Costly Interviews*

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Abstract

In this paper, we show how the interaction between costly screening and competition in decentralized markets may prevent efficient matching. We examine this phenomenon in a simple dynamic model of a professional labor market, where firms can pay a cost to interview applicants who have private information about their own ability. Inefficiencies arise when a firm decides not to interview potentially able candidates since it infers that sufficiently good candidates will be hired by more productive firms. This effect is robust to changes in the information structure of the market, but it can be mitigated by subsidizing screening costs.

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JEL codes: D82, J21, J44

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1 Introduction

In this paper, we construct a simple model of an entry-level professional labor market (such as those for lawyers, MBAs, academics, and others) where applicants have private information about their abilities and firms of different productivities can interview applicants at a cost to uncover that information. There is an exogenous interview schedule in which applicants are matched with firms in each period. Hiring takes place subsequent to the interview schedule. If a firm hires an applicant, production takes place and the surplus is split proportionally.

In this game, able applicants may not be hired. This phenomenon arises when a firm decides not to interview (and therefore does not hire) a potentially able applicant since it foresees sufficiently good candidates will be hired by more productive firms. In other words, competition from other firms for the candidate makes the firm anticipate that it will suffer from a *winner's curse* at the hiring stage.

This is a kind of unemployment that could, and in some cases, should be avoided, since the rejected applicant may actually be a good match for the firm. At the core of this inefficiency is an externality; firms do not consider workers' surplus from a match when they decide whether to interview a candidate. From a policy perspective, we demonstrate that lowering firms' screening costs through subsidies can improve welfare by increasing firms' surplus from a match, thereby mitigating the externality.

The effect illustrated here is different from *stigma* as described in the literature. There, it usually refers to a realized selection effect; somebody or something is inferred to have failed a screening test given their observable current state. For example, unemployment or unemployment duration may create an inference that a worker is of lower ability[1]. Our model differs in two ways. First, the observable current state does not provide any information - a firm knows that its current candidate may have been previously interviewed, but it has no information to use to update since job offers take place later in the game and interviews are unobservable. Second, it is the fact that firms

[1] See Greenwald (1986) and Lockwood (1991) for this effect in the context of the labor market. Taylor (1999) examines a similar "time-on-the-market" effect for the housing market. In the finance literature, the stigma effect can be found in Dell'ariccia, Friedman, and Marquez (1999) for the credit market, Landier (2006) for entrepeneurial finance, and Ennis and Weinberg (2013) in the context of the Fed discount window.

compete for workers that creates the negative inference. A low productivity firm that knows it will lose out on an able worker to a more productive firm will decide not to interview the worker.

A related paper is Ely and Siegel (2013), who also analyze a model of a labor market with screening costs. The two models share a strict ranking of firms and an exogenous wage structure. In both models, lower ranked firms may prefer not to incur the screening cost, anticipating a winner's curse. However, unlike Ely and Siegel (2013), our model has multiple workers and multiple rounds of interviews. Our model is also different in that the surplus from hiring is firm specific and the focus is on unemployment.

This paper is organized as follows. In Section 2, we set up the simple model with two firms and two applicants. In Section 3, we derive the market equilibrium and demonstrate the main result. In Section 4, we consider how subsidizing interviews can increase welfare. In Section 5, we extend the model to allow for uncertainty about firm types. In Section 6, we conclude. Proofs and a general model with F firms and X applicants can be found in the Appendix.

2 The Model

In this section, we examine the case of two firms and two applicants. The main result is shown in the Appendix to hold for the general case of multiple firms and applicants. Specifically, there are two firms $i = 1, 2$ of publicly observable productivity f_1 and f_2, where $f_2 > f_1 > 0$, and two applicants, $j = 1, 2$, who have privately observable productivity $x_j \in \{L, M, H\}$, where $H > M > L > 0$. The realization of the types of the two applicants are independent and determined by the probabilities p_L, p_M, and p_H, which are all positive and sum to one. A firm with productivity f_i who hires an applicant of ability x_j creates an output $\pi_{ij} = f_i x_j$. The players split the output from the match according to an exogenous sharing rule: firms get $\alpha\pi_{ij}$ and applicants get $(1 - \alpha)\pi_{ij}$, where $\alpha \in (0, 1)$. We explicitly model the surplus as multiplicative for ease of presentation, although any supermodular function should give the same results.

We assume that firms have an outside option equal to $\alpha f_i t$, which they receive if they do not hire anyone. The value of the threshold t is common across firms and $M > t > L$, implying that neither firm would willingly hire a type L applicant.[2] Applicants have a reservation payoff of zero if they are not hired.

The game has two periods. At the start of the game, nature draws a publicly observable interview schedule and the types of the two applicants. For simplicity, we will assume that interviews are costless in period 1, but costly in period 2. This assumption reduces the number of cases to analyze.[3]

In period 1, each firm is matched with an applicant. The firms observe the type of the applicant they are matched with, but not the type of the other applicant.

In period 2, the firms are matched with the applicants they did not match with in period 1. Each firm decides whether to interview the applicant it is matched with in the second period at a cost of $C > 0$. An interview fully reveals the applicant's type to the interviewing firm, but the other firm cannot observe this type or whether the applicant was interviewed.

Firms then choose whether to make any of the applicants an offer.[4] Firms make offers simultaneously and they can only make offers to applicants if they have interviewed them.[5] Finally, the applicants decide whether to accept any offer.

To summarize, the timeline of the game is:

[2] Applicants of type L are never hired in equilibrium in our model, but are necessary to justify the use of interviews over hiring without interviews. However, a modified model where interviews give incorrect signals about the applicants' type with a small probability would have similar results and have L applicants hired in equilibrium.

[3] We show in a previous version of the paper (Josephson and Shapiro (2012)) that in a game with positive and identical interview costs in both periods, there is an equilibrium such that all firms interview in the first period. In other equilibria of this game, some firms may opt out of interviewing in round one. This makes unemployment even more likely than in our model.

[4] Allowing firms to make (open) offers in the first period as well does not alter the main results.

[5] Assuming that $\alpha p_L f_2(t - L) > C$ is necessary and sufficient to ensure that neither firm 1 nor firm 2 would hire without interviewing.

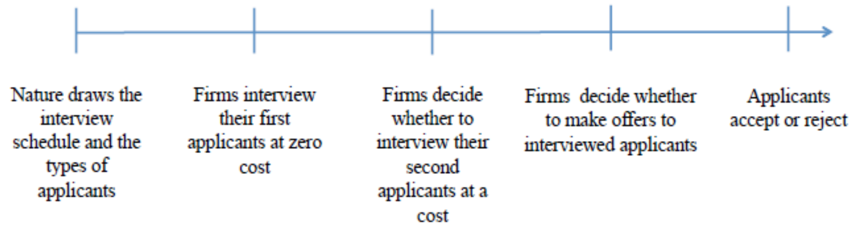

Figure 1: Timeline

We assume that the structure of the game is common knowledge to all participants and that the following conditions hold for $i = 1, 2$:

$$\alpha p_M f_i (M - t) < C, \tag{C1}$$

$$\alpha p_H f_i(H - M) > C. \tag{C2}$$

Condition C1 says that the firm would prefer to go unmatched rather than interview an applicant when it doesn't have the possibility of hiring a high type. This condition is key to our result. Note that the interview cost parameter C must be positive for this to hold.

Condition C2 implies that a firm with an applicant of type M in period 1 would prefer to interview a new applicant in the second period and make an offer to the best of the two. It converts the potential mismatch under C1 into a problem of unemployment for productive applicants.

The left hand sides of C1 and C2 represent the option values of interviewing and the right hand sides the cost.

In addition to the above conditions, we will for expositional purposes assume that if a firm is matched with an applicant of the same type in periods one and two, and it can hire either of them with probability one, then it will always prefer the latter. These conditions pin down parameters for which unemployment of able applicants will occur.

3 The market equilibrium

We start by analyzing the market solution, where firms maximize their profits by strategically making decisions about interviews and offers. To simplify notation, we use the convention that firm 1 is matched with applicant 1 and firm 2 with applicant 2 in period one. We summarize equilibrium properties in the following proposition:

Proposition 1 *In any Perfect Bayesian Equilibrium of the hiring game with two firms and two applicants:*
i) If $x_2 = H$, firm 2 will hire applicant 2. If $x_2 = M$ or L, firm 2 will interview applicant 1 and hire her if she is of type M or H.
ii) Firm 1 never interviews applicant 2.

The proof is in the appendix.

To understand this result, first note that firm 2 will always hire its first-period applicant if she is of type H. The applicant prefers an offer from the more productive firm, and there is no reason for firm 2 to interview in period 2 for such a draw.

The first property now follows from C2, which implies that if firm 2 is matched with and applicant of type M or L in the first period, it prefers to interview in the second period since the option value of being able to hire an applicant of type H exceeds the interview cost.

The second property follows by C1, which implies that firm 1 finds it too costly to discover whether the second-period applicant is of type M or L.

If the draw of applicant types is such that $x_1 = H$ or $x_1 = M$, and $x_2 = M$, then it follows from Proposition 1 that firm 2 will interview and hire applicant 1, but that applicant 2 will remain unemployed.

Corollary 1 *In any Perfect Bayesian Equilibrium of the hiring game with two firms and two applicants, if $x_1 = H$ or $x_1 = M$ and $x_2 = M$, applicant 2 will be unemployed.*

The key insight here is that the combination of potential competition and screening creates unemployment. The competition element is the low productivity firm's realization that it will not be able to hire an H worker who has been interviewed by a high productivity firm. The screening element is that given the remaining possible candidate types, the expected benefit to the low productivity firm from another interview does not cover the interview cost.

Notice that the screening element is inefficient because of an externality; the firm bears the full cost of the interview, but the M-type applicant shares the benefit if she were to be hired. In the following section, we will examine if the government can correct this through a subsidy.

A firm *will* interview its second-period applicant if she was previously interviewed by a less productive firm. This is a consequence of C2, which states that the firm is willing to interview if it its first interviewed worker is not of type H.

Lastly, by Corollary 1, the probability of an unemployed applicant of type M is $p_M (p_H + p_M)$.

4 Subsidies for Interviews

We now investigate if a social planner could improve on the market equilibrium by the use of transfers. More precisely, we will assume that the social planner must adhere to the given interview schedule, and study the effect of subsidizing the cost of interviews for the least productive firm.[6] The cost of the subsidy could be financed via an up-front lump-sum tax on firms which does not violate the firms' participation constraints.

The first best solution where there is perfect information about worker types leads to a fully assortative match. We now demonstrate that the appropriate subsidy also achieves the assortative match.

Proposition 2 *If firm 1's interview cost in period 2 is partly subsidized, by an amount S, such that $C > S > (C - \alpha p_M f_1 (M - t))$, then in any Perfect Bayesian Equilibrium:*
i) Firm 1 interviews in the second period if $x_1 = M$ or H; and the expected cost of the subsidy is $(1 - p_L) S$.
ii) Applicants of type L are not hired and the other types of applicants are matched assortatively with the firms.

The proof is in the appendix.

[6] The same equilibrium can be sustained if we assume the planner can force firm 1 to interview.

A key inefficiency of the market solution is an externality; each firm bears the full cost of any interview, but able applicants share the benefits if they are hired. By subsidizing the interview cost of the least productive firm, a social planner can potentially overcome this problem.

The argument of the proof is as follows. Firm 1 prefers not to use the subsidy if matched with an applicant of type L in the first period since the subsidy does not cover the full interview cost and since, for such a draw, it will never be able to hire an applicant of type M or H in the second period. If matched with an applicant of type M or H, it has incentives to use the subsidy to interview in the second period since it can potentially hire the least productive applicant, which may be of type M.

Subsidizing selected firms' interview costs could be employed also in a general setting with multiple applicants and firms, for instance by subsidizing the subset of firms receiving applicants from more productive firms in the second period. However, it may not be possible to achieve the assortative match in this case.

Comparing the outcome with a subsidy with the market solution, the market solution implies a net welfare loss given by:

$$(p_H + p_M)\, p_M f_1 \,(M - \alpha t) - (p_H + p_M)\, C \tag{1}$$

The first term represents the welfare loss from firm 1 not hiring when $x_1 = H$ or $x_1 = M$, and $x_2 = M$. The second term is actually a welfare gain; it represents the savings on the interview cost whenever $x_1 \neq L$, as firm 1 never interviews in the market solution.

The net welfare loss from the market solution is clearly decreasing in α, the share of surplus retained by the firm. This is because the externality that the firm imposes on workers by making a decision whether to interview is reduced - as α increases the firm internalizes more of the externality and its choice becomes the efficient choice for total surplus.

The net welfare loss itself may be positive or negative. To see this, suppose that C1 is satisfied for all $\alpha \in [0, 1]$. Then (1) is negative for α sufficiently close to one. It is positive for α sufficiently close to zero if and only if $p_M f_1 M - C$ is positive. On the other hand, If C1 is violated for α sufficiently close to one, then (1) is clearly positive for every α such that C1 holds.

The intuition for these comparative statics is the following. If the interview cost is not too large compared to the option value from matching with an applicant of type M, then welfare can be improved by subsidizing the interview cost so that all able applicants are matched. However, if the interview cost is so large that firm 1 would not interview, in spite of receiving almost all of the surplus from a match, then the gain for the applicant is too small to outweigh the cost of the subsidy.

While subsidies to employers are sometimes used as an active labor market policy to spur employment (see Heckman, LaLonde, and Smith (1999)), they focus on subsidizing hiring directly as opposed to subsidizing interviews. They also generally focus on applicants who have traditionally lower employment possibilities, such as young workers. Proposition 2 suggests that focusing on the demand side, i.e. firms with lower productivity that find it difficult to compete for workers, could reduce information asymmetries and unemployment[7].

5 Changing the Information Structure

So far, we have assumed that the firm productivities are common knowledge. Although this makes the model more tractable, it may not be realistic in markets where there are more than a few players. Hence in this section, we look at an example where this assumption is relaxed and show that unemployment of able applicants may still exist.

We change the model such that the productivities of firms are private information. More precisely, we assume there are two firms, $i = a, b$, and the productivity of each firm is drawn independently from a continuous distribution $G(\cdot)$ with support $[f_1, f_2]$, where $f_2 > f_1 > 0$ as before. Hence, in this setup f_1 and f_2 are not the productivities of the two firms, but the endpoints of the interval to which they belong. We maintain the assumption that C2 holds[8] for f_1 and f_2, implying that it holds for all productivities in

[7] Market institutions might develop alternative ways of resolving this issue, potentially aided by government. For example, internship programs (e.g. summer internships for MBAs (see Kuhnen and Oyer (2010)) and summer associate positions for lawyers (see Ginsburg and Wolf (2003))), temporary positions (for the case of Spain, see Guell and Petrongolo (2007)), and apprentice programs (see Wolter and Ryan (2011)) can take this role.

[8] We do not assume C1 holds since it is not necessary for the results in this section. The reason is that the inefficiency stems from the case where one firm has an H candidate

$[f_1, f_2]$.

If the draw is f_i, then firm i will believe it has the lowest productivity with probability $1 - G(f_i)$ and the highest productivity with complementary probability. We assume there are two applicants, one of productivity x_a, who may interview at firm a in period 1 and at firm b in period 2, and one of productivity x_b, who has the reverse interview schedule. When a firm interviews an applicant, the applicant learns the productivity of the firm. As in the main model, after the two rounds of interviews are complete, each firm may make one offer to an interviewed candidate, offers are made simultaneously, and applicants will then accept or reject offers.

The key result for the main model, that an able applicant may not be interviewed by a firm who would be a good match, holds also in this setting. We demonstrate this in the following proposition.

Proposition 3 *There is a symmetric equilibrium such that a firm with a first-period applicant of type:*
i) H does not interview in the second round, but makes an offer to the first-period candidate,
ii) M interviews iff $\alpha p_H f_i \left(G(f_i)H + (1 - G(f_i))\, t - M\right) \geq C$ and then makes an offer to the second-period candidate iff the candidate has type H and otherwise makes and offer to the first-period candidate,
iii) L interviews iff $\alpha p_H G(f_i) f_i (H - t) + \alpha p_M G(f_i) f_i (M - t) \geq C$ and then makes an offer to the second-period candidate iff that candidate has type M or H.

The proof is in the appendix.

This result points out that for draws where firm a interviews an H candidate in the first round, firm b interviews an M candidate in the first round, firm a has lower productivity than firm b and $\alpha p_H f_b \left(G(f_b)H + (1 - G(f_b))\, t - M\right) \geq C$, the M candidate will go unmatched. This is exactly the result from our main model; firm a won't interview because of the likelihood that it will not be able to hire an H type.

and the other has an M candidate in round 1. In our main model, if firm 1 had the H candidate, it would certainly lose it to firm 2. Now the firm with an H candidate in round 1 has a chance of keeping this candidate if the other firm does not interview; the other firm will not interview if it has sufficiently low productivity. The probability of this event is large enough that the firm with an H candidate prefers not to interview irregardless of C1.

6 Conclusion

In a simple model describing the interview process for professional labor markets, we have pointed out that inefficient unemployment may result if screening is costly and firms compete for workers. This occurs when applicants' types are private information and firms decide not to interview an applicant who was previously interviewed by a more productive firm. This could cause able applicants to go unemployed and productive vacancies to go unfilled. This effect applies to other markets as well, such as the housing market and credit market.

Our work suggests several directions for future research. First, changing the setting to allow for strategic wage setting and idiosyncratic preferences among firms and applicants are natural extensions. Second, analyzing interview markets for non-entry level applicants poses interesting challenges. Third, it would be of interest to understand how applicants match with firms given the inefficiencies explored in the paper, potentially in a framework with directed search.

A Appendix

A.1 The model with F firms and X applicants

We start by generalizing the two-period model to F firms and X applicants in order to illustrate that unemployment of able applicants exists also in a more realistic environment. Consider the general case with firms $i = 1, ..., F$ of heterogeneous productivities $f_1 < f_2 < ... < f_F$, with $F \geq 2$. Applicants are labeled by $j = 1, ..., X$ and can still be one of three types: L, M, or H. We assume that applicants are allocated according to an interview schedule which is random but has the properties that (i) no applicant interviews with the same firm twice, (ii) only one applicant is allocated to each firm in each period, and (iii) if there are less or equal number of agents on one side of the market, they should all be matched. We maintain conditions C1 and C2 for all firms and refer to the resulting game as *the general hiring game*.

A.2 Useful Lemmas

The following Lemmas will be used in the proofs of the propositions in the text.

Lemma 1 *In any Perfect Bayesian Equilibrium of the general hiring game, a firm with a first-period applicant of type H, who is matched with no firm or a firm of lower productivity in the second period, hires this applicant.*

Proof. Let firm i denote a firm whose first-period applicant j, of productivity $x_j = H$, is matched with no firm or a firm of lower productivity in the second period. First note that since applicant j knows the productivity of the firms it will be matched with in the first and second period, it will always accept an offer from firm i. Second, it is clear that firm i will never interview a possible second-period applicant $j+1$ since it would thereby incur the interview cost without any possibility of being matched with a more productive applicant. ■

Lemma 2 *In any Perfect Bayesian Equilibrium of the general hiring game, a firm with a first-period applicant who is not of type H and a second-period applicant who was unmatched or matched with a firm of lower productivity in the first period interviews its second-period applicant.*

Proof. Let firm i be a firm with a first-period applicant j of productivity $x_j = \varnothing$, M or L (where $\varnothing$ represents no applicant) and a second-period applicant $j+1$, who was interviewed by a less productive firm $i+1$ or no firm in the first period. It follows trivially from C2 that firm i interviews applicant $j+1$ if she is not interviewed by any firm in period 1. The same argument applies if the applicant is interviewed by a less productive firm $i+1$ since the applicant will always prefer an offer from i in the offer stage. ■

Lemma 3 *In any Perfect Bayesian Equilibrium of the general hiring game, a firm never interviews a second-period applicant who was matched with a firm of higher productivity in the first period.*

Proof. By Lemma 1, a firm i receiving an applicant $j+1$ from a more productive firm $i+1$ in the second period will never be able hire this applicant if $x_{j+1} = H$. Moreover, the probability of hiring an applicant $j+1$ of type M is at most p_M. Hence, by C1, firm i will strictly prefer not to interview in period 2. ■

A.3 Proof of Proposition 1

(i) Follows from Lemmas 1 and 2.

(ii) First note that firm 1 will never make an offer to applicant 1 if $x_1 = L$ since such an offer would be accepted and give the firm a worse payoff than the outside option. From Lemma 2, it follows that in any equilibrium, firm 2 interviews in period 2 if $x_2 \neq H$. From Lemma 3, it follows that firm 1 will never interview applicant 2. ■

A.4 Results for the General Hiring Game

Proposition 4 *In the general hiring game:*

i) In any Perfect Bayesian Equilibrium, firms only interview their second-period applicant if she was interviewed by a lower-productivity firm or no firm in the first period.

ii) In any Perfect Bayesian Equilibrium with $F = X$, there exists a draw of applicant productivities such that at least one applicant of type M will remain unemployed.

Proof. (i) Follows from Lemma 3.

(ii) Consider a sequence of at least three firms (for the case of two firms and two applicants the statement follows by Proposition 2 above). Define a *local maximizer* to be a firm that has a higher productivity than both the firm it gives an applicant to in period 2 and the firm that it receives an applicant from in period 2 – i.e. if we arrange firms in a circle such that the applicant matched with firm k in period 1 (whose productivity we denote as x_k) is matched with firm $k-1$ in period 2, firm k is a local maximizer if and only if $f^{k-1} < f^k > f^{k+1}$ (where we use superscripts to denote position in the circle). It is obvious that at least one local maximizer must exist for any sequence of firms. Let x_k and x_{k+1} be the productivity of firm k's first and second-period applicants respectively. By Lemma 2, firm k will interview an applicant of productivity x_{k+1} if $x_k = L$ or M. If, in addition, $x_{k+1} = M$ or H it will hire her. By Lemma 3, firm $k-1$ will not interview applicant k. Hence, an applicant k of type M will be unemployed if $x_{k+1} = M$ or H. ■

Interestingly enough, although more applicants than firms leads to unemployment, it may prevent unemployment of able applicants. Consider the case of two firms and four applicants. If the two firms do not interview any applicants in common, there is no room for adverse selection.

On the other hand, when there are more firms than applicants (i.e. $F > X$), unemployment of able applicants is possible, but not guaranteed. First, consider the case of three firms with productivities $f_3 > f_2 > f_1$, and two applicants. The first applicant is of type H and matches with firm 1 in period 1 and firm 3 in period 2, and the second applicant is of type M and matches with firm 3 in period 1 and firm 2 in period 3. In this case, the best firm will hire H, but the M applicant will remain unemployed because of the information problem. Second, consider the case of two firms and one applicant. In this case, the firm of highest productivity will always end up hiring the applicant if she is not of type L, implying no unemployment.

A.5 Proof of Proposition 2

First, note that the subsidy to firm 1 does not affect Lemmas 1 and 2. By Lemma 1, if firm 2 is matched with an applicant of type H in period 1, it hires this applicant and abstains from interviewing in period 2. By Lemma 2, if firm 2 is not matched with an applicant of type H in period 1, then it interviews in period 2. If firm 2's second-period applicant has weakly higher productivity than its first-period applicant and she is not of type L, firm 2 will make her an offer and hire her given our assumptions. If the second-period applicant is of type L and the first-period applicant is of type M, firm 2 will hire the latter. This demonstrates that firm 2 will always hire the most productive applicant, provided she is not of type L.

Firm 1 has no incentives to use the subsidy to interview in the second period if matched with an applicant of type L in period one since any second-period match of type M or H will be hired by firm 2. If, on the other hand, firm 1 is matched with an applicant of type M or H in the first period, it has incentives to use the subsidy and interview in period two. The reason is that there is a positive probability that the second period applicant is of type M, in which case it will not be hired by firm 2. In this case, firm 1 extends an offer to the least productive of the applicants provided she is not of type L. If both applicants are of type M, then firm 1 makes an offer to the applicant it was matched with last since the other applicant will be hired by firm 2. Firm 1's offer will be accepted since the applicant will not receive any offer from firm 2.

In conclusion, in any Perfect Bayesian Equilibrium applicants of type H and M will be matched assortatively with the firms, and applicants of type L will never be hired. The expected cost of the subsidy is $(1 - p_L) S$ since firm 1 interviews whenever its first-period applicant is of type M or H. ■

A.6 Proof of Proposition 3

We begin by proving two lemmas that will prove useful for the proof.

Lemma 4 *$\alpha p_H f_i \left(G(f_i)H + (1 - G(f_i))\, t - M\right) = C$ has a unique solution $\bar{f} \in (f_1, f_2)$.*

Proof. The equation must have at least one solution and it must be interior since the left-hand side is continuous in f_i, equals $\alpha p_M f_1 (t - M) < 0$ for $f_i = f_1$, and $\alpha p_H f_2 (H - M) > C$ for $f_i = f_2$ (by C2). To show that the solution is unique, differentiate the left-hand side with respect to f_i:

$$\alpha p_H \left(G(f_i)H + (1 - G(f_i))\, t - M\right) + \alpha p_H f_i g(f_i) (H - t)$$

The second term is non-negative, and the first term is positive for any f_i such that $\alpha p_H f_i \left(G(f_i)H + (1 - G(f_i))\, t - M\right) \geq C$. Hence, if $\bar{f}$ is a solution to the equation, then the left-hand side is larger than C for any $f_i \in (\bar{f}, f_2]$, ruling out multiple solutions. ■

Lemma 5 *$\alpha p_H G(f_i) f_i (H - t) + \alpha p_M G(f_i) f_i (M - t) = C$ has a unique solution $\hat{f} \in \left(f_1, \bar{f}\right)$.*

Proof. *The left-hand side of the equation is continuous and increasing in f_i. It takes the value zero for $f_i = f_1$, and $\alpha p_H f_2 (H - t) + \alpha p_M f_2 (M - t) > C$ for $f_i = f_2$ (by C2). This proves that the equation has a unique and interior solution $\hat{f}$. To show that $\hat{f} < \bar{f}$, we compute the difference between the the left-hand sides of the equations in Lemmas 4 and 5:*

$$\begin{gathered}
\alpha f_i G(f_i) \left(p_H (H - t)\right) + p_M (M - t)) \\
-\alpha f_i p_H \left(G(f_i)H + (1 - G(f_i))\, t - M\right) \\
= \alpha f_i (M - t) \left(p_M G(f_i) + p_H\right).
\end{gathered}$$

Since the difference is positive, it follows that $\hat{f} < \bar{f}$. ■

We will now prove the proposition by showing that there are no profitable deviations from the strategy when the other firm employs the same strategy. From Lemma 4 follows that there is a unique firm productivity $\bar{f} \in (f_1, f_2)$ such that the inequality on line ii) binds. From Lemma 5 follows that there is a unique firm productivity $\hat{f} \in \left(f_1, \bar{f}\right)$ such that the inequality on line iii) binds. Define the following variables:

$$\begin{aligned}
q &: = \Pr\left[f_j < f_i \mid f_j \geq \bar{f}, f_i\right] = \frac{\max\left\{G\left(f_i\right) - G(\bar{f}), 0\right\}}{1 - G(\bar{f})}, \\
q' &: = \Pr\left[f_j < f_i \mid f_j < \bar{f}, f_i\right] = \frac{\min\left\{G\left(f_i\right), G(\bar{f})\right\}}{G(\bar{f})}, \\
r &: = \Pr\left[f_j < f_i \mid f_j \geq \hat{f}, f_i\right] = \frac{\max\left\{G\left(f_i\right) - G(\hat{f}), 0\right\}}{1 - G(\hat{f})}, \\
r' &: = \Pr\left[f_j < f_i \mid f_j < \hat{f}, f_i\right] = \frac{\min\left\{G\left(f_i\right), G(\hat{f})\right\}}{G(\hat{f})}.
\end{aligned}$$

i) First, suppose that a firm has a first-period applicant of type H and deviates from the proposed strategy by interviewing for some f_i. It is clear that interviewing and not making any offer when at least one applicant is of type H or M is a dominated strategy. Define s_H and s_M to be the (possibly firm-productivity dependent) conditional probabilities of making an offer to the second-period candidates after observing a type H and M respectively (i.e. the conditional probabilities of making an offer to the first-period candidate are $1 - s_H$ and $1 - s_M$, respectively). The expected payoff from interviewing is:

$$\begin{aligned}
&\alpha p_H f_i \left(s_H \left(G\left(f_i\right) H + \left(1 - G\left(f_i\right)\right) t\right) + \left(1 - s_H\right) H\right) \\
&+\alpha p_M f_i \left(\begin{array}{c} s_M \left(\left(1 - G(\bar{f})\right) M + G(\bar{f}) \left(\left(1 - q'\right) t + q' M\right)\right) + \\ \left(1 - s_M\right) \left(G(\bar{f}) H + \left(1 - G(\bar{f})\right) \left(\left(1 - q\right) t + q H\right)\right) \end{array}\right) \\
&+\alpha p_L f_i \left(\left(1 - G(\hat{f})\right) r H + \left(1 - G(\hat{f})\right) \left(1 - r\right) t + G(\hat{f}) H\right) - C.
\end{aligned} \tag{2}$$

The expected payoff from not interviewing is:

$$\begin{aligned}
&\alpha p_H f_i H + \alpha p_M f_i \left(G(\bar{f}) H + \left(1 - G(\bar{f})\right) \left(\left(1 - q\right) t + q H\right)\right) \\
&+\alpha p_L f_i \left(\left(1 - G(\hat{f})\right) \left(r H + \left(1 - r\right) t\right) + G(\hat{f}) H\right).
\end{aligned} \tag{3}$$

The difference between (2) and (3) is:

$$\begin{aligned}
&-\alpha p_H f_i s_H \left(1-G\left(f_i\right)\right)(H-t) \\
&+\alpha p_M f_i s_M \begin{pmatrix} \left(1-G(\bar{f})\right)(M-(1-q)\,t-qH) \\ +G(\bar{f})\left((1-q')\,t+q'M-H\right) \end{pmatrix} - C
\end{aligned} \tag{4}$$

The first line of (4) is clearly non-positive. Evaluating the second line for $f_i \geq \bar{f}$ gives:

$$\begin{aligned}
& \alpha p_M f_i s_M \begin{pmatrix} \left(\left(1-G(\bar{f})\right)(M-t) - \left(G\left(f_i\right)-G(\bar{f})\right)(H-t)\right) \\ -G(\bar{f})\,(H-M) \end{pmatrix} - C \\
\leq\ & \alpha p_M f_i s_M \left(\left(1-G(\bar{f})\right)(M-t) - G(\bar{f})\,(H-M)\right) - C \\
=\ & -C\left(\frac{p_M f_i s_M}{p_H \bar{f}} + 1\right)
\end{aligned}$$

Evaluating the second line for $f_i < \bar{f}$ gives:

$$\begin{aligned}
& \alpha p_M f_i s_M \begin{pmatrix} \left(1-G(\bar{f})\right)(M-t) + \\ G\left(f_i\right)(M-t) - G(\bar{f})\,(H-t) \end{pmatrix} - C \\
\leq\ & \alpha p_M f_i s_M \left(\left(1-G(\bar{f})\right)(M-t) - G(\bar{f})\,(H-M)\right) - C \\
=\ & -C\left(\frac{p_M f_i s_M}{p_H \bar{f}} + 1\right)
\end{aligned}$$

Hence, the firm prefers not to interview if it has a first-period applicant of type H.

ii) Second, suppose that a firm has a first-period applicant of type M. Using the same notation as above, the expected payoff from interviewing is:

$$\begin{aligned}
& \alpha p_H f_i \left(s_H \left(G\left(f_i\right) H + \left(1-G\left(f_i\right)\right) t\right) + \left(1-s_H\right) M\right) \\
& +\alpha p_M f_i \left(s_M \left(\left(1-G(f_i)\right) t + G(f_i) M\right) + \left(1-s_M\right) M\right) \\
& +\alpha p_L f_i \left(\left(1-G(\hat{f})\right)\left(rM+(1-r)\,t\right) + G(\hat{f})M\right) - C.
\end{aligned} \tag{5}$$

The expected value from not interviewing is:

$$\begin{aligned}
& \alpha p_H f_i M + \alpha p_M f_i M \\
& +\alpha p_L f_i \left(\left(1-G(\hat{f})\right)\left(rM+(1-r)\,t\right) + G(\hat{f})M\right).
\end{aligned} \tag{6}$$

The difference between (5) and (6) is:

$$\alpha p_H f_i s_H \left(G\left(f_i\right) H+\left(1-G\left(f_i\right)\right) t-M\right)$$
$$-\alpha p_M f_i s_M\left(\left(1-G(f_i)\right)(M-t)\right)-C$$

Hence, the expected payoff is maximized if the firm interviews iff

$$\alpha p_H f_i\left(G\left(f_i\right) H+\left(1-G\left(f_i\right)\right) t-M\right) \geq C$$

and sets $s_M=0$ and $s_H=1$.

iii) Suppose lastly that the firm has a first-period applicant of type L. If it interviews and makes an offer to the second candidate iff she is not of type L, the expected payoff is

$$\begin{aligned}&\alpha p_H f_i\left(G\left(f_i\right) H+\left(1-G\left(f_i\right)\right) t\right) \\ &+\alpha p_M f_i\left(G\left(f_i\right) M+\left(1-G\left(f_i\right)\right) t\right)+\alpha p_L f_i t-C.\end{aligned} \tag{7}$$

If it does not interview, it strictly prefers not to make any offer, resulting in a payoff of $\alpha f_i t$. The difference between the two payoffs is thus:

$$\alpha p_H f_i G\left(f_i\right)(H-t)+\alpha p_M f_i G\left(f_i\right)(M-t)-C.$$

Hence, the expected payoff is maximized if the firm interviews iff the last expression is non-negative.■

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