Good News or Bad News? Information Acquisition and Applicant Screening in Competitive Labor Markets

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Abstract

We model a competitive labor market with heterogeneous firms of varying productivities, and consider two information-collection processes: searching for "good news" about applicants, and searching for "bad news." Under the former, firms seek positive signals to qualify applicants, and under the latter, negative signals to disqualify them. When searching for good news, firms collect too little information in equilibrium; however, aggregate profits are positive and applicants' choice of firms is efficient. When searching for bad news, firms collect too much information, profits dissipate, and applicants inefficiently match with firms of lower productivities. In both cases, too few applicants are admitted. We show that firms tend to search for good (bad) news for low (high) revenue positions. Moreover, as the cost of acquiring information decreases, applicants' expected payoffs rise and more firms search for good news.

Keywords: Information collection; screening; labor market; privacy

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1 Introduction

Job applicants reveal personal information online that may otherwise not be easily obtained, and which may be illegal for firms to request in the process of hiring.[1] With over two thirds of adults in the US registered on social networks (Pew, 2013), such personal information has become increasingly available. For employers, the availability of this information reduces search costs significantly and decreases the risk of detection. In effect, a new arena for information collection has been established — information that may have previously been very costly to obtain.

While use of social media services, such as LinkedIn, Facebook, Twitter, Foursquare, and Instagram, has become an integral component of an individual's online footprint (and in some cases, job search), such services have the potential of offering incredible pools of readily-accessible information (Acquisti and Gross, 2006; Narayanan and Shmatiko, 2009; Acquisti et al., 2011; Madejski et al., 2012; Acquisti and Fong, 2013). Facebook data analyzed by Johnson et al. (2012) indicated that 54% of sampled users made available to strangers at least some of the information on their profiles, and Facebook has stated that approximately 200 million people in the US and Canada currently have Facebook accounts (Facebook, 2013).

Anecdotes, surveys, and recent experiments suggest that employers have indeed been using online searches to screen job applicants (Andrews, 2012).[2] Acquisti and Fong (2013) have recently presented findings from two randomized experiments where they manipulate the online footprints of candidates. They point out that while the legal implications for obtaining online information about job candidates are not clear-cut and can be difficult to enforce, employers may end up discriminating based on such information, which would indeed raise privacy and legal concerns (Sprague, 2011, 2012). Testing the responses of over 4,000 US employers to candidates of different backgrounds, they find evidence of discrimination.

[1] See, for instance, `http://www.eeoc.gov/laws/statutes/index.cfm`.

[2] See, also: `https://www.privacyassociation.org/publications/2007_12_ponemon_institute_littler_mendelson_study` and `http://www.internetnews.com/webcontent/article.php/3861241/Microsoft+Survey+Online+Reputation+Counts.htm`

Given that their experiments focus on screenings for initial interviews, it is also plausible that increased scrutiny (and use of additional online information) may take place further along an interview process.[3]

The ongoing shift towards using online information has implications for market dynamics. Since obtaining information has become less costly for firms, it is natural to ask how much information firms collect, which and how many applicants are hired, and to which firms applicants choose to apply. This paper seeks to address these questions by modeling some of the underlying dynamics of information collection. We study a competitive market where firms are heterogeneous with respect to a one-dimensional summary attribute, referred to as productivity (e.g., employee billing rates for consultants, attorneys, and developers), and candidates are heterogeneous with respect to their match value to firms (e.g., due to employee fit, individual ability, and cost of training). Firms post wages, candidates apply, and firms then collect information about candidates and decide who to hire and who to reject.[4] We consider two separate information-collection regimes: searching for qualifying information or "good news" about applicants and searching for disqualifying information or "bad news." By examining these two information-collection processes in isolation, we are able to glean insights into the individual market dynamics that may subsequently play out under each one. We then identify conditions under which these collection processes may arise endogenously in equilibrium, and demonstrate that as the cost of acquiring information decreases, *ceteris paribus*, more firms are likely to search for "good news" about applicants.

We show that when searching for good news, firms end up collecting too little information about applicants, the probability of qualified candidates being hired is inefficiently low, and

[3]Other experiments detected discrimination based on information volunteered by job applicants during the application process (e.g., on an applicant's resumè), including discrimination based on an applicant's name, race, gender, sexual orientation, and level of attractiveness. See, for instance, Bertrand and Mullainathan (2004); Carlsson and Rooth (2007); Ruffle and Shtudiner (2010); Tilcsik (2011); Galarza and Yamada (2012); Bòo et al. (2012).

[4]While one may argue that firms would like to keep wages as private information, the availability of online information goes both ways. In particular, websites such as LinkedIn, Glassdoor, and PayScale provide salary information to applicants about different positions at numerous firms.

firms post positive (aggregate) profits. However, applicants efficiently choose the firms to which they apply — that is, their firm choice is aligned with that of a social planner.

For firms, mistakes when searching for good news involve false-negatives, that is, not identifying some of the good candidates. Because the social cost of each mistake ends up higher than the private cost to a firm, firms, consequently, acquire too little information. An applicant's expected utility when firms search for good news is not monotone increasing in wage — it is increasing over lower wages due to a higher chance of employment (firms screen less intensely because of lower costs associated with a hiring mismatch) and decreasing over higher wages due to a lower chance of being hired (firms screen more intensely). Since a higher wage does not necessarily attract applicants, firms end up posting positive profits.

When searching for bad news, in contrast, firms end up collecting too much information about applicants, post zero profits, hire too few applicants from a social-welfare perspective, and applicants *inefficiently* match with firms. In this case, firms' search for disqualifying information drives applicants to seek higher wages, despite higher wages being associated with higher screening intensities. Firms subsequently screen applicants too intensely. In the flavor of a Prisoner's Dilemma game, holding fixed applicants' choice of a firm, it is possible to generate an *ex-ante* Pareto improvement by reducing search intensities and decreasing wages. Furthermore, in equilibrium, the social gain from matching applicants with firms of higher productivities is greater than the expected costs of admitting applicants into those firms. Hence, it is possible to generate *ex-ante* Pareto improvements with respect to linking applicants with better-matched firms.

This matching distortion arises for the following reason. Applicants understand that if they apply to firms with lower productivities, then, due to lower costs of mismatching with undesirable employees, those firms will screen them less intensely. In an effort, therefore, to be hired, applicants attempt to match with firms of inefficiently-low productivities. Thus, when searching for bad news, inefficiencies may arise both in terms of the quantity of hired applicants and in terms of the quality of applicants' attempted matches. In addition to these inefficiencies, firms' incentives to acquire excessive amounts of information about applicants give rise to privacy concerns. They illustrate the tension between legislative action (e.g., to prevent certain private information from being used in hiring decisions) and progress in information technology, which facilitates the availability and accessibility of applicants' private information to employers.

This paper builds on the literature that examines private and public incentives for information acquisition. Posner (1978, 1981, 1993) argues that the protection of privacy can create inefficiencies in the marketplace, since it conceals potentially relevant information from other economic agents — in our case potentially negatively affecting firms' hiring decisions. Hirshleifer (1971, 1980) asserts that rational economic agents may end up inefficiently over-investing in collecting personal information about other parties — showing that contactual incompleteness may lead to a divergence between the marginal private benefit and the marginal social benefit of collecting information (see, also, Broecker, 1990; Burke et al., 2012; Kim and Wagman, 2013). This paper shows that both predictions may hold concurrently: a less costly process for information acquisition may indeed enhance welfare, and firms may indeed end up over-investing in acquiring information. However, we show that under-investment in information acquisition can also be an issue, and more so as information becomes easier to acquire. A separate literature track, including Villas-Boas (2004), Taylor (2004), Acquisti and Varian (2005), Calzolari and Pavan (2006), Hermalin and Katz (2006), Conitzer et al. (2012), and Taylor and Wagman (2014), examines cases of firms collecting information about consumers in order to price discriminate in monopolistic and oligopolistic product markets. This paper, in contrast, focuses on *hiring* discrimination and matching inefficiencies in competitive labor markets.

This paper is also related to a vast literature on personnel economics.[5] A stream of this literature examines a common problem that firms face in trying to hire applicants

[5] See Oyer and Schaefer (2011) for a recent survey. See Petrongolo and Pissarides (2001) for a survey of labor-market matching functions and matching frictions.

— matching with costly search and imperfect information — which also underscores our framework (c.f., Salop and Salop, 1976; Jovanovic, 1979; Rosen, 1982; Sattinger, 1993; Baker et al., 1994; Milgrom and Roberts, 1995; Farber and Gibbons, 1996; Barron et al., 1997; Burdett and Cunningham, 1998; Lazear, 2000; Autor, 2001). In Mortensen and Pissarides (1999), applicants sequentially sample wages from a known distribution, and an applicant's strategy is specified by an optimal stopping rule. In our framework, while firms post wages concurrently, applicants' choice is also influenced by employers' endogenously-determined screening intensities. Another part of the literature features an active role for employers accessing social networks to tap potential hires (c.f., Saloner, 1985; Montgomery, 1991; Simon and Warner, 1992; Casella and Hanaki, 2006, 2008), whereas employers in our model may use information from social media to screen individual applicants.

Our findings help extend the literature in several ways. First, our model is grounded in a simple theoretical framework that lends itself to predictions about information acquisition in labor markets. We identify frictions that are likely to emerge if employers' cost of acquiring information about applicants continues to shift downwards. Our analysis also demonstrates incentives for applicants to exert control over their online footprints, particularly as it pertains to information that may disqualify them (Goldin and Rouse, 2000; Aslund and Skans, 2012). More specifically, we show that when firms lack the ability to commit upfront to the amount of information they acquire, inefficiencies may result in the amount of information collected. These can lead to reduced welfare and an inefficiently small number of applicants being hired — no matter which firms applicants choose. At the same time, our findings suggest that the shift towards lower costs of acquiring information about applicants — due to employers searching online — may not necessarily be "all bad news." To that effect, we demonstrate that as the cost of information collection decreases, more positions will fall under the 'good news' information-collection process, and this transition can be welfare enhancing from the perspective of better matching applicants with firms. Overall, our findings point out that the increased availability of applicant information online has the following implications: (i) more positions may fall under the 'good news' search process; (ii) while wages may increase, the switch to searching for good news can benefit firms' profits; and (iii) for positions associated with firms searching for bad news, applicants may strategically choose to pursue suboptimal matches in an effort to be screened less intensely.

The remainder of the paper is organized as follows. Section 2 presents the model. Section 3 examines the case where firms search for good news about applicants and Section 4 reports the case where firms search for bad news. Section 5 presents a variant of the base model where a firm's search process is determined endogenously. Section 6 details several of the limitations of our framework and concludes. Omitted proofs are relegated to the Appendix.

2 The Model

The demand side of the market is composed of firms seeking to hire applicants. All firms are risk neutral and maximize expected profits. Each firm j is associated with a level of productivity, $q_j \in (0, Q]$, with $0 < Q < \infty$, and each productivity level is associated with at least two firms. For technical simplicity, we will assume that there is a continuum of firms over $(0, Q]$, although the qualitative nature of the results remains the same without this assumption. The supply side of the market consists of a continuum of ex-ante identical individuals who are looking to apply at one of the firms.[6] Individuals are assumed to be risk neutral and supply a single unit of labor. Let $v(q_j)$ denote firm j's revenue from filling a position, where more productive firms generate higher revenues with diminishing returns, such that $v(\cdot)$ is increasing, strictly concave, and bounded.

We further suppose that information is incomplete and initially symmetric, with uncertainty about match-relevant applicant characteristics. Specifically, the costs of bringing an applicant onboard as an employee either turn out to be low (c_L) or high (c_H), where firms of

[6] For tractability, we consider one application per applicant (in practice, applications may be costly due to time constraints or, for instance, due to professional schools using auction mechanisms to let students bid for interviews; c.f., http://www.businessweek.com/bschools/content/may2009/bs20090528_048488.htm).

different productivities incur different costs: A firm with productivity q incurs costs $c_H(q)$ or $c_L(q)$, depending on the applicant's type, where $c_H(q) - c_L(q) > 0$ is differentiable and weakly convex for $q \in (0, Q]$; that is, firms' costs of mismatching with applicants are increasing in their productivities at a non-decreasing rate (e.g., due to higher costs of training and/or reputational concerns of incurring hiring mismatches).[7] Furthermore, it is efficient for firms to hire only low-cost applicants; that is, $c_H(q) > v(q) > c_L(q)$ for $q \in (0, Q]$. However, depending on their process for information-collection, firms may end up hiring some high-cost applicants. The proportion of high-cost applicants in the population is $\lambda > 0$. Hence, it is appropriate to think of a single representative applicant whose probability of being a high-cost type is λ.

The game unfolds in several stages. First, each firm j simultaneously announces its wage, w_j, to hired applicants (that is, applicants who ultimately pass the screening process). Next, applicants apply at a firm of their choice. Firms then acquire information about applicants and make their hiring decisions.[8] The solution concept is subgame-perfect Nash equilibrium.

3 Searching for Good News

We first consider the case where firms search for information that positively distinguishes applicants. We begin by describing firms' process for collecting information and then characterize the resultant market equilibrium.

[7] Our findings largely go through without this assumption, except that if $c'_H(q) - c'_L(q) < 0$ holds over some range on q, applicants may end up matching with firms of inefficiently high productivities when employers search for bad news, and multiple equilibria can arise. The results for the case where employers search for good news are unchanged.

[8] One may extend our framework to accommodate multiple applications (both concurrent and sequential), with some additional assumptions. The nature of the results appears to remain similar; in the sequential version, there is an additional issue of adverse selection. The author of this paper examines this case in a product market (e.g., mortgage, insurance) along with two co-authors in Burke et al. (2012).

3.1 Information Acquisition

The information collection process is as follows. For each applicant, a firm chooses a sample size, or search intensity $n \geq 0$, which we treat for simplicity as a continuous variable. The cost to the firm of acquiring information about an applicant is kn, where $k > 0$. By choosing a search intensity n, the firm receives n conditionally independent Bernoulli signals, $X_1, \ldots, X_n$, where

$$\Pr\{X_i = 1|c\} = \begin{cases} \alpha, & \text{if } c = c_L, \\ 0, & \text{if } c = c_H \end{cases}$$

The parameter $\alpha \in (0, 1)$ represents intrinsic signal strength. If $\alpha = 1$, then a signal is fully informative, and if $\alpha = 0$, then signals contain no information. This process is interpreted as follows: the firm acquires a search report containing $i = 1, \ldots, n$ records, $\{X_1, \ldots, X_n\}$, for each of its applicants, and each record is either positive ($X_i = 1$) or neutral ($X_i = 0$).

It is possible to summarize all the information contained in an applicant's search report with the sufficient statistic $S_n \equiv \max\{X_1, \ldots, X_n\}$. That is, if $S_n = 1$, then a positive match had been detected and the applicant is deemed *qualified* (and will subsequently be hired in equilibrium); whereas, if $S_n = 0$, then all records were neutral, and the applicant is a low-cost type with probability

$$\mu(n) = \frac{(1 - \lambda)(1 - \alpha)^n}{\lambda + (1 - \lambda)(1 - \alpha)^n} < 1 - \lambda \tag{1}$$

and a high-cost type with the complementary probability, $1 - \mu(n)$. Admittance to the firm results in a payoff of w_j for the applicant and an expected payoff of $v(q_j) - w_j - E[c(q_j)|S_n] - kn$ for the firm. Rejection results in a payoff of zero for the applicant, whereas the firm still incurs the cost of information collection, $-kn$.

3.2 Equilibrium Characterization

Consider two or more firms of a given productivity level, q. The expected payoff to an applicant from applying to one of these firms, assuming it sets a wage w, is given by

$$\widetilde{U}(w,n) \equiv (1-\lambda)\left(1-(1-\alpha)^n\right) w. \tag{2}$$

This expression gives the probability of the applicant being hired, times the wage w. The problem facing a social planner in this context is to find the ideal combination of information-collection intensity n and productivity q:

$$\max_{(q,n)} U(q,n) \equiv (1-\lambda)(1-(1-\alpha)^n)(v(q)-c_L(q)) - kn \tag{3}$$

It will be useful to define the constant $m \equiv -\frac{k}{\ln(1-\alpha)}$. In the proceeding analysis, we assume that firms' information-collection technology is sufficiently effective (that is, m is sufficiently small) so that an interior solution obtains with screening intensity $n^* > 0$.[9] The socially efficient search intensity n^* is then characterized by the first-order condition:

$$(1-\lambda)(1-\alpha)^{n^*}(v(q)-c_L(q)) = m. \tag{4}$$

Condition (4) states that at n^*, the marginal social benefit of a match associated with productivity q equals the marginal social cost of acquiring more information about the applicant. In contrast, a firm with productivity q that posts a wage w selects its search intensity, $\tilde{n}_q(w)$, to maximize

$$\Pi = (1-\lambda)\left(1-(1-\alpha)^{\tilde{n}_q(w)}\right)(v(q)-w-c_L(q)) - k\tilde{n}_q(w) \tag{5}$$

That is, the firm seeks to equate its private benefit from information collection to its marginal

[9] A sufficient condition to guarantee an interior solution, which will be proven in Proposition 1, is given by $m < \min\{(1-\lambda)(v(q)-c_L(q)), \lambda(1-\lambda)(c_H(q)-c_L(q))\}$ for $q \in (0,Q]$.

cost, according to the first-order condition

$$(1-\lambda)(1-\alpha)^{\tilde{n}_q(w)}(v(q)-w-c_L(q))=m. \tag{6}$$

We have the following result.

Proposition 1 (Good News) *In equilibrium, firms collect an inefficiently small amount of information about applicants, the probability of admission is inefficiently low, industry profits are positive, and applicants match with firms of the planner-prescribed productivity.*

Proof. The proof proceeds in four steps.

[**Step 1.**] For a given productivity level q, substituting from (6) into (2), we obtain

$$\widetilde{U}(w,\tilde{n}_q(w))=\left((1-\lambda)-\frac{m}{v(q)-w-c_L(q)}\right)w.$$

Differentiation with respect to w yields

$$\frac{d\widetilde{U}(w,\tilde{n}_q(w))}{dw}=-\frac{m(v(q)-c_L(q))}{(v(q)-w-c_L(q))^2}+(1-\lambda)$$

and

$$\frac{d^2\widetilde{U}(w,\tilde{n}_q(w))}{(dw)^2}=-\frac{2m(v(q)-c_L(q))}{(v(q)-w-c_L(q))^3}<0.$$

Hence, $\widetilde{U}(w,\tilde{n}_q(w))$ is maximized at $\tilde{w}_q=v(q)-c_L(q)-\sqrt{\frac{m(v(q)-c_L(q))}{1-\lambda}}$; that is, as firms of productivity q compete to attract applicants, candidates would end up considering those firms that set a wage $\tilde{w}_q$.

[**Step 2.**] We now show that for any $q\in(0,Q]$ for which some candidates choose to apply, $m<\min\{(1-\lambda)(v(q)-c_L(q)),\lambda(1-\lambda)(c_H(q)-c_L(q))\}$ is a sufficient condition for an interior solution. Suppose for a given q, $v(q)>\lambda c_H(q)+(1-\lambda)c_L(q)$. For $m\geq\lambda(1-\lambda)(c_H(q)-c_L(q))$, the equilibrium outcome involves setting wages at $w_{q,0}=v(q)-\lambda c_H(q)-(1-\lambda)c_L(q)$ and hiring applicants without screening. Next, suppose $m<\lambda(1-\lambda)(c_H(q)-c_L(q))$. By Step 1, the unique equilibrium outcome will involve wages at $\tilde{w}$ and acquiring information optimally if

$$\tilde{w}_q > 0 \;\Leftrightarrow\; m < (1-\lambda)(v - c_L(q)).$$

Simple algebra can be used to show

$$v(q) > \lambda c_H(q) + (1-\lambda)c_L(q) \;\Leftrightarrow\; (1-\lambda)(v - c_L(q)) > \lambda(1-\lambda)(c_H(q) - c_L(q)) > m.$$

Now, suppose $v(q) < \lambda c_H(q) + (1-\lambda)c_L(q)$. For $m \geq (1-\lambda)(v(q) - c_L(q))$, no equilibrium in which the market is active exists. Specifically, if firms set wages higher than $v(q)$ and acquire no information, then they will clearly reject all applications. To see that no equilibrium with positive information collection exists either, note from (6) that a firm of productivity q will acquire information about an applicant *iff* $w < v(q) - c_L(q) - \frac{m}{1-\lambda}$; but $c_L(q) + \frac{m}{1-\lambda} \geq v(q)$. Hence, applicants will not apply to any firm with a wage that induces information collection. Consider $m < (1-\lambda)(v(q) - c_L(q))$. Simple algebra shows that this condition is equivalent to $\tilde{w}_q > 0$.

[Step 3.] We now show that firms make non-negative profit by pricing at $\tilde{w}_q$ and hiring qualified applicants. The expected profit per applicant from this strategy is given by

$$\widetilde{\Pi} = (1-\lambda)\left(1 - (1-\alpha)^{\tilde{n}_q(\tilde{w}_q)}\right)(v(q) - \tilde{w}_q - c_L(q)) - k\tilde{n}_q(\tilde{w}_q) \tag{7}$$

Using $m \equiv -\frac{k}{\ln(1-\alpha)}$ and $\tilde{w}_q = v(q) - c_L(q) - \sqrt{\frac{m(v(q)-c_L(q))}{1-\lambda}}$ together with (6), we have $(1-\alpha)^{\tilde{n}_q(\tilde{w}_q)} = \sqrt{\frac{m}{(1-\lambda)(v(q)-c_L(q))}}$. Substituting in (7) and simplifying, we have:

$$\begin{aligned}
\widetilde{\Pi} &= (1-\lambda)\left(1 - (1-\alpha)^{\tilde{n}_q(\tilde{w}_q)}\right)(v(q) - \tilde{w}_q - c_L(q)) - k\tilde{n}_q(\tilde{w}_q) \\
&= \sqrt{m(1-\lambda)(v(q) - c_L(q))} - m + m\ln\left(\sqrt{m/((1-\lambda)(v(q) - c_L(q)))}\right) \\
&= m\left(z^{-1} - 1 + \ln(z)\right),
\end{aligned}$$

where

$$z = \sqrt{\frac{m}{(1-\lambda)(v(q)-c_L(q))}}.$$

Note that $z = 1$ implies $\widetilde{\Pi} = 0$. Moreover,

$$\frac{d}{dz}\left(z^{-1} - 1 + \ln(z)\right) = z^{-1} - z^{-2}.$$

This is evidently negative *iff* $z < 1$. Hence, $m \in (0, \min\{(1-\lambda)(v(q)-c_L(q)), \lambda(1-\lambda)(c_H(q)-c_L(q))\})$ implies $\widetilde{\Pi} > 0$. At $m = 0$, the equilibrium involves perfect information; i.e., firms screen all applicants at zero cost and set the competitive wage of $v(q) - c_L(q)$. Moreover, as information becomes easier to acquire (that is, as m decreases), it is straightforward to see that both $\tilde{w}_q$ and $\tilde{n}_q(\tilde{w}_q)$ increase.

[**Step 4.**] The socially efficient search intensity and productivity are characterized by the first-order conditions (4) and $v'(q) = c_L'(q)$. The expected payoff to an applicant from applying to a firm of productivity q with a wage $\tilde{w}_q$ is given by:

$$\widetilde{U}(\tilde{w}_q, \tilde{n}(\tilde{w}_q)) \equiv (1-\lambda)\left(1-(1-\alpha)^{\tilde{n}(\tilde{w}_q)}\right)\tilde{w}_q. \tag{8}$$

Using (6) to substitute for $(1-\alpha)^{\tilde{n}(\tilde{w}_q)}$, we have $\widetilde{U} = \left(1-\lambda-\frac{m}{v(q)-\tilde{w}_q-c_L(q)}\right)\tilde{w}_q$. It follows from an application of the Envelope Theorem that

$$\left.\frac{\partial \widetilde{U}}{\partial q}\right|_{w_q=\tilde{w}_q} = -c_L'(q)\frac{m}{(v(q)-\tilde{w}_q-c_L(q))^2}\tilde{w}_q + (1-\lambda-\frac{m}{v(q)-\tilde{w}_q-c_L(q)})v'(q) = 0$$

Substituting in $\tilde{w}_q = v(q) - c_L(q) - \sqrt{\frac{m(v(q)-c_L(q))}{1-\lambda}}$ and simplifying, $\left.\frac{\partial \widetilde{U}}{\partial q}\right|_{w_q=\tilde{w}_q} = -c_L'(q) + v'(q) = 0$ results; that is, applicants apply to firms of the planner-prescribed productivity. ∎

For firms, mistakes in this environment involve false-negatives, i.e., not identifying some of the good candidates. Proposition 1 indicates that firms collect too little information about applicants — that is, the probability that qualified applicants are cast off as false-negatives is too high, and too few qualified applicants are ultimately hired. The social cost of each mistake is given by $v(q) - c_L(q)$. The private cost to a firm, however, is $v(q) - \tilde{w}_q - c_L(q)$. Since $\tilde{w}_q > 0$, the private cost of making a mistake is smaller than the social cost, and firms, consequently, acquire too little information.

An interesting feature of the equilibrium outcome characterized in Proposition 1 is that firms earn positive profits. The reason perfect competition fails in this setting is that an applicant's expected utility in the continuation equilibrium, $\widetilde{U}(w, \tilde{n}_q(w))$, is not monotone increasing. In particular, it is increasing for wages less than $\tilde{w}_q$ and decreasing for higher wages. Higher wages induce low levels of information collection, with many qualified applicants remaining undetected, and, therefore, result in low probabilities of being hired.

This feature is the key reason for why applicants attempt to efficiently match with firms; that is, for why applicants seek to match with firms of the planner-prescribed productivity. Since the inefficiently low search intensities of firms are already taken into account in firms' relatively low wages, there is no additional distortion in productivity matches. In other words, the relatively low wages already fully account for applicants' desire to receive sufficient evaluation (i.e., for the potential employer to examine sufficiently many of an applicant's records for positive qualifications). Since firms are forced to select these wages in equilibrium due to the competitive nature of the market, these wages already fully capture the distortion in screening intensities, enabling applicants to attempt to efficiently match with firms.

From the equilibrium wages and screening intensities identified in the proof of Proposition 1, it is straightforward to see that as information becomes less costly to acquire (that is, as k, and consequently m, decrease), firms acquire more information, wages increase, more applicants are hired, and applicants are better off in expectation.

Although firms are less likely to make hiring mistakes as a result of acquiring more information, they also incur larger operating expenses associated with higher wages, since applicants are less concerned about being mistakenly identified as a mismatch. The net impact of these contrasting effects on profits (over the range of m for which an interior solution obtains) is ambiguous. However, as $k \to 0$ (whereby $m \to 0$), it is clear that firms' profits dissipate, as applicants' types are perfectly revealed. Continuity in k entails that there exists a threshold $\bar{k} > 0$ such that profits decrease for $k < \bar{k}$. We conclude this section by summarizing the above observations in the following corollary.

Corollary 1 *When firms search for good news, as information becomes less costly to acquire, wages increase, more applicants are hired, and applicants' expected payoffs increase. There exists a threshold $\bar{k} > 0$ such that firms' profits decrease with a decrease in k for $k < \bar{k}$.*

4 Searching for Bad News

The information-collection process we now consider is one where firms search for disqualifying information about applicants. We first describe the revised screening process and then characterize the resultant equilibrium.

4.1 Information Acquisition

The specification of the model is identical except that a firm that chooses a search intensity n now receives n conditionally independent Bernoulli' signals $Y_1, \ldots, Y_n$, where

$$\Pr\{Y_i = 1|c\} = \begin{cases} 1, & \text{if } c = c_L, \\ 1-\alpha, & \text{if } c = c_H \end{cases}$$

As before, the parameter $\alpha \in (0,1)$ indicates intrinsic signal strength. If $\alpha = 1$, then a single signal is fully informative, and if $\alpha = 0$, then signals contain no information at all. This process is interpreted as follows. Each firm obtains a file containing n records, $Y_1, \ldots, Y_n$, for each of its applicants. Each record in the file is either positive ($Y_i = 1$) or negative ($Y_i = 0$). Since the probability of a false negative is zero in this setting, it is appropriate to regard the firm as searching for 'bad news' about its applicants.

The sufficient statistic $S_n \equiv \min\{Y_1, \ldots, Y_n\}$ summarizes the information acquired. In particular, if $S_n = 0$, then at least one of the records was negative and the applicant is associated with type c_H, whereas if $S_n = 1$, then all of the records were positive and the applicant is type c_L with the posterior probability

$$\frac{(1-\lambda)}{\lambda(1-\alpha)^n + (1-\lambda)} > (1-\lambda).$$

If $S_n = 0$, the applicant is rejected, and if $S_n = 1$, the applicant ends up being hired. As before, employment results in a wage of w_j for the applicant and an expected payoff of $v(q_j) - w_j - E[c(q_j)|S_n] - kn$ for the firm.[10] Rejection results in a payoff of zero for the applicant and $-kn$ for the firm. We maintain the notation that $m \equiv -\frac{k}{\ln(1-\alpha)}$, giving a measure of the efficacy of the information-collection technology, with lower values of m corresponding to better technologies involving low sampling costs and/or high signal strength.

4.2 Characterizing Equilibrium

The problem facing a social planner in this context is

$$\max_{(q,n)} U(q,n) \equiv (\lambda(1-\alpha)^n + (1-\lambda)) \left(v(q) - \frac{\lambda(1-\alpha)^n c_H(q) + (1-\lambda)c_L(q)}{\lambda(1-\alpha)^n + (1-\lambda)} \right) - kn \quad (9)$$

The first bracketed term denotes the probability that an applicant is hired; the second bracketed term gives the expected social benefit of hiring an applicant; and the last term denotes the cost of collecting information. We continue to focus on interior solutions. For m sufficiently small ($m < \lambda(c_H(q) - v(q))$ for $q \in (0, Q]$), an interior optimum obtains at (q^*, n^*) and is characterized by the following first-order conditions:

$$\lambda(1-\alpha)^{n^*}(c_H(q^*) - v(q^*)) = m \quad (10)$$

[10] We note that while we use the same notation k to denote a firm's marginal cost of acquiring information, this cost need not be the same as in the case of searching for good news.

and

$$v'(q^*) = \frac{\lambda(1-\alpha)^{n^*} c'_H(q) + (1-\lambda)c'_L(q)}{\lambda(1-\alpha)^{n^*} + (1-\lambda)}. \tag{11}$$

Condition (10) is analogous to Condition (4); at n^*, the marginal social cost of mismatching an applicant with a firm of productivity q^* equals the marginal social cost of collecting more information about the applicant. Condition (11) is similarly intuitive; at q^*, the marginal social gain of matching with a higher-productivity firm equals the (conditional) expected marginal cost of hiring an applicant who successfully passed screening.

Lemma 1 *An interior solution obtains for $m < \lambda(c_H(q) - v(q))$, $q \in (0, Q]$. For firms of a given productivity level q, applicants' expected utilities are increasing in wage.*

Lemma 1 indicates that for any level of productivity q, applicants will prefer applying to the firms that post the highest wages. Hence, in contrast to the previous section, firms' profits will dissipate in equilibrium.

Suppose a firm with productivity q posts a wage w. Then, it will acquire information about its applicants in accordance with the first-order condition

$$\lambda(1-\alpha)^n(c_H(q) + w - v(q)) = m. \tag{12}$$

Let us define the expected cost per hiring to be

$$AC(q,n) \equiv \frac{\lambda(1-\alpha)^n c_H(q) + (1-\lambda)c_L(q) + kn}{\lambda(1-\alpha)^n + (1-\lambda)}. \tag{13}$$

Armed with the result in Lemma 1, we obtain the following.

Proposition 2 (Bad News) *In equilibrium, firms collect an inefficiently high amount of information about applicants, earn zero profits, and applicants attempt to match with firms of inefficiently low productivities.*

Proposition 2 indicates that firms screen applicants too intensely. In other words, holding fixed applicants' chosen firm type, it is possible to generate an *ex-ante* Pareto improvement by reducing search intensities and decreasing wages. This inefficient collection of information stems from firms' inability to commit with respect to their screening intensities, coupled with the competitive pressures imposed by other firms.

Second, Proposition 2 indicates that, given equilibrium search intensities, applicants inefficiently match with firms. In particular, the social gain from a marginal match increase to higher-productivity firms is greater than the cost increase from admitting the applicants to those firms. Said another way, if firms' information-collection practices were held constant at the equilibrium level, a Pareto improvement can be obtained by matching applicants with marginally higher-productivity firms (leading to a gain in revenue that compensates for any increase in the expected costs of admitting the applicants).

This second distortion stems from (i) the non-contractibility of firms' information-collection practices, and (ii) because firms are driven to offer the highest wages they can manage, which comes at the cost of increased information collection. Consequently, applicants use another venue to dampen firms' excessive amount of information collection in equilibrium. In particular, applicants understand that if they apply to lower-productivity firms, then those firms will screen them less intensively. By applying to those lower-productivity firms, they attempt to match with firms that incur lower costs of mismatching and thereby possess diminished incentives for information collection. In an effort, therefore, to be hired, applicants inefficiently select lower-productivity firms.

The equilibrium when firms search for bad news thus resembles two layers of a Prisoner's Dilemma. First, the cost-benefit analysis (screening versus wages) shifts applicants' search in favor of higher wages, which in turn leads firms to collect too much information. Second, to mitigate this increased scrutiny, applicants inefficiently match with lower-productivity firms.

From the first-order condition (12), notice that as information becomes less costly to acquire (that is, as k decreases), then more information will be collected and fewer applicants will be admitted. However, wages to admitted applicants increase. To see this, suppose otherwise; that is, suppose k decreases and wages do not. If applicants apply to firms of type q, then a firm j of type q could screen applicants epsilon more intensely, slightly increase its wage, and by Lemma 1 applicants would choose it. Firm j's profit would be positive due to the decrease in k, thereby inducing other type q firms to raise their wages — a contradiction.

While wages rise with a decrease in k, the net effect on applicants' expected payoffs is not immediately clear. This is due to two opposing effects: fewer applicants are admitted (negative) but wages increase to ultimately admitted applicants (positive). In net, a decrease in k results in higher expected payoffs for applicants. Intuitively, as the cost of acquiring information decreases, the total rent 'pie' expands; because applicants extract all of the rents in equilibrium, their expected payoffs in turn increase.

In terms of the matching distortion, firms' amplified incentives to acquire information are counteracted by higher wages. The two have opposing effects on the change in applicants' choice of a firm type, whereby the net effect of a decrease in k on the matching distortion is ambiguous. However, since the matching distortion disappears as $k \to 0$, there exists a threshold $\tilde{k}$ such that a decrease in k for $k < \tilde{k}$ improves applicants' matching with firms.

We conclude this section with the following corollary which summarizes and formalizes the above observations. The proof is in the Appendix.

Corollary 2 *When firms search for bad news, as information becomes less costly to acquire, wages increase, fewer applicants are hired, and applicants' expected payoffs increase. There exists a threshold $\tilde{k} > 0$ such that the matching distortion diminishes with a decrease in k for $k < \tilde{k}$. Firms' equilibrium profits remain unchanged at* 0*.*

5 An Endogenous Process for Search

In this section, we consider a simple variant of the base model with an alternative information-collection technology, where, rather than searching for 'good news' or 'bad news,' the type of search process is determined in equilibrium. In particular, suppose that instead of collecting records about an applicant, a firm with productivity q chooses a probability α with which it receives an informative signal about an applicant. That is, α represents the firm's search intensity in this variant of the model. We assume that raising the likelihood of an informative signal is increasingly costly. For tractability, we consider quadratic cost $\kappa(\alpha) = k \cdot \alpha^2$ for achieving search intensity α, with the scaling parameter $k > 0$ sufficiently large to ensure an interior equilibrium.[11] If a firm chooses to acquire information about an applicant, it receives a signal s, where:

$$s = \begin{cases} c & \text{with probability } \alpha \\ \emptyset & \text{with probability 1-}\alpha \end{cases}$$

with $c \in \{c_L(q), c_H(q)\}$ denoting the applicant's type. Thus, with probability α the firm receives a perfectly informative signal, learning whether or not the applicant is a good match, and with probability $1 - \alpha$ the firm receives an empty signal and is left with the common prior.[12] We assume variables are normalized such that $1 > c_H(q) > v(q) > c_L(q) \geq 0$. All other aspects of the base model remain unchanged.

5.1 Searching for Bad News

Suppose some candidates choose to apply with firms of type q. Following an informative search, a firm of type q will hire an applicant revealed to be a low-cost type and reject an applicant revealed to be a high-cost type. Following an uninformative search, a firm will hire an applicant if the revenue generated exceeds the expected cost of matching with the applicant, i.e., if:

$$v(q) - w_q \geq \lambda c_H(q) + (1 - \lambda) c_L(q).$$

[11] A sufficient lower bound on k is $\frac{1}{4} \max_{q \in \{0,Q\}} (c_H(q) - c_L(q))$.

[12] It is straightforward to verify that the results would continue to hold if information were not perfect, but sufficiently informative. The key driver is that signals about applicants vary in their informativeness.

Equivalently, the wage w_q must satisfy

$$w_q \leq v(q) - \lambda c_H(q) - (1-\lambda)c_L(q). \tag{14}$$

If the wage posted by the firm satisfies (14), the firm will hire the applicant following an uninformative search; in other words, in a manner analogous to the base model, the firm is searching for *bad news*. Let $\alpha_{q,b}$ denote the firm's search intensity in this case. Then the firm's problem is given by:

$$\max_{\alpha_{q,b}} (1-\lambda)(v(q) - w_q - c_L(q)) + \lambda(1-\alpha_{q,b})(v(q) - w_q - c_H(q)) - k\alpha_{q,bn}^2.$$

Solving the above yields:

$$\alpha_{q,b}(w_q) = \frac{\lambda(c_H(q) - v(q) + w_q)}{2k}.$$

As in the base model, the amount of information a firm collects is unobservable and unverifiable, whereby firms of a given productivity compete solely on the basis of wages. Applicants, therefore, apply to whichever firm of a given type offers the most attractive terms: wage and implied screening intensity. An applicant's expected utility from applying to a firm of type q with wage w_q is given by:

$$U_q^{bn}(w_q, \alpha_{q,b}(w_q)) = (1 - \lambda\alpha_{q,b}(w_q))w_q \tag{15}$$

Increasing the wage a firm offers increases the intensity with which applicants are screened, thereby decreasing the chance an applicant is hired. However, it is straightforward to verify that the indirect cost of a lower probability of being hired is outweighed by the direct benefit of a higher wage conditional on admittance; that is:

$$\frac{\partial U_q^{bn}(w_q, \alpha_{q,b}(w_q))}{\partial w_q} > 0. \tag{16}$$

Thus, a firm of type q will set the highest possible wage consistent with (14), i.e.

$$w_q^{bn} = v(q) - \lambda c_H(q) - (1-\lambda)c_L(q), \tag{17}$$

implying

$$\alpha_{q,b} = \frac{\lambda(1-\lambda)(c_H(q) - c_L(q))}{2k}. \tag{18}$$

5.2 Searching for Good News

If the wage offered is higher than specified by (14), then a firm will only hire an applicant if he is revealed to be a low-cost type. In other words, the firm does not allow for false positives; i.e., in a manner analogous to the base model, the firm is searching for *good news*. Letting $\alpha_{q,g}$ denote the firm's search intensity under this condition, the firm then faces the following maximization problem:

$$\max_{\alpha_{q,g}}(1-\lambda)\alpha_{q,g}(v(q) - w_q - c_L(q)) - k\alpha_{q,g}^2$$

Solving this maximization problem yields:

$$\alpha_{q,g}(w_q) = \frac{(1-\lambda)(v(q) - w_q - c_L(q))}{2k}$$

When the wage does not satisfy (14), an applicant's expected utility is given by:

$$U_q^{gn}(w_q, \alpha_{q,g}(w_q)) = (1-\lambda)\alpha_{q,g}(w_q)w_q. \tag{19}$$

Differentiating with respect to w_q, we have that expected utility is non-monotonic in wage and is maximized when:

$$w_q^{gn} = \frac{v(q) - c_L(q)}{2}, \tag{20}$$

implying

$$\alpha_{q,g} = \frac{(1-\lambda)(v(q) - c_L(q))}{4k}. \tag{21}$$

We next examine when applicants prefer that firms search for good versus bad news.

5.3 Equilibrium with Endogenous Search

In equilibrium, applicants' expected utilities from applying to firms of type q when they search for bad and good news respectively are given by:[13]

$$U_q^{bn} = \max\{\left(1 - \frac{\lambda^2(1-\lambda)(c_H(q) - c_L(q))}{2k}\right)(v(q) - \lambda c_H(q) - (1-\lambda)c_L(q)), 0\} \tag{22}$$

and

$$U_q^{gn} = \frac{(1-\lambda)^2(v(q) - c_L(q))^2}{8k}. \tag{23}$$

One can observe that if $v(q) \to \lambda c_H(q) + (1-\lambda)c_L(q)$ (i.e., if hiring applicants without screening is not a profitable option for firms), applicants prefer the good-news scenario in which there are higher wages but also a higher chance of rejection. Subtracting expected utilities under the two scenarios in the case where $v(q) \geq \lambda c_H(q) + (1-\lambda)c_L(q)$ and differentiating yields:

$$\frac{\partial(U_q^{bn} - U_q^{gn})}{\partial v(q)} = 1 - \frac{\lambda^2(1-\lambda)(c_H(q) - c_L(q))}{2k} - \frac{(1-\lambda)^2(v(q) - c_L(q))}{4k} > 0. \tag{24}$$

It can be readily verified that for revenues $v(q)$ close to $c_H(q)$, $U_q^{bn} > U_q^{gn}$. Taken in combination with the above, this implies that there exists a unique $v^*(q) \in (\lambda c_H(q) + (1-\lambda)c_L(q), c_H(q))$ such that $\forall v(q) > v^*(q), U_q^{bn} > U_q^{gn}$, and vice versa. That is, there is a unique threshold above (below) which firms search for bad (good) news.

Moreover, it is apparent from (22) and (23) that as the cost parameter k increases, U_q^{bn} increases and U_q^{gn} decreases, whereby the threshold $v^*(q)$ moves downward. Said another way, as it becomes easier to obtain informative signals about applicants (that is, as k decreases), the revenue threshold (since mismatch costs $c_L(q)$ and $c_H(q)$ are held constant) below which a firm searches for good news increases; i.e., more firms are searching for good news. Intuitively, a lower cost for obtaining an informative signal helps assuage applicants' concerns about

[13] In the case of firms searching for bad news, since applicants would only consider jobs offering non-negative wages, applicants' utilities are bounded below by 0.

being mistakenly identified as a mismatch under the 'good news' regime, and induces them to seek its higher wages. We therefore have the following result:

Proposition 3 (Endogenous Search) *In the unique equilibrium outcome, for a given productivity level q, there exists a threshold $v^*(q)$ such that:*

Bad News: *If $v(q) > v^*(q)$, firms offer wages $w_q^* = w_q^{bn}$; applicants apply to the firms posting w_q^* and these firms acquire information according to $\alpha_q^* = \alpha_{q,b}$ and hire applicants not revealed to be the high-cost types, i.e., firms search for bad news.*

Good News: *If $v(q) \leq v^*(q)$, firms offer wages $w_q^* = w_q^{gn}$; applicants apply to firms offering w_q^* and these firms acquire information according to $\alpha_q^* = \alpha_{q,g}$ and only hire applicants revealed to be the low-cost types, i.e., firms search for good news.*

Process Selection: *As the cost of obtaining a more informative signal decreases, the threshold $v^*(q)$ increases, whereby more firms are searching for good news.*

Thus, for a position associated with productivity level q, firms will end up either searching for 'bad' or 'good' news about applicants depending on the revenue potential associated with a position. In particular, for positions associated with higher revenue potentials, firms will end up searching for bad news, and vice versa. When the cost of conducting an informative screening of an applicant decreases, more positions fall under the 'good news' collection process. As indicated in the analysis of the base model, this transition can be beneficial from a matching perspective; that is, assuming that positions are eventually filled, applicants will be better matched with firms. Moreover, we showed in Section 3 that under the 'good news' process, as the cost of acquiring information decreases, wages increase and more applicants are hired. Thus, perhaps surprisingly, the increased availability of applicants' information online, putting aside the impact on their privacy, can be welfare enhancing.

6 Conclusion

We examined two information-collection processes that may be used by firms to screen applicants: searching for "good news" about the match-value of applicants, and searching for "bad news." Under the approach of searching for good news, we showed that, in equilibrium, firms collected an inefficiently small amount of information about applicants and the probability of qualified candidates being hired was inefficiently low. However, applicants efficiently chose the types of firms to which they applied. Under the approach of searching for bad news, we showed that, in equilibrium, firms collected an inefficiently high amount of information about applicants and applicants inefficiently matched with firms. Upon identifying the dynamics under each process, we considered a variant of the base model, where the practice of searching for 'good' and 'bad' news can arise endogenously in equilibrium. We demonstrated that as the cost of conducting an informative screening of an applicant decreases, *ceteris paribus*, fewer firms will search for bad news, which can be welfare enhancing.

Our findings point out that when firms lack the ability to commit upfront to the amount of information they acquire, inefficiencies may result in the amount of information collected, leading to reduced welfare and an inefficiently small number of applicants being hired — no matter which firms applicants choose. In addition, our findings point out that the increased availability of applicant information online has the following implications: (i) more positions may fall under the 'good news' search process and result in better matches; (ii) while wages may increase, the switch to searching for good news can benefit firms' profits; and (iii) for positions associated with firms searching for bad news, applicants may strategically choose to pursue suboptimal matches in an effort to be screened less intensely.

Our framework is not without limitations. First, our model does not incorporate *ex-ante* asymmetric information between applicants and firms. While the restriction to symmetric information may be appropriate in some settings — for instance, if we consider a representative applicant in a specific category (e.g., a recent "honors" graduate of a successful undergraduate program), a more realistic model would incorporate asymmetric information, which may lead to signaling and self selection by applicants into specific firms (cf. Spence, 1973; Lazear, 2000, 2004; Janssen, 2002; Oyer and Schaefer, 2005). However, given our specification with a two-type distribution, incorporating *ex-ante* asymmetric information would not change the qualitative nature of our results, provided such information is imperfect. For instance, applicants who suspect themselves of being of low-match value to a firm would have to pool with high-type applicants in order to be considered, and our analysis will carry through. Furthermore, the argument that applicants' information about their match value to a specific firm is imperfect seems plausible. Second, whether searching for good or bad news, matches in our setting may be susceptible to renegotiation. This is because once a firm of a given productivity level expended the resources to hire an applicant, a firm with a higher productivity level may be willing to hire the applicant as well. In practice, firms attempt to resolve such issues in various ways, such as strategically choosing the timing of their interviews (e.g., using certain application deadlines), contractual exclusivity (e.g., non-compete agreements), and via reputational repercussions.

While our model does not explicitly account for such features, their consideration paves the way for future work, which can include a richer framework that incorporates asymmetric information with continuous types, renegotiations, capacity constraints, minimum admission requirements for firms, an information intermediary, and staggered deadlines for applications.

From the perspective of information collection as it pertains to the privacy of applicants, as applicants' concerns over privacy intensify, applicants are likely to exercise increased control over their online footprints, which may interact with firms' screening efforts. One way our framework can account for that is by considering an increase in firms' costs of acquiring information — which would indeed reduce the amount of information collected in equilibrium. However, it may also have the undesired effects of reducing applicants' expected monetary payoffs and leading more firms to searching for 'bad news' — along with the subsequent matching inefficiencies.

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Appendix

Proof of Lemma 1:

Proof. An applicant's expected utility from applying to a firm given a wage w and productivity q is specified by $U(w,q) = (\lambda(1-\alpha)^{n(w)} + 1 - \lambda)w$. The firm's expected profit from this applicant is given by

$$(\lambda(1-\alpha)^n + (1-\lambda))(v(q) - w) - (1-\lambda)c_L(q) - \lambda(1-\alpha)^n c_H(q) - kn.$$

Deriving the firm's profit with respect to n gives $\lambda(1-\alpha)^n(c_H(q) + w - v(q)) = m$, with the second-order condition specified by $\lambda(\ln(1-\alpha))^2(v(q) - w - c_H(q))(1-\alpha)^n < 0$. An interior solution thus obtains if the first-order condition is positive at $n = 0$ over non-negative wages, which is satisfied by $m < \lambda(c_H(q) - v(q))$. The applicant's expected utility can then be rewritten as

$$\left(\frac{m}{c_H(q) + w - v(q)} + 1 - \lambda\right) w.$$

Differentiating with respect to w yields $dU/dw = \frac{m(c_H(q) - v(q))}{(c_H(q)+w-v(q))^2} + (1-\lambda) > 0$. ■

Proof of Proposition 2:

Proof. The proof proceeds in three steps.

[**Step 1.**] We first show that the equilibrium wage set by a firm with productivity q, $\overline{w}_q$, satisfies $\overline{w}_q = v(q) - AC(q, \overline{n}_q)$, where $\overline{n}_q = n_q(\overline{w}_q)$ denotes its optimally chosen screening intensity. To see this, suppose by way of contradiction that $\overline{w}_q < v(q) - AC(q, \overline{n}_q)$, and let $\Sigma > 0$ denote aggregate equilibrium profit. The least profitable firm earns profit no greater than $\Sigma/2$. However, by choosing $\epsilon > 0$ sufficiently small, it could earn profit arbitrarily close to Σ by offering a wage $\overline{w}_q + \epsilon$. In particular, it would acquire information about applicants in accordance with (12) and all applicants would apply to it by Lemma 1.

[**Step 2.**] Let $\overline{q}$ denote applicants' chosen firm type. In equilibrium, the planner's solution is not obtained; that is, it does *not* hold that $\overline{q} = q^*$ and $\overline{n}_{\overline{q}} = n^*$. To see this, suppose by way of contradiction that $\overline{q} = q^*$ and $\overline{n}_{\overline{q}} = n^*$. Then, $\overline{w}_{\overline{q}} = v(\overline{q}) - AC(\overline{q}, \overline{n}_{\overline{q}}) = v(q^*) - AC(q^*, n^*)$ by Step 1. However, it must also hold at q^* that $v(q^*) = v(\overline{q}) > AC(q^*, n^*) = v(\overline{q}) - \overline{w}_{\overline{q}}$ (else applicants would not apply). But then inspection of (10) and (12) shows that this implies $\overline{n} > n^*$, a contradiction.

[**Step 3.**] It follows that the resultant firm type and search intensity, $(\overline{q}, \overline{n}_{\overline{q}})$, can be found by solving the Lagrangian

$$\max_{(n,q,\gamma)} \lambda(1-\alpha)^n(v(q)-c_H(q))+(1-\lambda)(v(q)-c_L(q))-kn+\gamma(m-\lambda(1-\alpha)^n(c_H(q)-AC(q,n))).$$

Substituting the solution into the first-order condition with respect to n and rearranging gives

$$\lambda(1-\alpha)^{\overline{n}_{\overline{q}}}(c_H(\overline{q}) - v(\overline{q})) = m - \overline{\gamma}(\lambda(1-\alpha)^{\overline{n}_{\overline{q}}}(c_H(\overline{q}) - AC(\overline{q}, \overline{n}_{\overline{q}})) + z),$$

where

$$z \equiv -\frac{\lambda(1-\alpha)^{\overline{n}_{\overline{q}}}}{\ln(1-\alpha)} \frac{\partial AC(\overline{q}, \overline{n}_{\overline{q}})}{\partial n}.$$

Notice that $AC(\overline{q}, n)$ attains its minimum at $n = \overline{n}_{\overline{q}}$. Hence, $\partial AC(\overline{q}, \overline{n}_{\overline{q}})/\partial n = 0$. Also, $c_H(\overline{q}) > v(\overline{q}) - \overline{w}_{\overline{q}} = AC(\overline{q}, \overline{n}_{\overline{q}})$. Finally, Step 2 implies $\overline{\gamma} > 0$. Together, these observations yield $\lambda(1-\alpha)^{\overline{n}_{\overline{q}}}(c_H(\overline{q}) - v(\overline{q})) < m$; that is, firms collect an inefficiently high amount of information about applicants.

Substituting the solution of the Lagrangian into the first-order condition for q and rearranging gives:

$$v'(\overline{q}) = \frac{\lambda(1-\alpha)^{\overline{n}_{\overline{q}}} c'_H(\overline{q}) + (1-\lambda)c'_L(\overline{q}) + \overline{\gamma}\lambda(1-\alpha)^{\overline{n}_{\overline{q}}}(c'_H(\overline{q}) - (\partial AC(\overline{q}, \overline{n}_{\overline{q}})/\partial q))}{\lambda(1-\alpha)^{\overline{n}_{\overline{q}}} + (1-\lambda)}.$$

Notice that

$$c'_H(\overline{q}) - \frac{\partial AC(\overline{q}, \overline{n}_{\overline{q}})}{\partial q} = \frac{(1-\lambda)(c'_H(\overline{q}) - c'_L(\overline{q}))}{\lambda(1-\alpha)^{\overline{n}_{\overline{q}}} + (1-\lambda)} > 0.$$

This observation yields

$$v'(\overline{q}) > \frac{\lambda(1-\alpha)^{\overline{n}_{\overline{q}}} c'_H(\overline{q}) + (1-\lambda)c'_L(\overline{q})}{\lambda(1-\alpha)^{\overline{n}_{\overline{q}}} + (1-\lambda)}.$$

That is, the social gain from a marginal increase in productivity is higher than the expected cost increase of admitting the applicants to those higher-productivity firms. ■

Proof of Corollary 2:

Proof. The increase in applicants' expected payoffs due to a decrease in k can be seen analytically. Taking an applicant's expected utility for a given wage w, firm type q, and search intensity n, $(\lambda(1-\alpha)^n + 1 - \lambda)w$, we substitute in $w = v(q) - AC(q, n)$ using (13) to obtain an applicant's expected utility as

$$U(q, n) = (1 + \lambda + \lambda(1-\alpha)^n)v(q) - (\lambda(1-\alpha)^n c_H + (1-\lambda)c_L + kn)$$

Since n is chosen optimally by firms given their wages, an application of the Envelope Theorem gives $\partial U/\partial k = -n$.

The matching distortion is characterized in the proof of Proposition 2 as a wedge between the planner's solution and an applicant solution specified by

$$\bar{\gamma}\lambda(1-\alpha)^{\bar{n}_{\bar{q}}} \frac{(1-\lambda)(c'_H(\overline{q}) - c'_L(\overline{q}))}{(\lambda(1-\alpha)^{\overline{n}_{\overline{q}}} + (1-\lambda))^2}$$

A derivative of this expression with respect to $\bar{n}_{\bar{q}}$ reveals that an increase in $\bar{n}_{\bar{q}}$ is guaranteed to always diminish this wedge only for sufficiently high values of $\bar{n}_{\bar{q}}$. Since $\partial\bar{n}_{\bar{q}}/\partial k < 0$, the result follows. ■