

## American Economic Association

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Source: *The American Economic Review*, Vol. 81, No. 5 (Dec., 1991), pp. 1408-1418

Published by: [American Economic Association](#)

Stable URL: <http://www.jstor.org/stable/2006929>

Accessed: 02-12-2015 15:12 UTC

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# Social Networks and Labor-Market Outcomes: Toward an Economic Analysis

By JAMES D. MONTGOMERY\*

Labor economists have long recognized that many workers find jobs through friends and relatives; personnel researchers argue that employee referrals are a useful device for screening job applicants. Because the use of employee referrals is both widespread and purposive, social structure—the pattern of social ties between individuals—may play an important role in determining labor-market outcomes. In this paper, I attempt to embed social structure in a stylized economic model of the labor market. Since the model assumes that both workers and firms choose between formal and informal hiring channels, it offers a framework for exploring the equilibrium relationship among social structure, wages, and profits. The model explains why workers who are well connected might fare better than poorly connected workers and why firms hiring through referral might earn higher profits. The model further predicts that changes in social structure will alter the income distribution: an increase in the density of social ties or in social stratification by ability generates greater wage dispersion.

The paper proceeds as follows. In Section I, I review the importance of employee referrals in the hiring process and discuss alternative explanations for their use. In Section II, I develop a formal model of the hiring process, discussing its major implications. (A formal analysis of the model is placed in the Appendix.) I briefly discuss

two extensions of the model in Section III and present conclusions in Section IV.

## I. The Importance of Social Networks

Numerous studies have examined the search methods used by job seekers, reporting whether jobs were located through help-wanted advertising, employment agencies, direct application, employee referral, or some other hiring channel (see e.g., Charles A. Myers and George P. Shultz, 1951; Herbert S. Parnes, 1954; Harold L. Sheppard and Harvey Belitsky, 1966; Albert Rees and Shultz, 1970; Mark S. Granovetter, 1974; Mary Corcoran et al., 1980; Rees and Wayne Gray, 1982; Howard Wial, 1988). A recurrent theme in this literature is the importance of friends and relatives as sources of employment information. Table 1 reports the relevant findings of four of these studies. While the frequency of alternative job-finding methods varies somewhat by sex and occupation, the following generalization seems fair: approximately 50 percent of all workers currently employed found their jobs through friends and relatives. Data on employers' recruitment methods also attest to the importance of social networks: Harry J. Holzer (1987), examining Equal Opportunity Pilot Project data, reports that 36 percent of firms interviewed filled their last openings with referred applicants; Karen E. Campbell and Peter V. Marsden (1990), analyzing data on 52 Indiana establishments, find that over 51 percent of jobs were filled through referral.

To explain the importance of employee referrals in the hiring process, one must first ask why job seekers would prefer this search method. Holzer (1988) extends a standard search model to permit multiple search methods. Analyzing data from the youth cohort of the National Longitudinal Survey,

\*Department of Economics, Northwestern University, Evanston, IL 60208. This paper is a revised version of the second essay in my Ph.D. dissertation; I am especially grateful to my thesis advisor, Bob Gibbons, for his comments and suggestions. Helpful comments were also received from Stuart Elliott, Harry Holzer, Winston Lin, Peter Marsden, Dale Mortensen, Matthew Rabin, and anonymous referees. Financial support, in the form of a National Science Foundation Graduate Fellowship, is also gratefully acknowledged.

TABLE 1—JOB-FINDING METHODS USED BY WORKERS

Source/data	Percentage of jobs found using each method					Sample size
	Friends/relatives	Gate application	Employment agency	Ads	Other	
Myers and Shultz (1951)/sample of displaced textile workers:						
First job	62	23	6	2	7	144
Mill job	56	37	3	2	2	144
Present job	36	14	4	0	46 <sup>a</sup>	144
Rees and Shultz (1970)/Chicago labor-market study, 12 occupations: <sup>b</sup>						
Typist	37.3	5.5	34.7	16.4	6.1	343
Keypunch operator	35.3	10.7	13.2	21.4	19.4	280
Accountant	23.5	6.4	25.9	26.4	17.8	170
Tab operator	37.9	3.2	22.2	22.2	14.5	126
Material handler	73.8	6.9	8.1	3.8	7.4	286
Janitor	65.5	13.1	7.3	4.8	9.3	246
Janitress	63.6	7.5	5.2	11.2	12.5	80
Fork-lift operator	66.7	7.9	4.7	7.5	13.2	175
Punch-press operator	65.4	5.9	7.7	15.0	6.0	133
Truck driver	56.8	14.9	1.5	1.5	25.3	67
Maintenance electrician	57.4	17.1	3.2	11.7	10.6	129
Tool and die maker	53.6	18.2	1.5	17.3	9.4	127
Granovetter (1974)/sample of residents of Newton, MA:						
Professional	56.1	18.2	15.9 <sup>c</sup>	— <sup>c</sup>	9.8	132
Technical	43.5	24.6	30.4	—	1.4	69
Managerial	65.4	14.8	13.6	—	6.2	81
Corcoran et al. (1980)/Panel Study of Income Dynamics, 11th wave:						
White males	52.0	— <sup>d</sup>	5.8	9.4	33.8 <sup>d</sup>	1,499
White females	47.1	—	5.8	14.2	33.1	988
Black males	58.5	—	7.0	6.9	37.6	667
Black females	43.0	—	15.2	11.0	30.8	605

<sup>a</sup>Most of these workers were rehired at a previous mill job or hired at a new mill established in one of the vacated mills.

<sup>b</sup>In computing the percentages, workers rehired by previous employers and those not reporting the job-finding source are excluded from the denominator and subtracted from the sample size.

<sup>c</sup>Agencies and ads are combined under the heading "formal means."

<sup>d</sup>Gate applications are included under "other."

he finds that contacting friends and relatives generates a job offer with relatively high probability. Given that this search method is also inexpensive, Holzer's model explains job seekers' heavy reliance upon social networks. However, as Holzer explicitly notes, his model assumes that firms' hiring strategies are exogenously given. To explain the widespread use of employee referrals, one must also ask why firms would wish to recruit workers through this hiring channel.

While firms might recruit through employee referrals solely because this is less expensive than more formal methods, researchers have argued that employee referrals also serve as a useful screening device.

Based upon their interviews with employers, Rees (1966) and Peter Doeringer and Michael Piore (1971) report that workers tend to refer others who are similar to themselves.<sup>1</sup> Given a labor market characterized by adverse selection, employers will thus solicit referrals from high-ability employees. In contrast, John P. Wanous (1980) argues that job applicants receive "realistic

<sup>1</sup>This claim is also found in personnel texts (see Herbert G. Heneman et al., 1980). The fact that social ties tend to occur among persons with similar attributes is well established in the social-network literature; see Marsden (1988) for evidence from the 1985 General Social Survey.

job previews" from those referring them.<sup>2</sup> If referred applicants have superior knowledge of their match quality, they will be self-selected: those job seekers who expect to be poorly matched will not bother to apply. Finally, Rees (1966) and others have argued that an employee will refer only well-qualified applicants, since his reputation is at stake.<sup>3</sup>

## II. The Model

### A. Assumptions

Building upon the observation that workers tend to refer others like themselves, I now develop a two-period model of the labor market. For simplicity, there is no discounting between periods. The following assumptions are made on workers and firms.

#### Workers:

Each worker lives one period.

There are many workers, with an equal number in each period.<sup>4</sup>

Workers may be of two types, either high or low ability. To simplify the model, I further assume that (a) one-half of the workers are of each type in each period and (b) high-ability workers produce one unit of output while low-ability workers produce zero units.

Workers are observationally equivalent; employers are uncertain of the ability of any particular worker.

#### Firms:

Each firm may employ (at most) one worker.

A firm's profit in each period is equal to the productivity of its employee minus the wage paid. (Product price is exoge-

nously determined and normalized to unity.)

Each firm must set wages before learning the productivity of its worker.

Firms are free to enter the market in either period.

The above assumptions are standard in labor-market models of adverse selection, particularly that of Bruce C. Greenwald (1986). Workers are observationally equivalent and unable to signal their ability to potential employers. Each firm must set its wage before learning the productivity of its employee; piece-rate compensation schemes and other forms of output-contingent contracts are prohibited. While this assumption may be extreme, it captures a plausible rationale for employer screening of job applicants (and thus the use of employee referrals). The large investment made by firms in employee selection, as reported by Rees (1966) and others, seems difficult to justify if firms can offer fully contingent contracts.<sup>5</sup>

Given the assumption of free entry of firms, expected profit (for entering firms) is driven to zero. Thus, firms will offer wages equal to the expected productivity of those workers on the market. *Ex post*, some firms will pay a wage higher than the productivity of its employee; others will pay a wage that is less than this productivity. (If the model were closed at this point, under the assumption that all workers in each period were hired through the market, all firms would offer a wage equal to  $\frac{1}{2}$  in each period.)

I further introduce the following assumptions on social structure.

#### Social Structure:

Each period-1 worker knows at most one period-2 worker, possessing a social tie with probability  $\tau \in [0, 1]$ .

For each period-1 worker holding a tie, the specific period-2 individual known is selected stochastically through a two-stage process. In the first stage, the period-2 worker's type is chosen. Con-

<sup>2</sup>This explanation is also found in Rees and Shultz (1970) and Granovetter (1974). Doug Staiger (1990) offers a formal model and empirical evidence.

<sup>3</sup>See Garth Saloner (1985) for a formal model.

<sup>4</sup>To simplify the analysis, I examine the model's equilibrium as the number of workers approaches infinity. To be more precise, I am thus assuming a continuum of workers, with an equal measure in each period.

<sup>5</sup>See Greenwald (1986) for further defense of this assumption.

ditional upon holding a tie, a period-1 worker knows a period-2 worker of his own type with probability  $\alpha > \frac{1}{2}$ . (The period-1 worker thus knows a worker of the other type with probability  $1 - \alpha < \frac{1}{2}$ .) In the second stage, the specific period-2 worker is chosen randomly from those of the appropriate type.

The social structure is thus characterized by two parameters which social-network researchers would label "network density" ( $\tau$ ) and "inbreeding bias" ( $\alpha$ ).<sup>6</sup> Given that social ties are assigned stochastically, some period-2 workers may possess several ties while others have none: the allocation of social ties is formally equivalent to an occupancy problem in probability theory, in which balls (social ties to period-1 workers) are dropped randomly into urns (period-2 workers). While the assumed social structure is rather simplistic, it thus captures an important fact: some workers are "well connected," while others are not.

Finally, I assume the following timing.

#### *Timing:*

Firms hire period-1 workers through the market, which clears at a wage  $w_{M1}$ .

Production occurs; each firm learns the productivity of its worker.

If a firm desires to hire through employee referral, it sets a referral offer; firm  $i$  may thus set an offer  $w_{Ri}$ .

Social ties are assigned.

Each period-1 worker possessing a social tie relays his firm's wage offer ( $w_{Ri}$ ) to his period-2 acquaintance.

Each period-2 worker compares wage offers received, either accepting one or waiting to find employment through the market.

Those period-2 workers with no offers (or refusing all offers) go on the market, which clears at a wage  $w_{M2}$ .

Production occurs.

More informally, the timing comprises three major stages. First, each firm hires a period-1 worker through the market and learns his ability. As period-1 workers are observationally equivalent (and cannot be referred for jobs by older workers), each firm hiring through the market obtains a high-ability worker with probability  $\frac{1}{2}$ . Second, learning the ability of its current worker, each firm sets a referral offer that is (potentially) relayed to an acquaintance of its worker. (Note that the period-1 worker merely conveys information; his action is nonstrategic.) In order to attract this acquaintance, the firm's offer must exceed both the period-2 market wage and any other referral offers received by the acquaintance. A firm not wishing to hire through referral will set no referral offer (or might alternatively offer a wage below  $w_{M2}$ , which has no probability of acceptance). Period-2 workers then compare all offers received, accepting the highest. Third, those period-2 workers who receive no offers are forced to find employment through the market, earning a wage equal to the average expected productivity of those on the market.

#### *B. Equilibrium*

Because the qualitative nature of the model's equilibrium is familiar from previous work on price dispersion and adverse selection, I briefly describe the equilibrium here and present the formal analysis in the Appendix. Given the assumed inbreeding bias between workers of similar ability, a firm will attempt to hire through referral if and only if it employs a high-ability worker in period 1. Referral wage offers are dispersed between  $w_{M2}$  and some  $\bar{w}_R$ ; the density of the referral-offer distribution is positive over this entire range.<sup>7</sup> Since most

<sup>6</sup>See Barry Wellman and S. D. Berkowitz (1988) for an informal introduction to social-network analysis; Ronald S. Burt (1980) and Berkowitz (1982) provide more technical overviews. For empirical estimates of network parameters, see Marsden (1987, 1988).

<sup>7</sup>Applying theorem 4 in Kenneth Burdett and Kenneth L. Judd (1983), wage dispersion arises because the probability that a period-2 worker receives exactly one referral offer is strictly between 0 and 1. Proposition 2.2 in Gerard R. Butters (1977) proves that the wage distribution must have no "gaps": if no wages were offered between  $w_1$  and  $w_2$  (where  $w_{M2} < w_1 < w_2 <$

workers receiving (and accepting) referral offers are of high ability, the period-2 market is characterized by a "lemons effect": competition between firms drives the market wage below the average productivity of the population.<sup>8</sup>

In equilibrium, each worker's wage is determined by both the number and type of social ties he holds: period-2 workers with more ties to high-ability period-1 workers receive more referrals and thus higher expected wages. Those workers with no social ties to high-ability workers (while possibly holding numerous ties to low-ability workers) are forced to find employment through the market, earning a relatively low wage due to the lemons effect. Note that wages are only indirectly a function of ability: the positive correlation between wages and ability results from the assumed inbreeding bias in social networks. The present model thus offers some justification for the belief that "it's not *what* you know but *who* you know." While the model abstracts away from other sources of information available to employers on the ability of job applicants, social networks will likely continue to influence wage determination in more realistic settings as long as firms are unable to offer fully output-contingent contracts.

Given the free entry of firms and the symmetric (lack of) information on the ability of workers, firms hiring through the market earn zero expected profit. However, given imperfect competition for referred workers, firms making referral offers earn a positive expected period-2 profit. (To main-

tain equilibrium wage dispersion, this expected profit must be constant across all referral offers made; firms offering higher wages have a higher probability of attracting a worker.) As in Greenwald (1986), the expectation of positive period-2 profits for a firm obtaining a high-ability period-1 worker drives the period-1 market wage above the average productivity of the population. Intuitively, there are two components to this wage: a worker in the period-1 market receives his expected productivity plus the "option value" of his period-2 referral. If a firm's period-1 employee is revealed to possess high ability (and a period-2 acquaintance), the firm exercises its option to make a referral offer; otherwise, the firm hires through the market and earns zero expected profit.

A change in either social-structure parameter has similar effects upon wages and profits. As network density or inbreeding bias increases, the lemons effect is exacerbated, and the period-2 market wage ( $w_{M2}$ ) falls: an increase in  $\tau$  generates more employee referrals, removing relatively more high-ability workers from the market; an increase in  $\alpha$  reallocates referrals from low-ability workers to high-ability workers. An increase in either parameter intensifies competition for referred workers, driving up the maximum referral wage offered ( $\bar{w}_R$ ): higher network density raises the probability that a period-2 worker receives multiple offers, while increased inbreeding bias raises the average quality of referred workers. While the referral-offer distribution is difficult to characterize, an increase in either  $\tau$  or  $\alpha$  thus generates greater wage dispersion, in the sense that the bottom wage falls while the top wage rises. An increase in either social-structure parameter boosts the expected period-2 profit of firms hiring through the period-1 market: higher  $\tau$  increases the probability that a firm makes a referral offer; higher  $\alpha$  generates referrals of higher average ability. Since the option value of a referral rises with  $\tau$  or  $\alpha$ , competition drives up the period-1 market wage ( $w_{M1}$ ). Because firms hiring through this market earn zero expected profit over the two periods, an increase in  $\tau$  or  $\alpha$  thus

$\bar{w}_R$ ), then a firm offering  $w_2$  could reduce its wage offer without reducing the probability that the offer is accepted, thus increasing expected profits.

<sup>8</sup>In contrast to George A. Akerlof's (1970) result, adverse selection does not completely eliminate the market: because some high-ability workers fail to receive referral wage offers, the market clears at a wage greater than zero. The parameter  $\tau$  plays the same role as Greenwald's (1986) parameter  $\mu$  (the exogenous probability of involuntary mobility): as  $\tau$  falls (or  $\mu$  rises), a larger percentage of period-2 workers are hired through the market, ameliorating the lemons effect and boosting the market wage.

redistributes income from referred workers to referring workers.<sup>9</sup>

The model's most novel predictions—linking social structure to the wage distribution and firm profit levels—must await future empirical testing. However, two other results have been previously examined. The prediction that workers hired through referral are of higher average quality has received some support in the personnel literature.<sup>10</sup> Further, the prediction that referred workers receive higher wages is supported by J. C. Ullman (1968) and Granovetter (1974). More recent research by Corcoran et al. (1980) and Staiger (1990) indicates, however, that referred workers earn higher wages only in the short term, perhaps only through the first year of job tenure. Combined with the finding in the personnel literature that referred workers have lower rates of quitting (see Ullman, 1966; Martin J. Gannon, 1971; Graham L. Reid, 1972; Philip J. Decker and Edwin T. Cornelius III, 1979), this result suggests a match-quality explanation for the use of employee referrals: referred workers have superior information on match quality, earning high starting wages due to self-selection; faster wage growth among nonreferred workers might result from greater mobility between jobs.

### III. Extensions<sup>11</sup>

While the preceding model assumed an inbreeding bias between workers of similar ability, I have ignored the strong inbreed-

<sup>9</sup>While this redistribution may have little net effect in a dynamic model where a given worker plays both these roles, this result becomes important when social ties connect members of different groups, as noted in Section III.

<sup>10</sup>See Raymond E. Hill (1970), James A. Breaugh (1981), and Donald P. Schwab's (1982) review article. Indeed, recent personnel research has taken the superiority of referred workers as given and attempted to test alternative theoretical explanations (see M. Susan Taylor and Donald W. Schmidt, 1983; Breaugh and Rebecca B. Mann, 1984).

<sup>11</sup>For a formal analysis of these extensions, see the third essay in Montgomery (1989), "Reinterpreting Models of Statistical Discrimination: Employee Referrals and the Role of Social Structure."

ing biases between individuals of the same race, religion, sex, age, and education (see Marsden, 1988).<sup>12</sup> Moreover, social-structure parameters may vary across groups: women or minorities may, for example, have fewer employed friends and thus have lower effective network densities. Extending the model, one might partition the population into two groups (e.g., male and female), with inbreeding by both ability and sex. If inbreeding within each group is complete, a comparison of the two groups is a simple comparative-statics exercise: holding constant the ability distribution, the group with higher network density or higher inbreeding by ability has lower market wages but greater wage dispersion. Assuming that inbreeding biases (as well as the ability distribution) are the same for males and females, the existence of cross-group ties benefits the group with higher network density (presumably males), raising the period-1 market wage for males while reducing period-2 female wages. An increase in network density redistributes income from referred workers to referring workers; as male network density rises relative to female network density, income flows from referred females to referring males.

The preceding model might also be extended to address the impact of social structure on production efficiency. (Given the assumed homogeneity of jobs and full employment, total output is fixed in the analysis above.) Suppose that each firm now possesses two technologies, one more ability-sensitive and another less ability-sensitive; high-ability workers are more productive in the former, while low-ability workers are more productive in the latter. If each firm must choose a technology for each worker before learning the worker's ability, this choice will be contingent upon the channel through which the worker is hired: one possible outcome is that referred workers are assigned to the more ability-sensitive job while market workers are not. In this case,

<sup>12</sup>Staiger (1990), examining data on referred workers from the youth cohort of the National Longitudinal Survey, reports that 85 percent of males but only 30 percent of females received a referral from a male.

an increase in either social-structure parameter raises total output by improving job matching: an increase in  $\tau$  means that more (primarily high-ability) workers will be assigned to the ability-sensitive job; an increase in  $\alpha$  results in more low-ability market workers and more high-ability referred workers, directly reducing incorrect job matches.

**IV. Concluding Remarks**

Previous research has highlighted the importance of employee referrals and offered a variety of explanations for their use. To explore the relationship between social networks and labor-market outcomes, I have developed an adverse-selection model which explicitly incorporates a simple social structure. Providing an equilibrium analysis of employee referrals, the model explains why workers who are well connected (possessing social ties to those in high-paying jobs) might fare better than those who are poorly connected and why firms hiring through referral might earn higher profits. The model further suggests that changes in social-structure parameters will alter the distribution of income: increases in network density and inbreeding bias generate greater wage dispersion. More generally, the model demonstrates that social structure may be successfully integrated into formal economic analysis. Continued interdisciplinary research on social networks should provide new insight into labor-market operation.

APPENDIX

In this appendix, I formally analyze the model specified in Section II-A. I begin by offering the following proposition to be proved later:

**PROPOSITION:** *A firm makes a referral offer if and only if it employs a high-ability worker in period 1; referral wage offers are dispersed over the interval  $[w_{M2}, \bar{w}_R]$ .*

First consider a given high-ability period-2 worker (H). Since all referral wage offers exceed the period-2 market wage, the prob-

ability that H would accept a referral wage offer  $w_{Ri}$  from firm  $i$  can be written:

$$\Pr\{H \text{ accepts } w_{Ri}\} = \Pr\{H \text{ receives no higher offer } w_{Rj} \forall \text{ firm } j \neq i\}.$$

As referral offers are allocated independently,

$$\begin{aligned} \Pr\{H \text{ accepts } w_{Ri}\} &= \prod_{j \neq i} \Pr\{H \text{ receives no higher offer } w_{Rj}\} \\ &= \prod_{j \neq i} [1 - \Pr\{H \text{ receives an offer } w_{Rj} > w_{Ri}\}]. \end{aligned}$$

The probability that firm  $j$  offers a wage  $w_{Rj} > w_{Ri}$  to H is in turn the product of two independent probabilities:

$$\begin{aligned} \Pr\{H \text{ receives an offer } w_{Rj} > w_{Ri}\} &= \Pr\{\text{firm } j \text{ makes offer to H}\} \\ &\quad \times \Pr\{w_{Rj} > w_{Ri}\}. \end{aligned}$$

If there were  $2N$  workers in period 1, free entry implies that  $N$  firms employ high-ability workers. If each firm chooses its referral wage offer by randomizing over the equilibrium wage distribution  $F(\cdot)$  (to be derived below),

$$\begin{aligned} \Pr\{H \text{ receives an offer } w_{Rj} > w_{Ri}\} &= \left(\frac{\alpha\tau}{N}\right) [1 - F(w_{Ri})] \end{aligned}$$

for all firms  $j$  employing a high-ability worker in period 1. Substitution yields

$$\begin{aligned} \Pr\{H \text{ accepts } w_{Ri}\} &= \left\{1 - \left(\frac{\alpha\tau}{N}\right) [1 - F(w_{Ri})]\right\}^{N-1}. \end{aligned}$$

As  $N$  approaches  $\infty$ ,

$$\Pr\{H \text{ accepts } w_{Ri}\} = e^{-\alpha\tau[1-F(w_{Ri})]}$$



(see Anatol Rapoport, 1963). Through similar analysis, one obtains the probability that firm  $i$ 's offer is accepted by a given low-ability worker (L):

$$\Pr\{L \text{ accepts } w_{Ri}\} = e^{-(1-\alpha)\tau[1-F(w_{Ri})]}.$$

Conditional upon the offer being received by a given worker, high-ability workers are less likely to accept any offer  $w_{Ri} < \bar{w}_R$ , since these workers tend to receive more offers. (For  $w_{Ri} = \bar{w}_R$ , however, both probabilities are equal to 1: since no firm offers a higher wage, workers always accept.)

Since a period-2 worker finds employment through the market only if he receives no offers,  $\Pr\{\text{market} | H\} = \Pr\{H \text{ accepts } w_{M2}\}$  and  $\Pr\{\text{market} | L\} = \Pr\{L \text{ accepts } w_{M2}\}$ . Given that  $F(w_{M2}) = 0$ , one obtains  $\Pr\{\text{market} | H\} = e^{-\alpha\tau}$  and  $\Pr\{\text{market} | L\} = e^{-(1-\alpha)\tau}$ . Since I have assumed a continuum of workers, one may use Bayes's rule to calculate the period-2 market wage:

$$\begin{aligned} w_{M2}(\alpha, \tau) &= \Pr\{H | \text{market}\} \\ &= \frac{\Pr\{\text{market} | H\} \times \Pr\{H\}}{\Pr\{\text{market} | H\} \times \Pr\{H\} + \Pr\{\text{market} | L\} \times \Pr\{L\}} \\ &= \frac{e^{-\alpha\tau}}{e^{-\alpha\tau} + e^{-(1-\alpha)\tau}} \end{aligned}$$

since  $\Pr\{H\} = \Pr\{L\} = \frac{1}{2}$ . (Note that if  $N$  were finite, the use of Bayes's rule would be inappropriate: the market wage would be stochastic and would depend upon the realized allocation of social ties.) Given  $\alpha > \frac{1}{2}$  and  $\tau > 0$ ,  $w_{M2}$  is always less than  $\frac{1}{2}$ , the average productivity of the population. It is straightforward to show that  $w_{M2}$  is decreasing in both  $\alpha$  and  $\tau$ .

Now consider the expected period-2 profit earned by a firm employing a high-ability worker and setting a referral wage  $w_R$ :

$$\begin{aligned} E\Pi_H(w_R) &= \Pr\{\text{high-ability period-2} \\ &\quad \text{referral hired} | w_R\} \cdot (1 - w_R) \\ &\quad + \Pr\{\text{low-ability period-2} \\ &\quad \text{referral hired} | w_R\} \cdot (-w_R). \end{aligned}$$

(If no referred worker is hired, either because the period-1 worker holds no social tie or because the referral receives a better offer, the firm hires through the market and receives zero expected profit.) The probability of hiring a high-ability period-2 referral is the product of two independent probabilities:

$$\begin{aligned} \Pr\{\text{high-ability period-2 referral hired} | w_R\} &= \Pr\{\text{offer made to a high-ability} \\ &\quad \text{referral}\} \times \Pr\{H \text{ accepts } w_R\} \\ &= \alpha\tau e^{-\alpha\tau[1-F(w_R)]}. \end{aligned}$$

Similarly, the probability of hiring a low-ability worker may be written

$$\begin{aligned} \Pr\{\text{low-ability period-2 referral hired} | w_R\} &= (1 - \alpha)\tau e^{-(1-\alpha)\tau[1-F(w_R)]}. \end{aligned}$$

By substitution,

$$\begin{aligned} E\Pi_H(w_R) &= \alpha\tau e^{-\alpha\tau[1-F(w_R)]}(1 - w_R) \\ &\quad + (1 - \alpha)\tau e^{-(1-\alpha)\tau[1-F(w_R)]}(-w_R). \end{aligned}$$

To maintain equilibrium wage dispersion, firms must earn the same expected profit on each referral wage offered:

$$E\Pi_H(w_R) = c \quad \forall w_R \in [w_{M2}, \bar{w}_R].$$

To determine this constant, note that the firm could potentially deviate from its specified strategy by offering a wage of  $w_{M2}$ ; the referred worker accepts the firm's offer only if no other offers have been received. The firm's expected profit is given by

$$\begin{aligned} E\Pi_H(w_{M2}) &= \alpha\tau e^{-\alpha\tau}(1 - w_{M2}) \\ &\quad + (1 - \alpha)\tau e^{-(1-\alpha)\tau}(-w_{M2}) \\ &= c. \end{aligned}$$

Substituting for  $w_{M2}$ ,

$$c(\alpha, \tau) = (2\alpha - 1)\tau / (e^{\alpha\tau} + e^{(1-\alpha)\tau}).$$

Given  $\alpha > \frac{1}{2}$ ,  $c > 0$ : firms employing high-ability workers with social ties earn positive expected profits. It is straightforward to show that  $c$  is increasing in both  $\alpha$  and  $\tau$ .

Given the preceding expression for  $c$ , the equilibrium referral-offer distribution  $F(\cdot)$  may be determined by setting  $E\Pi(w_R)$  equal to  $c$  for all potential wage offers  $w_R$ :

$$\begin{aligned} & \alpha\tau e^{-\alpha\tau[1-F(w_R)]}(1-w_R) \\ & + (1-\alpha)\tau e^{-(1-\alpha)\tau[1-F(w_R)]}(-w_R) \\ & = (2\alpha-1)\tau / (e^{\alpha\tau} + e^{(1-\alpha)\tau}) \\ & \quad \forall w_R \in [w_{M2}, \bar{w}_R]. \end{aligned}$$

Given a continuum of firms, the equilibrium referral-offer distribution  $F(\cdot)$  may be interpreted in two ways: either each firm randomizes over the entire distribution or else a fraction  $f(w_R)$  of firms offer each wage for sure.

Unfortunately, the previous equation does not yield a closed-form solution for  $F(w_R)$ . One can, however, derive an expression for the maximum wage offered:

$$\begin{aligned} \bar{w}_R(\alpha, \tau) &= \alpha - [(2\alpha-1)/(e^{\alpha\tau} + e^{(1-\alpha)\tau})] \\ &= \alpha - c/\tau. \end{aligned}$$

Intuitively, a firm offering a referral wage of  $\bar{w}_R$  attracts a referred worker with probability 1 (conditional upon its worker holding a social tie); the firm's expected profit,  $c$ , is thus equal to  $\tau(\alpha - \bar{w}_R)$ . One can show that  $\bar{w}_R$  is increasing in both  $\alpha$  and  $\tau$ .

The preceding analysis has already established that firms employing high-ability workers in period 1 will make referral offers: while hiring through the market generates zero expected profit, a referral offer generates constant positive profit over the range  $[w_{M2}, \bar{w}_R]$ ; a lower offer will never be accepted, while a higher offer increases the wage without increasing the probability of attracting a worker. To complete the proof of the initial proposition, I now demonstrate that firms employing low-ability workers in period 1 will hire through the market.

If such a firm were to deviate from the proposed equilibrium, making a referral offer  $w_R$ , its expected profit would be written

$$\begin{aligned} E\Pi_L(w_R) &= (1-\alpha)\tau e^{-\alpha\tau[1-F(w_R)]}(1-w_R) \\ & \quad + \alpha\tau e^{-(1-\alpha)\tau[1-F(w_R)]}(-w_R). \end{aligned}$$

By inspection, it is apparent that  $\partial E\Pi_L(w_R)/\partial w_R < \partial E\Pi_H(w_R)/\partial w_R$ . Since  $\partial E\Pi_H(w_R)/\partial w_R$  is (by construction) equal to zero for all  $w_R \in [w_{M2}, \bar{w}_R]$ ,  $\partial E\Pi_L(w_R)/\partial w_R$  is negative;  $E\Pi_L$  is maximized at  $w_R = w_{M2}$ . However, even at this wage, expected profits are negative. Substituting for  $w_{M2}$ ,

$$E\Pi_L(w_{M2}) = \frac{(1-2\alpha)e^{-\tau}}{e^{-\alpha\tau} + e^{-(1-\alpha)\tau}}$$

which is negative given  $\alpha > \frac{1}{2}$ . The proposition is thus proved: a firm employing a low-ability worker in period 1 prefers to hire through the market, earning zero expected profit.

Finally, consider the period-1 market. Firms hiring in this market earn an expected period-2 profit equal to the probability of obtaining a high-ability period-1 worker times the expected profit from a referral. Free entry thus drives the wage above expected period-1 productivity:

$$\begin{aligned} w_{M1}(\alpha, \tau) &= \frac{1}{2} + \left(\frac{1}{2}\right)c(\alpha, \tau) \\ &= \left(\frac{1}{2}\right)[1 + c(\alpha, \tau)]. \end{aligned}$$

Given the previous comparative-statics results on  $c$ ,  $w_{M1}$  is increasing in both  $\alpha$  and  $\tau$ .

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