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Employee Referrals and the Inter-Industry Wage Structure*

Adriana D. Kugler†

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† Universitat Pompeu Fabra, Department of Economics. E-mail: kugler@upf.es.

Abstract

This paper investigates the role of employee referrals in the labor market. Using an original data set, I find that industries that pay wage premia and have characteristics associated with high-wage sectors rely mainly on employee referrals to fill jobs. Moreover, unemployment rates are higher in industries which use employee referrals more extensively. This paper develops an equilibrium matching model which can explain these empirical regularities. In this model, the matching process sorts heterogeneous firms and workers into two distinct groups: referrals match "good" jobs to "good" workers, while formal methods (e.g., newspaper ads and employment agencies) match less-attractive jobs to disadvantaged workers. Thus, well-connected workers who learn quickly about job opportunities use referrals to jump job queues, while those who are less well placed in the labor market search for jobs through formal methods. The split of firms and workers between referrals and formal search is, however, not necessarily efficient. Congestion externalities in referral search imply that unemployment would be closer to the optimal rate if firms and workers 'at the margin' searched formally.

I. Introduction

In their 1962 study of the Chicago Labor Market, Albert Rees and George Shultz (1970) found that high wage employers relied extensively on employee referrals to fill their vacancies. They found that high wage employers who were satisfied with their work force preferred to use this hiring channel, because, in the their view, employee referrals provided them with initial screening and subsequent monitoring of new employees. Low wage employers, however, were either continuously trying to upgrade their work force or faced difficulties with employee cliques and, therefore, these employers preferred using formal hiring channels, such as newspaper advertisements and employment agencies.

Three decades after Rees' and Shultz' study, the link between the payment of wage premiums and referral hiring continues to be a pervasive phenomenon not only in Chicago, but all over the United States. An industry that hires 25 percent more of their work force through referrals than the average industry also pays wages that are 15.2 percent higher than the wages paid by the average industry in the economy.[1] Likewise, firm level data show that firms operating in industries that pay wage premiums are more likely to have hired their current employees through referrals.[2] In addition, the data reveal that industries with characteristics associated with the

[1]The data for this estimation are obtained by merging data from different sources. Data on the use of employee referrals by industry are obtained from the National Longitudinal Survey of Youth which asks a sample of 12,123 employees in all industries whether they were referred by a current employee. The industry premiums data are the Krueger and Summers' (1988) estimates obtained using the Current Population Survey. In addition, we merge data on industry characteristics from the National Organizations Survey which includes information on: profits, assets, sales, concentration ratios, capital intensity, percent of unionized workers, percent of male workers, and average establishment size in each industry. Finally, we also merge information on the average experience and average education in each industry, which are estimated from the Current Population Survey. The data are described in more detail in Section 2.

payment of wage premiums (e.g., high profits and small labor shares of income) rely more extensively on employee referrals. Firm level data also show that firms operating in industries with these characteristics are more likely to have hired their employees through referrals. This evidence on the link between the inter-industry wage structure and the use of referrals indicates that jobs filled through referrals are likely to pay wages above market clearing. Moreover, consistent with this interpretation, industry data reveals that unemployment rates are higher in industries that hire a larger percentage of workers through referrals. These empirical regularities have important policy implications, because they suggest that searching through friends and relatives for these rationed jobs leaves "too many persons unemployed waiting for good jobs, while less desirable [jobs] go begging." (Tobin, 1972)

Ethnographic studies of the labor market experience of working class youths further document the link between the payment of wage premiums and employee referrals. A study by Wial (1991) describes the workers' analogue of Rees' and Shultz' explanation for the effectiveness of employee referrals in filling high wage jobs. Wial's study of three ethnic neighborhoods of Boston found that workers believed that obtaining a "good" job[3] required either "luck or the help of a friend or relative who [would] put in a good word with the boss." (Wial, 1991) The perception of Boston youths that a good word put in by friends and relatives was crucial to

[2]Firm level data merged with corresponding industry and employee information are obtained from the National Organizations Survey. See Section 2 for more details about this data set.

[3]The workers in the Boston study considered "good" jobs to be jobs that offered high pay and considerable job security. Among the examples of "good" jobs provided by these employees were 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, the

obtain a "good" job coincides with the view of high wage employers in Chicago who indicated that employee referrals provided them with good information about the quality and future behavior of new employees. According to residents in the ethnic neighborhoods studied by Wial, however, low wage jobs could be easily obtained without the need of personal contacts. As a resident of South Boston, an Irish neighborhood, remarked, "There's always something. Anyone can do shipping and receiving or be a porter in a nursing home, and they're always hiring." (Wial, 1991)

This paper will explain why there might be such a link between the payment of wage premiums and reliance on employee referrals. Employee referrals can act as a bond for new employees: referred workers are compelled to work diligently out of obligation to those who found them their jobs. When a referee posts a bond ("puts in a good word") for the new employee, the threat of having to forfeit a friend's current and future support creates work incentives for the new employee. Thus, employee referrals like bonds posted by workers, fines levied on workers caught shirking, and an upward tilt in the age earnings profile provide a penalty for shirking which can substitute for the payment of wages above market clearing. However, in contrast to wage schemes which are subject to moral hazard from firms,[4] employee referrals are easier to enforce because they do not require honesty from the part of firms but they, instead, require honesty from the part of friends and relatives. Consequently, firms with honest workers benefit from hiring through employee referrals which replicate an honest work force and save them on the wages they have to pay to motivate new

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.

workers. However, referrals have no value for firms with dishonest employees because the "good word" from the referee cannot act as a bond for new employees. Firms with dishonest employees avoid using referrals which would only replicate a dishonest work force and, instead, they rely on formal hiring channels.

This paper develops a matching model which illustrates how the use of employee referrals and formal search channels generates labor market segmentation. Employee referrals allow firms with honest workers to lower the efficiency wages they have to pay to elicit honesty from new workers. Firms that have paid efficiency wages in the past are ensured of having honest workers and, thus, find it beneficial to use referrals. Firms that have not paid efficiency wages before, however, most likely have a dishonest work force and, thus, accrue no benefit from using employee referrals. Thus, firms choose simultaneously between paying efficiency wages and hiring through referrals, and paying the market clearing wage and hiring through formal channels. The firm's choice of the combination of wages and hiring channel depends on how costly it is to fill vacancies through employee referrals compared to formal channels. Filling jobs through referrals is more costly because referrals generate a smaller quantity of applicants than formal hiring channels and, thus, the use of employee referrals prolongs the time it takes to fill the vacancy. While firms hiring formally tend to receive a large number of interested applicants, firms hiring through employee referrals have to wait for current employees to approach their friends and relatives and then wait for them to express an interest in the job to arrange for an interview. Consequently, in the model, firms with heterogeneous arrival rates of

[4]It has been noted that firms using these wage schemes "have an obvious incentive to declare workers shirking and appropriate bonds, collect fines, or replace them with fee-paying workers." (Akerlof and

applicants split between referrals and formal hiring channels. The opportunity cost of holding a vacancy is low for firms with high arrival rates of applicants and, thus, they use referrals. The opportunity cost of holding a vacancy is, however, much higher for firms with low arrival rates and thus they hire formally.

Workers on their part would always prefer to obtain a high wage job. However, workers are aware that obtaining a "good" job requires the help of a friend or relative who is willing to put in a good word. Whether a worker decides to pursue a good job by using referrals or to search formally for a bad job depends on how long the worker would have to remain unemployed until he can locate a desirable job through his circle of friends and extended family. Workers searching through referrals have to wait until a job opens up at the establishment where a family member or friend works and then wait for this person to arrange an interview with the employer. Thus, in the model, workers with heterogeneous arrival rates of job offers split between referral search and formal search. Well-connected workers can expect to experience short unemployment spells when using referrals and, thus, prefer to search through this channel. Workers without many contacts, however, would experience painfully long unemployment spells if they searched through referrals and, thus, they rely on formal search.

The model shows that the matching process generates labor market segmentation. Search channels sort heterogeneous firms and workers into two distinct groups: referrals match "good" jobs to "good" workers, while formal channels match less attractive jobs to disadvantaged workers. Firms that attract a large number of applicants every time a vacancy opens hire through referrals and pay efficiency

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Yellen, 1986)

wages. Similarly, well-connected workers who can find jobs easily through personal contacts search through referrals, and earn high wages. By comparison, firms that receive few applicants per vacancy, use formal hiring channels and pay market clearing wages. Also, workers that receive few job offers through referrals, either because they face disadvantages in the labor market or because they are less productive, end up finding their jobs through formal channels and earning low wages.

Two major economic theories have been previously put forth to explain why referred workers earn higher wages than formal hires. Match-quality theories of referrals posit that personal contacts provide better match-quality information to potential applicants allowing them to self-select into those jobs in which they are more productive. Ability-based theories of referrals explain why firms may prefer to use employee referrals when the competitive labor market is characterized by adverse selection. While both of these theories can explain why particular individuals hired through referrals receive higher wages, neither of these theories can explain why firms that pay wage premiums to all workers rely more on employee referrals. Also, these two theories cannot explain why firms operating in industries with characteristics associated with high wage industries rely more on referrals, nor can they explain why unemployment rates are higher in industries that use referrals more extensively.

This paper offers a theoretical explanation of why employee referrals may be associated with the payment of wage premiums and with higher unemployment. As explained above, this explanation suggests that jobs filled through referrals are not only more desirable but they are also scarcer. Consequently, there are too many

people searching for jobs through personal contacts relative to the number of available jobs filled in this way. Referral matching, thus, generates problems of congestion in the labor market. To be precise, workers searching through referrals impose congestion externalities on each other: a worker deciding to join a queue for "good" jobs considers his probability of obtaining a job, but he does not consider the effect of his decision on others. This congestion externality implies that the number of workers searching through referrals is likely to be inefficiently high. Moreover, the unemployment rate is also likely to be inefficiently high because congestion prolongs unemployment spells for those searching through referrals,

Policies that increase search costs for the unemployed (such as unemployment taxes and job-start subsidies) can increase the incentives to use formal search channels and lower unemployment closer to its optimal rate. A rise in search costs increases the incentives to use formal channels, because the losses from long unemployment spells experienced when searching through referrals are larger. Consequently, by increasing formal search and reducing referral search, an increase in search costs mitigates congestion and reduces unemployment. Unemployment is reduced both because the number of unemployed workers who queue for "good" jobs is smaller and because the unemployment spells of those queuing for "good" jobs are shorter.

The rest of this paper proceeds as follows. Section II presents evidence from two different data sets on the link between referrals and the inter-industry wage structure. Section III models the matching process and derives the endogenous split between matches occurring through referrals and formal matches. Section IV shows the effects of the congestion externality on unemployment duration. Moreover, we

discuss market and non-market mechanisms to correct the externality, and present the welfare consequences of imposing a combination of taxes-cum-subsidies. Section V discusses the model in the context of the empirical regularities established in Section II and contrasts it against alternative theories of referrals. Section VI concludes.

II. Evidence on the Link Between Referrals and the Inter-Industry Wage Structure

This section establishes a link between referrals and the inter-industry wage structure. In particular, we determine the relations between referrals and the payment of wage premiums, industry characteristics, unemployment, tenure, and the occupational structure. We use an industry level data set, constructed by the author, which allows one to examine the relation between referral hiring, wage premiums, and industry characteristics at the one-digit, two-digit and three-digit levels of aggregation. We also present additional evidence from the National Organizations Survey on the relation between hiring channels and industry characteristics. The empirical regularities established by the data provide the appropriate background to develop and interpret the model in Section III.

II.1. The Industry Data

To investigate the relation between referral matching and the payment of efficiency wages, I merge data on employee referrals, industry wage premiums, and industry characteristics from various sources. I obtain data on the percentage of referred workers by industry from the 1982 wave of the National Longitudinal Survey of Youth. The advantage of using data from the NLSY is that we can obtain precise information on whether workers hired in a particular industry were referred by *current*

employees. Using the 1982 NLSY, I estimate the percentage of workers referred by current employees for one-digit, two-digit, and three-digit industries using 1980 Census classification codes.[5] The data for industry wage premiums is obtained from Krueger and Summers (1988). I use Krueger and Summers' wage differentials for one-digit, two-digit, and three-digit industries estimated with the 1984 Current Population Survey. I also use data for the 1980's from the Current Population Survey to estimate the average years of education and the average years of potential experience in each industry. Finally, I obtain data on industry characteristics for one-digit and two-digit industries from the National Organizations Survey, which is described below. Merging information from these various sources, I obtain data sets for one-digit, two-digit, and three-digit industries.

Tables 1 and 2 present correlation matrices which offer a first look at the data. Table 1 presents the correlation matrix of the percentage of referred workers in each industry, industry wage premiums, and a number of industry characteristics. The first column in the correlation matrix shows that the percentage of referred workers is positively correlated with industry premiums, profits, concentration ratios, capital's share of income, assets, sales, average establishment sizes, the percentage of unionized workers, and the percentage of men in the industry.[6] Table 2 presents the same correlation matrix as Table 1, but it includes a measure of wage premiums which contains fringe benefits as well as wage compensation. The first column corroborates

[5]A shortcoming of this data set is that it only includes people between the ages of 14 and 27. However, various studies have documented that older workers use personal contacts more extensively than younger workers (Granovetter, 1995; Corcoran et al., 1980). Thus, it is likely that, if there is a bias, the results will *underestimate* rather than overestimate the relation between employee referrals and different industry characteristics.

[6]Note that all other results in the matrix coincide with previous findings of the correlations between industry premiums and industry characteristics (see Dickens and Katz, 1987a).

that the percentage of referred workers in the industry is strongly correlated with the total compensation measure of industry wage premiums.

Tables 3 and 4 present similar correlation matrices to those in Tables 1 and 2, but using data for two-digit industries. Like the correlation matrices for the one-digit industry data, the correlation matrix in Table 3 shows that the percentage of workers hired by employee referrals is positively correlated with industry wage premiums. Moreover, the percentage of referred workers is positively correlated with various industry characteristics associated with high wage industries. Table 4 shows that the correlation between the percentage of referred workers and total compensation wage premiums is even stronger than the correlation between the share of referred workers and the measure of wage premiums which excludes nonwage compensation.

II.2. Empirical Regularities

A first look at the data shows that industries and firms that rely more on referrals also pay higher wages and have characteristics associated with high-wage sectors. In this section, we provide further evidence of the relation between referrals and the inter-industry wage structure.

II.2.1. The Link between Referrals and Industry Wage Premiums

The use of referrals is positively associated with the payment of wage premiums. Tables 1-4 show that the percentage of referred workers in an industry is strongly correlated with the payment of a wage premium in the industry. Moreover, regression analysis of inter-industry wage differentials on industrial hiring and other industry characteristics provides further evidence of this link. Tables 5, 6, and 7 show

the regressions of the estimated wage differentials for two-digit and three-digit industries on the percentage of referred workers in two-digit and three-digit industries, respectively.[7] The results of the regressions for two-digit industries corroborate that high wage industries rely more on employee referrals. Column (1) in Table 5 shows that industries where the share of referred workers is 25 percent higher than in the average industry pay a wage premium that is 15.17 percent higher than the average wage in all industries. This implies that, for example, an industry like primary metals which pays a 15 percent wage premium also hires 25 percent more of its workforce by referrals than the average industry in the economy. Using instead the total compensation measure of wage premiums shows that industries where the proportion of referred workers is 25 percent higher than in the average industry are associated with industries that pay a total compensation that is 22.99 percent higher than in the average industry (see Column (1) in Table 6). Thus, firms operating in industries that rely more on employee referrals not only pay higher wages, but they also provide more fringe benefits. Table 7 presents similar results using three-digit industry data.[8]

[7]This analysis differs from previous empirical studies which examine the 'returns' of referrals for *individual* employees by including a referral dummy into a standard wage regression (Corcoran et al., 1980; Staiger, 1990; Simon and Warner, 1992).

[8]Tables 5, 6, and 7 also present regressions which include controls for the average level of education and experience in the industry, as well as other industry characteristics (for regressions using two-digit industry data). We include these controls to verify that the relation between higher wages in the industry and reliance on referrals does not simply reflect the higher ability of referred workers. The regressions show an even stronger link between referrals and the payment of wage premiums when we control for average worker ability in the industry. Column (2) in Table 5 shows that, after controlling for differences in education and experience across industries, a 25 percent increase in referral hiring is associated with the payment of a 17.14 percent wage premium over the average wage in all industries. Column (2) in Table 6 shows that, after controlling for measured ability, a 25 percent higher proportion of workers hired through referrals is associated with total compensation that is 24.97 percent above the total compensation in all industries.

II.2.2. Characteristics of Industries Hiring through Referrals

The pervasiveness of referral hiring is also related to industry characteristics associated with the payment of high wages. Industries with higher profits, larger capital income shares (lower labor shares of income), higher concentration ratios, larger average establishment sizes, higher percentages of unionized workers, and higher percentages of men, rely more extensively on employee referrals. At the same time, previous studies of the inter-industry wage structure have shown that all of these industry characteristics are associated with the payment of wage premiums. (Dickens and Katz, 1986a, 1986b; Krueger and Summers, 1987, 1988) Thus, the links between industry characteristics and employee referrals provide further evidence of the relation between referral hiring and the inter-industry wage structure.

Tables 1-4 show positive correlations between the characteristics of high-wage industries and the use of employee referrals. Moreover, when we include industry profits, capital income shares, concentration ratios, and the percentage of unionized workers as controls in the wage differential regressions, the relation between the percentage of referred workers and the wage premiums weakens, thus, indicating that the referral variable was partially capturing the relation of these other industry characteristics with the wage premiums. (See columns (3)-(5) in Tables 5 and 6)

II.2.3. Referrals and Industry Unemployment Rates

The finding that industries with higher shares of referred workers pay higher wages suggests that firms operating in these industries pay wages above market clearing and, thus, ration their jobs. If this were the case, then we would expect to

find higher unemployment rates in industries that rely extensively on referrals. Table 8 presents the regression results of industry unemployment rates on the percentage of referred workers in each industry. Industries where the share of referred workers is higher have higher unemployment rates (see columns (1) and (2) in Table 8). I also find that the inverse relation between referral hiring and unemployment is greater in industries where jobs are more likely to be rationed. Column (3) in Table 8 shows a stronger association between unemployment and referral hiring in industries with higher profits, and presumably in which higher rents are paid.

II.2.4. Job Tenure of Referred Workers

Previous work on the inter-industry wage structure has demonstrated that turnover has a negative correlation with industry wage differentials. In particular, the evidence shows a positive relation between job tenure and industry wage differentials. (Krueger and Summers, 1988) If workers in industries hiring through referrals earned rents, then we would expect them to have longer job tenure than workers in industries hiring formally. In fact, the longer tenure of workers hired through referrals is well documented. Datcher (1983) uses the 1978 wave of the PSID, Staiger (1990) uses data from the 1982 NLSY, and Simon and Warner (1992) use the 1972 Survey of Natural and Social Scientists and Engineers to document the longer tenure of referred workers.

II.2.5. Types of Workers Hired through Referrals

Evidence on the inter-industry wage structure shows that industry premiums are paid uniformly across occupations. That is, industries that pay high wages to blue

collar employees also pay high wages to white collar employees, while industries that pay low wages to blue collar employees also pay low wages to white collar employees. We find, however, that industries do not use referral hiring uniformly across occupations. Instead, high-wage industries use referrals to hire workers in blue-collar and service occupations, but they tend to rely on formal methods to hire white-collar employees (evidence from the NOS is presented in Table 9).[9] An explanation of referrals, thus, must be able to account for differences in hiring channels across occupations.

II.3. Additional Evidence from the National Organizations Survey

We also analyze data from the National Organizations Survey (NOS)[10] to examine the relation between referral hiring and industry characteristics. We obtain significant coefficients with the expected signs on the relations between various industry characteristics and the likelihood of having been hired through a referral. We find that firms operating in industries that pay higher average wages are more likely to

[9]The greater reliance on referrals to hire blue-collar and service workers and the lesser use of referrals to hire white collar employees has also been documented with other data sets. Corcoran et al. (1980) present evidence from the PSID, Staiger (1990) presents evidence from the 1982 NLSY, and Holzer (1996) presents evidence from his Multi-City Employer Survey.

[10]This data set contains information which allows one to determine the relation between firms' hiring channels and the characteristics of firms and industries in which these firms operate. The NOS matches relevant information on employed respondents with information on their employers and industries. The NOS surveyed a representative sample of work establishments in the United States 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 (the GSS is an annual survey of the U.S. population conducted by the NORC). The 1991 GSS survey was used to construct the sample for the NOS because in this year a topical module dealing with work organizations was conducted which collected information on various aspects of work experience, including information on job-search methods, as well as the names, addresses, and phone number of the respondents' employers. The questionnaire to establishments focused on their characteristics, and on their human resource practices and policies. More importantly, this national database on work establishments has been supplemented with aggregate data from various government sources on the characteristics of the industries in which the establishments operate. The final sample consists of the 727 cases that provide complete data on establishments.

have hired their workers through referrals. The probit estimation in column (2) of Table 9 indicates that a firm operating in an industry that pays average wages of $26,500, instead of operating in an industry that pays wages of $19,800 on average, is 30 percent more likely to hire its employees through referrals. The NOS data also confirms that other industry attributes characterizing high-wage industries (i.e., industry profits and labor's shares of income) are associated with more extensive hiring through referrals (see columns (3) and(4) in Table 9).

III. The Matching Model with Referrals and Formal Search

In this section, I present a model in which heterogeneous workers and firms engage in a costly process of search in the labor market. They meet each other in the market either through referrals or through formal channels. Because some workers are better connected than others, and some firms are more attractive than others, the cost of search differs across workers and across firms using referrals. In the formal sector, all workers have access to the same information about jobs, and likewise all firms have access to the same information about applicants. Thus, all workers searching formally face the same search costs and, similarly, all firms searching formally face the same search costs. Moreover, formal channels are a quicker way of finding out about jobs and applicants and, thus, it is cheaper for both workers and firms to search formally. While formal search consists of one-on-one meetings with anyone who is available in the market, referral search is time-consuming because it requires one-on-one meetings with acquaintances in one's network.

Workers and firms split in their search by focusing on referrals or by focusing on formal channels. Depending on their search costs, some workers benefit from

focusing their search through referrals, while others find it beneficial to focus their search formally. Likewise, firms are divided into those that fill their jobs through referrals and those that fill formally.

When a firm with a vacancy meets an unemployed worker, they must choose a wage and the effort of the worker. In the tradition of Shapiro and Stiglitz (1984), a firm that wants to increase output by increasing effort, at the same level of monitoring, (or, equivalently, a firm that wants to save on monitoring costs) pays higher wages. In this paper, when a referral matches up a worker and a firm, the monitoring role played by the referee allows the firm to save on higher wages without reducing employee effort. Thus, firms hiring through referrals can motivate workers and increase output by paying wages that are moderately above the market wage. Firms hiring formally, however, pay the market wage because they do not find it worthwhile to pay the very high wages that would get their employees not to shirk.

III.1. Description of the Model

The entire system describing the model is presented in the table below. The following diagram provides a graphical representation of how the model works. This diagram describes the different states of workers and firms, as well as the choices that they make in the labor market (the model's equations corresponding to the workers' and firms' decisions are included in parenthesis). The diagram also describes how the matching process occurs and how the total number of jobs and unemployed workers is determined in the economy.

Workers (L)

Unemployed (U)		Employed (E)	
Search through Referrals (R) (Equation (1))	Search Formally (F) (Equation (2))	Exert Effort	Shirk
Decision of how to search depends on individual's i type (Equation (8) determines the arrival rate for individual i who is marginal between the two search channels).		Decision on whether to exert effort or not depends on the wage paid, which, in turn, depends on the search channel used by the firm and worker.	

Firms (K)

Vacant Jobs (O)		Filled Jobs (J)	
Search through Referrals (R) (Equation (3))	Search Formally (F) (Equation (4))	Pay Efficiency Wage (Equation (5))	Pay Market Wage (Equation (6))
Decision of how to search depends on firm's f type (Equation (7) determines the arrival rate for firm f that is marginal between the two search channels).		Decision on what wage to pay depends on the search channel used by the firm to fill the job.	

The model generates a correspondence between workers and firms using referrals, and between firms and workers using formal channels. In the steady-state equilibrium, the flow out of unemployment equals the flow into unemployment for workers using each search channel. Likewise, the flow of vacancies equals the flow of jobs being filled through each channel. These steady-state conditions determine the effectiveness of each search channel for workers and firms of all types.

Equilibrium

Referrals (R)		Formal Channels (F)	
Referred workers' flow into	Referral firms' flow of vacancies equals	Formal workers' flow into	Formal firms' flow of vacancies equals

unemployment equals flow out of unemployment (Equation (9))	flow of filled jobs (Equation (11))	unemployment equals flow out of unemployment (Equation (10))	flow of filled jobs (Equation (12))
Determine E_R and U_R	Determine J_R and O_R	Determine E_F and U_F	Determine J_F and O_F

THE MODEL

(1) $x(1-u_{Ri}) = \beta_i \, p_u^R \, u_{Ri}$

(2) $x(1-u_F) = \beta \, p_u^F \, u_F$

(3) $x(1-o_{Rf}) = (a_f + z) \, p_o^R \, o_{Rf}$

(4) $x(1-o_F) = (a + z) \, p_o^F \, o_F$

(5) $V_E^{Mi} = V_S^{Mi}$, for M = R, F.

(6) r = E(profits | referrals) + E(profits | formal)

(7) $V_o^{Ri} (\hat{o}_{wRi\,(\beta i) \in R} \, w_{Ri} \, g(w_{Ri}) \, dw_{Ri}) = V_o^{Fi} (\hat{o}_{wFi\,(\beta i) \in F} \, w_{Fi} \, g(w_{Fi}) \, dw_{Fi})$

(8) $V_u^{Ri}(w_{Ri}) = V_u^{Fi}(w_{Fi})$

(9) $[\hat{o}_{\beta i \in R} \; \beta_i \, p_u^R \, u_{Ri} \, L_R \, f(\beta_i) \, d\beta_i] = x \, [\hat{o}_{af \in R} \; (1 - o_{Rf}) \, K_R \, h(a_f) \, da_f]$

(10) $[\hat{o}_{\beta i \in F} \; \beta \, p_u^F \, u_F \, L_F \, f(\beta_i) \, d\beta_i] = x \, [\hat{o}_{af \in F} \; (1 - o_F) \, K_F \, h(a_f) \, da_f]$

(11) $[\hat{o}_{af \in R} \; (a_f + z) \, p_o^R \, o_{Rf} \, K_R \, h(a_f) \, da_f] = [\hat{o}_{\beta i \in R} \; \beta_i \, p_u^R \, u_{Ri} \, L_R \, f(\beta_i) \, d\beta_i]$

(12) $[\hat{o}_{af \in F} \; (a + z) \, p_o^F \, o_F \, K_F \, h(a_f) \, da_f = [\hat{o}_{\beta i \in F} \; \beta \, p_u^F \, u_F \, L_F \, f(\beta_i) \, d\beta_i]$

(13) $K = J_R + O_R + J_F + O_F$

(14) $L = [\hat{o}_{\beta}^{\beta} \, f(\beta_i) \, d\beta_i] = E_R + U_R + E_F + U_F$

III.2. Workers' and Firms' Decisions in the Labor Market

The above system describes the supply side and the demand side of the labor market. Below, we describe in more detail how the decisions of workers (the supply side) and the decisions of firms (the demand side) are made.

III.2.1. Workers

Workers can be either employed or unemployed. When workers are unemployed, they focus their search through referrals or through formal channels. Each worker faces a search cost s per unit time, and thus his total search cost depends on how quickly he is able to find a job. Workers searching through referrals find jobs at the rate $\beta_i \, p_u^R$ which depends on the arrival rate of encounters of worker of type i with those in his social network, $\beta_i \in [\underline{\beta},\bar{\beta}]$. Moreover, the arrival rate of jobs depends on the effectiveness of referral search, which is given by the proportionality factor, p_u^R. Workers searching formally find jobs at the rate βp_u^F which is the same for all workers. The rate at which workers find formal jobs depends on the effectiveness of formal search, which is given by a proportionality factor, p_u^F.

Once employed, workers choose whether to exert effort, $e=\hat{e}$, or to exert no effort, $e=0$. The workers disutility of work is $c(\hat{e})=\hat{e}^2$. Since shirkers face an exogenous probability q of being caught, a worker exerts effort only if he is paid a high enough wage. If the wage is very low, however, workers will not exert effort. In addition, however, referred workers can be perfectly monitored by their peer referees. Although peers do not report their friends to supervisors, they prefer for their co-workers to exert as much effort as they do.[11] When referred workers do not conform to their work ethic, referees impose peer-pressure on their co-worker

friends. Thus, a worker who is referred by a diligent referee loses face with him if he shirks, while a worker who is referred by a shirker is ostracized if he works. Accordingly, the cost of peer-pressure is

$$(e_W - e_R)^2 = \begin{cases} \theta\hat{e}^2 & \text{if } e_W \neq e_R \\ 0 & \text{if } e_W = e_R, \end{cases}$$

where e_W is the effort level of the referee and e_R is the effort level of the referred worker. When a high effort worker refers a friend, he imposes peer-pressure on his friend only if he fails to exert effort. Having been referred by a hard working referee, thus, acts as a performance bond for a new employee. The implicit bond is the referee's support which the new worker has to renounce when he shirks.

III.2.2. Firms

Firms have jobs that are either filled or vacant. It is assumed that each firm has only one job. All jobs are subject to an exogenous breakup rate x. When a job is vacant, the firm decides whether to focus its search through referrals or through formal channels. The cost to a firm from holding a vacancy is the foregone stream of profits during the time the vacancy remains unfilled. A firm f hiring through referrals fills its job at the rate $(a_f+z)p_o^R$, which depends on firm-specific factors, $a_f \in [a,a]$ (i.e., the idiosyncratic arrival rate of applicants) and on labor market factors that affect all firms, z (e.g., the relative abundance of the type of labor being hired). Moreover, the rate at which vacant jobs are filled depends on the effectiveness of referral search for firms, which is given by the proportionality factor, p_o^R. Firms searching formally fill

[11]See Jones (1984) for evidence and discussion of conformist behavior at the workplace.

jobs at the rate $(a+z)p_o^F$, which is the same for all firms. The rate at which firms fill jobs formally depends on the effectiveness of formal search, which is given by the proportionality factor, p_o^F.

Once the job has been filled through a given channel, the firm must then choose a wage that minimizes its labor costs per efficiency unit. A firm that pays a high wage can increase output by eliciting worker effort. A worker produces A units of output per unit time when he exerts effort, but only γA units of output when he shirks.

III.3. Solution to the Model

A firm that meets a worker through a given channel must choose a wage and, accordingly, the worker must choose whether or not to exert effort. Given the wage offer appropriate to each channel, a firm with a vacancy must decide either to use referrals or to search formally. Likewise, given the expected wage offers through each channel, workers must decide whether to focus their search through referrals or to search formally. In the steady-state equilibrium, there is a correspondence between workers and firms using each search channel.

III.3.1. The Choice of Wages

A firm that has filled a vacancy using a given channel has to decide on the wage offer it will extend its new worker. In particular, to maximize its gains, a firm must decide whether to offer a high wage that motivates the worker to produce a high level of output or to offer a wage that just satisfies the employee to come to work.

Define V_J^{Mi} as the lifetime stream of profits for a firm with a job filled with an individual of type i through method M (where M=R,F). Similarly, define V_O^{Mi} as the lifetime stream of profits of a firm filling its vacancies by method M with an expected group of applicants of type i. The optimal value equation for a firm with a job filled with individual i is

$$rV_J^{Mi} = (R(A) - w_{Mi} - r) + x(V_O^{Mi} - V_J^{Mi}), \tag{i}$$

where R(A) is the firm's revenue which is equal to A if workers exert effort and γA if workers shirk. When the vacancy has been filled by method M, the firm's goal is to pay a wage that maximizes its lifetime stream of profits, V_J^{Mi}. Thus, depending on how the firm's vacancy has been filled, the firm will either pay the lowest possible efficiency wage (which results in high output levels) or it will pay the market wage (which satisfies the employee to come to work).

The optimal value equation for firm f with a vacancy is

$$rV_O^{Mi} = - r + \int_{wMi\,(\beta i) \in M} p(a_f, M)(V_J^{Mi} - V_O^{Mi})\, g(w_{Mi})\, dw_{Mi}, \tag{ii}$$

where $p(a_f, M)$ is the rate at which firm f fills its vacant job when using search method M. This rate is equal to $(a_f+z)p_o^R$ if the job is filled through referrals and equal to $(a+z)p_o^F$ if the job is filled formally. Vacancies can be created or eliminated freely, but there is a fixed cost of capital r of maintaining a job (either filled or vacant). Only after the firm has incurred the fixed cost, nature assigns it an idiosyncratic arrival rate of applicants, a_f .

For a firm to elicit effort and obtain higher output, it must pay a high enough wage such that worker i is indifferent between working and shirking. Thus, the firm

must pay a wage that satisfies the no-shirking condition (NSC) given by equation (5) in the model: $V_E^{Mi} \geq V_S^{Mi}$, where V_E^{Mi} and V_S^{Mi} are the expected lifetime utilities for an employed non-shirker and for an employed shirker of type i, respectively, who obtained his job through method M. The asset equations for the worker i's lifetime utilities are

$$rV_E^{Mi} = w_{Mi} - c(\hat{e}) + x(V_U^{Mi} - V_E^{Mi}), \tag{iii}$$

$$rV_S^{Mi} = w_{Mi} - (e_W - e_R)^2 + (x+q)(V_U^{Mi} - V_S^{Mi}), \text{ and} \tag{iv}$$

$$rV_U^{Mi} = -s + p(\beta_i, M)(V^{Mi} - V_U^{Mi}), \tag{v}$$

where $p(\beta_i, M)$ is the rate at which an unemployed worker of type i using method M finds work. The arrival rate of job opportunities of individual i searching through referrals is $\beta_i p_u^R$, and the arrival rate of job opportunities for workers searching formally is βp_u^F. Substituting equations (iii), (iv), and (v) into the no-shirking condition yields the efficiency wage w_{Mi}^* that a firm which has filled its job through method M should pay to elicit effort from worker i. After determining the efficiency wage for each search channel in this way, we can contrast the wages firms hiring through referrals and firms hiring formally have to pay to motivate workers. The next lemma compares the efficiency wage a firm hiring through employee referrals must pay to the efficiency wage a firm hiring formally must pay.

LEMMA 1.1: The efficiency wage a firm has to pay is lower if worker i is hired by an employee referral than if he is hired formally:

$$w_{Ri}^* = \hat{e}^2 - s + (r+x+\beta_i p_u^R)\hat{e}^2(1-\theta)/q < w_F^* = \hat{e}^2 - s + (r+x+\beta p_u^F)\hat{e}^2/q.$$

(vi)

PROOF: All proofs are in the Appendix.

When firms use employee referrals, they are able to pay lower efficiency wages, without adversely affecting worker productivity, for two reasons. First, implicit bonding enforced by social networks allows firms to pay lower efficiency wages to motivate workers. This is because trustworthy referees initially put in a good word for their friends, but they credibly threaten to withdraw their support and impose sanctions whenever their referred friends shirk. Second, because it is harder for workers who search through referrals to find alternative job opportunities, firms hiring through referrals find it easier to motivate workers.

Lemma 1.1 shows that there is a low enough wage that get referred workers not to shirk, but the wage that gets formal hires not to shirk is much higher. If both firms hiring formally and firms hiring through referrals were willing to pay efficiency wages, then the labor market would consist exclusively of non-shirkers. In the non-trivial case in which some workers shirk and, thus, some firms do not pay efficiency wages, firms hiring through referrals pay efficiency wages because they can save on monitoring costs and firms hiring formally, instead, pay a market wage to shirkers.

The above Lemma indicates that the implicit bonding imposed by referees, allows firms hiring through employee referrals to lower efficiency wages and, thus, to reduce unemployment. The question then arises whether ingenious recruitment methods such as referrals can be so effective as to eliminate involuntary unemployment. Lemma 1.2 shows that under a strong condition on peer monitoring, the equilibrium efficiency wage does not require the payment of rents.

LEMMA 1.2: As the cost from peer-pressure imposed by referees gets to be as large as the workers' disutility for work, the wage paid by firms hiring through referrals approaches a lower bound:

$$\lim_{\theta \to 1} \quad w_{Ri}^{*} = \hat{e}^2 - s. \tag{vii}$$

This lemma determines that for referrals to eliminate the payment of efficiency wages, peer-pressure would have to be sufficiently strong to motivate workers without the payment of rents. However, corollary 2.1 below shows that when θ approaches 1, then every worker prefers to search formally and, thus, every match in the economy occurs through formal channels. Moreover, if the wage in condition (vii) is greater than the formal wage, firms can pay lower efficiency wages by using referrals but they cannot completely eliminate the payment of rents to motivate workers.

Rather than paying efficiency wages, employers hiring formally pay a wage high enough to attract shirkers to come to work, and low enough so that the employer does not expect to make losses. The formal wage, w_F, is thus determined by the zero-profit condition given by equation (6) in the model. The firm's expected profits must equal its fixed cost of capital, r:

$$r = E(\text{profits} \mid \text{referral}) + E(\text{profits} \mid \text{formal}). \tag{6}$$

Prior to incurring the fixed cost that allows the firm to create a vacancy, the firm does not know its type and, thus, it does not know its optimal search channel. Once, the firm has incurred the cost, nature assigns the firm an arrival rate of applicants, a_f. If the arrival rate of applicants is high enough to allow the firm to fill the vacancy

quickly, then the firm uses referrals. However, if the arrival rate is low, the firm relies instead on formal channels. Moreover, the expected efficiency wage the firm has to pay depends on the group of applicants with type i searching through referrals. Thus, the zero-profit condition for the average firm determines the formal wage:

$$r=[\hat{o}_{af \in R} (a_f+z)p_u^R (A- (\hat{o}_{wRi\,(\beta i) \in R} w_{Ri}\, g(w_{Ri}) dw_{Ri})) h(a_f) da_f]$$

$$+[\hat{o}_{af \in F} (a+z) p_u^F (\gamma A-w_F) h(a_f) da_f]. \qquad (6')$$

III.3.2. Division of Firms between the two Search Channels

Given that a job is filled through referrals, it is optimal for the firm to pay an efficiency wage that minimizes its labor cost per efficiency unit. Given that a job is filled formally, the firm pays the market wage because it is too costly to motivate workers. Thus, hiring through referrals allows firms to save on monitoring costs or, equivalently, to increase output at a given wage. The use of referrals, however, requires higher search costs than formal channels, because they require a longer period to fill a vacancy and, thus, higher foregone profits. Since the rate at which vacant jobs are filled through referrals, $(a_f+z)p_u^R$, differs across firms, some firms face lower search costs when using referrals than others. The split of firms between the two search channels is determined by comparing the lifetime stream of profits of a vacancy when the firm hires through referrals and pays efficiency wages, V_O^{Ri*}, to the lifetime stream of profits of a vacancy when the firm hires formally and pays the market wage, V_O^F. Firms with high arrival rates find it less costly to use referrals, while firms with low arrival rates face high search costs from filling the vacancy through referrals. Proposition 1 determines the division of firms between the two

search channels by establishing the cutoff arrival rate for the firm that is just indifferent between the two hiring channels.

PROPOSITION 1: For firms with idiosyncratic arrival rates of applicants $a_f \in [a_{crit}, a]$ it is optimal to hire by employee referrals and pay efficiency wages. For firms with arrival rates $a_f \in [a, a_{crit}]$ it is optimal to hire formally and pay the market wage, where a_{crit} is the cutoff arrival rate for the firm that is just indifferent between the two hiring channels. That is, a_{crit} is the solution to equation (7) in the model:

$$V_O^{Ri*} = V_O^F. \tag{7}$$

III.3.3. Division of Workers between the Two Search Channels

Workers are known to concentrate their time and effort on a few methods when searching for work.[12] In the model, workers will either concentrate in searching through formal channels or they focus their energy in reaching out to people in their social network to help them find work. As described in Wial's study in Boston, workers learn early on from their friends and relatives that the only way of obtaining a "good" job is through luck or personal contacts. Thus, from the workers perspective, the only conceivable way of acting, if one wants to obtain a job that pays a high wage, is by searching through referrals. That is, workers observe the wages paid by firms hiring through each channel and they focus their search accordingly.

While searching through one's network of friends provides better jobs, the lower arrival of job opportunities for some workers makes it very costly to insist on using this search method without prolonging their unemployment durations

[12]See, for example, the evidence presented by Holzer (1988).

excessively. Proposition 2 shows that the division of workers concentrating on referral search and workers focusing on formal search is determined by the arrival rate of encounters with those in one's network for the worker who is 'marginal' between the two methods.

PROPOSITION 2: For workers with idiosyncratic arrival rates of encounters with network members $\beta_i \in [\beta_{crit}, \beta]$, it is optimal to search through referrals. For workers with arrival rates of encounters with network members $\beta_i \in [\beta, \beta_{crit}]$, it is optimal to search formally, where β_{crit} is the arrival of encounters for the worker who is just indifferent between searching through his social network and searching through formal channels. That is, β_{crit} is the solution to equation (8) in the model:

$$V_U^{Ri*} = V_U^{Fi}. \tag{8}$$

COROLLARY 2.1: Since the cut-off arrival rate of job opportunities is

$$\beta_{crit} = [\beta p_u^F (w_F+s)\, q] / [p_u^R (r+x+\beta p_u^F)\, \hat{e}^2(1-\theta)], \tag{viii}$$

then,

$$\lim_{\theta \to 1} \beta_{crit} = \beta.$$

When the peer-pressure imposed by referees, $\theta\hat{e}^2$, is as costly as the disutility from work, $\hat{e}^2$, workers obtain minimal or no rents at all and, thus, do not derive any benefit from searching through referrals. Moreover, since searching through referrals provides less information on job opportunities, workers prefer to search formally. Hence, when worker rents are dissipated because of the effectiveness of peer-pressure, workers rely solely on formal search channels.

An Extension: Heterogeneity in Worker Ability. The assumption of heterogeneous arrival rates of encounters with those in one's social network may underlie heterogeneous abilities among individuals. That is, one may believe that workers have different arrival rates of encounters with network members because of differences in productivity. In such a case, we can assume that the productivity of each worker i is A_i, and that A_i is uniformly distributed from A to A. Then, the arrival rate of encounters for individual i can be assumed to be a function of his productivity, $\beta(A_i)=BA_i$. Substituting $\beta(A_i)=BA_i$ into the proof for proposition 2 yields the cutoff productivity, A_{crit} , for the worker who is just indifferent between searching through either method. Proposition 2' would then replace Proposition 2.

PROPOSITION 2': For workers with productivity $A_i \in [A_{crit}, A]$, it is optimal to search through referrals. For workers with productivity $A_i \in [A, A_{crit}]$, it is optimal to search formally, where A_{crit} is the productivity of the worker who is just indifferent between searching through his social network and searching through formal channels. That is, A_{crit} is the solution to

$$V_U^{Ri*} = V_U^{Fi}, \tag{8'}$$

and equal to $A_{crit} = [Ap_u^F (w_F+s) q] / [p_u^R (r+x+ABp_u^F) \hat{e}^2(1-\theta)]$.[13]

III.4. Equilibrium Matching and the Segmentation of the Labor Market

[13]This modification of the model would also require to adjust the division of firms between the two search channels. The rational expectations equilibrium would require that the expected productivity of firms using referrals would be equal to the mean productivity of workers searching through referrals. Likewise, the expected productivity of firms using formal channels would have to be equal to the mean productivity of workers searching formally.

In steady-state equilibrium, the flow into unemployment for workers who were hired through referrals is equal to the flow out of unemployment for workers searching through referral networks. This steady-state condition is given by equation (9) in the model:

$$[\hat{o}_{\beta i \in R} \ \beta_i \ p_u^R \ u_{Ri} \ L_R \ f(\beta_i) \ d\beta_i] = x \ [\hat{o}_{af \in R} \ (1 - o_{Rf}) \ K_R \ h(a_f) \ da_f].^{14} \tag{9}$$

Since we know that individuals with $\beta_i \in [\beta_{crit}, \beta]$ use referrals and firms with $a_f \in [a_{crit}, a]$ hire through referrals, we can substitute for these in the steady-state condition:

$$[\hat{o}^{\beta}_{\beta crit} \ \beta_i \ p_u^R \ u_{Ri} \ (1-F(\beta_{crit})) \ f(\beta_i) d\beta_i]$$

$$= x \ [\hat{o}^{a}_{acrit} \ (1 - o_{Rf}) \ (1-H(a_{crit})) \ h(a_f) \ da_f]. \tag{9'}$$

This condition yields the effectiveness of search for workers using referrals, p_u^R,

$$p_u^R = x[\hat{o}^{a}_{acrit} \ (1 - o_{Rf}) \ (1-H(a_{crit})) \ h(a_f) \ da_f] /$$

$$[\hat{o}^{\beta}_{\beta crit} \ \beta_i \ u_{Ri} \ (1-F(\beta_{crit})) \ f(\beta_i) \ d\beta_i].$$

Thus, the effectiveness of referral search for workers increases as more firms fill their vacancies through referrals, and it decreases as more unemployed workers search through referrals. The close form solution for p_u^R is determined by substituting equations (1) and (3) from the model into the p_u^R equation. Equation (1) determines that the probability that a worker searching through referrals moves from employment into unemployment is equal to the probability that he moves from unemployment into employment. Similarly, equation (3) determines that the probability that a firm hiring

through referrals fills a vacant job is equal to the probability that its filled job becomes vacant.

Likewise, to determine the effectiveness of formal search, we use the steady-state condition that the flow into unemployment of those who were hired formally is equal to the aggregate flow out of unemployment for those searching formally. This steady-state condition is given by equation (10) in the model:

$$[\hat{o}_{\beta i \in F} \beta p_u^F u_F L_F f(\beta_i) d\beta_i] = x [\hat{o}_{af \in F} (1 - o_F) K_F h(a_f) da_f]. \quad (10)$$

Since we know that individuals with $\beta_i \in [\beta, \beta_{crit}]$ use formal channels and firms with $a_f \in [a, a_{crit}]$ hire formally, we can substitute for these in the steady-state condition and then solve for the effectiveness of referral search, p_u^F,

$$p_u^F = x [\hat{o}_a^{acrit} (1 - o_F) H(a_{crit}) h(a_f) da_f] /$$

$$[\hat{o}_\beta^{\beta crit} \beta u_F F(\beta_{crit}) f(\beta_i) d\beta_i].$$

Thus, the effectiveness of formal search for workers increases with a greater number of firms filling their vacancies formally, and with a smaller number of unemployed workers searching formally. The close form solution for p_u^F is determined by substituting equations (2) and (4) from the model into the equation above. Equation (2) determines that the probability that a worker searching formally moves from employment into unemployment is equal to the probability that he moves from unemployment into employment. Similarly, equation (4) determines that the probability that a firm hiring formally fills a vacant job is equal to the probability that its filled job becomes vacant.

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[14] L_M is the proportion of workers using method M, and K_M is the proportion of firms hiring through method M.

To determine the rate at which firms using each method fill their jobs, we consider the steady-state conditions that the flow of vacant jobs equals the aggregate flow of unemployed workers going into jobs through each channel. Equation (11) determines that for firms using referrals, it must be that the flow of vacant jobs being filled through referrals is equal to the flow of unemployed workers hired through referrals,

$$[\int_{af \in R} (a_f + z)\, p_o^R\, o_{Rf}\, K_R\, h(a_f)\, da_f] = [\int_{\beta i \in R} \beta_i\, p_u^R\, u_{Ri}\, L_R\, f(\beta_i)\, d\beta_i]. \quad (11)$$

Substituting for the types using referrals into this steady-state condition yields the effectiveness of search for firms hiring though referrals, p_o^R,

$$p_o^R = [\int_{\beta crit}^{\beta} \beta_i\, p_u^R\, u_{Ri}\, (1-F(\beta_{crit}))\, f(\beta_i)\, d\beta_i] /$$

$$[\int_{acrit}^{a} (a_f + z)\, o_{Rf}\, (1-H(a_{crit}))\, h(a_f)\, da_f].$$

Thus, the rate at which firms hiring through referrals fill jobs increases with the number of workers searching through referrals and it decreases with the number of firms hiring through this channel.

Similarly, equation (12) determines that for firms hiring formally, it must be that the flow of vacant jobs filled formally is equal to the flow of unemployed workers hired formally,

$$[\int_{af \in F} (a + z)\, p_o^F\, o_F\, K_F\, h(a_f)\, da_f] = [\int_{\beta i \in F} \beta\, p_u^F\, u_F\, L_F\, f(\beta_i)\, d\beta_i]. \quad (12)$$

Substituting for the types using formal channels into the steady-state condition yields the effectiveness of search for firms hiring formally, p_o^F,

$$p_o^F = [\int_{\beta}^{\beta crit} \beta\, p_u^F\, u_F\, F(\beta_{crit})\, f(\beta_i)\, d\beta_i] /$$

$$[\int_{a}^{acrit} (a + z)\, o_F\, H(a_{crit})\, h(a_f)\, da_f].$$

Thus, the rate at which firms hiring formally fill jobs increases with the number of workers searching formally and decreases with the number of firms hiring through formal channels.

The steady-state conditions presented above show that the matching process generates labor market segmentation. Search decisions sort heterogeneous firms and workers into two groups: referrals match 'good' jobs to 'good' workers, while formal methods match less attractive jobs to disadvantaged workers.

The costs of referral search are lower for firms that offer more attractive conditions and receive more applicants, high a_f firms, and for well-connected workers who learn more quickly about job opportunities, high β_i workers. Thus, these firms and workers self-select into referral matches. Moreover, firms hiring through referrals pay efficiency wages and, hence, referred workers earn higher wages. Jobs filled through referrals, thus, attract queues of workers waiting for 'good' jobs and well-connected workers can use referrals to jump the queues for these good jobs.

Formal methods match less attractive firms, low a_f firms, to those workers facing less opportunities in the labor market, low β_i workers. Since the costs of referral search are higher for firms with low arrival rates of applicants and for workers with low arrival rates of job opportunities, these firms and workers self-select into formal matches. Moreover, firms hiring formally pay market clearing wages and, thus, workers hired through formal methods earn lower wages.

IV. Unemployment with Congestion Externalities in Referral Search

In deciding where to focus their search, workers consider their private gain from using employee referrals but they ignore the externality imposed on other

workers searching through this channel. A worker deciding to search through friends and relatives considers his probability of obtaining a job if focusing search in this way, but he does not take into account the effect of his decision on others. In fact, the worker lowers the probability of getting jobs for all other workers searching through referrals. By entering a queue for scarce "good" jobs, he lowers everyone else's arrival rate of job offers. Moreover, the negative externalities that result from congestion become worse as firms pay higher above market clearing wages and increase job rationing.

This congestion in the search process implies that the split in the population between formal search and search through referrals is not optimal. Moreover, because search activities determine the duration of unemployment, the unemployment rate is unlikely to be optimal. The lower arrival rate of job offers that results from congestion, increases the *duration* of unemployment for each worker searching through referrals. These congestion externalities cause the unemployment rate to be too high because unemployment spells are prolonged as a result of crowding. Below we will show that a combination of taxes and subsidies can increase formal search and, thus, reduce unemployment closer to its optimal rate.

IV.1. The Effects of Congestion on Unemployment Duration

The duration of unemployment for an individual depends inversely on his probability of obtaining a job. In particular, the duration of unemployment for an unemployed worker searching through formal methods is

$$D_{Fi} = (1/\beta p_u^F). \tag{ix}$$

Similarly, the unemployment duration for a worker i searching through referrals is

$$D_{Ri} = (1/ \beta_i \, p_u^R). \tag{x}$$

Comparing (ix) and (x) shows that a given individual i experiences longer unemployment duration when searching through referrals compared to when searching formally. The longer spells of unemployment when searching through referrals result for two reasons: (1) referrals are a more time-consuming channel of finding jobs, and (2) congestion in referral search occurs because too many workers search for a good job and these 'good' jobs are scarce. This congestion prolongs the time a worker must wait for a good job. The effect of crowding on the duration of unemployment can be seen by substituting for the arrival rate of job offers through referrals, p_u^R, into equation (x):

$$D_{Ri} = [\int_{\beta crit} \beta_i \, u_{Ri} (\int_{\beta crit} f(\beta_i) d\beta_i) \, f(\beta_i) \, d\beta_i] /$$

$$\beta_i \, x \, [\int_{acrit}^{a} (1 - o_{Rf}) (\int_{acrit}^{a} h(a_f) \, da_f) \, h(a_f) \, da_f]. \tag{x'}$$

Unemployment duration for workers searching through referrals is longer when the number of workers using referrals is large, β_{crit} is small. The increased congestion decreases the arrival of job opportunities through referrals and, thus, lowers the likelihood of finding a good job. Thus, workers searching through referrals experience longer unemployment spells due to the negative externality in referral search. Moreover, when the number of jobs filled through referrals is smaller (jobs filled through referrals are scarcer), a_{crit} is large, workers searching through referrals experience longer spells of unemployment because they have to wait longer in the queue to obtain a good job.

The average duration of unemployment in the economy is the average duration of unemployment for workers searching through referrals plus the average duration of unemployment for workers searching formally, which can be obtained by using equations (ix) and (x),

$$D = D_R + D_F$$

where,

$$D_R = \{ \int_{\beta crit} [\int_{\beta crit} \beta_i \, u_{Ri} \, (1-F(\beta_{crit})) \, f(\beta_i) \, d\beta_i] /$$

$$\beta_i \, x[\int_{acrit} (1 - o_{Rf}) \, (1-H(a_{crit})) \, h(a_f) \, da_f] \, f(\beta_i) \, d\beta_i \} / (1-F(\beta_{crit}))$$

and,

$$D_F = \{ \int_{\beta}^{\beta crit} [\int_{\beta}^{\beta crit} \beta \, u_F \, F(\beta_{crit}) \, f(\beta_i) \, d\beta_i] /$$

$$\beta x[\int_{a}^{acrit} (1 - o_F) \, H(a_{crit}) \, h(a_f) \, da_f] \, f(\beta_i) \, d\beta_i \} / F(\beta_{crit}).$$

In equilibrium, workers searching formally experience shorter unemployment spells than workers using referrals because the rate at which unemployed workers searching formally find jobs is higher. By contrast, while well-connected workers self-select into referral search, congestion in referral search prolongs the time they must wait for good jobs. This finding accords with the evidence provided by Clark and Summers (1979) and Summers (1986) which indicates that "persons losing high wage jobs are most likely to experience protracted spells of unemployment." (p.382)

IV.2. Market and Non-market Mechanisms to Reduce Unemployment

At the margin, inducing workers to search formally decreases congestion in referral matching and reduces the average duration of unemployment in the economy.

Thus, increasing the incentives for workers to search through formal channels mitigates the externalities and increases the efficiency of the labor market.

A Market Mechanism. One way of overcoming congestion externalities is to set up a missing market for referrals. The payment of referral bonuses to current employees does precisely this. In their pioneering study of referrals, Rees and Shultz (1970) indicated that several of the establishments they interviewed "paid bonuses to [current] employees for referrals who were hired; in one case the bonus was fifty dollars per hire." The payment of bonuses increases the peer-pressure imposed on referred workers who shirk, because current workers would be forced to forfeit the bonuses paid by their employers. In turn, greater peer-pressure by referees decreases the efficiency wage that employers have to pay. Thus, the bonus is a transfer from the referred worker to his friend. The effect of this bonus is to reduce the benefit from using referrals and to increase, at the margin, the number of workers who search formally (see Corollary 2.1). The payment of referral bonuses could then decrease the average duration of unemployment by mitigating congestion externalities. Given the benefit of paying referral bonuses, why then are these bonuses not used more widely? Although a worker prefers for other workers to pay a transfer to their referees because this reduces congestion, he personally prefers to earn higher rents rather than transfer the bonus to his referee. Thus, while firms that pay referral bonuses increase the referees incentives to recruit his friends and relatives, these referees face greater difficulty attracting job applicants.

Taxes and Subsidies. A second way of reducing congestion is by introducing the proper combination of taxes and subsidies that correct the inefficiencies in the market.

Imposing a tax on the unemployed not only reduces shirking incentives, as proposed by Shapiro and Stiglitz, but the tax also increases the incentives to search formally. Similarly, a subsidy paid to unemployed workers who start a new job increases the incentive to search through formal channels which are less time-consuming. Because referrals prolong the spell of unemployment relative to formal methods for a given individual, an increase in the costs of search provides incentives for workers to use formal search channels. Moreover, the increase in formal search that would ensue from taxing the unemployed or from paying them a job-start subsidy, reduces the extent of congestion in referral matching and shortens unemployment duration for workers using referrals. Consequently, a tax on the unemployed or a subsidy paid to unemployed workers who start a job would help reduce unemployment closer to its optimal rate.

In addition, providing wage subsidies or vouchers to firms that hire the unemployed can also help mitigate crowding in referral search. As it has been indicated, the problem of congestion arises because jobs filled through referrals are rationed. Providing a wage subsidy increases short-run profits, promoting entry and increasing the number of jobs in the economy. Moreover, increasing the overall number of jobs increases the probability of obtaining a job through referrals and reduces the duration of unemployment for workers searching through this method.

When the number of people using referrals is very large, imposing taxes on the unemployed, paying subsidies for job-start, or providing wage vouchers to firms that hire the unemployed would decrease the unemployment rate and increase welfare. We conduct welfare analysis to show this formally. Total welfare in the economy is

equal to the sum of utility and profits for all employees and firms matching through referrals and formal channels. Thus, the welfare function is,

$$W = A(E_R + E_F) - rK - \hat{e}^2 E_R - s(U_R + U_F).^{15}$$

To see how an unemployment tax (or, equivalently, an employment subsidy for the unemployed) and a wage subsidy would affect social welfare, we consider the effect of a change in both search costs and the total number of jobs. Proposition 3 provides the conditions under which the taxes-cum-subsidies proposed above would increase welfare.

PROPOSITION 3: When the number of workers using referrals is very large, β_{crit} is small (e.g, θ is small), then $\partial^2 W/\partial K \partial s > 0$. When the number of workers searching through referrals is small, β_{crit} is large (e.g., θ is large), then $\partial^2 W/\partial K \partial s < 0$.

This proposition indicates that when the number of workers searching through referrals is large and, presumably, congestion externalities are severe, an increase in search costs increases the welfare improvement from creating more jobs. If on the contrary, most workers search formally, imposing a tax on the unemployed would decrease welfare when new jobs are being created.

V. Discussion of the Model and the Evidence

Previous economic theories of referrals cannot explain the link between referrals and the inter-industry wage structure. In contrast, the bonding theory of referrals presented in this paper is consistent with the empirical regularities documented in Section II.

[15]The total number of filled and vacant jobs in this economy is determined endogenously and given by equation (13) in the model, $K = J_R + J_F + O_R + O_F$.

V.1. Match-Quality and Ability-Based Theories of Referrals

Match-quality theories developed to explain the widespread use of referral search in the labor market cannot explain the relation between referrals and inter-industry wage differentials. According to these theories, referrals provide prospective applicants with superior match-quality information which allows them to self-select into jobs in which they are more productive. (Staiger, 1990; Simon and Warner, 1992) While these theories are able to explain why workers hired through referrals earn higher wages, they cannot explain why industries that pay wage premiums to all workers rely more extensively on employee referrals. Neither can match-quality theories explain why product market characteristics (e.g., profits, concentration ratios) should be associated with greater reliance on employee referrals. Moreover, match-quality explanations of referrals would predict lower turnover and lower unemployment in sectors hiring through referrals, because, according to these theories, referrals help to smooth frictions associated with search in the labor market. The evidence in Section II shows that individual workers hired through referrals have longer tenures, but that unemployment is higher in sectors where employee referrals are used more extensively.[16]

Ability-based theories of referrals explain why firms may want to use referrals when the labor market is characterized by adverse selection. One version of this theory suggests that employers solicit referrals from high-ability employees when they cannot observe the quality of applicants. (Montgomery, 1991) Another version argues that referees tend to refer high quality applicants because they may feel that their own

reputation is at stake when making a referral. (Saloner, 1985). Like match-quality theories, ability-based theories of referrals can explain why referred workers earn higher wages. Moreover, a modified version of this model which allows for two sectors with different technologies, an ability-sensitive technology and a less-ability sensitive technology, can explain the association between industry wage differentials and referral hiring that we observe in the data. Moreover, this version of the theory may explain why product market characteristics related to technology are associated with greater reliance on employee referrals. Ability based-theories, however, have difficulty explaining the higher unemployment and lower turnover of workers in sectors that rely extensively on referrals. Finally, contrary to the empirical findings, these theories predict that workers with higher measured ability (in terms of education, occupation, etc.) would be hired through referrals.

V.2. The Bonding Theory of Referrals and the Inter-Industry Wage Structure

The bonding theory of referrals presented in this paper is able to explain the relation between referrals and the inter-industry wage structure. This theory argues that, when firms hire through referrals, they are able to replicate an honest work force without the need to share a significant fraction of their rents. Rent-sharing firms can, thus, save on labor costs by relying on employee referrals. Consequently, jobs filled through referrals tend to be scarce and, thus, employees looking for work in this way tend to face congestion in their search.

This bonding theory can explain why sectors that pay wage premiums rely more extensively on employee referrals. The theory can also explain why product

[16]Match-quality theories do not predict anything with respect to the types of workers one should

market characteristics associated with the payment of rents are related to the use of referrals in an industry. Moreover, according to the theory, industries that rely on referrals pay rents and ration their jobs, and thus the higher unemployment observed in these industries. In addition, the theory predicts that the excessive search for scarce jobs can generate congestion which further increases unemployment by lengthening the average spell of unemployment. The scarcity of jobs filled through referrals can also explain why referred workers have longer tenures. If referred workers indeed earned rents, we would expect them to have lower turnover and longer tenures.

It remains to explain the link between referrals and the occupational structure. The evidence in Section II indicates that referrals are used more widely to hire blue-collar and service workers compared to white-collar employees. A careful examination of the model suggests an explanation why firms would tend to hire specialized workers through formal methods, while hiring less-specialized workers through referrals. When employers face a higher arrival rate of applicants, for example because of the relative abundance of the applicant group been sought (e.g., unskilled workers), they face a lower opportunity cost of holding a vacancy and, thus, they are more likely to use time-consuming channels such as referrals to fill their vacancies. On the contrary, when employers search for very specialized skills (e.g., a bassoon player, or a deep sea diver), they expect to receive a limited pool of applicants and, thus, they focus their search through formal channels.[17]

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expect to match through referrals.

[17]In the model, higher values of z, higher arrival rates for all firms, are associated with lower values of the cutoff arrival rate, a_{crit}.

VI. Conclusion

Previous research has documented that workers who find their jobs through referrals earn higher wages and have longer tenures than workers hired formally. This paper provides new evidence on the link between referrals and the inter-industry wage structure.

The paper develops a matching model with referrals and formal search methods which can explain why rent sharing firms rely more on referrals. First, I find that the gains from paying wages above market clearing are the greatest for firms hiring through referrals because of the peer monitoring role played by referees. A firm hiring through referrals can pay lower wages to motivate workers because the referees provide an implicit bond for new employees. Thus, when the benefit from paying efficiency wages is greater, firms use referrals more widely. Second, whether firms rely on employee referrals depends on the cost of filling vacancies through this method. The opportunity cost of using referrals is the prolonged time the vacancy remains unfilled due to the smaller applicant pool obtained through referrals. Thus, firms that are more attractive and have higher arrival rates of applicants rely more on employee referrals. Similarly, workers' decisions on where to focus their search activities depends on the opportunity cost of relying on friends and relatives to obtain jobs. While referrals are a way of obtaining 'good' jobs, when workers search through referrals they learn about fewer job opportunities. Thus, well-connected

workers who receive more job offers self-select into referral matches, but disadvantaged workers tend to focus their search formally.

The matching process generates labor market segmentation. Moreover, the payment of wages above market clearing implies that jobs filled by employee referrals are rationed and workers must queue to obtain these high-wage jobs. Since network size varies, well- connected workers (those belonging to large networks) can use referrals as an exercise in queue jumping. By contrast, workers belonging to restrictive networks may never even attempt queuing for these good jobs. Moreover, since networks are a by-product of social interactions, some demographic groups (e.g., men compared to women) may have more access than others to jobs in high-wage industries.[18]

The implications of the model are borne out by the empirical evidence. First, I find that industries with a higher proportion of referred workers pay wage premiums. Also, industries with industry characteristics identified with high-wage industries rely more extensively on referrals. I also find that, even after controlling for worker quality and other industry characteristics, industries with higher percentages of referred workers provide higher total compensation (including wage compensation and fringe benefits). Finally, as predicted by the model, unemployment rates are higher in industries that have a larger percentage of referred workers.

The analysis indicates that the equilibrium unemployment rate in the economy is unlikely to be efficient. The split of workers between referrals an formal search is not optimal because there are congestion externalities in referral search. When

[18]The results in Tables 1-4 show that, in fact, industries where a larger fraction of workers is hired through referrals also have a larger fraction of male workers.

deciding to search through referrals workers generate congestion because, by entering a queue for good jobs, they lower everyone else's probability of obtaining a job. When jobs are rationed, this congestion prolongs the average unemployment duration in the economy. Workers searching through referrals stay "too long" waiting for good jobs. Moreover, while those who are first in the queue may do well in the long term by using referrals, those who are last in the queue may experience long spells of unemployment due to a poor start. Early successful matches mediated through referrals can lead workers to accumulate more contacts and, thus, to further improve their matches over time. However, poor early matches due to lack of information may initiate a history of unemployment for those searching through restricted networks which can become self-sustaining. The presence of congestion externalities and path-dependency suggests that improving the incentives for workers "at the margin" to search formally would reduce the duration of unemployment. This may be why public employment service programs seem to reduce unemployment spells for both program participants and for non-participants (Meyer, 1991). Moreover, since the isolation of the long-term unemployed from personalized networks worsens the psychological effects of unemployment, increased incentives to use public employment offices can help to mitigate the discouraged worker effect that long-term unemployed workers tend to experience.

The division of firms between the two search channels is also unlikely to be efficient because firms' choices of hiring methods impose external effects on each

other.[19] When a firm decides to use employee referrals, it increases the hiring rate for workers searching through networks and makes it harder to motivate new employees. The greater is the hiring rate through referrals, the higher the efficiency wage required to motivate workers and the higher the level of involuntary unemployment. At the margin, it is optimal to induce firms to hire formally. In the United States and Europe, public policy discussions have suggested the need to improve the services provided by public employment agencies in order to increase firms' incentives to use formal channels. In Europe, it has been argued that allowing private agencies to provide similar services may be beneficial. The availability of private employment agencies would induce more firms to hire formally and help to reduce unemployment. The general equilibrium analysis in this paper contributes to an understanding of what policies directed at workers and employers can improve the efficiency of the labor market.

APPENDIX

[19]The discussion here closely follows David Levine's analysis (Levine, 1989) of firms' external effects when there is moral hazard.

Division of Firms between the two Search Channels

Proof of Lemma 1.1:

To ensure that an employed worker hired through referrals exerts effort, the firm has to pay a wage to satisfy the no-shirking condition (NSC): $V_E^{Ri} \geq V_S^{Ri}$. Thus, the lowest wage the firm can pay and still satisfy the NSC is given by:

$$V_E^{Ri} = V_S^{Ri}$$

$$(w_{Ri} - \hat{e}^2) + x(V_U^{Ri} - V_E^{Ri}) = (w_{Ri} - \hat{e}^2) + (x+q)(V_U^{Ri} - V_E^{Ri}).$$

Thus,

$$(V_E^{Ri} - V_U^{Ri}) = \hat{e}^2(1 - \theta)/q.$$

Furthermore, using equation (8) from the model to solve for w_R, rearranging, and then substituting (v) and the above derivation of worker rents yields:

$$w_{Ri} = \hat{e}^2 + x(V_E^{Ri} - V_U^{Ri}) + rV_E^{Ri}$$

$$w_{Ri} = \hat{e}^2 + (r+x)(V_E^{Ri} - V_U^{Ri}) + rV_U^{Ri}$$

$$w_{Ri} = \hat{e}^2 + (r+x)(V_E^{Ri} - V_U^{Ri}) - s + \beta_i p_u^R (V_E^{Ri} - V_U^{Ri})$$

$$w_{Ri}^* = \hat{e}^2 - s + (r+x+ \beta_i p_u^R) \hat{e}^2 (1 - \theta)/q.$$

The last line, gives the lowest wage the firm can pay to still satisfy the NSC, w_{Ri}^*.

The lowest wage a firm hiring formally can pay and still satisfy the no-shirking condition must meet the condition: $V_E^{Fi} = V_S^{Fi}$. Solving this problem as described above yields the rents earned by workers hired through formal methods: $(V_E^{Fi} - V_U^{Fi}) = \hat{e}^2/q$. Thus, workers hired by firms that satisfy the NSC and hire through formal methods earn higher rents than workers hired through referrals. The lowest wage satisfying the NSC when firms hire formally is:

$$w_F^* = \hat{e}^2 - s + (r+x+ \beta p_u^F) \hat{e}^2/q.$$

Proof of Lemma 1.2:

Using w_{Ri}^* from Lemma 1.1 and taking the limit of the efficiency wage as $\theta \rightarrow 1$ yields,

$$\lim_{\theta \rightarrow 1} \quad \hat{e}^2 - s + (r+x+\beta_i p_u^R) \hat{e}^2(1 - \theta)/q = \hat{e}^2 - s.$$

Proof of Proposition 1:

Given the wages that firms pay when they choose each hiring method, we can determine how firms split in the use of the two hiring channels. When a firm holds a vacancy, it focuses on the hiring method that maximizes its lifetime stream of profits. Firms whose lifetime stream of profits are greater when they use referrals and pay efficiency wages, V_O^{Ri*}, than when they use formal channels and pay the market wage, V_O^F, will prefer hiring through employee referrals and, vice-versa. Thus, to determine the division of firms between the two hiring channels, we compare the lifetime stream of profits given the optimal wage/hiring channel combinations. If $V_O^{Ri*} > V_O^F$, then firms hire through referrals. By contrast, if $V_O^{Ri*} < V_O^F$, then firms hire through formal channels. Thus, the firm for which $V_O^{Ri*} = V_O^F$ is the firm which is just indifferent between hiring through referrals and hiring through formal methods. Moreover, while the benefits from using referrals are uniform across firms, the cost of using referrals increases as the firm's idiosyncratic arrival rate gets smaller. We can, thus, determine the cutoff (or critical value) arrival rate for the firm which is just indifferent between the two methods by equating V_O^{Ri*} to V_O^F and solving for a_{crit},

$$V_O^{Ri*} = V_O^F$$

$$\{-r + [(a_{crit}+z) p_o^R (A- (\hat{o}_{wRi(\beta i) \in R} w_{Ri}^* g(w_{Ri}^*) dw_{Ri}^*))/(r+x+(a_{crit}+z) p_o^R)] \}=$$

$$\{-r + [(a+z) p_o^F (\gamma A-w_F)/(r+x+(a+z) p_o^F)] \}$$

Solving for this equation we then obtain the critical value for the idiosyncratic arrival rate of applicants, a_{crit},

$$a_{crit} = -\{ (a+z)(r+x+zp_o^R)p_o^F [A(1-\gamma) - ((\hat{o}_{wRi(\beta i) \in R} w_{Ri}^* g(w_{Ri}^*) dw_{Ri}^*) - w_F)] \} /$$

$$\{ (r+x)(A - (\hat{o}_{wRi(\beta i) \in R} w_{Ri}^* g(w_{Ri}^*) dw_{Ri}^*) +$$

$$(a+z)p_o^F [A(1-\gamma) - ((\hat{o}_{wRi(\beta i) \in R} w_{Ri}^* g(w_{Ri}^*) dw_{Ri}^*) - w_F)] \}$$

In equilibrium, firms with arrival rates $a_f \in [a_{crit}, a]$ hire through referrals, while firms with arrival rates $a_f \in [a, a_{crit}]$ hire through formal channels.

Division of Workers between the two Search Channels

Proof for Proposition 2:

In order to determine who uses referrals and who uses formal methods, I find the arrival rate of offers for an individual who is just indifferent between using either search method, β_{crit}. The value of β_{crit} is, thus, given by equating the expected lifetime utility when the worker searches through referrals to the expected lifetime utility when the worker searches formally:

$$V_U^{Ri} = V_U^{Fi}$$

$$- s + \beta_{crit} p_u^R (V_E^{Ri} - V_U^{Ri}) = - s + \beta p_u^F (V_E^{Fi} - V_U^{Fi})$$

Substituting for $(V_E^{Ri} - V_U^{Ri})$ and $(V_E^{Fi} - V_U^{Fi})$ and rearranging, yields the cutoff arrival rate of offers,

$$\beta_{crit} = [\beta p_u^F (w_F+s) q] /[p_u^R (r+x+\beta p_u^F) \hat{e}^2(1 - \theta)] ,$$

Since $(V_U^{Ri} - V_U^{Fi})$ is increasing in β_i , unemployed workers with arrival rate of offers $\beta_i \in [\beta_{crit}, \beta]$ search through referrals, and unemployed workers with arrival rate of offers $\beta_i \in [\beta, \beta_{crit}]$ search through formal methods.

Proof of Corollary 2.1:

Taking the limit of β_{crit} from Proposition 2 as $\theta \to 1$:

$$\lim_{\theta \to 1} \quad [\beta p_u^F (w_F+s) q] / [p_u^R (r+x+\beta p_u^F) \hat{e}^2(1-\theta)] \to \infty.$$

Proof for Proposition 2':

We assume that workers are heterogeneous with respect to ability and that worker productivity is uniformly distributed from A to A. Moreover, we assume that the arrival rate of offers of each worker i depends positively on his productivity. In particular, we assume that $\beta(A_i) = BA_i$.

In order to determine who uses referrals and who uses formal methods, I find the productivity of the individual who is just indifferent between using either search method, A_{crit}. The value of A_{crit} is, thus, given by equating the expected lifetime utility when the worker searches through referrals to the lifetime utility when the worker searches formally:

$$V_U^{Ri} = V_U^{Fi}$$

$$- s + BA_{crit} \; p_o^R (V_E^{Ri} - V_U^{Ri}) = - s + AB \; p_o^F (V_E^{Fi} - V_U^{Fi})$$

Substituting for $(V_E^{Ri} - V_U^{Ri})$ and $(V_E^{Fi} - V_U^{Fi})$ and rearranging, yields the cutoff arrival rate of offers,

$$A_{crit} = [Ap_u^F (w_F+s) q] / [p_u^R (r+x+ABp_u^F) \hat{e}^2(1-\theta)] ,$$

Since (V_U^{Ri} - V_U^{Fi}) is increasing in A_i , unemployed workers with arrival rate of offers $A_i \in [A_{crit},A]$ search through referrals, and unemployed workers with arrival rate of offers $A_i \in [A,A_{crit}]$ search through formal methods.

Welfare Analysis

Proof for Proposition 3:

Total welfare in the economy is equal to the sum of utility and profits for all employees and firms matching through referrals and formal channels. Thus, the welfare function is,

$$W = A(E_R + E_F) - rK - \hat{e}^2 E_R - s(U_R + U_F),$$

where the total number of filled and vacant jobs in this economy is $K = J_R + J_F + O_R + O_F$. Moreover, the total number of employed and unemployed workers in the economy is $L = E_R + E_F + U_R + U_F$. Thus, we can substitute $U_R + U_F = L - E_R - E_F$ into the welfare function,

$$W = A(E_R + \gamma E_F) - rK - \hat{e}^2 E_R - s(L - E_R - E_F).$$

To observe the welfare effects of an increase in the total number of jobs, we take the derivative of the welfare function with respect to K,

$$\partial W/\partial K = (A - \hat{e}^2 + s)\partial E_R/\partial K + (\gamma A + s)\partial E_F/\partial K - r. \quad \text{(xi)}$$

To find $\partial E_R/\partial K$ and $\partial E_F/\partial K$ we use the definitions of L and K (equations (13) and (14) in the model) together with the steady-state conditions to obtain two equations in terms of E_R and E_F. Using the steady-state conditions which determine that the inflow into unemployment has to equal the flow out of unemployment for each method, we can obtain U_R and U_F in terms of E_R and E_F, respectively, and the parameters of the model:

$$U_R = 2xE_R / [\int_{\beta crit}^{\beta} \beta_i \, p_u^R \, f(\beta_i) \, d\beta_i]$$

and

$$U_F = 2xE_F / [\int_{\beta}^{\beta crit} \beta \, p_u^F \, f(\beta_i) \, d\beta_i].$$

Substituting these two expressions into L yields,

$$L = E_R + 2xE_R / [\int_{\beta crit}^{\beta} \beta_i \, p_u^R \, f(\beta_i) \, d\beta_i] + E_F + 2xE_F / [\int_{\beta}^{\beta crit} \beta \, p_u^F \, f(\beta_i) \, d\beta_i]. \quad \text{(xv)}$$

Similarly, we can use the steady state conditions which determine that flow of filled vacancies has to equal the flow out of newly available jobs. We can obtain O_R and O_F in terms of E_R and E_F, respectively, and the parameters of the model:

$$O_R = 2xE_R / [\int_{acrit}^{a} (a_f + z) p_o^R \, h(a_f) \, da_f].$$

and

$$O_F = 2xE_F / [\int_{a}^{acrit} (a + z) p_o^F \, h(a_f) \, da_f].$$

Substituting these two expressions into K yields,

$$K = E_R + 2xE_R / [\int_{acrit}^{a} (a_f + z) p_o^R \, h(a_f) \, da_f] + E_F + 2xE_F / [\int_{a}^{acrit} (a + z) p_o^F \, h(a_f) \, da_f]. \quad \text{(xvi)}$$

We then solve for E_R using equation (xv) and substitute E_R into (xvi). This gives an expression for E_F in terms of exogenous variables which allows to take the derivative of E_F with respect to K. Likewise, we can solve for E_F using equation (xv) and substitute E_F into (xvi). This gives an expression for E_R in terms of exogenous variables which allows to take the derivative of E_R with respect to K.

To see how an unemployment tax or, equivalently, an employment subsidy for the unemployed affects the welfare effect of a change in the number of jobs, we take the derivative of (xiv) with respect to s, the search cost:

$$\partial^2 W / \partial K \partial s = \partial E_R / \partial K + \partial E_F / \partial K. \quad \text{(xvii)}$$

The sign of (xvii) is given by:

$$\text{Sign } \{ \partial^2 W/\partial K \partial s\} = \text{Sign } \{[p_u^R \ \beta^2 + p_u^F \ \beta^2 - (p_u^R + p_u^F) \ \beta_{crit}^2]\}$$

Thus, if β_{crit} is small (e.g., θ is small), then $\partial^2 W/\partial K \partial s > 0$. If, on the contrary, the number of workers searching formally is large, β_{crit} is large (e.g., θ is large), then $\partial^2 W/\partial K \partial s < 0$.

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