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Promotion: Turnover and Preemptive Wage Offers

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This paper examines the strategic promotion and wage decisions of employers when employees may be more valuable to competing firms, even in the presence of firm specific human capital. Competing employers must incur a cost to learn the quality of their match with a manager. Because promotion signals that workers are potentially valuable managers in other firms, it can induce turnover. To preempt competition for a promoted worker, an employer may offer a wage so high that it discourages competitors from acquiring information and bidding up the wage further or hiring the worker away. Also, to avoid competition, employers will fail to promote some less well-matched workers who should be promoted.

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Recently several papers have demonstrated how the non-observability of a worker's skills by competing firms can explain several "puzzling" aspects of promotion and compensation (Baker et al. [1988])[1]. The key insight of Waldman [1984], is that if a worker's employer alone observes the worker's ability, then competing firms can only infer the ability level indirectly from the worker's vita (e.g. of past positions, wages, education, training). Since it is optimal to promote only relatively able workers, upon promotion competing firms revise upwards their forecast of a worker's ability, causing a sharp wage increase. Hence, an employer has an incentive to exploit strategically its private information about an able worker by not promoting the worker as quickly or often as is socially optimal. An employer strategically trades off the gain from placing an able worker where the worker is most productive against the wage cost of revealing the worker's ability to other firms.

Standard theories of turnover predict that workers-firm separations are due to failure: if for some reason a worker is less productive than anticipated then, due to wage rigidities or to eliminate moral hazard on the part of the firm, the worker must leave despite any firm specific skills that were acquired. If workers are valued equally by all firms, equilibrium turnover is inefficient and leads to wage decreases[2]. The fact that wages often rise with turnover suggests that some portion of a worker's productivity is match-specific and that learning about matches with competitors takes place before the worker switches employers. The combination of firm-specific matches and non-observability of productivity by competing firms raises several questions. How does the possibility of losing a worker affect an employer's decision to promote? Is it always in an employer's interest to make low initial wage offers to promoted workers and then allow outside competition to determine the final retention wage? The existence of large and varied wage increases received by different workers upon promotion suggests that the answer to this last question is no. Thus, is it that the wage offer itself is used by employers to communicate additional information about their matches with workers? Competition by firms for workers appears somewhat sporadic:

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[1] See e.g. Waldman [1984], [1990], Ricart i Costa [1988], Milgrom and Oster [1987], or Bernhardt [1991]. Gibbons and Katz [1989] provide additional empirical support.

[2] Representative models from the different classes of models include Macleod and Malcomson (1988), Waldman (1990) and Jovanovic (1979). (In this latter paper, turnover is efficient -- due to learning about a bad worker-firm match -- but wages do not increase upon separation.)

intense at the entry stage, active later only if their interest is attracted. In this paper we examine these issues of promotion and turnover by developing a model of the relationships between worker-firm matches, promotion probabilities and wage offers.

The model we develop examines the strategic promotion and wage decisions of employers when employees may be more valuable to competing firms; promotion communicates that possibility, so that promotion can induce turnover.[3] The possibility of firm specific matches for managers means that, despite acquired skills specific to the current employer, a manager may be more productive at a well-matched competing firm. Promotion of a laborer reveals to competitors that the worker is a productive manager with whom they may have a match. It may then be worthwhile for a competitor to expend some resources to determine the worker's value.[4] If so, a bidding war for the worker emerges, and the winner, the firm at which the worker is most valuable, pays a wage just equal to the value of the worker to the losing firm. We show how the theory can explain the empirical regularity that individuals who change jobs receive pay increases, but those increases are lower on average than those of individuals who are promoted from within (Topel [1986]).

Workers who are promoted may be offered wages which depend on the quality of their match with their employer. To preempt competition for a worker, an employer may offer a wage so high that it discourages competitors from acquiring information and bidding up the wage further or hiring the worker away. A high wage signals a good worker-firm match, indicating to competing firms that it would be unprofitable to incur the cost of determining the value of its match with the worker. The better a worker's match, the more attractive it is for the employer to preempt competition with a high wage offer.

Somewhat less productive managers are promoted, but are not offered preemptive wages. A promotion and low wage encourage other firms to acquire information about the worker and to compete for the worker's services. Despite this competition, the less productive worker's expected wage is less than the

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[3] See Lazear [1986] for a (non-strategic) paper in which workers may develop negative firm specific human capital, and hence be more valuable to competitors so that turnover may result.

[4] Throughout the paper we assume it is the competing firm which pays the cost of acquiring information, but the analysis is similar were a worker, unaware of his or her match quality, to pay this cost instead.

preemptive wage.

The exogenous cost to a competing firm of acquiring information about a worker affects wages, but does not generally alter promotion decisions. The greater is this cost, the more attractive it is to make preemptive wage offers. Since it is less profitable for a competing firm to examine workers, competition is more easily deterred, so that the marginal *preempted* worker is of lower quality. But, because the employer always faces competition for the marginal *promoted* worker, provided the information acquisition cost is not so large that the competitor never acquires information, this cost does not affect the measure of promoted workers. Surprisingly, the greater is this cost, the greater are expected lifetime wages: for smaller information acquisition costs, employment opportunities at each firm are poorer substitutes, and firms exploit this heterogeneity.

Interestingly, if firms were prohibited, perhaps by union rules, from offering different (and thus preemptive) wages upon promotion, expected profits are unchanged. Turnover is greater in this case, but competing firms examine too many workers. They incur costs to examine even those workers with whom the initial employer has a very good match. Although expected profits are unaffected by such legislation, the economy is more efficient as more workers are placed efficiently, so that average wages increase.

We also determine the conditions under which employers choose never to offer preemptive wages. Preempting competition is unattractive if ignorant bidding for workers by competing firms is always more costly than informed bidding. If a competing firm does not acquire information, it still bids wages of promoted workers up to the expected value of managers. While on average correct, an ignorant bidder sometimes under- or over- bids for individual workers. If the information a competing firm acquires does not allow it to increase the expected value of its match with a worker (for example through optimal placement), then the wage an employer expects to pay a worker bid for ignorantly is never less than that it expects to pay due to informed competition. In such circumstances employers prefer to compete against informed bidders, and so never attempt to preempt information acquisition.

Fishman [1988] was the first to study the attractiveness of preemptive bids. He did so in the context of firm takeovers; he shows how, to discourage other bidders in a takeover, a firm which identifies a target may make a preemptively high tender offer to the target shareholders. We borrow from

Fishman in our analysis.

The way in which turnover is generated and the potential for bidding wars is related to Waldman [1990]. In Waldman, turnover arises because both the employer's and the competitor's information about the worker is noisy -- and the competitor may receive a more optimistic signal. Bidding wars result from the winner's curse problem which makes the employer initially reluctant to offer wage increases until it learns from the bidding war about the other firm's signal about the worker[5]. In our paper, turnover occurs because the worker may be more valuable to a competitor, and bidding wars can emerge because employers want to retain their workers with the lowest wages possible.

Section 2: The Model

In a two period economy, two ex ante identical risk neutral profit maximizing firms, x and y, hire risk neutral workers competitively. Workers, who live both periods, inelastically supply one unit of labor each period to the firm of their choice. There is no discounting. Each firm has a constant returns to scale technology which employs the sole (labor) input. There are two occupational levels within a firm, laborers and managers, which are denoted by the superscripts ℓ and m respectively. When referring to firms it is necessary to distinguish between the firm which employed a worker in the first period and that which did not. The first period employer is denoted firm z, and referred to as the employer; the firm which did not hire the worker in the first period, but might compete for the worker's services in the second period, is denoted firm v, and referred to as the competitor. Clearly, for any particular worker, if firm x is firm z, then firm y is firm v, and vice versa.

Only a fraction λ, $0<\lambda<1$, of workers are potentially productive in management. Let individual workers be indexed by i. If worker i has managerial potential, then i has potential at both firms. Let $\gamma_i=1$ indicate that worker i

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[5] Waldman only permits the competing firm to make a single wage offer, so that bidding wars are truncated. This truncation is vital to his analysis. Were workers to generate specific skills (or were information acquisition costly) and were there no arbitrary limit to the offer-counter offer sequence then allocation of workers would be efficient and there would be no turnover. Similarly, in this paper, without worker-firm matches, competing firms would not expend resources to determine a worker's value because firm specific skills would always make the worker more valuable to his or her employer, so that there would be no equilibrium turnover. Hence, it would not be worth a competitor's while to acquire information about a worker's productivity.

has management potential; $\gamma_i=0$ indicates the worker is only productive as a laborer. To simplify the analysis, we assume that

(A0) There are sufficiently few workers with managerial potential that in period 1 it is optimal to employ a worker of unknown ability as a laborer.

A laborer in period 1 produces output $g_1^{\ell}>0$, which is the same at each employer. In period 2, the output of a laborer retained by a period 1 employer exceeds the output produced if the laborer switches employers because of firm specific skills accumulated in the first period. If retained by a first period employer, a laborer produces $g_2^{\ell}+f_2^{\ell}$, which exceeds g_2^{ℓ} ($\geq g_1^{\ell}$) the output produced if the laborer switches employers: $f_2^{\ell}>0$ represents firm specific, non-transferable skills valued only by the firm providing period 1 employment, whereas g_2^{ℓ} reflects general skills which are valued equally by both firms.

Figure 1 depicts the career possibilities of any particular worker i. The payoffs at the terminal nodes of the tree are the wage received by worker i in period 1 and 2. At node 1 nature moves, determining whether the worker has management potential; all other nodes represent career points at which hiring or promotion decisions are made. Workers with management potential start period 1 at node 2; workers without such potential start at node 3. Unaware of whether worker i is at node 2 or 3, firms compete for the worker and offer identical period 1 wages, for i's service as a laborer.

The first period employer z earns first period profits per worker of

$$\pi_1^z(w_1^z) = g_1^{\ell} - w_1^z,$$

where w_1^z is z's first period wage offer. The equilibrium first period wage is calculated below. At the end of period 1, having observed whether worker i is a productive manager, employer z must make a wage offer, w_2^z, and decide whether or not to promote i to management.

The Productivity of Managers

If worker i is a productive manager then, at the end of period one, i's employer z (=x or y) costlessly observes the quality of their worker-firm managerial match, θ_z^i, where θ_z^i is drawn from $H(\cdot)$ with density $h(\cdot)$ on $[\underline{\theta},\bar{\theta}]$. We make the following assumptions about worker firm matches:

(A1) The quality of worker i's match in management at firm y is independent of that at x.[6]

(A2) The greater is θ^i, the more productive is worker i in management[7]:

$$\partial f_2^m(\cdot)/\partial\theta_z^i > 0;\ \partial g_2^m(\cdot)/\partial\theta_z^i > 0.$$

(A3) The least-well matched potential manager is more productive as a laborer, and there exists some match quality ($\ddot{\theta}$) such that the worker is equally productive as a manager or laborer:

$$f_2^m(\underline{\theta}) < f_2^{\ell};\ g_2^m(\underline{\theta}) < g_2^{\ell}$$

$$\exists\ \ddot{\theta} \in (\underline{\theta},\bar{\theta}) \text{ such that } f_2^m(\ddot{\theta}) = f_2^{\ell};\ g_2^m(\ddot{\theta}) = g_2^{\ell}.$$

In Figure 1, productive managers i who start period 1 at node 2, end period 1 at node 4 or 5 depending upon which firm hires them. At node 4, firm x is firm z and firm y is firm v; the opposite is true at node 5. The quality of worker i's match with firm z is depicted by the continuum of continuation possibilities at each of node 4 and 5; sufficiently good matches lead to promotion, the others do not. A worker i at node 6 or 7, without management potential, is never promoted.

The Competing Firm's Decision

The firm which failed to hire worker i in period 1, firm v, costlessly observes employer z's initial period 2 wage and employment offer $(w_2^z(\theta_z^i),L_z)$, $L_z \in \{\ell,m\}$. Conditioning on this wage and employment offer, firm v decides whether to invest c>0 to learn the quality of its match with i. Let $D_v(w_2^z,L_z)$ denote this decision:

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[6] The assumption that worker-firm matches are iid is an unnecessary simplification. What is required for the qualitative results to carry over to the case of correlated abilities is that the expected value to a competitor of incurring the cost c to learn the worker's productivity is decreasing in θ_z^i, and that it must be possible for the worker to be more valuable to a competitor than to his employer. If matches are too closely correlated, because of the firm specific skills generated, all workers are more valuable to their first period employers, so no turnover occurs in equilibrium. The model can be extended to allow for additional asymmetry between the firms; see Bhattacharyya (1990) for such a model in the context of firm takeovers.

[7] Observe that because of the matching component, only the ex ante expected productivity of general skills is the same at both firms.

$$D_v(w_2^z, L_z) = \begin{cases} 1 \text{ indicates } & v \text{ acquires information about worker } i \\ 0 \text{ indicates } & v \text{ does not acquire information.} \end{cases}$$

Depending on parameter values, it may be most profitable for firm v to try to hire and place a promoted worker into management without acquiring information about the match quality. The simplest assumption which prevents the competitor from hiring managers without acquiring information is:

(A4) The expected value of a manager placed without information about match quality is less than the value of a laborer:

$$E_{\theta_v^i}\{g_2^m(\theta_v^i) \mid \gamma_i=1,\ D_v=0\} < g_2^\ell.$$

This does not mean that, on average, workers actually placed in management are less productive than laborers. Because of **(A3)**, some workers should not become managers; by acquiring match information firm v can optimally place these workers as laborers, so that the expected product of correctly placed managers is greater:

$$E_{\theta_v^i}\{g_2^m(\theta_v^i) \mid \gamma_i=1,\ D_v=0\} < E_{\theta_v^i}\{g_2^m(\theta_v^i) \mid \gamma_i=1,\ D_v=1\}.$$

We can generalize **(A4)** by allowing information acquisition to be part of a broader placement process. Suppose that a firm has many managerial positions and that match information allows them to place managers efficiently. Define

$$g_2(\theta_v^i) = \max\{g_2^\ell,\ g_2^{m1}(\theta_v^i),\ g_2^{m2}(\theta_v^i),\ldots,g_2^{mn}(\theta_v^i)\},$$

where m1...mn are the n possible management positions. Even though all managers may be more productive than laborers ($g_2^{mj}(\underline{\theta}) > g_2^\ell$, j=1...n), informed bidding by firm v is most profitable if match information is sufficiently valuable in placing managers. Uninformed bidding is precluded by[8]

(A4') The expected value, net of information costs, for optimally placing a worker is greater than the expected value of a randomly placed manager:

$$E_{\theta_v^i}\{g_2(\theta_v^i) \mid \gamma_i=1\} - c > \max_j E_{\theta_v^i}\{g_2^{mj}(\theta) \mid \gamma_i=1, D_v=0\}.$$

For most of the paper, we assume that it is most attractive for firm v to acquire information before competing for a manager; to reduce notation we

[8] This assumption is stronger than necessary. Because information acquisition allows firm v to reject poor matches, there is an option value to information.

assume **(A4)** holds, but extensions of our conclusions to **(A4')** are immediate. In Section 7, we relax assumption **(A4)** and consider the consequences.

In addition we assume

(A5) Firm v's expected profits from inspecting potential managers are such that v would like to compete for worker i if all it knows about worker i is that he or she is a capable manager:

$$E_{\theta_v^i}\left\{g_2^m(\theta_v^i) - \min\{g_2^m(\theta_v^i),\ f_2^m(\theta_z^i) + g_2^m(\theta_z^i)\} \mid \gamma_i=1,\ D_v=1\right\} - c > 0.$$

(A6) Firm v only wants to inspect workers who are revealed by the promotion decision of period 1 employer z to be capable managers:[9]

$$\lambda E_{\theta_v^i}\left\{g_2^m(\theta_v^i) - \min\{g_2^m(\theta_v^i),\ f_2^m(\theta_z^i) + g_2^m(\theta_z^i)\} \mid \gamma_i=1,\ D_v=1\right\} - c < 0.$$

The Determination of Period 2 Wages

If v does acquire information about a worker, then a bidding war results. Ultimately worker i is employed efficiently at the firm with which i is best matched and receives a wage equal to the lesser of the two firm's valuations:

$$w_2(\theta_v^i, \theta_z^i, w_2^z(\theta_z^i), L_z=m, D_v=1) = \min\left\{f_2^m(\theta_z^i) + g_2^m(\theta_z^i),\ \max\{g_2(\theta_v^i),\ w_2^z(\theta_z^i)\}\right\}.$$

If worker i is more valuable to competing firm v, period 1 employer z will bid up the wage to $f_2^m(\theta_z^i) + g_2^m(\theta_z^i)$ before losing i; if worker i is more valuable to z, then v will bid up to $g_2(\theta_v^i)$, so that i will receive the maximum of $g_2(\theta_v^i)$ and $w_2^z(\theta_z^i)$. In equilibrium in the event of competition (see below), firm z will never offers a wage greater than that necessary to retain the worker, so that $g_2(\theta_v^i) \geq w_2^z(\theta_z^i)$.

In equilibrium, if firm v does not acquire information then it will not succeed in hiring worker i so that its profits are zero. However, uninformed bidding still plays an important role in determining wages. If $D_v=0$, firm v makes a competitive wage and employment offer given its limited information. If $L_z=m$, v recognizes that the worker is productive in management, i.e. $\gamma_i=1$, and is therefore prepared to bid period 2 wages up to $\max\{g_2^\ell, E_{\theta_v^i}\{g_2^m(\theta_v^i) \mid D_v=0\}\}$. If $L_z=\ell$, v expects i to be more productive as a

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[9] Because of this assumption the conditioning of expectations on $\gamma_i=1$ is suppressed unless it is necessary to avoid confusion.

laborer and bids wages up to g_2^{ℓ}. This last condition means that the period 2 profit-per-laborer of firm z is equal to the firm specific productivity, f_2^{ℓ}.

Equilibrium

Let conditional density $G_v(\theta_z^i|w_2^z,L_z)$ denote firm v's (updated) beliefs about θ_z^i, conditional on firm z's initial period 2 wage and employment offer. A pure strategy for firm x is (1) a period 1 wage offer, w_1^x, (2) if x is the period 1 employer, an initial period 2 wage and promotion offer $\{w_2^x(\theta_x^i),L_x(\theta_x^i)\}$ for each θ_x^i, and (3) if y is the period 1 employer, a period 2 information acquisition decision $D_x(w_2^y, L_y)$[10]. Similarly a pure strategy for firm y is a collection $\{w_1^y, D_y(w_2^x, L_x), w_2^y(\theta_y^i), L_y(\theta_y^i)\}$. A pure strategy by a worker is a period 1 and 2 selection of an employer.

Equilibrium: Subsuming the (trivial) decision of the worker to work for the firm which makes it the greatest wage offer, an equilibrium is a collection

$\{w_1^{y*}, w_2^{y*}(\theta_y^i), L_y^*(\theta_y^i), D_y^*(w_2^x, L_y), G_y(\theta_x^i|w_2^x,L_x)\}$,

$\{w_1^{x*}, w_2^{x*}(\theta_x^i), L_x^*(\theta_x^i), D_x^*(w_2^y, L_y), G_x(\theta_y^i|w_2^y,L_y)\}$

such that

(a) If firm z (=x or y) is the period 1 employer, then $w_2^{z*}(\theta_z^i)$, $L_z^*(\theta_z^i)$ maximize expected period 2 profits given the strategy of the other firm, $D_v^*(w_2^z, L_z)$.

(b) If firm v (=x or y) does not employ worker i in period 1, then $D_v^*(w_2^z,L_z)$ maximizes firm v's expected period 2 profits given $w_2^{z*}(\theta_z^i),L_z^*(\theta_z^i)$.

(c) w_1^{x*} maximizes firm x's total expected profits given w_1^{y*}, $w_2^{y*}(\theta_y^i)$, $L_y^*(\theta_y^i)$, $D_y^*(w_2^x, L_2^x)$.

(d) w_1^{y*} maximizes firm y's total expected profits given w_1^{x*}, $w_2^{x*}(\theta_x^i)$, $L_x^*(\theta_x^i)$, $D_x^*(w_2^y, L_y)$.

(e) firm v's beliefs $G_v(\theta_z^i|w_2^z,L_z)$ about the match of worker i at employing firm z are consistent with firm z's strategy and Bayes' rule, z,v = x,y.

As is the case with signalling games, without introducing refinements there are a plethora of equilibria. This is because beliefs are not restricted sufficiently by the equilibrium concept. In what follows, we restrict

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[10] That is, we subsume the bidding war in the specification of strategies and equilibrium to reduce notation. The bidding war is the unique outcome of an infinite sequence of offers and counter-offers to the worker from the firms.

out-of-equilibrium beliefs by requiring beliefs to be credible in the sense of Grossman and Perry [1986]. This restriction is discussed in the appendix. Even without such restrictions, all equilibria share the following characteristics:

Period 1 employer z's period 2 equilibrium strategy is

(a) if worker i has no managerial potential, i.e $\gamma_i=0$, or has a bad match, i.e. $\theta_z^i < \hat{\theta}$, then do not promote and offer wage $w_2^z(\theta_z^i) = g_2^{\ell}$,

(b) if worker i has limited managerial potential with z, $\hat{\theta} \leq \theta_z^i < \dot{\theta}$, then promote i and offer wage $w_2^z(\theta_z^i) \leq g_2^{\ell}$,

(c) if worker i is well matched with z, $\theta_z^i \geq \dot{\theta}$, then promote i and offer preemptive wage $\bar{w} > g_2^{\ell}$.

The intuition is as follows: **(a)** If firm z promotes a poorly-matched, but competent worker, this reveals to v that the worker is a potential manager that it can scoop. It will pay c to determine whether the worker is more productive at v, as is likely. To avoid losing such workers and foregoing specific skills f_2^{ℓ}, employer z prefers not to promote. Not only are these marginally-matched workers misplaced by employer z, but it is likely that they are employed at the wrong firm: it is socially optimal for v to invest c and determine its match with such workers. **(b)** If i is better matched, z prefers to take the risk of promoting and potentially losing i. As v will expend resources to learn about the worker and then bid up the wage, z initially offers a low wage, the minimum wage conceivably necessary to retain the worker in those instances where the worker is more productive at z, which equals the minimum conceivable value of worker i to firm v.[11] **(c)** As θ_z^i increases, the expected period 2 wage firm z pays if v learns θ_v^i increases. Eventually, z prefers to pay i a preemptive wage $\bar{w}$ to signal that i is so well-matched with firm z that v would waste resources determining its match with i. This preemptive wage is less than or equal to the wage it would expect to pay were v to learn θ_v (and be able to place the worker efficiently). Given v's

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[11] This equality between the wage of some managers (those not competed for) and that of all laborers can be relaxed without affecting any of the qualitative results of the model by interpreting information acquisition as part of a management placement process as described following **A4**, and assuming that instead of **A2**, $g_2^{mj}(\underline{\theta}) > g_2^{\ell}$, $\forall j$. In this case the wage offered by z on promotion, is equal to the lowest possible value a manager could have at firm v, $\min_j g_2^{mj}(\theta^i)$, which by assumption exceeds the wage paid to laborers. If **A4'** holds, so that all non-preempted managers are investigated by firm v, nothing else is changed by this reinterpretation of placement.

beliefs, $G_v(\theta_z^i | w_2^z, L_z)$, $\bar{w}$ is just sufficient that v expects acquiring costly information about worker i to be unprofitable.

This strategy and the credibility restriction on beliefs together imply that the following proposition is true.

Proposition 1: In the unique credible equilibrium, if informed competition for some promoted managers is profitable, then

(a) Workers i who are not managerial material or who period one employer z is likely to lose, i.e. those workers i such that $\gamma_i=0$ or $\theta_z^i<\hat{\theta}$, z employs as laborers with an initial period 2 wage offer $w_2^z = g_2^\ell$. v does not acquire information about such workers. $\hat{\theta}$ is independent of the information cost c, provided c is not so high as to prevent firm v from ever acquiring information, and is given by the solution to

$$g_2^m(\hat{\theta}) + f_2^m(\hat{\theta}) - E_{\theta_v^i}\left\{ \min\{g_2(\theta_v^i),\ g_2^m(\hat{\theta}) + f_2^m(\hat{\theta})\} \mid D_v=1 \right\} - f_2^\ell = 0. \tag{2}$$

(b) Workers i who have reasonably good managerial matches with z, i.e. $\theta_z^i \in [\hat{\theta}, \theta^*)$, z offers a management position and initial period 2 wage offer $w_2^z = g_2^m(\underline{\theta})$. Competing firm v acquires information about i, and hires i away if and only if $g_2(\theta_v^i) - \{g_2^m(\theta_z^i) + f_2^m(\theta_z^i)\} > 0$. θ^* solves

$$E_{\theta_v^i, \theta_z^i}\left\{g_2(\theta_v^i) - \min\ \{g_2(\theta_v^i),\ f_2^m(\theta_z^i) + g_2^m(\theta_z^i)\} \mid \theta_z^i \geq \theta^*,\ D_v=1 \right\} = c. \tag{3}$$

(c) Workers i who have very good managerial matches with z, i.e. those workers $\theta_z^i \in [\theta^*, \bar{\theta}]$, are employed by z in management and offered preemptive wage

$$\bar{w}^* = E_{\theta_v^i}\left\{\min\{g_2(\theta_v^i),\ f_2(\theta^*) + g_2(\theta^*)\} \mid D_v=1 \right\}. \tag{4}$$

(d) Firms x and y make initial wage offers

$$w_1^{x*}(c) = w_1^{y*}(c) = g_1^\ell + E\pi_z^{2*}(c) - E\pi_v^{2*}(c), \tag{1}$$

where $E\pi_j^{2*}$ is the expected period 2 profit of firm j. ∎

Proof:

(a) All signalling equilibria feature the same measure of promoted workers. For the marginal worker promoted, worker $\hat{\theta}$, employer z just equates the benefits of inefficiently placing $\hat{\theta}$ as a laborer and avoiding competition to retain $\hat{\theta}$'s firm specific skills, with the potential gains and risks of promoting $\hat{\theta}$ to management, knowing that the promotion will lead to competition. Let $\pi_t^j(\cdot)$ denote the period t profits per worker of firm j, as a function of the worker's match quality at each of the firms, the wage offers made, and promotion and information acquisition decisions taken. Then, $\hat{\theta}$ is given by the solution to

$$E_{\theta_v^i}\left\{\pi_2^z(\hat{\theta},\theta_v^i,L_z=m,w_2^z=g_2^\ell,D_v=1)\right\} = \pi_2^z(\hat{\theta},\theta_v^i,L_z=\ell,w_2^z=g_2^\ell,D_v=0).$$

Substituting, $\hat{\theta}$ is given by the solution to

$$E_{\theta_v^i}\left\{\max\{g_2^m(\hat{\theta}) + f_2^m(\hat{\theta}) - g_2(\theta_v^i),\ 0\}\ |\ D_v=1\right\} = f_2^\ell.$$

This is illustrated in Figure 2. The initial wage offer made by firm z to non-preempted managers must equal the minimum possible value of those workers to firm v. If not, it would sometimes be the case that firms z would pay more than the value at firm v of such workers, and so would earn greater profits by reducing the wage.

The measure of workers who are promoted is invariant to fluctuations in the cost c that v must pay to learn the worker's productivity, provided that c is not prohibitively high, i.e. provided that

(A7) The expected profits of firm v from informed bidding for a worker, conditional on that worker having a match at firm z equal to or greater than $\hat{\theta}$ is positive:

$$E_{\theta_v^i,\theta_z^i}\left\{g_2^m(\theta_v^i) - \min\ \{g_2^m(\theta_v^i),\ f_2^m(\theta_z^i) + g_2^m(\theta_z^i)\}\ |\ \theta_z^i \ge \hat{\theta},\ D_v=1\right\} - c > 0.$$

Under **(A7)**, the measure of workers promoted does not vary with c: as c varies, the employer faces the same bidding war for the same marginal promoted worker $\hat{\theta}$.

(b) The credibility requirement leads to a unique equilibrium preemptive wage bid by employer z. θ^* is the solution to

$$E_{\theta_v^i,\theta_z^i}\left\{\pi_2^v(\theta_v^i,\theta_z^i,w_2^z(\theta_z^i),L_z=m,D_v=1)\ |\ \theta_z^i \ge \theta^*\right\} = 0. \qquad (5)$$

If z can credibly signal that $\theta_z^i \ge \theta^*$, then it is not profitable for v to acquire information about its match with i. Substituting,

$$E_{\theta_v^i,\theta_z^i}\left\{g_2^m(\theta_v^i) - \min\ \{g_2^m(\theta_v^i),\ f_2^m(\theta_z^i) + g_2^m(\theta_z^i)\}\ |\ \theta_z^i \ge \theta^*,\ D_v=1\right\} = c^{12}.$$

[12] This expression emerges because if $g_2^\ell \ge g_2^m(\theta_v^i)$, then employer z always retains the worker.

(c) The minimum preemptive wage $\bar{w}^*$ necessary to signal $\theta_z^i \geq \theta^*$ must signal that firm z is indifferent between paying $\bar{w}^*$ and retaining the worker with certainty, and paying the minimum promotion wage and facing competition for the worker. Thus, $\bar{w}^*$ solves

$$\pi_2^z(\theta^*, \theta_v^i, w_2^z(\theta_z^i) = g_2^m(\underline{\theta}), L_z = m, D_v = 1) = \pi_2^z(\theta^*, \theta_v^i, w_2^z(\theta_z^i) = \bar{w}^*, L_z = m, D_v = 0).$$

Substituting,

$$E_{\theta_v^i}\left\{f_2^m(\theta^*) + g_2^m(\theta^*) - \min\{g_2(\theta_v^i),\ f_2^m(\theta^*) + g_2^m(\theta^*)\} \mid D_v = 1\right\} = f_2^m(\theta^*) + g_2^m(\theta^*) - \bar{w}^*.$$

Simplifying,

$$\bar{w}^* = E_{\theta_v^i}\left\{\min\{g_2(\theta_v^i),\ f_2(\theta^*) + g_2(\theta^*)\} \mid D_v = 1\right\}.$$

That is, $\bar{w}^*$ is the least preemptive wage that can credibly signal a good match, and θ^* is the least productive worker for whom z has an incentive to preempt competition by paying $\bar{w}^*$. Figure 3 illustrates the calculation of $\bar{w}^*$.

Only an equilibrium in which the preemptive offer equals $\bar{w}^*$ satisfies the credibility condition. It cannot be less, so suppose that in an equilibrium, the preemptive offer $\tilde{w}$ exceeds $\bar{w}^*$. Then v must acquire information about the worker if $w_2^z < \tilde{w}$. But given an (out-of-equilibrium) offer, $w_2^z = \bar{w}^*$, the credibility condition requires beliefs that $\theta_z^i \in [\theta^*, \bar{\theta}]$, and from above it is not optimal for v to compete, a contradiction.

(d) Clearly, in equilibrium, $w_1^{x*} = w_1^{y*}$, or else the firm which wins worker i in period 1 could increase profits by decreasing its wage offer marginally. Also, $E\pi_z = E\pi_v$: the initial employer's expected profits must equal those of the competing firm. Otherwise, if $E\pi_z < E\pi_v$, then the winning period 1 employer would marginally reduce its wage offer, lose the worker to the competition and increase profits. Similarly, if $E\pi_z > E\pi_v$, the losing bidder would raise its period 1 wage offer marginally, winning the worker.

The competing firm's period 2 expected profits per worker equal

$$\lambda \Pr(\theta_z^i \in [\hat{\theta}, \theta^*))\left\{E_{\theta_z^i, \theta_v^i}\left\{g_2^m(\theta_v^i) - \min\{g_2^m(\theta_v^i),\ f_2^m(\theta_z^i) + g_2^m(\theta_z^i)\} \mid \theta_z^i \in [\hat{\theta}, \theta^*)\right\} - c\right\}, \quad (6)$$

which we denote as $E\pi_v^{2*}(c)$, to indicate its dependence on the information costs. That is, with probability $\lambda \Pr(\theta_z^i \in [\hat{\theta}, \theta^*))$ worker i is a competent manager who receives a non-preemptive wage offer so that v competes and earns expected profits,

$$E_{\theta_z^i,\theta_v^i}\left\{g_2^m(\theta_v^i) - \min\{g_2^m(\theta_v^i),\ f_2^m(\theta_z^i) + g_2^m(\theta_z^i)\} \mid \theta_z^i\in[\hat{\theta},\theta^*)\right\} - c.$$

Firm z's ex ante expected period 2 profits per worker equal

$$\lambda \Pr(\theta_z^i\in[\hat{\theta},\theta^*))E_{\theta_z^i,\theta_v^i}\left\{f_2^m(\theta_z^i) + g_2^m(\theta_z^i) - \min\{g_2^m(\theta_v^i),\ f_2^m(\theta_z^i)+g_2^m(\theta_z^i)\} \mid \theta_z^i\in[\hat{\theta},\theta^*)\right\} +$$

$$\lambda \Pr(\theta_z^i\in[\theta^*,\bar{\theta}])E_{\theta_z^i}\left\{f_2^m(\theta_z^i) + g_2^m(\theta_z^i) - \bar{w}^* \mid \theta_z^i\in[\theta^*,\bar{\theta}]\right\} + \left\{(1-\lambda) + \lambda \Pr(\theta_z^i\in[\underline{\theta},\hat{\theta})\right\}f_2^{\ell},$$

which we denote as $E\pi_z^{2*}(c)$. Combining these observations, then

$$w_1^{x*}(c) = w_1^{y*}(c) = g_1^{\ell} + E\pi_z^{2*}(c) - E\pi_v^{2*}(c). \qquad \blacksquare$$

Figure 1 summarizes the possible wages for any worker i. All workers receive w_1^{z*} in the first period. A worker i without management potential (node 5 or 6), or with a poor match with firm z ($\theta_z^i<\hat{\theta}$) receives wage $w_2 = g_2^{\ell}$ in the second period. A worker i promoted, but not preempted, is competed for by firm v, and receives $w_2 = \min\ \{g_2(\theta_v^i),\ f_2^m(\theta_z^i) + g_2^m(\theta_z^i)\}$. A worker i who is promoted and given a preemptive wage offer by z receives $w_2 = \bar{w}^*$.

Section 3: Characterizing Propositions

The proofs to the following propositions are straightforward, but, for the sake of brevity, are relegated to the appendix.

Proposition 2: Expected wages are monotone increasing in match quality, θ_z^i.

Proposition 3: The greater the cost c to firm v of acquiring information, the lower the preemptive wage $\bar{w}^*$. An increase in c decreases a worker's *ex ante* expected wage in period 2, and increases firm z's *ex ante* expected period 2 profits. The decrease in the worker's expected wages equals the increase in firm z's expected period two profits.

Proposition 4: First period wages increase with increases in c. An increase in c causes compensation to be loaded earlier in workers' careers. Total expected profits to both firms decrease with increases in c. Increases in c help less able and poorly matched workers at the expense of the best matched workers. *Ex ante* expected wages *rise* with increases in c.

Proposition 5: As c increases, the economy as a whole becomes more inefficient because managers who should be working at v, work instead at z.

Propositions 2 and 5 are immediate. The intuition for propositions 3 and 4 is as follows: The greater the cost to a competing firm of acquiring information about a worker, the less attractive that is that option and hence the lower is the preemptive wage necessary to discourage competition. Preemption is therefore more attractive as c increases, so that the quality of the marginal preempted worker, θ^*, must fall. More workers are retained at with lower expected wages so that expected profits must increase.

While the employer's period 2 profits increase dollar for dollar with the fall in expected period 2 wages, *total expected profits fall*, because it must pay a greater first period wage to compensate the worker for its greater period 2 monopsony powers. Since first period competition means that expected total profits to both the competing firm and the period 1 employer are identical, as c increases the employer's expected profit must fall with that of the competitor.

This decline in wages is not spread evenly across worker matches. As c rises, the preemptive wage falls and first period wages rise (to compensate workers for the expected fall in second period wages), so the effect of an increase in c is to transfer wages from well-matched workers to less well-matched workers (all workers receive the same first period wage). The net expected effect of an increase in c on wages is positive, however, because the increase in c reduces the *ex ante* heterogeneity of firms, and hence their ability to exploit (through the second price wage auction for the worker's labor) productivity differences across firms. First period wages must both compensate the workers (in expectation) for the fall in second period wages, and reduce the profits of the first period employer to that of the competitor.

Section 4: Infeasible Preemptive Wage Offers

Consider now the effect of preventing firms from making different wage offers to workers upon promotion: preemptive wage offers are infeasible. Employers can, however, compete against outside offers to retain workers. In practice this may result from institutional features, such as union contracts or pay equity plans, which impose narrowly defined pay ranges on individual jobs.

Prohibiting preemption does not affect the determination of the match quality of the marginal promoted worker, $\hat{\theta}$, as z recognizes that competition for $\hat{\theta}$ will occur upon promotion. Consequently, z continues to fail to promote some workers who should be in management so that promotion remains just as inefficient.

Conditional on promotion, however, worker placement is now efficient: all managers work for the employer with whom they are best-matched. The information acquisition process, though, is still not efficient, but for a different reason. Efficient information acquisition decisions require that firm v acquire information about those workers $\theta_z^i < \theta^e$, where θ^e solves

$$E_{\theta_v^i}\left\{g_2^m(\theta_v^i) - \min\{g_2^m(\theta_v^i),\ f_2^m(\theta^e) + g_2^m(\theta^e)\} \mid \gamma_i = 1\right\} = c.$$

Whereas with preemption, some workers who should have been examined by firm v were not (those with matches $\theta^* \leq \theta_z^i < \theta^e$), now firm v examines workers upon whom it unconditionally expects to lose money ($\theta_z^i > \theta^e$).

Consider the effect on profits. The additional workers for whom firm v competes are those with matches $\theta_z^i \geq \theta^*$ at firm z. By definition v earns zero expected profits from inspecting these workers, so that v's expected profits must be unchanged. Firm z now expects to pay higher wages to those workers with matches $\theta_z^i \geq \theta^*$ that it retains after competition, and it also expects to lose more workers. Hence, its expected second period profits are lower if cannot make preemptive wage offers. Specifically, the reduction in these profits equals:

$$\lambda \Pr(\theta_z^i \in [\theta^*, \bar{\theta}]) E_{\theta_z^i, \theta_v^i}\left\{\min\{g_2(\theta_v^i),\ f_2^m(\theta_z^i) + g_2^m(\theta_z^i)\} - \bar{w}^* \mid \theta_z^i \in [\theta^*, \bar{\theta}],\ D_V = 1\right\}$$

However, *ex ante* expected profits to firm z remain unchanged. This follows directly from the fact that firm v's expected profits remain unchanged, and must, in equilibrium, equal those of firm z. Hence the two information acquisition distortions must be of equal magnitude from the perspective of the firms: firms are indifferent with respect to legislation preventing preemptive wage offers.

Total output, however, is greater if preemption is infeasible, due to the improved placement of workers. Because expected profits are unchanged, all of the additional surplus generated by the legislation is captured by the workers. First period wages decline due to the reduction in firm z's second period profits, as bidding for workers of unknown ability becomes less active. *Ex ante* expected second period wages rise because of the increase in the expected wages of workers who would have been offered the preemptive wage. The transfer from well-matched workers to less able and poorly matched workers does not occur because well-matched managers at firm z are paid all of their value at firm v. The wage effects do not offset each other: the rise in the expected period 2 wage is greater than the fall in the period 1 wage, so *ex ante* expected wages rise.

Summarizing these results yields:

Proposition 6: When it is infeasible to offer differential wages upon promotion (i.e. it is infeasible to make preemptive wage offers):

(a) Promotion remains as inefficient as with preemptive wages.

(b) Conditional (on firm v acquiring information) turnover is efficient, but unconditional turnover is excessive.

(c) *Ex ante* expected profits remain unchanged; *ex ante* expected wages rise.

(d) Period two wage dispersion increases, as wages of workers well matched with first period employer z, rise in expectation, and those of workers who would not receive preemptive wages remain unchanged.

Section 5: Large Information Acquisition Costs

Thus far we have assumed that, knowing only that a worker is worth promoting at firm z ($\theta_z^i \geq \ddot{\theta}$), firm v will acquire information and compete. If the cost of acquiring information becomes sufficiently large, acquiring information becomes unprofitable. This occurs when

$$c > E_{\theta_v^i, \theta_z^i}\left\{g_2^m(\theta_v^i) - \min\{g_2^m(\theta_v^i),\ f_2^m(\theta_z^i) + g_2^m(\theta_z^i)\} \mid \theta_z^i \geq \ddot{\theta},\ D_v=1\right\}.$$

In this case, promoted managers are paid the same wage as laborers, and z promotes any worker more valuable as a manager. Effectively, the preemptive wage is reduced to g_2^ℓ.

As c increases and θ^* falls toward $\ddot{\theta}$, it first passes $\hat{\theta}$, the match quality at which firm z is indifferent between promoting a worker and not, given that firm v acquires information upon promotion. When $\theta^* = \hat{\theta}$, firm z is also indifferent between promoting and preempting the worker, and retaining the worker as a laborer. This requires that the profits from the marginally preempted worker equal those from second period laborers; that is, $\theta^* + f_2^m - \bar{w}^* = f_2^\ell$, so that $\bar{w}^* = \theta^* + f_2^m - f_2^\ell$. For θ^* between $\hat{\theta}$ and $\ddot{\theta}$, firm z only promotes workers who are better matched than θ^*, and pays them the (low) preemptive wage. Were firm z to promote a worker such that $\ddot{\theta} \leq \theta_z^i < \theta^* \leq \hat{\theta}$, it would prefer not to pay the preemptive wage; but this would lead to competition, and by the definition of $\hat{\theta}$, employer z would prefer to not promote such a worker, knowing that firm v would compete.

Finally, if c is prohibitive, the expected profits of both firms are zero. This follows because in the absence of turnover, the competing employer must earn no profit, and for the reasons given above, profits for the period one employer must equal those of the competitor. Consistent with proposition 4, *ex ante* expected wages continue to rise with c, until $\theta^* = \ddot{\theta}$, at which point they are at a maximum.

These observations are summarized in

Proposition 7: As c rises, it eventually reaches a prohibitive level at which no workers are hired away from firm z. This occurs when

$$c = E_{\theta_v^i,\theta_z^i}\left\{g_2^m(\theta_v^i) - \min\{g_2^m(\theta_v^i),\ f_2^m(\theta_z^i) + g_2^m(\theta_z^i)\} \mid \theta_z^i \geq \hat{\theta},\ D_v=1\right\},$$

at which point $\theta^*=\hat{\theta}$. As c rises further, θ^* falls below $\hat{\theta}$. Firm z promotes and preempts any match equal to or greater than θ^*, with preemptive wage $\bar{w}^* = \theta^* + f_2^m - f_2^\ell$. Finally when

$$c > E_{\theta_v^i,\theta_z^i}\left\{g_2^m(\theta_v^i) - \min\{g_2^m(\theta_v^i),\ f_2^m(\theta_z^i) + g_2^m(\theta_z^i)\} \mid \theta_z^i \geq \ddot{\theta},\ D_v=1\right\}$$

all workers more valuable as managers than laborers are promoted and receive wage $\bar{w}^* = g_2^\ell$. When c is prohibitive, both firms earn zero expected profits.■

That is, only when information costs become very large, do they affect the probability of promotion. The marginal promoted worker leaves the competing firm indifferent between acquiring information and not. Consequently, once c is sufficiently high, increases in c lead to greater promotion.

Section 6: An Example

This section explores the economic significance of preemptive bidding and information costs by illustration with a simple numerical example. We consider the economy with the following parameterizations:

$$g_2^m(\theta_z^i) = g_2^m(\theta_v^i) = \theta^i \qquad \theta^i \sim \text{uniform } [0,2],\ \ddot{\theta} = 1.05$$

$$f_2^m = f_2^\ell = f \in (0,0.3); \quad c \in (.001,.025)$$

The assumption that $f_2^m = f_2^\ell$ is an unimportant simplification. Part (a) of Figures 4 - 7 depicts four series, all functions of the cost of information c: $\hat{\theta}$, the match quality of the marginal promoted worker; $\bar{w}^*$, the preemptive wage;

θ^*, the match quality of the marginal preempted worker; and θ^e, the match quality of workers at firm z above which firm v would not acquire information if it knew the match quality. Recall that θ^* is calculated taking into account the incomplete information firm v has about the preempted worker's match at firm z: firm v knows only that $\theta_z^i \geq \theta^*$, and chooses not to acquire information. θ^e is calculated taking into account the actual match quality at firm z, and so is the socially efficient marginal unexamined worker. Part (b) of Figures 4 - 7 shows how the probability of preemption varies with the cost of information c.

The importance of this illustration is how **very** small information costs can lead to a large measure of managers receiving preemptive wage offers. For instance, Figures 4 - 7 show that costs as low as 0.1% of the (unconditional) expected value of managers leads z to preempt competition for 11% of its managers when f=0, and 62% when f=0.3. This further demonstrates that the attractiveness of preemptive wage offers is increased dramatically by the development of even slight levels of firm specific skills which make it less costly to deter competition for promoted managers; this shifting of the preemption level is summarized in Figure 8, which plots θ^* as a function of c for each of the levels of firm specific capital considered.

Figure 7(a) clearly illustrates how, as the information costs increase, the allocational efficiency of the economy falls: as c increases from 0.001 to 0.005, the difference between θ^e and θ^* almost doubles. Figure 7(a) also shows the possibility of prohibitively large c (where no turnover occurs); for information costs greater than 0.012 all promoted workers are preempted, so turnover is zero.

Figure 9 plots promotion inefficiency as a function of firm specific skills. Promotion inefficiency is the measure of the difference between $\hat{\theta}$, the marginal worker promoted, and $\ddot{\theta}$, marginal worker who is more productive as a manager than laborer. Figure 9 illustrates that, as f increases, (for c small) employer z makes more conservative promotion decisions to avoid losing those skills, and hence promotion is less efficient.

Finally, Figure 10 shows how turnover is affected by increases in c and f. Figure 10(a) plots the probability of turnover conditional on promotion, i.e. conditional on $\theta_z^i \geq \hat{\theta}$. For f=0, an increase in c from 0.001 to 0.025 reduces the chance of turnover by 7 percentage points, or about 34%. Higher levels of firm specific capital lead to greater reductions: at f=0.2, the same increase in c lowers the probability of turnover by 11 percentage points, a reduction of 100%. Figure 10(b) plots the probability of turnover conditional on *non-preemptive* promotion. This rises with c because as θ^* falls, the probability a non-preempted manager has a better match at the competing firm increases. The functions plotted in 10(b) end at the point of zero turnover.

Section 7: Uninformed Bidding

Suppose now that assumption **A4** is relaxed so that uninformed bidding and hiring of managers by competing firms may be attractive. Promotion reveals enough information to encourage competition, but not information acquisition, leading to blind bidding wars. One possibility is that information acquired by firm v allows it to avoid hiring workers without managerial ability, but does not alter the expected value of managers. In this case, the following is true:

Proposition 8: If information about a worker with managerial ability is unnecessary for placement, i.e. if $E_{\theta_v^i}\{g_2(\theta_v^i)|D_v=1\} = E_{\theta_v^i}\{g_2^m(\theta_v^i)|D_v=0\}$, then firm z never offers a preemptive wage. Firm z promotes all workers with matches $\theta_z^i \geq \hat{\theta}$, and pays a non-preemptive wage $w_2^z \leq g_2^m(\underline{\theta})$.

The proof of Proposition 8 is in the appendix. The intuition for this result is that, to preempt firm v from acquiring information, firm z must pay the worker's expected productivity at firm v, even if the worker is better matched at v than z. If firm v determines its match with workers, firm z only pays the expected value at v of workers who are more productive at z. Indeed if c is large enough to prevent information acquisition, there may be an incentive for firm z to help cover the cost of information, rather than face an uninformed bidder.

The rest of this section supposes that the information acquired by firm v increases the expected value of managers, and describes how the equilibria of the economy change when either

(A8) The expected productivity at firm v of uninspected managers is greater than the productivity of laborers in period 2, but less than the productivity of the marginal promoted worker at firm z:

$$g_2^\ell \leq E_{\theta_v^i}\{g_2^m(\theta_v^i)|D_v=0\} \leq f_2^m(\hat{\theta}) + g_2^m(\hat{\theta});$$

or,

(A8') The expected productivity at firm v of uninspected managers is greater than the productivity of the marginal promoted worker at firm z:

$$E_{\theta_v^i}\{g_2^m(\theta_v^i)\,|\,D_v=0\} \geq f_2^m(\hat{\theta}) + g_2^m(\hat{\theta}),$$

where $\hat{\theta}$ is given by the solution to equation (2).

If either **A8** or **A8'** hold, the competing firm may prefer to bid on a promoted worker without acquiring information about match quality. Relaxing **A4** leads to a floor beneath the quality of the marginally preempted worker in the following sense. If $\bar{w}^* < E_{\theta_v^i}\{g_2^m(\theta_v^i)\,|\,D_v=0\}$, a promoted and preempted (with $\bar{w}^*$) worker's wage is bid up to $E_{\theta_v^i}\{g_2^m(\theta_v^i)\,|\,D_v=0\}$. But when

$$E_{\theta_v^i}\{g_2^m(\theta_v^i)\,|\,D_v=0\} > \quad E_{\theta_v^i}\left\{\min\{g_2(\theta_v^i),\ f_2^m(\theta_v^i) + g_2^m(\theta_v^i)\}\ |\ D_v=1\}\right\},$$

firm z would expect to pay a higher wage to a marginally preempted worker than it would were it to face informed competition.[13] Firm z therefore does not want to discourage information acquisition by competing firm v about such workers. Define $\tilde{\theta}$ as the solution to

$$E_{\theta_v^i}\{g_2^m(\theta_v^i)\,|\,D_v=0\} = \quad E_{\theta_v^i}\left\{\min\{\ g_2(\theta_v^i),\ f_2^m(\tilde{\theta}) + g_2^m(\tilde{\theta})\}\ |\ D_v=1\}\right\}.$$

Firm z does not want to preempt information acquisition for workers with matches $\theta_z^i \in [\underline{\theta},\tilde{\theta})$ and will make wages offers which encourage informed competition: $\tilde{\theta}$ represents a 'preemption floor'.[14]

When the cost of information acquisition, c, is sufficiently small, replacing **A4** with **A8** changes none of the qualitative results of the model. In particular, if

$$E_{\theta_z^i,\theta_v^i}\left\{\ g_2(\theta_v^i)\ -\ \min\ \{g_2(\theta_v^i),\ f_2^m(\theta_z^i)+g_2^m(\theta_z^i)\}\ |\ \theta_z^i\in[\hat{\theta},\theta^*),D_v=1\right\}\ -\ c > 0,$$

then acquiring information conditional on a promotion is profitable, but bidding $E_{\theta_v^i}\{g_2^m(\theta_v^i)\,|\,D_v=0\}$ never wins the marginally promoted worker. Assumption **A8** does mean that $\tilde{\theta} > \ddot{\theta}$, so that as c increases, the preemption floor eventually defines the minimum level of preemptive promotion: $\tilde{\theta}$ replaces $\ddot{\theta}$ as the limiting promotion level, and $E_{\theta_v^i}\{g_2^m(\theta_v^i)\,|\,D_v=0\}$ replaces g_2^ℓ as the limiting promotion (and preemption) wage. Note that a wage offer of $\bar{w}^*$ by firm z prevents competition if $\tilde{\theta} > \theta^*$, so the preemptive wage is no longer unique.

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[13] Firm z's belief that firm v will bid the wage of a preempted worker up to $E_{\theta_v^i}\{g_2^m(\theta_v^i)\,|\,D_v=0\}$ even though in equilibrium $\theta_z^i \geq \theta^*$, so that firm v will never win the worker, can be justified: firm v will bid this way if there is a small chance of an error being made by firm z.

[14] In earlier sections, the floor beneath θ^* was $\ddot{\theta}$.

The equilibrium wage is unique, though, as uninformed bidding drives the wage for preempted managers to $E_{\theta_v^i}\{g_2^m(\theta_v^i)\,|\,D_v=0\}$.

Unlike **A8**, assumption **A8'** allows the possibility that firm v wins a worker whose match with firm z is $\hat{\theta}$. Under **A8'** the equilibria are of three varieties, depending on whether the competing firm **(a)** always, **(b)** never, or **(c)** sometimes acquires information about (non-preemptively promoted) managers.

(a) If information costs and the expected productivity of managers is such that it is always **more** profitable for firm v to acquire information about workers than to bid ignorantly:

$$E_{\theta_z^i,\theta_v^i}\left\{ g_2(\theta_v^i) - \min \{g_2(\theta_v^i),\ f_2^m(\theta_z^i)+g_2^m(\theta_z^i)\} \mid \theta_z^i\in[\hat{\theta},\theta^*),D_v=1\right\} - c >$$
$$E_{\theta_z^i,\theta_v^i}\left\{ g_2^m(\theta_v^i) - \min \{E_{\theta_v^i}\{g_2^m(\theta_v^i)\},\ f_2^m(\theta_z^i)+g_2^m(\theta_z^i)\} \mid \theta_z^i\in[\hat{\theta},\theta^*),D_v=0\right\}$$

then firm v always chooses to acquire information about workers who are promoted at firm z, but do not receive the preemptive wage. (This case corresponds to **(A4')**). If, in addition, c is small enough that $\theta^* > \tilde{\theta}$, all of the propositions obtained before continue to hold. If, instead, $\theta^* < \tilde{\theta}$, only workers with match at least $\tilde{\theta}$ receive preemptive promotions. Firm z invites informed bidding wars for less well-matched managers.

(b) If information costs are prohibitive,

$$c > E_{\theta_v^i,\theta_z^i}\left\{g_2^m(\theta_v^i) - \min \{g_2^m(\theta_v^i),\ f_2^m(\theta_z^i) + g_2^m(\theta_z^i)\} \mid \theta_z^i \geq \hat{\theta},\ D_v=1\right\},$$

then, in equilibrium, firm v never expends resources to determine its match with a worker. A consequence is that promoted workers receive period 2 wage $E_{\theta_v^i}\{g_2^m(\theta_v^i)\,|\, D_v=0\}$, but *fewer* workers are promoted than when information costs are not prohibitive. Under **A8'** when it becomes too costly for firm v to determine the quality of its match, a worker must be better-matched to be promoted. Essentially, since v does not acquire information, it makes "mistakes" and makes excessively attractive wage offers to workers who turn out to be relatively unproductive at v and are more productive at z.

Only workers with ability at least $\hat{\theta}^P$ are promoted where $\hat{\theta}^P$ solves

$$f_2^m(\hat{\theta}^P) + g_2^m(\hat{\theta}^P) - E_{\theta_v^i}\{ g_2^m(\theta_v^i) \mid \gamma_i=1,D_v=0\} - f_2^{\ell} = 0.$$

Since

$$E_{\theta_v^i}\{ \min\{g_2(\theta_v^i),\ g_2^m(\hat{\theta}) + f_2^m(\hat{\theta})\} \,|D_v=1\} - E_{\theta_v^i}\{g_2^m(\theta_v^i) \mid \gamma_i=1,\ D_v=0\} < 0,$$

then $\theta^P > \hat{\theta}$. There is no turnover in equilibrium, so expected profits of both firms are zero.

(c) Finally, c can take on an intermediate value, so that

$$0 < E_{\theta_z^i,\theta_v^i}\left\{ g_2(\theta_v^i) - \min\ \{g_2(\theta_v^i),\ f_2^m(\theta_z^i)+g_2^m(\theta_z^i)\} \mid \theta_z^i\in[\hat{\theta},\theta^*), D_V=1\right\} - c \leq$$

$$E_{\theta_z^i,\theta_v^i}\left\{ g_2^m(\theta_v^i) - \min\ \{E_{\theta_v^i}\{g_2^m(\theta_v^i)\},\ f_2^m(\theta_z^i)+g_2^m(\theta_z^i)\} \mid \theta_z^i\in[\hat{\theta},\theta^*), D_V=0\right\}.$$

In this instance, no pure strategy equilibrium exists. c is sufficiently high that in the event of a promotion, given the promotion rule which leads to beliefs that $\theta_z^i\in[\hat{\theta},\theta^*)$, the competitor prefers not to acquire information and instead bid ignorantly, although both alternatives are profitable. But this cannot be an equilibrium for employer z would lose all workers θ_z^i who it promotes such that $E_{\theta_v^i}\{g_2^m(\theta_v^i)\} \geq f_2^m(\theta_z^i)+g_2^m(\theta_z^i)$.

A mixed strategy equilibrium does exist, however. In the equilibrium, employer z only promotes workers with match at least $\hat{\theta}$, where

$$E_{\theta_z^i,\theta_v^i}\left\{ g_2(\theta_v^i) - \min\ \{g_2(\theta_v^i),\ f_2^m(\theta_z^i)+g_2^m(\theta_z^i)\} \mid \theta_z^i\in[\hat{\theta},\theta^*), D_V=1\right\} - c =$$

$$E_{\theta_z^i,\theta_v^i}\left\{ g_2^m(\theta_v^i) - \min\ \{E_{\theta_v^i}\{g_2^m(\theta_v^i)\},\ f_2^m(\theta_z^i)+g_2^m(\theta_z^i)\} \mid \theta_z^i\in[\hat{\theta},\theta^*), D_V=0\right\}.$$

In the event of a non-preemptive promotion, this promotion rule leaves v indifferent between acquiring information about the worker and just bidding ignorantly for the worker. In turn, the competing firm v, in the event of a non-preemptive promotion, plays a mixed strategy and acquires information about the manager with probability P, where P solves

$$PE_{\theta_v^i}\left\{ \max\{\ f_2^m(\hat{\theta}) + g_2^m(\hat{\theta}) - g_2^m(\theta_v^i),\ 0\} \right\} = f_2^{\ell}.$$

P leaves z indifferent between promoting worker match $\hat{\theta}$ and not.

The mixed strategy equilibrium still features preemptive wage offers because, for a given c, the knowledge that $\theta_z^i \geq \theta^*$ discourages firm v from acquiring information, and there exists a $\bar{w}^*$ which signals such a match. Preempted workers receive the equilibrium wage

$$\bar{w} = \max\left\{ E_{\theta_v^i}\{g_2^m(\theta_v^i) \mid D_V=0\},\ E_{\theta_v^i}\{\min\{g_2(\theta_v^i),\ f_2^m(\theta^*) + g_2^m(\theta^*)\} \mid D_V=1\} \right\}.$$

Section 9: Concluding Comments

The results extend robustly. Both the two-period horizon (see Bernhardt

[1991]) and the risk-neutrality assumptions are innocuous. That the worker-firm match is only in management is a convenience. What is necessary is that it is attractive to the competition to find out about its match with the worker *only* if the worker is promoted. As noted earlier, one can relax the assumption that the worker-firm matches are independent across firms and the qualitative results are unchanged. The model can be extended to allow for partial preemption so that the first period employer only prevents some of its potential competitors from acquiring information (see Bhattacharyya [1990] for this extension in the context of firm takeovers). This also allows for asymmetries between firms, so that "better" firms -- those with higher average match qualities -- can grow at the expense of less fortunate competitors. Finally, the nature of the results are unchanged if uninformed workers, rather than competing firms, must pay the cost of acquiring information about their match quality.

If the concept of worker-firm matching is extended to worker-*job* matching, the model yields predictions about internal worker sorting. In particular, diseconomies of scale due to agency problems which may limit the efficient size of firms will be offset in part by the ability of large firms to place workers more efficiently than small firms. Promotion within one department in a firm signals to other departments that a worker is potentially able and should be investigated, but none of the motives for concealment of information are present internally, if departments seek to maximize joint profits. If the true match of a worker is known to all departments within a firm, more workers will be investigated profitably within a firm than across firms (see Proposition 5). Furthermore, it is reasonable to assume that the cost of investigating a firm's own employees is less than the cost incurred checking outside workers. For these reasons, the model predicts a proportionally greater amount of "turnover" between departments within a single firm than between two competing firms. In larger firms, workers are placed more efficiently, increasing profits.

Appendix

Credible Beliefs

The preemptive wage bid by employer z, while it must be sufficiently great, is not unique because firm v's beliefs are not pinned down off the equilibrium path. We address this by requiring that beliefs satisfy Grossman and Perry's [1986] notion of credible beliefs[15]. For Θ, a non-empty subset of $[\hat{\theta},\bar{\theta}]$, let $G_\Theta(\theta_z^i)$ denote the conditional density of θ_z^i given $\theta_z^i \in \Theta$, and let $\hat{D}_v(w_2^z, L_z;\Theta)$ denote firm v's optimal response given w_2^z, L_z and beliefs $G_\Theta(\theta_z^i)$.

Credibility Condition: Consider an out-of-equilibrium initial wage and employment offer by firm z, w_2^z, L_z. If there exists a nonempty subset of $[\underline{\theta},\bar{\theta}]$, say Θ, such that firm z's expected profits in period 2,

$$E_{\theta_v^i}\{\pi_2^z(\theta_z^i,\theta_v^i,w_2^z,L_z,\hat{D}_v(w_2^z, L_z;\Theta))\} \geq E_{\theta_v^i}\{\pi_2^z(\theta_z^i,\theta_v^i,w_2^z,L_z,D_v^*(w_2^z, L_2))\}$$

if and only if $\theta_z^i \in \Theta$, then $G_v(\theta_z^i|w_2^z,L_z) = G_\Theta(\theta_z^i)$.

Credibility restricts the extent to which beliefs that are formed in response to out-of-equilibrium initial offers can be specified arbitrarily. Consider an out-of-equilibrium offer w_2^z,L_z. Were v to believe that $\theta_z^i \in \Theta$, then its optimal response would be $\hat{D}_v(w_2^z, L_z;\Theta)$. Now, given that w_2^z,L_z elicits response $\hat{D}_v(w_2^z, L_z;\Theta)$, which employers would have preferred to offer w_2^z,L_z rather than to follow the "equilibrium" strategy? If it is those with $\theta_z^i \in \tilde{\Theta} \neq \Theta$, then beliefs that $\theta_z^i \in \Theta$ would not be confirmed. Every subset of $[\underline{\theta},\bar{\theta}]$ can be tested in this way. If there is a unique nonempty subset, Θ, for which, given a response $\hat{D}_v(w_2^z, L_z;\Theta)$, z would have deviated from the equilibrium strategy and offered w_2^z,L_z if and only if $\theta_z^i \in \Theta$, then the credibility condition requires v's beliefs to be consistent with $\theta_z^i \in \Theta$ and Bayes' rule.

Proofs to Propositions

Proof to Proposition 2: If $\theta_z^i<\hat{\theta}$, the worker is not promoted and receives period 2 wage g_2^ℓ, so wages are constant for $\theta_z^i\in[\underline{\theta},\hat{\theta})$; for $\theta_z^i\in[\hat{\theta},\theta^*)$ expected wages are strictly increasing because, given the independence of match quality across firms,

---

[15] This discussion follows Fishman [1988] closely.

$$E_{\theta_v^i}\{w_2|\theta_z^i\in[\hat{\theta},\theta^*)\} = E_{\theta_v^i}\left\{ \min\{g_2(\theta_v^i),\ f_2^m(\theta_z^i) + g_2^m(\theta_z^i)\} \mid D_v=1 \right\}$$

is strictly increasing in θ_z^i; for $\theta_z^i\in[\theta^*,\bar{\theta}]$, wages are constant and equal to

$$\bar{w}^*=E_{\theta_v^i}\left\{\min\{ g_2(\theta_v^i),\ f_2(\theta^*) + g_2(\theta^*)\} \mid D_v=1 \right\}.$$ ■

Proof to Proposition 3: The first statement follows directly from proposition 1 (c) and (d): from (5), θ^* falls with increases in c, and $\bar{w}^*$, given by (6), falls with decreases in θ^*. The probability that a worker is promoted is unchanged with an increase in c. If the worker is promoted and competed for, his period two wage is, in effect, determined by a second price auction, and so is unchanged. However, as θ^* falls with an increase in c, competition is less likely. If the worker is promoted and preempted (which is more likely with a lower θ^*), he or she receives the lower $\bar{w}^*$. To see that the decrease in expected wages is equal to the increase in firm z's expected second period profits consider two different information costs, and their associated preemption wages and match qualities, where $c_1 < c_2$:

$$c_1,\ \bar{w}_1,\ \theta_1^*,\quad \text{and}$$

$$c_2,\ \bar{w}_2\ ,\ \theta_2^*.$$

Workers with matches $\theta_z^i \geq \theta_1^*$ receive the preemptive wage both before and after an increase in c, and so the reduction $\bar{w}_1 - \bar{w}_2$ is a direct transfer to firm z. Workers with matches $\theta_2 < \theta_z^i < \theta_1^*$ have their expected wages reduced by

$$\bar{w}_2 - E_{\theta_v^i}\{w_2|\theta_z^i\} =$$

$$\bar{w}_2 - \Pr\{g_2^m(\theta_v^i) < f_2^m(\theta_z^i)+g_2^m(\theta_z^i)\}\, E_{\theta_v^i}\left\{g_2^m(\theta_v^i)|f_2^m(\theta_z^i) + g_2^m(\theta_z^i) > g_2^m(\theta_v^i)\right\} \quad (7)$$

$$- \quad \Pr\{g_2^m(\theta_v^i) \geq f_2^m(\theta_z^i)+g_2^m(\theta_z^i)\}(f_2^m(\theta_z^i) + g_2^m(\theta_z^i)).$$

The expected gain in profits for firm z equals

$$f_2^m(\theta_z^i) + g_2^m(\theta_z^i) - \bar{w}_2 -$$

$$\Pr\{g_2^m(\theta_v^i) < f_2^m(\theta_z^i)+g_2^m(\theta_z^i)\}\, E_{\theta_v^i}\left\{f_2^m(\theta_z^i)+g_2^m(\theta_z^i)-g_2^m(\theta_v^i)\ \ |f_2^m(\theta_z^i)+g_2^m(\theta_z^i) < g_2^m(\theta_v^i)\right\}. \quad (8)$$

Manipulation shows expressions (7) and (8) are identical. Finally, workers with matches $\theta_z^i \geq \theta_2^*$ receive the same expected wage under both costs. Thus the net change in wages and profits is zero. ■

Proof to Proposition 4: The first statement follows directly from equation (3):

$$w_1^{x*}(c) = w_1^{y*}(c) = g_1^{\ell} + E\pi_z^{2*}(c) - E\pi_v^{2*}(c),$$

because $E\pi_v^{2*}(c)$ is decreasing in c (from equation (2)) and $E\pi_z^{2*}(c)$ increasing in c (by proposition 3). The first period wage increase reflects firm z's increased monopsony power in period 2: turnover declines as firm v competes for fewer and fewer workers. Total expected profits to both firms decrease because the profits to the competing firm fall, and in equilibrium these profits must equal those of the original employer. This equilibrating process is what causes the first period wage to rise.

The redistribution effect arises as follows. All workers receive the same period one wage, which by proposition 4 increases with c. Period 2 wages of workers who do not receive the preemptive wage are unchanged by an increase in c. Well matched workers are preempted and receive $\bar{w}^*$, which by proposition 3 falls with c. This result stems from the fact that *ex ante* all workers are identical, so the competition which transfers to workers the gain from inefficient placement (between firms) of preempted workers does so independently of either the recipient's management ability or quality of match at firm z.

That total *ex ante* expected wages rise also follows from equation (3): the rise in period 1 wages must compensate for *both* the decrease in firm v's expected profit, and the increase in firm z's expected period 2 profit; by proposition 2 the latter alone is equal to the decrease in workers' *ex ante* expected period 2 wages. ∎

Proof to Proposition 5: Efficient information acquisition decisions require that firm v acquire information about those workers $\theta_z^i < \theta^e$, where θ^e solves

$$E_{\theta_v^i}\left\{g_2^m(\theta_v^i) - \min\{g_2^m(\theta_v^i),\ f_2^m(\theta^e) + g_2^m(\theta^e)\} \mid \gamma_i = 1\right\} = c.$$

Clearly, $\theta^e > \theta^*$. Both θ^e and θ^* fall with increases in c, but $\theta^e - \theta^*$ increases. Note that there is no increased inefficiency in placement between labor and management, as promotion decisions are unaffected by c. ∎

Proof to Proposition 8: Consider first a firm z with a match so high that firm v will never hire the worker away, that is: $f_2^m(\theta_z^i) + g_2^m(\theta_z^i) > g_2^m(\bar{\theta})$. If firm v acquires information about the worker, the wage firm z expects to pay is equal to the expected value of the worker at firm v, $E_{\theta_v^i}\{g_2(\theta_v^i) | D_v=1\}$. If firm v does not acquire information, it bids up worker i's wage to $E_{\theta_v^i}\{g_2^m(\theta_v^i) | D_v=0\}$; by assumption firm z is indifferent between these outcomes, and does not value preempting firm v's acquisition of information.

Next consider a firm z match, call it θ_*, not quite so good, such that $f_2^m(\theta_*) + g_2^m(\theta_*) < g_2^m(\bar{\theta})$. If firm v does not acquire information the expected wage firm z pays if it keeps the worker is still $E_{\theta_v^i}\{g_2^m(\theta_v^i) | D_v=0\} = E_{\theta_v^i}\{g_2(\theta_v^i) |\ g_2(\theta_v^i)<g_2(\bar{\theta})\}$. However, if information is acquired the expected wage for workers retained by z is now $E_{\theta_v^i}\{g_2^m(\theta_v^i) |\ g_2^m(\theta_v^i) < f_2^m(\theta_*) + g_2^m(\theta_*)\} < E_{\theta_v^i}\{g_2^m(\theta_v^i) | D_v=0\}$. Thus it never pays for a firm with some possibility of losing the worker to preempt. Finally, the decision governing the promotion decision is unchanged. ■

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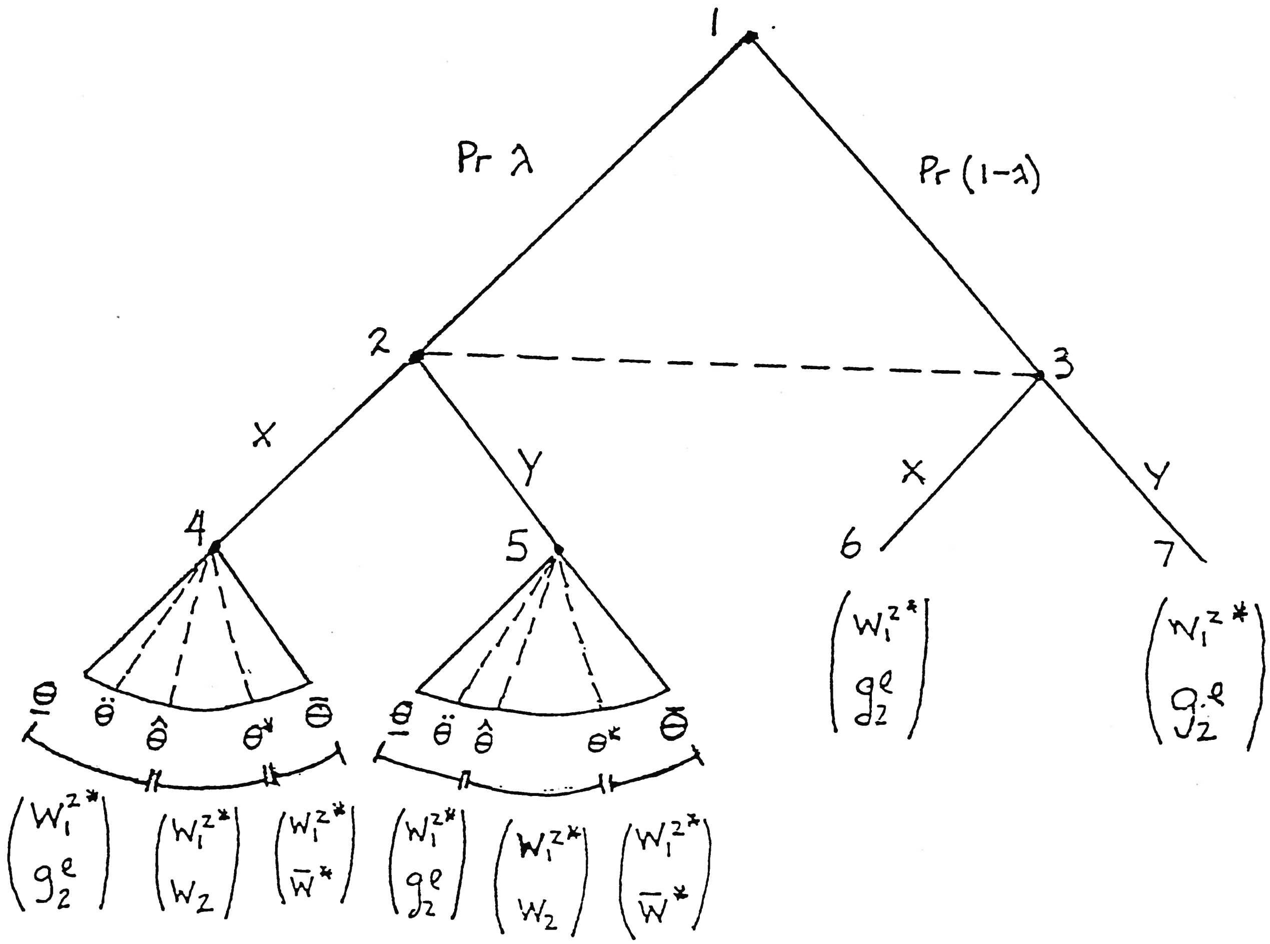
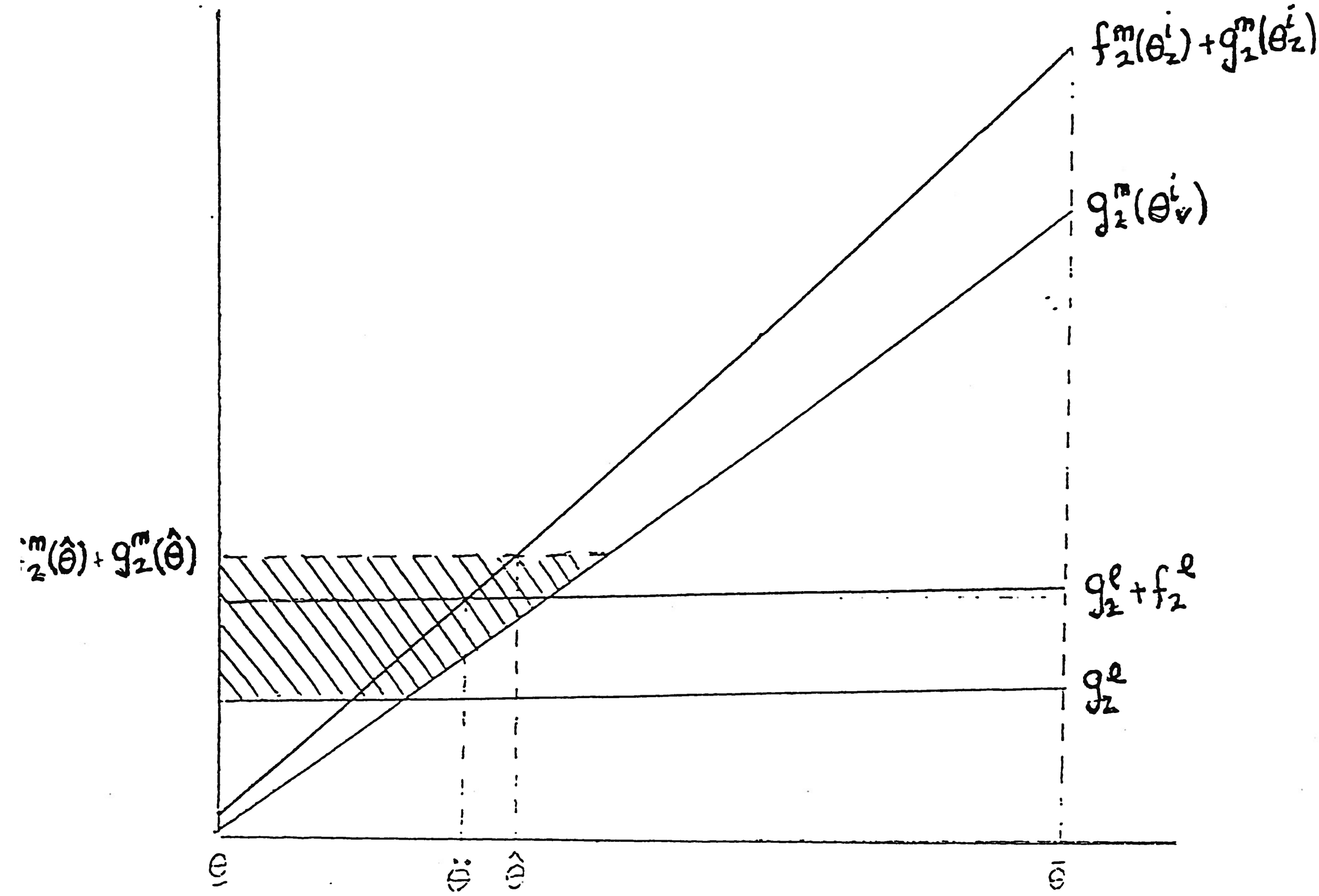
FIGURE 1



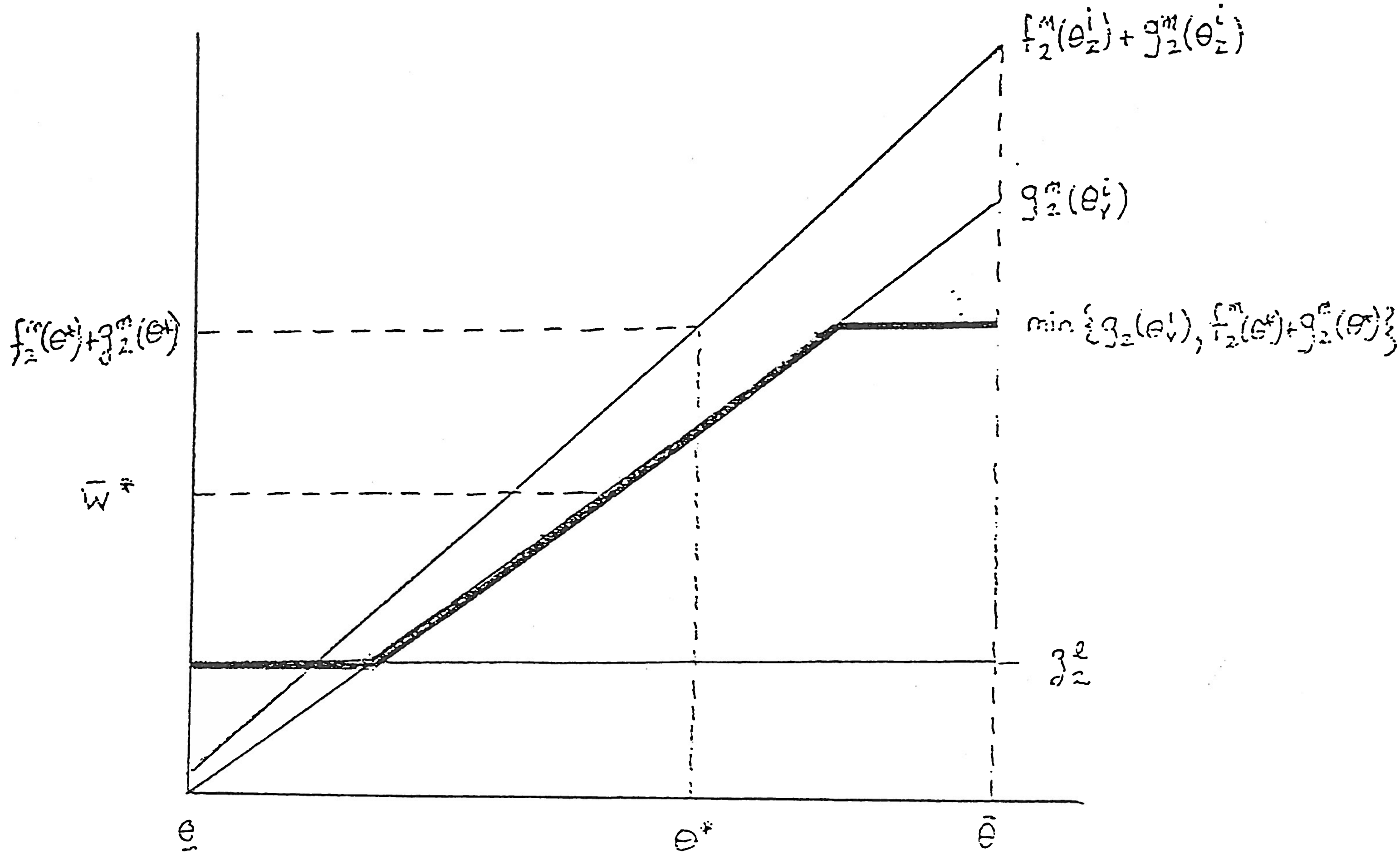
$$W_2 = \min\{g_2(\theta_v^i),\ f_2^m(\theta_2^i) + g_2^m(\theta_2^i)\}$$

FIGURE 2



Expectation of the shaded area is equal to f_2^ℓ

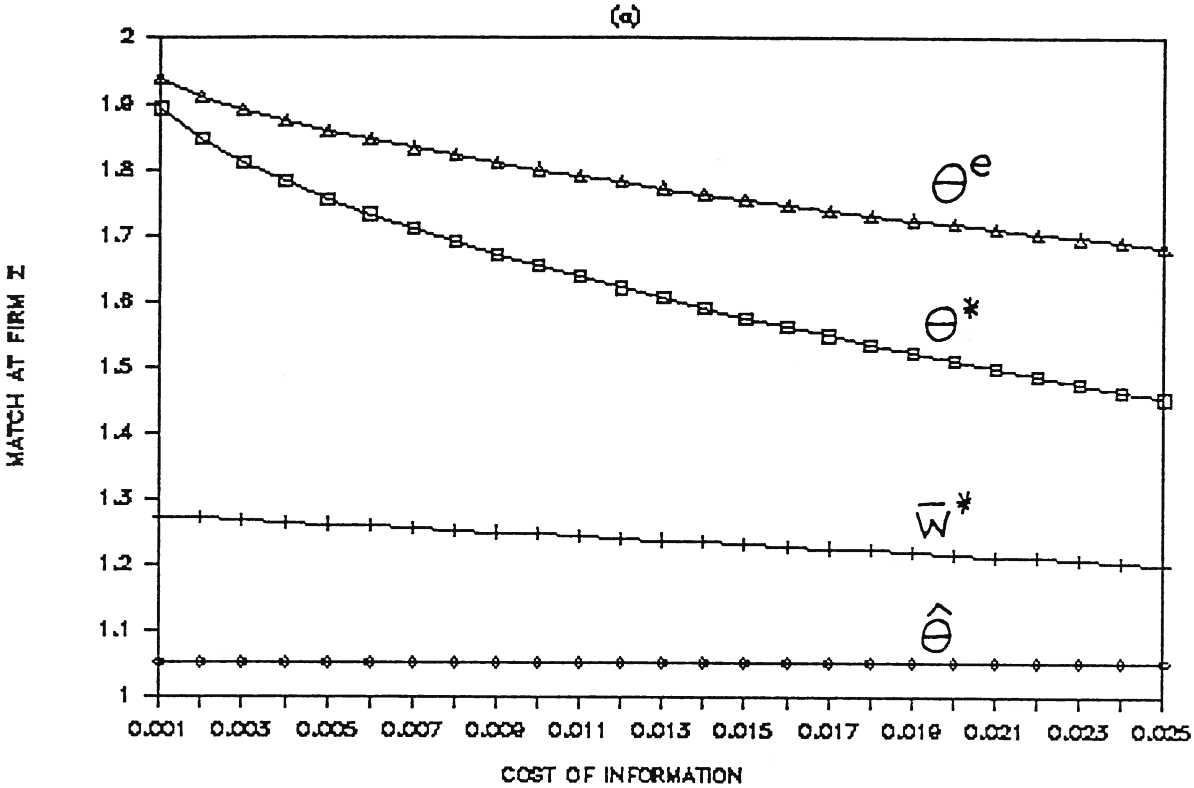
FIGURE 3



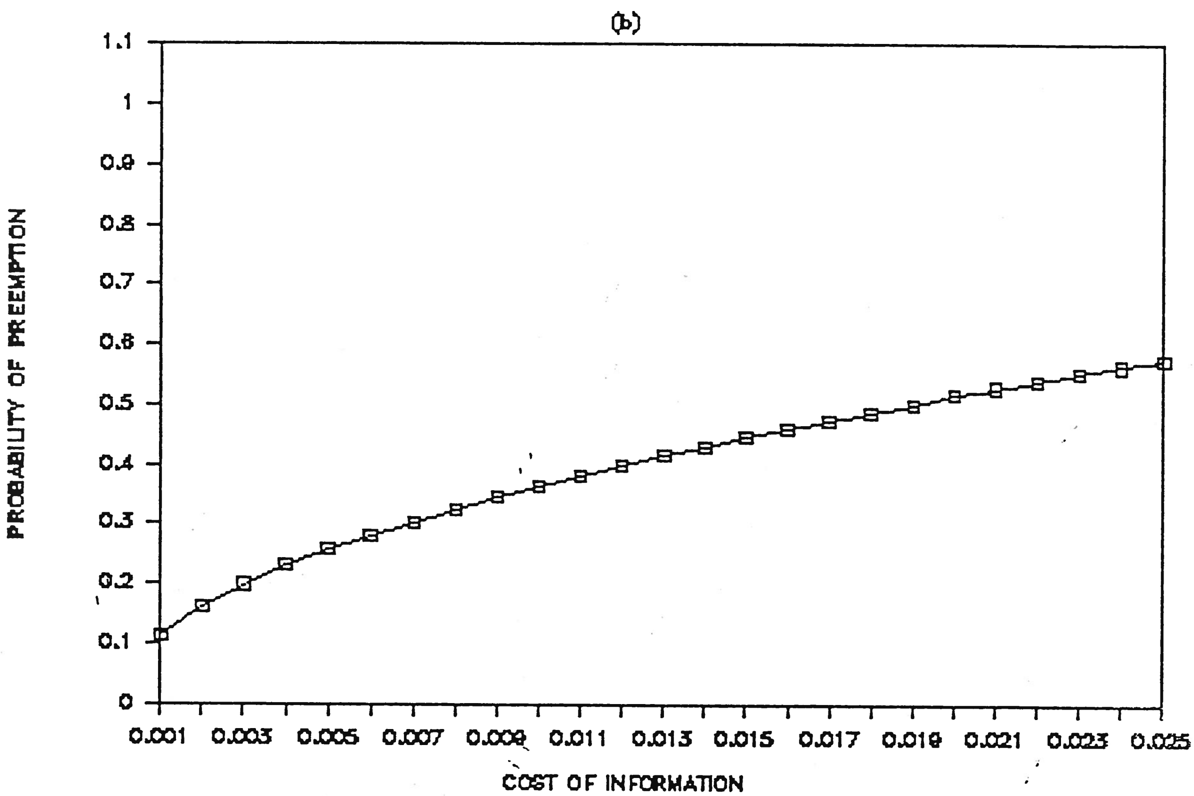
$$g_2(\theta_v^i) = \text{MAX}\{g_2^l, g_2^m(\theta_v^i)\}$$

$$\bar{W}^* = E_{\theta_v^i}\{\min\{g_2(\theta_v^i), f^m(\theta^*) + g_2^m(\theta^*)\}\}$$

Figure 4: f=0



(a)
MATCH AT FIRM Z
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
Θ^e
Θ^*
$\bar{W}^*$
$\hat{\Theta}$
0.001
0.003
0.005
0.007
0.009
0.011
0.013
0.015
0.017
0.019
0.021
0.023
0.025
COST OF INFORMATION



(b)
PROBABILITY OF PREEMPTION
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.001
0.003
0.005
0.007
0.009
0.011
0.013
0.015
0.017
0.019
0.021
0.023
0.025
COST OF INFORMATION

Figure 5: f=0.1

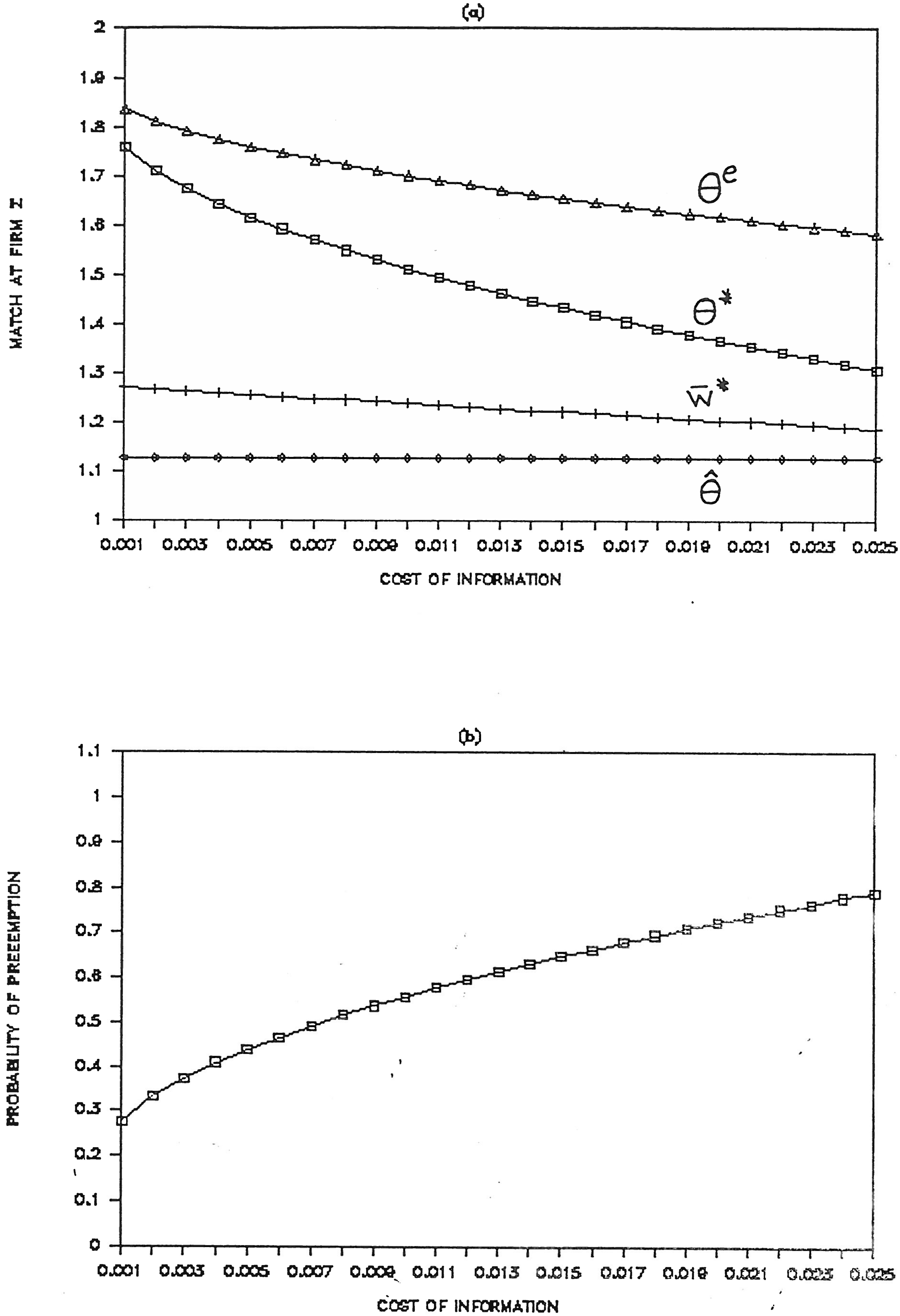
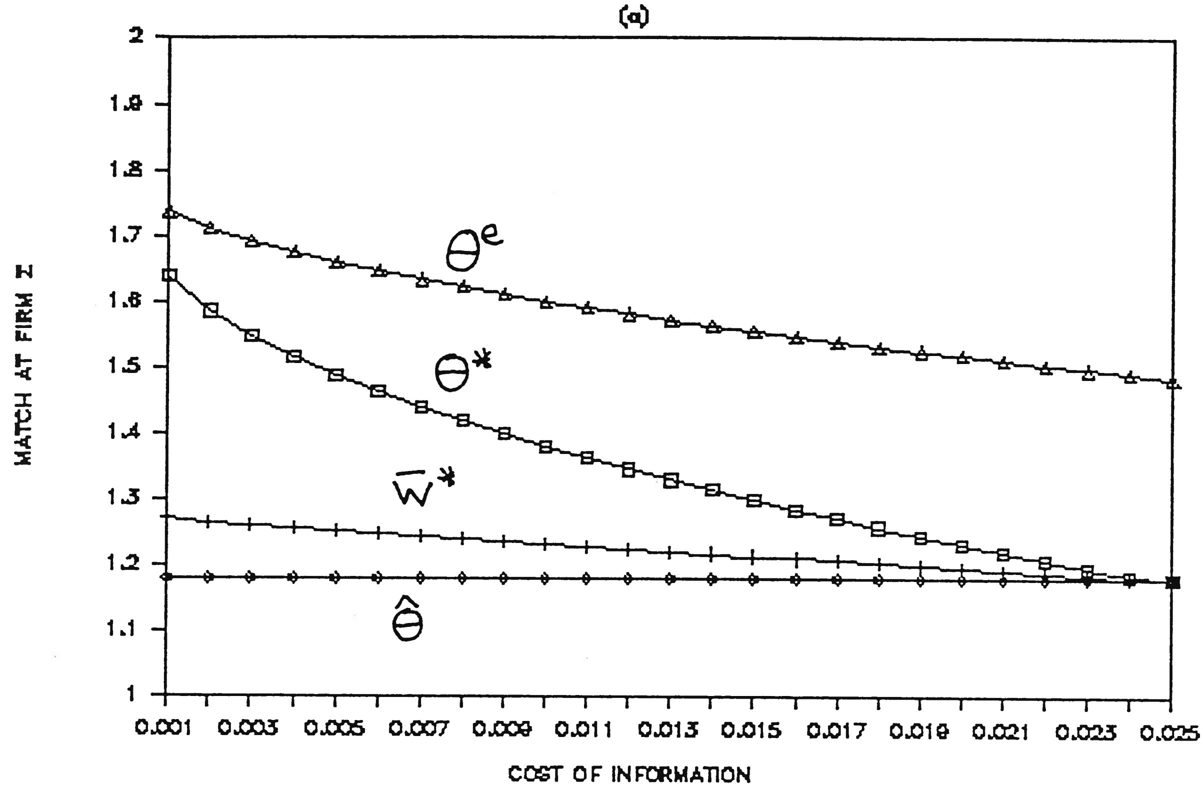

(a)
MATCH AT FIRM 2
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
Θ^e
Θ^*
$\bar{w}^*$
$\hat{\Theta}$
0.001 0.003 0.005 0.007 0.009 0.011 0.013 0.015 0.017 0.019 0.021 0.023 0.025
COST OF INFORMATION
(b)
PROBABILITY OF PREEMPTION
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.001 0.003 0.005 0.007 0.009 0.011 0.013 0.015 0.017 0.019 0.021 0.023 0.025
COST OF INFORMATION

Figure 6: f=0.2


(a)
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
MATCH AT FIRM Z
Θ^e
Θ^*
$\bar{w}^*$
$\hat{\Theta}$
0.001 0.003 0.005 0.007 0.009 0.011 0.013 0.015 0.017 0.019 0.021 0.023 0.025
COST OF INFORMATION

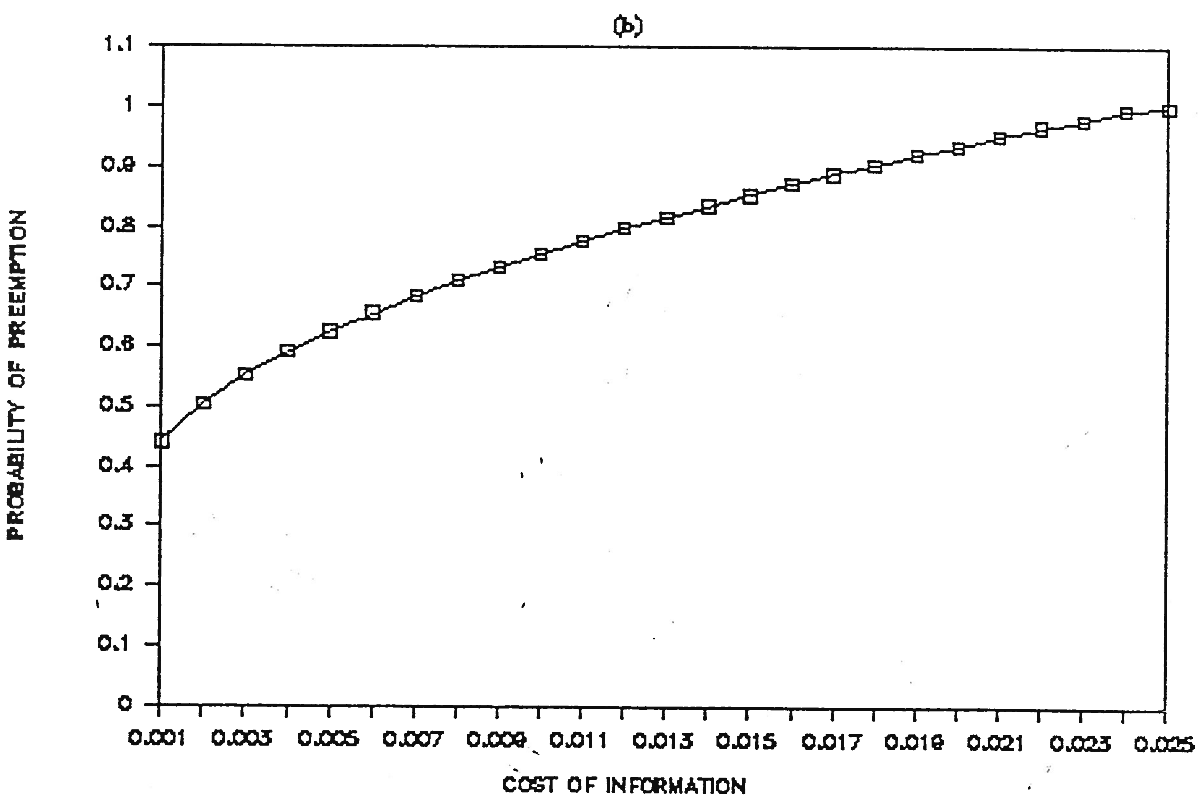

(b)
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
PROBABILITY OF PREEMPTION
0.001 0.003 0.005 0.007 0.009 0.011 0.013 0.015 0.017 0.019 0.021 0.023 0.025
COST OF INFORMATION

Figure 7: f=0.3

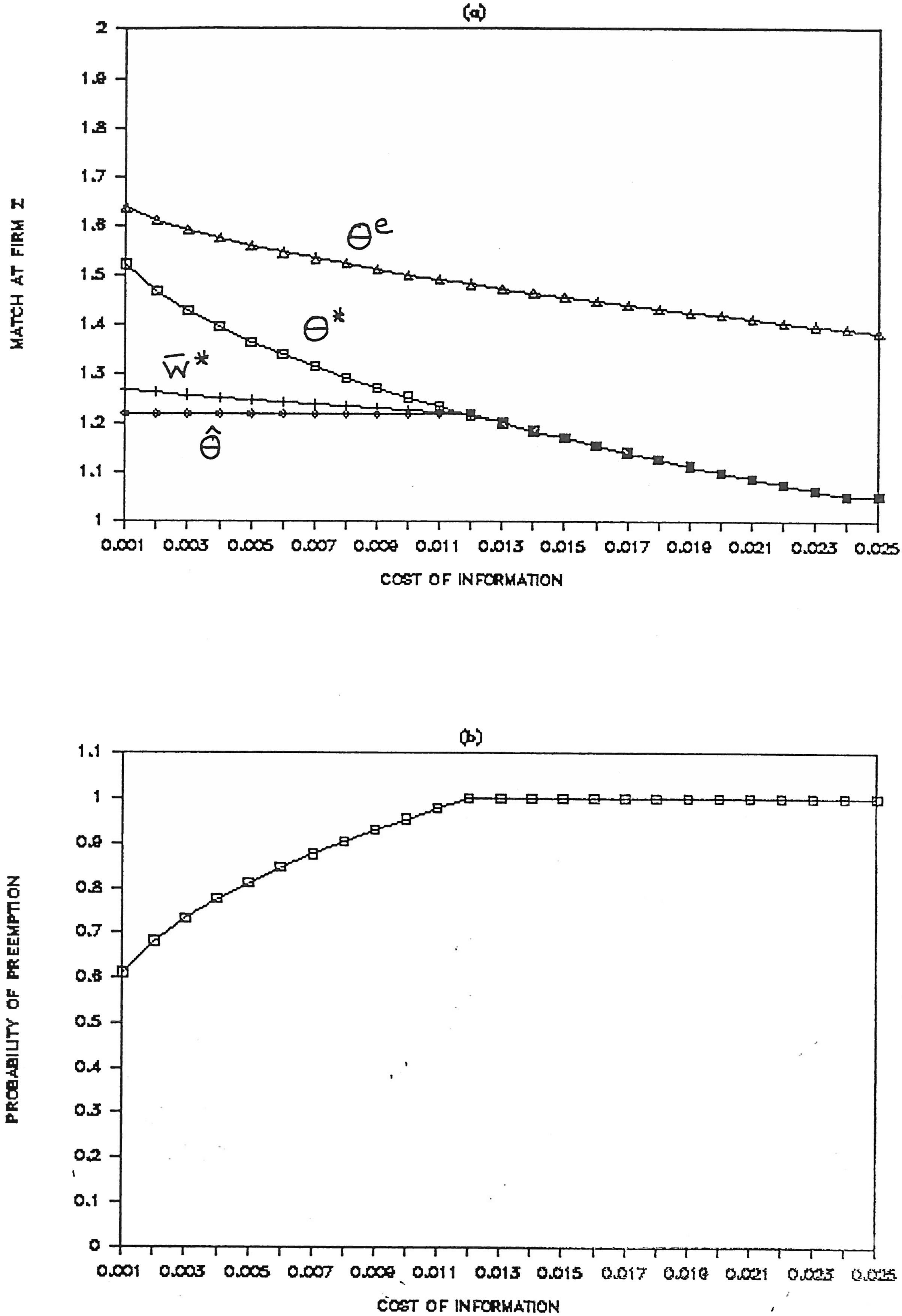

(a)
MATCH AT FIRM Z
COST OF INFORMATION
θ^e
θ*
W̄*
θ̂
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.001
0.003
0.005
0.007
0.009
0.011
0.013
0.015
0.017
0.019
0.021
0.023
0.025
(b)
PROBABILITY OF PREEMPTION
COST OF INFORMATION
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0

Figure 8: Marginal Preempted Worker

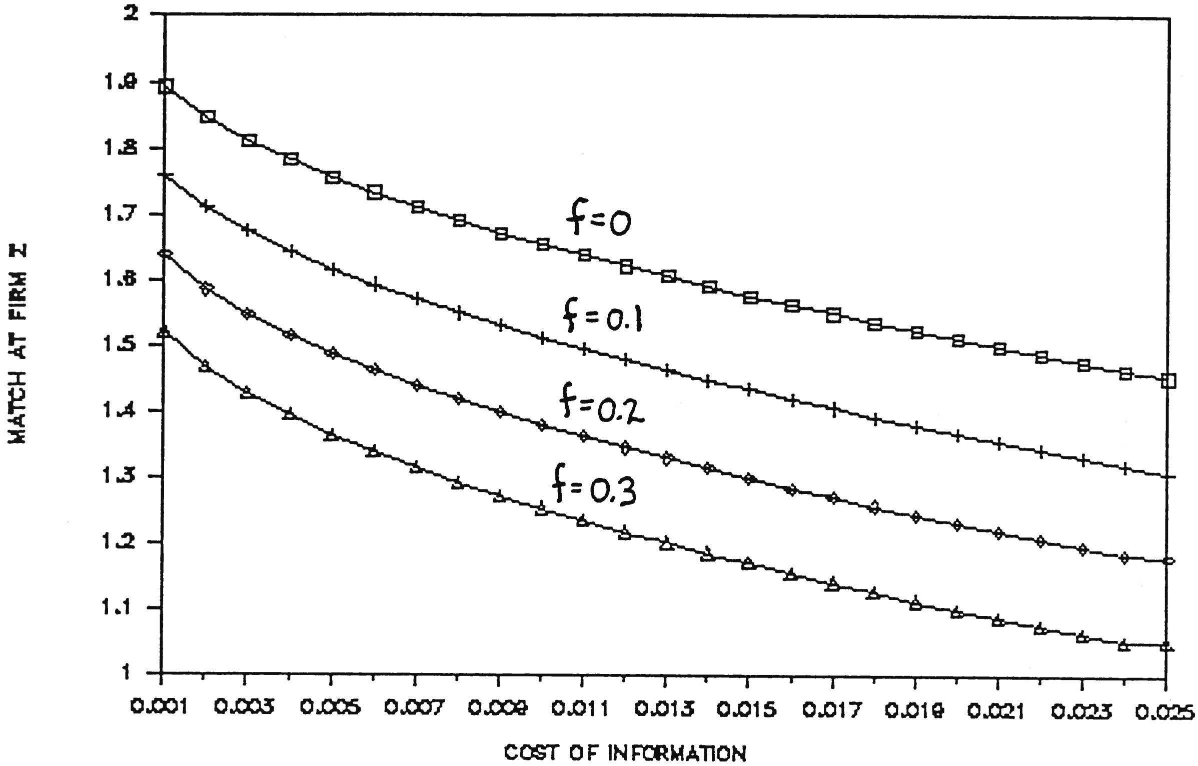


Figure 9: Promotion Inefficiency

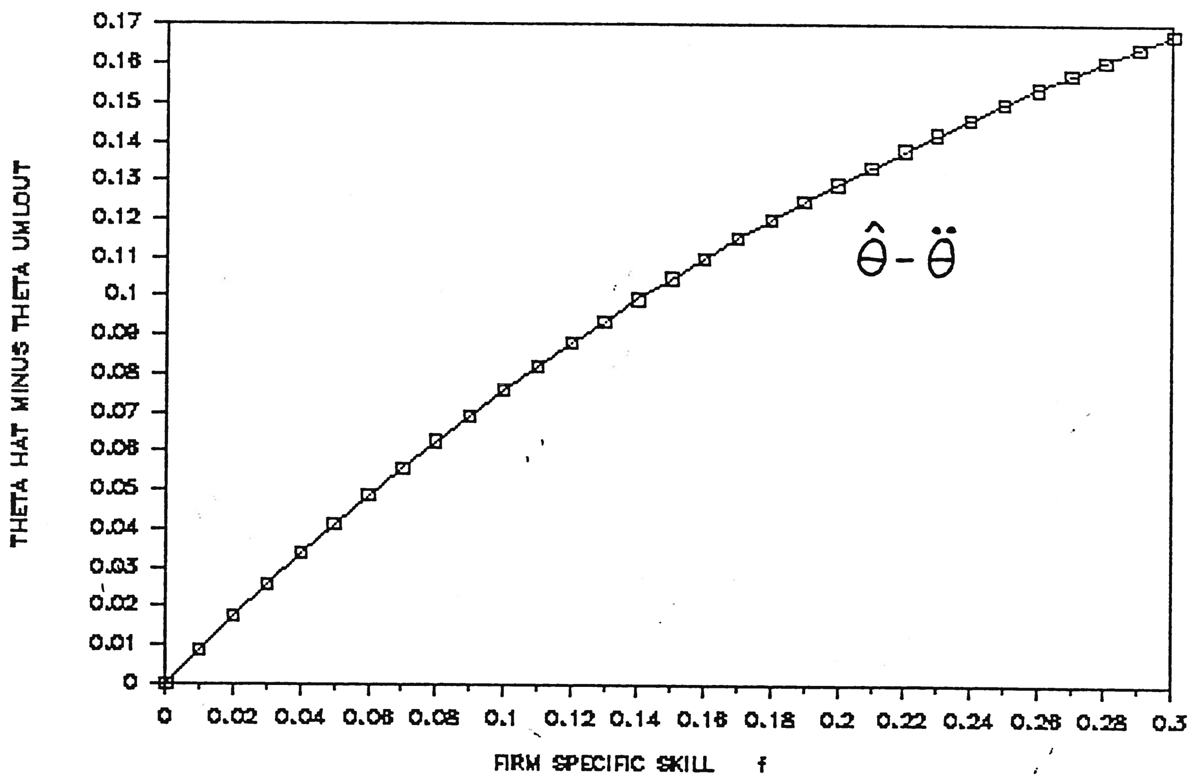
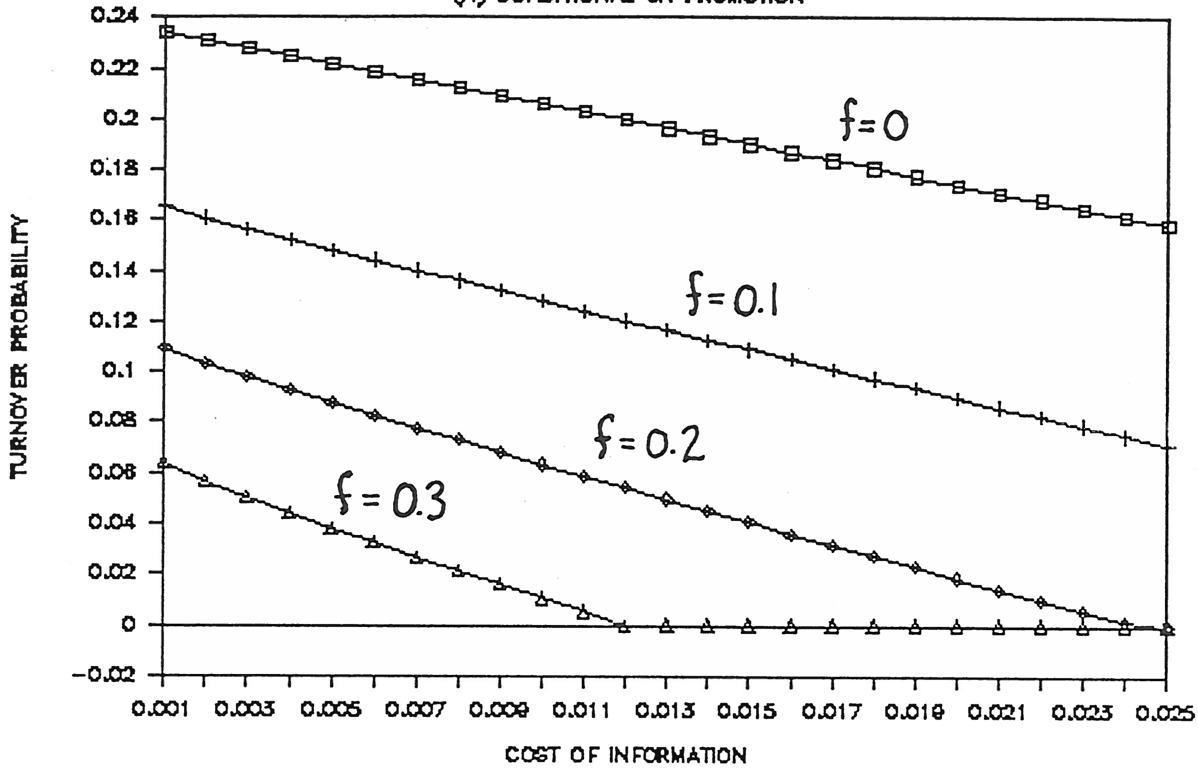


Figure 10: Probability of Turnover

(A) CONDITIONAL ON PROMOTION



Probability of Turnover

(B) NON-PREEMPTIVE PROMOTION