, I show that a firm would not want to evaluate all job-seekers even if the application costs are vanishingly small, as a selective applicant pool is a valuable information source to assess person-organization fit.

There are two main simplifications of the model. First, only one firm actively evaluates applicants. This allows for a straightforward characterization of equilibrium, but obviates the competition effects among firms in the presence of variations among applicants in firm-specific productivity.

Second, the model posits that all uncertainty surrounding the productivity of a worker regards its firm-specific component. In equilibrium, this leads to both positive assortative matching and positive selection. This setup can well approximate situations where general human capital can be easily observed, albeit there is uncertainty over the fit of a candidate to a firm. Nevertheless, there are situations where general human capital is also uncertain and can be only (imperfectly) appraised by firms through interviews. In this case, a high type that indicates a high match value with a given firm also implies a higher outside option when matching with other firms. This effect can then lead to both positive and adverse selection. Alonso (2014a) provides an initial exploration of this scenario.



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