



Employee referrals and efficiency wages

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Abstract

Many workers believe personal contacts are crucial for obtaining jobs in high-wage sectors. On the other hand, firms in high-wage sectors report using employee referrals to screen and monitor new employees. This paper develops a matching model that can explain the link between inter-industry wage differentials and employee referrals. Referrals lower monitoring costs because high-effort referees can exert peer pressure on co-workers, allowing firms to pay lower efficiency wages. On the other hand, informal search provides fewer contacts than formal methods. In equilibrium, referrals match high-paying jobs to well-connected workers, while formal methods match less-attractive jobs to less-connected workers. Industry-level data show a positive correlation between industry wage premiums and employee referrals. Moreover, evidence using the National Longitudinal Survey of Youth (NLSY) shows similar OLS and fixed-effects estimates of the ‘returns’ to employee referrals, but insignificant effects after controlling for sector of employment. This evidence is more consistent with an efficiency wage explanation than either an ability or matching explanation of referrals.

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1. Introduction

In their 1962 study of the Chicago Labor Market, [Rees and Schultz \(1970\)](#) found that employers in high-wage sectors rely extensively on employee networks to fill vacancies. According to the study, high-wage employers prefer hiring through referrals because they provide screening and monitoring of new employees. In contrast, employers in low-wage sectors prefer using formal methods, such as newspaper ads and employment agencies.

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Ethnographic studies of the workplace also document the link between the payment of wage premiums and employee networks. For example, a study of Boston's labor market by [Wial \(1991\)](#) found that workers believe that obtaining a 'good' job requires either "luck or the help of a friend or relative who put[s] in a good word with the boss."¹ In contrast, according to the working class youths studied by Wial, low-wage jobs are easily obtained without the need for personal contacts.

This paper develops an equilibrium matching model that generates a link between inter-industry wage differentials and use of employee referrals, as suggested by these accounts. In the model, workers and employers match through referrals or formal methods. The benefit of using referrals is that they lower monitoring costs, since workers can exert peer pressure on co-workers. The cost of using referrals is that they provide fewer contacts for workers and firms than formal methods. Since the size of referral networks varies across firms and workers, there is heterogeneity in the efficiency of referral search. This means that while firms and workers with large networks prefer to use referrals, others are better off using formal methods. Moreover, since referrals lower monitoring costs, firms relying on referrals find it cheaper to elicit effort by paying efficiency wages than firms using formal hiring methods. In equilibrium, the matching process generates segmentation in the labor market: referrals match 'good' high-paying jobs to well-connected workers, while formal methods match less attractive jobs to less-connected workers.

To test the implications of the model, I match [Krueger and Summers \(1987\)](#) estimates of industry wage premiums with estimates from the NLSY on the percentage of workers hired through employee referrals by industry, controlling for (CPS) average education and experience by industry, and information on industry characteristics (e.g., unionization rates, sales, assets, profits, concentration ratios) from the National Organizations Survey. The data show positive correlations between industry wage premiums and the percentage of workers hired through employee referrals.

Since the correlations based on industry-level data could be capturing the correlation between industry premiums and percentage referred and other omitted factors (e.g., workers' unobserved ability in the sector), I also present evidence using individual-level data from the NLSY. Fixed-effects estimates of the 'returns' to employee referrals are only slightly lower than OLS estimates, suggesting that referred workers are not earning higher wages simply because they have higher unobserved ability. Moreover, fixed-effects estimates are larger for the subsample of industry-switchers, indicating that referrals are particularly useful for those changing sectors. On the other hand, the 'returns' to referrals disappear once sector of employment is controlled for, suggesting that the variation in referral premiums is between, and not within, sectors.

The analysis in this paper links together two important strands of literature in labor economics: research on the inter-industry wage structure and efficiency wages, and

¹ Workers in Wial's study considered 'good' jobs to be jobs that offered high pay and considerable job security. Examples of 'good' jobs provided by these employees included jobs in Public Utilities, Transportation, Repair Services, and Construction, all industries which have been documented to pay wage premiums (see, [Krueger and Summers, 1987, 1988](#)). Finally, workers in the study saw 'good' jobs as being scarce, in the sense that there was always an excess supply of entry-level job applicants for these jobs.

research on the incidence of employee referrals. The latter literature has documented that referred workers earn higher wages and have higher productivity and lower quit rates, without controlling for sector of employment.² This work generally argues that referred workers earn higher wages and have higher productivity because referrals provide information either to employers about the unobserved quality of workers or to workers about the quality of matches.³ The model in this paper suggests instead that referrals lower monitoring costs, allowing referred workers to obtain high-paying jobs and making it less likely for them to quit. There is little empirical evidence, however, examining the link between use of referrals and firm and industry characteristics.⁴ On the other hand, the literature on the inter-industry wage structure shows persistently higher wages and lower quit rates in some sectors and lower wages and higher quit rates in other sectors after controlling for observed human capital characteristics, working conditions, and individual fixed effects.⁵ This paper provides evidence that industry wage premiums are correlated with use of employee referrals. Moreover, the evidence suggests that the reason why referred workers earn higher wages is not because they have higher unobserved ability or better matches but because they are hired in high-wage sectors.

The paper is organized as follows. Section 2 models the matching process and derives the endogenous split between referral and formal matches in the economy. Section 3 presents empirical evidence on the payment of wage premiums to referred workers and contrasts the evidence against alternative explanations of the ‘returns’ to employee referrals. Section 4 concludes.

2. Theoretical setup: matching with referrals and formal search

This section introduces an equilibrium matching model that generates a link between inter-industry wage differentials and use of employee referrals. In the model, workers and

² The higher wages, higher productivity, lower turnover, and higher tenure of referred workers are documented by Corcoran et al. (1980), Datcher (1983), Staiger (1990), Simon and Warner (1992), Korenman and Turner (1994), and Holzer (1997). These studies, however, do not control for sector of employment.

³ See Saloner (1985) and Montgomery (1991) for explanations of referral use based on unobserved worker quality and Staiger (1990) and Simon and Warner (1992) and Mortensen and Vishwanath (1994) for match quality explanations.

⁴ Aside from the study of the Chicago labor market by Rees and Schultz (1970), only a study by Holzer (1997) attempts to relate firm characteristics to use of employee referrals.

⁵ See, for example, Krueger and Summers (1987, 1988) who estimate large and significant industry wage premiums using a variety of control strategies with CPS and QES data. Similarly, Gibbons and Katz (1992) provide further evidence from the DWS using a sample of approximately exogenous industry-switchers (i.e., workers displaced by plant closings). More recently, Abowd et al. (1999) have used matched employer–employee French data to decompose annual compensation per worker into personal and firm heterogeneity. Consistent with the payment of noncompetitive wages, they find that firms that pay higher wages, controlling for person effects, are more productive and more profitable. Similarly Dickens and Katz (1987) find that industry wage premiums are positively correlated with profits, sales, and concentration ratios. Also, consistent with the payment of non-competitive wages, Holzer et al. (1991) find that high-wage jobs attract more applicants and Campbell (1993) finds that high wage jobs have lower quit rates.

firms can search through referrals or formal methods.⁶ The benefit of referrals is that they lower monitoring costs because high-effort referees can exert peer pressure on co-workers. The downside of referrals is that they provide fewer contacts for workers and firms. Heterogeneity in the size of referral networks, however, implies that some firms and workers may rely more on referrals while others may rely more on formal methods.

2.1. Structure

Workers can be either employed or unemployed. The unemployed get unemployment benefits, b , while searching for a job. The arrival rate of offers is $p(\theta)$ when searching formally and $\beta_i p(\theta)$ when searching through referrals, where $p(\theta)$ is the arrival rate of job offers, $\theta = v/u$ is the ratio of vacancy to unemployment rates, and β_i is the arrival rate of encounters with those in individual i 's social network. Workers differ in the size of their social networks. In particular, the arrival rate of encounters with those in the network is distributed uniformly over the unit interval. I assume the matching function is such that $p'(\theta) > 0$. See Pissarides (1990) for a discussion of the properties of the matching function.

Firms can have either filled or vacant jobs. There is free entry and there is a sunk cost, K , of entry, so that the expected value of a vacancy is K in equilibrium. Firms face a cost, C , of maintaining a job either filled or vacant, where C can be thought of as reflecting the cost of capital. The arrival rate of applicants is $q(\theta)$ when using formal methods and $\gamma_j q(\theta)$ when using referrals, where $q(\theta)$ is the arrival rate of acceptances and γ_j is the arrival rate of encounters with the network members of firm j 's employees. The arrival rate of firms' encounters with those in their employees' networks is distributed uniformly over the unit interval. I assume $q'(\theta) < 0$. The exogenous separation rate from all jobs is denoted by λ .

Once jobs are filled, firms pay the wage, w_M , that minimizes labor costs per efficiency unit when hiring through method M , where $M = R, F$. Employment contracts are negotiated in advance and cannot be renegotiated. Firms paying low wages obtain only ϕA units of output from employed shirkers where $1 > \phi \geq 0$, while firms paying high wages elicit worker effort and obtain A units of output per unit of time. Firms that do not find it worthwhile to pay efficiency wages to eliminate shirking bargain with workers to share the economic rents generated from matches.⁷ Rents are shared according to Nash bargaining, where π is the bargaining power of workers. In contrast, firms wanting to elicit effort from workers pay the efficiency wage which satisfies the no-shirking condition.⁸

⁶ The model assumes a binary choice between informal and formal search to capture the fact that most firms and workers concentrate their search by using either personal contacts or formal methods, while few use other search methods. See, for example, Barron and Bishop (1985) for evidence on firms' use of search methods and Holzer (1988) and Harrison Ports (1993) for evidence on workers' use of search methods.

⁷ Frictions in the labor market imply that matches generate economic rents equal to the sum of the cost of search and the cost of hiring.

⁸ Due to the problem of observability of effort, it is assumed that firms pay efficiency wages because they cannot specify an enforceable employment contract, where the wage paid to an individual depends on his actual effort level. As in Malcomson (1981), Shapiro and Stiglitz (1984), and MacLeod and Malcomson (1989), the types of contracts described here are incomplete contracts with discretionary dismissals. See Malcomson (1981) for a detailed discussion of the problem of observation and why this generates incomplete contracts. Also, see Akerlof and Yellen (1984) for a survey of efficiency wage models.

Once employed, workers choose whether to exert effort, e , or to exert no effort. Workers' disutility of work is e^2 . Individual effort levels are observed by firms only with an error, so that there is imperfect monitoring. Shirkers are caught and dismissed with probability κ . In addition, referees can lower firms' monitoring costs through peer effects. The social psychology literature highlights the importance of peer pressure in both increasing and reducing effort in work groups, suggesting that workers prefer conformist behavior at the workplace.⁹ Moreover, since current employees are often thought to "put their reputations on the line" when referring friends, these friends are likely to be specially prone to peer pressure from referees.¹⁰ A simple formulation of this idea models peer pressure as costing $\rho(e_W - e_R)^2$ in terms of worker utility, where e_W is the effort level of a referee and e_R is the effort level of a referred worker.

2.2. Solution

2.2.1. Choice of wages

Firms decide whether to offer high wages that motivate workers to produce a high level of output or to offer low wages. The goal of each firm j is to pay the wage that maximizes the lifetime stream of profits of a job filled through referrals and formal methods, $J_R(j)$ and J_F . The Bellman equations for firm j with a job filled through referrals and formal methods are

$$rJ_R(j) = Q(A) - w_R - C + s(V_R(j) - J_R(j)), \quad (1a)$$

$$rJ_F = Q(A) - w_F - C + s(V_F - J_F), \quad (1b)$$

where $Q(A)$ is revenue which equals A if firms pay efficiency wages and ϕA if firms pay bargained wages, and s is the separation rate which equals λ if firms pay efficiency wages and $\lambda + \kappa$ if firms pay bargained wages. $J_R(j)$ and J_F are the values of vacancies filled through referrals and formal methods by firm j , where the Bellman equations for vacancies are

$$rV_R(j) = -C + \gamma_j q(\theta)(J_R(j) - V_R(j)), \quad (2a)$$

$$rV_F = -C + q(\theta)(J_F - V_F). \quad (2b)$$

To elicit effort, firms must pay a wage high enough for workers to be indifferent between working and shirking. This means the wage has to satisfy a no-shirking condition, such that the expected lifetime utility for an employed worker is at least equal to the

⁹ According to this literature, the workplace is often characterized by informal norms among workers that regulate work effort by setting lower as well as upper limits. See for example, Roethlisberger and Dickson (1939), Dalton (1948), Roy (1952), Jones (1984), Elster (1989), Kandel and Lazear (1992), and Levine (1992) for accounts of this kind of behavior.

¹⁰ While peer effects within work groups may operate even when workers do not refer each other, peer effects are likely to be stronger when workers interact both at work and in a social context.

expected lifetime utility for an employed shirker. Lifetime utilities for those matched through referrals are determined by

$$rE_R(i) = w_R - e^2 + \lambda(U_R(i) - E_R(i)), \quad (3a)$$

$$rS_R(i) = w_R - \rho e^2 + (\lambda + \kappa)(U_R(i) - S_R(i)), \quad (4a)$$

where $U_R(i)$ is the lifetime utility for unemployed worker i searching through referrals,

$$rU_R(i) = b + \beta_i p(\theta)(E_R(i) - U_R(i)). \quad (5a)$$

Similarly, lifetime utilities for employed and unemployed workers matched through formal methods are

$$rE_F = w_F - e^2 + \lambda(U_F - E_F), \quad (3b)$$

$$rS_F = w_F + (\lambda + \kappa)(U_F - S_F), \quad (4b)$$

where U_F is the lifetime utility for an unemployed worker searching formally,

$$rU_F = b + p(\theta)(E_F - U_F), \quad (5b)$$

The no-shirking conditions when matched through referrals and formal methods are $E_R(i) \geq S_R(i)$ and $E_F \geq S_F$, respectively. Substituting Eqs. (3a), (4a), (5a) and Eqs. (3b), (4b), (5b) into the no-shirking condition yields the efficiency wages, $w_R^e(i)$ and w_F^e , paid by firms using referrals and formal methods. Lemma 1 compares these (all proofs are in Appendix A).

Lemma 1. *Efficiency wages paid when hiring formally and when hiring through referrals compare as follows:*

$$(w_F^e - w_R^e(i)) = [(r + \lambda + \beta_i p(\theta))\rho + p(\theta)(1 - \beta_i)]e^2 / \kappa > 0,$$

for all i .

Firms using employee referrals pay lower efficiency wages for two reasons. First, referrals lower monitoring costs, allowing firms to pay lower efficiency wages to motivate workers. High-effort referees are willing to put in a good word for their friends, but since they “put their reputations on the line” they credibly threaten to impose peer pressure on shirking friends. Second, since referral search is less effective in generating contacts, it is harder for workers using referrals to find alternative job opportunities and thus firms can pay lower wages to motivate workers.

Firms may instead choose to pay the market wage and tolerate shirking. Since there are frictions in the labor market, matches generate economic rents that are split between workers and firms according to Nash bargaining. The Nash-bargaining condition for worker i and firm j matched through referrals is

$$(1 - \pi)(E_R(i) - U_R(i)) = \pi(J_R(j) - V_R(j)). \quad (6a)$$

Substituting worker i 's and firm j 's surpluses when using referrals into Eq. (6a) yields the market wage paid to worker i by firm j if hiring through referrals:

$$w_R^*(i,j) = \frac{\{\pi(r + \lambda + \kappa + \beta_i p(\theta))\phi A + (1 - \pi)(r + \lambda + \kappa + \gamma_j q(\theta))b\}}{\{r + \lambda + \kappa + (1 - \pi)\gamma_j q(\theta) + \pi\beta_i p(\theta)\}}.$$

Similarly, the Nash-bargaining condition for workers and firms matched formally is

$$(1 - \pi)(E_F - U_F) = \pi(J_F - V_F). \quad (6b)$$

Substituting the formal surpluses into the Nash-bargaining condition (Eq. (6b)) yields the formal market wage:

$$w_F^* = \frac{\{\pi(r + \lambda + \kappa + p(\theta))\phi A + (1 - \pi)(r + \lambda + \kappa + q(\theta))b\}}{\{r + \lambda + \kappa + (1 - \pi)q(\theta) + \pi p(\theta)\}}.$$

Lemma 2 compares the market wages paid by firms hiring through referrals and formal methods.

Lemma 2. *Market wages are lower when hiring formally than when hiring through referrals:*

$$(w_F^* - w_R^*(i,j)) \leq 0,$$

for all i and j , if $q(\theta) \gg p(\theta)$.

A firm j filling jobs using referrals chooses between paying efficiency wages, $w_R^e(i)$, or market wages, $w_R^*(i,j)$, to worker i depending on which maximize the lifetime stream of profits, $J_R(j)$. Comparing $J_R(j)$ for firm j when paying efficiency and market wages, it follows that firm j hiring through referrals pays efficiency wages if $A \geq w_R^e(i) + \{(r + \lambda + \gamma_j q(\theta))(\phi A - w_R^*(i,j))\} / (r + \lambda + \kappa + \gamma_j q(\theta))$ and market wages if $A < w_R^e(i) + \{(r + \lambda + \gamma_j q(\theta))(\phi A - w_R^*(i,j))\} / (r + \lambda + \kappa + \gamma_j q(\theta))$. Similarly, firms using formal methods choose between paying efficiency wages, w_F^e , and market wages, w_F^* , depending on which maximize their lifetime stream of profits, J_F . Firms hiring formally pay efficiency wages if $A \geq w_F^e + \{(r + \lambda + q(\theta))(\phi A - w_F^*)\} / (r + \lambda + \kappa + q(\theta))$ and market wages if $A < w_F^e + \{(r + \lambda + q(\theta))(\phi A - w_F^*)\} / (r + \lambda + \kappa + q(\theta))$.

Lemmas 1 and 2 imply the difference between efficiency and market wages is greater when using formal methods than when using referrals, i.e., $(w_F^e - w_F^*) > (w_R^e(i) - w_R^*(i,j))$, for all i and j . In addition, since $(r + \lambda + \gamma_j q(\theta)) / (r + \lambda + \kappa + \gamma_j q(\theta))$ increases with γ_j , there are three possible configurations of wage choices in equilibrium:

Case 1. $A \geq w_F^e + \{(r + \lambda + q(\theta))(\phi A - w_F^*)\} / (r + \lambda + \kappa + q(\theta)) > w_R^e(i) + \{(r + \lambda + \gamma_j q(\theta))(\phi A - w_R^*(i,j))\} / (r + \lambda + \kappa + \gamma_j q(\theta))$. Firms hiring through referrals and formal methods pay efficiency wages.

Case 2. $w_F^e + \{(r + \lambda + q(\theta))(\phi A - w_F^*)\} / (r + \lambda + \kappa + q(\theta)) > A \geq w_R^e(i) + \{(r + \lambda + \gamma_j q(\theta))(\phi A - w_R^*(i,j))\} / (r + \lambda + \kappa + \gamma_j q(\theta))$. Firms hiring through referrals pay efficiency wages and firms hiring formally pay market wages.

Case 3. $w_F^e + \{(r + \lambda + q(\theta))(\phi A - w_F^*)\} / (r + \lambda + \kappa + q(\theta)) > w_R^e(i) + \{(r + \lambda + \gamma_j q(\theta))(\phi A - w_R^*(i, j))\} / (r + \lambda + \kappa + \gamma_j q(\theta)) > A$. Firms using referrals and formal methods pay market wages.

For the rest of this section, I focus on Case 2. In Case 1, all workers opt to search formally since efficiency wages are higher when using formal methods than when using referrals, and formal methods are also a more efficient search method. This implies that no firm will ever find it worthwhile to search through referrals. In Case 3, all firms opt to hire formally since market wages are lower when using formal methods than when using referrals and formal methods are also more efficient search methods. This implies that no worker will ever find it worthwhile to search through referrals. This means that the use of both referrals and formal search may only arise in Case 2.

2.2.2. Firms' choices of hiring methods

In Case 2, firms decide between hiring through referrals and paying efficiency wages or hiring formally and paying bargained wages. Since the benefit of using referrals rises with firms' arrival rates of encounters, γ_j , firms connected to larger networks prefer to use referrals while firms with smaller networks prefer to use formal methods. The critical value of the arrival rate of encounters which makes a firm indifferent between the two methods is

$$\bar{\gamma} = \{(r + \lambda + \kappa)(\phi A - w_F^*)\} / \{(r + \lambda + \kappa)(A - E(w_R^e(i) | R)) + q(\theta)((1 - \phi)A - (E(w_R^e(i) | R) - w_F^*))\}, \quad (7)$$

which gives $\bar{\gamma}$ as a function of the labor market tightness parameter, θ , and the average wages paid through formal and referral methods, w_F^* and $E(w_R^e(i) | R)$. Consequently, firms with idiosyncratic arrival rates of encounters $\gamma_j \in [\bar{\gamma}, 1]$ find it optimal to use employee referrals and pay efficiency wages, while firms with arrival rates $\gamma_j \in [0, \bar{\gamma}]$ find it optimal to hire formally and pay the market wage. The critical value that triggers the use of referrals falls as the cost of tolerating shirking increases (i.e., ϕ decreases), workers' productivity increases (i.e., A increases), and the separation rate falls (i.e., λ falls).

2.2.3. Workers' choices of search methods

In practice, workers typically concentrate on a few methods when searching for work. In the model, this dichotomy is captured by assuming workers use either formal methods or social networks.

Unemployed workers observe the wages paid by firms hiring through each method and focus their search accordingly. In particular, worker i chooses the search method that maximizes the value of being unemployed. As for firms, the workers' benefit of using referrals rises with the arrival rates of encounters, β_i . Workers connected to larger networks find it easier to rely on referrals, while workers with smaller networks prefer relying on formal methods. The critical value of the arrival rate of encounters which makes a worker indifferent between the two methods is

$$\bar{\beta} = \{\kappa\pi(\phi A - b)\} / \{(1 - \rho)e^2(r + \lambda + \kappa + (1 - \pi)q(\theta) + \pi p(\theta))\}. \quad (8)$$

Consequently, workers with idiosyncratic arrival rates of encounters with network members $\beta_i \in [\beta, 1]$ find it optimal to rely on employee referrals to find jobs, while workers with arrival rates $\beta_i \in [0, \beta]$ find it optimal to search formally. The critical value that triggers search through referrals falls as the disutility of effort, e , decreases; the cost of peer pressure, ρ , decreases; the probability of being caught shirking, κ , decreases; the separation rate, λ , increases; and unemployment benefits, b , increase.

The split of firms and workers into the two search methods indicates that, in Case 2, the matching process generates segmentation in the labor market, where referrals match ‘good’ high-paying jobs to well-connected workers and formal methods match less attractive jobs to less-connected workers.

2.2.4. Vacancy creation

To close the model, the vacancy and unemployment rates need to be determined. The vacancy rate is pinned down using the free-entry condition. Since firms’ network size is only realized after entry, free entry implies that the expected value of a vacancy must be equal to the sunk cost of creating the vacancy,

$$\bar{\gamma}V_F^* + (1 - \bar{\gamma})V_R^e = K, \quad (9)$$

where $(1 - \bar{\gamma})$ and $\bar{\gamma}$ are the probabilities of using referrals and formal methods; V_F^* is the expected value a formal vacancy which offers market wages, and V_R^e is the expected value of a referral vacancy which offers efficiency wages, and their corresponding Bellman equations are

$$rV_R^e = -C + E[\gamma; q(\theta)(A - w_R^e(i))/(r + \lambda + \gamma; q(\theta)) | R],$$

$$rV_F^* = -C + [q(\theta)(\phi A - w_F^*)/(r + \lambda + \kappa + q(\theta))].$$

The free-entry condition above provides a relationship between $\bar{\gamma}$ and the labor market tightness parameter, θ , and the average wages paid through formal and referral methods, w_F^* and $E(w_R^e(i) | R)$. Eq. (7), which determines the split of firms between the two search methods, provides the other relationship between $\bar{\gamma}$ and θ . Figs. 1 and 2 graph the search behavior and free-entry conditions in $\theta - \bar{\gamma}$ space, and determine the equilibrium values of $\bar{\gamma}$ and θ .

2.2.5. Steady-state unemployment

The unemployment rate is determined by the steady-state condition. In steady state, the flow into unemployment for workers hired through both methods has to be equal to the flow out of unemployment for workers searching through both methods. Thus, the steady-state condition is

$$\lambda(1 - u) + \bar{\gamma}\kappa(1 - u) = \bar{\beta}p(\theta)u + (1 - \bar{\beta})E[\beta_i p(\theta)u | R],$$

where $(1 - u)$ and u are the shares of employed and unemployed workers, and $(1 - \bar{\beta})$ and $\bar{\beta}$ are the shares of workers using referrals and formal methods, respectively. Solving for the unemployment rate yields,

$$u = 2(\lambda + \bar{\gamma}\kappa) / \{2(\lambda + \bar{\gamma}\kappa) + p(\theta)(2\bar{\beta} + (1 - \bar{\beta})(1 - \bar{\beta}^2))\}, \quad (10)$$

which falls with $\bar{\beta}$. That is, greater referral search by workers increases the unemployment rate because referral networks are less efficient in generating contacts. In addition, externalities in search further increase unemployment since workers' reliance on referrals generates congestion in social networks.

2.3. Matching, labor market segmentation, and unemployment benefits

In Case 2, the matching process generates labor market segmentation, with well-connected workers using referrals to jump job queues for good jobs and those with less connections searching formally. This division of firms and workers between referrals and formal search is, however, unlikely to be efficient because of congestion externalities in search. Workers deciding to search through referrals consider their probability of obtaining 'good' jobs without considering the negative effects of their decisions on others. By searching through referrals, workers lower everyone else's probability of getting good jobs and this congestion implies that 'too many' people search through referrals making unemployment inefficiently high.

Policies that reduce the use of referrals move unemployment closer to its optimal level. For example, a reduction in unemployment benefits reduces workers' reliance on referrals,

$$\frac{d\bar{\beta}}{db} = -\kappa\pi/\{(1-\rho)e^2(r+\lambda+\kappa+(1-\pi)q(\theta)+\pi p(\theta))\} + d\bar{\beta}/d\theta \\ \times d\theta/db < 0.$$

This is because unemployment benefits implicitly subsidize search, so a reduction in unemployment benefits induces workers to rely on more effective search methods. In addition, the reduction in unemployment benefits lowers the efficiency wages paid by firms hiring through referrals, making referral jobs less attractive.

This reduction in use of referrals unambiguously lowers unemployment, because workers rely on faster search methods and there is less congestion in search. This is captured by the first term in the comparative statics of the unemployment rate with respect to b ,

$$du/db = du/d\bar{\beta} \times d\bar{\beta}/db + du/d\theta \times d\theta/db,$$

where, as shown above, $du/d\bar{\beta} < 0$ and $d\bar{\beta}/db < 0$. The second term, however, can be either positive or negative depending on whether π is high or low. For low π , a reduction in unemployment benefits reduces unemployment not only because workers rely more on formal methods, thus reducing congestion, but also because formal and referral wages fall and firms generate more vacancies.

3. Evidence on employee referrals and industry wage premiums

The model in the previous section establishes a theoretical link between employee referrals and wage premiums. In particular, the model suggests the reason why referred workers earn higher wages is that they are hired by firms paying wage premiums to avoid shirking. In this section, I explore this idea empirically.

3.1. Evidence from industry data

To investigate the relation between use of employee referrals and inter-industry wage premiums, I merge data on industry wage premiums, percentage of referrals by sector, and industry characteristics from various sources. I use two measures of industry premiums estimated by Krueger et al. (1987) using the 1984 Current Population Survey (CPS), with and without labor quality controls where the controls include education and its square, six age dummies, eight occupation dummies, gender and race dummies, a central city dummy, a union member dummy, an ever married dummy, veteran status, and interactions of marriage, education, and age with gender. I estimate the percentage of workers referred by current employees in two-digit industries from the 1982 National Longitudinal Survey of Youth (NLSY). The advantage of using data from the 1982 NLSY is that it contains precise information on whether workers hired in a particular industry were referred by *current* employees.¹¹ I use the 1984 CPS to estimate the average years of education and potential experience in two-digit industries. Finally, I obtain data on industry characteristics for two-digit industries from the National Organizations Survey (NOS), including the percentage of unionized workers in the industry, industry concentration, and average establishment size, average profits per firm, sales and assets in the industry.¹²

Table 1 shows descriptive statistics for the industry data in the full sample and in the subsamples of industries relying more and less on employee referrals. The percentage of referred workers in two-digit industries goes from 10.9% to 57.8%, with a mean of 38% and a standard deviation of 9.3%. The table shows that industries where the use of employee referrals is above the mean pay higher industry premiums, have workers with higher average experience and lower average education, and have a higher percentage of unionized workers, larger establishments, higher concentration, higher average profits per firm, and higher average sales and assets. Table 2 shows correlations of the percentage of referred workers and various industry characteristics. The correlation between the percentage of referred workers and wage premiums are 0.4 and 0.34 for measures with and without labor quality controls. In addition, the percentage of referred workers is positively correlated with factors generally associated with high-wage industries. In particular, the correlations between percentage of referred workers and average experience and percentage of union are 0.39 and 0.25. The correlations between percentage referred and average industry concentration, average establishment size, average profits per firm,

¹¹ Since 1982, the NLSY asked workers whether their jobs were found through personal references from *current* employees, this provides a measure of referrals which closely captures the peer monitoring story presented in the previous section. A shortcoming of the NLSY is that it only includes persons between the ages of 14 and 27. However, the use of these data is unlikely to introduce significant positive biases, since not only do older workers use personal contacts more extensively than younger workers (Granovetter, 1995; Corcoran et al., 1980) but they are also more likely to be hired in high-wage sectors.

¹² The NOS surveyed a representative sample of work establishments in the US in 1991. The probability sample of all types, sizes, and ages of establishments used to generate the data set was obtained from information provided by respondents to the 1991 General Social Survey (GSS). The 1991 GSS was used to construct the sample because in this year, the GSS asked questions on work organizations, including the names, addresses, and phone numbers of respondents' employers. This national database was then supplemented with aggregate data from various government sources on the characteristics of the industries in which the establishments operate.

Table 1
Descriptive statistics, industry data

Variable	Full sample	Industries above mean of percentage referred in all industries	Industries below mean of percentage referred in all industries
Quality unadjusted industry premiums	0.028 (0.143)	0.066 (0.102)	−0.014 (0.171)
Quality adjusted industry premiums	0.065 (0.266)	0.114 (0.227)	0.01 (0.302)
Average experience	19.443 (2.182)	20.444 (1.676)	18.324 (2.177)
Average education	12.18 (1.138)	11.575 (0.76)	12.856 (1.124)
Percentage of union	18.842 (10.285)	20.889 (10.522)	16.387 (9.772)
Industry concentration	0.478 (0.27)	0.523 (0.24)	0.42 (0.303)
Average establishment size	43.97 (39.59)	54.02 (45.49)	31.05 (26.66)
Average sales	8383.507 (12,217.35)	10,759.39 (14,144)	5159.088 (8424.67)
Average assets	10,378.07 (16,750.75)	12,046.7 (19,529.53)	8113.505 (12,368.88)
Profits per firm	0.5089 (0.8479)	0.5657 (0.8584)	0.4317 (0.8593)
<i>N</i>	36	19	17

The table shows means for variables at the industry two-digit SIC level. Standard deviations are in parenthesis. The first column shows the means for the full sample, while the second column shows the means for the industries where the percentage of referred workers was above 38% and the third column shows the means for industries where the percentage of referred workers was below 38%. The percentage referred are calculated as the percentage of workers in the NLSY in 1982 who found jobs through friends working with the employer at the time the job was found. The industry wage premiums are the returns to industry affiliation estimated by [Krueger and Summers \(1987\)](#) with cross-sectional data from the 1984 CPS at the two-digit SIC level, with and without the following controls: education, age, sex, race, union, status, a central city dummy, marital status, and several interaction of marital status with sex and age. Average experience and average education for each two-digit industry were estimated using the 1984 CPS. The rest of the industry characteristics (i.e., percentage of union, industry concentration, average establishment size, average sales, average assets, and average profits per firm) come from the National Organizations Survey.

sales and assets are 0.18, 0.28, 0.1, 0.2, and 0.07, respectively. On the other hand, percentage referred is negatively correlated with average education in the industry.

The correlation between percentage referred and industry premiums in [Table 2](#) may be reflecting the higher experience or unionization rates of referred workers rather than any direct relation between referrals and industry premiums.¹³ [Table 3](#) reports the

¹³ Previous work offers mixed evidence on the association between unionization rates and use of referrals. For example, [Holzer \(1997\)](#) uses Employment Opportunity Pilot Project (EOPP) data and finds no association between proportion of workers covered by collective bargaining and firms' hiring methods. [Koch and Hundley \(1997\)](#) use data from a survey of human resources practices conducted at Columbia University and find that unionized firms are less likely to use employee referrals, newspapers ads, walk-ins and private employment agencies, but just as likely to use government employment agencies as nonunionized firms.

Table 2
Correlation matrix of industry characteristics (two-digit industries)

	Percentage of referral	Industry premiums	Quality adjusted premiums	Average experience	Average education	Percentage of union	Establishment size	Industry concentration	Average sales	Average assets	Profits per firm
Percentage of referral	1.000 (36)	0.395 (36)	0.342 (36)	0.388 (36)	−0.37 (36)	0.245 (33)	0.275 (32)	0.178 (34)	0.199 (33)	0.07 (33)	0.099 (33)
Industry premiums		1.0000 (36)	0.936 (36)	0.343 (36)	0.219 (36)	0.426 (33)	0.337 (32)	0.744 (34)	0.498 (33)	0.562 (33)	0.555 (33)
Quality adjusted premiums			1.000 (36)	0.264 (36)	0.409 (36)	0.47 (33)	0.255 (32)	0.68 (33)	0.467 (33)	0.557 (33)	0.527 (33)
Average experience				1.000 (36)	−0.37 (36)	0.487 (33)	0.514 (32)	0.315 (34)	0.436 (33)	0.308 (33)	0.359 (33)
Average education					1.000 (36)	−0.079 (33)	−0.189 (32)	0.102 (34)	−0.06 (33)	0.097 (33)	0.057 (33)
Percentage of union						1.000 (33)	0.396 (32)	0.397 (33)	0.584 (32)	0.554 (32)	0.497 (32)
Establishment size							1.000 (32)	0.521 (32)	0.835 (32)	0.676 (32)	0.737 (32)
Industry concentration								1.000 (34)	0.655 (33)	0.726 (33)	0.687 (33)
Average sales									1.000 (33)	0.917 (33)	0.953 (33)
Average assets										1.000 (33)	0.924 (33)
Profits per firm											1.000 (33)

The table presents pairwise correlations of the variables described in Table 1. The number of observations for each pairwise correlation is in parenthesis.

Table 3
Regressions of industry wage premiums

Regressor	Unadjusted industry wage premiums			Quality adjusted industry wage premiums		
	(1)	(2)	(3)	(4)	(5)	(6)
Percentage of referred	0.007 (0.002)	0.006 (0.003)	0.005 (0.003)	0.014 (0.004)	0.012 (0.004)	0.01 (0.004)
Average experience	0.237 (0.01)	0.016 (0.012)	0.008 (0.01)	0.042 (0.016)	0.023 (0.018)	0.014 (0.015)
Average education	0.065 (0.19)	0.063 (0.02)	0.033 (0.021)	0.166 (0.031)	0.165 (0.03)	0.124 (0.032)
Percentage of union	–	0.004 (0.002)	0.003 (0.002)	–	0.009 (0.003)	0.008 (0.003)
Other industry characteristics	NO	NO	YES	NO	NO	YES
R^2	0.359	0.392	0.563	0.5	0.615	0.691
N	36	33	32	36	33	32

The table presents coefficients of regressions of unadjusted industry premiums in columns (1)–(3) and of quality adjusted premiums in columns (4)–(6). Standard errors are in parenthesis. The other industry controls included in columns (3) and (6) are: the industry concentration, and the average establishment size, average profits per firm, sales and assets in the sector.

correlation between percentage referred and industry premiums after controlling for other industry characteristics. The results show positive correlations between both the labor quality adjusted and unadjusted measures of industry premiums and percentage referred, after controlling for average experience, average education, percentage unionized, industry concentration, and average establishment size, average profits per firm, sales and assets in the industry. The correlation using the labor quality adjusted measure controlling for all industry characteristics indicates that industries where 10% more of the workforce was hired through referrals pay premiums which are 0.1 higher or, equivalently, the difference in the wage premium paid in the insurance and the machinery production sectors.

3.2. Evidence from micro-data

The industry level data provides some evidence suggesting referred workers earn higher wages because they are hired into high-wage sectors. However, it may be that referred workers earn higher wages because they have higher unobserved ability. I use individual-level data from the NLSY to control for individual fixed effects in wage regressions with an indicator of whether the person was referred by a current employee.

Table 4 shows descriptive statistics of the 1982 NLSY sample used for the analysis. The sample is restricted to workers who are not self-employed, in school, or in the military at the time of the 1982 interview. The first column shows descriptive statistics for this sample. The characteristics of this sample reflect the focus on young workers. Average hourly wages in the sample are \$6.16, average experience and tenure are 4 and 1.6 years, average schooling is 11.6 years, and only 27% of those in the sample are married, only 3% found their current job through a union, but more than half are employed in the retail and service sectors.

Table 4
Descriptive statistics, NLSY 1982

Variable	Full sample	Referred	Not referred
Hourly wage	6.158 (0.5)	6.17 (0.472)	6.13 (0.556)
Male (%)	55.38	57.49	50.75
White (%)	72.95	72.63	73.67
Black (%)	21.59	22.02	20.63
Other race (%)	5.46	5.35	5.7
Married (%)	27.14	27.62	26.1
Education	11.571 (1.794)	11.453 (1.843)	11.832 (1.653)
Experience (years)	4.017 (2.094)	4.09 (2.141)	3.853 (1.978)
Tenure (weeks)	76.577 (67.104)	79.967 (68.231)	69.223 (64.023)
Living in SMSA (%)	74.35	73.56	76.08
Union found job (%)	3.02	2.97	3.14
Mining (%)	1.57	1.83	1.01
Construction (%)	8.76	8.97	8.29
Manufacturing (%)	24.47	27.6	17.59
Transportation (%)	5.46	5.14	6.16
Retail (%)	25.06	25.83	23.37
Finance, insurance, and real state (%)	5.42	4.4	7.66
Business services (%)	6.44	6.69	5.9
Personal services (%)	5.03	3.65	8.04
Entertainment (%)	1.22	1.26	1.13
Professional services (%)	12.33	11.31	14.57
Public sector (%)	4.24	3.31	6.28
Industry-switchers from 1981 to 1982	35.08	34.97	35.33
<i>N</i>	2142	1410	732

The table reports means and percentages in 1982. Standard deviations are reported in parenthesis where appropriate. The first column provides descriptive statistics on the full sample, while the second column provides statistics on the sample of referred workers and the third column on the sample of workers who found their jobs through other methods. Referred workers are defined as workers who found their job through a personal contact working with the employer at the time the person found the job.

Columns (2) and (3) of Table 4 contrast the characteristics of individuals who did and did not find their 1982 job through a referral. Referred workers are defined as workers who found their job through a personal contact working with the employer at the time the person found the job. Referred workers earn higher wages, are more likely to be male, less likely to live in an SMSA and are less educated, but have more experience and tenure than nonreferred workers.¹⁴ More importantly, referred workers are more likely to be employed in sectors considered as high-wage sectors such as mining, construction, and manufacturing and less likely to be employed in low-wage sectors such as personal and public sector

¹⁴ The difference in hourly wages between referred workers and workers who were not referred is statistically significant at the 5% level.

Table 5
Effects of referrals on hourly wage levels, NLSY

Regressor	(1)	(2)	(3)	(4)
Referred	0.04 (0.023)	0.081 (0.035)	0.083 (0.034)	0.054 (0.03)
Referred×tenure	–	–0.001 (0.0)	–0.001 (0.0)	–0.001 (0.0)
Other controls	NO	NO	YES	YES
Industry dummies	NO	NO	NO	YES
R^2	0.001	0.177	0.226	0.298
N	2465	2255	2142	2142

The table reports coefficients of wage regressions estimated in levels. Robust standard errors are in parenthesis. The first column does not include any controls. The second column adds an interaction of the referred dummy with tenure as well as education, experience, experience squared, tenure, and tenure squared. The third column adds male and marital status dummies, race dummies, a dummy for whether the person lived in an SMSA, a dummy for whether the person found the job through a union, and interactions of marital status with the male dummy and tenure. The last column controls for industry affiliation.

services. In contrast, referred workers are less likely to have found their job through a union contact and probably less likely to be affiliated to a union.¹⁵

Table 5 presents results from regressions of log hourly wages on a referral dummy. The first column reports the results without any covariates and shows that referred workers earn wages which are 4% higher than those who are not referred. However, aside from affecting wage levels, referrals may also affect the returns to tenure. This is because firms can elicit effort by both paying wage premiums and by tilting the tenure-earnings profile so that the firm makes it costly for workers to shirk early on in their careers.¹⁶ If referrals impose peer pressure, we can expect referrals to reduce the need to tilt the tenure-earnings profile and to reduce the returns to tenure. To check for this possibility, column (2) includes an interaction of the referral dummy with tenure as well as tenure, tenure squared, experience, experience squared, and education to control for human capital. Including the interaction term and the human capital controls increases the “return” to being referred to 8.1%. Moreover, the results indicate that referred workers have flatter tenure-earnings profiles than nonreferred workers. Column (3) includes other controls including: male and marital status dummies, race dummies, a dummy for whether the person lived in an SMSA, a dummy for whether the person found the job through a union, and interaction of the marital status dummy with the male dummy and tenure. The results show that referred workers earn hourly wages that are 8.3% higher than those of nonreferred workers, after controlling for whether the job was found through a union contact to be sure that the referral premium is not simply capturing union rents. However, the results in column (4) show that the significance of the “return” to being referred drops substantially once sector

¹⁵ While the NSLY does not have information about union affiliation in 1982, it does ask workers whether they found their current job through a union contact. Since having found a job through a union contact is likely to be related to union affiliation, this variable is used as a proxy for union membership.

¹⁶ Lazear and Moore (1984) argue that the steepness of the tenure-earnings profiles reflects the desire to provide work incentives for wage and salary workers. They also provide empirical support of this proposition by comparing the tenure-earnings profiles of wage and salary workers to those of self-employed workers who should not be subject to agency problems.

Table 6
Effects of referrals on hourly wage changes for industry-switchers and industry-stayers, NLSY

Regressor	Full sample				Industry-switchers			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Referred	0.049 (0.022)	0.084 (0.041)	0.079 (0.043)	0.043 (0.039)	0.095 (0.046)	0.164 (0.071)	0.166 (0.074)	0.093 (0.068)
Referred×tenure	–	–0.001 (0.0)	–0.001 (0.0)	0.0 (0.0)	–	–0.001 (0.001)	–0.001 (0.001)	0.0 (0.001)
Other controls	NO	NO	YES	YES	NO	NO	YES	YES
Industry dummies	NO	NO	NO	YES	NO	NO	NO	YES
R ²	0.003	0.006	0.012	0.08	0.007	0.011	0.025	0.123
N	1769	1629	1562	1559	615	566	544	544

The table reports coefficients of wage regressions estimated in first differences. Robust standard errors are in parenthesis. Columns (1) and (5) report results without any controls. Columns (2) and (6) report results adding an interaction of the referred dummy with tenure as well as differences in education and tenure. Columns (3) and (7) add male, marital status, and race dummies, an interaction of marital status dummy with the male dummy, a dummy for whether person found job through a union, and differences in whether the person lived in an SMSA from 1981 to 1982. Columns (4) and (8) control for industry affiliation.

dummies are included, suggesting that the variation in referral premiums is between, and not within, sectors.

As already indicated, it is possible that referred workers are both employed in high-wage sectors and have higher unobserved ability (although, as noted above they have lower schooling). Table 6 presents fixed-effects regressions which control for time-invariant individual effects. Column (1) in Table 6 reports the results without any controls and shows a “return” to being referred of 5%. Column (2) shows a higher “return” of 8.4% once the interaction between the referred dummy and tenure is included, as well as tenure, experience, and differences in education. Column (3) adds other controls including: male, race, and marital status dummies, a dummy for whether the current job was found through a union contact, and interactions of marital status with a male dummy and tenure, and differences in whether the person lived in an SMSA between 1981 and 1982. After including all the controls, the results show a slightly smaller referral premium of 7.9% in the fixed-effects regression compared to the levels regression, suggesting that unobserved ability can account at most for a small part of the referral premium.¹⁷ Also, as for the levels regressions, the results from the fixed-effects regressions show flatter tenure-earnings profiles for referred than for nonreferred workers. However, the referral premium and differential tilt in the tenure-earnings profile as a result of being referred become insignificant after controlling for industry dummies, suggesting that the higher wages of referred workers and their flatter tenure-earnings profile are associated with sector of employment.

Columns (5)–(8) in Table 6 limit the analysis to industry-switchers, since if referrals are mainly capturing the premiums associated with certain industries, then the referral

¹⁷ This estimate is necessarily less precise (i.e., *p*-value of 0.065) because of the smaller sample when estimating the regression in differences.

premium should be higher for industry-switchers than for industry-stayers. The specification without any controls in column (5) shows indeed a higher referral premium of 9.5% for industry-switchers. Column (6) shows an even higher referral premium of 16.4%, after including tenure, experience, differences in schooling, and the interaction term between the referral dummy and tenure. The “return” to referrals is slightly higher after including the rest of the covariates. In addition, all specifications show flatter tenure-earnings profiles for referred workers. As before, however, the referral premium and the flatter tenure-earnings profile of referred workers disappear once the current sector of employment is controlled for, suggesting that what matters is what sectors referred workers switched into.

3.3. Other possible explanations of the referral premium

The evidence presented above suggests that referred workers earn higher wages because they are hired into high-wage sectors. This evidence is consistent with the view that workers use referrals to jump to the front of the queue for high-paying jobs. Moreover, an explanation of referrals as simply a way of getting good jobs is also consistent with the lower quit rates of both referred workers and of workers employed in high-wage sectors found in the data.

Two alternative explanations have been offered, however, for the referral premium based on the view that referrals provide additional information to firms or workers. Referrals may provide information to firms about the unobserved ability of heterogeneous workers, allowing firms to hire the most productive workers (e.g., [Saloner, 1985](#); [Montgomery, 1991](#)). Alternatively, referrals may provide prospective job applicants with information about match quality, allowing them to self-select into those jobs in which they are most productive (e.g., [Staiger, 1990](#); [Simon and Warner, 1992](#)). While both of these explanations of referrals can explain why referred workers earn higher wages, they cannot explain why the referral premium should be associated with sector of employment (or why industry-level use of referrals should be associated with industry premiums). Moreover, evidence from the NLSY shows that the referral premium does not go away once controlling for individual fixed effects, suggesting that the referral premium cannot be explained by a standard worker heterogeneity story (i.e., time-invariant individual effects). A less standard worker heterogeneity story with two sectors (one with an ability-sensitive and one with a less ability-sensitive technology) like the one offered by [Montgomery \(1991\)](#), however, would be able to explain the relation between referrals and wages across sectors. On the other hand, while match-quality explanations can explain why referred workers have lower quit rates, heterogeneous ability explanations cannot explain this empirical regularity.

Another possible explanation for the correlation between industry wage premiums and use of referrals is nepotism or favoritism. For example, in a model like [Goldberg's \(1982\)](#), less competitive industries may be able to afford maximizing utility rather than profits and to both pay wage premiums and use referrals or nepotistic practices. However, a model such as Goldberg's would also predict lower profits in these sectors. In contrast, I find a positive correlation between average profits per firm and industry-level use of referrals, suggesting against a nepotism story of referrals.

4. Conclusion

This paper develops an equilibrium matching model in which high-wage firms rely on referrals to fill jobs. Referrals lower monitoring costs since high-effort referees can exert peer pressure on coworkers, allowing firms to pay lower efficiency wages. The cost of using referrals is that they provide fewer contacts for workers and firms. Heterogeneity in the size of referral networks implies that while some firms and workers may prefer to use referrals, others are better off using formal methods. In equilibrium, the matching process generates segmentation in the labor market: referrals match ‘good’ high-paying jobs to well-connected workers, while formal methods match less attractive jobs to less-connected workers. Congestion externalities, however, may imply an inefficient split of firms and workers between the two search methods. This means that while well-connected workers may do well by using referrals to jump queues for good jobs, the unemployment rate would be lower if workers “at the margin” were induced to search formally.

The model suggests referred workers earn higher wages and have lower quit rates because referrals are a way of getting a good job. This paper provides new empirical evidence showing that industry-level use of referrals to fill job vacancies is correlated with industry wage premiums (adjusting for worker skills). Moreover, evidence from the NLSY shows similar OLS and fixed-effects estimates of the referral premium, suggesting that unobserved ability is not accounting for the higher wages earned by referred workers. Finally, the results show that the referral premium disappears when sector dummies are included, suggesting that the variation in referral premiums is between, and not within, sectors. This is more consistent with an efficiency wage story of referrals than either an ability or matching story.

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Appendix A

Proof of Lemma 1. The no-shirking condition (NSC) for a referred worker i is

$$E_R(i) = S_R(i),$$

$$(w_R^e(i) - \rho e^2) + \lambda(U_R(i) - E_R(i)) = (w_R^e(i) - e^2) + (\lambda + \kappa)(U_R(i) - E_R(i)),$$

$$(E_R(i) - U_R(i)) = (1 - \rho)e^2/\kappa.$$

Adding and subtracting $rU_R(i)$ in Eq. (3a), and then substituting $rU_R(i)$ from Eq. (5a) and $(E_R(i) - U_R(i))$ from above, I obtain $w_R^e(i)$:

$$w_R^e(i) = e^2 + \lambda(E_R(i) - U_R(i)) + rE_R(i),$$

$$w_R^e(i) = e^2 + (r + \lambda)(E_R(i) - U_R(i)) + b + \beta_i p(\theta)(E_R(i) - U_R(i)),$$

$$w_R^e(i) = e^2 + b + (r + \lambda + \beta_i p(\theta))(1 - \rho)e^2/\kappa.$$

Using the NSC for formal hires and solving as described above yields the rents earned by workers hired formally, $(E_F - U_F) = e^2/\kappa$. The lowest wage satisfying the NSC for formal hires is

$$w_F^e = e^2 + b + (r + \lambda + p(\theta))e^2/\kappa.$$

Comparing the formal and referral efficiency wages:

$$(w_F^e - w_R^e(i)) = [(r + \lambda + \beta_i p(\theta))\rho + p(\theta)(1 - \beta_1)]e^2/\kappa > 0,$$

for all i . □

Proof of Lemma 2. Subtracting Eq. (2a) from Eq. (1a) and rearranging yields the surplus for firms hiring through referrals and paying market wages,

$$(J_R(j) - V_R(j)) = (\phi A - w_R)/(r + \lambda + \kappa + \gamma_j q(\theta)).$$

Similarly, subtracting Eq. (5a) from Eq. (3a) and rearranging yields the surplus for workers hired through referrals and getting market wages,

$$(E_R(i) - U_R(i)) = (w_R - b)/(r + \lambda + \kappa + \beta_i p(\theta)).$$

The market wage paid by firms hiring through referrals is obtained by replacing the firms' and workers' surpluses into Eq. (6a):

$$(1 - \pi)[(w_R^*(i, j) - b)/(r + \lambda + \kappa + \beta_i p(\theta))] \\ = \pi[(\phi A - w_R^*(i, j))/(r + \lambda + \kappa + \gamma_j q(\theta))].$$

Solving for the referral market wage yields,

$$w_R^*(i,j) = \frac{\{\pi[r + \lambda + \kappa + \beta_i p(\theta)]\phi A + (1 - \pi)[r + \lambda + \kappa + \gamma_j q(\theta)]b\}}{\{r + \lambda + (1 - \pi)\gamma_j q(\theta) + \pi\beta_i p(\theta)\}}.$$

Similarly, subtracting Eq. (2b) from Eq. (1b) and rearranging yields the surplus for firms hiring formally and paying market wages,

$$(J_F - V_F) = (\phi A - w_F)/(r + \lambda + \kappa + q(\theta)).$$

Subtracting Eq. (5b) from Eq. (3b) and rearranging yields the surplus for workers hired formally and getting market wages,

$$(E_F - U_F) = (w_F - b)/(r + \lambda + \kappa + p(\theta)).$$

The market wage paid by firms hiring formally is obtained by replacing the firms' and workers' surpluses into Eq. (6b):

$$(1 - \pi)[(w_F^* - b)/(r + \lambda + \kappa + p(\theta))] = \pi[(\phi A - w_F^*)/(r + \lambda + \kappa + q(\theta))].$$

Solving for the formal market wage yields,

$$w_F^* = \frac{\{\pi(r + \lambda + \kappa + p(\theta))\phi A + (1 - \pi)(r + \lambda + \kappa + q(\theta))b\}}{\{r + \lambda + \kappa + (1 - \pi)q(\theta) + \pi p(\theta)\}}.$$

Comparing the formal and referral market wages yields,

$$(w_F^* - w_R^*(i,j)) = \pi(1 - \pi)(\phi A - b)\{(r + \lambda + \kappa)((1 - \beta_i)p(\theta) - (1 - \gamma_j)q(\theta)) + p(\theta)q(\theta)(\gamma_j - \beta_j)\}.$$

So, sufficient conditions for $(w_F^* - w_R^*(i,j)) \leq 0$ for all i and j are:

- (i) $(\phi A - b) > 0$, and
- (ii) $\{(r + \lambda + \kappa)((1 - \beta_i)p(\theta) - (1 - \gamma_j)q(\theta)) + p(\theta)q(\theta)(\gamma_j - \beta_j)\} \leq 0$.

Condition (i) is always satisfied and condition (ii) is satisfied if $(\gamma_j - \beta_i) < 0$ and/or if $q(\theta)$ is sufficiently greater than $p(\theta)$. \square

Critical values that trigger referral search

In Case 2, firm j chooses the search method that maximizes its value of a vacancy by comparing $V_R^e(j)$ and V_F^* , where these are given by the following Bellman equations,

$$rV_R^e(j) = -C + \gamma_j q(\theta)[(A - E(w_R^e(i)|R))/(r + \lambda + \gamma_j q(\theta))],$$

$$rV_F^* = -C + q(\theta)[(\phi A - w_F^*)/(r + \lambda + \kappa + q(\theta))].$$

The critical value that triggers use of referrals, $\bar{\gamma}$, is obtained by equating $V_R^e(j)$ and V_F^* and is given by Eq. (7).

Similarly, worker i chooses the search method that maximizes the value of being unemployed by comparing $U_R^e(i)$ and U_F^* , which are given by

$$rU_R^e(i) = b + \beta_p p(\theta)[(w_R^e(i) - b)/(r + \lambda + \beta_p p(\theta))],$$

$$rU_F^* = b + p(\theta)[(w_F^* - b)/(r + \lambda + \kappa + p(\theta))].$$

The critical value that triggers use of referrals, $\bar{\beta}$, is obtained by equating $U_R^e(i)$ and U_F^* and is given by Eq. (8).

Slope of the free-entry (FE) curve

Totally differentiating the free-entry condition Eq. (9) with respect to θ , yields the slope of the free-entry curve,

$$\begin{aligned} d\bar{\gamma}/d\theta = & \{ -(1 - \bar{\gamma})q(\theta)(A - E(w_R^e(i)|R))E[\gamma_j/(r + \lambda + \gamma_j q(\theta))|R] \\ & + (1 - \bar{\gamma})q(\theta)E[\gamma_j/(r + \lambda + \gamma_j q(\theta))|R] \times dE(w_R^e(i)|R)/d\theta \\ & - [\bar{\gamma}q'(\theta)(1 - q(\theta))(\phi A - w_F^*)/(r + \lambda + \kappa + q(\theta))] \\ & + [\bar{\gamma}q(\theta)/(r + \lambda + \kappa + q(\theta))] \times dw_F^*/d\theta \} \\ & / \{ -q(\theta)[(A - E(w_R^e(i)|R))E[\gamma_j/(r + \lambda + \gamma_j q(\theta))|R] \\ & - [(\phi A - w_F^*)/(r + \lambda + \kappa + q(\theta))] - \bar{\gamma}/(r + \lambda + \kappa + q(\theta)) \} < 0, \end{aligned}$$

where the numerator is positive since $q'(\theta) < 0$ and $dE(w_R^e(i)|R)/d\theta > 0$ and $dw_F^*/d\theta > 0$, and the denominator is negative since profits out of a referral hire are higher than out of a formal hire. Thus, the free-entry condition is unambiguously downwardly sloping.

Slope of the search behavior curve

Totally differentiating Eq. (7) with respect to θ yields the slope of the search behavior curve. Since the denominator of the derivative is the square of the original denominator, then the sign of the slope is the same as the sign of the numerator of the derivative,

$$\begin{aligned} d\bar{\gamma}/d\theta \propto & - (r + \lambda + \kappa + q(\theta))(A - E(w_R^e(i)|R)) \times dw_F^*/d\theta \\ & + (r + \lambda + \kappa + q(\theta))(\phi A - w_F^*) \times dE(w_R^e(i)|R)/d\theta \\ & - q'(\theta)(A - (E(w_R^e(i)|R) - w_F^*))(\phi A - w_F^*) - q(\theta)\phi A \times dw_F^*/d\theta, \end{aligned}$$

where $q'(\theta) < 0$ and $dE(w_R^e(i)|R)/d\theta$ and $dw_F^*/d\theta > 0$, so the first and the last terms are negative and the second and third terms are positive. However, as π decreases,

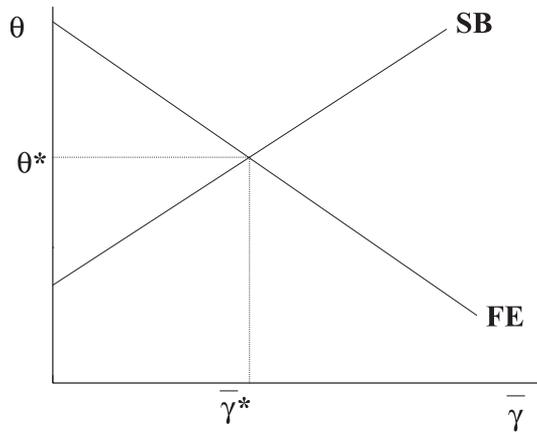


Fig. 1. Equilibrium with low π .

$dE(w_R^e(i)|R)/d\theta$ increases so that the second term becomes larger and it is more likely for $d\bar{\gamma}/d\theta$ to be positive. On the contrary, as π increases, $dE(w_R^e(i)|R)/d\theta$ decreases so that the second term is smaller and it is more likely for $d\bar{\gamma}/d\theta$ to be negative. There are two effects at work here. An increase in labor market tightness, θ , reduces the arrival rate of applicants, $q(\theta)$, and makes firms want to rely more on formal methods. On the other hand, a higher θ increases w_F^* and make firms want to rely more on referrals. If π is low, the first effect dominates and the search behavior curve slopes upward as in Fig. 1. If π is high, the second effect dominates and the search behavior curve slopes downward as in Fig. 2.

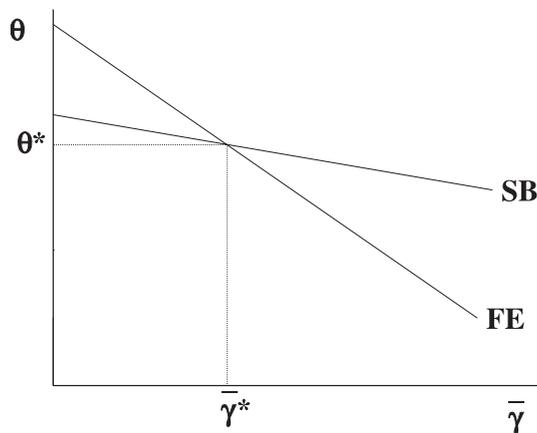


Fig. 2. Equilibrium with high π .

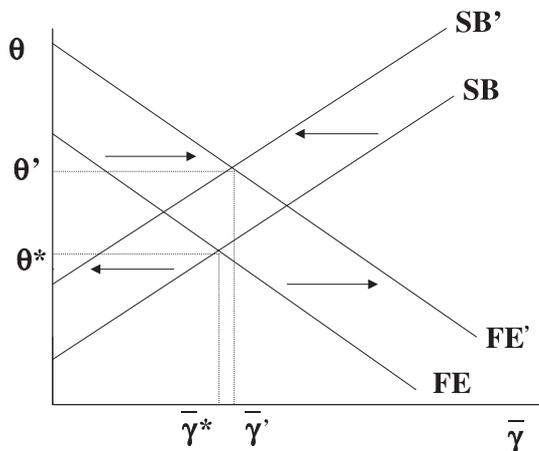


Fig. 3. Effect of a reduction in b , low π .

Effects of unemployment benefits on the critical value of referral search

Totally differentiating Eq. (8) with respect to b yields

$$d\bar{\beta}/db = -\kappa\pi/\{(1 - \rho)e^2(r + \lambda + \kappa + (1 - \pi)q(\theta) + \pi p(\theta))\} + d\bar{\beta}/d\theta \times d\theta/db.$$

The first term is clearly negative. The second term can also be shown to be negative both for low and high values of π . Note that

$$d\bar{\beta}/d\theta = \{-\pi\kappa(\phi A - b)((1 - \pi)q'(\theta) + \pi p'(\theta))\} / \{(1 - \rho)e^2(r + \lambda + \kappa + (1 - \pi)q(\theta) + \pi p(\theta))^2\}.$$

Since $q'(\theta) < 0$ and $p'(\theta) > 0$, $d\bar{\beta}/d\theta$ is positive for low values of π and negative for high values of π . The sign of $d\theta/db$ is obtained by doing comparative statics of Figs. 1 and 2 with respect to b . Fig. 3 shows that, for low values of π , a reduction in b unambiguously

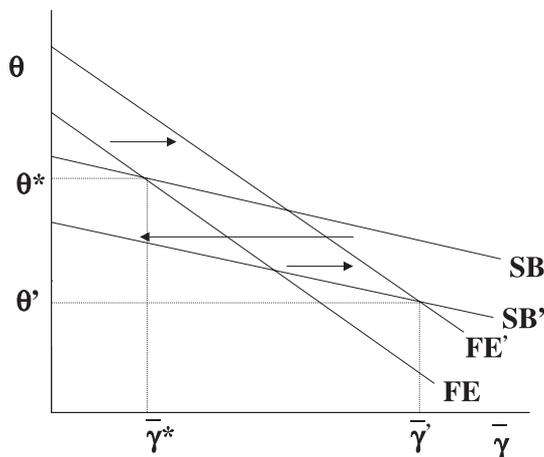


Fig. 4. Effect of a reduction in b , high π .

increases θ , while Fig. 4 shows that, for high values of π , a reduction in b unambiguously reduces θ . This means that $d\theta/db$ is negative for low values of π and positive for high values of π . Consequently, the second term in $d\beta/db$ is always negative.

Effect of unemployment benefits on the unemployment rate

Totally differentiating Eq. (10) with respect to b yields,

$$du/db = du/d\bar{\beta} \times d\bar{\beta}/db + du/d\theta \times d\theta/db,$$

where, as shown above, $du/d\bar{\beta} < 0$ and $d\bar{\beta}/db < 0$, so the first term is positive. The second term can be either positive or negative depending on whether π is high or low. Since $du/d\theta < 0$, the second term is also positive for low values of π but negative for high values of π .

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